

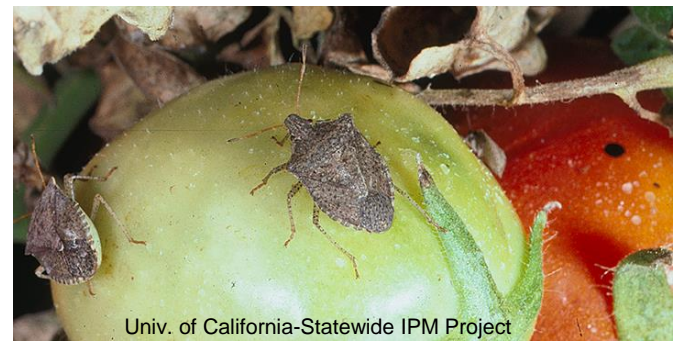


Curriculum

Tomato pest management

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College of Agriculture
Tennessee State University
Nashville, TN



Goal

The goal of this training is to educate stakeholders on arthropods (pest insects and mites) that damage tomatoes 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 tomatoes

Course Outline

1. Introduction: background information on tomatoes
2. Arthropod pests (insects and mites) of tomatoes
 - a) Early season pests
 - b) Pests during fruit set to harvest
3. Summary
4. References

1. Introduction

Tomatoes



- An easy and popular vegetable to grow
- Problems/issues: caused by nutrient deficiencies, diseases, and / or arthropod (insect and mite) pests
- Need to assess the symptoms and use appropriate control measures
- Good cultural practices: reduce or eliminate many problems

Tomatoes in Tennessee

- 2012: TN ranked 6th in the nation for production of fresh-market tomatoes (tied with GA & VA)
- TN produces ~ 3% U.S. fresh market
- Acres planted: 2013: ~3800, 2018: 4200
- TN: ~550 tomato greenhouses/2.2 million sq. ft.
- Value of production: 2018: ~\$ 5.4 million, 2013: ~\$ 2.3 million, 2001: ~\$ 10 million,

<https://ipmdata.ipmcenters.org/documents/cropprofiles/TNtomato2014.pdf>

https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=TENNESSEE

TN Production regions/areas for fresh-market tomatoes

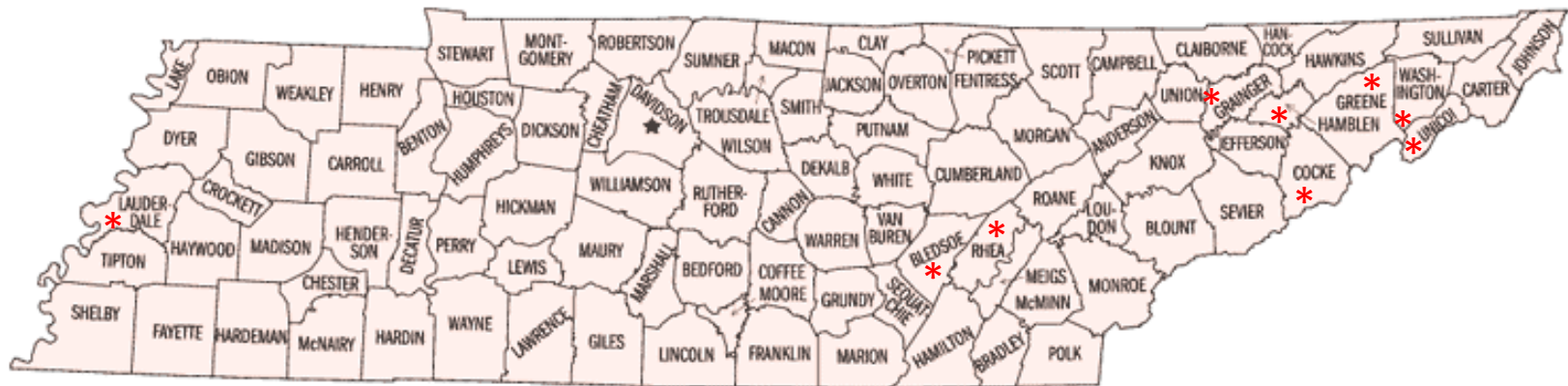


Photo: <https://tennessee.hometownlocator.com/maps/statecountymap.cfm>

- Three major production areas for fresh-market tomatoes:
 - Western Tennessee (Lauderdale County),
 - Eastern Tennessee (Cocke, Grainger, Washington, Unicoi, Greene and Hamblen Counties)
 - East-central Tennessee (an area known as Walden's Ridge which includes Bledsoe and Rhea Counties).
- Other production is scattered across the state.

Course Outline

1. Introduction: background information on tomatoes
2. Pest arthropods (insects and mites) of tomatoes
 - a) Early season pests
 - b) Pests during fruit set to harvest
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4. References

Pest arthropods of tomatoes in TN



- Common pests: ~ 14 species of insects and mites
- 6 species are most often observed in the majority of fields throughout the state.
 - tomato fruitworm, stink bugs, thrips, aphids, Colorado potato beetle and flea beetles
- Other arthropod pests occur more sporadically from field to field and from year to year.

Pest arthropods of tomatoes

Broadly categorized as,

1. Early season pests
2. Pests during fruit set to harvest

Early season pests

1. Flea beetles
2. Aphids
3. Colorado potato beetle
4. Cutworms

Flea beetles

Flea beetles



- Common pest but rarely injurious
- 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”)

Flea beetles



- 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 beetles

Potato flea beetle
Epitrix cucumeris

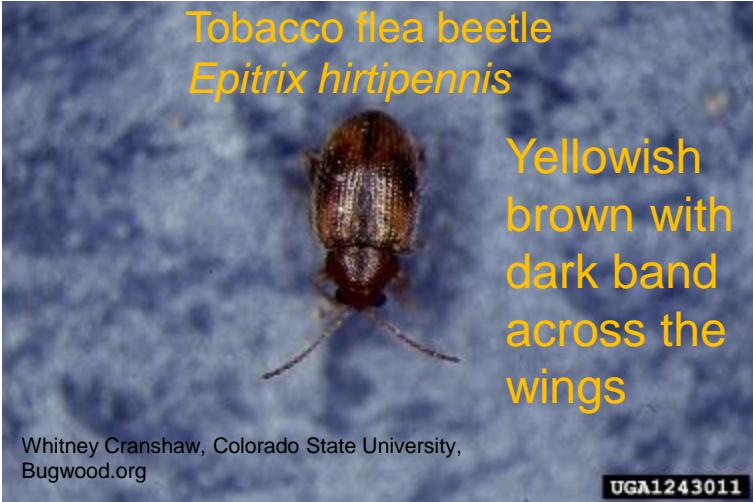


Brownish
black

Whitney Cranshaw, Colorado State University,
Bugwood.org

5541296

Tobacco flea beetle
Epitrix hirtipennis



Yellowish
brown with
dark band
across the
wings

Whitney Cranshaw, Colorado State University,
Bugwood.org

UGA1243011

Potato flea beetle



Kansas Department of Agriculture,
Bugwood.org

5512271

Tobacco flea beetle



Russ Ottens, University of Georgia, Bugwood.org

UGA5203029

Flea beetle damage



Flea beetle management



- Scouting: yellow/white sticky traps
- Cultural control
 - Floating row covers
 - Water deters adults: watering: mid-day
 - Adjusting planting dates
 - Crop rotation
 - Trap crops (mustard, radish)
 - Companion plants (onions, dill, marigold)



