Managing Pests of Vegetable and Fruit Crops in High Tunnel Production

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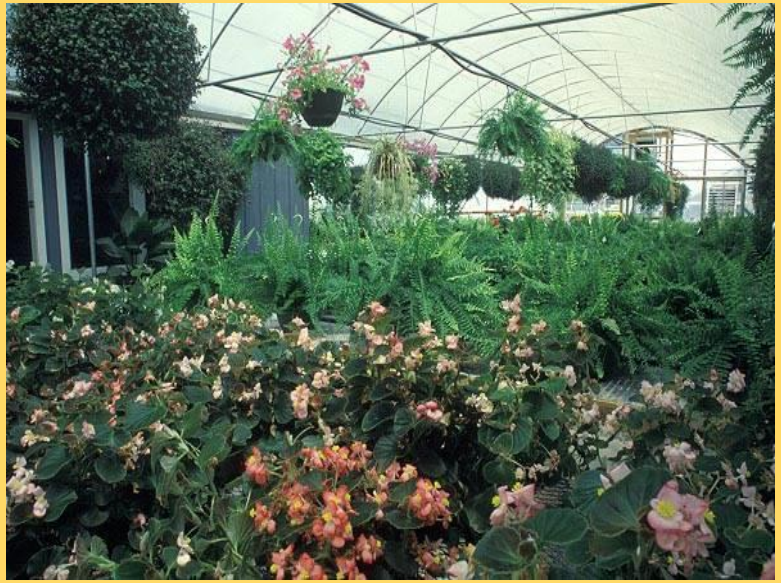
Why High Tunnels?

- ✓Production season in the State is short and high tunnel is a technology to extend the season
- ✓**C**ontrolled **E**nvironment **A**griculture **(CEA)**
  - Semi-closed or closed production area
  - Reduce effects of biotic and abiotic factors
  - Increase profitability
  - Flexibility in what and when to grow
  - Reliable and timely availability of produce



What do we know about development of Insects and other arthropods?

- ✓Insects are Ectotherms
- ✓Body temperature is highly influenced by temperature of the surroundings
- ✓Humidity and photoperiod can also be important

- For example, in *Helicoverpa armigera* egg period was observed **7.9 days at 28°C** but extended **10.4 days at 25°C**

- 60% of adult striped cucumber beetle developed from egg to adult at 81°F (27°C)

- **Aphids can produce 1-5 generation more with 2°C increase in temperature**

Survival of striped cucumber beetle at constant temperatures

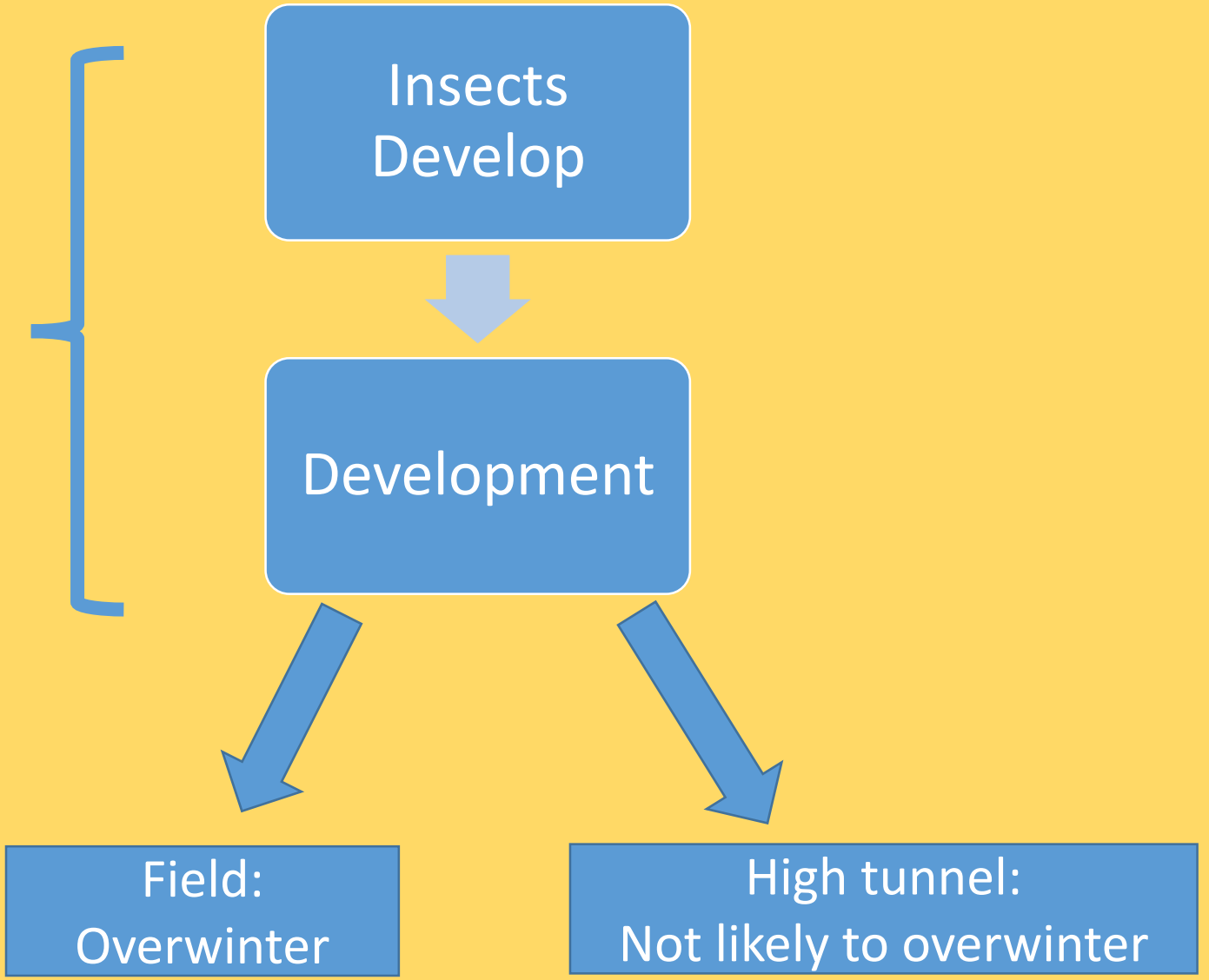
Temperature (°C)	Survivorship				χ^2
	Males	Females	Total	Percent	
18	43	44	87	44	0.011ns
24	49	64	113	57	2.009ns
27	62	58	120	60	0.133ns
30	35	41	76	38	0.474ns
33	6	2	8	4	1.000ns
36	0	0	0	0	na
Total	195	209	404	34	0.491ns

Temperature range that is conducive for insects and plants is 25-28C

Challenges of using High Tunnels

- ✓ Normal development cycle (overwintering, diapause etc.) of insect may be **altered** thereby allowing insects to develop faster or slower than normal
- ✓ Because conditions in high tunnels are mostly favorable for both plants and insects;
  - Pest problems may increase all year round
  - Frequent control will be required year round (resistance issues with frequent application of insecticides)
  - May increase cost of production
  - Safety concerns when insecticides are used

April to October



November-March

Challenges of High Tunnel in Small Farms

- ✓ Strong competition from large commercial farms
- ✓ Same standards for produce marketing
- ✓ Limited market opportunities
- ✓ Soil fertility and nutrient management
- ✓ Inadequate availability of certified seeds
- ✓ **Insect pest and disease management**

What Does the Markets (both local and export) Require?

Countryside grocery store

Large retail store

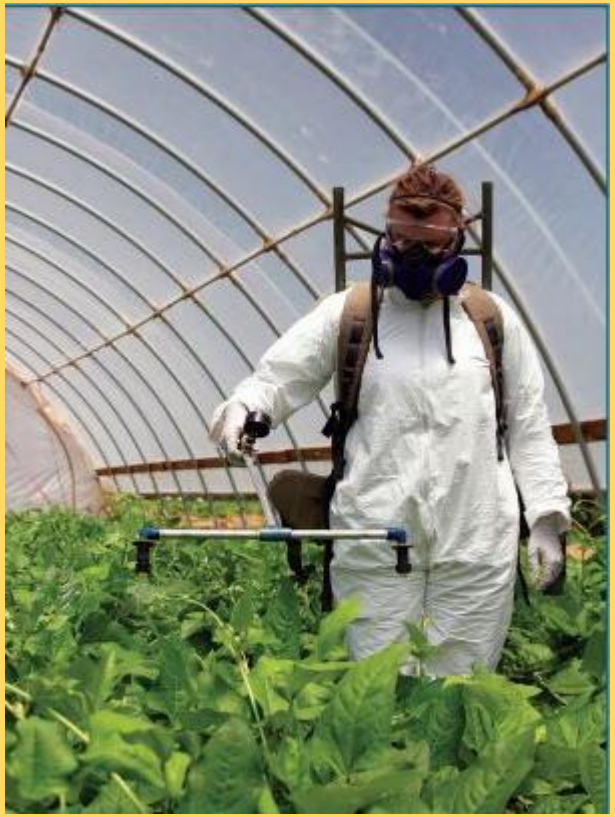
Roadside marketing

- Fresh and Unblemished
- Good looking
- Healthy

How do we Meet Consumers Preference?

