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Pepper Pest Management (Extension Curriculum)

Kaushalya Amarasekare
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Pepper Pest Management

Kaushalya Amarasekare Ph.D.

Assistant Professor of Entomology

Dept. of Agricultural and Environmental Sciences

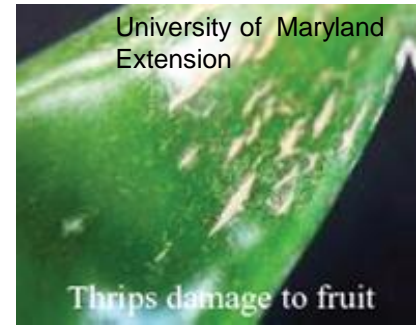
College of Agriculture

Tennessee State University

Nashville, Tennessee



snaped.fns.usda.gov



University of Maryland
Extension

Thrips damage to fruit

Goal

The goal of this training is to educate stakeholders on arthropods (pest insects and mites) that damage peppers and methods to manage them using integrated pest management (IPM) techniques

Objectives

Upon completion of this training, the participants will be able to 1) teach, 2) demonstrate and 3) guide growers, small farmers, backyard and community gardeners, master gardeners, and other stakeholders on management of pest arthropods in peppers

Course Outline

1. Introduction: background information on bell and chili pepper
2. Pests of pepper
 - a) Seedling Pests
 - b) Foliage Feeders
 - c) Pod Feeders
3. Summary
4. References

Introduction



agmrc.org



chili pepper

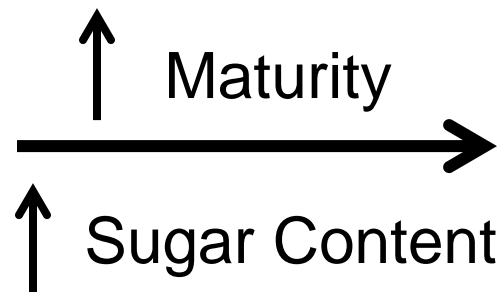
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wifss.ucdavis.edu

Peppers

- Family Solanaceae
 - *Capsicum annum L.*
 - Bell/sweet peppers and chili
- Peppers: consumed as
- Fresh
 - Dried
 - Ground as spices
 - Processed (canned, pickled, brined or in salsas)

Bell Pepper

- 2017: U.S. consumption of fresh bell peppers ~ 11.4 lbs./person
- High in vitamin C and dietary fiber
- Provide small amounts of several vitamins and minerals
- Usually sold as fresh produce



Chili Pepper



- 2017: U.S. consumption of chili peppers ~ 7.7 lbs./person
- High in vitamin C
- Small amounts of vitamin A and B-6, iron and magnesium
- Sold as fresh produce and dried (whole peppers, crushed or powdered)



U.S. green pepper production

- U.S. rank: 5th in the global production (China, Mexico, Turkey and Indonesia)
- 2017 fresh market production:
 - 1.6 million lbs.
 - Grown in 43,300 acres
 - Value: \$ 646 million

U.S. green pepper production

Bell Pepper

- Major U.S. states of production: California, Florida, Georgia, New Jersey, Ohio, North Carolina and Michigan
- Field / Greenhouse:
 - Majority: grown in the field
 - Smaller volume: grown in greenhouse

Chili Pepper

- Major U.S. states of production: California, New Mexico, Texas and Arizona
- Majority: grown in the field

Bell pepper production in Tennessee

- Not ranked in the U.S. production
- ~10% of the U. S. production
- 2012-2017: number of operations growing bell pepper increased by 280% and number of acres increased by 8%
- Almost all production for fresh market

Chili pepper production in Tennessee

- Tennessee is not ranked in the U.S. production
- <1 % of the U. S. production
- 80% of hot peppers are for fresh market production

Course Outline

1. Introduction: background information on bell and chili pepper
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Pests of Pepper

Cutworm damage



ortho.com

Flea beetle damage



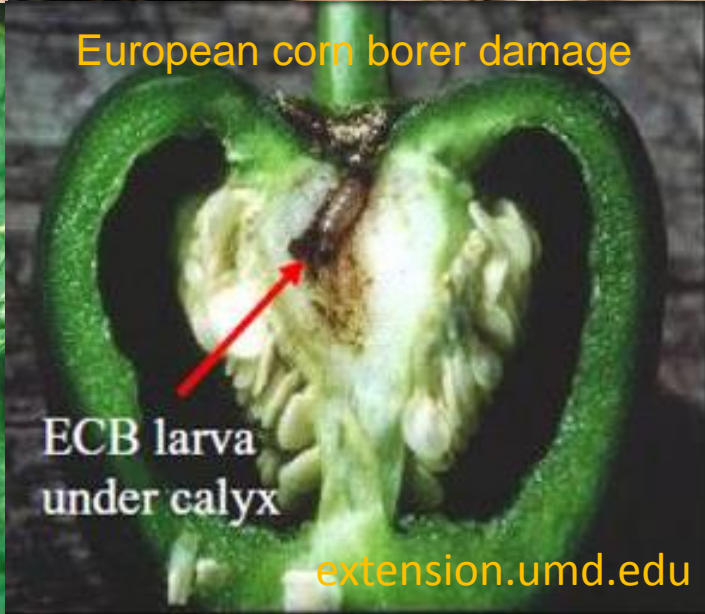
ucanr.edu

Thrips damage to leaves



omafra.gov.on.ca

European corn borer damage



ECB larva
under calyx

extension.umd.edu

Pests of pepper

1. Seedling Pests
2. Foliage Feeders
3. Pod Feeders

Pests of sweet pepper

1. Seedling Pests

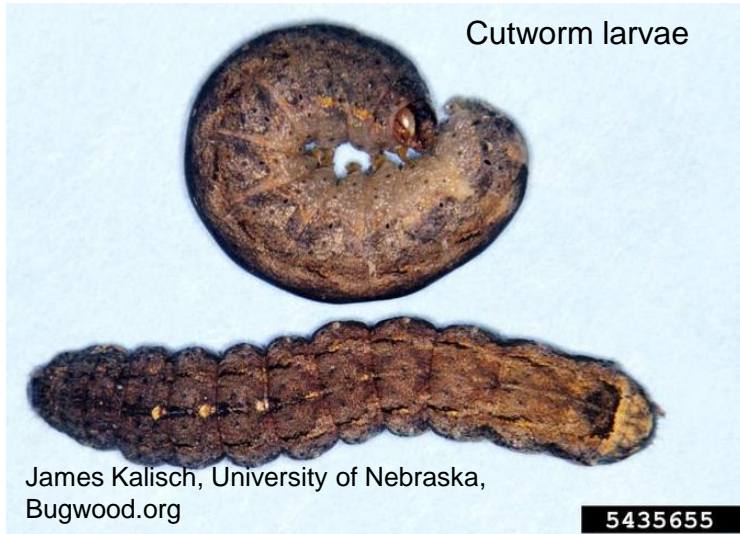
Seedling Pests

1. Cutworms
2. Tomato fruitworm
3. Thrips

Cutworms

Cutworms

(Lepidoptera: Noctuidae)



- Abundant in previous grass sod grown fields
- Larvae: several species of night-flying moths
- No damage from adults:
 - night-flying moths
- Curl up into a tight "C" when disturbed
- Polyphagous: common hosts:
 - asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato, tomato and turf grass



Damage



- Feed on roots and foliage of young plants
- Cut down young plants as they feed on stems at or below the soil surface
- Black cutworms:
 - Can cause severe injury to the base of plants, often killing them
- In most cases, entire plants will be destroyed
- Climbing cutworms:
 - e.g. Variegated cutworm
 - move up on plants and feed upon foliage, buds and shoots

Cutworms

1. Black Cutworm (*Agrotis ipsilon*)
2. Variegated Cutworm (*Peridroma saucia*) (Climbing cutworm)

Black Cutworm (*Agrotis ipsilon*)

(Lepidoptera: Noctuidae)

Adult



University of Florida

University of Florida



Oregon State University

Larva



University of Florida

University of Florida



University of Florida

University of Florida

Variegated Cutworm (*Peridroma saucia*) (Lepidoptera: Noctuidae)



Identification of black cutworms



Adult

1. Relatively large with wingspans of 1.5-2.0 inches
2. Brownish color
3. Single, black, dagger-like mark on each forewing