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

e.g. Thiamethoxam, Carbaryl

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

Early season pests

1. Flea beetles ✓
2. Aphids
3. Colorado potato beetle
4. Cutworms

Aphids

Aphids

Potato aphid
Macrosiphum euphorbiae



Green peach aphid
Myzuz persicae



- The most common pest insect
- Two species: potato aphid *Macrosiphum euphoribae*, green peach aphid (*Myzus persicae*)
 - Potato aphid: most common aphid
- Early spring: winged aphids migrate into tomato fields

Aphid damage



- Aphids suck plant sap from leaves and stems
- Damage causes twisted and curled leaves, stunted new growth, gall formation, poor plant growth and plant dieback
- Feeding increases plant susceptibility to early blight



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

Aphid damage



- Vectors of viruses
- Transmit cucumber mosaic virus (CMV).
- CMV: wide host range:
 - Vegetables: cucurbits (squash, cucumber, pumpkin, and melon), beans, spinach, tomato, lettuce, and beets
 - Annuals and perennials: impatiens, gladiolus, petunia, and *Rudbeckia*.
- Viruses cause: mottling, yellowing, or curling of leaves, stunting of plant growth and misshapen fruits

Aphid management

Potato aphids

J. Obermeyer, Purdue Extension Entomology



Ants feeding on honeydew

plantinfo.co.za/aphids



- 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 leaves and stems for the presence of aphids
- Presence of ants can indicate aphid infestations

Aphid management



Weeds in tomatoes

Mark Schonbeck, Virginia Association for Biological Farming, vegetables.ces.ncsu.edu/tomatoes-weeds/



STEPHEN AUSMUS (K10498-2)
USDA ARS Online Magazine Vol. 51, No. 7

Tomatoes grown on black plastic

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:

A strong spray of water

- Help to wash off aphids and any honeydew or sooty mold that may be present
- Aphids can get washed off after a heavy rain

Aphid management

Biological control

Many natural enemies:

1. Lady beetles: both adults and larvae are voracious predators of aphids
2. Lacewing larvae (aphid lions) and adults of *Chrysopa* spp.
3. Syrphid fly larvae
4. Aphid midge larvae
5. Parasitoids



Aphid management

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

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

1. **Neem (azadirachtin):** plant based insecticide, an anti-feedant.
2. **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.
3. **Conventional/broad-spectrum insecticides:** longer lasting but kill a variety of insects, including natural enemies.

Early season pest insects

1. Flea beetles ✓
2. Aphids ✓
3. Colorado potato beetle
4. Cutworms

Colorado potato beetles

Colorado potato beetle

Leptinotarsa decemlineata

Coleoptera: Chrysomelidae



- Infrequent /minor pest of tomatoes
- 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
- 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" tall: 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.

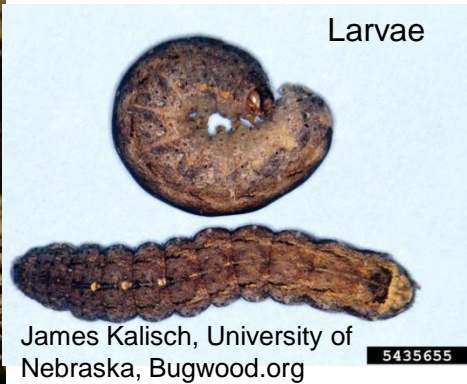
Early season pests

1. Flea beetles
2. Aphids
3. Colorado potato beetle
4. **Cutworms**

Cutworms

Cutworms

Lepidoptera: Noctuidae



- Larvae: several species of night-flying moths
 - Cut down young plants as they feed on stems at or below the soil surface
 - Curl up into a tight "C" when disturbed.
- Climbing cutworms:
 - move up on plants and feed upon foliage, buds and shoots.
- No damage from adults
- Common hosts:
 - asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato, tomato and turfgrass

Cutworms

The black cutworm (*Agrotis ipsilon*) and variegated cutworm (*Peridroma saucia*)

- Both cause damage in the larval stage when they sever newly set transplants
- Chew on stems of young plants
- On mature plants, they can also feed on fruits touching the ground
- Often a problem where:
 - Grass has previously been grown
 - Conservation-tillage systems are used

Black cutworm larva



Black cutworm adult



Variegated cutworm larva



Variegated cutworm adult



Cutworm management

- Control: easier when larvae are young
- Regular check for larvae: late afternoon and evening when active
- Damage: inspect in the morning when damage is fresh
 - Plants cutoff near the ground
 - Wilting
 - Droppings on the ground
- 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



Clemson University - USDA
Cooperative Extension Slide
Series , Bugwood.org

UGA1233216



Bruce Potter
University of Minnesota
Extension



University of Minnesota
Extension



Bruce Potter
University of Minnesota
Extension

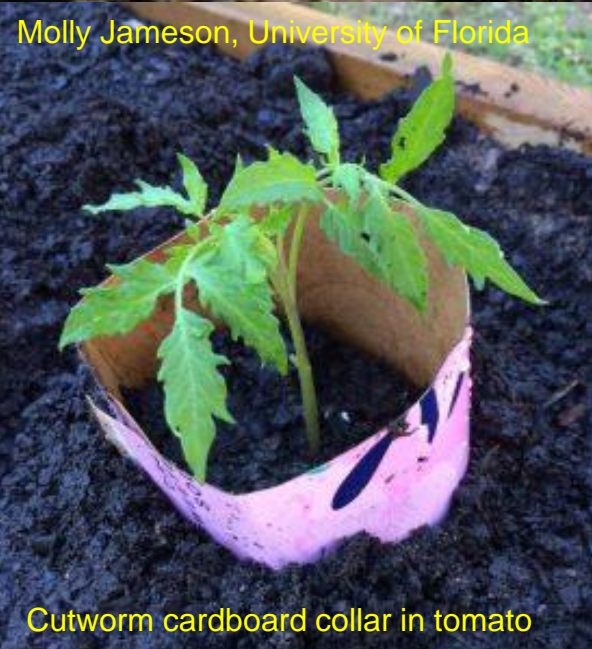
Cutworm management

Cultural control:

- Avoid fields where grass has previously been grown
- Remove weeds and plant residue to reduce egg-laying sites and seedling weeds that nourish small cutworms
- Tilling the field
 - Tilling in the fall to destroy or expose overwintering larvae or pupae
 - Conventional-tillage systems
- Avoid green manure (use compost)



Aluminum foil barrier
University of Minnesota
Extension



Molly Jameson, University of Florida
Cutworm cardboard collar in tomato

Cutworm management

- Physical:
 - Placing aluminum foil or cardboard collars around transplants. Creates a barrier that physically prevents cutworm larvae from feeding on plants
- Chemical:
 - Home gardens: not necessary
 - Severe infestation: apply insecticides in the evening (carbaryl, cyfluthrin, permethrin)

Pests of tomatoes

Broadly categorized as,

1. Early season pests ✓
2. Pests during fruit set to harvest

Pests during fruit set to harvest

1. Tomato fruitworm
2. Stink bugs
3. Thrips
4. Hornworms
5. Armyworms
6. Tomato pinworm
7. Cabbage looper
8. Whiteflies
9. Vegetable leafminer
10. Mites

Tomato fruitworm

Tomato Fruitworms

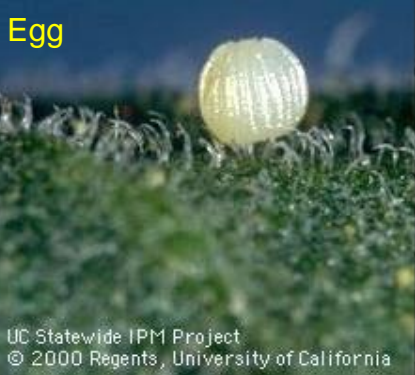
Corn Earworms / Cotton Bollworm

Helicoverpa zea (Lepidoptera: Noctuidae)



- One of the most important pest insects
- Also known as corn earworm and /or cotton bollworm
- Polyphagous: wide host range (e.g. corn, tomato, cotton, eggplant, pepper, soybean)
- Typically feed inside the fruit, creating a water cavity contaminated with feces
- Damaged fruits will ripen prematurely
- Any feeding results unmarketable fruit

Egg



UC Statewide IPM Project
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UC Statewide IPM Project, University of California

Pupa



Adam Sisson, Iowa State
University, Bugwood.org

5465674

Adult



Ronald Smith, Auburn University,
Bugwood.org

Tomato fruit worms

- Adults:
 - Medium- sized moths tan/brown
 - Wingspan 1-1.3"
 - Lays up to 2500 eggs
- Eggs:
 - Individually laid
 - Dome-shaped
- Larvae:
 - Yellowish green to nearly black with black tubercles
 - Feed and develop inside the fruit, creating a water cavity contaminated with feces
 - Cannibalistic
 - Pupate in soil

Tomato fruitworm

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* traps 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
 - Mineral oil

Stink bugs



David Cappaert, bugwood.org

UGA2116061



Frank Peairs, Colorado State University, Bugwood.org

5364094

Stink bugs

Hemiptera: Pentatomidae



- Brown (*Euschistus servus*) and green (*Chinavia hilaris*) stink bugs are common
- Polyphagous
- Adults:
 - Distinctly shield shaped and either brown or green
 - Overwinters as adults on the ground under leaves in protected areas
- Nymphs:
 - Resemble adults but do not have developed wings

Damage on green fruit appears as pinpricks



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Irregular blotches caused by stink bugs



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White spongy tissue from stink bug damage



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Stink bug damage

- Adults and immatures:
 - Feed on developing fruits causing discolored blemishes
- On green fruit:
 - Damage appears as dark pinpricks, surrounded by a light discolored area that turns yellow or remains light green on ripe fruit
- Tissues below the surface turn corky
- Stink bugs may also carry yeast and other pathogens on their mouthparts:
 - That may cause fruit decay when introduced during feeding

Stink bug Management



- Monitoring stink bug populations and their levels of parasitism are important for making treatment decisions
 - Often not observed until damage has begun
- Cultural control
 - Cut grass or weeds in areas surrounding the field in late fall helps reduce overwintering populations

Stink bug Management

Black parasitized eggs in stink bug egg cluster



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Egg of *T. pennipes*,
on left wing pad of a
5th instar nymph of
the green stink bug

- Biological control
 - The various life stages of the green stink bug may be parasitized by species of Hymenoptera and Diptera
 - Numerous natural enemies:
 - *Tricopoda pennipes*, a tachinid parasitic fly
 - Birds, toads, spiders, other insect-eating animals and insects predators
- Chemical control:
 - Effective but destroy IPM programs

Herb Pilcher, USDA-ARS, Bugwood.org

UGA2134081

Brown marmorated stink bug

Brown marmorated stink bug



Kristie Graham, USDA ARS,
Bugwood.org

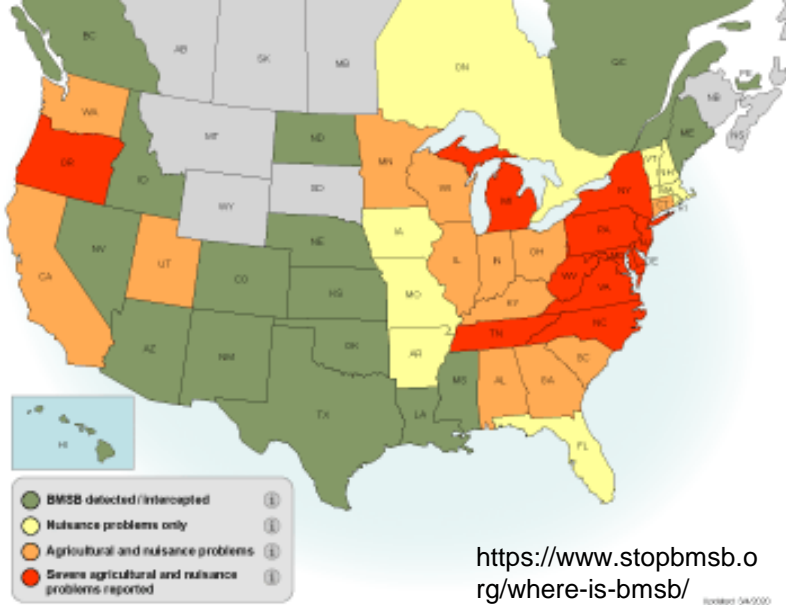
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UM Extension

University of Maryland Extension

Brown marmorated stink bug (BMSB)



- Exotic invasive pest species to the U.S.
- Native to China, Japan, Taiwan and Korea
- First found in 1998 in Pennsylvania
- Polyphagous: wide range of hosts
 - Fruits
 - Vegetables
 - Field crops
- Nuisance pest: overwinter at homes



BMSB damage



Feeding injury on pepper.
By Tom Kuhar



BMSB Damaged Seed. David Owens,
Virginia Tech



BMSB Damaged Seed. David Owens,
Virginia Tech



BMSB damage in blueberry.
By Cesar Rodriguez-Saona and
Doug Pfeiffer.



