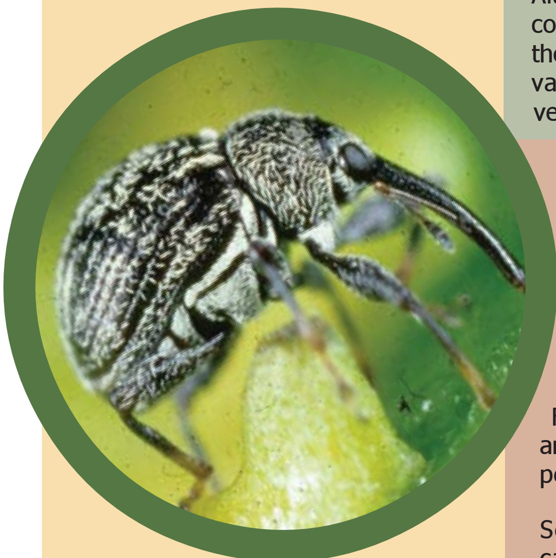
PEST MANAGEMENT: Monitoring

Action thresholds are levels of pest density or damage that result in consistently measurable losses in yield quantity or quality.

ACTION THRESHOLDS:

The cornerstone of IPM is knowledge of the pests attacking a crop and an understanding of the relationship of density of those pests to crop damage. Therefore, every IPM program is dependent upon periodic scouting to ascertain pest density and upon establishment of densities when treatment is warranted, i.e. thresholds.

Although thresholds based upon the economics of the crop and upon the cost of treatment have been developed for some pests of vegetables, these "economic" thresholds generally have not been used because of the variability and unpredictability of the ultimate market value of winter vegetables. Therefore, action thresholds have been utilized.



PEST OUTBREAKS:

All pests are attacked by a complement of natural enemies including insects, mites, viruses, fungi and bacteria. Natural enemies keep many, if not most, insects or mites under sufficient control so that economic damage is avoided. When these natural enemies provide insufficient control **(Figure 1)** or provide control only after serious damage has been inflicted **(Figure 2)**, an insect or mite becomes a major pest.

Favorable weather may permit insects or mites to increase to high densities and escape the controlling influences of natural enemies and, thus, become pests.

Secondary outbreaks of pests are caused by applications of broad spectrum pesticides that decimate natural enemies, thus allowing an insect or mite population to increase to damaging levels **(Figure 3)**.

When insects or mites develop resistance to pesticides applied for their control or for the control of other insects, not only do they escape the controlling effects of the pesticide, but they also escape the controlling effects of natural enemies which are not pesticide resistant and which are killed.

Non-native insects or mites may become pests when introduced into Florida without their natural enemies. Native natural enemies may eventually switch to the introduced insects and mites and exert some level of natural control.

Why do we experience pest outbreaks?

- *Disruption of natural control*
- *Pesticide resistance*
- *Invasive species*
- *Secondary pest problems*
- *Weather*
- *Migration*

Figure 1. Natural enemies provide insufficient control of the pepper weevil, *Anthonomus eugenii*. Photograph by: Skip Choate.

Figure 2. Natural enemies provide control only after serious damage has been inflicted by the beet armyworm, *Spodoptera exigua*. Photograph by: Dave Schuster.

Figure 3. *Liriomyza spp.* leafminers on tomato are an example of a secondary pest. Photograph by: James Castner.

Prepared by: Dr. David Schuster

WHY ALL GROWERS SHOULD SCOUT:

- Improve knowledge of pest presence and dynamics.
- Reduce pesticide costs.
- Reduce unnecessary pesticide applications.
- Reduce potential environmental contamination.
- Integrate biological control by conserving natural enemies.
- Reduce worker and consumer pesticide exposure.
- Improve knowledge of pesticide selection, timing and effectiveness.
- Better manage pesticide resistance.

SAMPLING FOR PEPPER:

- Select one vegetative bud per plant and count beet armyworm larvae, broad mites and aphids on young leaves.
- Select leaf from middle canopy and inspect for caterpillar eggs.
- Count thrips and *Orius* predators/10 flowers.
- Inspect flower buds and small fruit for pepper weevil feeding.
- Inspect fallen flower buds and fruit for pepper weevil larvae.

HOW TO SCOUT:

- Place yellow sticky traps (whiteflies, leafminer, aphids) and pheromone traps (pepper weevil, tomato pinworm, tomato fruitworm, beet armyworm) around field perimeter and check twice weekly.
- Map field in two acre grids **(Figure 4)**.
- Select 6-10 contiguous plants in each grid twice weekly.
- Observe each plant for flying insects.
- Inspect each plant for caterpillars (focus on new damage), true bugs, predators, etc.

Figure 4. Fields can be divided into two-acre segments for sampling. Courtesy of: UF/IFAS.

Sampling for Tomato:

- Inspect whole plant or select terminal leaflets of 3rd or 7th leaf.
  - ➔ Count whitefly nymphs on whole plant or terminal leaflet.
  - ➔ Count aphids, caterpillar eggs and leafminer larvae on whole plant or terminal 3 leaflets.
- Select lower leaf and inspect for mites and count tomato pinworm larvae
- Count thrips/10 flowers.
- Inspect 10 fruit for caterpillar and true bug damage.

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Green Peach Aphid: *Myzus persicae*
Potato Aphid: *Macrosiphum euphorbiae*

Biology & Lifecycle: Winged females of both species invade fields and give rise to non-winged colonies. Both winged and non-winged forms are all females and give birth to living young. They feed on the undersides of leaves in the upper canopy, although the potato aphid may also feed on stems and petioles. The adult to adult period is very short, being 10-14 days. Winged green peach aphids land, deposit a few young, and then alight again, repeating this sequence over and over. When populations of both aphids reach high numbers or when host plants senesce, winged forms are produced and disperse to new host plants.

Environmental Factors: Aphids may be present year round, but are usually more abundant during warmer months in the spring and fall crop seasons. The insects oversummer on volunteer plants and on weeds such as American black nightshade, *Solanum americanum* (especially potato aphid), lambsquarter (*Chenopodium* spp.) and pigweed (*Amaranthus* spp.).

Adult: Adults are pear-shaped and have two rear horns (cornicles) that point upward and backward from the top of the body. Green peach aphids are light to dark green or yellowish, while potato aphids are green or pink. Potato aphids are larger ($^{1}/_{10}$ inch) and more elongated than green peach aphids ($^{1}/_{16}$ inch). Winged females of both species are slightly smaller and have a darker middle body section **(Figure1)**.

Nymphs: Adults give birth to living nymphs which are small versions of the adults in coloring and presence of cornicles **(Figure 2)**.

Host range: The green peach aphid has a very broad host range, feeding on hundreds of plants in over 40 plant families. Almost all vegetable crops can be attacked including tomato and especially pepper. The potato aphid predominates on tomato and potato.

Damage to Tomato: Adults and nymphs have piercing-sucking mouthparts, and feeding on the undersides of upper leaves produces yellowing of the upper surfaces **(Figure 5)**. Leaves and stems may be distorted, especially by potato aphid feeding and plants may wilt. Aphids produce a sugary substance called honeydew, which serves as a medium for sooty mold growth. Most damage is inflicted by transmitting plant viruses such as *Potato virus Y* and *Tobacco etch virus*.

Figure 1. Winged female aphid. Photograph by: Jeff Brushwein.

Figure 2. Aphid with immatures. Photograph by: Jeff Brushwein.

Figure 3. Aphid on underneath side of leaf. Photograph by: Dave Schuster.

Actual Size:

Adult
$^{1}/_{16}$ -$^{1}/_{10}$ inch

Nymphs
$<^{1}/_{16}$ -$^{1}/_{10}$ inch

Monitoring:

Traps: Yellow sticky or pan traps can be used to monitor movement of adults into fields.

Scouting: The undersides of the terminal three leaflets of one leaf per six plants are examined for the presence of aphids. Potato aphids are counted on at least 30 leaves per field, selecting the leaf below the highest open flower.

Action Thresholds: 3-4 aphids per terminal three leaflets
50% of leaves are infested

Prepared by: Dr. David Schuster

Green Peach Aphid: *Myzus persicae*
Potato Aphid: *Macrosiphum euphorbiae*

CULTURAL CONTROLS:

Field Manipulations: Aluminized plastic mulch, which reflects ultraviolet light, may be used to repel aphids and reduce virus transmission during the first weeks of plant development.

New crops should not be planted near infested crops and infested crops and weeds should be destroyed.

NATURAL ENEMIES:

- Both species of aphids are attacked by a large range of natural enemies including lady beetles, flower fly larvae, lacewing larvae, predatory midges and parasitic wasps, especially *Diaeretiella rapae* and *Aphidius nigripes* for the green peach and potato aphids, respectively.
- Timed applications of selective insecticides and avoidance of broad spectrum insecticides can enhance biological control.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action thresholds are reached. Application of insecticides rarely is effective in managing the viruses transmitted by aphids. The systemic nicotinoids (several products, 4A), soaps, detergents and oils can be used.

RESISTANCE MANAGEMENT:

- Cultural practices, particularly the use of UV reflective mulches, should be integrated with judicious use of insecticides. Insecticides of different chemical classes should be alternated.

Figure 4. Potato aphid. Photograph by: Jeff Brushwein.

Figure 5. Plant damage. Photograph by: Dave Schuster.

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References:

Capinera, J.L. 2001. Green peach aphid, *Myzus persicae* (Sulzer) (Insecta: Hemiptera: Aphididae) UF/IFAS EENY-222, http://creatures.ifas.ufl.edu/veg/aphid/green_peach_aphid.htm.

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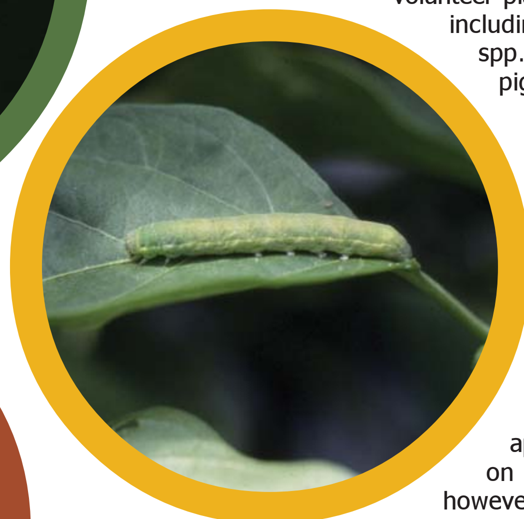
Beet Armyworm: *Spodoptera exigua*

Biology & Lifecycle: Female adults lay clusters of greenish-white eggs on the undersides of leaves, often near the tips of branches or near flowers, and cover them with hair like scales from their bodies. Hatching larvae feed gregariously but soon become mobile and solitary, often feeding in the vegetative buds, especially in pepper, and covering the feeding site with webbing. Mature larvae drop to the soil, often on the edge of the plastic mulch covering the production beds, and form a cell about ½ inch deep and pupate inside. The egg to adult period lasts about 3 weeks.

Environmental Factors: The beet armyworm is active year round, but is usually more abundant in tomato and pepper during warmer months in both the spring and fall. The insect may over summer on volunteer plants and numerous weed species, including lambsquarters (*Chenopodium* spp.), purslane (*Portulaca* spp.) and pigweed (*Amaranthus* spp.).



Adult: Adults are medium sized moths with a wing span of about 1 to 1¼ inch and are nocturnal. The front wings are mottled gray and brown, with an irregular banding pattern and a bean shaped white spot. The hind wings are whitish gray with a dark band on the edge.

Larvae: Usually pale green and appear smooth with fine, white lines on the dorsal surface **(Figure 2)**; however, older larvae have dark stripes on the sides of the bodies and may have triangular shaped black spots on the dorsal surfaces **(Figure 1)**. There may be a small black spot above the middle pair of true legs.

Host range: The beet armyworm has a very wide host range and can be a serious pest of vegetable, field and ornamental crops. Both tomato and pepper are attacked, but pepper appears to be preferred in Florida. Many common weeds also can serve as larval hosts.

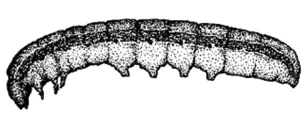
Damage: Larvae may complete development on foliage but inflict most damage when they feed on fruit, causing shallow holes or gouges **(Figure 4)**. Larvae often bore inside pepper fruit, where they complete their development. It is not uncommon to cut an infested pepper fruit and discover a beet armyworm moth inside **(Figure 5)**. Damaged fruit are rendered unmarketable and may rot due to invasion of secondary microorganisms.

Figure 1. Darker phase of beet armyworm larva. Photograph by: Dave Schuster.

Figure 2. Lighter phase of beet armyworm larva. Photograph by: Dave Schuster.

Figure 3. Armyworm eggs on pepper. Photograph by: Dave Schuster.

Actual Size:



Late instar larva

Monitoring:

Traps: Sticky, pheromone baited traps placed on field perimeters can be used to indicate when adults are migrating into fields.

Scouting: The whole plant (when small) or the terminal three leaflets of the 3rd or 7th leaf can be examined for the presence of eggs. Newly damaged foliage or vegetative terminals, especially in pepper, can be examined for the presence of larvae. A sample of 10 fruit is examined for the presence of recent damage.

Action Thresholds: one larva per 6 plants pre-bloom
presence of one egg or larva post-bloom

Prepared by: Dr. David Schuster

Beet Armyworm: *Spodoptera exigua*

CULTURAL CONTROLS:

Start Clean: Tomato and pepper fields should not be planted near or adjacent to old, infested fields.

Field Manipulations: Fields should be destroyed immediately after final harvest by deep disking to destroy infested fruit and pupating larvae.

Volunteer plants and weed hosts should be destroyed during the summer off season by frequent disking.

NATURAL ENEMIES:

- Although the beet armyworm is attacked by numerous natural enemies, they usually do not cause mortality soon enough to prevent crop injury. The most important species of parasitic wasps observed attacking larvae include *Meteorus autographae*, *Cotesia marginiventris* and *Chelonus insularis*.
- Eggs and young larvae are attacked by generalist predators, including big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.) and minute pirate bugs (*Orius* spp.).
- A commercially available nuclear polyhedrosis virus is specific and may be effective.
- Natural enemies can be conserved by avoiding broad spectrum pyrethroid, organophosphate and carbamate insecticides. Fewer insecticide applications and applications of new, reduced risk insecticides can also enhance biological control.

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CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.
- Insecticides should be timed to treat eggs and hatching larvae for best control. Larvae feeding within silk webbing may be more difficult to control.

RESISTANCE MANAGEMENT:

- The efficacy of pyrethroid insecticides (many products, 3) has declined to very low levels in research plots in Florida. Chemicals of different classes, especially the newer reduced risk insecticides, should be rotated.

Figure 4. Feeding damage on pepper calyx covered with silk. Photograph by: Dave Schuster.

Figure 5. Below: (left) External Feeding damage on pepper; (right) Pupa developing inside fruit. Photograph by: Dave Schuster.