- ✓ Frequent application of insecticides (weekly or 10-14 days interval)
- ✓ This is not sustainable (ecologically, economically and health wise)

Pests



Natural enemies

Can Consumers Accept some Level of Damage?

Stink bug damage

Thrips damage

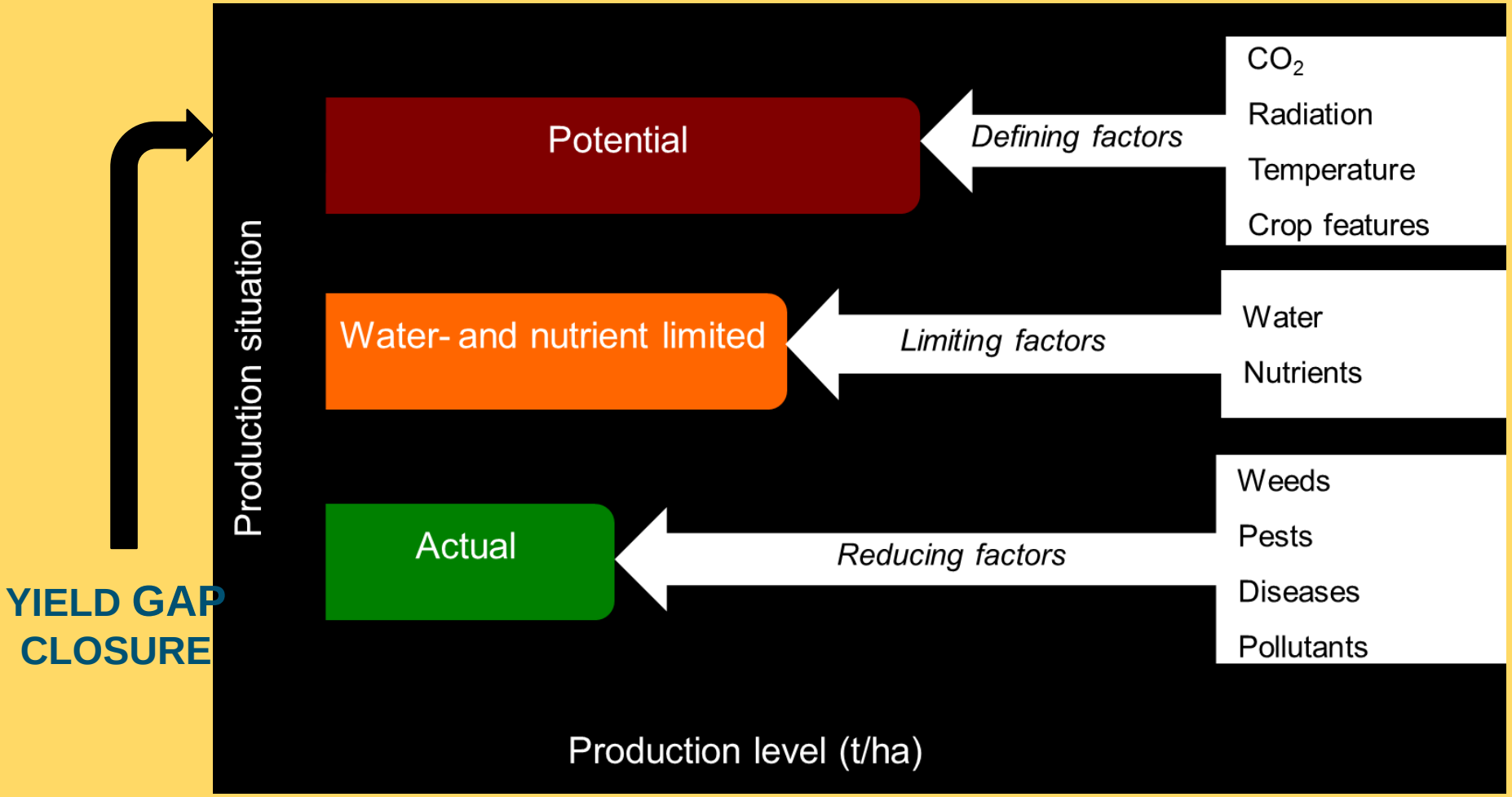
Grade 1 tomato

Frass from caterpillars

- ✓ More often than not the answer is **NO!!**
- ✓ Because many consumers feel these are not safe and healthy
- ✓ Lowering of standards (not acceptable??)

How can we reduce inputs and at the same time achieve effective control of insect pests in high tunnel production?

Production Ecological Principles



Van Ittersum and Rabbinge, Field Crops Research, 1997

Pest Management in High Tunnels

- Similar pest problems we find in the field can occur in high tunnels
- Pest know no borders (can inhabit anywhere)
- Although high tunnels are built to prevent pest, this is not always the case
- Even the most protected environments could have insects

What is IPM?

Integrated Pest Management is a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment.

IPM tools include:

- Alter surroundings
- Add beneficial insects/ organisms
- Grow plants that resist pests
- Disrupt development of pest
- Prevention of pest problem developing
- Disrupt insect behaviors
- Use pesticides

1 IDENTIFY/ MONITOR

Determine the causal agent and its abundance (contact your local extension agent for help).

2 EVALUATE

The results from monitoring will help to answer the questions: Is the pest causing damage? Do we need to act? As pest numbers increase toward the economic threshold further treatments may be necessary.

3 PREVENT

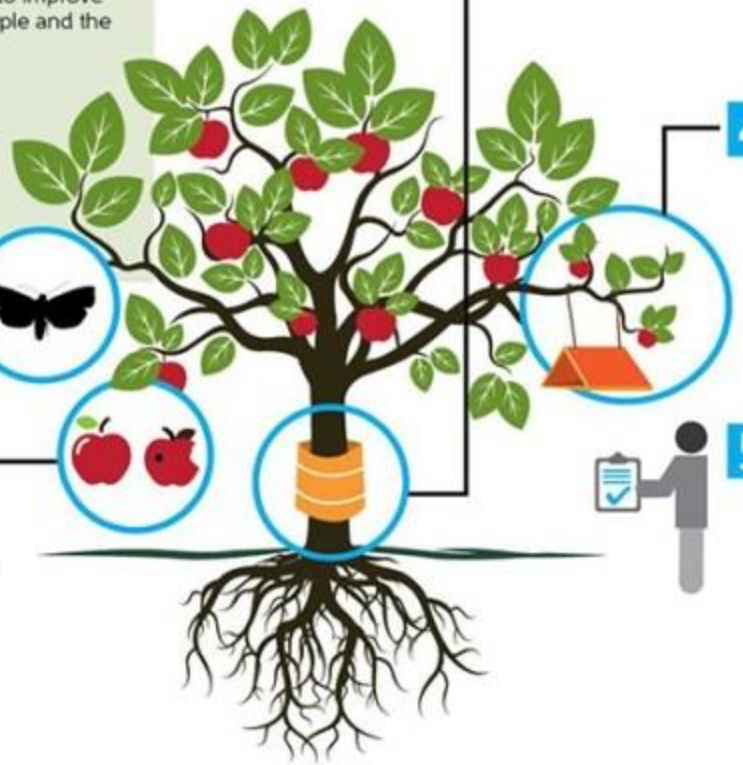
Some pest problems can be prevented by using resistant plants, planting early, rotating crops, using barriers against climbing pests, sanitation, and sealing cracks in buildings.

4 ACTION

IPM uses multiple tools to reduce pests below an economically damaging level. A careful selection of preventive and curative treatments will reduce reliance on any one tactic and increase likelihood of success.