BMSB-injured snap bean.
By Tom Kuhar



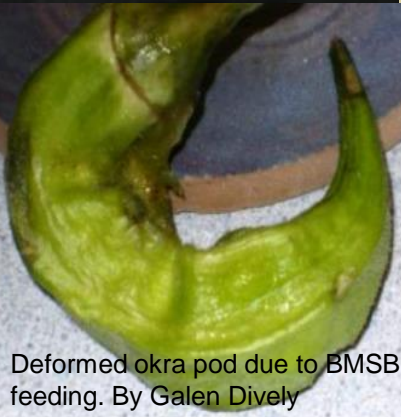
BMSB damage in corn By Tom
Kuhar.



BMSB damage on cherries
By Peter Shearer



Bosc pear damage By Yan Wang



Deformed okra pod due to BMSB
feeding. By Galen Dively



Feeding injury on tomato
By Tom Kuhar



BMSB damage on apples By Tracy
Leskey and Torri Hancock

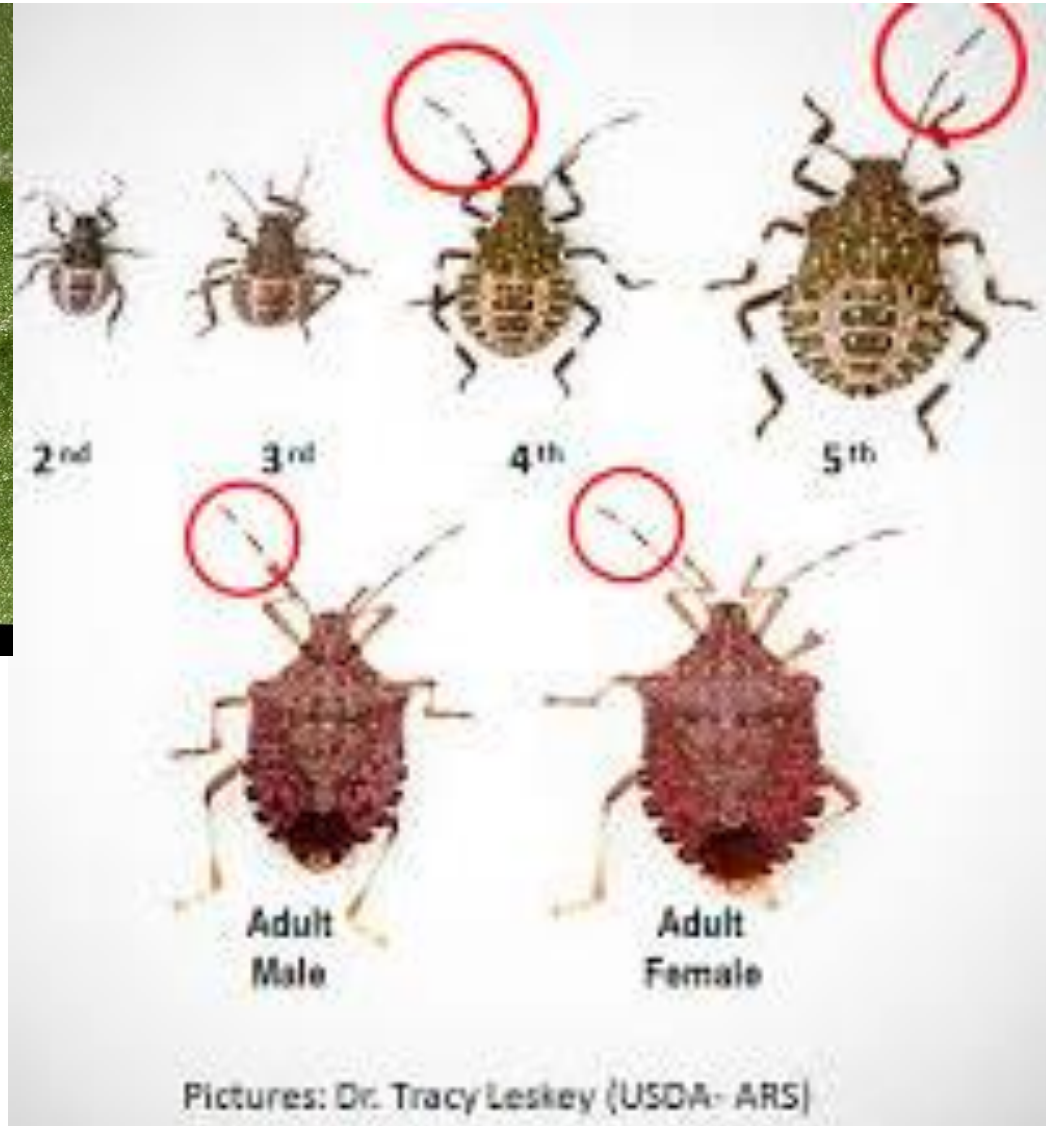


BMSB on grapes. By Cesar
Rodriguez-Saona and Doug
Pfeiffer



BMSB feeding injury in peas

BMSB eggs, nymphs and adults



BMBS management



- Presently, no viable strategies for control
- Field monitoring:
 - Pheromone traps
- Insecticides:
 - Very short-lived effect
 - Insecticide resistance development.
- Even where insecticide is effective,
 - Repopulation occurs through migration from non-treated areas.
- On-farm insecticide use is not ideal
 - Disruption of IPM programs

Classical Biological Control

Natural enemies:

- Identified from the country of origin of the pest insect
- After quarantine suitable candidates are released to the affected areas
- *Trissolcus japonicus* (Hymenoptera: Scelionidae), one of the exotic parasitoids collected in foreign explorations is promising and currently under quarantine evaluation.