References:

Capinera, J.L. 1999. Beet armyworm, *Spodoptera exigua* (Hübner) (Insecta: Lepidoptera: Noctuidae)UF/IFAS EENY-105,http://creatures.ifas.ufl.edu/veg/leaf/beet_armyworm.htm.

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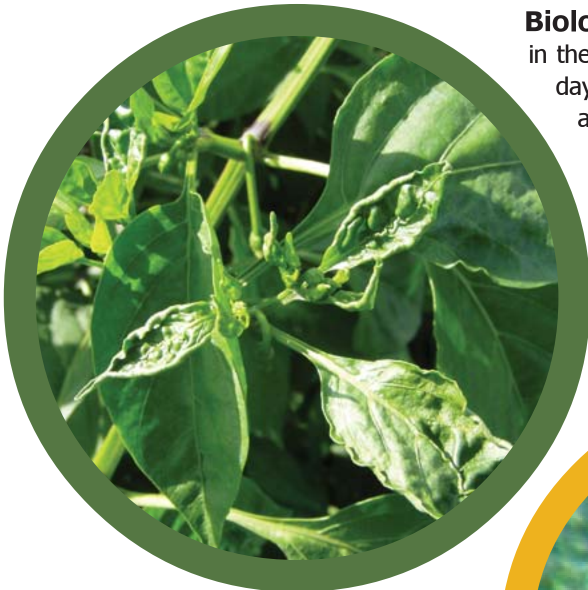
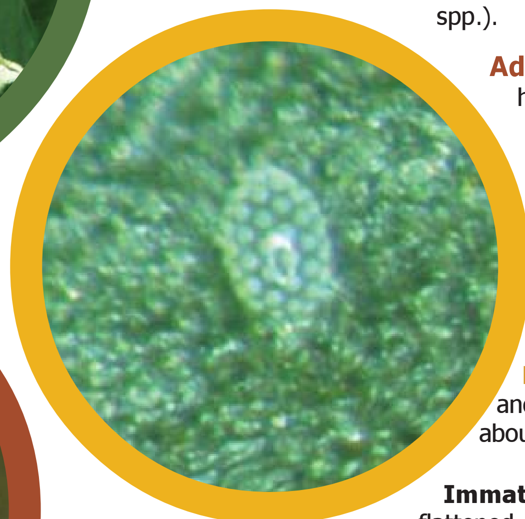
Broad Mite: *Polyphagotarsonemus latus*



Biology & Lifecycle: Eggs are laid singly on the undersides of apical leaves, in the depressions of small fruit and on flowers. The larval stage feeds for 2-3 days and develops into a quiescent nymphal stage. The life cycle only requires about 7 days under optimal conditions of 75°F and high humidity. The mites can disperse by hitching a ride on the legs of adults of the sweetpotato whitefly, *Bemisia tabaci*.

Environmental Factors: Broad mites may be present year round, but are more abundant during the warmer months in the spring and fall. The mite may oversummer on volunteer crop plants and weeds, including pigweed (*Amaranthus* spp.), beggartick (*Bidens* spp.), jimson weed (*Datura* spp.) and galinsoga (*Galinsoga* spp.).



Adult: Very small, requiring a 14X hand lens to be observed **(Figure 4)**. Whitish and oval with four pairs of legs. Females have a white stripe on their backs and whip-like hind legs. Males are smaller than the females without the strip and carry the females with enlarged hind legs **(Figure 3)**.

Eggs: Eggs are elliptical, colorless and translucent and are covered with about 30 whitish bumps **(Figure 2)**.

Immature stages: Larvae are whitish, flattened and oval with three pairs of legs. The nymphal or pupal stage is quiescent, clear and pointed at both ends **(Figure 3)**.

Host range: Over 60 plant families host broadmites. Vegetables that are attacked include tomatoes, eggplant and pepper, although damage is most severe on pepper.

Damage: Adults and larvae use their piercing-sucking mouthparts to inject a toxin which causes leaf petioles to elongate **(Figure 6)**; leaves to become twisted, hardened and shrunken; and vegetative and flower buds to abscise. Often the damage is the first indication of an infestation and is easily confused with herbicide injury. If damage is severe, the plants may not recover and put on new growth even after the mite populations is removed with pesticides.

Figure 1. Pepper plant damage due to broad mite infestation. Photograph by: David Schuster.

Figure 2. Broad mite egg, notice the bumps on the surface. Photograph by: David Schuster.

Figure 3. Male carrying female nymph. Photograph by: Elio Jovicich.

Actual Size:

Adult

Less than .02mm or 1/50 inch

Monitoring:

Scouting: The undersides of very young leaves should be examined with a hand lens or leaves should be collected and examined with a dissecting microscope.

Action Thresholds: Although no threshold has been developed, as few as 10 mites per pepper plant can cause injury.

Prepared by: Dr. David Schuster

Broad Mite: *Polyphagotarsonemus latus*

CULTURAL CONTROLS:

Field Manipulations: Weeds within and around fields should be destroyed, although the wide host range makes this less effective.

The movement of people or equipment from infested to uninfested areas should be avoided.

NATURAL ENEMIES:

- Predatory mites and pathogenic fungi are the major natural enemies of broad mites. Inoculative releases of the predatory mites *Neoseiulus californicus* and *N. barkeri* may be used for biological control, especially in greenhouses.

CHEMICAL CONTROLS:

- Miticides should be applied when the presence of mites is first observed. Sulfur has long been used to manage broad mites, but endosulfan (cylcodiene organochlorine, 2A) and other new miticides are effective.

RESISTANCE MANAGEMENT:

- No resistance has been reported in Florida.
- Rotation of products of different chemical classes is an important resistance management tactic.

Figure 4. Broad mite adult. Photograph by: Dave Schuster.
Figure 5. Seedling damage. Photographed by: Elio Jovicich.

Figure 6. Broad mite damage. Photograph by: Dave Schuster.

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References:

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Fasulo, T. R. 2000. Broad mite, *Polyphagotarsonemus latus* (Banks) (Arachnida: Acarina: Tarsonemidae) UF/IFAS EENY-183, http://creatures.ifas.ufl.edu/orn/broad_mite.htm.

Tobacco Hornworm: *Manduca sexta*
Tomato Hornworm: *Manduca quinquemaculata*

Biology & Lifecycle: Females lay large, greenish eggs singly on the undersides of leaves in the upper canopy. Larvae feed on foliage, leaving only veins or consuming entire leaves. Mature larvae drop to the soil, burrow 4-5 inches deep and form a cavity in which they pupate. There are five instars and the egg to adult period lasts about 30-50 days.

Environmental Factors: Hornworms are most active April-November in north Florida, but are abundant for only the first two generations because many pupae enter diapause. They are active year round in south Florida.

Adult: Very large moths with 3 to 5 inch wingspan. Forewings are dull-grayish or grayish-brown and hind wings have alternating light and dark bands. The sides of the abdomen of the tobacco hornworm have 6 yellow-orange spots while those of the tomato hornworm have 5 spots. The adults feed on nectar of flowers, especially at dusk, hovering similar to small humming birds **(Figure 6)**.

Larvae: Both species are very large, reaching up to about 2½ inches by the fifth instar. Larvae are usually pale green with a characteristic "horn" at the rear end. Tobacco hornworm larvae have 7 whitish, straight lines pointing diagonally on each side **(Figure 1)**. The sides of tomato hornworm larvae have 7 whitish "v"-shaped marks pointing toward the head.

Host range: Both hornworm species are restricted to hosts in the family Solanaceae, particularly tomato and tobacco, although they have been reported to occasionally feed on eggplant, pepper and potato. Wild hosts include groundcherry, *Physalis* spp.; horsenettle, *Solanum carolinense*; jimsonweed, *Datura stramonium*; and nightshades, *Solanum* spp.

Damage: Larvae damage plants by consuming foliage and can cause high levels of defoliation **(Figure 4)**. Occasionally, green fruit are also fed upon.

Figure 1. Mature tobacco hornworm larva. Photograph by: Dave Schuster.

Figure 2. Young hornworm larva. Photograph by: Dave Schuster.

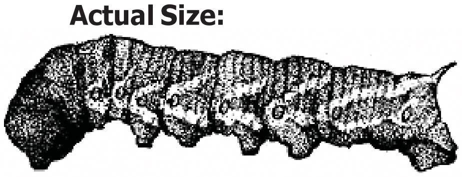
Figure 3. Hornworm egg. Photograph by: Dave Schuster.

Monitoring:

Scouting: Light traps can be used to monitor adult activity. The upper portions of plants are inspected season long for larvae, concentrating where fresh feeding is evident.

Action Thresholds: Control should be initiated when larger larvae are detected.

Actual Size:



Larva
up to about 2½ inches by the fifth instar.

Tobacco Hornworm: *Manduca sexta*
Tomato Hornworm: *Manduca quinquemaculata*

CULTURAL CONTROLS:

Field Manipulations: Soil tillage can destroy 90% of the pupae.

Because *Polistes* spp. wasps prefer hornworm larvae, wasp shelters or nesting boxes can be erected.

Completed crops should be destroyed in a timely manner and re-growth and volunteer plants should be controlled. Weeds can serve as larval hosts, but are unimportant relative to crops.

NATURAL ENEMIES:

- Hornworm eggs and larvae are heavily parasitized by parasitic wasps and flies, respectively, and, if left undisturbed, will usually control hornworm populations **(Figure 5)**.
- Timed insecticide applications and the use of *Bacillus thuringiensis* and other selective insecticides can enhance biological control by conserving natural enemies.

CHEMICAL CONTROLS:

- Insecticides should be applied when large larvae are present.
- Products containing *Bacillus thuringiensis* have been particularly useful and conserve natural enemies.

RESISTANCE MANAGEMENT:

- Products containing *B. thuringiensis* var. *kurstaki* (11B2) and *B. thuringiensis* var. *aizawei* (11B1) should be rotated with each other and with conventional insecticides of different chemical classes.

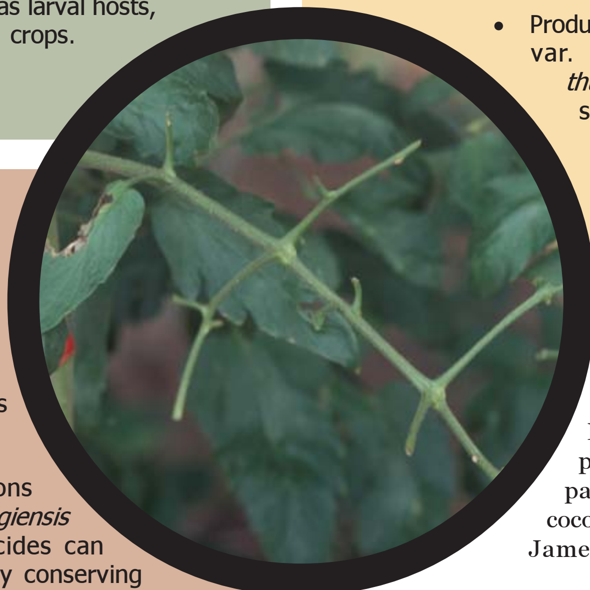


Figure 4. Defoliation by tobacco hornworm larva. Photograph by: James Castner.

Figure 5. Hornworm larvae parasitized by *Braconid* sp. Note: parasitic wasp larvae spinning its cocoon in lower left. Photograph by: James Castner.

Figure 6. Adult tobacco hornworm, *Manduca sexta*. The sides of the abdomen have 6 yellow-orange spots while those of tomato hornworm have 5 spots. Photograph by: John Capinera.

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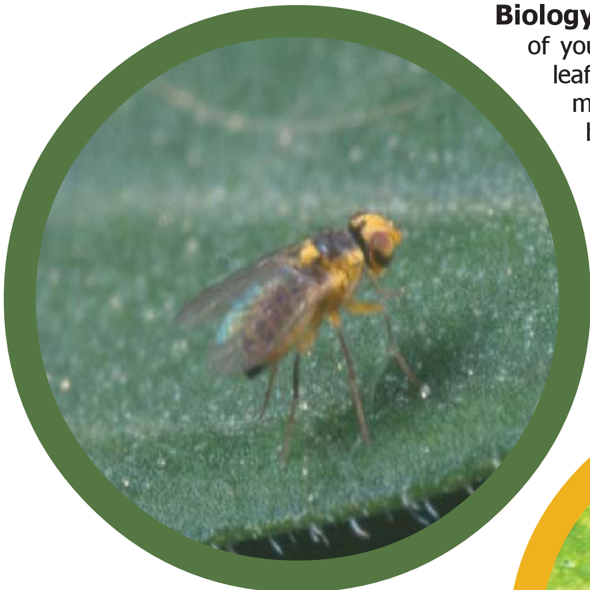
Vegetable Leafminer: *Liriomyza sativae*
American Serpentine Leafminer: *Liriomyza trifolii*



Biology & Lifecycle: Female adults insert eggs individually in the upper surfaces of young leaves. Hatching larvae feed within the leaves, forming serpentine leafmines **(Figures 2 & 3)**. Mature larvae exit through a slit at the end of the mines and drop to the soil or plastic mulch surface, where they form orange-brown, barrel-shaped pupariae. Adults emerge about 9 days later. Females also use their ovipositors to make larger holes **(Figure 4)** and feed on the exuding cell contents. The egg to adult period lasts about 2-3 weeks at temperatures of about 80°F. *L. trifolii* predominates in Florida.

Environmental Factors: Leafminers are present year round, but are usually more abundant March-June. The insect over summers on volunteer crop plants and weeds, especially American black nightshade, *Solanum americanum* and Spanish needles, *Bidens alba*.

Adult: Adults are small flies about 1/8 inch in length and are black on the top and yellow on the head, sides and undersides **(Figure 1)**. The upper surface of the black thorax of *L. sativae* adults is shiny while that of *L. trifolii* is matte. Adults occur on the upper surfaces of leaves on the tops of plants.

Larvae: Yellowish maggots that reside inside the leaves and that have black, sickle-shaped mouth hooks for feeding **(Figure 2)**.

Host range: Both *L. sativae* and *L. trifolii* have wide host ranges including crop hosts and weeds. Vegetables that are attacked include bean, celery, eggplant, pepper, potato, squash and tomato. Tomato is usually more heavily attacked than pepper in Florida.

Damage: While feeding punctures (also called stippling) can be unsightly, economic damage is inflicted through leafmining **(Figure 4)**. Heavy leafmining can reduce photosynthesis and cause leaf desiccation and leaf drop, which can result in sun scalding of fruit **(Figure 3)**. Leafmines also can serve as entry points for bacterial and fungal diseases.

Figure 1. Adult leafminer. Photograph by: Jeff Brushwein.

Figure 2. Leafminer larvae on a tomato leaf. Photograph by: David Schuster.

Figure 3. Tomato damage from leafminer feeding. Photograph by: David Schuster.

Actual Size:

Adult
1/8 inch

Larvae
<1/8 inch

Monitoring:

Traps: Adults are attracted to yellow and commercially available yellow sticky traps can be used to monitor changes in leafminer adult densities. Traps should be placed at the middle to lower portions of the plants and should be checked twice a week.