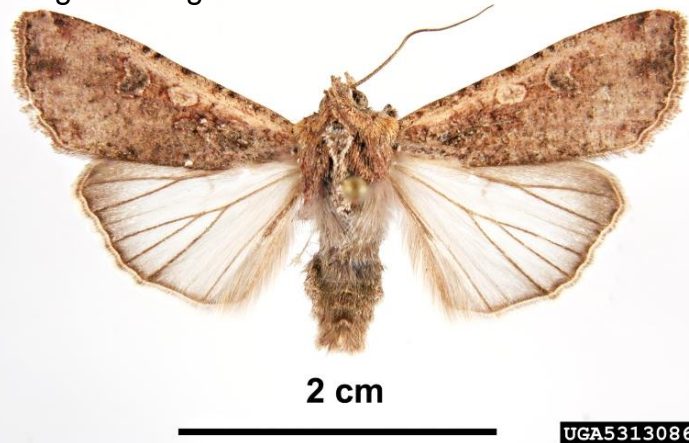


Larva

1. Rough, grainy skin ranging from light gray to black
2. Pale indistinct, narrow stripe along the center of the back
3. Curl into a "C" shape when disturbed

Identification of variegated cutworm

Pest and Diseases Image Library,
Bugwood.org



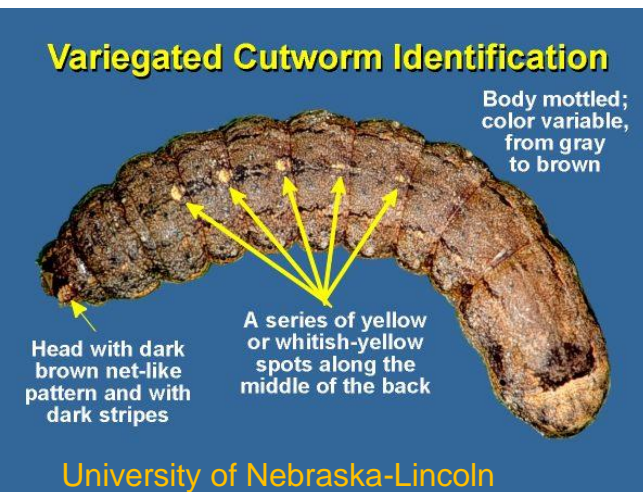
Adult

1. Large moth with a wingspread of 1 $\frac{3}{4}$ "
2. Forewings: light tan color and black markings. Two pale eyelike marks, separated by a black bar, appear in the upper middle
3. The hind wings: silvery white



Larva

1. Brownish-grey
2. Diamond-shaped marks along the back and light lines along the sides
3. Up to 2" long

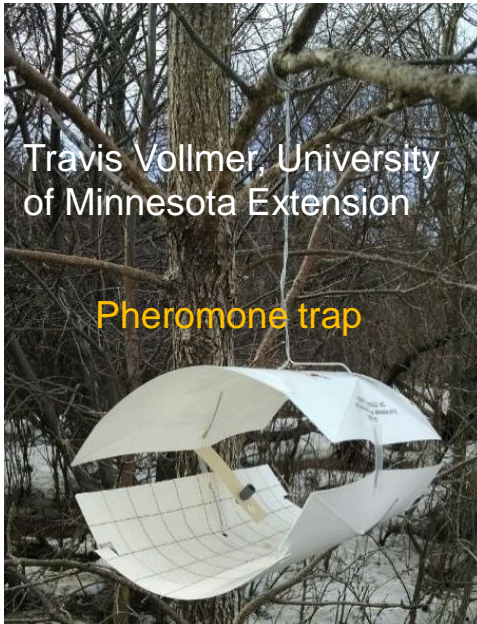


Cutworm management



- Control: easier when larvae are young
- Regular check: late afternoon and evening when active
 - Inspect in the morning when damage is fresh (plants cutoff near the ground, wilting, droppings on the ground)
 - To verify presence: run your hand over the soil, rolling over soil clumps and other potential hiding places within a one foot square area of the damage

Cultural management



Travis Vollmer, University of Minnesota Extension

Pheromone trap



Michele Walfred, University of Delaware

Black light trap

- Mowing
 - Grassy areas surrounding the field a week or two prior to transplant
- Avoid certain areas for planting:
 - Where grass sod was previously grown
- Use of pheromone traps:
 - Female sex pheromone lures: attracts males
 - Aid in determining when present
- Black light traps:
 - not effective as pheromone traps
- Scouting

Cutworm management



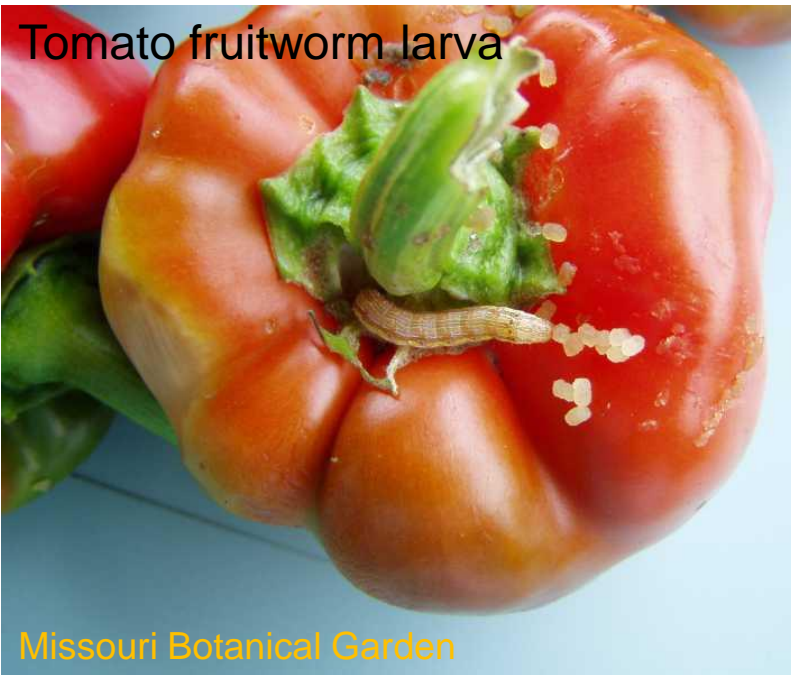
- Physical:
 - Placing aluminum foil or cardboard collars around transplants
 - Creates a barrier that physically prevents larvae from feeding on plants
- Chemical:
 - Home gardens: not necessary
 - Severe infestation: apply insecticides in the evening (carbaryl, cyfluthrin, permethrin)
 - Fields with history of cutworms/ previously grass sod grown

Tomato Fruitworm

Tomato fruitworm

Helicoverpa zea

(Lepidoptera: Noctuidae)



- One of the most important pests of vegetables and field crops
- Also known as:
 - Corn earworm or cotton bollworm
- Polyphagous:
 - Wide host range (e.g. corn, tomato, cotton, eggplant, pepper, soybean)
- Come as migratory swarms from the south of the US

Tomato Fruitworm



- Adults emerge from overwintering sites in early May
- Female lays eggs on open foliage / younger leaves
- Eggs hatch 3-4 days
- 5-6 larval instars develop in 2-3 weeks

Tomato Fruitworm damage



- Larvae feed on tender leaves, stems, flowers and fruits
- Typically feed inside the fruit, creating a water cavity contaminated with feces
- Damaged fruits
 - Ripen prematurely
 - Rot
- Any feeding results unmarketable fruit



Egg



UC Statewide IPM Project
© 2000 Regents, University of California

Larva



Alton N. Sparks, Jr.,
University of Georgia,
Bugwood.org

UGA1327007

Pupa



Adam Sisson, Iowa State
University, Bugwood.org

5465674

Adult



Ronald Smith, Auburn University,
Bugwood.org

Tomato fruitworms

- Eggs:
 - Individually laid
 - Dome-shaped
- Larvae:
 - Feed and develop inside the fruit
 - Cannibalistic
 - Pupate in soil
- Pupae:
 - Found in soil
- Adults:
 - Medium- sized moths tan/brown
 - Wingspan 1-1.3”
 - Lays up to 2500 eggs



Adults



© Howell C. Curtis



Larva

Identification

Adult

- Fore wings:
 - light yellow-olive/yellowish brown in color
 - single dark spot near the center of each forewing
- Hind wings:
 - Creamy white basally and blackish distally, and usually bear a small dark spot centrally

Larva

- Head: tan color
- Body:
 - Alternating light and dark stripes run lengthwise
 - Skin is coarse and has small, thorn-like projections/ black tubercles

Tomato fruitworm management

Heavy rainfall



- Drowns pupae
- Limit moth flights
- Washes eggs
- Create favorable conditions for fungal diseases of larvae