5 MONITOR

Continue to monitor the pest population. If it remains low or decreases, further treatments may not be necessary, but if it increases and exceeds the action threshold, another IPM tool should be used.



WHERE CAN YOU PRACTICE IPM?

Buildings and Homes:
Inspect, identify pests, keep pests out, clean to deny pests food and water, vacuum, trap, or use low-risk pesticides.

Farms:
Check for pests/pest damage regularly, identify accurately, choose pest-resistant plant varieties, encourage/introduce beneficial insects, time planting to avoid pests, and if needed use low-risk pesticides.

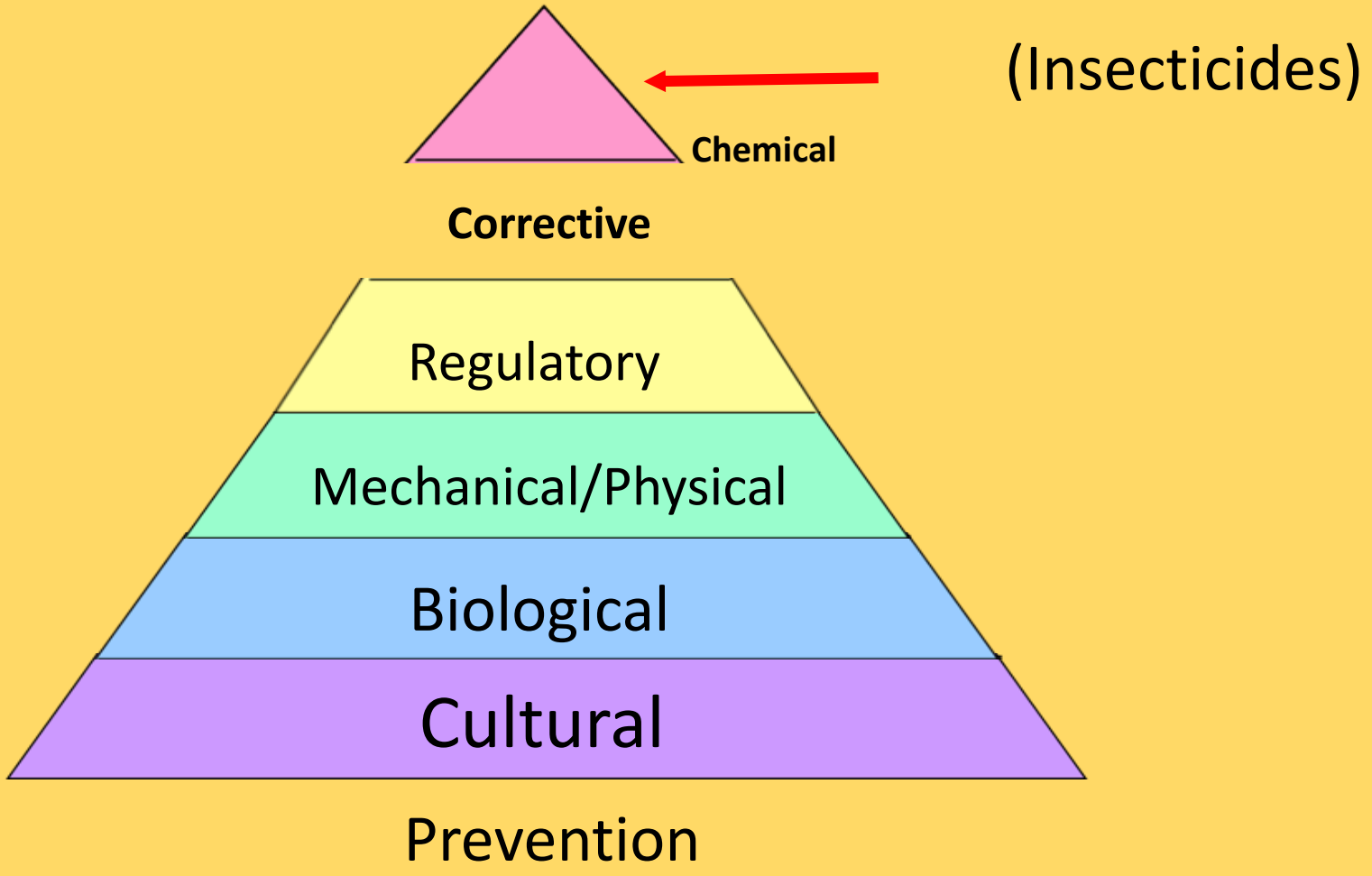
Managed Natural Systems:
Identify the pest and use management options that have minimal risks to pollinators, humans, and pets.

The Entomological Society of America is the largest organization in the world serving the needs of entomologists and other insect scientists. ESA stands as a resource for policymakers and the general public who seek to understand the importance and diversity of earth's most diverse life form—insects. Learn more at www.entsoc.org.

Basic IPM Approach and Practice in High Tunnels

- ✓Type of crop grown (cabbage, pepper, okra, cucumber etc.)
- ✓Identification and description (color, size, shape etc.)
- ✓Distribution and host range
- ✓Biology, behavior and ecology (where adults, egg, larva & pupa live and spend winter)
- ✓**Damage and economic importance ($$$$$$)**
- ✓Monitoring tools (traps, lure, predictive models, phenology of plant etc.)
- ✓**Management tactics (organic and conventional)**
  - Cultural Control
  - Biological Control
  - Host Plant Resistance
  - Chemical Control
    - ❖Synthetic pesticides
    - ❖Biopesticides
    - ❖OMRI approved compounds
      - ❖ (organic production)

Developing ecologically-based IPM is based on one or several methods



STEP 1: Design and Location

- ✓ Proper insect screening nets and roofing
- ✓ Access doors and vent
- ✓ Any small crevice will allow small insects like aphids, whiteflies, mites, scales to enter

Location is Critical

Step 2: Practice Proper Sanitation

- ✓The goal of sanitation is to eliminate all possible sources of the pest infestations.
  - Remove weeds inside and outside the high tunnel
    - grass flowering-increase in Thrips population
  - Remove weeds around nurseries.
  - dispose of dead/diseased plants.
  - In high tunnels/greenhouses:
    - quarantine infested plants in a separate room.
    - medium pasteurization (especially if it contains soil).
    - algae control-fungus gnats.

What to Consider During Planting

- **Variety Selection**
  - Choose insect/disease resistant varieties.
  - If possible, rotate crops.
- **Water requirement**
  - **Too much moisture:**
    - leaf diseases
    - root rots
    - fungus gnats
    - algae
  - **Too little moisture:**
    - stresses the plant and predisposes it to disease
    - hot, dry conditions favor spider mites
- **Temperature**
  - Plants begin to stress at temperatures of 95 degrees F. and higher.
  - Temperature fluctuations.
- **Growing medium**
  - Should have good aeration/drainage.
  - Monitor EC.

Too Much Moisture Results in Dealing with Two Pests:

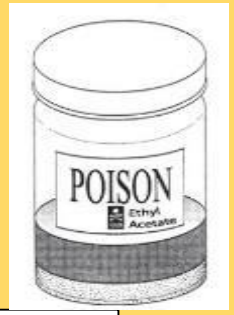
Fungus Gnat Adult

Shore Fly Adult

Step 3: Scouting and Record Keeping

- ✓Scouting also called “monitoring’
- ✓Perform weekly
- ✓In high tunnels focus monitoring near doorways, vents, heating systems and fans
- ✓1 sticky card per 1,000 square feet.
  - Yellow: attracts most flying insects
  - Blue: for thrips
- ✓Replace cards on a regular basis (7-10 days interval)

Tools for IPM Implementation in High Tunnel



Handheld and backpack sprayers for spot application

Monitoring and scouting equipment

Step 4: Biological Control Tactic





Deploy good insects to control bad insects

Step 5: Chemical Control

How much do you have to buy?

Regulations for storing your pesticides

Biorational Pesticides

- Insecticidal Soaps
- Horticultural Oils
- *Bacillus thuringiensis (Bt)-bacteria*
- *Beauveria bassiana-fungus that infects the chitin exoskeleton of many pests*
- Diatomaceous Earth
- Insect growth regulators (IGR's)
  - kill insects by disrupting their development

Types of Insecticides

- Organophosphates (e.g. phosmet, chlorpyriphos)
- Pyrethroids (lambda cyhalothrin etc)
- Carbamates
- Organochlorines
- Neonicotinoid (Imidacloprid, Thiamethoxam etc)
- Insect growth regulators
- Microbials
- Botanicals (e.g. neem seed extracts, homemade pepper spray etc.)