Scouting: Fresh stippling indicates adult leafminer presence. The number of leafmines with living larvae is counted either on the whole plant or the terminal three leaflets of the third or seventh leaf from the top of the plant (depending upon the size of plants). The number of leafmines with dead larvae can be used to estimate the efficacy of insecticide treatments or the success of biological control.

Action Thresholds: 0.7 larva/plant or three leaflets for timing insecticidal sprays

Prepared by: Dr. David Schuster

Vegetable Leafminer: *Liriomyza sativae*
American Serpentine Leafminer: *Liriomyza trifolii*

CULTURAL CONTROLS:

Start Clean: Transplants should be free of eggs or larvae.

Field Manipulations: Weeds and senescent crops can be reservoirs of migrating adults. Therefore, weeds should be destroyed and crop residues plowed deeply.

New fields should not be planted adjacent to old fields.

High levels of nitrogen fertilization can increase levels of leafmining.

NATURAL ENEMIES:

- At least 14 species of parasitic wasps have been observed attacking leafminer larvae in Florida. If parasites are not disrupted with pesticides, larval parasitism can reach nearly 100%. However, growers sometimes object to the amount of leafmining that results even though economic damage usually has not occurred.
- Parasite larvae feed either on or within leafminer larvae and can be viewed by excising infested leaflets, holding them up to the sun and viewing them with a 15X hand lens.
- Parasitism of leafminer larvae in American black nightshade and Spanish needles also can reach 100%, but the parasite species in weeds are not the ones most abundant in tomato crops.
- Natural enemies can be conserved by avoiding broad spectrum pyrethroid, organophosphate and carbamate insecticides. Timed insecticide applications and applications of new, reduced risk insecticides for other pests can also enhance biological control.

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CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.
- Insecticides should be timed to control younger larvae when they are easier to control. Agri-Mek® (abamectin) also can be applied to control adults and reduce oviposition.

RESISTANCE MANAGEMENT:

- The efficacy of pyrethroid insecticides (many products, 3) has declined to very low levels in research plots in Florida. Resistance to Trigard® (cyromazine, 17) and Agri-Mek (avermectins, 6) has been documented in Florida but has been managed by rotation of chemicals of different classes.
- Applying insecticides based upon the threshold and in conjunction with biological control will reduce the number of applications.

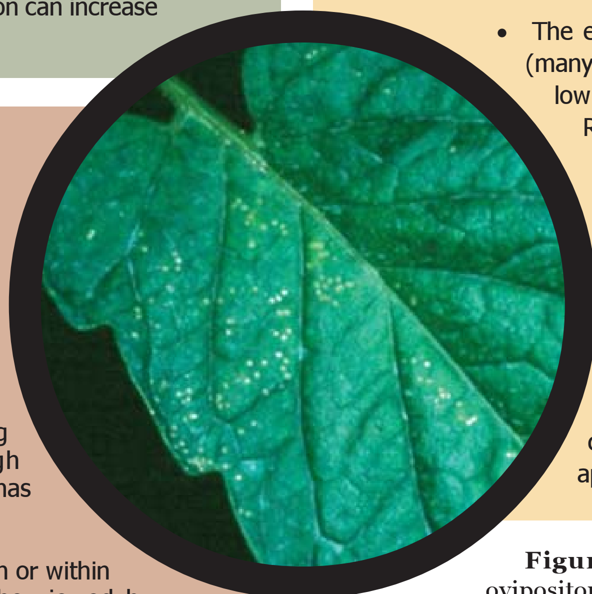

Figure 4. Females use their ovipositors to make large holes and feed on the exuding cell contents. Photograph by: Dave Schuster.

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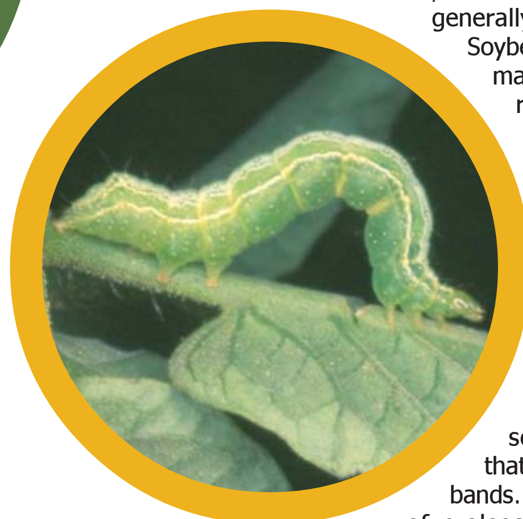
IPM Integrated Pest Management Florida — UF UNIVERSITY of FLORIDA IFAS Extension

Cabbage Looper: *Trichoplusia ni*
Soybean Looper: *Pseudoplusia includens*

Biology & Lifecycle: Females lay flattened, finely ridged eggs singly on the undersides of leaves. Young larvae feed underneath leaves, leaving the upper leaf epidermis intact to form "windows." Older larvae chew irregular holes. Larvae usually pupate underneath leaves in a loose silk cocoon **(Figure 4)**. The number of larval stages varies from 5-7 and the egg to adult period lasts about 2-4 weeks for the cabbage looper and 4-5 weeks for the soybean looper.

Environmental Factors: Loopers are present year round in south Florida, but are usually more active from August-October and April-June. Adults migrate to northern areas in the spring.



Adult: Large moths with wingspans of about 1-1/4 to 1-3/4 inches. Forewings are generally dark with lighter patches. Soybean looper moths have silvery markings on the forewings that resemble a "dog leg" with detached "foot." The silvery markings on the forewing of the cabbage looper are "U"-shaped and a circle or dot that often are connected **(Figure 1)**.

Larvae: Pale green with distinct white stripes down the sides **(Figure 2)**. On the top surface there are several smaller white stripes that are clustered into two broad bands. Larvae only have three pairs of prolegs and crawl by sequentially arching then straightening, giving them the appearance of "looping" along.

Host range: The two looper species have wide host ranges including tomato and pepper. The cabbage looper appears to prefer crucifer crops while the soybean looper prefers soybean. The insects over summer on a variety of weeds including dock (*Rumex* spp.), lambsquarters (*Chenopodium album*) and wild lettuce (*Lactuca* spp.) for the cabbage looper; and dock, pigweed (*Amaranthus* spp.), cocklebur (*Xanthium* spp.), wild sunflower (*Helianthus* spp.) and pepperweed (*Lepidium virginicum*) for the soybean looper.

Damage to Tomato: Larvae damage plants by consuming foliage, but usually do not inflict extensive defoliation to tomato or pepper. Sometimes fruit are attacked and, when this occurs in Florida, the soybean looper is often the culprit **(Figure 3)**.

Figure 1. Cabbage looper adult. Photograph by: Lyle Buss.

Figure 2. Looper larva on tomato leaflet. Photograph by: Dave Schuster.

Figure 3. Fruit damage by looper larva. Photograph by: Dave Schuster.

Actual Size:

Late instar larvae
about 1¼ inch

Monitoring:

Scouting: Black light and pheromone baited traps can be used to monitor adult activity. Whole plants are inspected season long for larvae, concentrating on foliage with fresh feeding.

Action Thresholds: 1 larva per 6 plants

Prepared by: Dr. David Schuster

Cabbage Looper: *Trichoplusia ni*
Soybean Looper: *Pseudoplusia includens*

CULTURAL CONTROLS:

Field Manipulations: Weeds and old crops can be reservoirs of migrating adults.

Tomato and pepper crops should not be planted near or adjacent to soybean or crucifer fields or fields with the weeds indicated on pg. 53.

NATURAL ENEMIES:

- Parasitic wasps attack looper eggs (*Trichogramma* spp.) and larvae, especially *Copidosoma floridanum*.
- Parasitic flies and a nuclear polyhedrosis virus attack larvae.
- Generalist predators, including big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.) and minute pirate bugs (*Orius* spp.) are known to feed on loopers.
- Timed insecticide applications and the use of selective insecticides can enhance biological control.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.
- Products containing *Bacillus thuringiensis* have been particularly useful and conserve natural enemies.

RESISTANCE MANAGEMENT:

- Products containing *B. thuringiensis* var. *kurstaki* (11B2) and *B. thuringiensis* var. *aizawai* (11B1) should be rotated with each other and with conventional insecticides of different chemical classes.

Figure 4. Cabbage looper pupa. Photograph by: James Castner.

Figure 5. Mature larva. Photograph by: James Castner.

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Stewart, S. 2002. Soybean Looper: Biology and Approaches for Improved Management. MS State Univ. Ext. Serv., Information Sheet 1400, http://msucares.com/pubs/infosheets/is1400.htm.

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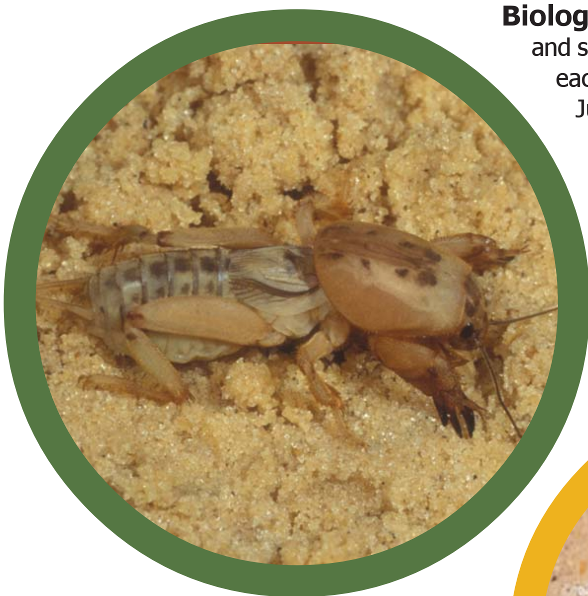
Tawny Mole Cricket: *Scapteriscus vicinus*
Shortwinged Mole Cricket: *Scapteriscus abbreviatus*



Biology & Lifecycle: Adults and larger nymphs chew on stems of seedlings and smaller plants at the soil surface. The tawny mole cricket has one generation each year and overwinters as adults, which lay eggs in April through early June. Nymphs grow slowly through the summer months and start becoming adults in September. The shortwinged mole cricket is almost restricted to coastal areas. Most eggs are laid in late spring through early summer. Females of both species lay clutches of eggs in underground egg chambers.

Environmental Factors: Tawny and shortwinged mole crickets are present year-around, with adults and large nymphs overwintering but inactivated by cold temperatures and drought (they burrow deeper underground). Irrigation during drought allows them to be active. Flooding forces them to migrate to higher ground.

Adult: Adults are large, about 1¼ inches, with wings longer than body (tawny mole cricket **(Figure 3)**) or very much shorter than body (shortwinged mole cricket **(Figure 1)**). Both adults and nymphs have enlarged and toothed forelegs for digging; expanded femurs (base of the hind legs) for jumping, although only nymphs jump. All species have soft bodies, with the middle body section protected by a hardened cover (pronotum).

Immature: Nymphs range from less than 1/8 inch at hatching to about 1 inch several months later, resembling the adults but without trace of wings in the first 4 instars and with small wing buds in later instars. The number of molts varies from 6 to 9 **(Figure 5)**.

Host range: Both species attack seedlings of eggplant, sweet pepper, tobacco, tomato and cabbage.

Economic Importance: Mole crickets cause more damage to turf and pasture grasses than tomato and pepper because of the use of soil fumigants.

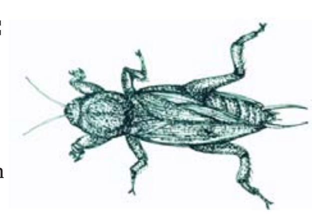
Damage: Mole crickets kill plants by girdling and severing small plants at the soil surface **(Figure 4)**. Severed plants may be pulled below ground to be consumed. Both the tawny and shortwinged and a third pest mole cricket species, southern mole cricket, disturb roots and desiccate plants by tunneling as well.

Figure 1. Shortwinged mole cricket adult. Photograph by: Lyle Buss.

Figure 2. Shortwinged mole cricket eggs are buried in chambers in the soil. Photograph by: Lyle Buss.

Figure 3. Tawny mole cricket adult. Photograph by: Lyle Buss.

Actual Size:



Adult
about 1¼ inch

Monitoring:

Scouting: Galleries (tunnels just under the soil surface, like miniature mole galleries) are evidence of presence. Dead plants are evidence of activity. Mole crickets may be flushed from the soil by flooding a small area with a 0.5% soap solution. No thresholds have been developed.

Prepared by: Dr. Howard Frank

Tawny Mole Cricket: *Scapteriscus vicinus*
Shortwinged Mole Cricket: *Scapteriscus abbreviatus*

CULTURAL CONTROLS:

Transplants: Use larger transplants with larger stems.

Field Manipulations: Mole crickets can quickly invade fields cleared of crickets with fumigation or other methods. Therefore, locate fields away from sources of mole crickets (such as bahiagrass or bermudagrass pastures) and plant in large blocks with proportionally little edge.

NATURAL ENEMIES:

- Buy and apply the beneficial nematode *Steinernema scapterisci* in spring or fall. Populations of this nematode should establish permanently (but will be destroyed in strips where soil is fumigated). It is harmless to non-target organisms and is exempt from EPA regulations.
- Encourage a population of the beneficial wasp *Larra bicolor* F. by planting suitable nectar source plants for the adult wasps. The wasp lays eggs on pest mole crickets, and the wasp grubs that hatch from the eggs kill the mole crickets.UF/IFAS is distributing these wasps to all Florida counties [see http://molecrickets.ifas.ufl.edu/mcri0007.htm].
- The parasitoid *Ormia depleta* was imported from Brazil and distributed to many southern counties. It is attracted to the calls of male mole crickets and has resulted in reduced mole cricket injury in southern Florida.

CHEMICAL CONTROLS:

- The use of broad spectrum soil fumigants under plastic film kills mole crickets in the planting bed; however, crickets survive in the untreated area between rows and can re-invade the treated planting beds. Commercial baits can be applied between beds to control residual crickets.

RESISTANCE MANAGEMENT:

- Integrating chemical and biological controls, including both parasitoids and nematodes, reduces the reliance on chemicals for management.

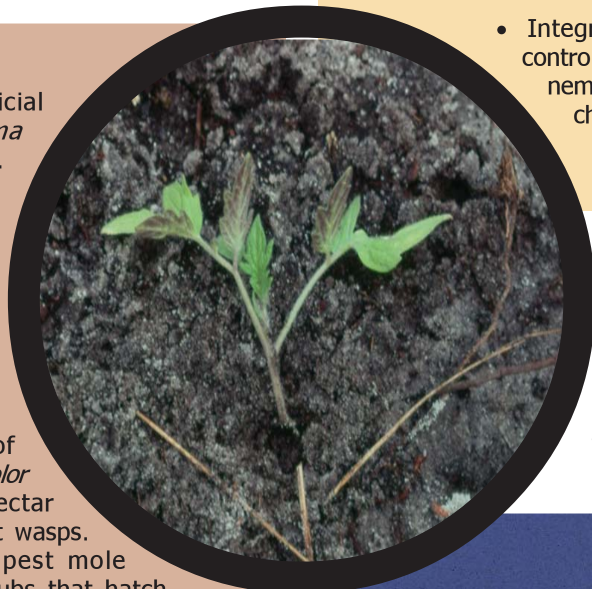


Figure 4. Seedling severed at soil surface by mole cricket feeding. Photograph by: David Schuster.