Tomato fruitworm management

- **Cultural and physical:**
 - Early planting
 - Monitoring for eggs and small larvae
 - Sanitation: Collect and dispose infested fruit
 - Avoid planting near corn
 - Growing resistant varieties
 - Deep ploughing
 - Trap crops
 - *Heliothis* trap baited with pheromone



Tomato fruitworm management



- Biological control
 - Tachinid fly *Eucelatoria* spp.
 - *Trichogramma* spp. and *Telenomus helithidis* (egg parasitoids) & *Campletis sonorensis*, *Hyposoter exiguae* and *Cotesia marginiventris* (larval parasitoids)
 - Generalist predators
 - Lady beetle, big-eyed bugs, lacewings, minute pirate bugs
- Chemical control
 - Developed resistance to many insecticides
 - BT- *Bacillus thuringiensis*
 - Mineral oil
 - Spinosad, Methoxyfenozide, Indoxacarb

Seedling Pests

1. Cutworms
2. Tomato fruitworm
3. Thrips

Thrips

Thrips



Whitney Cranshaw, Colorado State University,
Bugwood.org

UGA1243058

Thrips



Bruce Watt, The University of Maine, ©Bruce Watt
Cooperative Extension

Thrips

(Thysanoptera: Thripidae)

- Microscopic/minute insects (~ 1mm)
- Slender body with fringed wings
- Major pests of fruits, vegetables, field crops and ornamental plants
- Vectors of plant diseases

Adult



5370035

Jack T. Reed, Mississippi State University, Bugwood.org

Adult



5554357

David Cappaert, Bugwood.org

Thrips

Thysanoptera: Thripidae

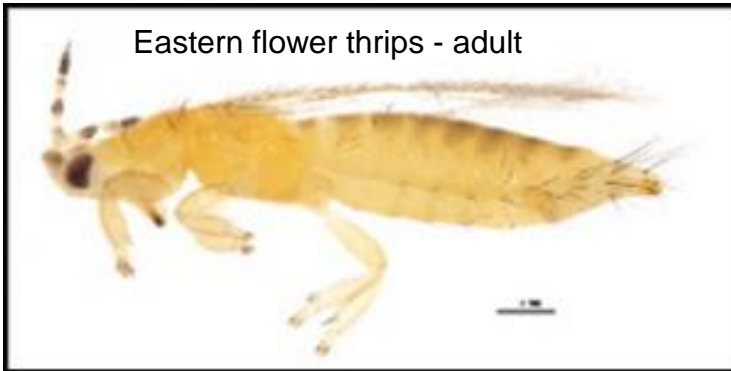
- Two important species in Tennessee
 - Melon thrips (*Thrips palmi*)
 - Eastern flower thrips (*Frankliniella tritici*)

James Castner, University of Florida



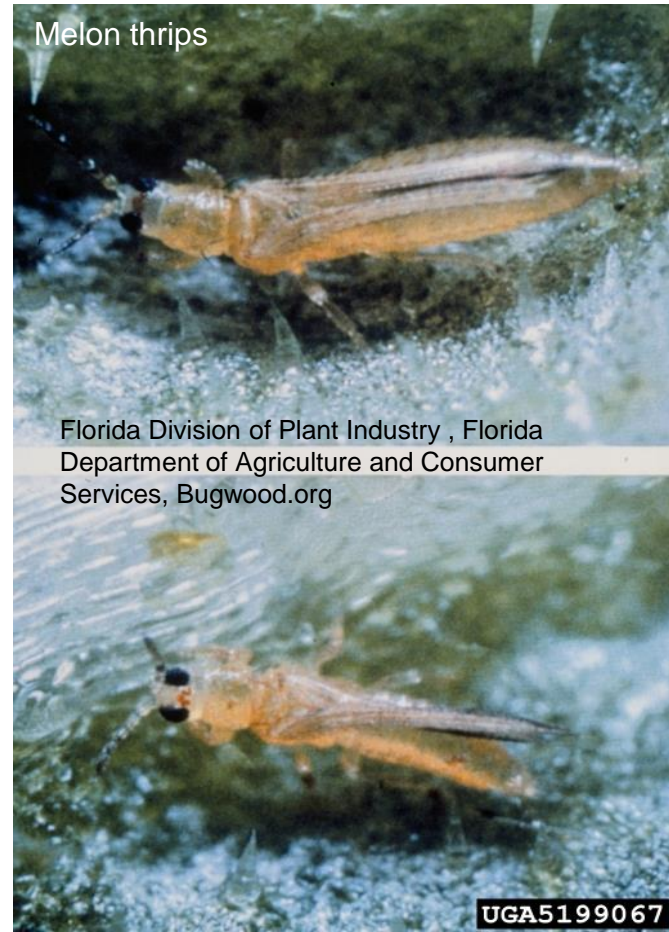
Eastern flower thrips - adult

Eastern flower thrips - adult



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Melon thrips



Florida Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Bugwood.org

UGA5199067

Thrips



- Damage:
 - Directly by
 - Ovipositing in small, developing fruits before stamens have been shed
 - Feeding on fruits, flowers and leaves
 - Indirectly by transmitting tomato spotted wilt virus (TSWV)
- High numbers: cause damage
- Thrips feeding
 - Distorts plant growth
 - Deforms flowers
 - Causes white-to-silvery patches on emerging leaves that often have tiny black fecal specks in them

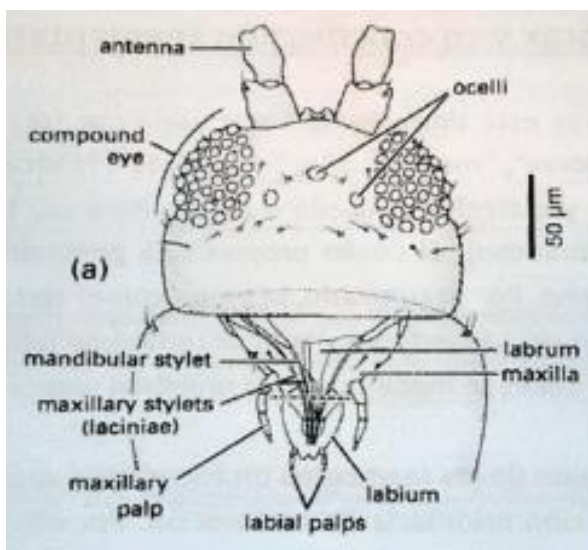
Thrips damage

Direct damage

1. Feeding on plant material

Rasping-sucking mouthparts

Rasp / break the leaf tissue and suck the sap



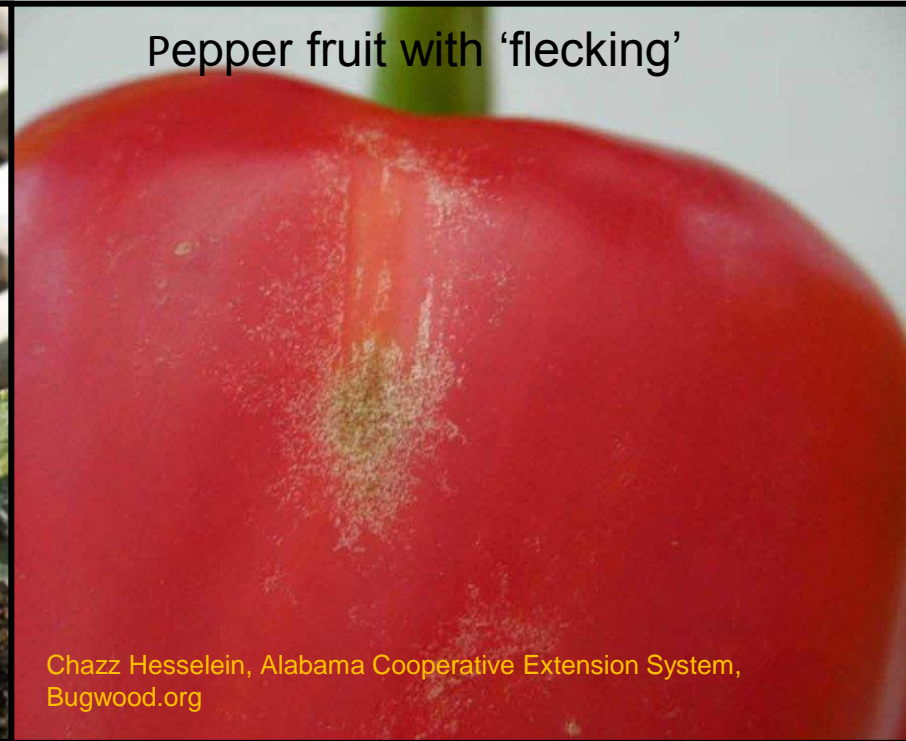
Thrips feeding damage

Thrips damage on leaves



Vivek Kumar, Entomology and Nematology Department, University of Florida.