Adult *Trissolcus japonicus* emerging from a BMSB egg. Elijah J. Talamas, ARS USDA



Female *Trissolcus japonicus*. Elijah J. Talamas, ARS USDA

Classical Biological Control



Female *Trissolcus japonicus*. Elijah J. Talamas, ARS USDA

T. japonicus :

- Recently, *T. japonicus* was inadvertently found in Maryland. Although we are not aware of how *T. japonicus* came to the U.S., this will be the breakthrough that we were expecting to happen in the BMSB management

Thrips

Thrips

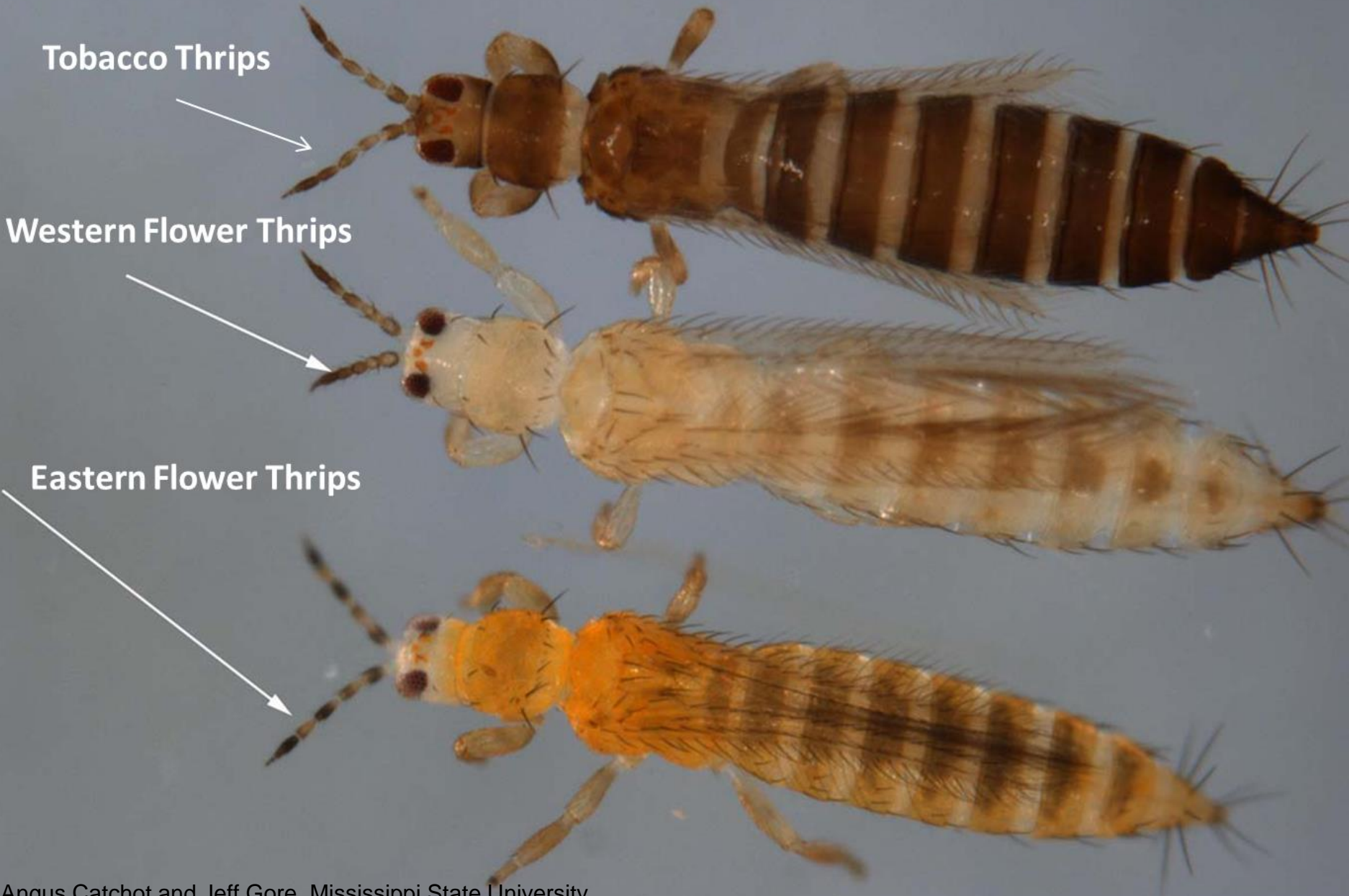
Tobacco Thrips



Western Flower Thrips

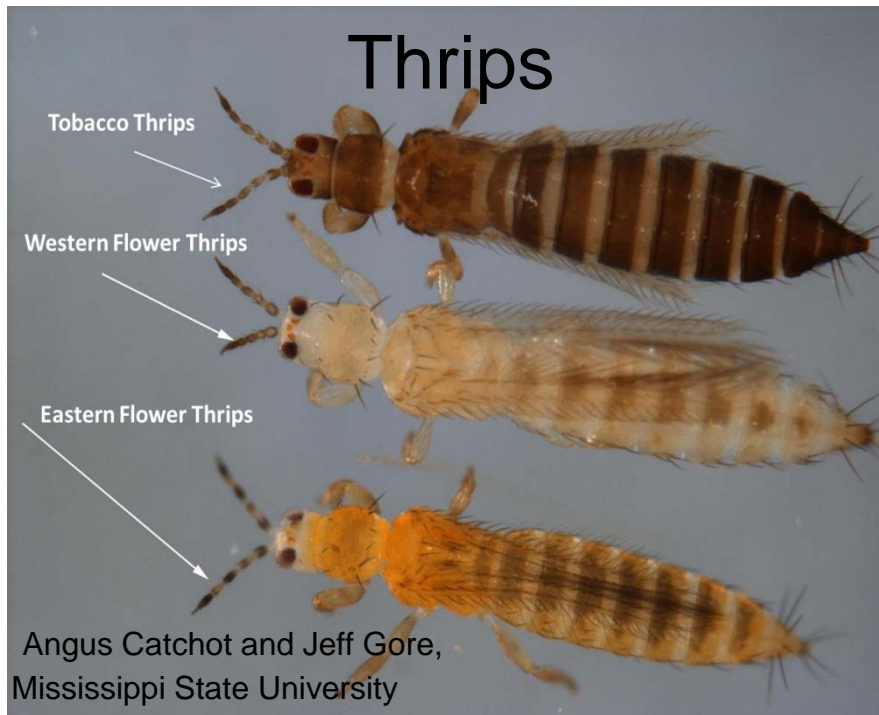


Eastern Flower Thrips



Thrips

Thysanoptera: Thripidae



- Tobacco thrips (*Frankliniella fusca*)
- Western flower thrips (*F. occidentalis*)
- Eastern flower thrips (*F. tritici*)