Figure 5. Short winged mole cricket life cycle. Photograph by: James Castner.

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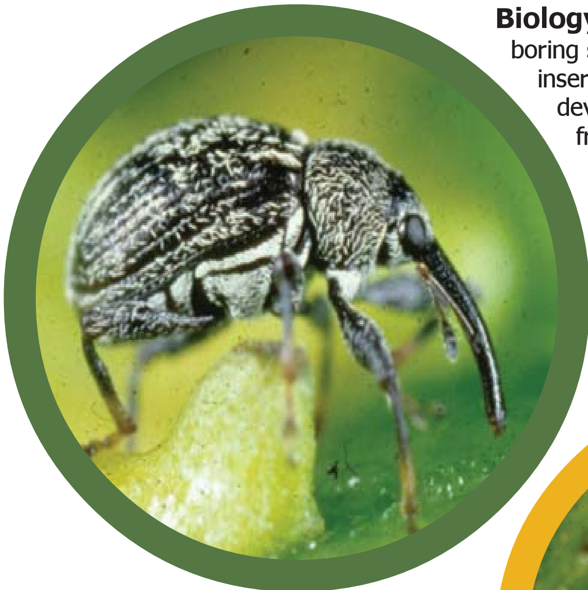
Pepper Weevil: *Anthonomus eugenii*



Biology & Lifecycle: Adults feed on vegetative buds, flower buds and fruit by boring small holes. Females bore holes in flower buds and small, immature fruit, insert an egg and seal the hole with a liquid that darkens and hardens. Larvae develop and pupate inside the buds or fruit. Larvae feed in the pod wall of fruit and migrate to the seed core. Larvae pupate in cells formed with anal secretions. Adults chew their way out through a circular hole, mate and begin laying eggs within a few days. The egg to adult period takes about 2 weeks at temperatures above 80°F and adults can survive 3-4 months if food is available.

Environmental Factors: Present year round, but most abundant March-June. Insects over summer on volunteer or abandoned pepper plants and on nightshade.

Adult: Small (1/8 inch), black oval shaped beetles with a long snout and elbowed antennae. They appear 'dusted' due to the presence of small scales **(Figure 1)**. Adults are found on vegetative and flower buds and on fruit.

Larvae: Small, white legless grubs with yellowish brown heads **(Figure 2)**. The 3 larval stages range in size from about 1/16 to 1/5 inch in length and all occur inside buds and fruit.

Host range: Pepper weevils attack all species of pepper (*Capsicum* spp.) as well as nightshades (*Solanum* spp.). American black nightshade (*S. americanum*) is an important alternative host plant. If the weed is left unmanaged, pepper weevil populations can be maintained during the summer and migrate to fall pepper plantings.

Damage: Feeding destroys flower buds and immature fruit. Larvae feed on the developing seeds inside fruit and cause the core to brown and sometimes become moldy **(Figure 3)**. Infested fruit have yellow calyxes and stems, turn yellow or red at the base prematurely and fall from the plant. Fruit drop is the most common and noticeable sign of infestation **(Figure 4)**. Feeding punctures by adults can provide an entry point for fungal disease **(Figure 5)**.

Figure 1. Adult Pepper Weevil. Photograph by: Jeff Brushwein.

Figure 2. Pepper weevil larva developing inside a Bell pepper. Photograph by: David Schuster.

Figure 3. Pepper sliced open to show damage and frass from pepper weevil feeding. Photograph by: E. Rodriguez.

Actual Size:

Adult
About 1/8 inch

Larvae
1/16-1/8 inch

Monitoring

Traps: Commercially available pheromone-baited, yellow sticky traps should be placed on the perimeters of fields prior to bloom. The bottoms of the traps should be just at or slightly above the top of the plant canopy and trap height should be adjusted as the plants grow. Traps should be monitored at least twice a week and treatments initiated when the first adult is captured.

Scouting: Inspect two terminal, vegetative buds per plant in the morning at least twice weekly. Sampling should be concentrated on field perimeters.

Action Thresholds: 1 adult per 400 terminal buds
1 adult per trap

Prepared by: Dr. David Schuster

Pepper Weevil:
Anthonomus eugenii

CULTURAL CONTROLS:

Start Clean: Inspect transplants for adults.

Field Sanitation: All cull, damaged and fallen fruit should be removed from the field and destroyed. Examine some of the dropped fruit for larvae **(Figure 4)**.

Field Manipulations: Abandoned fields provide food and shelter for pepper weevils to reproduce. Therefore, pepper fields should be deep plowed (at least 10 inches) block by block immediately after harvest.

Sequential plantings in nearby fields should be avoided.

Volunteer pepper and nightshade plants should be destroyed year round, but especially during the summer off season.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is met.
- Insecticide treatments target adults because all other stages are protected within the fruit.

RESISTANCE MANAGEMENT:

- Pyrethroid insecticides (many products, IRAC Group 3) are no longer effective.
- Following cultural controls to delay and reduce infestations and using action thresholds to initiate sprays may reduce the number of sprays and slow the development of resistance.
- Chemicals of different classes should be rotated **(see Appendix 5)**.

NATURAL ENEMIES:

- Parasitic wasps have been observed attacking weevil larvae in Florida, with *Catolaccus hunteri* being the most abundant. Releases of this parasitoid on field perimeters and in young pepper crops have reduced pepper weevil damage.
- Avoidance of broad spectrum insecticides will help conserve natural enemies and may enhance biological control.

Figure 4. Fruit drop is a common sign of infestation by the pepper weevil. Photograph by: David Schuster.

Figure 5. Newly emerged adults chew holes through fruit wall rendering them unmarketable. Photograph by: David Schuster.

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Tomato Russet Mite: *Aculops lycopersici*

Biology & Lifecycle: Eggs are laid on the undersides of leaves, on leaf petioles and on stems on the lower portion of plants. The two nymphal instars usually do not move far from where they hatched and tend to congregate on the edges of leaves. When damage to lower plant parts increases, the mites move up to younger foliage. As plants begin to die, mites may aggregate at the highest parts of the plants and are picked up and spread by the wind. The egg to adult period is less than a week in warm weather.

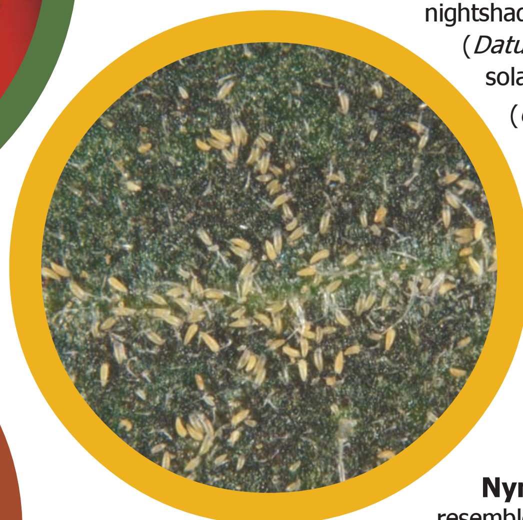
Environmental Factors: Russet mites may be present year round, but are more abundant during hot, dry weather such as occurs April-June. The source of infestations is uncertain but may arise from nightshades (*Solanum* spp.), jimson weed (*Datura stramonium*), petunia, other solanceous plants and field bindweed (*Convolvulus arvensis*).

Adult: Very small: requiring a 14x hand lens to be observed. The mite is tapered and wedge shaped, with two pairs of legs at the broader head end and long hairs on the tapered, posterior end. Generally translucent and yellowish, tan or pink **(Figure 3)**.

Nymphs: The two nymphal stages resemble smaller versions of the adults.

Host range: The russet mite feeds primarily on plants in the family Solanaceae. Vegetables that are attacked include tomatoes, eggplant, pepper, potato and tomatillo; however, in Florida damage has only been observed on tomato.

Damage: Adults and nymphs have piercing-sucking mouthparts and feeding on the undersides of lower leaves and on petioles and stems produces a greasy appearance, which becomes bronzed **(Figures 1 & 5)**. Leaves may yellow, curl upwards, dry out and drop. Damage starts at the bottom of plants and moves upward and may be confused with nutritional deficiencies, plant disease or water stress. The mite was rarely damaging in Florida, but recently has increased in incidence.



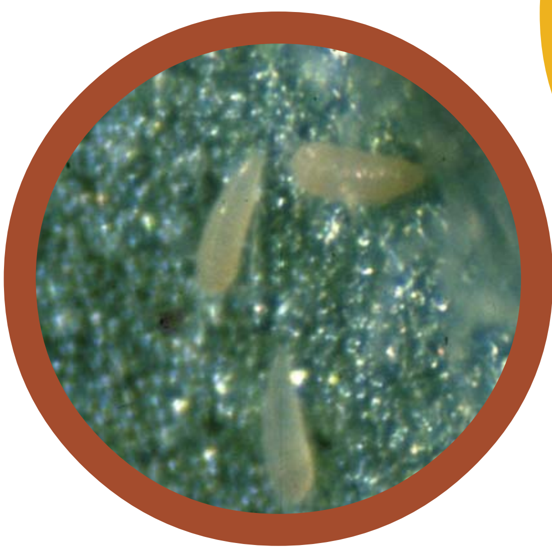


Figure 1. Progression of damage by tomato russet mite. Photograph by: Dave Schuster.

Figure 2. A large infestation of tomato russet mites on the tomato leaf. Photograph by: Lyle Buss.

Figure 3. Tomato russet mites feeding on tomato leaf. Photograph by Dave Schuster.

Actual size:

Adults are minute and coneshaped.

Monitoring:

Scouting: Because of the minute size of the mites, monitoring is usually done by watching for damage and then confirming mite presence with a hand lens or with a microscope.

Action Thresholds: None

Prepared by: Dr. David Schuster

Tomato Russet Mite: *Aculops lycopersici*

CULTURAL CONTROLS:

Start Clean: Transplants should be free of eggs, nymphs or adults.

Field Manipulations: Planting in hot, dry periods should be avoided.

New crops should not be planted near infested crops and infested crops and weeds should be destroyed.

The movement of people or equipment from infested to uninfested areas should be avoided.

CHEMICAL CONTROLS:

- Miticides should be applied when damage is observed and the presence of mites is confirmed. Sulfur has long been used to manage russet mites, but endosulfan (cylcodiene organochlorine, 2A) and other new miticides are effective.

RESISTANCE MANAGEMENT:

- No resistance has been reported in Florida.
- Rotation of products of different chemical classes is an important resistance management tactic.

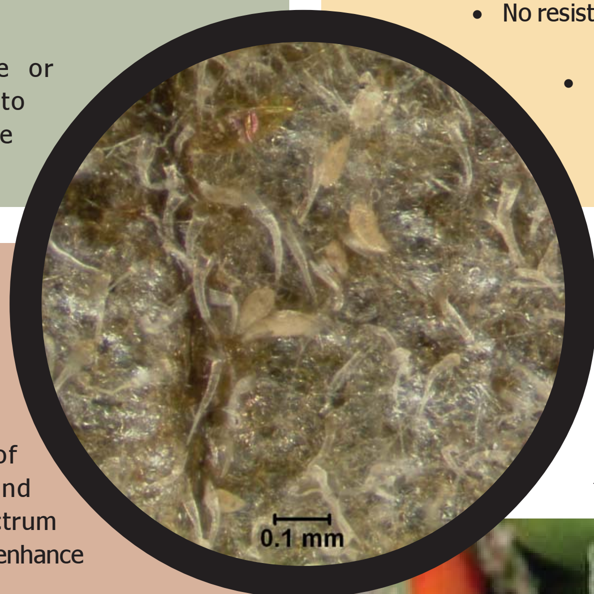


Figure 4. Tomato russet mites. Photograph by: Lyle Buss.

Figure 5. Leaves and stems damaged by tomato russet mite turn bronze. Photograph by: Jack Kelly Clark, University of California Statewide IPM Program.

NATURAL ENEMIES:

- Predatory mites are the major natural enemies of russet mites.
- Timed applications of selective miticides and avoidance of broad spectrum insecticides/miticides may enhance biological control.

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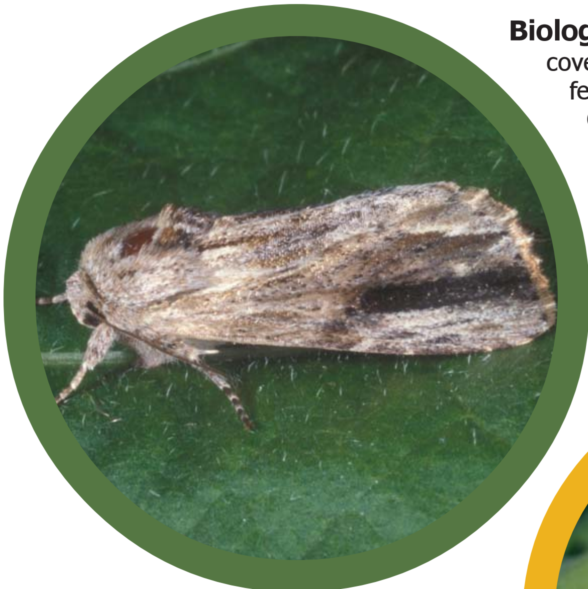
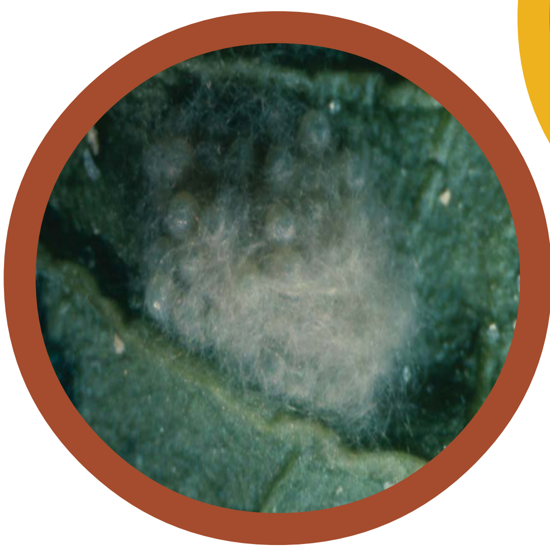
Southern Armyworm: *Spodoptera eridania*



Biology & Lifecycle: Female adults lay clusters of greenish-white eggs and cover them with hair like scales from their bodies **(Figure 3)**. Hatching larvae feed gregariously, leaving the upper leaf surface intact and forming "windows." Older larvae disperse throughout the same and adjacent plants and eat holes in leaves, resulting in a shot hole appearance. Mature larvae drop to the soil, often on the edge of the plastic mulch covering the production beds, and form a cell about 2-5 inches deep and pupate inside. The egg to adult period lasts about 4-6 weeks.