Pepper fruit with 'flecking'



Chazz Hesselein, Alabama Cooperative Extension System,
Bugwood.org

Damaged plant tissues become speckled and white

Thrips damage

Direct damage

1. Feeding on plant material
2. Egg laying (oviposition) on plant material

Thrips oviposition damage

Thrips oviposition on leaves



Thrips damage

Direct damage

1. Feeding on plant material
2. Egg laying (oviposition) on plant material

Indirect damage

Transmitting diseases

Diseases transmitted by thrips

Tomato spotted wilt virus (TSWV)



Photo credit: M. McGrath
Long Island Horticultural Research &
Extension Center, Cornell University

Thrips

- May be present throughout the growing season
- Plant injury:
 - Caused by both nymphs and adults rasping the leaves and floral tissues and then sucking the exuding sap
 - This causes reddish, gray or silvery speckled areas on the leaves
 - With severe infestations, these areas can interfere with photosynthesis and result in retarded growth



Vivek Kumar, - University of Florida

Thrips



- Heavy infestations during the bloom stage may cause damage to developing pods
- Aggregate on pods and are well hidden from sprays
 - Russeting damage from continual feeding during pod development

Thrips Management

- Avoid planting next to onions, garlic or cereals, because high thrips numbers often build up on these crops
- Avoid fields near greenhouses where ornamentals (cut flowers) are grown because these plants serve as hosts for the virus and thrips
- Use biologically based Integrated Pest Management (IPM) programs that conserve natural enemies
 - e.g. Use of reduced risk-insecticides such as e.g. Spinosad, Indoxacarb if / when chemical control is needed

Pests of sweet pepper

1. Seedling Pests
2. Foliage Feeders

Foliage feeders

1. Hornworms
2. Spider mites
3. Aphids
4. Flea beetles
5. Leaf miners
6. Colorado potato beetle

Foliage Feeders





Tobacco hornworm

R.J. Reynolds Tobacco Company, R.J.
Reynolds Tobacco Company, Bugwood.org

UGA1402126



Tomato hornworm

Whitney Cranshaw, Colorado State University,
Bugwood.org

UGA5304010

Hornworms

Lepidoptera: Sphingidae

- Minor pest
- Larvae: can cause extensive defoliation and also feed on fruit
- Rarely found in commercial peppers because they are controlled by insecticides applied for other insect pests
- Two species:
 - Tobacco hornworm (*Manduca sexta*)
 - Tomato hornworm (*Manduca quinquemaculata*)

Damage





Tobacco hornworms

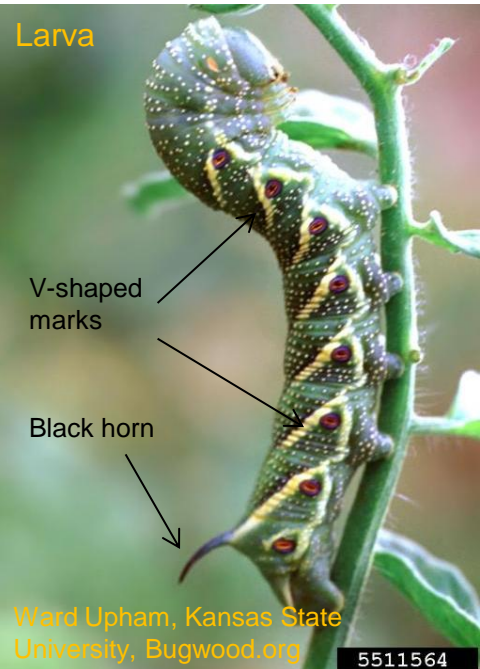
Manduca sexta

- Also known as Carolina sphinx moth/tobacco hawk moth (adults) and goliath worm (larvae)
- Feeds on plants of Family Solanaceae: tobacco and tomato
- Defoliate tomato plants
- 7 white diagonal lines with black border
- Red horn



Tomato hornworms

Manduca quinquemaculata



- Feeds on plants of Family Solanaceae: tomato, peppers, eggplant and potato
- Defoliate plants
- 8 white whitish or yellowish "V"-shaped marks laterally, and pointing anteriorly
- Black horn



Crop monitoring



Scott D. Stewart, University of Tennessee



Hand picking

GEORGE BREDEHOFT / CREATIVE COMMONS



Soil tillage

Janice E. Carey, University of California-ANR

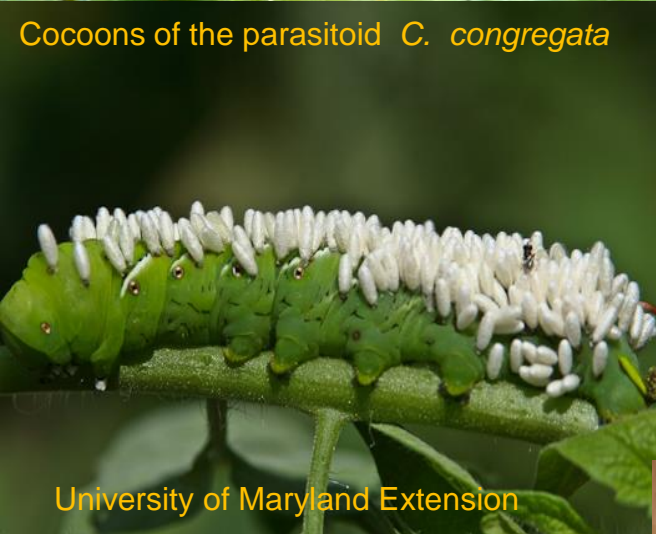
Hornworm management

- Cultural/physical practices:
 - Crop rotation
 - Examine plants frequently
 - Hand picking and destruction
 - Place in soapy water
 - Control by soil tillage/disking after harvest
 - Mature larvae: burrow to a depth of 10 to 15 cm, and pupate



Parasitoid *Cotesia congregata*

Justin Bredlau, Virginia Commonwealth University



Cocoons of the parasitoid *C. congregata*

University of Maryland Extension



Newly emerged adult of *C. congregata*

Hornworm management

Biological control:

- Abundant natural enemies:
 - Parasitoids, tachinid flies, *Polistes* wasp
 - Many parasitoids (e.g. *Cotesia congregata*)
 - Should not destroy larvae with parasitoid pupae



Polistes wasp



Galveston County Master Gardener Association, Inc.



Jon Yuschock, Bugwood.org

5558520



R.J. Reynolds Tobacco Company, Bugwood.org

UGA1440132



Tachinid fly

David Cappaert, Bugwood.org

Hornworm management

Chemical control

- When larvae in early instars
- Late instar larvae: difficult to kill
- *Bacillus thuringiensis* (BT)

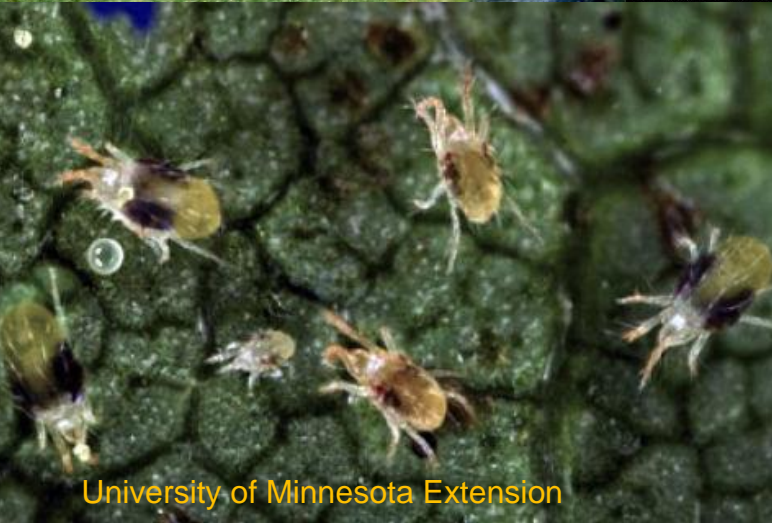


Foliage Feeders



Spider mites

Arthropoda: Arachnida: Acari



- 8-legged mites appear as tiny, reddish, greenish, or yellow moving dots on the undersides of leaves
- They are very tiny, about 1/50th inch long
- When a heavy infestation occurs webbing will also be present



5426930

Spider mite Damage

- The plant looks bronzed and has a yellowed discoloration
- Webbing indicates a spider mite infestation
- These symptoms may be confused with drought stress



Whitney Cranshaw, Colorado State University,
Bugwood.org

UGA1325008



UM Extension

University of Maryland Extension



UK Entomology University of
Kentucky



Purdue University Extension

Spider mite Damage



University of Maryland Extension



University of Minnesota Extension

- Leaves infested: lightly stippled with pale blotches.
- Heavy infestations:
 - Entire leaf appears light in color, dries up, often turning reddish-brown in blotches or around the edge.
- Greatest damage to peppers occurs during dry, hot weather which is favorable for development of extremely large mite populations.