Conventional Pesticides Application

- Licensed Applicator
- Pesticides Use and Safety training
- Re-entry interval (REI)
- Pre-harvest interval (PHI)
- Material Safety Data Sheets (MSDS)
- Residue and Resistance management
  - rotate between groups/active ingredients

Calibration of Spray Equipment

- Application rate of spray (lit/m) = $\dfrac{\text{Flow rate L/min} \times 10{,}000\text{m}^2}{\text{Walking speed (m/min)} \times \text{swath width (m)}}$

Or

- For field application: measure out a distance of 100 m square and determine quantity of liquid required to spray the entire area. That should give you the application rate of your sprayer in L/ha.

Common Hemipteran Pests of Vegetables

Common Hemipteran Pests

Aphids

Whiteflies

Harlequin bug

GSB

Squash bug

Tarnished plant bug

BSB

Red shouldered bug

BMSB

Which others

LFB

Which others??

Common Stink Bugs

Brown stink bug

Green stink bug

Red shouldered stink bug

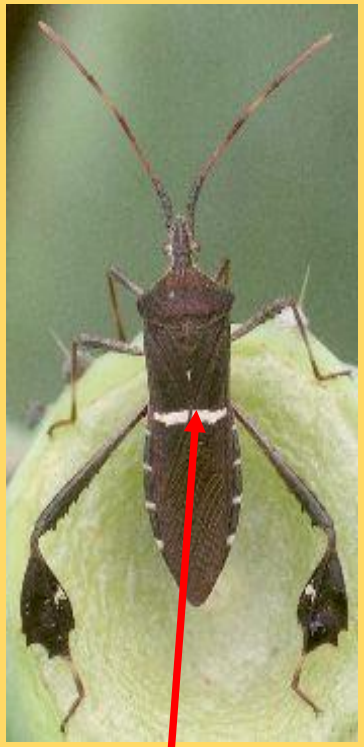
BMSB

Why have stink bugs become important?

- ✓Stink bugs often were kept under control **by insecticide sprays applied** to control primary pest species
  - Mainly considered as secondary pests
  - Most control in vegetables and small fruits also took care of stink bugs

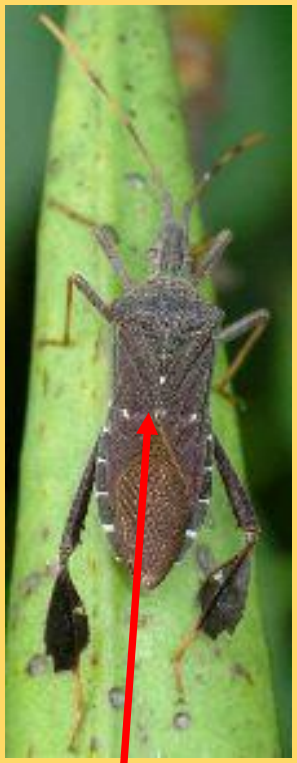
- ✓Recent changes in management of vegetable and fruit crops have resulted in changes in insect abundance
  - Increasing adoption of **post-FQPA regulations** for many fruit crops
  - Renewed interest in **organic agriculture**
  - Adoption of Bt crops resulted in reduced insecticide use in cotton and soybeans (*Greene and Herzog 1999,* Roberts 1999)