Environmental Factors: The southern armyworm is active year round, but is usually more abundant in tomato and pepper during warmer months in both the spring and fall. The insect may over summer on volunteer plants and numerous weed species, especially pigweed (*Amaranthus* spp.) and pokeweed (*Phytolacca americana*).

Adult: Moderate sized nocturnal moths with a wing span of about 1¼ to 1½ inches. Front wings are gray and brown, with an irregular banding pattern, and may have either a bean shaped white spot in the middle or a black band extending from the center to the edge **(Figure 1)**.



Larvae: Orangish heads and green to black-green bodies with three narrow yellow or white stripes on the dorsal surface **(Figure 2)**. A broader yellow stripe on the side is broken by a black spot on the first, often swollen, body segment behind the true legs.

Host range: The southern armyworm has a very wide host range and can be a pest of many vegetable crops, including both tomato and pepper; however, the pest is often more abundant on tomato.

Damage to Tomato: Larvae may complete development on foliage **(Figure 5)** but inflict most damage when they feed on fruit, causing shallow holes or gouges **(Figure 4)**. Damaged fruit are rendered unmarketable and may rot due to invasion of secondary microorganisms.

Figure 1. Southern armyworm adult female. Photograph by: Lyle Buss.

Figure 2. Southern armyworm larva. Photograph by: David Schuster.

Figure 3. Armyworm eggs on pepper leaf. Photograph by: David Schuster.

Actual Size:

Larva
<2 inches

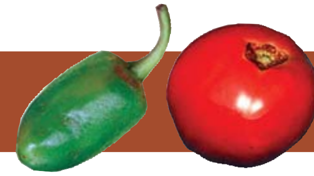
Monitoring:

Scouting: The whole plant (when small) or the terminal three leaflets of the 3rd or 7th leaf can be examined for the presence of eggs. Newly damaged foliage can be examined for the presence of larvae. A sample of 10 fruit is examined for damage and the presence of recent damage.

Action Thresholds: one larva per 6 plants pre-bloom
one egg or larva per 6 plants post-bloom

Prepared by: Dr. David Schuster

Southern Armyworm:
Spodoptera eridania



CULTURAL CONTROLS:

Start Clean: Tomato and pepper fields should not be planted near or adjacent to old, infested fields.

Field Manipulations: Fields should be destroyed immediately after final harvest by applying a foliar herbicide to destroy infested plants and by deep disking to destroy pupating larvae.

Volunteer plants and weed hosts should be destroyed during the summer off season by frequent disking.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.

- Insecticides should be timed to treat eggs and hatching larvae for best control. Older larvae may be more difficult to control.

RESISTANCE MANAGEMENT:

- No resistance has been reported to any insecticide in Florida. Chemicals of different classes, especially the newer reduced risk insecticides, should be rotated.

NATURAL ENEMIES:

- The most important species of parasitic wasps observed attacking larvae include *Meteorus autographae*, *Cotesia marginiventris* and *Chelonus insularis*.

- Generalist predators, including big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.) and minute pirate bugs (*Orius* spp.) may attack eggs and young larvae.

- Natural enemies can be conserved by avoiding broad spectrum pyrethroid, organophosphate and carbamate insecticides.

- Fewer insecticide applications and applications of new, reduced risk insecticides can also enhance biological control.

Figure 4. Shot hole damage to fruit by southern armyworm larvae Photograph by: David Schuster.

Figure 5. Early instars feeding. Photograph by: Lyle Buss.

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IPM Integrated Pest Management Florida

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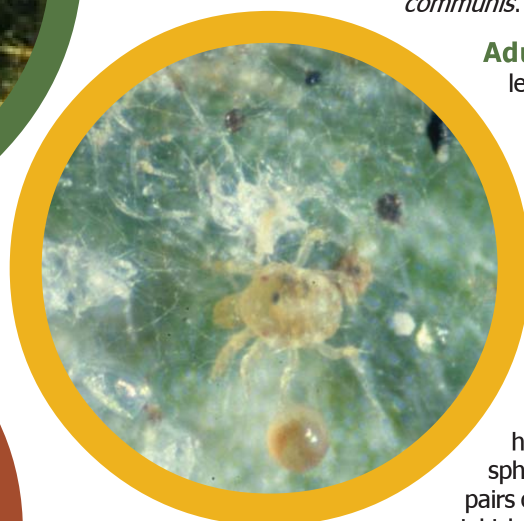
Twospotted Spider Mite: *Tetranychus urticae*
Spider Mite: *Tetranychus evansi*

Biology & Lifecycle: Eggs are laid singly on the undersides of lower leaves, which are covered with silk strands. There is one larval instar and two nymphal instars, all of which occur on the undersides of lower leaves. The population will move up to younger foliage as mite densities increase. At very high densities, mites may aggregate at the highest parts of the plants and are picked up by the wind via a silk strand and dispersed **(Figure 4)**. The egg to adult period is one to two weeks.

Environmental Factors: Present year round, but are usually more abundant during hot, dry weather such as occurs April-June. The mites over summer on volunteer plants and on weeds such as American black nightshade, *Solanum americanum* and castor bean, *Ricinus communis*.



Adult: Adults are about 0.5mm in length and have four pairs of legs. Females are oval shaped, males are triangular-shaped and both sexes have dark spots on either side of the top of the body. *T. urticae* is usually greenish yellow or nearly translucent **(Figure 1)** and *T. evansi* is reddish-orange; however, *T. urticae* may also have reddish-orange forms.

Immatures: The stage hatching from the eggs is the spherical larval stage, which has three pairs of legs and is translucent, yellowish or pinkish. The next two nymphal stages resemble the adults and are green to red and have four pairs of legs **(Figure 2)**.

Host range: Both *T. urticae* and *T. evansi* have broad host ranges. The former attacks numerous vegetables, with tomato, bean and cucurbit crops being attacked most often. In Florida, the spider mite most often found attacking solanaceous crops like tomato, eggplant and potato is *T. evansi*. Tomatoes are more often attacked than pepper.

Damage to Tomato: Adults, larvae and nymphs have piercing-sucking mouthparts Feeding on the undersides of lower leaves produces yellow spotting or stippling on the upper surfaces **(Figure 3)**. Leaves may turn yellow to bronze, desiccate and drop. Damage may appear to be due to nutritional deficiencies or plant disease to the untrained eye.

Figure 1. *T. urticae* adults on leaf. Photograph by: James Castner.

Figure 2. *T. evansi* nymph, egg and silking on tomato. Photograph by: Dave Schuster.

Figure 3. Leaf stippling by spider mite feeding on underside of leaf. Photograph by: Dave Schuster.

Actual Size:

Adult
0.5mm

Monitoring:

Scouting: The undersides of the terminal three leaflets of one leaf per six plants are examined for the presence of mites. Leaf damage may be ranked 1-5, where 1 is few yellow stipples and 5 is total leaf area covered with stippling and dry patches present.

Action Thresholds: 10 adults, larvae or nymphs per plant or damage ranking of 2 or above

Adult *T. evansi*. Photograph by: Dave Schuster.

Twospotted Spider Mite: *Tetranychus urticae*
Spider Mite: *Tetranychus evansi*

CULTURAL CONTROLS:

Start Clean: Transplants should be free of eggs, larvae, nymphs or adults.

Field Manipulations: Planting in hot, dry periods should be avoided. Dusty conditions interfere more with mite predators than with spider mites, which are partially protected by their silk webbing.

Increasing plant spacing and applying overhead irrigation may reduce mite infestations.

Excessive nitrogen should be avoided and plants should not be water stressed.

New crops should not be planted near infested crops and infested crops and weeds should be destroyed.

NATURAL ENEMIES:

- Spider mites are often kept in check by numerous natural enemies, especially predaceous mites. Predaceous mites can be distinguished from spider mites because they have longer legs, they are more active and they are often red or orange in color.
- Releases of commercially available predaceous mites have been successful for managing spider mites on greenhouse crops, but limited releases on field-grown tomatoes in Florida have been unsuccessful to date.
- Timed applications of selective miticides and avoidance of broad spectrum insecticides/ miticides can enhance biological control.

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CHEMICAL CONTROLS:

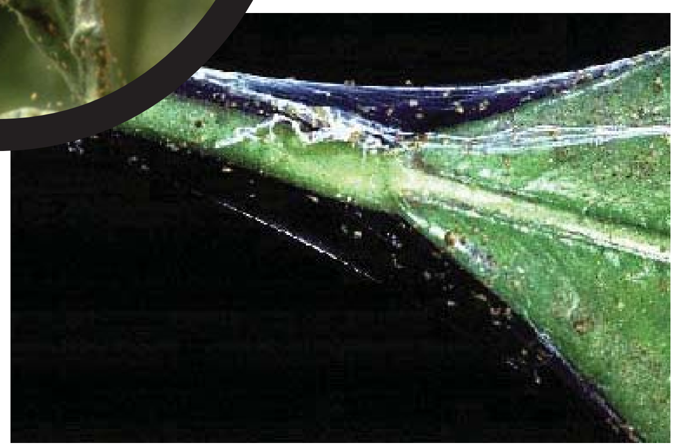
- Miticides should be applied when the action thresholds are reached. The heavy silk webbing associated with higher mite populations provides some protection from miticides and may make control more difficult.

RESISTANCE MANAGEMENT:

- Resistance to Agri-Mek® (avermectins, 6) in *T. urticae* has been documented in Florida, but resistance has been managed with judicious use and rotation with other chemical classes.

Figure 4. Spider mites aggregating for wind dispersal. Photograph by: Dave Schuster.

Figure 5. Webbing produced by twospotted spider mites. Photograph by: James Castner.



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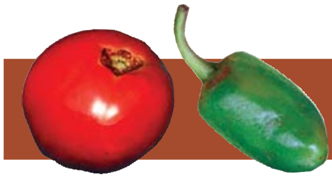
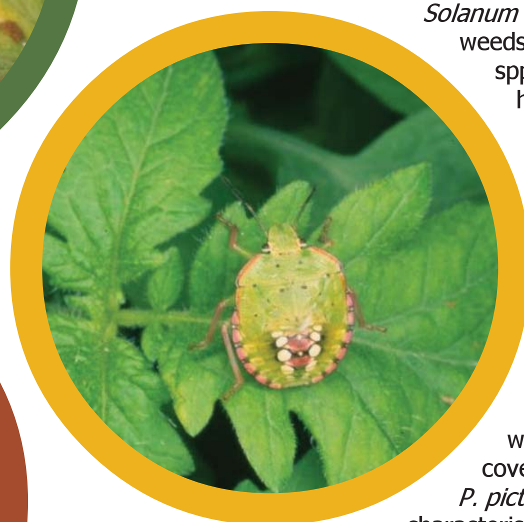


Stink bugs & Leaffooted bugs:

Southern Green Stink Bug – *Nezara viridula* **Brown Stink Bug** – *Euschistus servus*
Leaffooted Bugs – *Leptoglossus phyllopus; Phthia picta*

Biology & Lifecycle: Female stink bugs lay barrel-shaped eggs in clusters of 20 or more on the undersides of leaves. Eggs of leaffooted bugs are metallic and ovate, or sometimes flattened laterally, and are laid in rows on stems or in clusters along veins under leaves **(Figure 6)**. Nymphs aggregate upon hatching but soon disperse throughout the plant. There are usually five nymphal stages and the egg to adult period lasts about 30 days.

Environmental Factors: Stink bugs and leaffooted bugs are present year round, but are usually more abundant April-June. The insects over summer on weeds such as American black nightshade, *Solanum americanum* and on leguminous weeds and cover crops such as *Sesbania* spp, beggarweed (*Desmodium* spp.), hairy indigo (*Indigofera hirsuta*) and *Aeschynomene* spp.



Adult: Adult stink bugs are shield-shaped **(Figure 1)** and about ½ inch in length. Leaffooted adults are ¾ inch in length with parallel sides. Stink bugs are usually pale green or light brown, while leaffooted bugs are usually darker brown. *L. phyllopus* has a white band running across the wing covers and has the hind tibia flattened. *P. picta* **(Figure 4)** has neither of these characteristics.

Nymph: Stink bug nymphs are similar in shape to adults but are more rounded and may be brightly colored in black, green, orange and white **(Figure 2)**. Leaffooted bug nymphs are also similar in shape to adults, but are colored bright orange.

Host range: Stink bugs and leaffooted bugs are polyphagous and attack plants in many plant families. Vegetables commonly attacked include bean, cucumber, pea, pepper, squash and tomato. The southern green stink bug shows a preference for legumes and crucifers, while the leaffooted bug reportedly prefers thistles.

Figure 1. Adult Southern Green Stink Bug, *Nezara viridula*. Photograph by: David Schuster.

Figure 2. Southern Green Stink Bug nymph. Photograph by: David Schuster.

Figure 3. Stinkbug feeding damage. Photograph by: David Schuster.

Damage: Both adults and nymphs of stink bugs and leaffooted bugs have piercing-sucking mouthparts and feed on leaf, stem and blossom tissue; however, fruit feeding causes the most damage. Stink bug feeding on tomato and pepper fruit appears as pinpricks surrounded by subsurface white, corky tissue that turns yellow upon ripening. Leaffooted bugs usually feed more deeply, resulting in misshapen and discolored fruit.

Actual Size:

Adult Stink bug
About ½ inch

Adult Leaffooted bug
About ¾ inch

Monitoring:

Scouting: Plants are not sampled prior to flowering. Post-bloom, whole plants are inspected for nymphs and adults. Gently shaking plants can cause adults to fly, making them easier to detect. After fruit set, 10 fruit per six plants are inspected for damage.

Action Thresholds: 1 nymph or adult per plant

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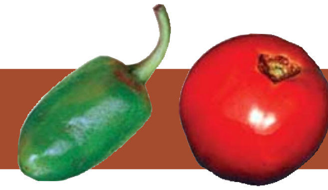

Stink bugs & Leaffooted bugs:

CULTURAL CONTROLS:

Field Manipulations: Weeds and senescent crops can be reservoirs of migrating adults. Tomato and pepper crops should not be planted near or adjacent to fields with legume cover crops or fields with weeds like nightshade, beggarweed or thistles.

Legume or crucifers may be used as trap crops, if the subsequent bug populations are managed.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.
- Insecticides used most often to control bugs include the pyrethroid insecticides (many products, 3) and endosulfan (several products, 2A).

RESISTANCE MANAGEMENT:

- No insecticide resistance in stink bugs or leaffooted bugs has been reported in Florida.

NATURAL ENEMIES:

- Parasitic wasps attack eggs and parasitic flies attack nymphs and adults.
- Generalist predators include fire ants (*Solenopsis invicta*), grasshoppers, big-eyed bugs (*Geocoris spp.*), damsel bugs (*Nabis spp.*) and spiders.
- Timed insecticide applications can enhance biological control.