Monitoring for mite damage

5360619



Cultivation for weed removal

K.A. Barbarick, Bugwood.org

5365206



High pressure water spray

Management

Cultural/Physical

- Check plant regularly
- Cultivate to remove weeds
- Mow field edges prior to planting
- Scouting during hot dry weather conditions
- Use a high pressure water spray:
 - Dislodge spider mites
 - Wash away their protective webbing



Green lacewing larva

UGA9005037

Adult *Phytoseiulus persimilis* (right) feeding on an egg of twospotted spider mite, *Tetranychus urticae*



Jack Kelly Clark

UC Statewide IPM Project
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Predatory mite, *Phytoseiulus persimilis* (right), feeding on a twospotted spider mite, *Tetranychus urticae*



Jack Kelly Clark

UC Statewide IPM Program
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Management

Biological

- Generalist predators
 - lady beetles (e.g. *Stethorus* sp.), lacewing larvae and predatory mites (e.g. *Phytoseiulus persimilis*) control spider mites
- Excessive use of insecticides kill natural enemies



Stethorus lady beetle

Sonya Broughton, Department of Agriculture & Food
Western Australia, Bugwood.org

5187007

Management

Chemical

- Insecticides: e.g. insecticidal soap and horticultural oil
- Treatments should be applied when mites become numerous and their damage appears excessive
- Target the underside of leaves as well as the top.
- Repeat applications may be needed
- Water plants thoroughly before spraying
- Spray in the early morning or early evening.
- These steps will reduce the risk of further stressing plants and causing injury.

Foliage Feeders



Lyle J. Buss, University of Florida

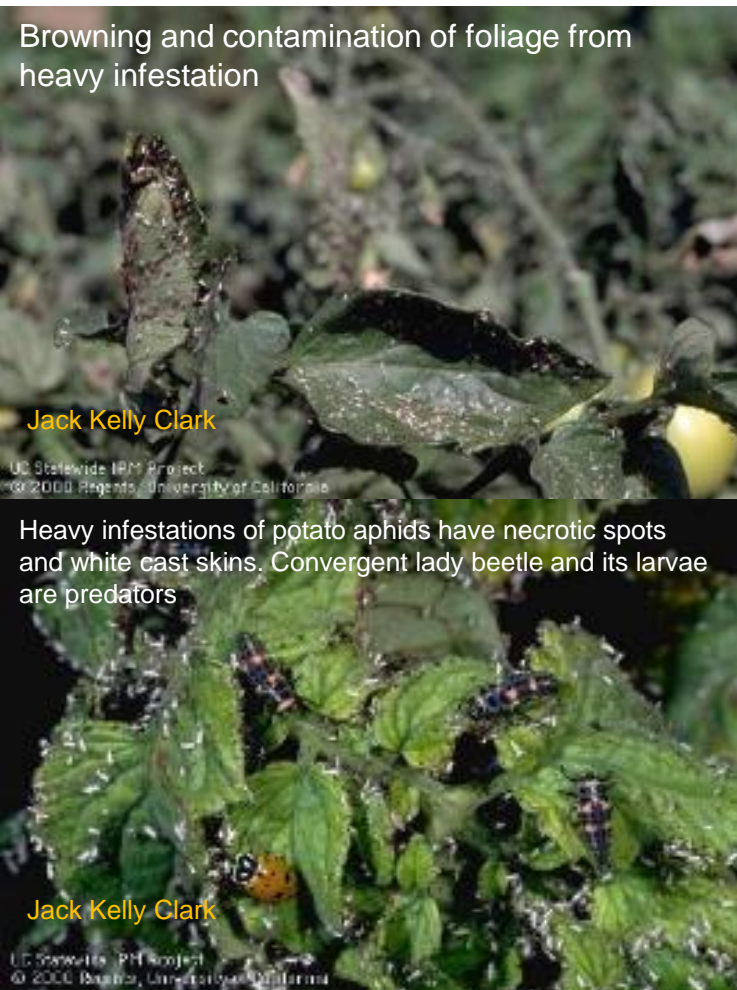
Aphids

(Hemiptera: Aphididae)

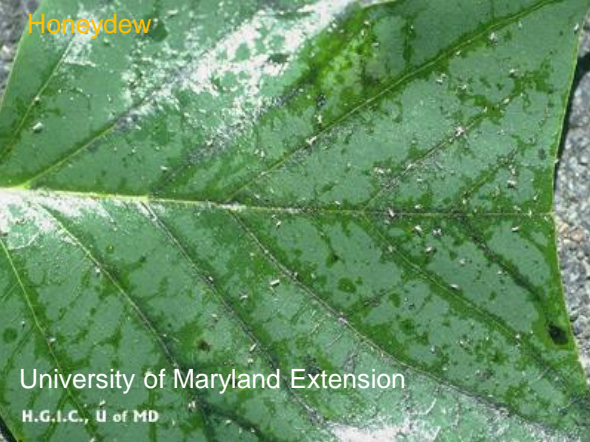
- Most common pest insect
- Green peach aphid (*Myzus persicae*)
- Early spring: winged aphids migrate into tomato fields
- Feed on plants from time of planting until last harvest
- Reduce the vigor of blossom clusters so that blossoms fall and no peppers set



Aphid damage



- Suck plant sap from leaves and stems
- Feeding causes the leaves to be crinkled and malformed.
- Twisted and curled leaves, stunted new growth, gall formation, poor plant growth and plant dieback
- Feeding increases plant susceptibility to early blight
- Winged migrants move from field to field spreading virus diseases



Honeydew

University of Maryland Extension
H.G.I.C., U of MD

Aphid damage

Secrete excess sugars in the form of sticky “honeydew.”

- Ants feed on honeydew: mutualistic relationship, protect aphids from natural enemies
- Honeydew supports the growth of black sooty mold
- Sooty mold reduces the photosynthetic area of the leaf, which can ultimately result in smaller fruits



Black Sooty mold on tomato

University of Hawaii at Manoa



David Cappaert,
Bugwood.org

UGA2107019

Aphid management



- Cluster in shaded places on the leaves, stems and blossoms.
- Plants should be inspected for aphids regularly throughout the growing season.
 - Because aphid populations can “explode” it is important to monitor plants as often as possible.
- Carefully check terminals, stems and underside of leaves for the presence of aphids



Aphid management

Cultural:

- Weed management
 - Weeds can support large colonies of aphids.
- Excessive nitrogen can favor aphid reproduction:
 - Application of less soluble forms of nitrogen in small portions throughout the season is less likely to promote infestations.
- Infestation is reduced when grown on black plastic

Aphid management

Physical:

- Establishment is often reduced by wet weather
- During cool, dry weather in the early spring, large numbers develop quickly.
- A strong spray of water
 - Help to wash off aphids and any honeydew or sooty mold that may be present



Lady beetle- adult

Kansas Department of Agriculture,
Bugwood.org

5512202



Lady beetle- larva

Frank Peairs, Colorado State
University, Bugwood.org

5361227



Green lacewing - adult

Whitney Cranshaw, Colorado State
University, Bugwood.org

5490408



Green lacewing
- larva

Bradley Higbee, Paramount
Farming, Bugwood.org

UGA9005036



Syrphid fly-
(flower fly/hover
fly) adult

Steven Katovich, Bugwood.org

UGA1388017



Syrphid fly- (flower fly/hover fly)
larva

Steven Katovich, Bugwood.org

5490093



Aphid midge adult

Jack Kelly Clark
Univ. of California Statewide
IPM Project

UC Statewide IPM Project
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Aphid midge larva

Whitney Cranshaw, Colorado State
University, Bugwood.org

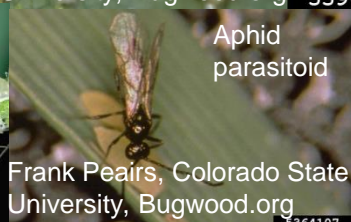
5596695



Aphid parasitoid

Jack Kelly Clark
Univ. of California Statewide
IPM Project

UC Statewide IPM Project
© 2001 Regents, University of California



Aphid
parasitoid

Frank Peairs, Colorado State
University, Bugwood.org

5361227

Aphid management

Natural/biological control

Many natural enemies:

1. Lady beetles: both adults and larvae are voracious predators of aphids
2. Lacewing larvae
3. Syrphid fly (flower fly/hover fly) larvae
4. Aphid midge larvae
5. Aphid parasitoids



Green peach aphids
John L. Capinera, Entomology and Nematology Department, Univ. of Florida



Parasitoid laying her egg in an aphid
Jack Kelly Clark Univ. of California
UC Statewide IPM Project
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Mummified aphids
UT Crops - Univ. of Tennessee



Aphid mummies and emerged parasitoid
Univ. of California Statewide IPM Project
© 2001 Regents, University of California

Aphid management

Natural/biological control

Parasitoids:

- Several species of tiny stingless wasps parasitize aphids.
- The wasp larva develops inside the aphid slowly killing it.
- The aphid eventually turns into an aphid mummy (light brown hardened shell of the host aphid) from which the wasp escapes by cutting an exit hole in the mummy.
- The wasp overwinters as a fully grown larva in the mummy.

