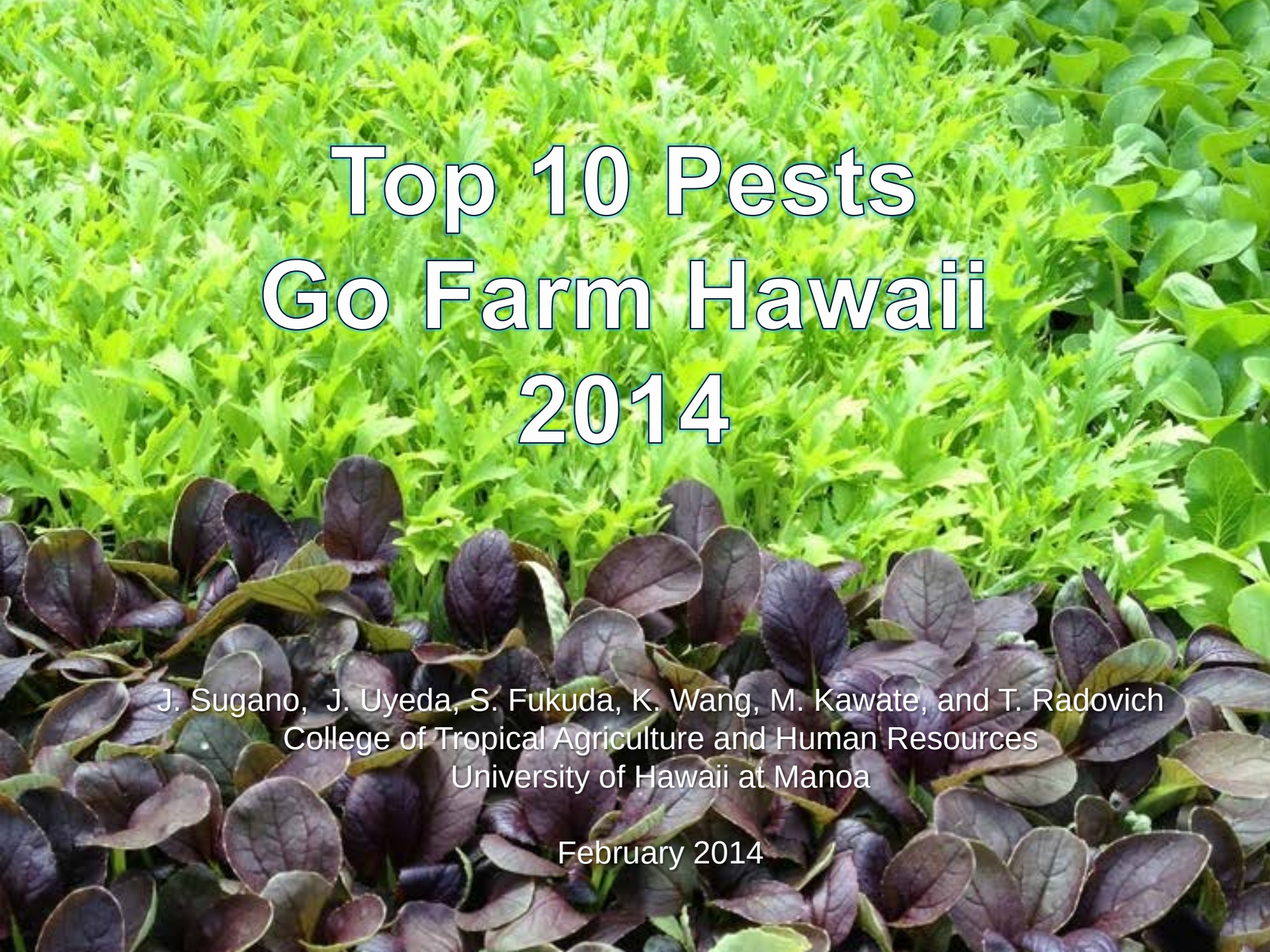


Top 10 Pests Go Farm Hawaii 2014

J. Sugano, J. Uyeda, S. Fukuda, K. Wang, M. Kawate, and T. Radovich
College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

February 2014

Agricultural Crop Pests

- Plant or animal detrimental to humans or human concerns (as agriculture or livestock production)
  - includes insects, animals and plant diseases that predate upon, or otherwise cause damage to plants

Source: Miriam-Webster dictionary


In farming...


Pests are endless

Constant need for Integrated Pest Management

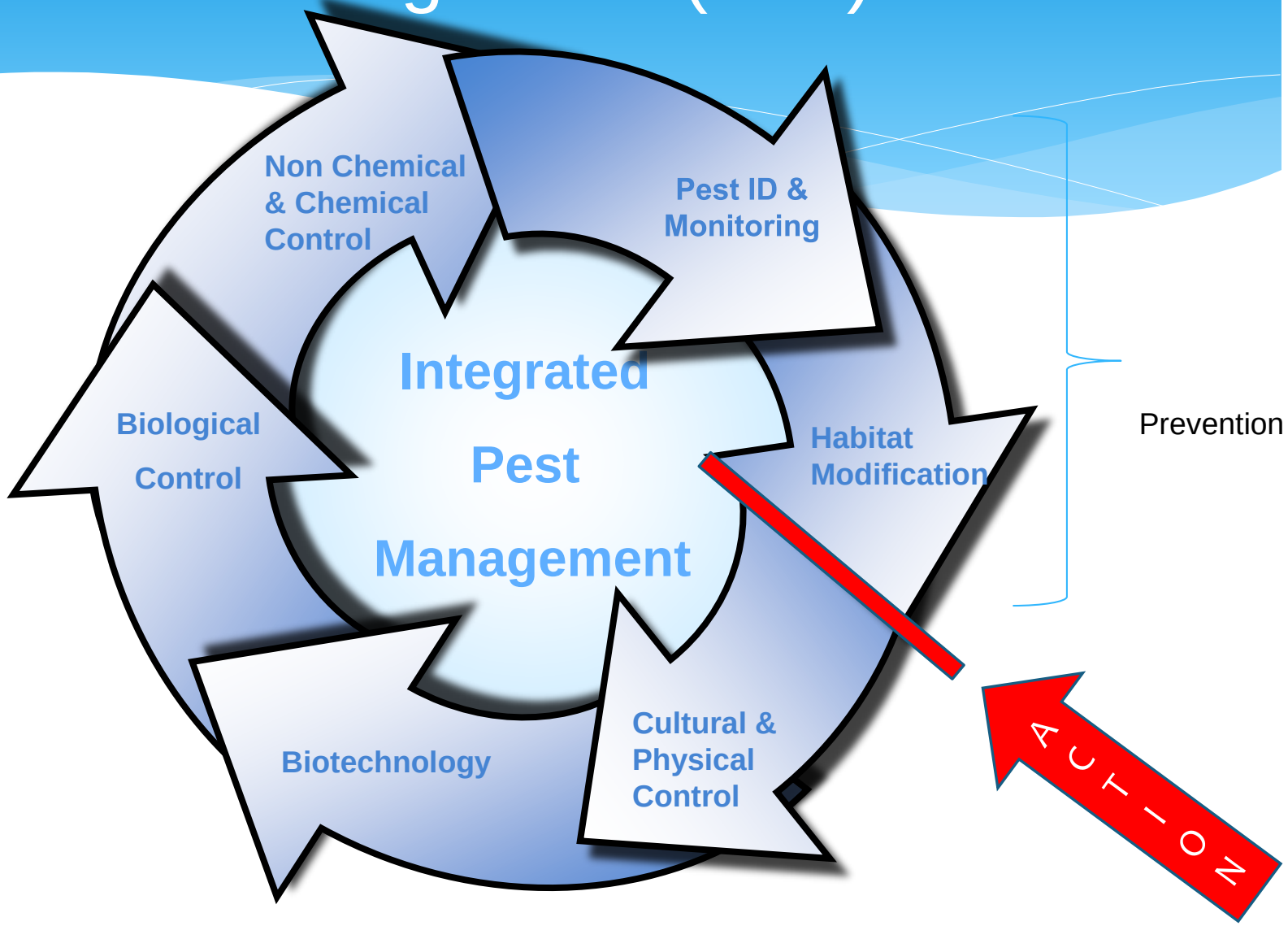
The use of **all possible pest control methods** in a well organized and harmonious way in order to achieve long term pest control.

Top 10 Agricultural Pests Go Farm 2014

1. Mites
2. Leaf hoppers
3. White peach scale
4. Aphids
5. Ants
6. Fruit flies
7. Cabbage looper
8. Pickleworm
9. Snail and slugs
10. Cutworms

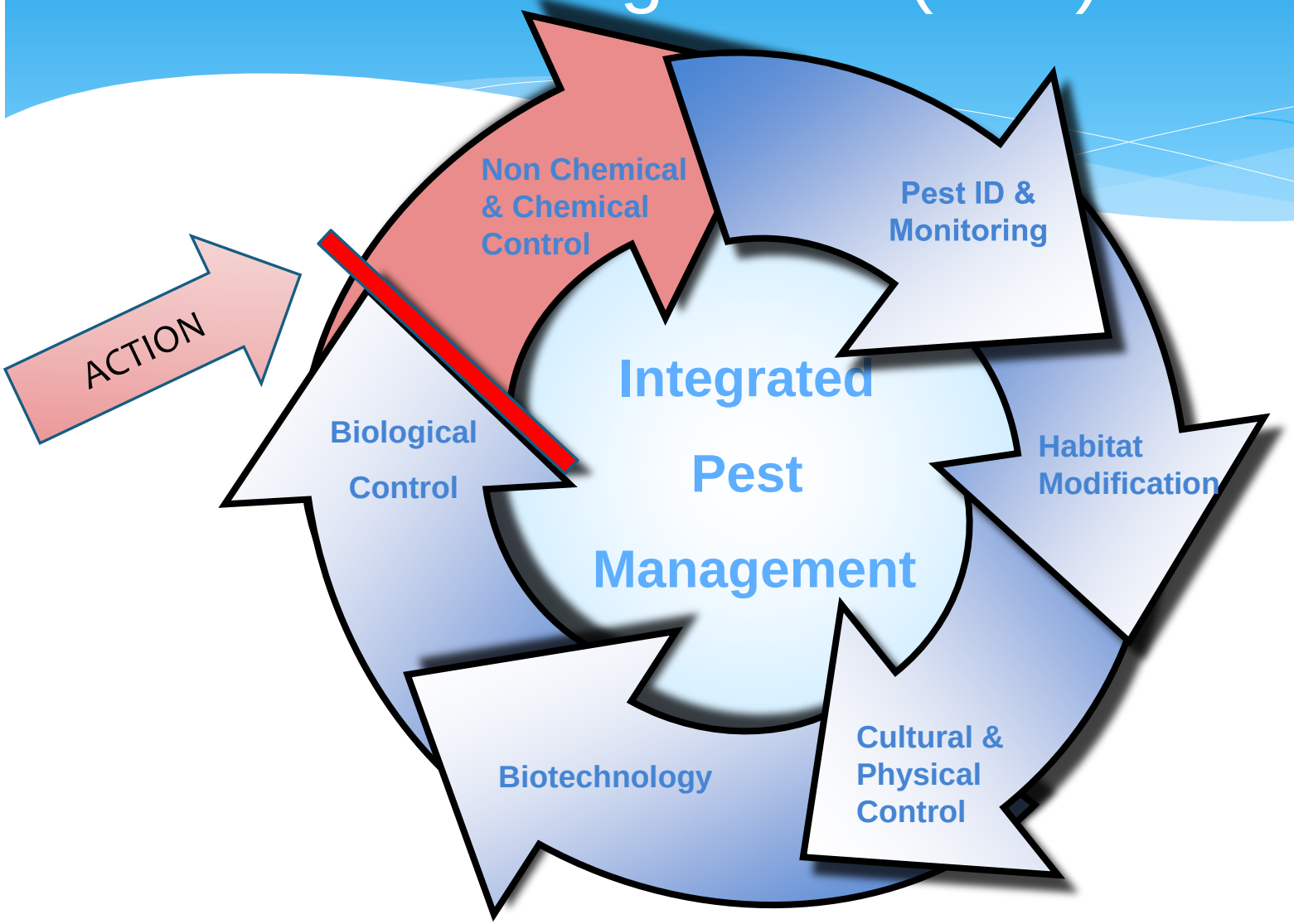
Components of IPM

Components of Integrated Pest Management (IPM)