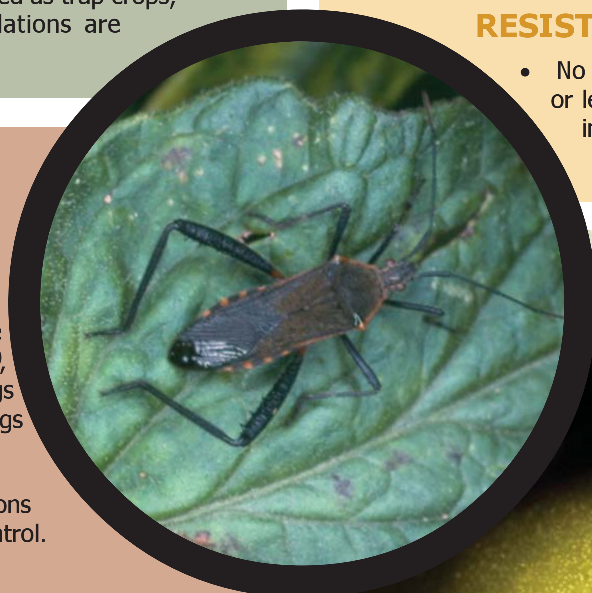

Figure 4. Adult Leaffooted bug, *Phthia picta*. Photograph by: Lyle Buss.
Figure 5. Leaffooted bug, *Leptoglossus phyllopus*, early stage nymph. Photograph by: David Schuster.
Figure 6. Top: Eggs of southern green stink bug, *Nezara viridula.* Photograph by: James Castner. Bottom: Leaffooted bug eggs. Photograph by: David Schuster.

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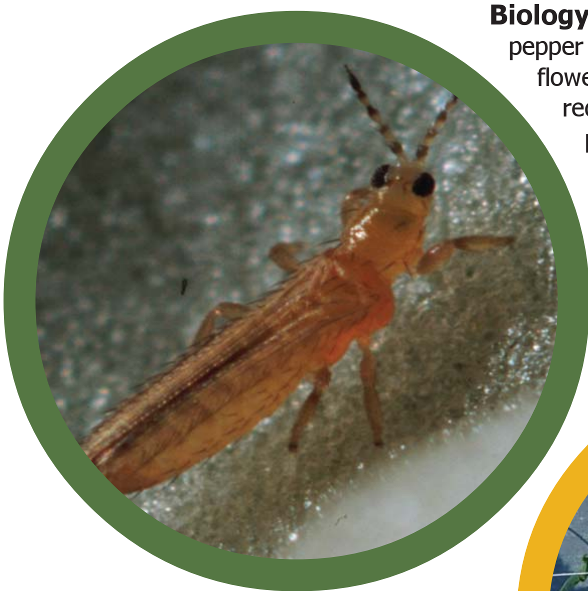
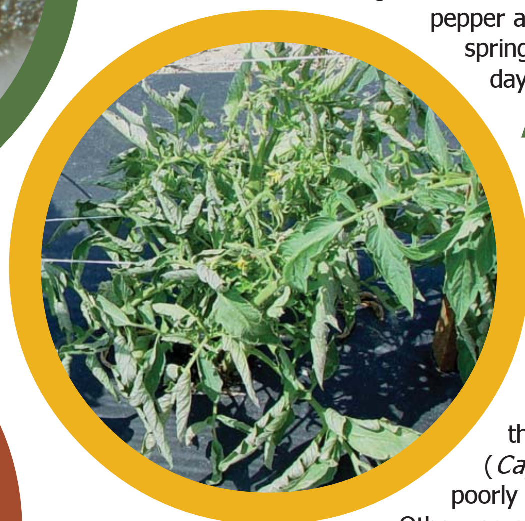
Florida Flower Thrips: *Frankliniella bispinosa*



Biology & Lifecycle: Adult thrips insert individual eggs into the flower tissues of pepper and tomato. The eggs hatch in about 5 days. Larval development in the flowers and small fruits requires 4 to 6 days. Pre-pupal and pupal development requires about 5 days. The pre-pupae move to the soil surface and the pupae occur just under the soil surface under the plant. The adults live 3 weeks or more and they feed primarily on flower tissues and pollen. Pollen-feeding increases fecundity.

Environmental Factors: Florida flower thrips live year-round in southern Florida. Populations are greatest during spring and summer in southern and central Florida and in late spring and summer in northern Florida. Large numbers of thrips migrate into tomato and pepper as the citrus bloom declines in the spring. A generational cycle takes 20 days or less in hot weather.



Adult: Very small ($^1/_{10}$ inch), light yellow with fringed wings and 8-segmented antennae. Adults aggregate in the flowers.

Larvae: Minute and white, both larval instars aggregate in the flowers and small fruit.

Host Range: Florida flower thrips reproduce poorly on peppers (*Capsicum* spp.) and even more poorly on tomatoes (*Lycopersicon* spp.). Other reproductive hosts in Florida include a wide range of crops, weeds and native plant species. Adults are commonly found in the flowers of tomato and pepper.

Economic Importance: Vectors *Tomato spotted wilt virus* (TSWV) which is the key pest of tomato, pepper and other crops in northern Florida. Problems with the disease are less severe in central and southern Florida.

Damage: Feeding by the adults and larvae on flowers and small fruits is rarely damaging to tomato or pepper. Feeding in blossoms can result in bloom drop, while feeding on small fruit can result in pitting of large fruit, primarily at the blossom end. TSWV transmission results in unmarketable fruit **(Figure 3)**.

Figure 1. Florida flower thrips adult female. Photograph by: Cheryle O'Donnell.

Figure 2. Tomato plant infected with TSWV. Photograph by: Hank Dankers.

Figure 3. Necrotic ring spots on tomato fruit infected with TSWV. Photograph by: Hank Dankers.

Actual Size:

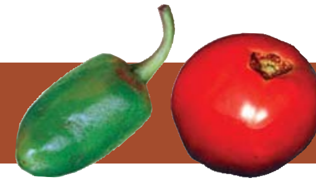
Adult
About $^1/_{10}$ inch

Monitoring:

Scouting: The total number of thrips of all species can be estimated in the field by beating individual flowers onto a white plastic board. Thrips must be placed in vials of alcohol and examined at 40X magnification using a stereoscope in order to distinguish Florida flower thrips from the other thrips species.

Action Thresholds: $\geq$ 10 thrips per flower
Incidence of spotted wilt incidence >5% in the field

Prepared by: Dr. Joe Funderburk



CULTURAL CONTROLS:

Ultraviolet-Reflective Mulch: UV-reflective mulch reduces the introduction of Florida flower thrips adults into production fields. This is the most effective tactic to control primary spread of TSWV (i.e. thrips acquire the virus when developing on plant hosts outside the field).

Do Not Over-Fertilize: Over-fertilization with nitrogen increases the number of thrips and the incidence of TSWV.

Resistant Cultivars: Cultivars resistant to TSWV are available for tomatoes and peppers.

Monitor: Frequent monitoring of once or twice weekly is needed to assess thrips numbers and to determine the incidence of TWSV.

Distinguishing the adults from the western flower thrips (*Frankliniella occidentalis*) and the eastern flower thrips (*Frankliniella tritici*) is not possible using a hand lens.

CHEMICAL CONTROLS:

- Spraying to control adult flower thrips is not economically justified.
- Insecticidal control of adult Florida flower thrips does **not** prevent primary spread of the TSWV.
- Insecticidal control of larvae developing on plants infected with TSWV is effective in preventing spread.
- Use reduced-risk insecticides that conserve minute pirate bug populations. Natural infestations of this predator in pepper typically control the Florida flower thrips.

RESISTANCE MANAGEMENT:

- Insecticide resistance has not been documented in populations of flower thrips.
- Employ alternative cultural control and plant resistance tactics in an IPM program as the best option to control thrips and avoid insecticide resistance development.

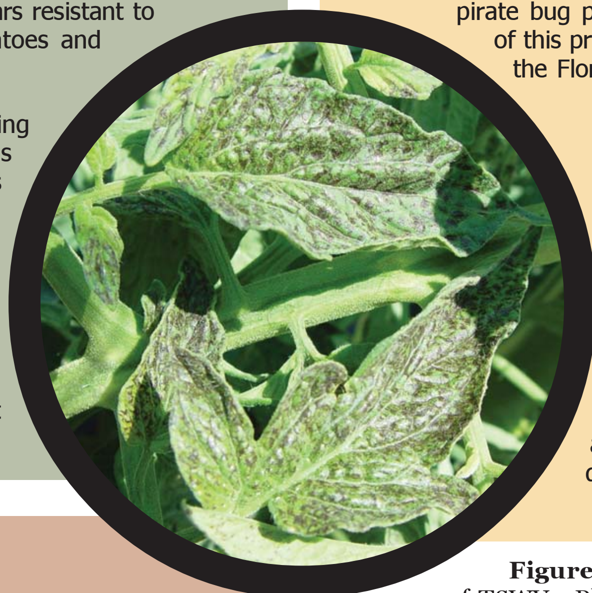


Figure 4. Tomato leaf with symptoms of TSWV. Photograph by: Hank Dankers.

NATURAL ENEMIES:

- The minute pirate bug, *Orius insidiosus,* naturally invades fields and is an important predator. Management programs for pepper and tomato should be designed to conserve its populations.

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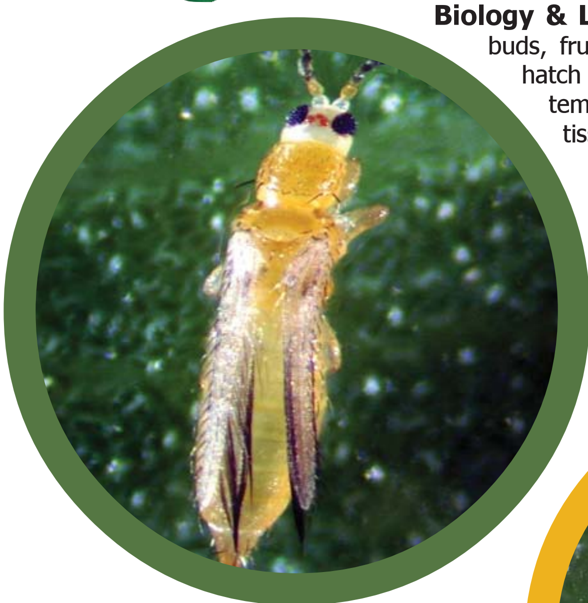
Melon Thrips: *Thrips palmi*



Biology & Lifecycle: Adult thrips insert individual eggs into the developing flower buds, fruit pods and under heavy populations, the leaves of pepper. The eggs hatch in about 8 days. Larval development requires 4 to 12 days depending on temperature. The adults live about 3 weeks and feed primarily on flower tissues and pollen.

Environmental Factors: Melon thrips live year-round in southern Florida. Populations are greatest in the winter and spring. A generational cycle takes about 20 days. Populations are not usually damaging in central Florida. Populations are not established in northern Florida.

Adult: Very small (1/10 inch), light yellow with fringe wings **(Figure 1)**. Adults aggregate in the flowers and small fruits.

Larvae: Minute and off-white **(Figure 2)**. Both larval instars aggregate in the flowers and small fruit of pepper, and sometimes are found on the leaves. The pre-pupae move to the soil surface and the pupae occur just beneath the soil surface under the plant.

Economic Importance: Cosmetic damage on fruits are an economic problem under some conditions in southern Florida.

Host range: Melon thrips reproduce on peppers (*Capsicum* spp). Pepper is a poorer host than winter melon (*Benincasa hispida*), eggplant or cucumber. Tomato is not a host. Other reproductive hosts in Florida include a wide range of crops, weeds and native plant species. The adults are common in the flowers feeding on the pollen of other plant species that are not reproductive hosts.

Damage: Feeding by the adults and larvae can result in flecking on the surface of fruit and under heavy infestations, fruit deformity **(Figure 3)**. The larvae and adults aggregate under the calyx and on the parts of the fruit touching leaves and stems. Damage can sometimes occur on leaves.

Figure 1. Melon thrips adult female. Photograph by: Kelly Sims.

Figure 2. Melon thrips larva. Photograph by: Kelly Sims.

Figure 3. Flecking on pepper due to feeding by the adults and larvae. Photograph by: Jyotsna Sharma.

Actual Size:

Adult
About 1/10 inch

Monitoring:

Scouting: The total number of thrips of all species and the number of minute pirate bugs can be estimated in the field by beating individual flowers, fruits and leaves onto a white plastic board. Differentiating melon thrips from other species under field conditions requires specific training and equipment. Thrips can be placed in vials of alcohol and examined at 40X magnification using a stereoscope in order to distinguish melon thrips from the common flower thrips species.

Action Thresholds: In pepper, 2 or 3 thrips larvae and adults per flower or fruit is tolerable. A ratio of one minute pirate bug per 180 thrips is adequate to result in suppression of thrips.

Prepared by: Dr. Joe Funderburk

Melon Thrips:
Thrips palmi

CULTURAL CONTROLS:

Ultraviolet-Reflective Mulch: UV-reflective mulch reduces the influx of migrating adults into production fields **(Figure 4)**.

Monitor: Frequent monitoring of once or twice weekly is needed to assess melon thrips numbers. Distinguishing the adults of melon thrips from the Florida flower thrips, *F. bispinosa,* and the western flower thrips, *F. occidentalis,* is not reliable using a hand lens.

NATURAL ENEMIES:

- The key natural enemy capable of suppressing populations is the minute pirate bug, *Orius insidiosus* **(Figure 5)**.
- These predators naturally invade fields, and management programs of pepper and other crops in Florida designed to conserve its populations.

CHEMICAL CONTROLS:

- Spray peppers with reduced-risk insecticides to conserve minute pirate bug, *Orius insidiosus,* populations when numbers of adults or larvae exceed the action threshold. Natural infestations of this predator typically control thrips for most of the production season.
- During periods of intense infestations, reducing thrips numbers below the action threshold with insecticides is not possible.
- Spraying broad-spectrum insecticides especially pyrethroids (numerous products; 3) suppresses populations of the predator minute pirate bug,and frequently results in a great buildup in melon thrips populations.

RESISTANCE MANAGEMENT:

- Melon thrips have developed resistance to organophosphate (several products; 1B) and pyrethroid (numerous products; 3) insecticides.
- Employ alternative cultural control and biological control in an IPM program as the best option to avoid the development of insecticide resistance.
- Rotation of chemical classes is a resistance management option, although it does not guarantee against the development of insecticide resistance.