Aphid management- Insecticides

- Treatments for aphids:
 - In early spring plantings may be postponed until distinct colonies of immature aphids are found
 - Initiate treatments for aphids in late summer plantings when winged adults are found on young plants
 - If it is absolutely necessary to use an insecticide, choose a low impact insecticide that is less toxic, and “easy” on natural enemies and pollinators

Aphid management- Insecticides

- Insecticides:
 - **Neem (azadirachtin):** plant based insecticide, an anti-feedant
 - **Insecticidal soap and horticultural oil:** "knock down" options. It is important to get thorough coverage with these materials and target the underside of leaves as well as the top
 - **Conventional/broad-spectrum insecticides:** long-lasting but kill a variety of arthropods including natural enemies (beneficial insects and mites, and spiders)

Foliage Feeders

Flea beetles

Flea beetles



- Common pest
- Small insects: 1/10th – 1/16th inch
- Overwinters as adults, active in early spring
- Infest solanaceous crops
- Attack foliage leaving small round holes (“shot-gun appearance”)
- Enlarged hind legs, jump vigorously when disturbed

Flea beetles

Flea Beetle



David Cappaert, Michigan State University, www.insectimages.org

- Large numbers: may destroy entire leaf
- Can be a serious pest early in the season when plants are 4-6 inches tall
- Larger plants can withstand the damage without a yield loss
- Larvae feed on roots, but cause no losses

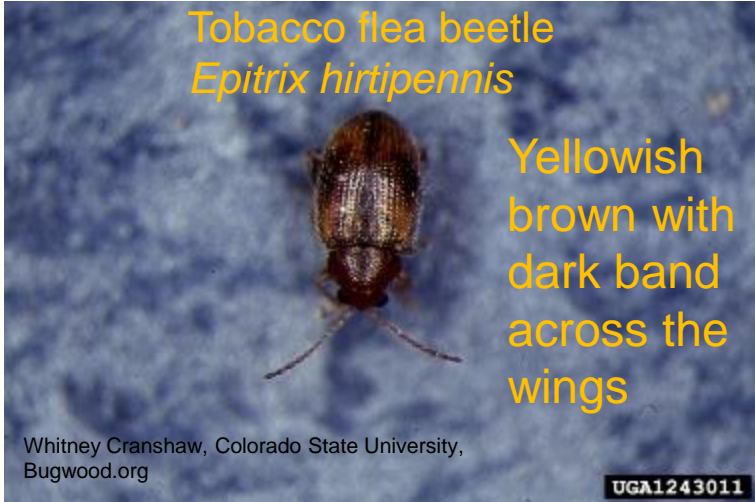
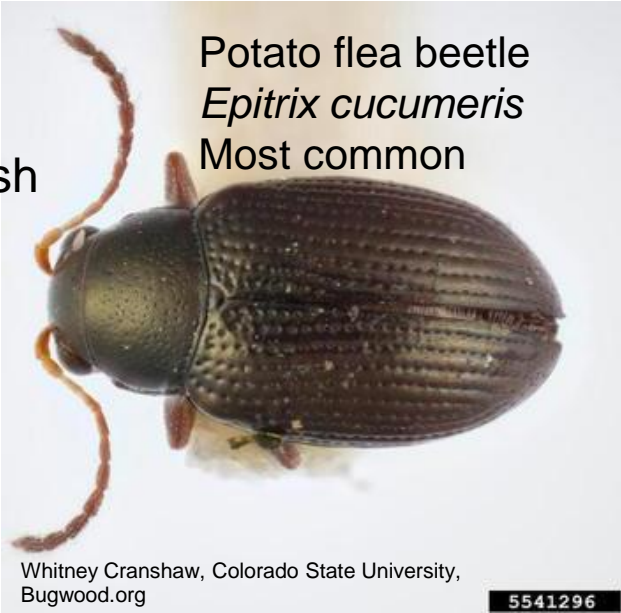
Flea beetle damage



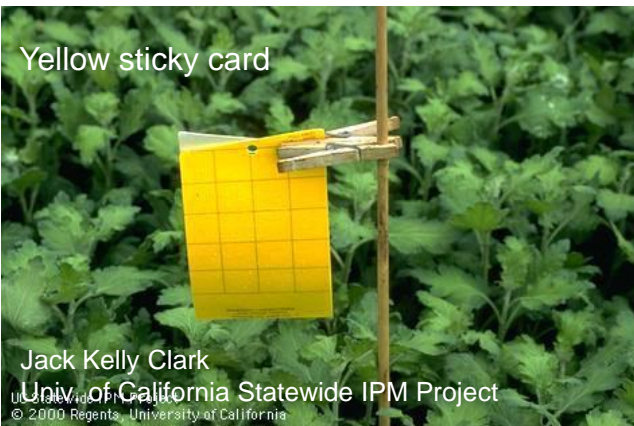
- Their injury consists of small, rounded or irregular holes eaten through or into the leaf
- May attack peppers at any time during the growing season but are often most numerous early in the season.

Flea beetles

Brownish
black



Flea beetle management



- Scouting: yellow/white sticky traps
- Cultural control
 - Floating row covers
 - Water deters adults: watering: mid-day
 - Crop rotation
 - Trap crops (mustard, radish)
 - Companion plants (onions, dill, marigold)
 - Keeping fields free of weeds
 - Adjusting planting dates, late planting also favors growth of host plants over establishment of flea beetles.
 - Destroy plant residues and piles of culled potatoes to prevent beetle buildup
 - Trash around plant beds where beetles hibernate should be destroyed

Flea beetle management

Biological control

- Generalist predators
 - Green lacewing larvae (*Chrysoperla* spp. & *Chrysopa* spp.)
 - Big-eyed bugs (*Geocoris* spp.)
 - Damsel bugs (*Nabis* spp.)
- Entomopathogenic nematodes (*Steinernema* spp. and *Heterorhabditis* spp.)
- Fungal pathogens: *Beauveria bassiana* products



Flea beetle management

Chemical control

- Use only if necessary
- Foliar applications are commonly used
- Once plants have more than 4 true leaves, treatment is not usually necessary.

Foliage Feeders



J. Castner, University of Florida.

Leaf miners

Diptera: Agromyzidae

- Infestations: first detected as the slender, white, winding trails
- Caused by larvae feeding through the interior of leaves.
- Leaves:
 - Weaken
 - Reduce photosynthetic area
- Mines serve as points where decay and disease may begin.
- With severe infestations, heavy leaf loss may lead to sun scald of fruits.

Leaf miners

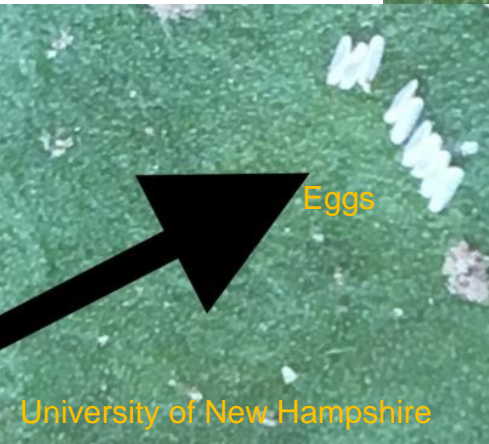


J. Castner, University of Florida



Leaf miners

- *Liriomyza* spp.
- Polyphagous: Solanaceae crops, cucurbits etc.
- Adults: tiny, shiny, black flies with yellow markings.
- Adult females: lay eggs within the leaves. They are inserted just below the epidermis
- Eggs hatch and white to pale yellow, legless larvae with black mouthparts mine the leaves for about 5-7 days.