Some Common True Bugs that looks alike

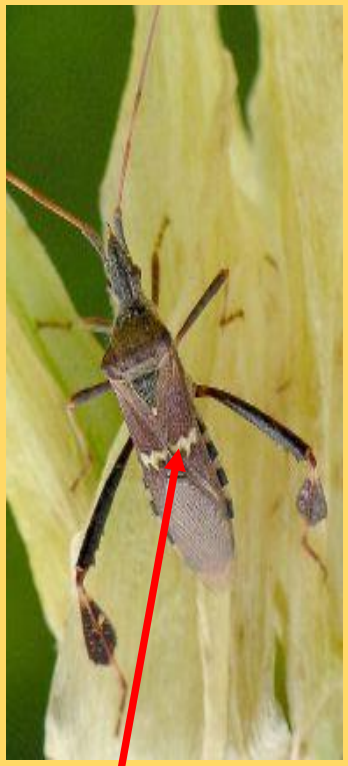


L. phyllopus

L. zonatus



L. oppositus



L. clypealis

Leptoglossus spp

Leaf-footed bugs

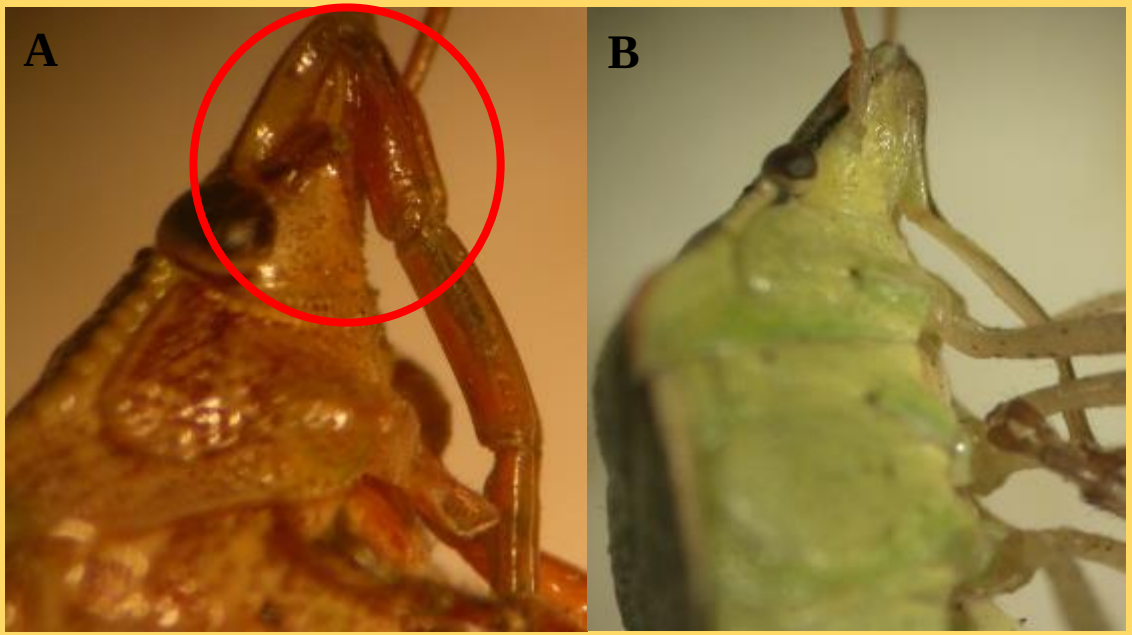
Common Squash Bug, *Anasa tristis*

Horned Squash Bug, *Anasa armigera*

Anasa spp

Squash bugs

Differentiating Predatory Stink Bug and Pest Stink Bug



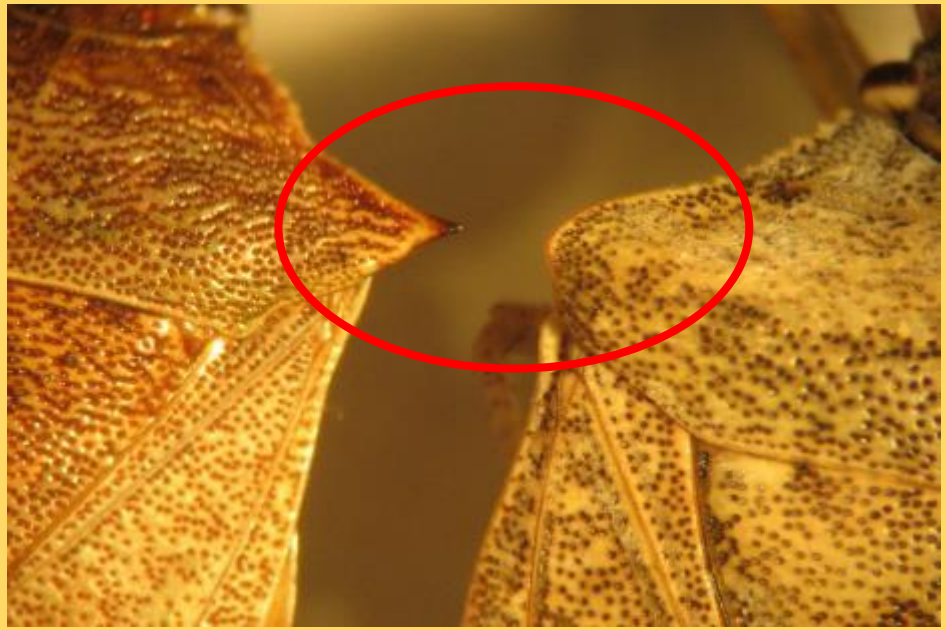


Photo by Clement Akotsen-Mensah

Two Squash Bug Species

The Common Squash Bug, *Anasa tristis*

The Horned Squash Bug, *Anasa armigera*

First instar

1st and 2nd instar

2nd and 3rd instar

Anasa tristis

Anasa armigera

4th instar

5th instar

Anasa tristis

Anasa armigera

Aphids

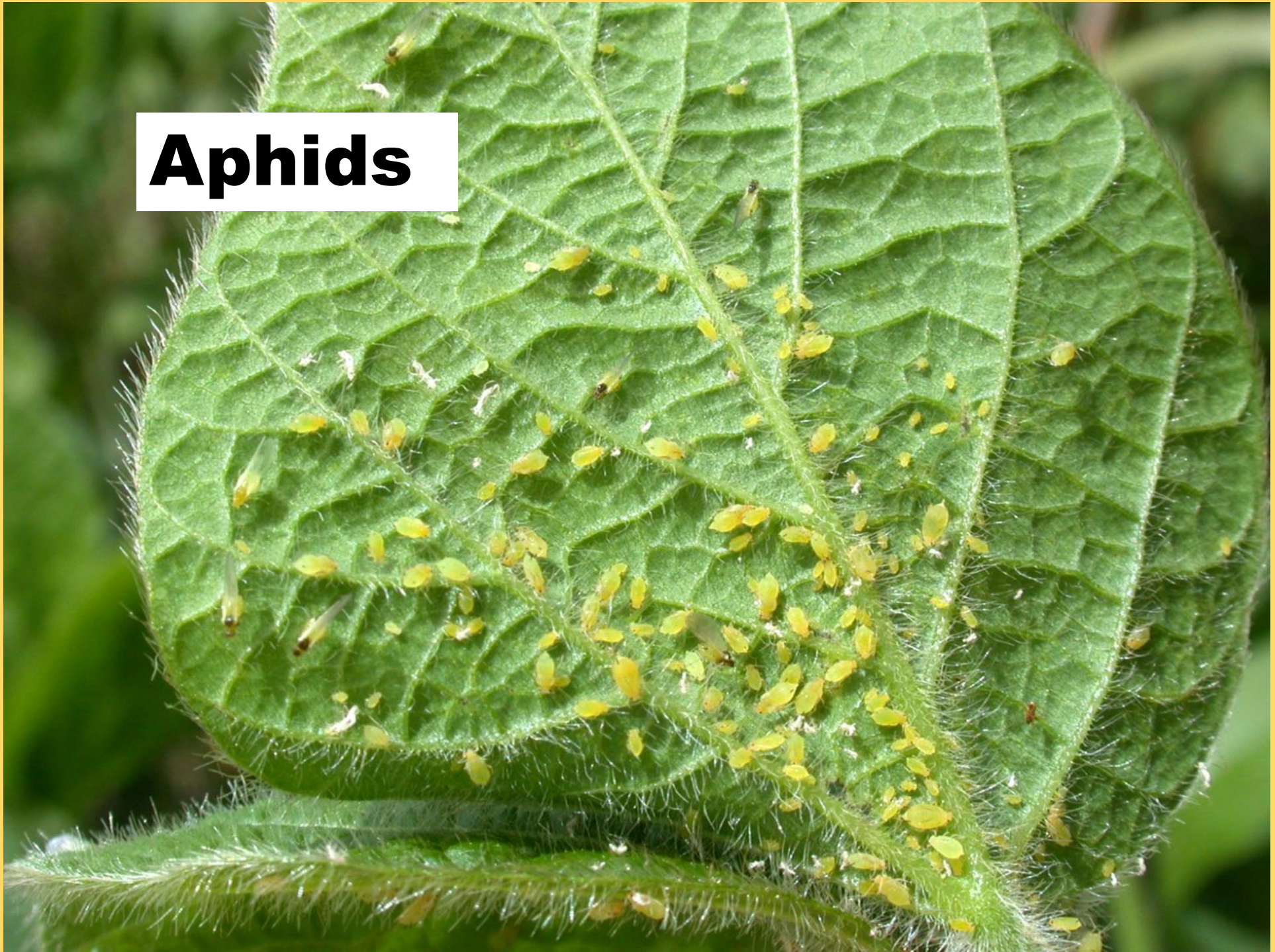
- ✓Aphids are small soft-bodied sucking insects; suck juices from terminal buds, leaves, stems, and sometimes fruits, causing plant parts to shrivel, turn yellow, and eventually dry up
- ✓Aphids vary from light green, pink, yellow, and red to black
- ✓Adults give birth to living young, and reproduction can be very rapid
- ✓They feed from early spring through late fall, and some are vectors (carriers) of disease organisms.

Common Aphids of Vegetable and Fruit Crops

Potato aphid
(*Macrosiphum euphorbiae)*

Myzus spp

Wooly apple aphids


Aphids

What to look for if Aphids are present?

Honeydew and Ants

Sooty mold

Management of Aphids-Multiple Tactics

Cultural Control

Companion crops

Nasturtiums are very attractive to aphids (blackfly, greenfly, whitefly)

Nettles

Chervil is said to be very attractive to slugs.

French Marigold

Radish

Trapping/Monitoring

Install blue and yellow sticky traps to monitor (picture by J. Pinero)

Biological Control

Chemical Control: Insecticides

Pyrethrin

Azadirachtin

Beauveria bassiana

Spinosad

Whitefly

- ✓ **Whiteflies** may attack many of the leafy vegetables but are more problematic on tomatoes and peppers
- Several species are known
  - Bemisia spp and Trialeurodes spp
- On certain crops like tomatoes they also vector viruses
- They are small fragile looking insects
- Not true flies so they have four wings
- They are found on the undersides of the leaf - both immatures and adults

Whitefly

- A typical complaint maybe “large numbers of small white insects fly up in clouds if I disturb the plant.”
- Adults and nymphs produce large **quantities of honeydew** which is colonized by sooty mold.
- Whiteflies are difficult to control and may require 3 to 4 applications of insecticide four to five days apart.
- Systemic insecticides are especially helpful in controlling whiteflies.
- Soap solutions may be used, but coverage must be thorough.

Whitefly: Common Pest of Greenhouse Tomato

Greenhouse Whitefly

Silverleaf Whitefly

Whitefly Damage

Management of Whiteflies-Multiple Tactics

Cultural Control

Bunker crop using papaya

Trapping/Monitoring

Install blue and yellow sticky traps to monitor (picture by J. Pinero)

Biological Control

Silverleaf Whitefly Parasitoid

Greenhouse Whitefly Parasitoid

Chemical Control: Insecticides

Recommended products include:

1.Abamectin
2.Azadiractin
3.Beauveria bassiana
4.Buprofezin
5.Endosulfan
6.Flonicamid
7.Kinoprene
8.Novaluron
9.Potassium bicarbonate
10.Pymetrozine
11.Pyridaben
12.Pyriproxyfen
13.Pyrethroid + Acephate
14.Pyrethroid + Azadiractin

Harlequin Bug

- Harlequin bugs actually refers to a group of sucking pests and not one specific species.
- They attack cole crops (*Brassica oleracea*), such as broccoli, ***cabbage, collards, cauliflower, Brussels sprouts*** and even tomato and okra when the cole crops aren't available.
- The adults and immature feed side by side on the plant.
- Unlike other pests, these eggs if seen on cabbage or broccoli are unique for harlequin bugs
- A generation takes about 2 months so there can be several generations per year.
- They can literally suck a plant to death which is unusual for other sucking pests.

Adult

Egg

Nymphs

Management of Harlequin Bug-Multiple Tactics

Cultural Control

Proper sanitation

Crop rotation and intercropping

Plant border rows of mustard in around the main crop (collard, Brussels sprout etc.)