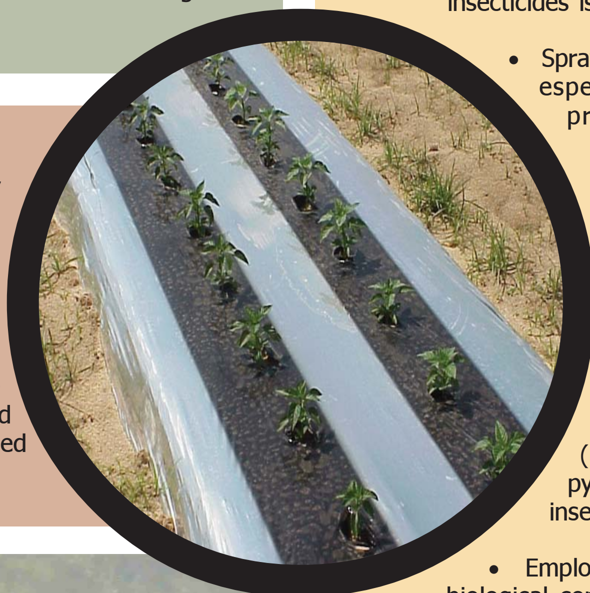


Figure 4. UV-reflective mulch with black strips to increase soil temperature. Photograph by: Joe Funderburk.

Figure 5. Biological control in action, the minute pirate bug preying on melon thips. Photograph by: Joe Funderburk.

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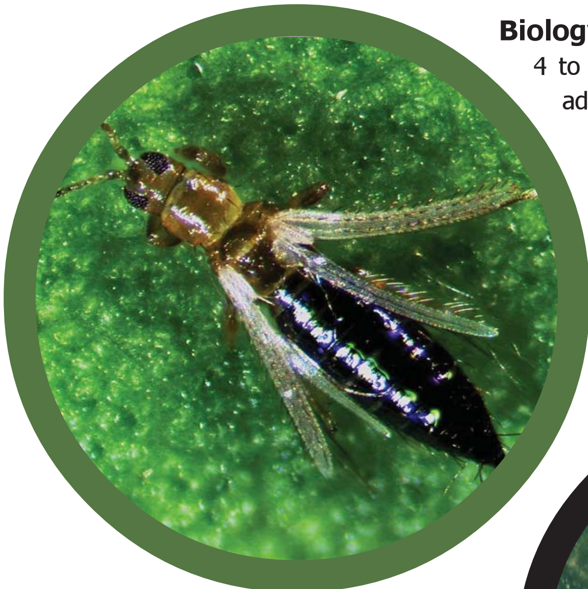
Tobacco Thrips: *Frankliniella fusca*



Biology & Lifecycle: Eggs hatch in about 6 days. Larval development requires 4 to 6 days. Pre-pupal and pupal development requires about 5 days. The adults live 3 weeks or more and they prefer to feed on flower tissues and pollen. Pollen-feeding increases fecundity. Tobacco thrips reproduce in peanuts (*Arachis hypogeae*) where the larvae acquire *Tomato spotted wilt virus* (TSWV). Adults migrate to nearby fields of tomato and pepper and transmit the virus.

Environmental Factors: Tobacco thrips live year-round in Florida. Populations are greatest during the spring. A generational cycle takes 20 days or more, depending on temperature.

Adult: Very small ($^{1}/_{10}$ inch), light brown to black with fringe wings and 8-segment antennae **(Figure 1)**. The adults aggregate in the flowers and are sometimes found on the foliage.

Larvae: Minute, off-white and wingless; both larval instars aggregate in the flowers and on developing fruit.

Host Range: Tobacco thrips do not reproduce on peppers (*Capsicum* spp.), and reproduce very poorly on tomatoes. Other reproductive hosts in Florida include a wide range of crops, weeds, and native plant species.

Damage: Feeding by the adults and larvae is not known to inflict economic damage on tomato or pepper. However, tobacco thrips vector TSWV, the key disease of tomato, pepper, and other crops in northern Florida **(Figures 3 & 4)**. The transmission of TSWV results in unmarketable fruit. Problems with the disease are less severe in central and southern Florida.

Figure 1. Tobacco thrips adult female. Photograph by: Kelly Sims.

Figure 2. Tobacco thrips adult male which looks similar to larvae but has wing pads. Photograph by: Lyle Buss.

Figure 3. Pepper plant infected with *Tomato spotted wilt virus*. Photograph by: Stuart Reitz.

Actual Size:

Adult
About $^{1}/_{10}$ inch

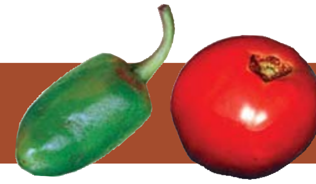
Monitoring:

Scouting: The total number of thrips of all species can be estimated in the field by beating individual flowers onto a white plastic board. Thrips must be placed in vials of alcohol and examined at 40X magnification using a stereoscope in order to distinguish Tobacco thrips from the other thrips species.

Action Thresholds: Incidence of tomato spotted wilt exceeds 5% in the field

Prepared by: Dr. Joe Funderburk

Tobacco Thrips:
Frankliniella fusca



CULTURAL CONTROLS:

Ultraviolet-Reflective Mulch: UV-reflective mulch reduces the influx of thrips adults into production fields. This is the most effective tactic to control primary spread of TWSV (i.e. thrips acquire the virus when developing on plant hosts outside the field).

Resistant Cultivars: Cultivars resistant to TSWV are available for tomatoes and peppers.

Monitor: Frequent monitoring of once or twice weekly is needed to assess thrips numbers and to determine the incidence of tomato spotted wilt. The adults of tobacco thrips can be distinguished from the adults of Florida flower thrips (*Frankliniella bispinosa*), western flower thrips (*Frankliniella occidentalis*) and the eastern flower thrips (*Frankliniella tritici*) by their distinctively darker coloration.

NATURAL ENEMIES:

- The minute pirate bug, *Orius insidiosus,* naturally invade fields and is an important predator. Management programs for pepper and tomato should be designed to conserve its populations.
- The most important natural enemy of tobacco thrips is the nematode parasite, *Thripinema fuscum*, which sterilizes the parasitized female thrips.

CHEMICAL CONTROLS:

- Spraying to control adult tobacco thrips is not economically justified.
- Insecticidal control of adult tobacco thrips does not prevent primary spread of the TSWV.
- Insecticidal control of larvae developing on plants infected with TSWV is effective in preventing spread.
- Reduced-risk insecticides should be used to conserve minute pirate bug populations in pepper.

RESISTANCE MANAGEMENT:

- Insecticide resistance has not been documented in populations of tobacco thrips.
- Employ alternative cultural control and plant resistance tactics in IPM programs as the best option to control thrips and avoid insecticide resistance development.

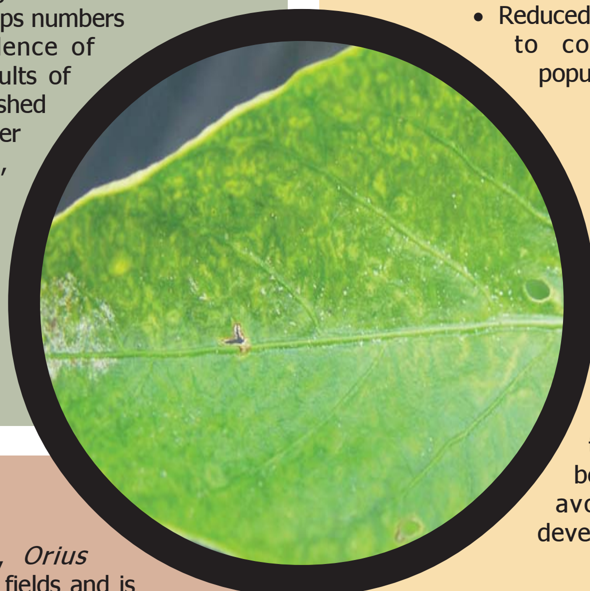


Figure 4. Ring spots from *Tomato spotted wilt virus* infection of pepper. Photograph by: Hank Dankers.

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Sims, K., J. Funderburk and D. Boucias. 2005. Host-parasite biology of *Thripinema fuscum* (Tylenchida: Allantonematidae) and *Frankliniella fusca* (Thysanoptera: Thripidae). Journal of Nematology 37: 4-11.

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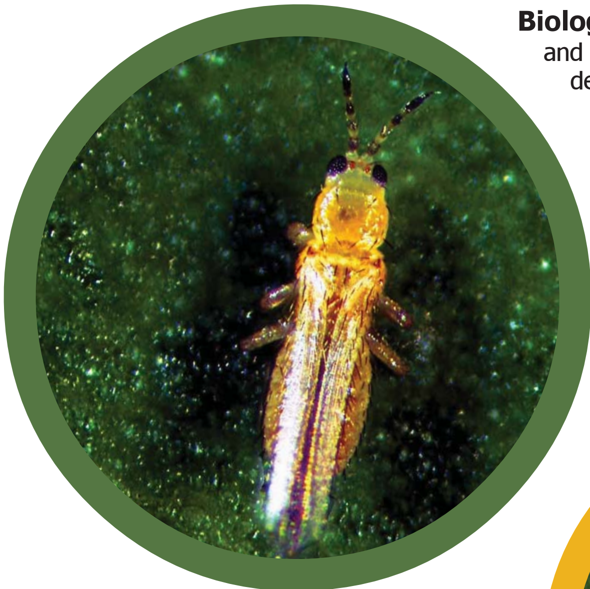
Momol, M.T., S.M. Olson, J.E. Funderburk, J. Stavisky and J.J. Marois. 2004. Integrated management of tomato spotted wilt on field-grown tomato. Plant Disease 88: 882-890.

Reitz, S.R., E.L. Yearby, J.E. Funderburk, J. Stavisky, M.T. Momol and S.M. Olson. 2003. Integrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field-grown pepper. Journal of Economic Entomology 96: 1201-1214.

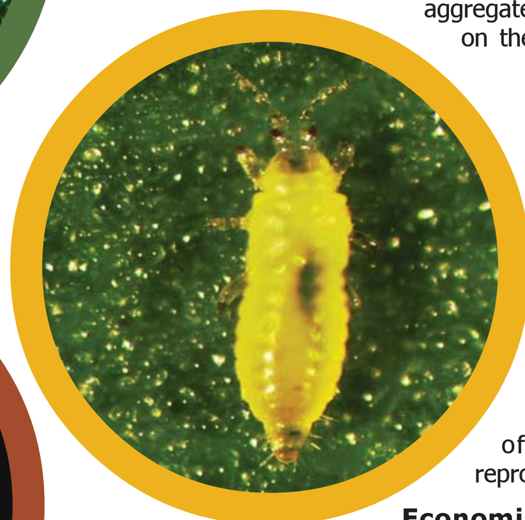
Western Flower Thrips: *Frankliniella occidentalis*



Biology & Lifecycle: Thrips insert individual eggs into the developing flower buds and fruit pods of pepper and tomato. The eggs hatch in about 6 days. Larval development in the flowers and small fruits requires 6 to 8 days depending on temperature. The adults live about 3 weeks and feed primarily on flower tissues and pollen. Pollen-feeding increases fecundity 2 to 4 fold.

Environmental Factors: Reproduction occurs year-round. Populations are greatest from April to June in northern Florida and from February to May in southern Florida. Generational cycles take about 20 days in hot weather and as long as 60 days in the winter in northern Florida.

Adult: Very small (1/10 inch), light yellow with fringe wings and 8-segmented antennae **(Figure 1)**. Adults aggregate in the flowers, and are rarely found on the terminal, unexpanded leaves.



Larvae: Minute and white, both larval instars aggregate in the flowers and small fruit **(Figure 2)**. Pre-pupae move to the soil surface and pupate beneath the soil surface under the plant.

Host range: Reproduction occurs on peppers *(Capsicum spp.)*, tomatoes and a wide range of crops, weeds and native plant species. Adults feed on the flowers of plant species that are not reproductive hosts as well.

Economic Importance: A key pest of tomato, pepper and other crops in northern Florida and is less important in central and southern Florida. Cosmetic damage on fruits from feeding **(Figure 4)** is an economic problem under some conditions in all areas of the state.

Damage: Adult females lay individual eggs on the small fruit inside of the flower resulting in halo spots. Feeding by the adults and larvae can result in flecking on the surface of fruit and under heavy infestations, fruit deformity. *F. occidentalis* is the primary vector of *Tomato spotted wilt virus* (TSWV) which renders fruit unmarketable **(Figure 3)**.

Figure 1. Western flower thrips adult female. Photograph by: Joe Funderburk.

Figure 2. Western flower thrips larva. Photograph by: Joe Funderburk.

Figure 3. Halo spots on fruit due to egg laying into the tomato. Photograph by: David Schuster.

Actual Size:

Adult
About 1/10 inch

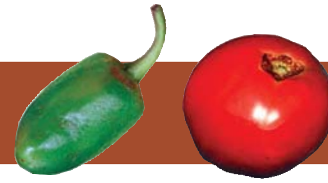
Monitoring:

Scouting: The total number of thrips of all species can be estimated in the field by beating individual flowers onto a white plastic board. Thrips must be placed in vials of alcohol and examined at 40X magnification using a stereoscope in order to determine western flower thrips from the other flower thrips species.

Action Thresholds:
In tomato, > 0.5 adults per flower. If tomato spotted wilt incidence exceeds 5% in the field, once per week applications of an insecticide for control of the larvae reduces spread of the disease in susceptible cultivars.

In pepper, 2 to 3 larvae or adults per flower is tolerable. A reduced-risk insecticide that does not suppress natural populations of predatory minute pirate bugs can be used to suppress adults and larvae.

Western Flower Thrips:
Frankliniella occidentalis



CULTURAL CONTROLS:

Ultraviolet-Reflective Mulch: UV-reflective (aluminum) mulch reduces the introduction of western flower thrips adults into production fields. This is the most effective tactic to control primary spread of TSWV (i.e. thrips acquire the virus when developing on plant hosts outside the field).

Do Not Over-Fertilize: Over-fertilization with nitrogen increases the number of western flower thrips and the incidence of TSWV.

Resistant Cultivars: Cultivars resistant to TSWV are available for tomatoes and peppers.

Monitor: Frequent monitoring of once or twice weekly is needed to assess western flower thrips numbers and to determine the incidence of TSWV.

Distinguishing the adults from the Florida flower thrips (*F. bispinosa*) and the eastern flower thrips (*F. tritici*) is not possible using a hand lens.

NATURAL ENEMIES:

- The key natural enemy capable of suppressing populations is the minute pirate bug, *Orius insidiosus*. These predators naturally invade fields and management programs of pepper and other crops in Florida are designed to conserve its populations.
- No natural enemies are important in suppressing western flower thrips in tomato.

CHEMICAL CONTROLS:

- Spray tomatoes when numbers of adults or larvae exceed the action threshold.
- Use reduced-risk insecticides to conserve minute pirate bug, *Orius insidiosus,* populations in pepper. Natural infestations typically control the *F. occidentalis* for most of the production season.
- During periods in the spring of intense infestations, reducing thrips numbers below the action threshold with insecticides is not possible.