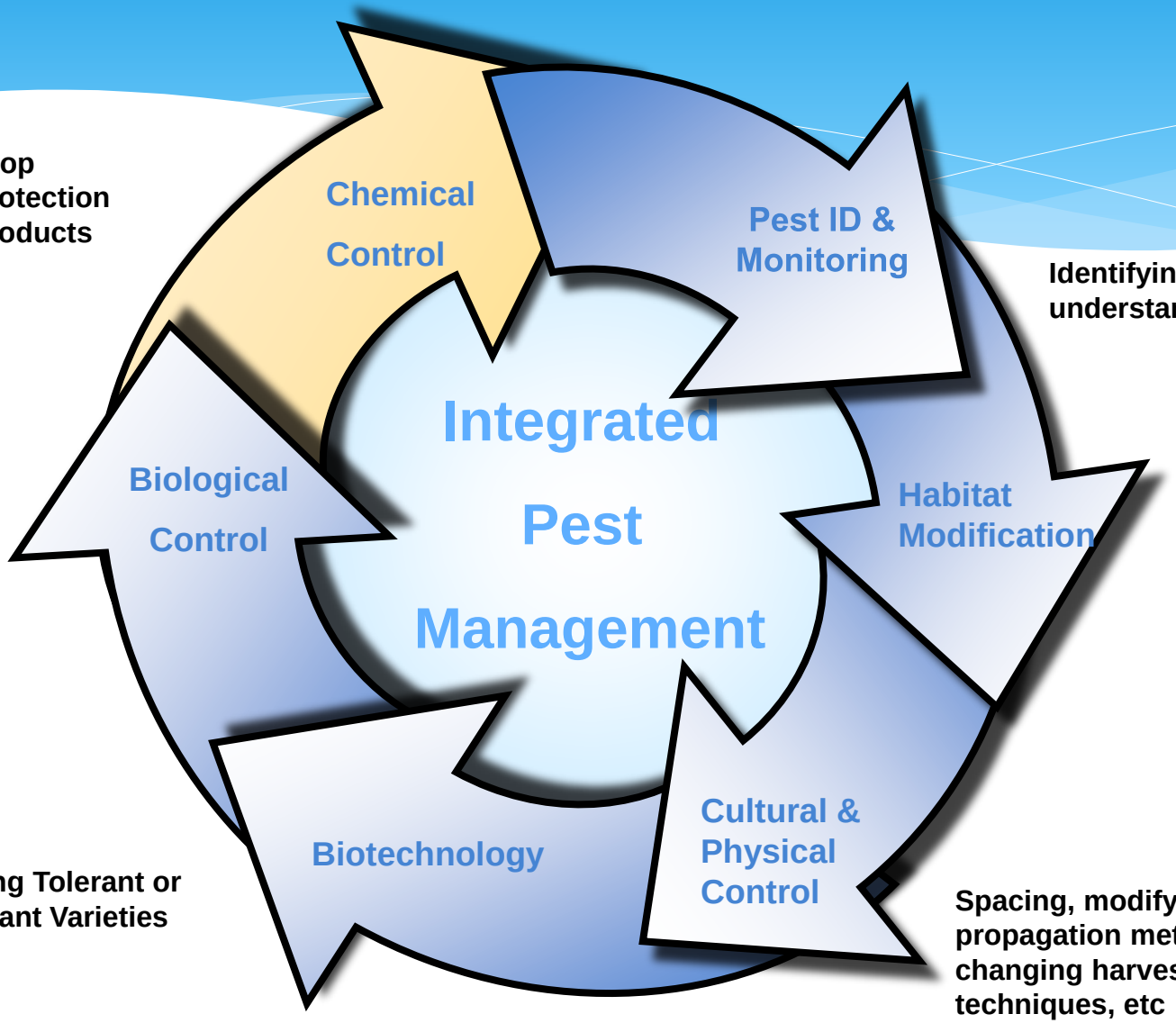
Sugano, 1997

Components of Integrated Pest Management (IPM)



Sugano, 2015

Ex: Basil Integrated Pest Management



Crop Protection Products

Identifying the pest and understanding its lifecycle

Biological measures

Environmental conditions:

Wind barriers

Wind direction

Aeration

Drainage, etc

Utilizing Tolerant or Resistant Varieties

Spacing, modifying propagation methods, changing harvest techniques, etc

PROPER Pest Identification

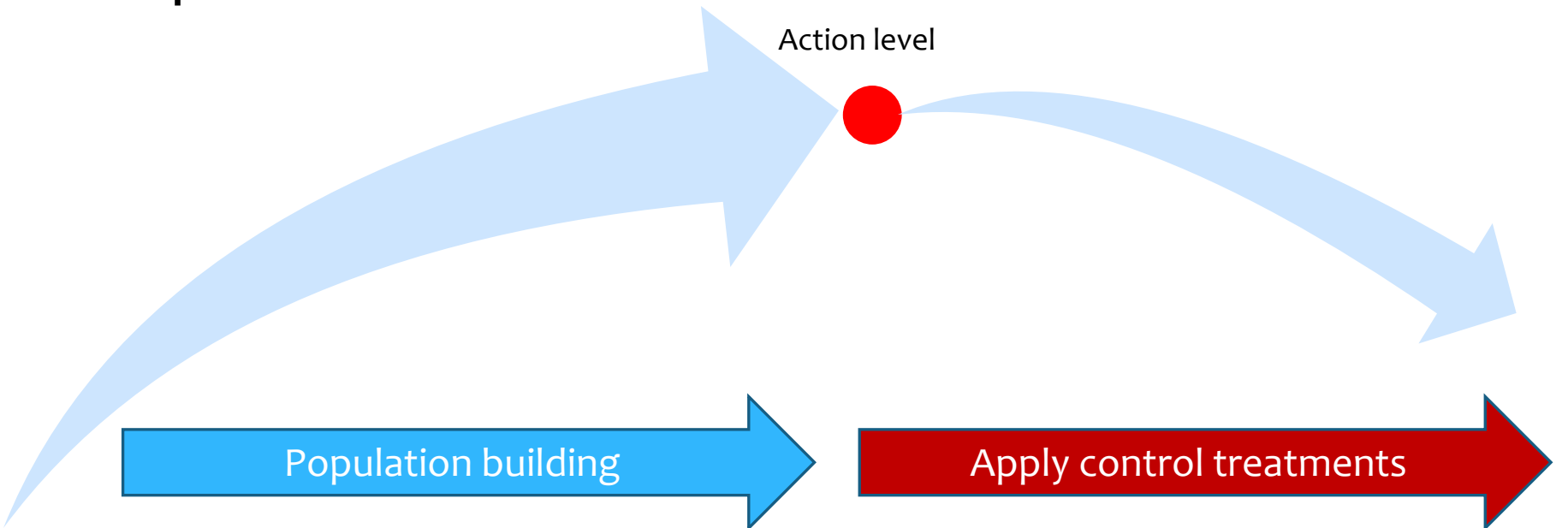
* Proper identification
* Utilize correct pest control techniques for specified crop

Pest Monitoring & Timely Action

* Pest population
* Level of infestation
* Plant location
* Natural enemies
* Time of year
* Contributing conditions
* Environmental conditions

Pest Control in IPM Systems

- Treatments based on monitoring data
- Control measures are used after action threshold is surpassed



Habitat Modification

- Eliminate breeding sites
- Eliminate conditions favorable to pest build up
  - Removal of food or habitat sources
  - Reflective devices
  - Field sanitation
  - Buffer zone
  - Time of year
  - Etc.

Cultural & Physical Control

- Manipulation of cultural practices or installation of physical barriers to disadvantage the pest
  - Tillage
  - Crop rotation
  - Screens/ barriers
  - Spacing
  - Weed mat, mulch, etc.

Other Non- Chemical Control

* Hot water system
* Ozone
* Etc.

Biological Controls

* The use natural predators, parasites, pathogens, etc. to control pests
* Encourage beneficial insects

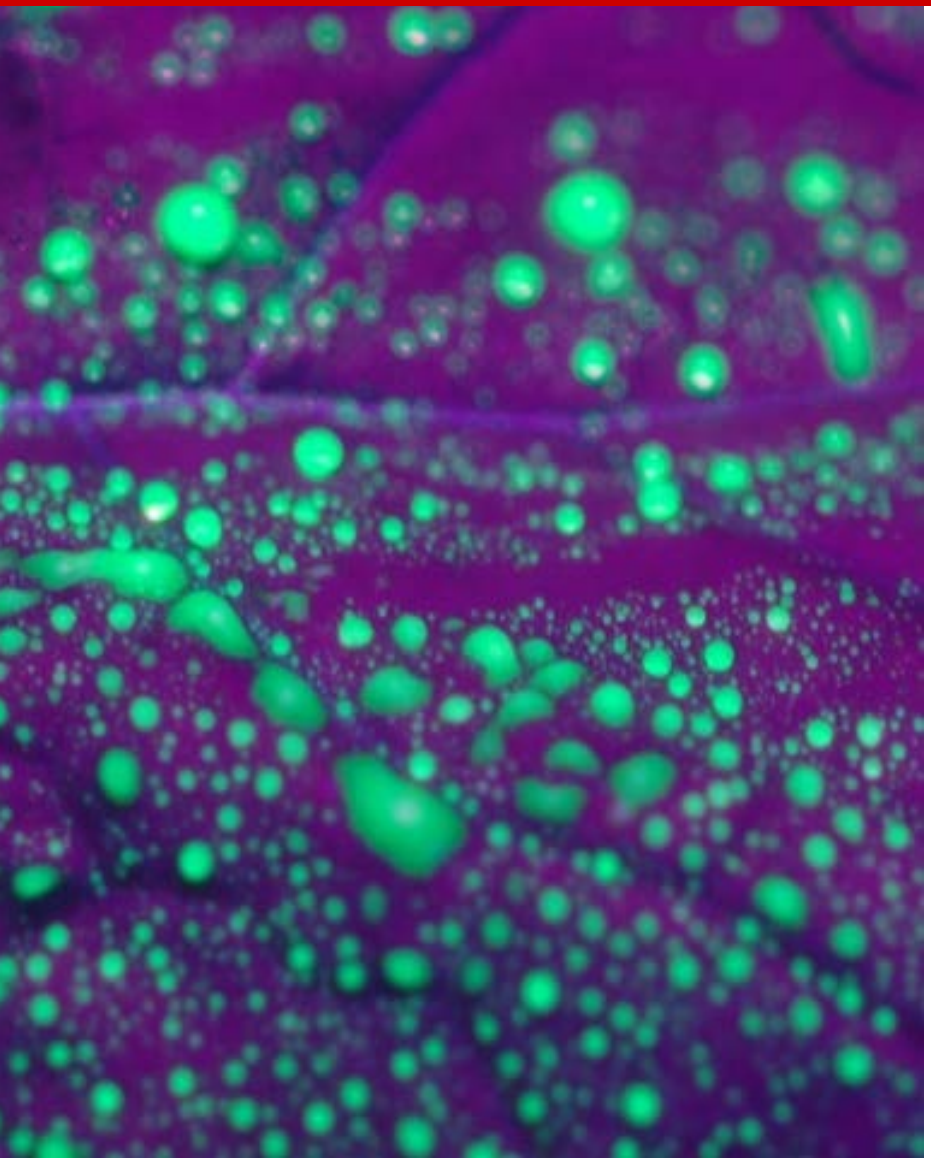
Biotechnology

* Application of scientific techniques to modify and improve plants, insects and pathogens
  * Selective breeding
  * Pest resistance
  * Resistant root stock
  * Etc.

Chemical Control

- Typically considered after other control methods
- Responsible use of crop protection chemicals (pesticides)
- Treatments based on monitoring data
- Applied after action threshold is surpassed

Chemical Control



- Low toxicity chemicals are considered first
- Selective vs. broad spectrum chemicals
- Rotate with other chemicals (resistance)
  - Oils
  - Soaps
- Good spray coverage
- Appropriate pesticide selection

IPM Approach for Go Farm's Top 10 Pests

1. Mites
2. Leaf hoppers
3. White peach scale
4. Aphids
5. Ants
6. Fruit flies
7. Cabbage looper
8. Pickleworm
9. Snail and slugs
10. Cutworms

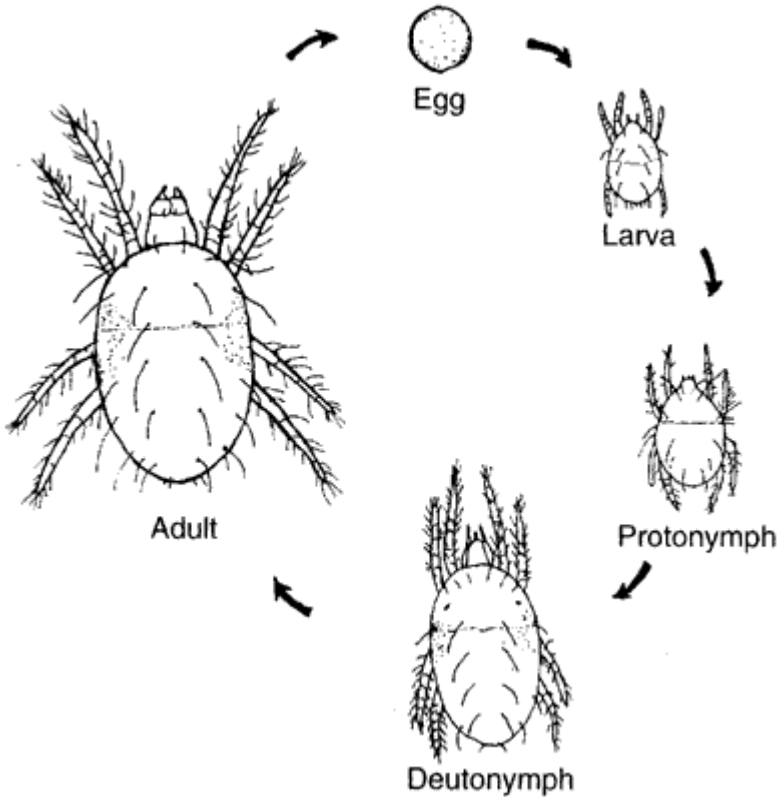
1) Go Farm Pest: Mites

* Arthropods: Adult and nymphs feed on underside of plants
* They have rasping and sucking mouthparts similar to thrips (sap feeders)
* Result in a brown to russet discoloration of leaves, stems, fruit and flowers