Trapping

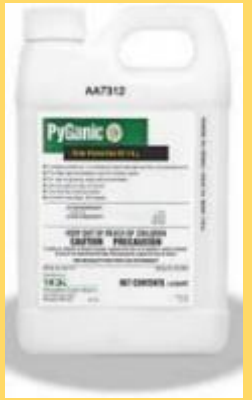
Install traps in tunnels to monitor

Biological Control

Predatory stink bugs (*Podisus spp*) and lady beetles (Harmonia spp)

Ground beetles

Chemical Control: Insecticides



Pyrethrin

Azadirachtin

Beauveria bassiana

Spinosad

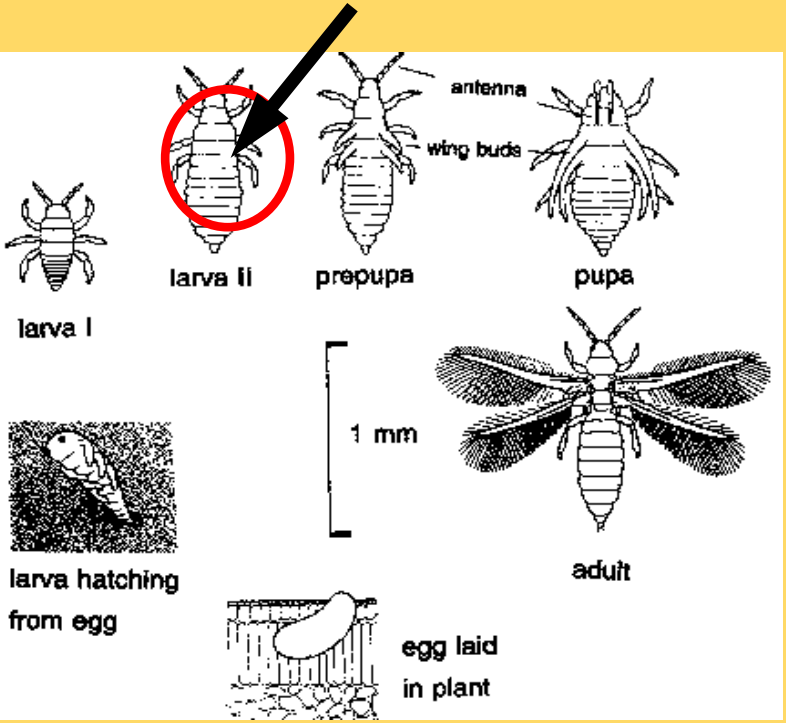
Thrips

- ✓**Thrips** are very small insects usually measuring only 1 to 2 millimeters in length.
- ✓The adult forms have narrow, nearly **veinless wings fringed** with relatively long hairs.
- ✓Asymmetric mouthpart
- ✓Thrips will feed either on leaves or flowers depending on the species
- ✓Western flower Thrips and other species are important pests of field tomatoes and peppers
- ✓They can develop as immatures on weedy hosts at the edge of the field then move into the field

Thrips

- ✓This feeding causes a flecking, bleaching, or silvering of the damage leaves
- ✓Thrips are relatively easy to control with systemic and certain contact insecticides, but during times of the year when large numbers of thrips are on the move, resulting in continual re-infestation, it can be very difficult to maintain control of Thrips

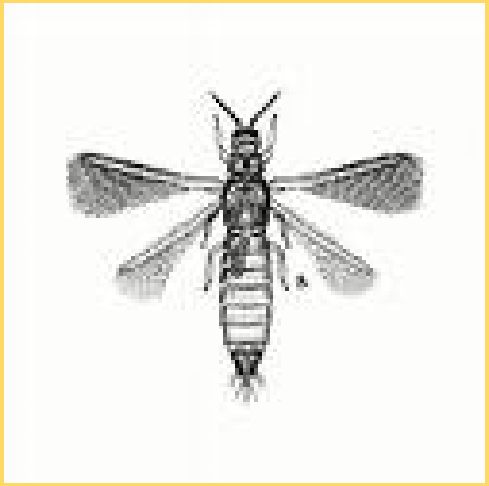
Thrips life cycle



Species and Damage of Thrips

Frankliniella spp

Thrips palmi



Thrips tabaci

Scirtothrips sp

Damage

Management of Thrips-Multiple Tactics

Cultural Control

No trap crop developed for this insect

Trapping/Monitoring

Install blue and yellow sticky traps to monitor (picture by J. Pinero)

Biological Control

Predatory Thrips

Chemical Control: Insecticides

Pyrethrin

Azadirachtin

Beauveria bassiana

Spinosad

Spider Mites

Two spotted spider mite pest of many vegetables in greenhouses

Signs of mites damage to cucumber

Spider Mites (Not Insects)

Adult Male and Eggs

Adult Female

Diapausing Adult Female

- ✓ Likely a secondary pest in some fruit crops
  - Can be flared by broad spectrum insecticides
  - Resistance to miticides
  - Several species may occur, TSSM (*Tetranychus urticae*) and CREM (*Panonychus citri*) probably most common
- ✓ **Spider mites** are characterized by their ability to produce **stipling and silk/webbing**
- ✓ Damage: Stippling, reduce tree vigor, photosynthetic ability of leaves
- ✓ Pest of most fruit crops especially Apples, peaches, pears and cherries
- ✓ Common Species:
- ✓ Two-spotted spider mite: *Tetranychus urticae*
- ✓ European spider mite: *Panonychus ulmi*

Managing Spider Mites

- Monitoring 100 leaf samples
- Augmentative release = <u>if > 1 mite/leaf (> 50% leaves spider mite-infested)</u>
  - Order predatory mites *Amblyseius fallacis*
    - Source: Rincon-Vitova Insectaries, Inc., Ventura, CA 93002, 800-248-2847, http://www.rinconvitova.com
  - Spray water & sprinkle predatory mites on about 6 leaves/tree
  - Apply 5,000 predator mites per acre ($72/acre)

Common Coleopteran (Beetles) Pests of Vegetables

Cucumber Beetle

- ✓The most common cucumber beetles in Missouri are the 12-spotted and striped cucumber beetles
  - Usually oval shaped
  - Can be colorful with stripes or spotted markings (may fade with age)
  - Prefers shady cool places such as leaf and melon undersides;
  - Keep leaves dry and lift fruits to keep the underside dry

Adults

12-spotted cucumber beetle

Diabrotica undecimpunctata howardi Barber

Striped cucumber beetles

(*Acalymma vittatum*)

Banded cucumber beetle

Diabrotica balteata

Cucumber Beetle-Host Crops

✓Cucumber beetles feed on >280 plants

- Corn
- Lima and Snap Beans
- Peas
- Pumpkins
- Potatoes
- Sweet Potatoes
- Peanuts
- Eggplant
- Tomato
- Summer and Winter Squash

Cucumber Beetle

✓Adults: overwinter in weedy areas – therefore keep weeds cut down all year;

- They damage plants primarily by chewing on the lower stems and early leaves
- In the early season they may attack roots
- **They may be vectors of some disease organisms (bacterial wilt disease)**

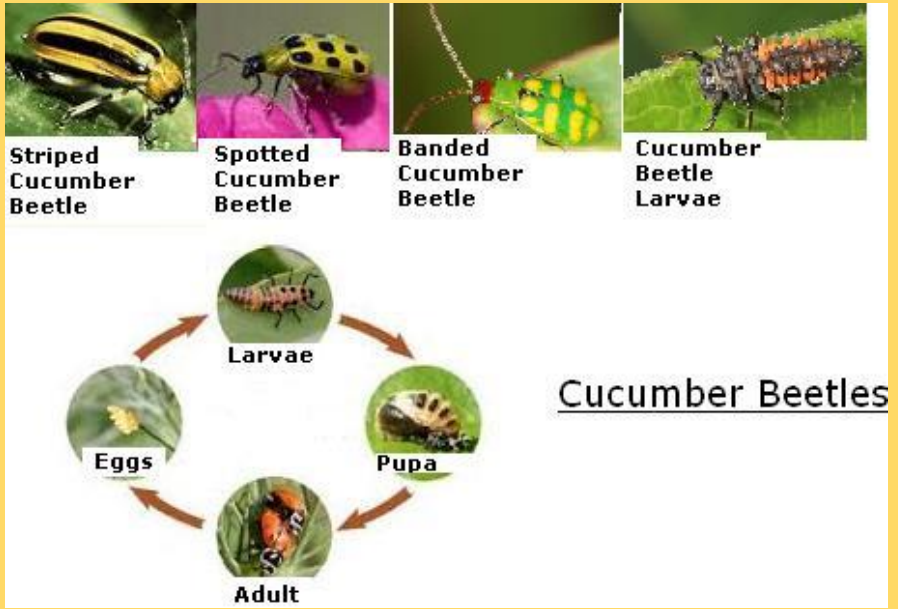
✓The striped type is a yellowish-orange with black stripes down its back