Puparium

Lyle J. Buss, University of Florida

Leaf miners

- The larva leaves the leaf mine and drops to the soil to pupate
- The puparium is initially yellowish, then golden brown, but turns darker brown with time



Adult leaf miner

Lyle J. Buss, University of Florida

Management of leaf miners

Cultural practices

- Destruction of weeds and deep plowing of crop residues are recommended
- Adults experience difficulty in emerging if they are buried deeply in soil
- Scout field for natural enemies
- Parasitoids of the families Braconidae, Eulophidae, and Pteromalidae are important in natural control, and in the absence of insecticides usually keep this insect at low levels of abundance

Leaf miners

Chemical control

- Leaf miners: can develop resistance to insecticides
- Use of more selective pest control materials such as *Bacillus thuringiensis* is recommended as it allows survival of the leaf miner parasitoids.

Leaf miners

- Sampling: Counting mines in leaves is a good index of past activity, but many mines may be vacant
- Counting live larvae in mines is time consuming, but more indicative of future damage

Foliage Feeders



David Cappaert, Michigan State University, www.insectimages.org

UGA5178045

Colorado potato beetle

Leptinotarsa decemlineata

Coleoptera: Chrysomelidae



- May occur in damaging numbers in pepper fields.
- Commonly encountered in commercial fields
- 0.5” in size
- Convex beetle with yellowish black with 10 black stripes on wings

Colorado potato beetle



- Adults: overwinter in soil
- Eggs are similar to lady beetle eggs
- Migrate into fields in spring
- Both adult and larvae feed on leaves and terminal growth
- Larvae can rapidly defoliate small plants
- When plants are ~ 8": feeding doesn't affect the yield

Colorado potato beetle

Adult

Dept. of Entomology, University of Minnesota

Eggs

Dept. of Entomology, University of Minnesota

Larvae

Dept. of Entomology, University of Minnesota

- Has developed resistance to commonly used insecticides: e.g. carbaryl and endosulfan
- Biological control: common predators attack eggs and larvae,
 - But the level of control achieved is not adequate for commercial production
- *Bacillus thuringiensis*:
 - Var. san diego (M-Trak @ 2 qt/acre) and var. tenebrionus (Trident II @ 4 qt/acre) are effective against larvae.

Pests of sweet pepper

1. Seedling Pests
2. Foliage Feeders
- 3. Pod Feeders**

Pod feeders

1. European corn borer
2. Pepper maggot
3. Pepper weevil
4. Stinkbugs
5. Beet armyworm
6. Tarnished plant bug
7. Thrips
8. Tomato fruitworm

Pod Feeders



European Corn Borer (ECB)

Ostrinia nubilalis (Lepidoptera: Crambidae)



- One of the most serious and difficult to control pest
- Polyphagous, >200 host plants
- Eggs are laid underside of the leaves
- Newly emerged larvae feed on leaf tissue for a short period and then tunnel into stems or fruit.
- Larvae often burrow into the fruit beneath the calyx

European Corn Borer



ECB: season-long pest

- Direct injury to the fruit
 - Damage and entry holes near the calyx
- Fruits: no longer acceptable for market
- Premature fruit dropping
- Premature fruit ripening
- Fruit rotting as a result of pathogens entering the feeding wound
- When rotting begins, larvae usually leave the fruits to infest others



ECB

Identification



- **Larvae:**
 - Light brown or pinkish gray in color dorsally
 - Brown to black head capsule
 - Yellowish brown thoracic plate
 - Round dark spots on each body segment
- **Adult:**
 - Small moth
 - Female: pale yellow to light brown in color, with both the forewing and hindwing crossed by dark zigzag lines and bearing pale, often yellowish, patches
 - Male: darker in color, usually pale brown or grayish brown, but also with dark zigzag lines and yellowish patches

ECB Management

- Spring plantings are less subject to infestations than late plantings
- Controlling larvae before they reach the pepper fruit is essential
- Within two to 12 hours after hatching, the young larvae crawl to the calyx of pepper pods
- Once under the calyx, they are protected from insecticides and natural enemies

ECB Management



- Infested fruits are easily overlooked
 - Close examination of the calyx for signs of feeding, entry holes and frass (fecal debris)



ECB Management

Chemical control

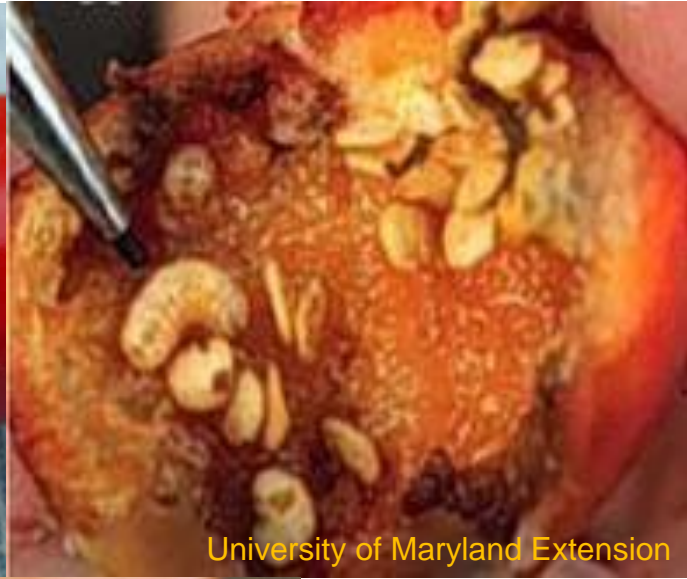
- Timing is the key to successful control
 - Should be timed such that larvae are controlled before entering the fruits and stems
 - Initiate sprays at the first sign of egg masses to target larvae
- Not effective against eggs
- Insecticides: Spinosad, Methoxyfenozide

ECB Management



- Biological control: predators and parasitoids
- Native predators: insidious flower bug, green lacewings and ladybird beetles
- Parasitoids: *Trichogramma* spp. (*Trichogramma ostriniae*)-commercially available

Pod Feeders





Pepper
Maggots

Jude Boucher, University of Connecticut
Cooperative Extension



Pepper Maggot

omafra.gov.on.ca



Pepper Maggots Adult

University of Connecticut
CT IPM

Pepper Maggots

Zonosemata electa

Diptera: Tephritidae

- Adults: size of a house fly
- Maggots:
 - Feed on the developing seeds and soft tissue of the pepper core for 15-20 days
 - After which they tunnel out of the fruit leaving a large exit hole.
 - Maggots drop to the soil where they burrow into the soil to pupate.

Management

Cultural practices

- Field sanitation:
 - Adult flies: attracted to rotting fruits
 - Remove and destroy rotting fruits
 - Alternate hosts such as horse nettle should be eradicated from the field and field margins
- Crop rotation
 - Should not be planted in or near fields with a history of infestations
- Monitoring: trap/bait combination - rectangular, yellow, sticky-trap baited with a vial of 30% liquid ammonia

Management

Cultural practices

- Fly monitoring: using hot-cherry pepper as indicator plants spaced 25-100 meters apart around the perimeter (within the outer rows) of the field
 - Cherry-peppers: preferred host to bell peppers and should be checked every 3-4 days for egg laying stings or scars
 - Stings are easy to recognize on the smooth surface of the cherry pepper and appear as shallow indentations of the fruit surface with tiny scars

Management

Chemical control

- By timing insecticide applications with the first observation of stings on the indicator fruit, damage to the main crop can be avoided with a minimum of spraying
- Sprays, therefore, should be targeted at the adult fly as soon as it is detected in traps or by indicator plants
- Insecticides: Mustang (pyrethroid), Carbaryl

Pod Feeders



Adult



Pepper Weevil

Anthonomus eugenii

Coleoptera: Curculionidae

- Most important damage: destruction of blossom buds and immature pods
 - Crop may be entirely lost if the infestation is severe and early.
- Infested pods turn yellow and fall from the plant
 - Often they are malformed.
- First sign of infestation: few fallen pods
 - But by this time serious damage may be already done and within the next 10 days a large part of the crop may fall.



Pepper Weevil Damage

- Feeding within the pods:
 - Causes the seeds and cores to turn black
 - Often an entire core becomes a mass of decayed tissue and frass
 - Pods that appear to be sound may show this condition when opened
- Feeding punctures in the pods do not damage peppers intended for drying
 - But they appear as dark specks at the bottom of depressed areas and lower the quality of fruit used green or for canning.
 - Canned peppers: punctures appear as black spots when cooked.
- Damage to blossom buds is similar to that done to pods, the larvae feed in the bud and cause it to fall
 - Feeding punctures in the buds cause them to drop.