Photo credit: Dr. Ted Radovich Dr. Scot Nelson & Jari Sugano

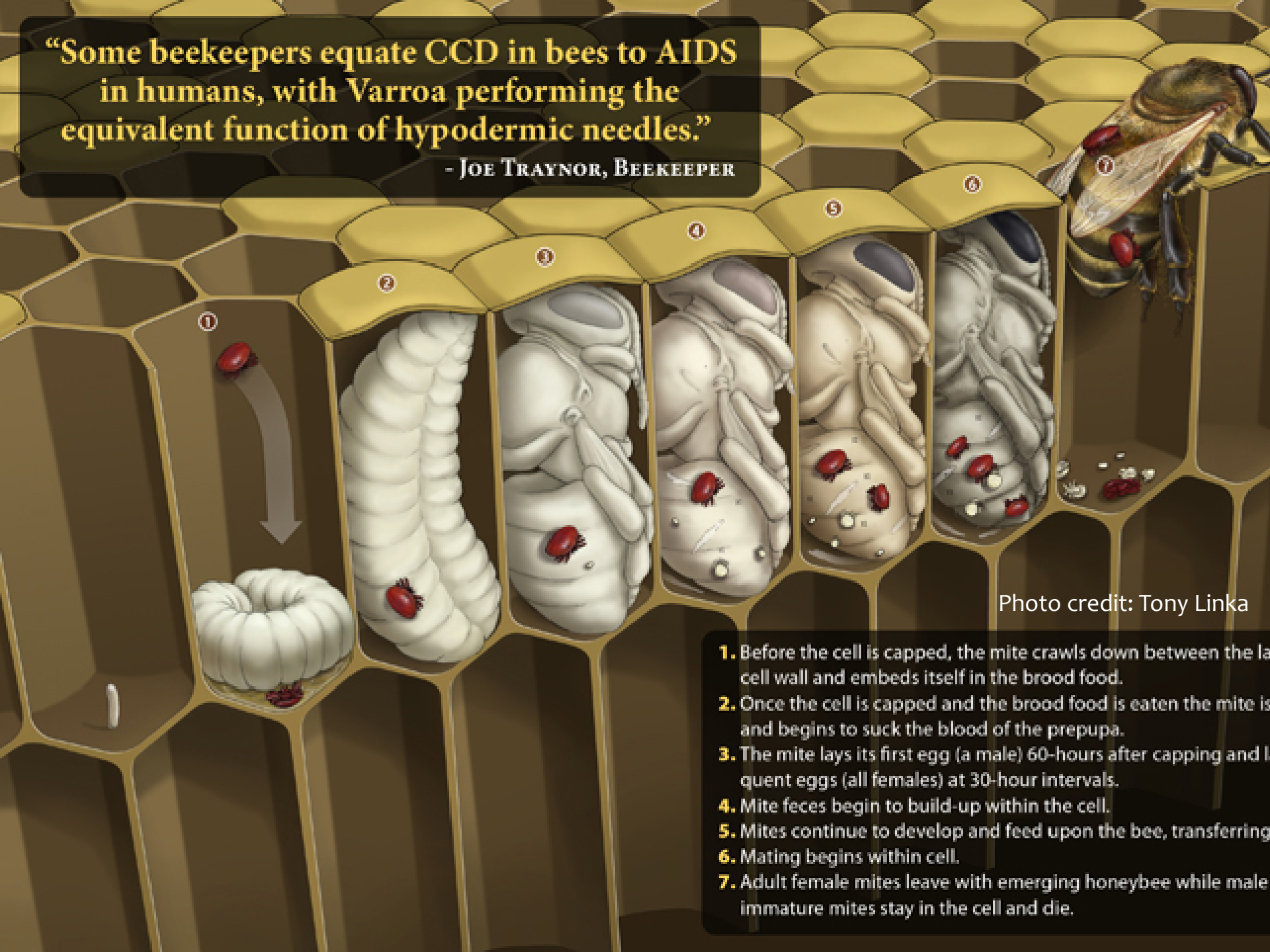
Ex. Broad Mite Lifecycle *Polyphagotarsonemus latus*

* Lifecycle from egg to adult: fast as 4 to 6 days to weeks.
* Lifecycle dependent on temperature
* Year round pest-Summer
* Common mites: Spider mites, Two spotted, Broad, Russett, Varroa, etc.



Source: Knowledge master
Photo credit: www.planthealth.info

Symptoms


"Some beekeepers equate CCD in bees to AIDS in humans, with Varroa performing the equivalent function of hypodermic needles."
- Joe Traynor, Beekeeper
1
2
3
4
5
6
7
Photo credit: Tony Linka
1. Before the cell is capped, the mite crawls down between the la cell wall and embeds itself in the brood food.
2. Once the cell is capped and the brood food is eaten the mite is and begins to suck the blood of the prepupa.
3. The mite lays its first egg (a male) 60-hours after capping and l quent eggs (all females) at 30-hour intervals.
4. Mite feces begin to build-up within the cell.
5. Mites continue to develop and feed upon the bee, transferring
6. Mating begins within cell.
7. Adult female mites leave with emerging honeybee while male immature mites stay in the cell and die.

Control Strategies

* **Monitoring:** Scouting for distortion or discoloring
* **Physical Control:** Barriers
* **Cultural Control:** Crop rotation
* **Non-Chemical control:** Hot water
* **Chemical Control:** Vendex, Abamectin, Sulfur, Horticultural oils, etc
* **Biological:** Banker plants (testing)

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.

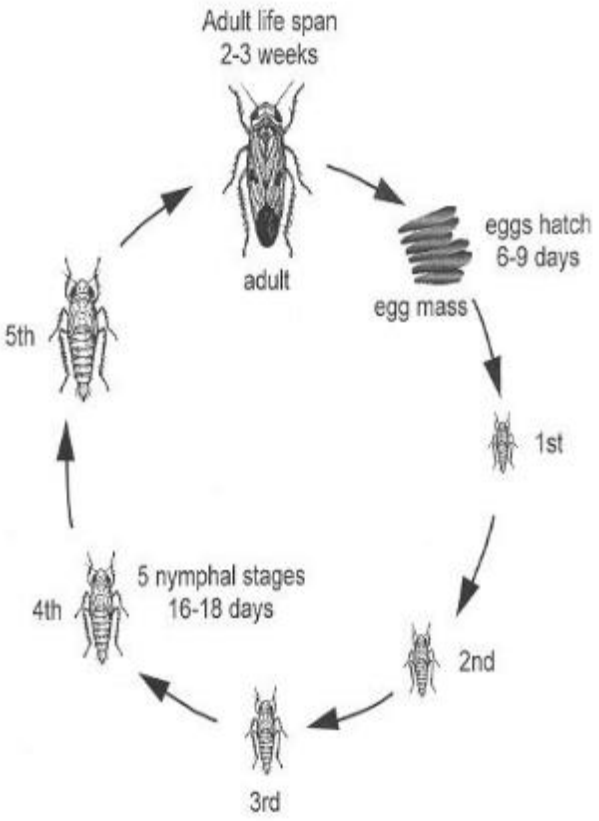
Informal Hot Water Trial (2013)

2) Go Farm Pest: Leaf Hoppers

- Pierce plant's vascular tissue and withdraw plant sap (phloem)
- Cause plants to discolor, twist and distort.
- Saliva can be toxic to plants
  - Steven’s leafhopper, two spotted
- Some leafhopper are **vectors** and transmit plant diseases
  - Example: Aster Yellows Leaf Hopper (Phytoplasma)

Ex. Steven's Leaf Hopper Lifecycle *Empoasca stevensi*

* Total: 3 major life stages (27-37 days)
  * Egg stage is inserted into plant tissue
  * Nymph: 5 immature stages
    * Walking and jumping
  * Adults are the final developmental stage
    * Completely functional wings



Source: Knowledge master
Photo credit: www.knowledgebank.irri.org


UC Statewide IPM Project
© Regents, University of California

How to Recognize Symptoms of Aster Yellows in Watercress

Yellowing in watercress due to an uncertain cause was first reported by a farmer in September 2000. After extensive efforts, including laboratory analyses and greenhouse and field tests, CTAHR's virology laboratory identified a phytoplasma in watercress in October, 2001. This pathogen appears to be closely related to two other phytoplasmas, western North American aster yellows and onion yellows from Asia. Phytoplasmas are a group of microscopic organisms that cause over 700 diseases in plants. Phytoplasmas grow and multiply within host plants and insect vectors. In host plants, phytoplasmas are found only in the phloem tissue of leaves, stems, and roots. When the concentration of phytoplasmas within the plant reaches a certain level, it is believed to cause hormonal imbalance, resulting in the development of symptoms such as chlorotic leaves, stunting, flower petals changing to a green color (phyllody or virescence), and witches'-broom (shoot proliferation). This is the second phytoplasma to be identified in Hawaii; the first was on a native forest tree, 'ohi'a (*Metrosideros excelsa*).

In October 2001, the Hawaii Department of Agriculture confirmed the presence of a recently introduced leafhopper vector of phytoplasma in watercress. This leafhopper is known locally as the watercress leafhopper. It has not been formally identified, but appears to be closely related to the aster yellows leafhopper, *Macrosteles fascifrons*.

The leafhopper feeds by inserting its mouthparts into the watercress phloem tissue. After a noninfected leafhopper feeds on a phytoplasma-infected watercress plant, it takes about 2–4 weeks for the insect to become a persistent vector. Then the leafhopper can infect other noninfected watercress plants. It may take several weeks or longer before plant symptoms such as chlorosis or shoot proliferation appear on a newly infected plant, and during this time, noninfected leafhoppers can acquire the phytoplasma by feeding on the symptomless infected plant. Because watercress plants can be infected without showing symptoms, watercress from the Aiea–Waipahu production areas should not be used as planting material for other areas on Oahu or the Neighbor Islands. Also, these plants can carry leafhopper eggs within the leaves, petioles, and stems.

Phytoplasmas can spread via (1) watercress leafhoppers, (2) using infected planting material, (3) grafting, and (4) parasitic plants (e.g., dodder). Phytoplasmas cannot be transmitted by rubbing sap from infected plants onto healthy plants or by cutting tools used in farming practices. Phytoplasmas are not known to be transmitted by seeds.

Best Management Practices

1) Start with noninfected planting material.
2) Manage and completely control the watercress leafhopper in the watercress and in borders surrounding the field.
3) Aggressively rogue infected watercress plants.
4) Control all known weed hosts of the phytoplasma both within and around the borders of the farm (see weed host photos, far right).
5) Fertilize periodically with a high-nitrogen, slow-release fertilizer.
6) Do not transport watercress planting material outside of the Aiea–Waipahu watercress production area.
7) Backyard gardeners and new growers should not plant watercress unless they know that the planting material is free of the phytoplasma and the leafhopper.

Insect Vector

watercress leafhopper

watercress leafhopper

Weed Hosts

parrot's feather
Myriophyllum brasiliense

Flora's paintbrush
Emilia sonchifolia

sow thistle
Sonchus oleraceus

broadleaved plantain
Plantago major

amaranth
Amaranthus species

false daisy
Eclipta prostrata

Cooperative Extension Service
College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Insect Pests
Jan. 2004
IP-15

Hopper Burn on Papaya Caused by the Stevens Leafhopper

Richard H. Ebesu, Department of Plant and Environmental Protection Sciences

Stevens leafhopper, *Empoasca stevensi*, can be a serious pest of papaya. The leafhoppers are found mostly on the underside of the leaves. They feed on the plant sap, causing a drying of the leaf tissue called "hopper burn." The leafhopper releases saliva into the plant tissue as it inserts its needle-like stylet mouthparts. The saliva is toxic to the plant: the leaves turn yellow, their edges dry and their tissue dies, and the plant becomes stunted (Figure 1). Young plants are more susceptible, yet plants of all ages are attacked. The red-fleshed commercial papaya cultivars like 'Sunrise' are more susceptible to hopper burn than the yellow-fleshed cultivars like 'Waimanalo Low-Bearing' and 'Kapaho', although some yellow-fleshed cultivars (notably 'Line 5') may be susceptible. Common symptoms of leafhopper feeding are puncture marks along the leaf veins and petiole and the resulting bleeding of milky white latex from the plant. The plant usually recovers after removal of the leafhoppers, but large populations of leafhoppers can severely damage the plant.

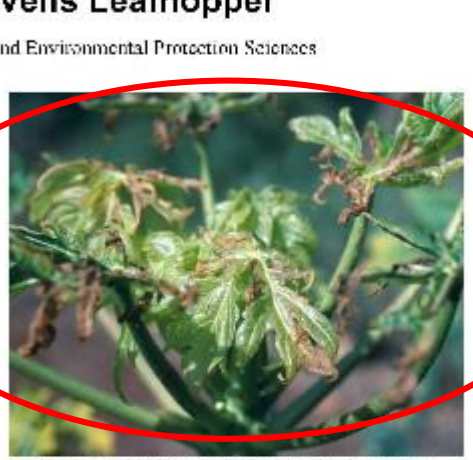


Figure 1. Severe damage to a papaya plant caused by Stevens leafhopper feeding.

Figure 2. Stevens leafhopper adult, about ¼ inch long.