✓Spotted cucumber beetles also vector other diseases like

- *Squash mosaic virus*, *Cucumber mosaic virus*, *Bean mosaic virus*, and *Maize chlorotic mottle virus*

Cucumber Beetle

- ✓ Adults lay eggs early in spring on the soil surface
- ✓ Eggs hatch in about 3 to 10 days, and larvae will feed on plant roots for 2 to 3 weeks
- ✓ They pupate in the soil and emerge as beetles
- ✓ Beetles feed, mate, and repeat the life cycle; several generations may occur annually
- ✓ To control damage, observe plants for signs of feeding and apply insecticide as necessary.
- ✓ Thorough coverage is necessary.



Management of CB-Multiple Tactics

Cultural Control

- **Intercrops, covers and screens**
- **Trap crop:** Blue Hubbard is an effective trap crop
- **Mulches:** zucchini plus sunn hemp (*Crotalaria juncea* L.) fewer beetles were found

Trapping/Monitoring

- **Indole, cinnamaldehyde** alone or in combination with **trimethoxybenzene** are attractive kairomones can attract beetles (Capinera 2008).
- Install traps in field to monitor

Biological Control

- Soldier Beetles
- Ground Beetles,
- Braconid Wasps
- Tachinid Flies
- Entomopathogenic Nematodes

- Provide conditions to enhance natural enemies
- Plant flowering plants

Chemical Control: Insecticides

Pyrethrin

Spinosad

Azadirachtin

Organic producers may reduce pressure by using mechanical control methods like floating row covers in the early part of the day and then remove the cover to allow pollination.

Conventional

- imidacloprid (Provado)
- acetamiprid (Assail)
- dinotefuran (Venom)
- Bifenthrin (Brigade): Pyrethroid
- zetacyper (Mustang Max): Pyrethroid

Treat if numbers exceed five or more per mature plant

Colorado Potato Beetle (CPB)

- ✓ The **Colorado potato beetle** feeds primarily on Irish potatoes
- ✓ It is sometimes called the potato bug.
- ✓ It sometimes attacks tomato and eggplant.
  - May start development on solanaceous weeds before they infest the field
- ✓ Both larvae and adults make irregular holes in the leaves, which may lead to defoliation.
- ✓ Adults are black and yellow striped beetles
- ✓ Adults over winter along edges of gardens and emerge in early spring to lay eggs on leaves and stems of plants.

Colorado Potato Beetle-Host Crops

- ✓ Solanaceous plants
  - Common Nightshade
  - Tomato
  - Eggplant
  - Ground Cherry
  - Horse-nettle
  - Pepper (Rarely)
  - Tobacco
  - Belladonna (nightshade family)
  - Henbane

Tomato

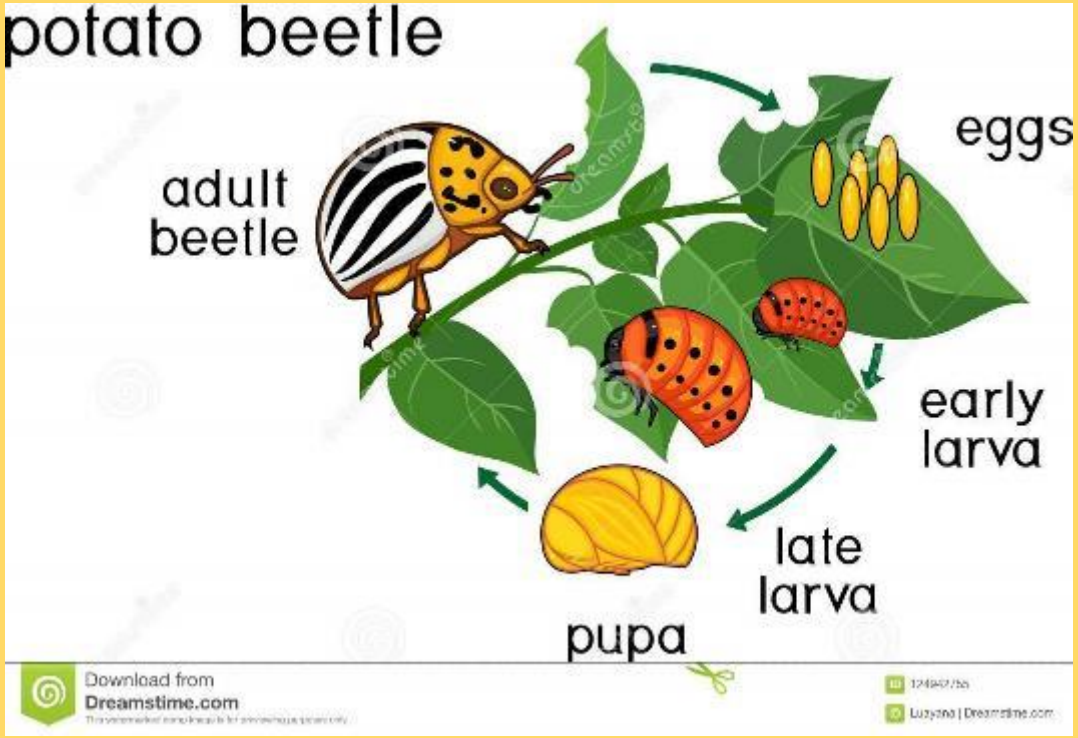
Horse-nettle

Belladonna

Henbane

Colorado Potato Beetle

- Eggs hatch in about 3 to 10 days
- The larvae feed for two to three weeks.
- Larvae pupate on the leaves and emerge as adults.
- Several generations occur annually.
- Low populations may need no control, but larger populations require application of an insecticide with thorough coverage.



Management of CPB-Multiple Tactics

Trap cropping

Horse nettle or nightshade sentinel plants

Scouting

- Scout beetles on 30-50 plants (or later in the season, stalks) in V-shaped pattern and stop at 10 sites across the field.
- Randomize your selection of sites using a set number of paces (e.g. stop every 10 paces)
- Select 3-5 plants at each location if plants are less than 12-18” tall; if plants are larger, select 3-5 stalks.
- Alternatively, select 30-50 plants or stalks individually at random across the field.

Threshold

- **Treat if:**
- ✓ 10% defoliation is observed
- ✓ Adults: 25 beetles/50 plants
- ✓ Small larvae: 4/plant
- ✓ Large larvae: 1.5/plant or stalk, based on a count of 50 plants/stalks

https://ag.umass.edu/vegetable/fact-sheets/colorado-potato-beetle-management

Biological Control

Stink bugs (podisus) and lady beetles (Harmonia spp.)