Pepper Weevil

- Eggs are deposited singly beneath the surface of the bud or pod
- The female creates an egg cavity with her mouthparts before depositing the egg, and seals the puncture containing the egg with a light brown fluid that hardens and darkens

Management

- Purchase transplants certified to be weevil free
- Plants purchased from southern states should be inspected closely
- Growers should not accept any plants with fruiting structures
- During the growing season, cut open and examine fallen blossom buds and small fruits for evidence of infestation
- Begin treatments for pepper weevils when any fruits are found infested with adult or immature weevils

Pod Feeders



Frank Pears, Colorado State University,
Bugwood.org

UGA1481076



Susan Ellis, Bugwood.org



Russ Ottens, University of
Georgia, Bugwood.org

UGA1242026

Southern Green Stink Bug (*Nezara viridula*)



Frank Peairs, Colorado State University; Bugwood.org
UGA1481076

Stink bugs

(Hemiptera: Pentatomidae)

- Stink bugs: southern green stink bug, brown stink bug and green stink bug
- Green stink bugs: predominant spp.
- Stink bugs are polyphagous:
 - Hosts: native and ornamental trees, shrubs, vines, weeds, and crops
 - Build up on these host plants and move to other crops late in the season

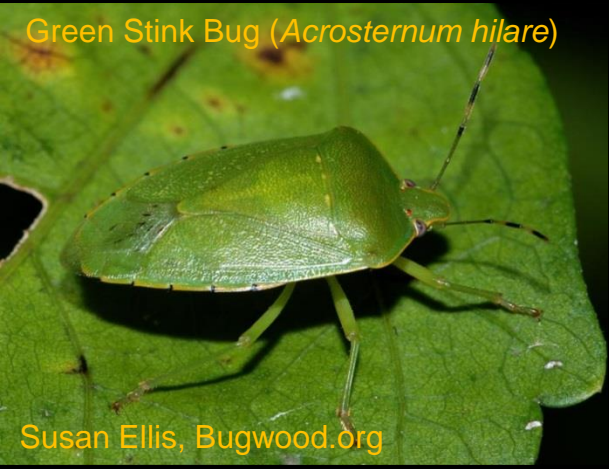
Brown Stink Bug (*Euschistus servus*)



Russ Ottens, University of Georgia; Bugwood.org

UGA1242026

Green Stink Bug (*Acrosternum hilare*)



Susan Ellis, Bugwood.org

Stink bug damage on pepper



Celeste Welty, Ohio State University

C. Welty

Damage

- Direct pests that attack and damage the parts of the plants we use or sell
- Stink bugs inflict a mechanical injury to the pod
 - Feed with piercing-sucking mouthparts
- Degree of damage:
 - Depends on the developmental stage of the pod when it is pierced by the stink bug's needlelike mouthparts
 - Areas around the feeding sites fail to color properly, resulting in discolored hard areas underneath the fruit skin

Stink bug damage to pepper is visible underneath the skin



: Ric Bessin, University of Kentucky

Stink bugs

- Overwinter as adults and become active in spring when temperatures rise above 70 F degrees
- Reach high population levels in late September or early October
- Cultural control: difficult to scout
- Biological Control: natural enemies (insect predators and parasitoids)
- Chemical control: Carbaryl, pyrethroids

Pod Feeders



John Capinera, University of Florida, Bugwood.org



Beet Armyworms

Lepidoptera: Noctuidae
(*Spodoptera exigua*)

- Polyphagous species:
 - Asparagus, bean, beet, broccoli, cabbage, cauliflower, celery, chickpea, corn, cowpea, eggplant, lettuce, onion, pea, pepper, potato, radish, spinach, sweet potato, tomato, and turnip
- Significant pest of vegetables:
 - Because of wide host range and resistance to insecticides
- Eggs: laid in clusters of 50-150 eggs on the underside of leaves
- Weed hosts:
 - Lambsquarters, *Chenopodium album*; mullein, *Verbascum* sp.; pigweed, *Amaranthus* spp.; purslane, *Portulaca* spp.; Russian thistle, *Salsola kali*; *Parthenium* sp.; and *Tidestromia* sp.



Damage



- Larvae feed on both foliage and fruit
- Young larvae:
 - Feed gregariously and skeletonize foliage
- Mature larvae:
 - Become solitary and eat large irregular holes in foliage
- Pods/fruits are susceptible to larval damage
 - Bores into the calyx end/pod wall

Identification

Larva

- Light-green to black larva with four pairs of abdominal prolegs and a dark head
- Many fine, white wavy lines along the back and a broader stripe along each side
- Distinctive dark spot on each side just above the second pair of true legs



Adult

- Forewings: mottled gray and brown, and with an irregular banding pattern and a light colored bean-shaped spot
- Hind wings: more uniform gray or white color, and trimmed with a dark line at the margin



Management

- Regular monitoring of the leaves and fruits
 - Pheromone traps are useful for determining when major flights occur
 - Treatments may be necessary if fruit damage is occurring
- Many natural enemies:
 - wasps *Hyposoter exiguae* and *Chelonus insularis*, and the tachinid fly *Lespesia archippivora*
- Viral diseases may also be important
 - however, none of these organisms provide reliable control of armyworms when they feed on the fruit
- Biological control and sprays of *Bacillus thuringiensis* or the Entrust (formulation of spinosad)

Pod Feeders



Russ Ottens, University of Georgia, Bugwood.org

5367988

Tarnished Plant Bug

Hemiptera: Miridae (*Lygus lineolaris*)



- It has piercing-sucking mouthparts
- Polyphagous: a serious pest on small fruits and vegetables
- Adult:
 - Small 5-6mm long
 - Head: yellowish-brown, with the frons smooth with black submedian lines.
- Summer adults:
 - Pale yellow with few black markings to reddish brown, or almost completely black with few pale yellow markings
- Nymphs:
 - Newly hatched nymphs are yellowish green and about 1 mm long
 - Older nymphs are yellow green to green and wingless.

Tarnished Plant Bug



- Primarily attack the young flower buds causing them to abort
 - Young flower buds turn yellow to black after feeding
- Infestations may be heavy in spring plantings
 - Fruit set can be very poor if the bugs are not controlled
- Both nymphs and adults feed on pepper
 - Nymphs are difficult to find unless high numbers are present

Management

- Cultural control:
 - Scouting
 - Control weed species that are attractive to tarnished plant bugs (butterweed, fleabane, goldenrod, vetch, dock, and dog fennel)
 - The removal of preferred host plants from edges of nurseries and destruction of favorable overwintering sites
- Biological control:
 - Parasitoids: egg parasitoid *Anaphis iole* and the nymphal parasitoid *Leiophron uniformis*, *Peristenus pallipes* and *Peristenus pseudopallipes* (Hymenoptera)
- Chemical control:
 - Treat if one adult per six plants is found
 - Insecticides: pyrethroid (bell pepper only)

Course Outline

1. Introduction: background information on bell and chili pepper
2. Pests of pepper
 - a) Seedling Pests
 - b) Foliage Feeders
 - c) Pod Feeders
3. Summary
4. References

Summary

- Pepper pest Insect and mite populations fluctuate from field to field and from year to year
- These pests are grouped into three categories
 1. Seedling pests (cutworms, tomato fruitworm, thrips)
 2. Foliage feeders (hornworms, spidermites, thrips, flea beetles, Colorado potato beetle, leaf miners)
 3. Pod feeders (stink bugs, tomato fruitworm, pepper weevil, pepper maggots, tarnished pant bug, beet armyworm, thrips, European corn borer)

Pepper pest management

Integrated approach is important for managing pest insects in pepper

- Eliminate competition from weeds
- Keep the plant growing vigorously with proper water and nutrients
- Keep the garden clean of plant debris
- Rotate crops
- Space plants for maximum air circulation
- Monitor for pests and natural enemies
- Use resistant varieties
- Keep insecticides as a last resort

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TENNESSEE STATE UNIVERSITY

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Contact information:

Kaushalya Amarasekare, Ph.D.

Assistant Professor (Entomology) and IPM Coordinator,
Extension Specialist TSU Cooperative Extension Program

Tennessee State University,

Dept. of Agricultural and Environmental Sciences,

Room 202 P, Farrell Westbrook Hall,

3500 John A Merritt Blvd,

Nashville, TN 37209

email: kamarase@tnstate.edu

Phone: 615 963 5001