Thrips



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

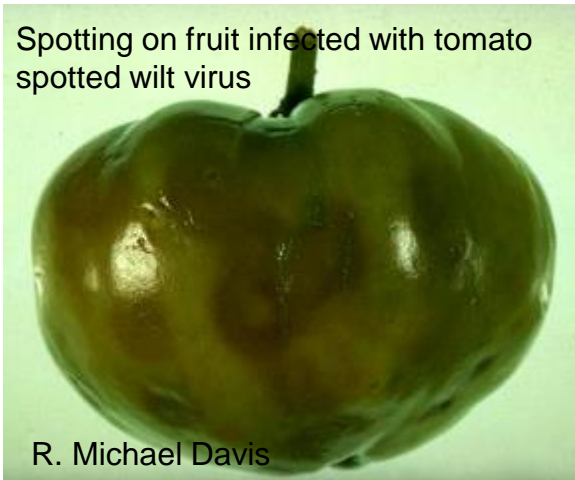
Thrips

Spotting on fruit infected with tomato spotted wilt virus



R. Michael Davis

Spotting on fruit infected with tomato spotted wilt virus



R. Michael Davis

- 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
 - Insecticide treatments for thrips are usually not warranted but may be needed for suppression of TSWV

Hornworms

Hornworm



Celeste Welty, the Ohio State University

C. Welty



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 tomatoes because they are controlled by insecticides applied for other insect pests
- Two species:
 - Tobacco hornworm
 - Tomato hornworm

Tobacco Hornworm

Damage



Ohio State University

Joe Boggs, OSU Extension©

tucson.com

Hornworm Damage



09.15.2012

Missouri Botanical Garden

Ohio State University

Joe Boggs, OSU Extension©



Tobacco hornworms

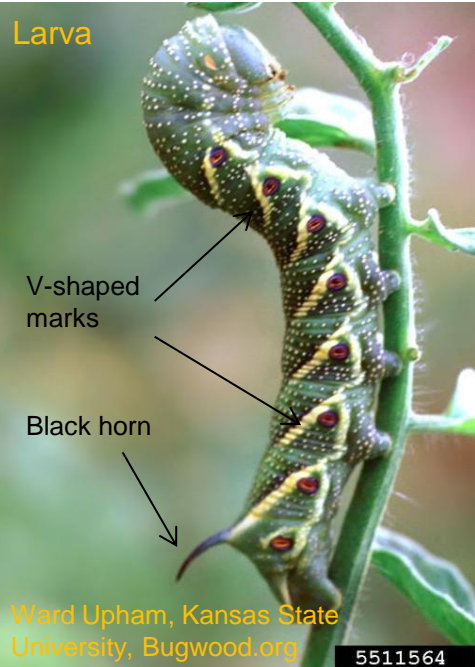
Manduca sexta

- 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 quinque maculata



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



Hornworm management

- Cultural practices:
 - Examine plants frequently
 - Hand picking and destruction
 - Mature larvae: burrow to a depth of 10 to 15 cm, and pupate
 - Control by soil tillage



Scott D. Stewart, University of Tennessee



GEORGE BREDEHOFT / CREATIVE COMMONS

Soil tillage



Janice E. Carey, University of California-ANR

Parasitoid *Cotesia congregata*



Cocoons of the parasitoid *C. congregata*



University of Maryland Extension

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<http://aggie-horticulture.tamu.edu/galveston>

Newly emerged adult of *C. congregata*



Hornworm management

Biological control

Abundant natural enemies:

- Parasitoids, tachinid flies, *Polistes* wasp
- Many parasitoids (e.g. *Cotesia congregates*)
- 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

UGA2107021

Hornworm management

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



Armyworms

Late instar larva (dark form) of the southern armyworm, *Spodoptera eridania*
Lyle J. Buss, University of Florida

Armyworms



Beet armyworm larva-jack Kelly Clark-UC State-wide IPM Program

Armyworms

Spodoptera spp. (Lepidoptera: Noctuidae)



- Sporadic pest
- Strong flyers, disperses long distances annually during the summer months
- When infestations occur can cause extensive damage
- Fruit feeding: damages the crop
- Often feeds externally on fruit
- Leave shallow dry scars or relatively neat holes that usually do not contain feces



Damage



Southern armyworm, *Spodoptera eridania*, second and third instar larvae on tomato. Lyle J. Buss, University of Florida



Tomato fruit feeding injury by the southern armyworm, *Spodoptera eridania*. Lyle J. Buss, University of Florida

Armyworm Identification

Body sleek with small head

Broad, dark band along the top of the body



Brown net-like pattern and dark arcs on head



Body mottled and variable in color from brownish to dark green, with alternating and contrasting stripes

Department of Entomology,
University of Nebraska

Light colored inverted "Y" on forehead

Armyworms

- Three species:
 - Beet armyworm, *Spodoptera exigua*
 - Southern armyworm, *Spodoptera eridania*
 - Yellowstriped armyworm, *Spodoptera ornithogalli*
- Beet armyworm:
 - Difficult to control
 - High reproductive capacity
 - Resistance to pesticides

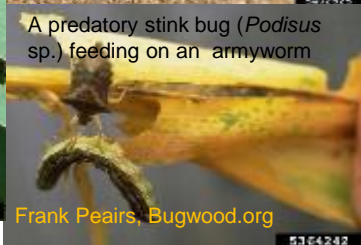


Armyworm management



- Sampling for adults:
 - Black-light traps and pheromone traps
- Cultural practices:
 - Early planting
 - Use of early maturing
 - Host plant resistant varieties
 - Controlling weeds: serve as oviposition hosts
 - Tomato fields
 - Adjacent to tomato fields

Armyworm management



Biological control:

- *Bacillus thuringiensis*
- *Polyhedrosis virus*
- Parasitoids:
 - Braconids, Ichneumonids (*Hyposoter exiguae*), Tachinid flies
- General predators:
 - ground beetle, the striped earwig, the spined soldier bug and the insidious flower bug/minute pirate bug, *Orius insidiosus*
- Vertebrates: birds, skunks, and rodents

Armyworm management

Chemical control: resistance to many pesticides

- Most chemical insecticides provide poor control of armyworms, particularly beet armyworm
- Biologically based pesticides: *Bacillus thuringiensis* products and nuclear polyhedrosis virus



Tomato pinworm

Pinworm larva

Tomato Pinworm



Jack Kelly Clark
University of California IPM Project

Pinworm adult



Jack Kelly Clark
University of California IPM Project

Damage on fruits



Jack Kelly Clark,
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Tomato pinworm

Keiferia lycopersicella

Lepidopera: Gelechiidae



- A sporadic pest that is usually imported with transplants from southern production regions or greenhouses
- Occasionally, populations develop late in the season in eastern Tennessee, and migrating moths may be the source of these infestations



Tomato pinworm



- Eggs:
 - Seldom noticed because of their small size
 - Laid singly on lower surfaces of leaves
- Early instar larvae:
 - Light colored
 - Smooth appearance
 - Lack the obvious tubercles and bristles of newly hatched tomato fruitworms or tobacco budworms