The winged adult leafhopper is about ⅛ inch long and slender, less than ⅛ inch wide. It is light yellowish-green with two longitudinal white stripes on top of its thorax, just behind the head (Figure 2). The immature stages (nymphs) are light green and look like the adults only they are smaller and without wings. The leafhoppers normally run quickly or jump when the leaf is turned over to observe the underside.

The female lays her eggs singly, mostly in the veins on the underside of the leaf. Usually, only the puncture wound where the female laid the egg can be seen. On average, the eggs take 10 days to hatch and the immature leafhoppers take 12–15 days to complete five growth stages before turning into adults. On becoming an adult, the female lays her first egg after 7 days. Females live for an average of 6 weeks, producing an average of seven eggs per week. The complete life cycle of a female will take about 26 days.

The Stevens leafhopper is very similar to the southern garden leafhopper (*Empoasca solana*), which is also light green but is slightly longer than the Stevens leafhopper. The southern garden leafhopper is found on many plants including green beans, spiny amaranth, and the weed black nightshade (or popolo, *Solanum nigrum*). It has also been reported on papaya but it does not seem to be the major cause of hopper burn on papaya.

Host plants

The Stevens leafhopper may be found on papaya throughout the year but appear to be most damaging in the warm summer months when the populations are at their highest. Besides papaya, it has been reported on cowpea, plumeria, lima bean, and the Mexican fire plant (*Euphorbia heterophylla*). It has been known to rest on the weed *Stegesbeckia orientalis*.

Control

There are no known biological control agents for the Stevens leafhopper. General predators such as spiders and small wasps may eat them, and a fungal disease can infect them if conditions are right. Insecticides registered for papaya may help to reduce leafhopper populations provided that spray coverage is adequate. Papaya plants are sensitive to many pesti
stickers used with them, and use
for potential damage before proc
applications. Control of leafhopp
tions are small is easier than afte
present in large numbers. Leafh
be monitored with yellow stick
the plants.

References

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Empoasca stevensi Young (He
ical and its toxicity to papaya. M
University of Hawaii at Mano
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Control Strategies for Leaf Hoppers

Best Management Practices

1) Start with noninfected planting material.
2) Manage and completely control the watercress leafhopper in the watercress and in borders surrounding the field.
3) Aggressively rogue infected watercress plants.
4) Control all known weed hosts of the phytoplasma both within and around the borders of the farm (see weed host photos, far right).
5) Fertilize periodically with a high-nitrogen, slow-release fertilizer.
6) Do not transport watercress planting material outside of the Aiea–Waipahu watercress production area.
7) Backyard gardeners and new growers should not plant watercress unless they know that the planting material is free of the phytoplasma and the leafhopper.

Control Strategies: Leaf Hoppers

* **Monitoring:** Scouting for feces, toxicity, etc
* **Physical Control:** Barriers
* **Cultural Control:** Crop rotation, clean planting material, weed management, nutrient management, etc.
* **Biological control:** Encourage beneficial insects
* **Chemical Control:** Venom, pyrethroids, etc.

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemicals listed. These products are just general recommendations.

3) Go Farm Pest: White Peach Scale *Pseudaulacaspis pentagona*

* Armored scale that pierces plant tissue and withdraws plant sap
* Cause plants to discolor, twist and distort.
* Often vectors and excrete attractive honeydew that turns black with the formation of a fungal sooty mold.
* Crawls up from the base of the tree to fruit column
* Female and male scales
* Move with the wind and on worker's clothing

Control Strategies: WPS

* **Monitoring:** Scouting (orange alive)
* **Physical Control:** Barriers around base
* **Cultural Control:** Crop rotation, evaluate wind direction, buffer zones, etc.
* **Biological control:** Encourage beneficial insects
* **Non-chemical control:** Clean boxes
* **Chemical Control:** Movento, Applaud, Horticultural oils (BioCover), Fujimite, etc.
  * Re-assess after chemical applications

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.

WHITE PEACH SCALE IN PAPAYA **LIFECYCLE IN HAWAII**

Pseudaulacaspis pentagona

Native to China / Japan – maybe Italy?? Introduced to US in early 1900's

Pest of many crops – peaches, citrus, woody ornamentals, passion fruit, papaya in HI

Initially detected in HI in 1997; only present on the Big Island so far...

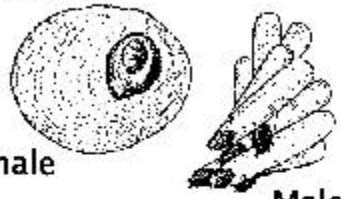
Life cycle and biology

Has more than four generations per year in Florida – may be as many as eight in Hawai'i

Up to 100 eggs per female, hatch within 4 days, crawlers emerge

Females release pheromone to attract males

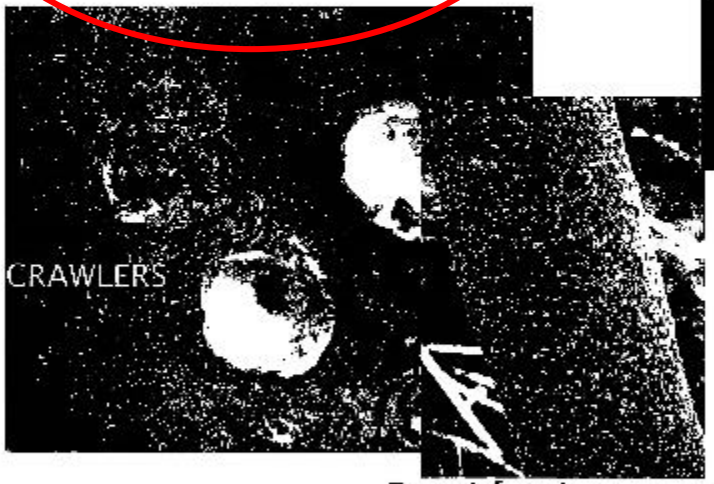
Do not disperse rapidly



Female

Male

Male scales



CRAWLERS

Dense infestation on papaya

Aphelinid wasp parasitizing insect

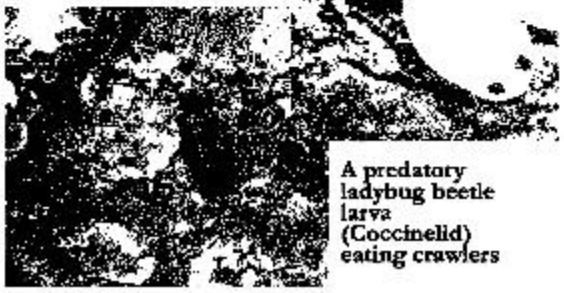
Controlling WPS

Worldwide: biological control can be effective

In Europe – Tiny wasps (Aphelinidae spp.) used since early 1900's

Two have been effective in Italy – *Encarsia berlesei* and *Pteroptrix orientalis*

Predatory insects, such as ladybugs, can also help control WPS



A predatory ladybug beetle larva (Coccinelid) eating crawlers

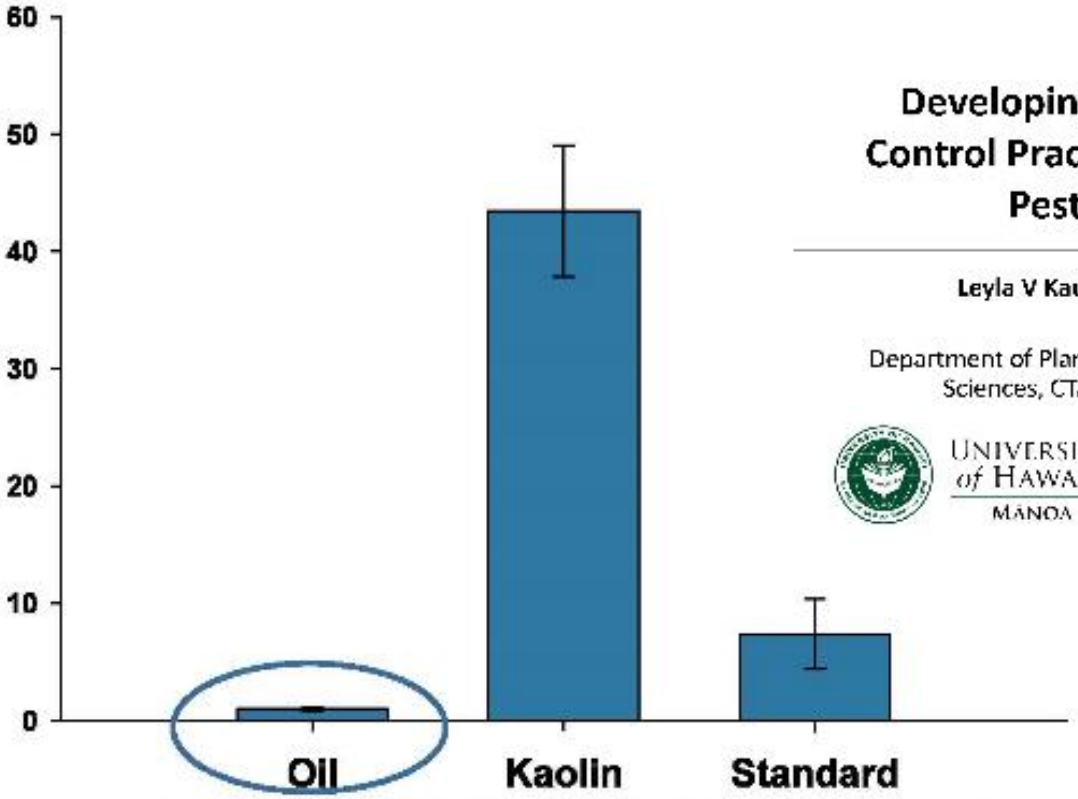
Photograph by Lyle J. Buss, University of Florida.

Data from Dr. M. Kawate of the CTAHR IR-4 Program

CONTROL

APPLAUD
5 apps at irregular intervals based on the reproductive stage of the WPS (picture is ~2 months after the last treatment)

Pest density on tree trunks - 2012



Developing Sustainable Pest Control Practices Against Major Pests in Papaya

Leyla V Kaufman & Mark G Wright

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UNIVERSITY of HAWAI'I MĀNOA

WESTERN SARE Sustainable Agriculture Research & Education

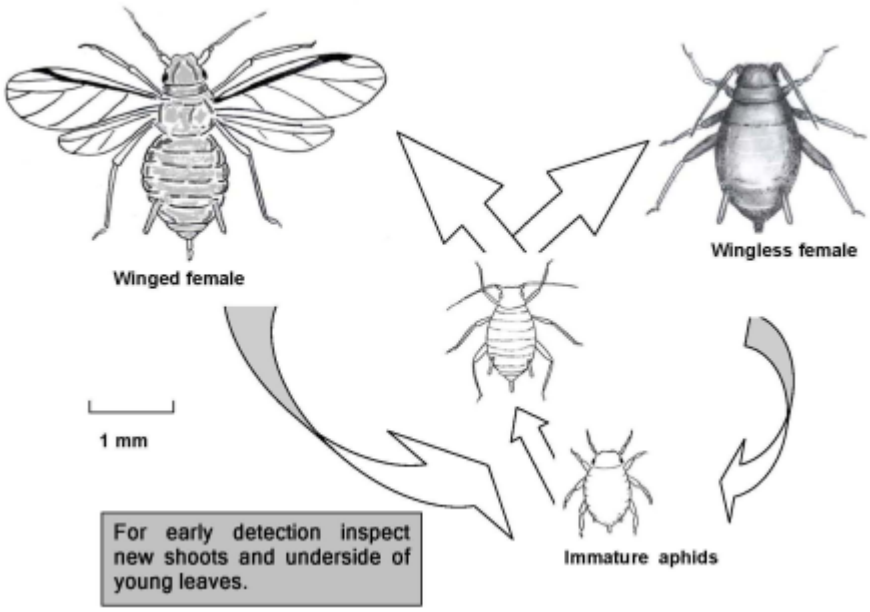
Data from Drs. Kaufman & Wright, CTAHR PEPS

4) Go Farm Pest: Aphids

* Soft bodies insects that pierce and suck on plant parts (phloem feeder)
* Causes plants to discolor, twist and distort.
* Excrete attractive honeydew that turns black with the formation of a fungal sooty mold
* Sometimes plant vectors (BBTV, PRV, ZYMV)
* Produce wings and fly when populations high
* Higher populations along field edges
* Cabbage, root, green peach, banana, corn, potato, etc.

Ex. Banana Aphid Lifecycle *Pentalonia nigroneruosa*

* Reproduction occurs without mating
* All females, females bear live females
* Four nymph stages
* Nymph to adult lifecycle estimated at 9 to 16 days
* Adult life span estimated at 8 to 26 days
* Estimated 30 generations produced per year in Hawaii.