Ground beetle

Chemical Control: Insecticides

Pyrethrin

Azadirachtin

Beauveria bassiana

Spinosad

Check label before use

June and Japanese Beetles

- ✓ Are pests of many crops (over 400+)
- ✓ Highly mobile and sporadic and difficult to control
- ✓ One generation per year and flight activity usually peaks at the time when fruits and vegetables are about to be harvested
- ✓ Both causes defoliation and direct feeding on fruiting parts and also on root of grasses
- ✓ Defoliation may not be economically significant (case by case basis)
- ✓ Fruit feeding greater concern

June beetle

Japanese beetle

Damage starts in late June or July

Green June beetle and Japanese beetle

Damage starts in late June or July

Management of June and Japanese Beetles-Multiple Tactics

Cultural Control

- ✓ *No trap crop has been developed for this insect*
- ✓ *Because they are highly polyphagous*
- ✓ *Grasses serve as reservoir for they development*

Trapping/Monitoring

Install traps in field to monitor (picture by J. Pinero)

No economic threshold

Biological Control

Wheel bug eating JB

nematodes

Chemical Control: Insecticides

Beauveria bassiana

Spinosad

Pyrethrin

Azadirachtin

Common Lepidopteran (Moths and Butterflies) Pests of Vegetables

Major Fruit and Vegetable Pests

Common Lepidopteran Pests

Armyworms

- ✓ Beet armyworm (*Spodoptera exigua*)
- ✓ Fall armyworm (*Spodoptera frugiperda*)
- ✓ Army worm (*Pseudaletia unipuncta*)
- ✓ Western yellowstriped armyworm (*Spodoptera praefica*)

Cutworms

- ✓ Army cutworm (*Euxoa auxiliaris*)
- ✓ Glassy cutworm (*Crymodes devastator*)
- ✓ Clover cutworm (*Scotogramma trifolii*)
- ✓ Bronzed cutworm (*Nephelodes minians*)
- ✓ Variegated cutworm (*Peridroma saucia*)
- ✓ Western bean cutworm

Fruitworms/ budworms

- ✓ Tobacco budworm (*Heliothis virescens*)
- ✓ Tomato fruitworm/cotton bollworm/Corn earworm (*Heliothis zea*)
- ✓ Speckled green fruitworm (*Orthosia hibisci*)

Others

- ✓ Cattail caterpillar (*Simyra henrici*)
- ✓ Septis moths (*Septis spp.*)
- ✓ Zebra caterpillar (*Melanchra picta)*

WBC and CEW heads. Note the broad bands behind WBC head and the warts on the CEW.

(Photo Credit: Marlin Rice)

Common Lepidopteran Pests

Photo by Peter Jentsch Cornell University

Corn/Tomato/Bollworm

They have more setae (hairs) than armyworms

male fall armyworm, *Spodoptera frugiperda* . Photograph by Lyle J. Buss, University of Florida.

Hornworms

Pinworms

Corn earworm/Tomato fruit worm/Cotton Bollworm

- Two caterpillars on tomato: *fruit worm and hornworm. Hornworm are most distinct
- **Host plants:** Egg plants, tomatillos, and okra, corn, cotton etc.

- **Feeding habit/preference/behavior:** on the tips of the corn ear or bore into the fruit of tomatoes

- **Description:**
  - Adults: have more setae (hairs) than armyworms; moth stage does not cause damage
  - Egg: eggs laid in late afternoon in plant terminals and/or fruit; lay the eggs on leaves

Adult Earworm (Photo Credit: J. Obermeyer)

Tomato fruit worm eggs

Corn earworm/Tomato fruitworm/Cotton Bollworm

✓ Description:

- **Larva (caterpillars)**: have four prolegs, **curl into a C-shape;**
- Varies in color from light pink to dark grey with stripes down its back and sides;
- Larva feeds for 3 to 5 days on the corn silk until they are large enough to penetrate between the shuck and kernels;
- Larva feed for a total of about 14 days, they emerge to pupate in the soil

- **Pupa:** overwintering stage; moths emerge in 10 to 12 days and mate to restart the cycle

Earworm larvae come in many different colors (Photo Credit: J. Obermeyer)

Earworm larvae (Photo Credit: Akotsen-Mensah)

Important Pests of Cabbage In High Tunnel

- Aphids
- Diamond back moth
- Thrips
- Cabbage looper
- Stink bugs
- Whiteflies

Management of Armyworm and Earworm

Cultural Control

FAW:
Push and pull using Napier grass (*Pennisetum purpureum*) or Brachiaria grass (pull), while driving them away from the main crop using a repellent intercrop (push), *Desmodium* spp., commonly known as desmodium,

Desmodium also attracts natural parasitoids and predators to the field.

Trapping

Install Scentry wing traps in field to monitor

Add lures

https://www.arbico-organics.com/product/3858/pest-solver-guide-caterpillars-moths

Biological Control

Commonly parasitoids are *Archytas marmoratus, Cotesia marginiventris* and *Chelonus texanus*

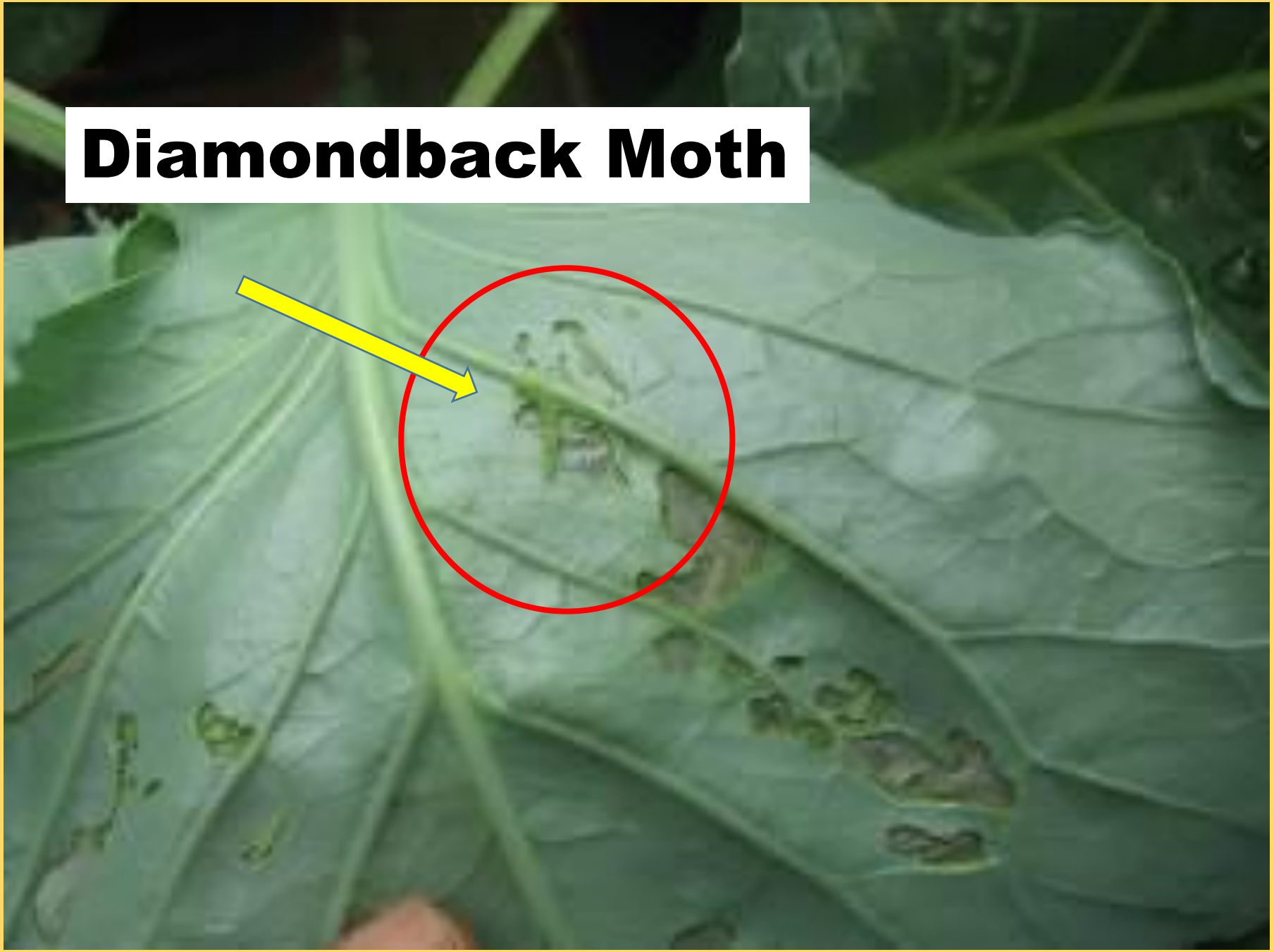
Stink bugs (podisus) and lady beetles (*Harmonia* spp

Ground beetles

Chemical Control: Insecticides

- Permethrin
- Esfenvalerate
- Cyfluthrin
- Bifenthrin
- Cyhalothrin (lambda or gamma), and
- Spinosad

- 3 to 5 days after eggs hatch and before larvae penetrate the ear or fruit
- If 4 or more fall armyworms per square foot, control is necessary to prevent economic loss.
- The affected areas can be harvested or sprayed to remove the pest.
- Applications must be repeated at five-day intervals until corn silks have turned brown and dried.
- Thorough coverage is essential


Diamondback Moth

Leaf miners on cucumber leave

Request

Please take a **voluntary survey** for me to know your needs so we can work together to look for answers

Thank You!