Tomato pinworm

Late instar larva



Pupa



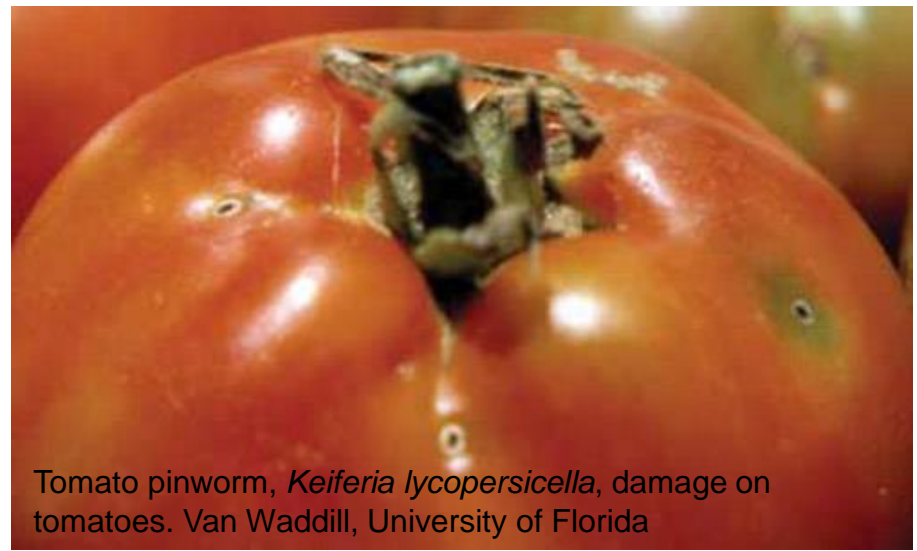
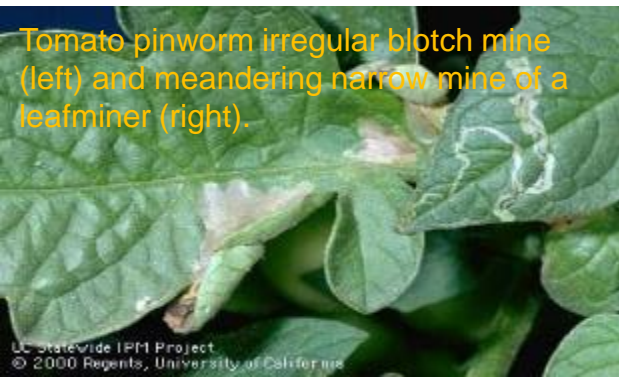
Adult



- Later instar larvae:
 - Most often found in fruits
 - Gray or yellowish with an irregular band of red or purple across each segment
 - Either pupate in leaf shelters or drop to the ground to pupate
- Pupa:
 - Slender and brown
 - Enclosed in a loose silk cocoon with adhering soil or plant debris
- Adult:
 - Small, 6–8 mm long
 - Light gray, peppered with small black flecks

Tomato pinworm damage

- Moths deposit eggs on leaves
- First two larval instars mine in leaves
- Subsequent instar larvae bore into fruit, usually under the calyx and infested fruit is not marketable



Tomato pinworm, *Keiferia lycopersicella*, damage on tomatoes. Van Waddill, University of Florida

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Tomato pinworm management

Pheromone traps are tied to stakes and placed level with plants



- Keep infestations below damaging levels in the current season
 - Careful monitoring
- Host-free periods: reduce the overwintering population that will attack later crops
 - Completely destroy all tomato plants and fruits in a greenhouse and field before setting a summer crop in the field.
 - Destroy other solanaceous host plants in the field's vicinity
- Mating disruption pheromone
- Use pinworm-free transplants

Tomato pinworm management



- Biological control:
 - Parasitoids, including *Apanteles* spp., *Sympiesis stigmatipennis*, and *Parahormius pallidipes*, can be important in controlling pinworm in unsprayed or lightly sprayed fields.
- Chemical control
 - Insecticides

Cabbage looper

Cabbage looper



Cabbage looper

Trichoplusia ni

Lepidoptera: Noctuidae



- Minor pest of tomatoes
- Controlled with insecticides applied for other insects
- Infrequently encountered in commercial operations
- Larval feeding:
 - Confined to foliage

Cabbage looper



Larva:

- Distinctive looping movement in which they arch the middle portion of their body to bring the prolegs or hind legs forward to meet the front legs
- Green, with a narrow white stripe along each side and several narrow lines down the back
- Smooth-skinned with only a few long bristles down the back
- Grow up to 1.5 inches long
- Mature larvae spin silken cocoons and pupate, usually attached to leaves

Cabbage looper



- **Adults:**
 - Brownish moths with a distinctive silvery figure-8 on the front wings



- **Eggs:**
 - Ridged and dome-shaped and usually laid singly on the undersurface of leaves
 - Similar to fruitworm eggs, but flatter, and have finer ridges radiating from the top

Cabbage looper management



- **Damage:** not serious enough to require control measures so treatment is rarely recommended
- **Biological control:**
 - Common parasitic wasps of cabbage looper larvae
 - *Copidosoma truncatellum*
 - *Hyposoter exiguae*
 - Egg parasitoids:
 - *Trichogramma* spp.
- *Bacillus thuringiensis* products
- Nuclear polyhedrosis virus

Whiteflies

Whiteflies



Jack Kelly Clark
University of California State-Wide IPM Project

Whiteflies

Hemiptera: Aleyrodidae

- Infestations: sporadic
- Adults are tiny (0.06 inch, 1.5 mm long), yellowish insects with white wings
- Transmit viruses
 - Tomato infectious chlorosis virus
 - Gemini viruses e.g. tomato yellow leaf curl
- Adult and nymph feeding
 - Reduce the rate of photosynthesis
 - Stunt growth
 - Sooty mold growth on whitefly honeydew
 - Accumulates on fruit and leaves reducing photosynthesis



Damage



Whiteflies

Hemiptera: Aleyrodidae



- Field: Greenhouse whitefly (*Trialeurodes vaporariorum*)
- Greenhouse: Silverleaf whitefly (*Bemisia argentifolii*) and sweetpotato whitefly (*Bemisia tabaci*)

Greenhouse whitefly



- Nymphs:
 - Elevated in profile with edges perpendicular like a cake or hat box
 - Many long waxy filaments around the edge of their bodies
- Adults:
 - Very similar in appearance to silverleaf whitefly adults, but hold their wings flatter over the back with no space between the wings where they meet in the center

Sweetpotato whitefly



- **Nymphs:**
 - Convex or rounded in profile
 - From above they are oval, whitish and soft
 - Unlike greenhouse whitefly nymphs, do not have filaments
- **Adults:**
 - Hold their wings rooflike over their bodies
 - The wings do not meet in the back as they do in greenhouse whitefly adults, but have a slight space between them