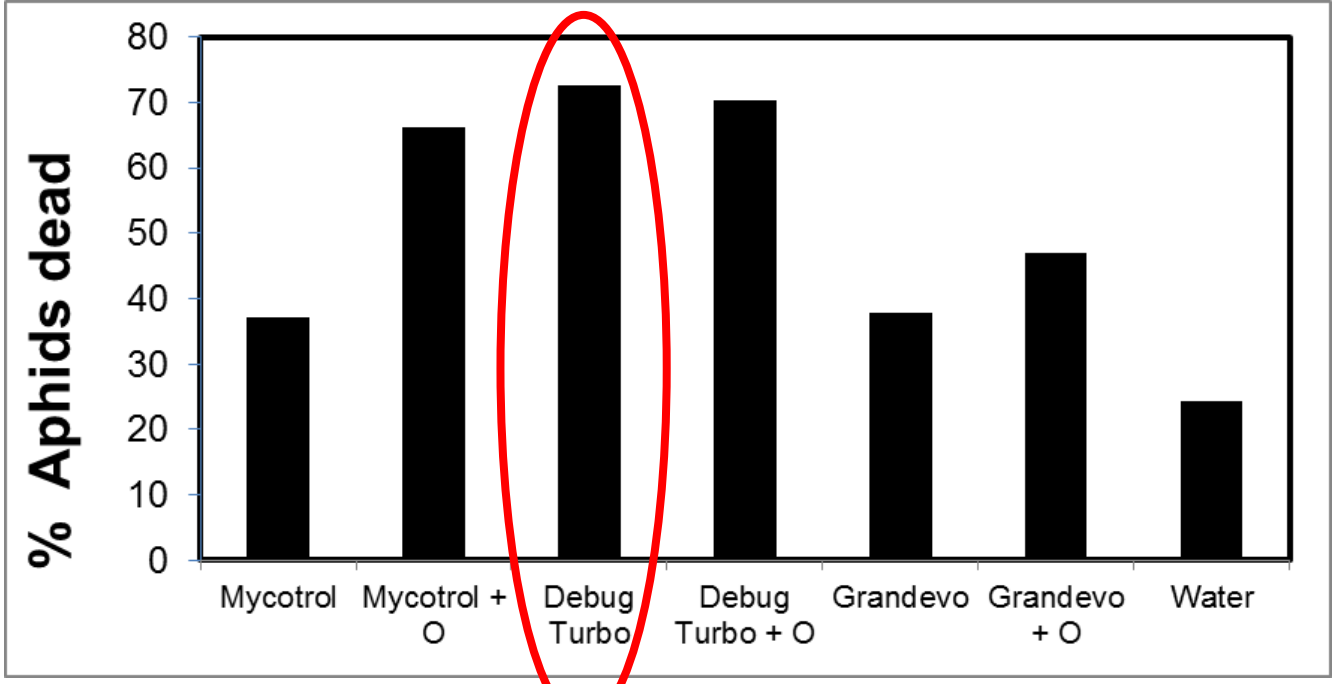
Source: Knowledge master
Photo credit: www.infonet-biovision.org

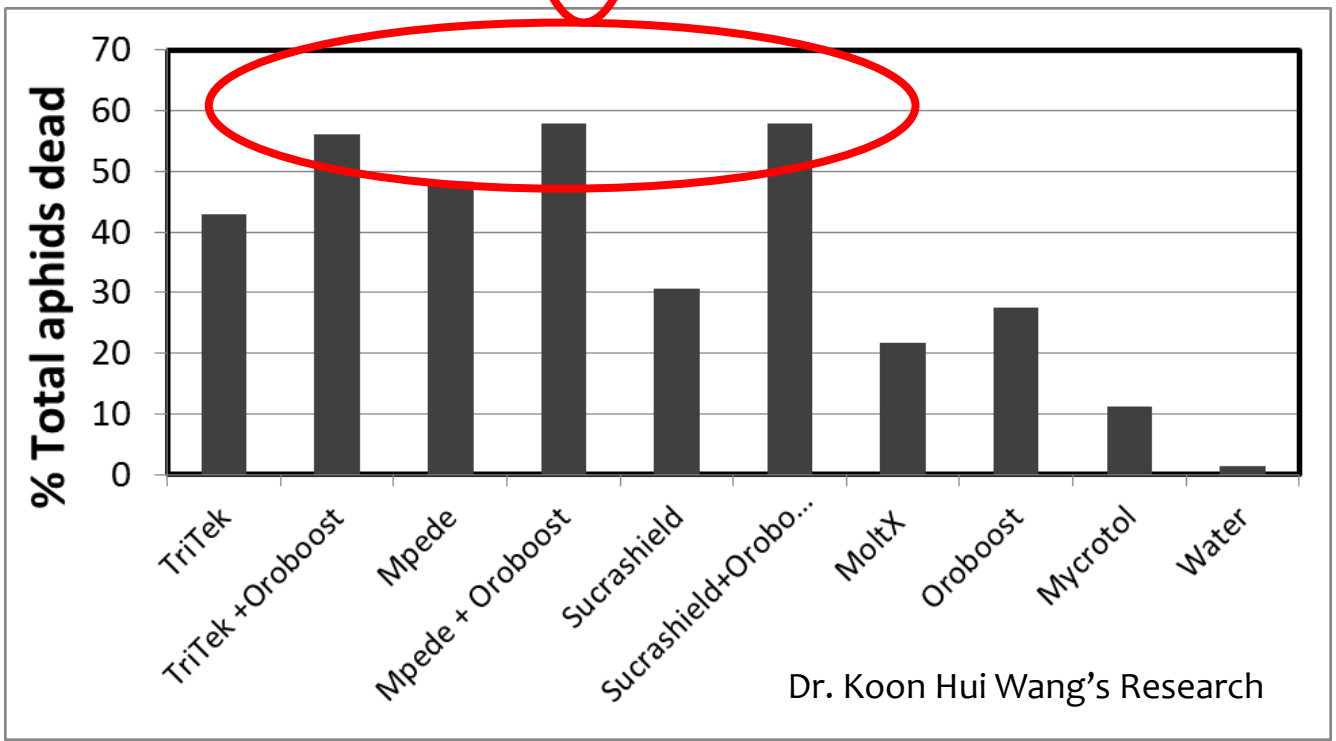


Control Strategies: Aphids

* **Monitoring:** Monitoring traps
* **Physical Control:** Barriers
* **Cultural Control:** Nutrient management, crop rotation, timely knock down, ant management (protect aphids), etc.
* **Biological control:** Encourage natural biologicals (wasp, lady bugs, etc.), companion planting
* **Chemical Control:** Contact and systemic insecticides such as Admire, Provado, DeBug Turbo, Pyrethrin 4.0, etc.

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.


% Aphids dead
80
70
60
50
40
30
20
10
0
Mycotrol
Mycotrol + O
Debug Turbo
Debug Turbo + O
Grandevo
Grandevo + O
Water


% Total aphids dead
70
60
50
40
30
20
10
0
TriTek
TriTek +Oroboost
Mpede
Mpede + Oroboost
Sucrashield
Sucrashield+Orobo...
MoltX
Oroboost
Mycrotol
Water
Dr. Koon Hui Wang's Research

5) Go Farm Pest: Ants

* Scavengers, predators and feeders
* They are honeydew consumers and protect pests from natural enemies (aphids, mealy bugs, scales, WF)
* Promotes sooty mold development (photosynthesis)
* Sugar loving ants vs. grease loving ants
* Excrete formic acid which causes crop damage



Photo source: http://en.wikipedia.org/wiki/File:Scale_and_sooty_mold_on_a_Eucalyptus_tree.jpg

Ants that produce formic acid are attracted to flower nectaries and to sap-feeding insects that secrete honeydew. They climb the plants to feed and, when startled, eject formic acid from their abdomens, causing blackened spots and trails.

Entire bunches may be damaged by

Startled and disturbed ants scatter over the banana fingers, spraying formic acid and leaving burnt, sunken trails.

Severe formic acid injury to a hand Hawai'i caused by *Anoplolepis grac*

Affected bunches are left in the field and are not harvested.

De-flowering the fingers on a banana bunch by plucking them off and severing the male flowers (the hanging "bell") will remove the sweet flower nectaries that attract sugar-loving ants in the subfamily Formicinae.

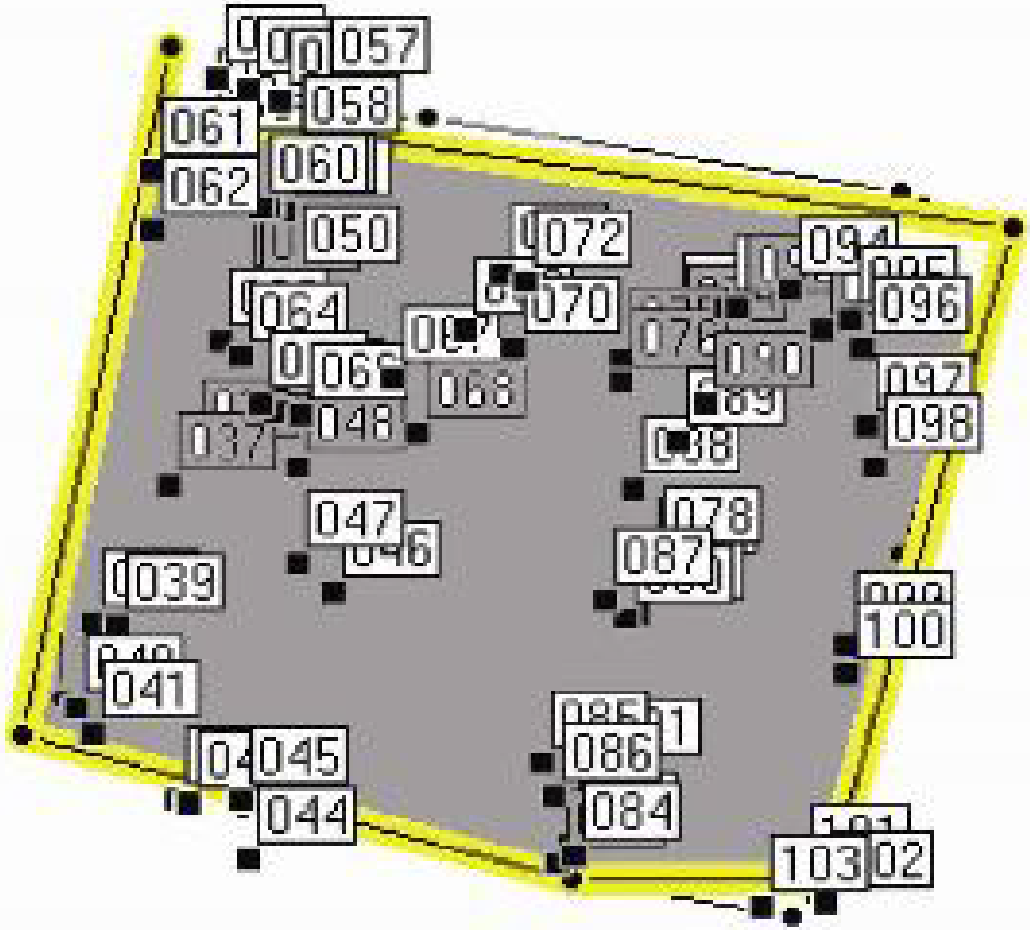
Fruits in bunches should be de-flowered to make them less attractive to foraging ants.

The flowers shown here may attract sweet-loving ants that may produce formic acid secretions when disturbed. This "bell" should be severed from the bunch.

Control Strategies: Ants

* **Monitoring:** Bait system
* **Physical Control:** Barriers or buffers
* **Cultural Control:** Minimize debris, sanitation
* **Biological control:** Encourage natural biological, ant competition, manage honeydew excreters, etc.
* **Chemical Control:** Diazinon, Esteem, Amdro, Boric acid, Fripronil, etc. (bait stations)

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.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103
02

6) Go Farm Pest: Fruit Flies

- **Fruit Flies**
  - Adult females sting fruits and vegetables resulting in blemishes
  - Larvae tunnel within fruit
    - Oriental fruit fly, Melon fly, Mediterranean fruit fly, Malaysian fruit fly



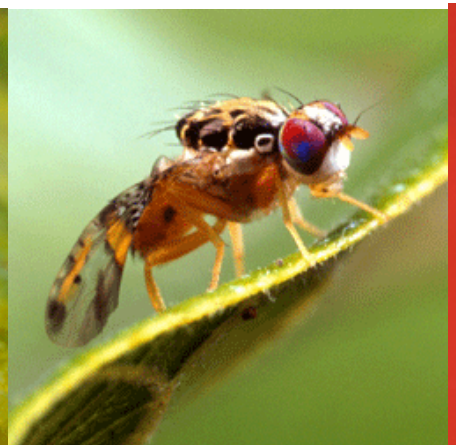



Photo credit: USDA ARS

Ex. Melon Fly Lifecycle
Bactrocera dorsalis

Adult Stage (months)

Female adults cause blemished inside fruits and vegetables.

Egg Stage
(1-1.5 days)

Eggs are deposited by the adult fly into the fruit or vegetable. Eggs hatch within 24-48 hours at 25 degrees Celsius

Larvae Stage (11-15 days)

Larvae damage fruits and vegetables through feeding and tunneling.

Pupae Stage
(10 days)

Larvae form a puparium that allow the insect to develop into an adult.

Adult flies emerge from the puparium.

Oriental Fruit Fly Biology

Control strategies should be targeted at trees WITHIN orchard

Melon Fly Biology

Control strategies should be targeted OUTSIDE of fields or gardens

Control Strategies: Fruit Fly

* **Monitoring:** Pheromone system
* **Physical Control:** Barriers, bagging
* **Cultural Control:** Field sanitation, timely knock down, crop rotation, trap crops
* **Biological control:** Encourage natural biological parasitoids
* **Chemical Control:** Success, Malathion, GF-120 Protein Bait, Pheromones + Fripronil, etc.

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.

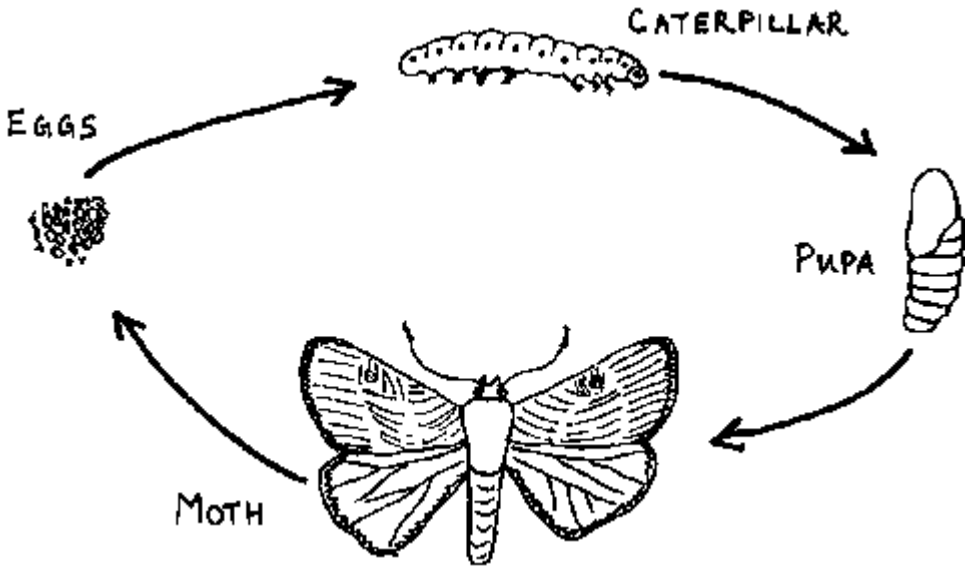

PROTEIN
BAIT

7) Go Farm Pest: Cabbage Looper *Trichoplusia ni*

* Cabbage loopers feed on crucifers as well as many other crops
* Damage to crop foliage
* Evidence of feeding include wet, sticky frass material
* Easily identified by its ‘looping’ or arched movement
* Easily resistant to various crop protection chemicals

Ex. Cabbage Looper Lifecycle *Trichoplusia ni*

- Complete metamorphosis:
- Eggs typically deposited on the lower leaf surface
  - Eggs hatch in 3-4 days.
- Larvae Stage: (12 to 20 days)
  - The first two larval stages create "windows" by feeding on epiedermis of leaves
  - Older larvae chew through the entire leaves and create larger holes, occasionally fedd on fruit rinds and on flowers
- Pupal Stage: 9 days
- Adult stage: Approximately 24 days, nectar feeders



Source: Knowledge master
Photo credit: www.nzdl.org




Photo Credit: utahpests.usu.edu, www.missouribotanicalgarden.org, www.extension.umn.edu, greenlifeinsocal.com

Control Strategies: Cabbage worm

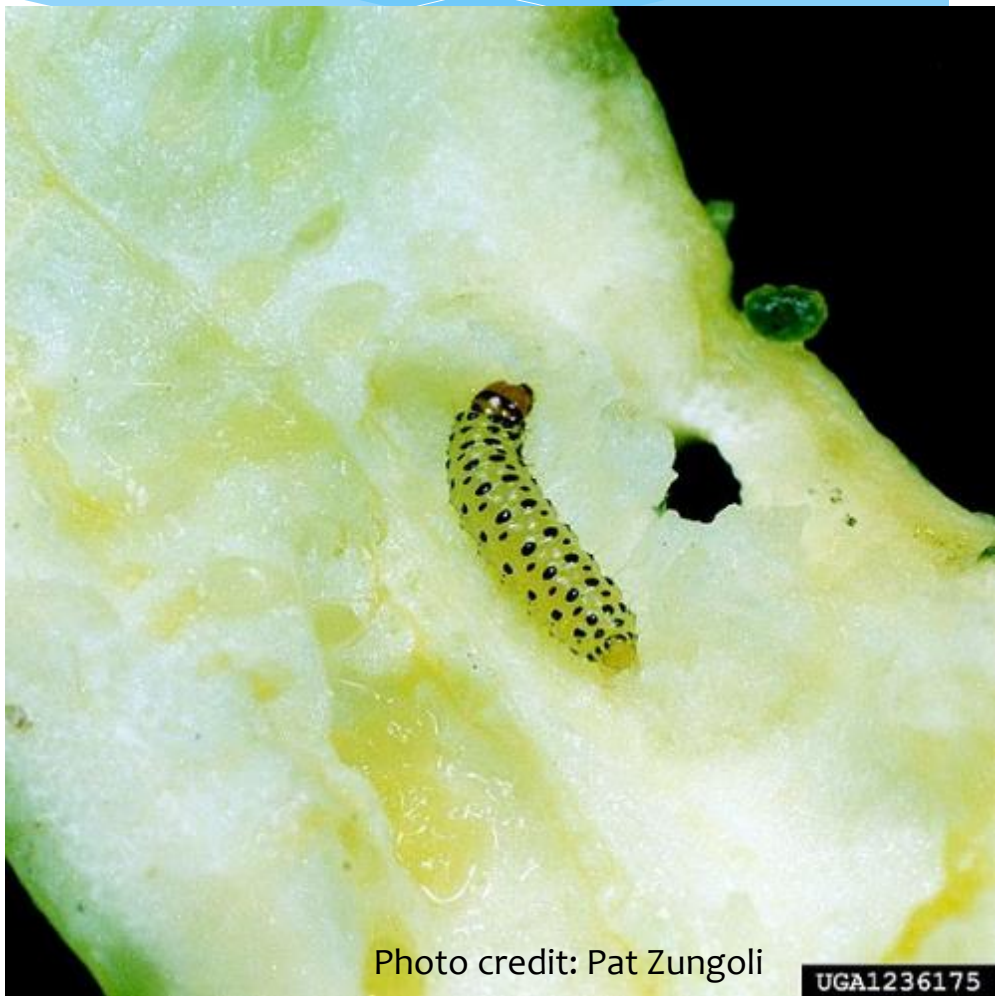
* **Monitoring:** Scouting with pheromones and light
* **Physical Control:** Barriers
* **Cultural Control:** Field sanitation, timely knock down, crop rotation, weed management, etc.
* **Biological control:** Encourage natural biological
* **Chemical Control:** Coragen, Proclaim, Avant, Radiant, Bt, Synapse, Lannate, Intrepid, etc.

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.


Start 21/11/13
Day 11
Radiant

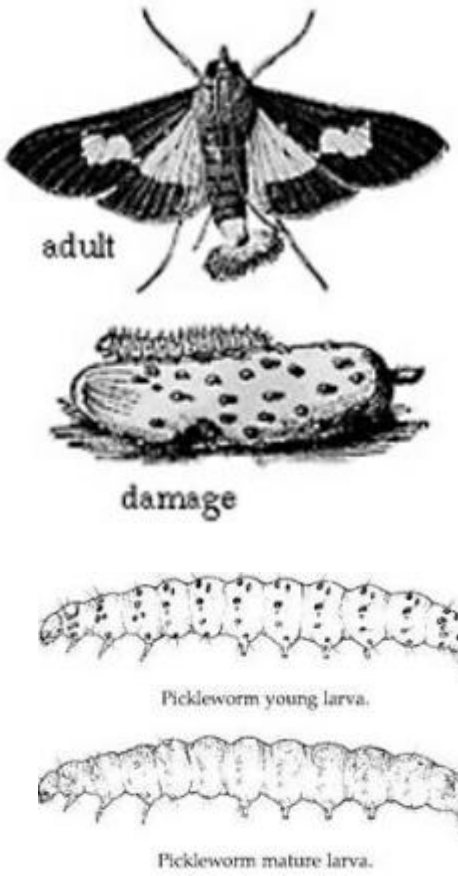
8) Go Farm Pest: Pickleworm *Diaphania nitidalis*

- Pest of squash, cucumber, cantaloupe, and pumpkin.
- Tunnel and feed on foliage, stems, and fruit
- Leave behind a distinctive hole and frass



Ex. Pickleworm Lifecycle
Diaphania nitidalis

* Complete metamorphosis in 30 days
* **Eggs**: Laid in small clusters of individually on buds, flowers etc.
  * Each moth can lay 300-400 eggs
* **Larval Stage: Five instars**
  * Immature larvae, spotted and found in flower buds or stems
  * Older 5th Instar stage: Spots fade
* **Pupal Stage: (8-9 days)**
  * Pupate outside of fruit, on leaf surfaces at and the base of plants
* **Adult Stage**:
  * Adult moth that are active only at night



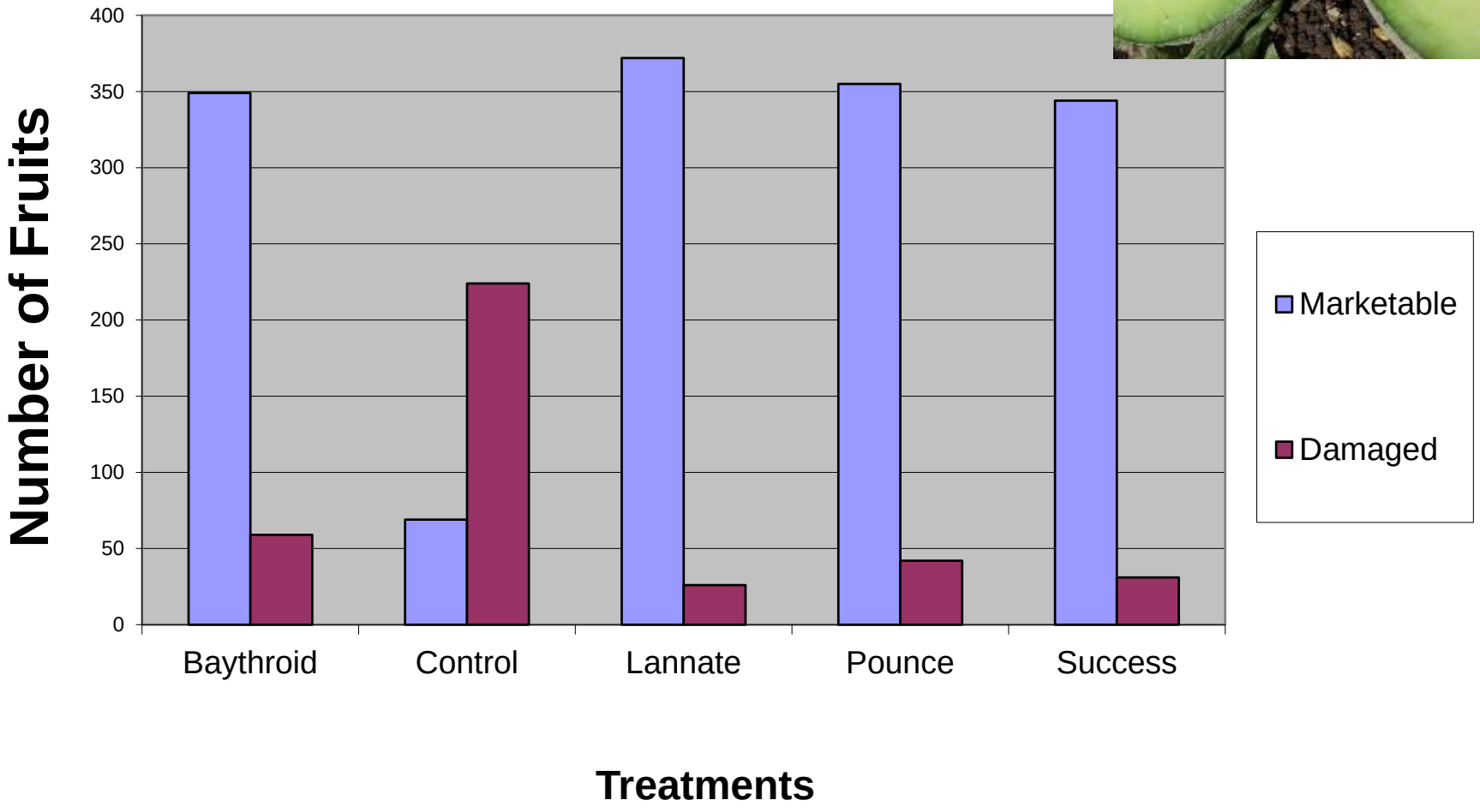
Source: HDOA, and University of Florida
Photo credit: http://pubs.ext.vt.edu, www.simplykitchengarden

Control Strategies: Pickleworm

* **Monitoring:** Scouting flowers and stems
* **Physical Control:** Barriers, bagging (pollination)
* **Cultural Control:** Field sanitation, timely knock down, crop rotation, etc.
* **Biological control:** Encourage natural biological
* **Chemical Control:** Success, Pyrethroids, Organophosphates, Bt, etc.

** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.

Evaluation of Chemicals for Pickleworm Control (2006)

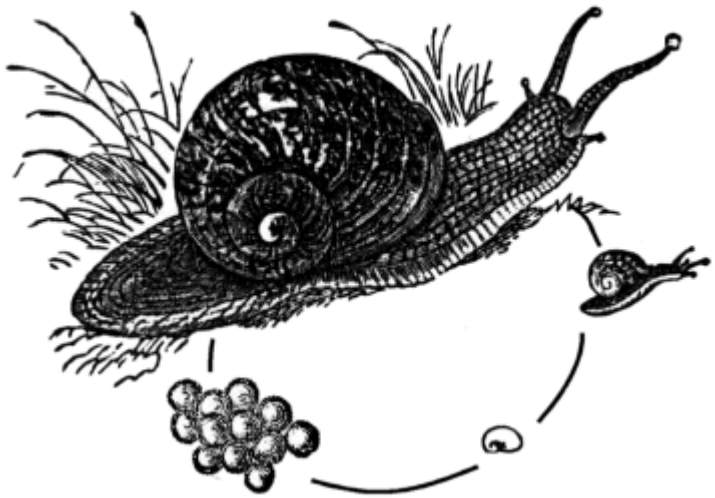


9) Go Farm Pest: Snails and Slugs

* Gastropods scrape at seeds, seedlings, tubers, young plants
* Problem for low-growing vegetables
* Active in the evenings and are commonly associated with seedlings magically disappearing overnight
* Food safety issue
  * Rat Lung Worm Disease

Ex. Black Slug Lifecycle
Veronicella leydigi

* **Eggs**
  * Eggs are typically laid in groups
  * Eggs hatch within 2 weeks to a month after deposited
* **Nymphs**
  * They are able to reproduce at 3 to 5 months
  * **Survive up to 2 years**
* **Adults**
  * Hermaphrodite, having both male and female reproductive parts in the same animal, however, still need to mate

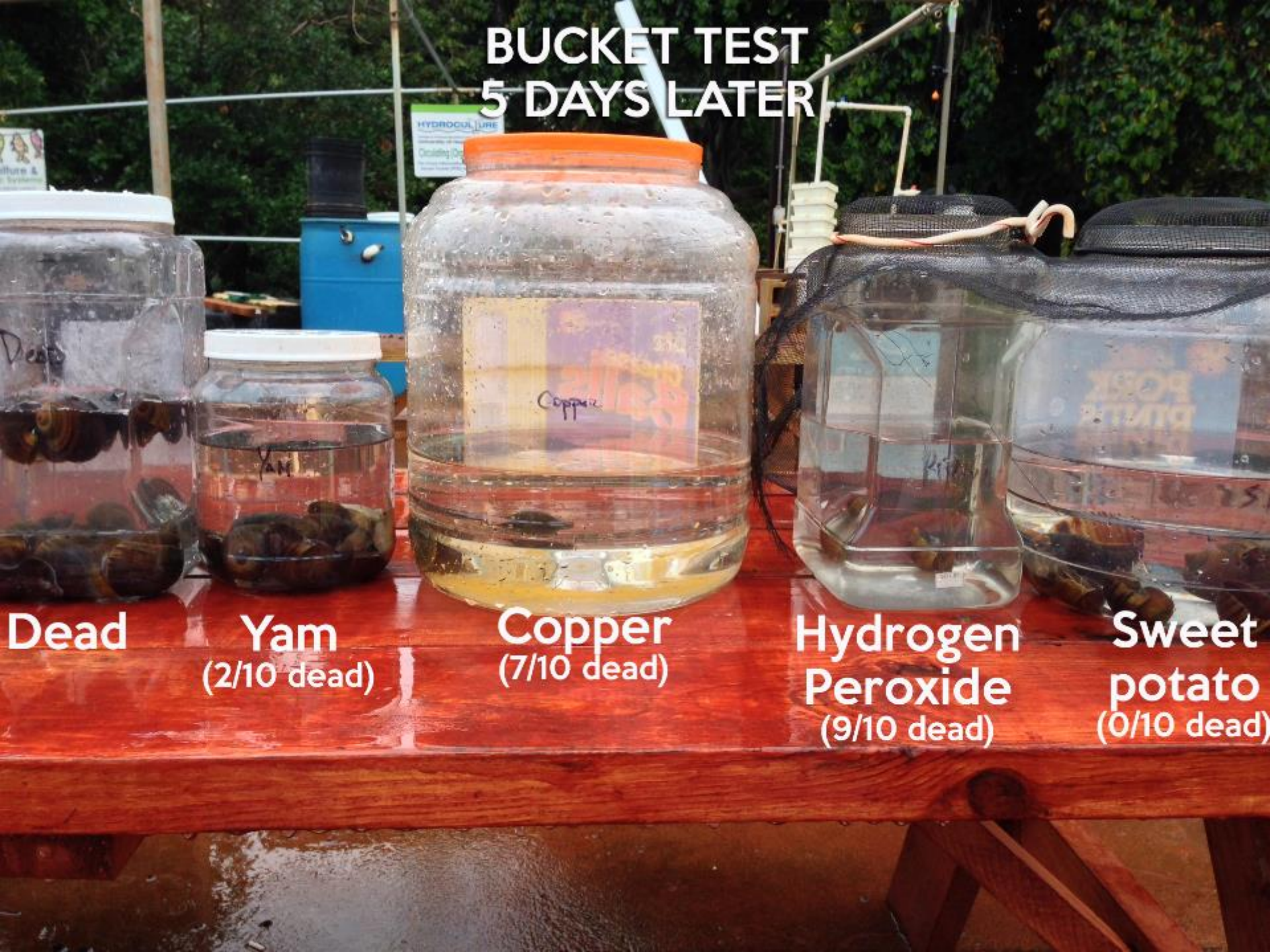


Source: Knowledge Master
Photo credit: webspace.webring.com

Control Strategies: Slugs and Snails

* **Monitoring:** Scouting for damage, eggs, etc.
* **Physical Control:** Barriers, bags, water control
* **Cultural Control:** Field sanitation, timely knock down, crop rotation, weed management, etc.
* **Biological control:** Ducks
* **Non-Chemical Control:** Salt, corn meal, beer, copper, etc.
* **Chemical Control:** Iron phosphite, metaldahyde, Mesurol (Methiocarb), etc.

**** NOTE, this pest attacks multiple crops. Please read and follow labels before utilizing any chemical listed. These products are just general recommendations.

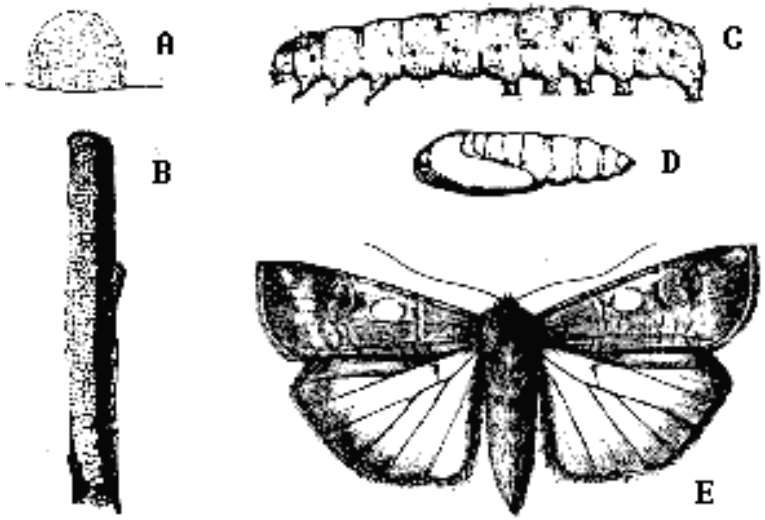

BUCKET TEST
5 DAYS LATER
Dead
Yam
(2/10 dead)
Copper
(7/10 dead)
Hydrogen
Peroxide
(9/10 dead)
Sweet
potato
(0/10 dead)

10) Go Farm Pest: Cutworms

* Feed at night at base of seedling at soil level
  * Defense against predators
* Larvae are inactive and hide under soil surface during the day and feed at night
* Damage newly planted field causing plants to topple
* Sometimes they drag seedlings into their burrows
* May cause injury to flower buds, fruits and vegetables
* Common: black armyworm, variegated, armyworm (group), etc.
* Curl when touched

Ex. Verigated Cutworm Lifecycle *Peridroma saucia*

- **EGGS**
  - Eggs are laid in masses comprising of 30 to 360 eggs.
  - Eggs are generally deposited in parallel rows of uneven numbers,
  - Eggs hatch in 4-7 days in warm weather
- **LARVAE**
  - The larval stage lasts from 20-28 days.
  - Color varies, as the name implies
- **PUPAE**
  - Cutworm pupates under surface debris or in the soil.
  - The spines are black with white tips.
  - This stage lasts for 2-3 weeks.
- **ADULTS**
  - The adult life ranges from 8 to 13 days.



Variegated cutworm. A, Egg. B, Egg mass. C, Larva. D, Pupa. E, Adult.

Source: Knowledge master
Photo credit: ipm.ncsu.edu

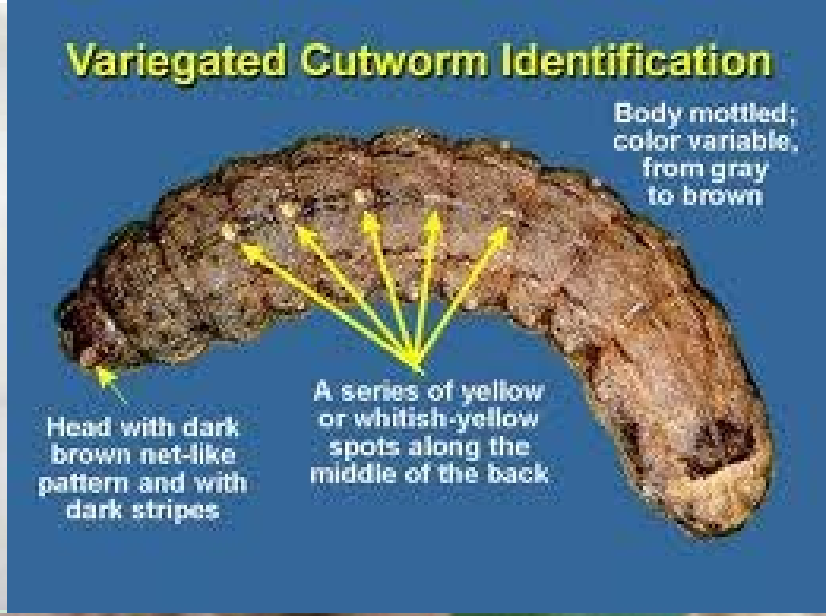


Photo credit: entomology.unl.edu, http://www.omafra.gov; www.extension.umn.edu, http://cutworm.org/, bugwood.org , wikipedia

Integrated Pest Management
Pest Identification: Common Pests

Proper identification and understanding the nature of the pest are the key steps in selecting the best pest management strategy.

Chewing Pests

Chewing pest feed on the foliage, stems, fruit or roots. Pests within this group include beetles, caterpillars, earwigs, leaf miners, etc.

Ants

Ants are honeydew consumers and protect pests from natural enemies. Honey dew secretions promote sooty mold development. There are sugar vs. fat loving ants.

Sucking Pests

These pest pierce plant's vascular tissue and withdraw plant sap. They cause plants to discolor, twist and distort. Pests within this group include aphids, whiteflies, mealy bugs, scales and leaf hoppers.

Fruit Flies

There are 2 fruit flies in Hawaii: Oriental fruit fly, Melon fly, Mediterranean fruit fly, Malaysian fruit fly. Adult females sting fruits and vegetables resulting in blemishes. Larvae tunnel within fruit.

Mites

Mites have rasping and sucking mouthparts. Damage results in a brown to russet discoloration of leaves, stems, fruit and flowers.

Thrips

Thrips have rasping and sucking mouthparts. Damage results in discoloration and scarring of leaves, stems, fruit and flowers.

Nematodes

Roundworms that attack the root system of plants and impair water and nutrient uptake. Symptoms: stunting, poor plant growth, narrow and weak stems, foliar chlorosis, root rotting and galling, plant toppling and poor root development.

Slugs and Snails

Slugs and snail are problem for low growing vegetables. They are active in the evenings and are commonly associated with seedlings magically disappearing overnight.

Plant Hoppers

Plant hoppers damage leaves, stems, fruits, and flowers. They also serve as vectors for plant diseases, especially phytoplasmas.

Weeds

Weeds (annuals, biennials, perennials, etc.) often outcompete plants for food, sunlight, etc. They are fast growing, prolific seed producers, etc. Some weeds may be alternative hosts for crop pests (insects and diseases).

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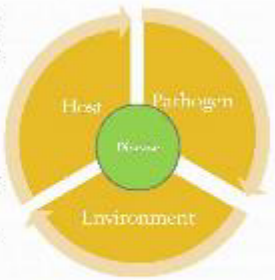
University of Hawai'i at Manoa
LIFE Land Development Partner Education
SARE

Integrated Pest Management
Pest Identification: Common Diseases

Plant diseases are the result of a physiological or morphological change in a plant that results in abnormal growth, appearance or development due to a pathogen. Pathogens are parasitic organisms that cause a disease. Pathogens include: fungi, bacteria, viruses, nematodes, phytoplasma.

The diagram to the right illustrates the three factors required for disease development: a host plant, casual pathogen and a favorable environmental conditions. Managing these factors can also help prevent and suppress disease populations.



Fungal Pathogens

Common plant disease composted of thread-like structures called hyphae. Reproduce and disperse by spores. Common fungal pathogen include: powdery mildew, downy mildew, *Alternaria*, *Cercospora*, *Phythophthora*, etc.

Nematode Pathogens

Roundworms that attack the root system of plants and impair water and nutrient uptake. Symptoms: stunting, poor plant growth, narrow and weak stems, foliar chlorosis, root rotting and galling, plant toppling and poor root development.