Silverleaf whitefly



- **Nymphs:**
 - Similar to sweetpotato whitefly nymphs
 - Unlike greenhouse whitefly nymphs, do not have filaments
- **Adults:**
 - Very similar in appearance to greenhouse whitefly adults, but hold their wings flatter over the back with space between the wings

Whitefly management

Encarsia luteola, a whitefly parasitoid



Eretmocerus sp., a whitefly parasitoid



IPM practices

- Good cultural practices
 - Host free periods
 - Maximize the distance and time interval between host crops
 - Sanitation: removal of crop residues
 - Weed control
- Biological control
 - Conserving natural enemies
 - Big-eyed bugs, lacewing and ladybeetle larvae, parasitoids (*Encarsia* and *Eretmocerus* spp.)
- Routinely monitoring fields
- Chemical control
 - Using pesticides only when necessary
 - Difficult at high population levels

Vegetable leafminer

Vegetable leafminer

Larva

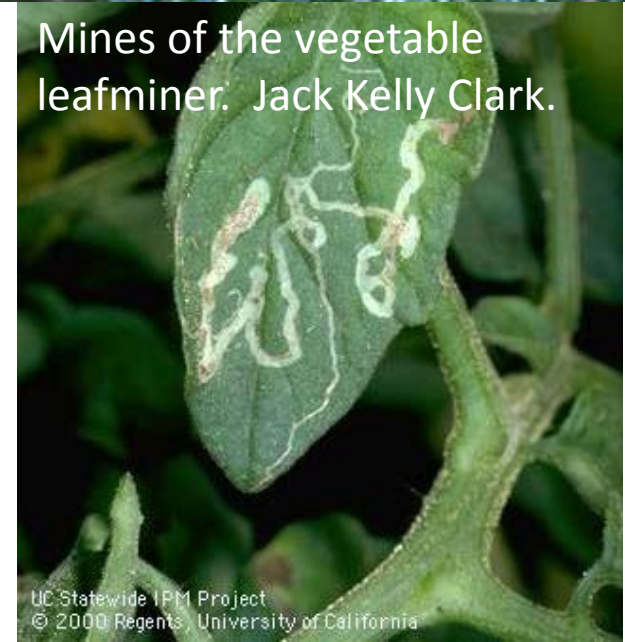


Beet armyworm larva-jack Kelly Clark-UC State-wide IPM Program

Adult



Mines of the vegetable leafminer. Jack Kelly Clark.



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Vegetable leafminer

Liriomyza sativae

Diptera: Agromyzidae



- Minor pest that develops to large densities only when broad spectrum insecticides are sprayed extensively
- Normally a pest of late summer tomatoes and can reach high numbers
- Adults: small black flies that insert eggs into leaves
- Larvae:
 - Feed between the upper and lower leaf surface and create mines.
 - Polyphagous

Vegetable leafminer damage



- Feeding results in serpentine mines
 - slender, white, winding trails
- Heavily mined leaflets have large whitish blotches
- Leaves injured by leafminers drop prematurely
- Heavily infested plants may lose most of their leaves
- If it occurs early in the fruiting period, defoliation can reduce yield and fruit size and expose fruit to sunburn

Vegetable leafminer management

Biological control:

- Most important aspect of management is conserving their natural enemies
 - Which are often killed by broad-spectrum insecticides applied for other tomato pests
- A complex of at least five different parasitic wasps of the vegetable leafminer occurs in Tennessee
- The insecticide methomyl:
 - Particularly toxic to these parasites and populations may be reduced when methomyl applications are made for other pests



Vegetable leafminer management



Cultural control:

- Check transplants for leafminers or mines before planting and destroy any plants that are infested
- Leafminers reach damaging levels earlier when infestations begin on transplants
- Varieties with curled leaves are less susceptible to damage and may provide suitable alternatives where damage is expected
- Reduce early infestations in a new crop by removing old plantings immediately after the last harvest

Vegetable leafminer management

- **Chemical control:**
 - Chemical control is rarely necessary.
 - Reduce the risk of outbreaks
 - Applying insecticides for fruit pests only when monitoring shows treatment is needed
 - Choosing insecticides that are least likely to harm leafminer parasitoids



Mites

Mites



Two spotted spider mite-jack Kelly Clark-UC State-wide IPM Program
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Spider Mite significant damage on tomato plant

Mites

Arthropoda: Arachnida: Acari



- Two-spotted spider mites (*Tetranychus urticae*) and carmine spider mites (*Tetranychus cinnabarinus*) are sporadic pests
- ~15% of tomato fields can get infested with mites
- Infestations can be difficult to control



Mite damage

- Damage: feeding on foliage, reducing the rate of photosynthesis, and, thus, reducing overall yields
- High populations and damage is often observed during hot dry weather
- Mite feeding:
 - Results in the destruction of chlorophyll
 - Leaves become pale, stippled, and in later stages of infestation dry up and die
 - Loss of color is pronounced on the under surface of leaves before it becomes apparent on the upper side
 - Light infestations can be tolerated, but when heavy, can result in lowered yield and reduced quality of fruit

Mite management



- **Biological control:**
 - Important component of mite management
 - Take measures to ensure the survival of predators and parasitoids
 - Lady beetles, minute pirate bugs, lacewing larvae and other generalist predators
- **Cultural Control**
 - Start monitoring for spidermites during the vegetative growth stage
 - Minimize dust and encourage naturally occurring natural enemies by limiting chemical rates and the number of applications.
 - Control weeds in or at the edges of the field
 - Good water management increases plant tolerance to these pests

Summary

Tomato pest insect management

- Tomato is an important crop for Tennessee
- Tomato pests are broadly categorized as,
 1. Early season pests
 2. Pests during fruit set to harvest

Tomato pest insect management

Integrated approach is important for managing pest insects in tomato

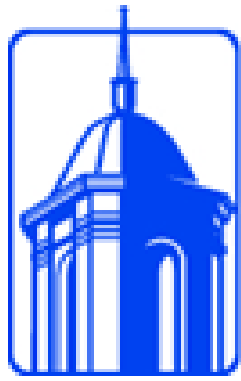
- Eliminate competition from weeds
- Keep the plant growing vigorously with proper water and nutrients
- Keep the garden clean of plant debris
- Rotate crops
- Space plants for maximum air circulation
- Monitor for pests and natural enemies
- Use resistant varieties
- Keep insecticides as a last resort

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Acknowledgment

- Tennessee State University
- Tennessee Cooperative Extension Program
- USDA-NIFA Capacity Building Grant (2019-38821-29060)



TENNESSEE STATE UNIVERSITY

Thank you!

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