Viral Pathogens

Viruses have a nucleic acid surround by a protein coat. They can only survive on living plant tissue. Once infected there is no cure. They are mainly transmitted by insect vectors. Common plant viruses include: Banana Bunchy Top Virus, Tomato Spotted Wilt Virus, etc.

Bacterial Pathogens

Bacterial pathogens reproduce quickly and form masses called colonies. They are spread primarily via rain, or splashing water. They often enter plant tissue through natural openings or injury sites. Examples include: *Xanthomonas*, *Pseudomonas*, *Erwinia*, etc.

Phytoplasma

Phytoplasma is a bacteria which parasitizes on the phloem of plant tissue via an insect vector. Symptoms range from yellowing of plant tissue, cupping of leaves and even death of infected plants. Leafhoppers are often associated with vectoring of phytoplasmas like the Watercress Aster Yellows (WAY).

Example of a Plant Vector

Plant vectors are organisms that can transmit a pathogen such as a bacterium, virus, or phytoplasma into a plant.

EXAMPLES:
Banana aphid → Banana Bunchy Top Virus (BBTV)
Western flower thrips → Tomato Spotted Wilt Virus (TSWV)
Aster Yellow Leaf Hopper → Watercress Aster Yellow Phytoplasma
Onion thrips → Iris Yellow Spot Virus (IYSV)

Integrated Pest Management Prevention Strategies

Prevention is an important strategy in avoiding and keeping a pest populations below economic threshold levels. Prevention strategies include practices such as but not limited to: field and equipment sanitation, utilizing pest free or resistant planting materials, managing alternative host materials, installation of physical barriers, reflective mulches, crop rotation, modifying crop spacing, trap crops, encouraging beneficial insects, timely crop destruction, etc.

Habitat Modification

Eliminate pests breeding sites. Eliminate favorable conditions such as pest / disease build up, removal of food or habitat sources, sanitation of fields and adjacent areas, etc.

Physical Measures

Installation of physical barriers or devices to discourage the pests such as: screens, barriers, sprinkler systems, wires, etc.

Cultural Measures

Manipulation of cultural practices to disadvantage the pest such as: crop rotation, fallow periods, crop spacing, companion planting, crop selection, aeration, worms waste conversion, reflective mulches, etc.

Biotechnology

Application of scientific techniques to modify and improve plants, insects and pathogens such as: selective breeding (hybridization), variety screening, genetically modified crops, etc.

Encouraging Beneficial Insects

The use of natural predators, parasites, parasitoids, etc. to manage pests. Examples include: ladybugs, hoverflies, spiders, etc.

EXAMPLES

Integrated Pest Management Control Strategies

Control strategies are often utilized after action thresholds are surpassed. IPM aims to utilize all possible pest control methods in a well organized and harmonious way in order to achieve long-term pest control. Chemicals are not prohibited but often used as a last resort.

Biological Releases

The use of natural predators, parasites, parasitoids, etc. to manage pests. Examples include ladybugs, hoverflies, spiders, etc.

Other Non- Chemical Measures i.e., Mulch, Hot Water Treatments

Out of the box, non-chemical control strategy are also utilized in IPM. Pesticide are not encouraged in aquaculture systems. However, it is allowed if label language does not prohibit it and the crop is listed on the label.

Chemical Measures

Use of a chemical to prevent, destroy, or repel pests. Typically considered after other control methods. Low toxicity chemicals are considered first. If available, use selective vs. broad spectrum chemicals. Chemicals should always be rotated with other chemicals to minimize resistance issues. Application and timing intervals are important.

Pesticide Safety Reminders:

A pesticide is defined as a chemical used to prevent, destroy, or repel pests in all types of systems and farming operations.

- Read and follow the label
- Calculate the treatment area
- Calibrate your equipment
- Do not apply more than the maximum allowable limit

Pesticide Use in Aquaponics are allowed IF:

- Label language does not prohibit it
- If there is a reference that the pesticide is harmful to fish, then be aware of consequences if used.
- Crop is listed on the label

Integrated Pest Management
Chemical Control Strategies






Reduced Risk Products (1 of 2)

Bacillus *subtilis/ pumilus*
Derived from a soil bacterium that is antagonistic to fungal and disease pathogens by means of nutrient competition, site exclusion, colonization, attachment of the bacteria to the fungal pathogen, etc.
Example: Serenade Max (o), Sonata (o)

***Bacillus thuringiensis* (Bt)**
Derived from a bacterium which is selectively toxic to many moth and larvae. When ingested, Bt produces an endotoxin in the insects gut which is toxic to the insect.
Examples: Dipel (o), Crymax, XenTari (o)

Beauveria bassiana
Spores of the Beauveria bassiana come into contact with the body of an insect host, germinate, enter the body, and grow inside, eventually killing the insect. The fungus multiplies and destroys the internal structures of the host under high humidity environments
Examples: BotaniGard, Mycotrol (o)

Copper products
Controls blights, mildew, anthracnose, but commonly associated with bacteria control
Example: Basic Copper 53 (o), Nucop 50DF (o), Champ WG (o)

Diatomaceous earth:
Naturally occurring substance comprised of the fossilized remains of diatoms. Insects such as roaches, ants, silverfish, fleas, etc. come in contact with this powder and die from desiccation.

EM, Compost Teas:
Fungicidal and nutritional supplement
Examples: Bokashi, Agripower

Horticultural Oils:
Cover, wet, and suffocate, over wintering eggs, nymphs and adults. Effective on scale insects.
Examples: Volck oil, JMS Stylet-oil (o), Biocover

Hydrogen Dioxide
Oxidizes rapidly on contact.
Examples: Oxidate (o)

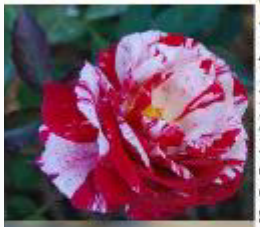
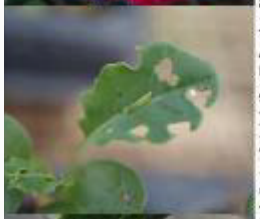
Insecticidal Soaps:
Potassium Salts of Fatty Acids typically disrupt membranes of soft body pests leading to rapid death by evaporation.
Example: Mpede (o)

Kaolin Clay:
Common food additive approved by the FDA. It primarily serves as a protective barrier, distracts pest from the host plant and deters pest movement and damaging behavior.
Examples: Surround WP (o)

Neem Oil/ Azadirachtin: (IGR) ** many labels say it is toxic to fish
Disrupts insects' hormonal balance so they die before they molt, suppresses some insects' desire to feed, and it also repels. It has fungicidal properties as well.
Examples: Trilogy (o), Neemix (o), Debug Turbo (o), Molt X (o)

NOTE: (o) Refers to products approved for organic production by the Organic Materials Review Institute (OMRI).

Integrated Pest Management
Chemical Control Strategies


Reduced Risk Products (2 of 2)

Natural / Essential Oils:
Pepper, citrus, clove, mint, oils. Caution as oils can burn. Herbicide properties.
Examples: Ecotec (o)

Phosphorous Acid
Different from P fertilizers, phosphorus acid has fungicide properties that are especially effective against
Oomycete pathogens, such as *Phytophthora*, *Phythium*, and Downy mildews. Systemic properties.
Examples: Aliette, Fungi-Phite, Fosphite

Potassium Bicarbonate
Used as a contact fungicide mainly for powdery mildew in organic farming systems.
Examples: Armicarb (o), Kaligreen (o), Milstop (o)

Pyrethrin:
Derived from the blossoms of the pyrethrum flower, a chrysanthemum (contact). Breaks down in the environment quickly.
Example: Pyganic (o)

Reynoutria sachalinensis
Bio fungicide used to enhance plant health and trigger the plant's natural defenses to control fungal and bacterial diseases. Delays onset of disease through multiple modes of actions. Plant based extract with systemic properties.
Example: Regalia (o)

Spinosad
Derived from a bacteria in the soil. Kills by contact and ingestion. (Nerve and stomach poison)
Examples: Entrust (o), Radiant, GF-120 NF (o)

Spirotetramat
A new insecticide with a novel mode of action which interferes with lipid biosynthesis. It prevents molting and causes death of immature pest stages.
Example: Movento

Steinernema carpocapsae
Entomopathogenic nematodes are used as a biological control of insect pests. Entomopathogenic nematodes only infect insects. Entomopathogenic nematodes live inside the body of their host and are most effective on soil dwelling insect pest.
Example: Nematac

Streptomyces lydicus WYEC 108
Beneficial bacterium that colonizes on the surface of the roots and leaves. It attacks many soil borne and foliar diseases via different modes of action.
Example: Actinovate (o)

Sulfur
Inhibits the attack of healthy plants by fungus disease by creating an environment that is not conducive to disease growth. Also effective on selected mites.
Examples: Sulfur DF (o), Kumulus DF (o)

NOTE: (o) Refers to products approved for organic production by the Organic Materials Review Institute (OMRI).

Integrated Pest Management
Chemical Control Strategies

Chemical Mode of Actions:

AFFECTS NERVOUS SYSTEM

Avermectin

It is derived from a soil microorganism. They bind to the chloride channel and when activated can inhibit the channels effectiveness, cause twitches, tremors, and death.
Examples: Agri-Mek, Avid, Proclaim

Carbamates

They are known as *cholinesterase inhibitors*. Carbamates also act like a nerve poison which causes the neurotransmitters to continue to fire and over stimulates the pest to death.
Example: Sevin, Furadan, Lannate, Vydate

Neonicitinoids/ Imidicloprid

Neonicitinoids continue to stimulated the nerves of pest and similar to cholinesterase inhibitors, they overstimulate the nervous system which causes poisoning and death.
Example: Assail, Admire Pro, Provado

Organophosphates

They are known as cholinesterase inhibitors. Organophoshates acts like a nerve poison which causes the neurotransmitters to continue to fire and over stimulates the pest to death.
Example: Orthene, Lorsban, Diazinon, Nemacur, Malathion, Dursban, Dibrom

Pyrethroid

Synthetic versions of pyrethrins, from the chrysanthemum family. They overexcite the sodium channel and prevent the channel from closing.
Example: Baythroid, Asana, Warrior, Pounce, Ambush

AFFECTS ENERGY LEVELS

Hydramethylnon

This chemical binds to a protein in the electron transport system which blocks the formation of ATP. Insects basically "run out of gas" and die.
Example: Amdro, Combat, Max Force

AFFECTS INSECT DEVELOPMENT (MOLTING)

Insect Growth Hormones (IGR)

IGR's stops the molting transition to the adult stage and keeps the insects in the immature state. Inhibits chitin synthesis which interrupts molting, suppresses female oviposition & reduces egg viability. Insects are unable to transition to the adult stage and often cannot produce viable offspring.
Example: Intrepid, Esteem, Applaud

HYDROCULTURE

Integrated Pest Management
Beneficial Insects & Insectary Plants

K.-H. Wang and J. [illegible]
University of Hawai'i at Mānoa, College of Tropical Agriculture and Human Resources

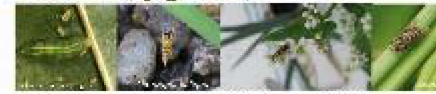
Insectary plants are plants that produce pollen or nectar, or provide [illegible] to attract arthropod predators including lady beetles, hoverflies, lacewing, spiders, parasitoid wasps etc.

Lady Beetle (Coccinellidae)

The lady beetle, [illegible] larvae and adult [illegible] aphids, scales, and mealybugs.

Insectary plants for lady beetles
- [illegible]
- Cowpea
- Marigold, cosmos
- Oleander (white lady beetle)
- [illegible]

Hoverflies (Syrphidae)



Hoverflies larvae eat aphids and other soft bodied insects, and adults eat nectar and pollen.

Insectary plants for hoverflies
- [illegible]
- [illegible]
- Marigold, cosmos
- Basil
- Carrot

Green Lacewing (Chrysopidae)

The lacewings, [illegible] adult will eat pollen, nectar and honeydew, and the larvae eat aphids, various larvae and the eggs of other insects.

Insectary plants for lacewings
- Cowpea
- Bay Leaf
- Carrot [illegible]
- Oleander [illegible]
- Red Cosmos
- Wild Lettuce [illegible]

Pirate or Assassin Bug

The pirate bug adults feed on small arthropods like thrips, aphids and insect eggs. The assassin bug adults will eat beetles, caterpillars and flies.

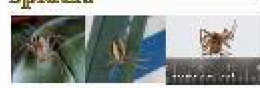
Insectary plants for pirate or assassin bugs
- [illegible]
- [illegible]
- Oleander [illegible]
- Sunn hemp (*Crotalaria juncea*)
- Cowpea [illegible]
- Marigold, cosmos

Parasitoids & Wasps

Parasitoid wasps, such as [illegible] aphids and [illegible]. They like to find burrows in woody materials to build their nests. [illegible]

Insectary plants for parasitoid wasps
- Cilantro
- Buckwheat
- Milkweed
- Almost all insectary plants

Spiders



Spiders are generalist [illegible] especially when no harmful broad spectrum insecticides are used. They are frequently found wandering on the [illegible] or building webs to catch their preys.

Function of Insectary Plants

- [illegible]
- Attract pollinators.
- Supply [illegible]
- [illegible]

Attracting Beneficials to Aquaponic System

- [illegible]
- [illegible]
- [illegible]

Reference and Photo Credit:
[illegible]
Concept and photo by Koon-Hui Wang and Jane [illegible], unless specified otherwise in the photo.