RESISTANCE MANAGEMENT:

- Few insecticides are effective in suppressing *F. occidentalis*. Resistance has developed to many products including carbamate (1A), organophosphate (1B) and synthetic pyrethroid (3) insecticides. Resistance to neonicotinoid (4A) insecticides also is reported.
- Alternative cultural control and plant resistance tactics are the best options to control thrips and to avoid the development of resistance.
- Rotate chemical classes, although this does not guarantee against the development of insecticide resistance.

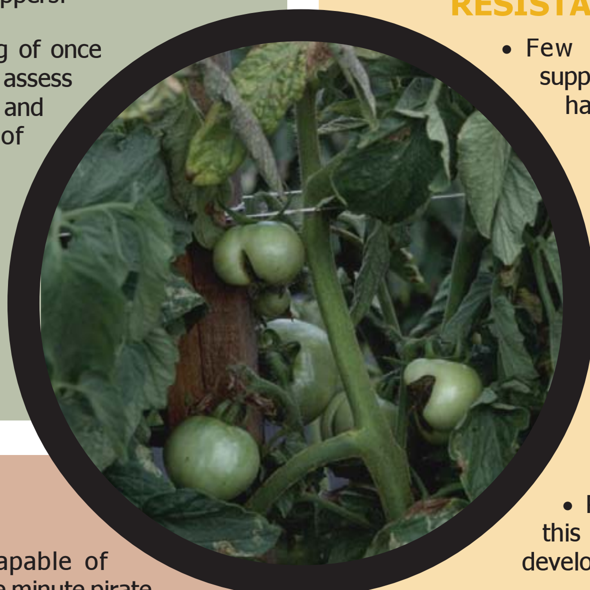


Figure 4. Tomato spotted wilt damage to tomatoes. Photograph by: David Schuster.

References:

Funderburk, J. and J. Stavisky. 2004. Biology and economic importance of flower thrips. UF/IFAS Pub. ENY682, http://edis.ifas.ufl.edu/IN415.

Momol, M.T., S.M. Olson, J.E. Funderburk, J. Stavisky and J.J. Marois. 2004. Integrated management of tomato spotted wilt on field-grown tomato. Plant Disease 88: 882-890.

Reitz, S.R., E.L. Yearby, J.E. Funderburk, J. Stavisky, M.T. Momol and S.M. Olson. 2003. Integrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field-grown pepper. Journal of Economic Entomology 96: 1201-1214.

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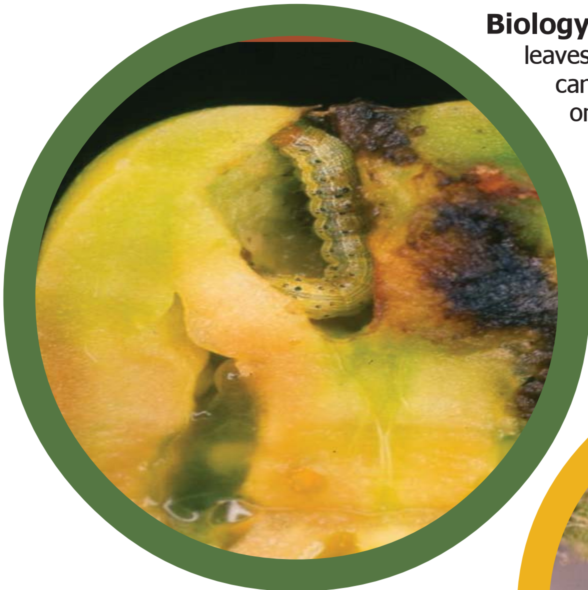
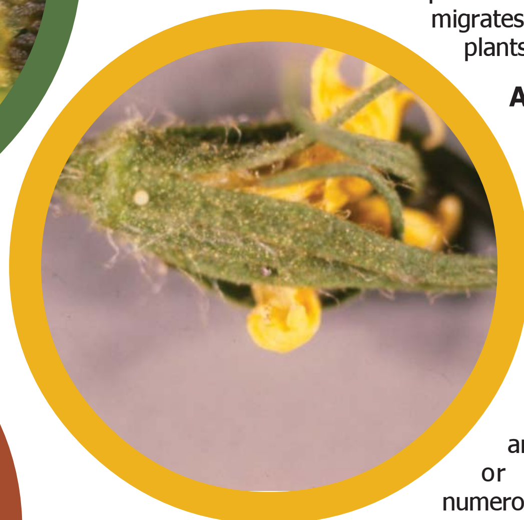
Tomato Fruitworm (Corn Earworm): *Helicoverpa (Heliothis zea)*



Biology & Lifecycle: Female adults lay oval, heavily ridged eggs individually on leaves, especially those immediately below the uppermost flowers in the upper canopy. Hatching larvae prefer to bore into small, green fruit, but may feed on buds, flowers or stems if fruit are not present. Larvae may complete their development inside a single fruit or may move to other fruit. Mature larvae drop to the soil and form a cell 2-4 inches deep and pupate inside. The egg to adult period lasts about 30 days.

Environmental Factors: The tomato fruitworm is active year round, but is usually more abundant in tomato and pepper during warmer months of both the spring and fall. The insect may over summer on volunteer plants and numerous weed species, and migrates into tomato and pepper after the plants begin flowering.



Adult: Medium-sized moths **(Figure 4)** with a wing span of about 1 to 1¼ inch. They are yellowish brown and may sometimes have a slight greenish tinge. The front wings usually have an obscure dark spot in the center and a dark band followed by a lighter band around the edge. The hind wings are whitish gray with a dark band on the edge. Adults are nocturnal and feed on nectar or other plant exudates from numerous plant species, including citrus.

Larvae: Hatching larvae have black heads with white bodies and spines with black bases **(Figure 1)**. Older larvae have orange or light brown heads and yellowish to nearly black bodies that retain the black-based spines **(Figure 5)**. The top of the larvae have fine, white lines and the sides have a broad dark band with a light band below it.

Host range: The tomato fruitworm has a very wide host range, but among vegetable crops appears to prefer corn and tomato. Other vegetables attacked include pepper and other solanceous crops, and crucifer and cucurbit crops. Many common weeds serve as larval hosts.

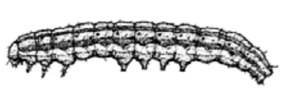
Damage: Larvae bore deeply into fruit, usually at or near the calyx. Infested fruit are rendered unmarketable and usually rot due to invasion of secondary microorganisms **(Figure 3)**.

Figure 1. Internal tomato fruit damage by tomato fruitworm larva. Photograph by: Dave Schuster.

Figure 2. Tomato fruitworm egg on tomato flower. Photograph by: Dave Schuster.

Figure 3. External tomato fruit damage by tomato fruitworm larva. Photograph by: Dave Schuster.

Actual size:



Larvae grow to a size of about 1½ inches in length.

Monitoring:

Traps: Blacklight and conical, pheromone baited traps placed on field perimeters can be used to indicate when adults are migrating into fields.

Scouting: The leaves immediately above and below the highest flower cluster, as well as the flowers themselves, are examined for the presence of eggs. A sample of 10 fruit is examined for damage and the presence of larvae.

Action Threshold: 5-10 moths/trap/night or the presence of one egg or larva

Prepared by: Dr. David Schuster

Tomato Fruitworm (Corn Earworm): *Helicoverpa (Heliothis zea)*

CULTURAL CONTROLS:

Start Clean: Tomato and pepper fields should not be planted near or adjacent to post-silking corn fields.

Sanitation: Cull fruit from infested fields should be disposed of as far from production fields as possible.

Field Manipulations: Abandoned fields can be a reservoir of migrating adults and, therefore, should be destroyed immediately after final harvest by deep disking to destroy infested fruit and pupating larvae.

Volunteer plants and weed hosts should be destroyed during the summer off season by frequent disking.

NATURAL ENEMIES:

- Natural enemies do not usually cause high enough mortality of tomato fruitworm to prevent crop injury. Nevertheless, the parasitic wasp, *Trichogramma pretiosum*, attacks eggs and can account for 40 to 80% parasitism.

- Eggs and young larvae are attacked by generalist predators, including lacewings (*Chrysopa* spp. and *Chrysoperla* spp.), big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.) and minute pirate bugs (*Orius* spp.).

- The most important species of parasitic wasps observed attacking larvae include *Cotesia* spp., *Microplitis croceipes* and *Hyposoter exiguae*.

- Natural enemies can be conserved by avoiding broad spectrum pyrethroid, organophosphate and carbamate insecticides. Fewer insecticide applications and applications of new, reduced risk insecticides can also enhance biological control.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.

- Insecticides should be timed to control eggs and hatching larvae. Once larvae enter fruit, they are less accessible to insecticides and are more difficult to control.

RESISTANCE MANAGEMENT:

- Applying insecticides based upon the threshold and in conjunction with cultural controls will reduce the number of applications. Chemicals of different classes should be rotated.

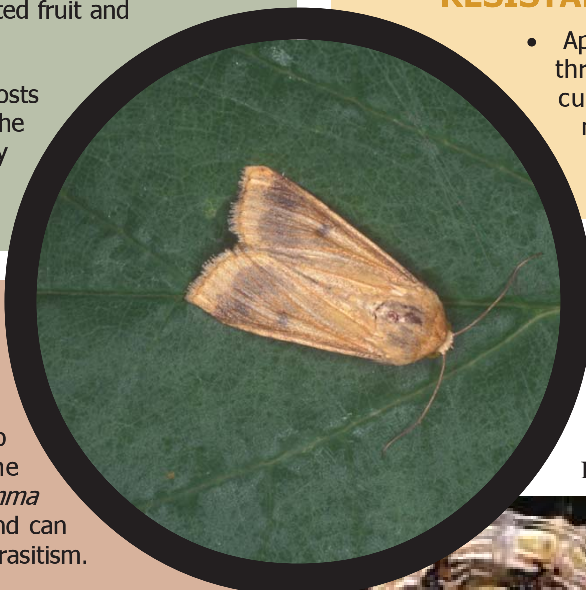


Figure 4. Tomato fruitworm adult. Photograph by: Lyle Buss.

Figure 5. Mature larva feeding on foliage. This brown form is characteristic of this insect, though other colors occur. Photograph by: Lyle Buss.

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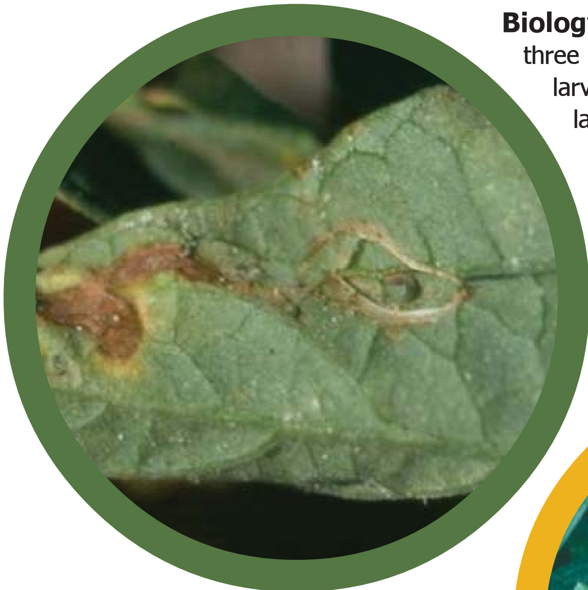
References:

Capinera, J.L. 2000. Corn Earworm: *Helicoverpa* (=*Heliothis*) *zea* (Boddie) (Lepidoptera: Noctuidae) UF/IFAS EENY-145, http://creatures.ifas.ufl.edu/veg/corn_earworm.htm.

Flint, M.L. (Technical Editor). 1998. Integrated Pest Management for Tomatoes, Fourth Edition. Univ. Calif., Statewide Integrated Pest Management Project, Div. Agric. Natural Resources, Publ. 3274.

Tomato Pinworm: *Keiferia lycopersicella*



Biology & Lifecycle: Female adults lay eggs individually or in groups of two or three on the undersides of leaves in the upper third of the canopy. Hatching larvae bore into leaves, where their feeding causes a blotch mine. Older larvae feed protected in leaf rolls or folds held together by silking. Larvae may also bore into fruit, usually under the calyx or where infested foliage touches fruit. Mature larvae drop to the soil or plastic mulch surface where they form a silken cocoon covered with sand grains. Infestations often begin on the perimeters of fields. The egg to adult period lasts about 3 weeks at temperatures above 80°F.

Environmental Factors: The tomato pinworm may be present year round, but is usually more abundant March-June. The insect over summers primarily on volunteer crop plants, especially tomato.

Adult: Adults are small, light brown moths about ¼ inch in length and are most active just after sundown and for a few hours thereafter.

Immature: Newly hatched larvae are yellowish-gray with a dark head **(Figure 2)**. Older larvae become progressively darker, changing from brownish-orange to bluish-purple, and reach about 3/8 inch in length **(Figure 1)**.

Host range: Tomato is the most important host plant; however, egg-plant and potato are also attacked. The insect is recorded from the weed *Solanum bahamese* in Florida. Other solanaceous plants, such as pepper, *Capsium* spp. and nightshades, *Solanum* spp., are not hosts.

Damage: Larvae can complete development on foliage **(Figure 3)** and occasionally can inflict nearly 100% defoliation; however, greatest economic damage occurs when larvae attack fruit **(Figure 4)**. Larval damage at the calyx may go undetected and fruit entering the market chain may rot due to invasion of secondary pathogens at the feeding site. Rotting, infested fruit can cause non-infested fruit to rot in shipping boxes.

Figure 1. Mature tomato pinworm larva. Photograph by: David Schuster.

Figure 2. Tomato pinworm larva. Photograph by: James Castner.

Figure 3. Tomato pinworm foliar damage. Photograph by: James Castner.

Actual Size:

Larva
About 3/8 inch

Monitoring:

Traps: Commercially available Pherocon 1C traps baited with pheromone dispensers should be placed on the perimeters of tomato fields and should be monitored at least twice a week. Traps should be placed above the plant canopy and should be raised as the plants grow.

Scouting: One leaf from the lower canopy of each of six contiguous plants per two acres should be selected and examined for the presence of larvae.

Action Thresholds:
5 moths/trap/night for initiating mating disruption
0.7 larva/leaf for timing insecticidal sprays

Prepared by: Dr. David Schuster

Tomato Pinworm:
Keiferia lycopersicella

CULTURAL CONTROLS:

Start Clean: Transplants should be free of eggs or larvae.

Mating Disruption: Commercial dispensers and liquid encapsulated formulations of mating disruptant can be applied when indicated by pheromone-baited traps.

Sanitation: Cull fruit from infested fields should be disposed of as far from production fields as possible.

Field Manipulations: Abandoned fields can be a tremendous reservoir of migrating adults. Therefore, fields should be destroyed block by block immediately after final harvest by treating with an effective insecticide combined with a foliarly-applied burn down herbicide.

New fields should not be planted adjacent to old fields.

Volunteer plants should be destroyed, especially during the summer off season, by frequent disking or other suitable methods.

CHEMICAL CONTROLS:

- Insecticides should be applied when the action threshold is reached.
- Insecticides should be timed to control younger larvae when they are in the blotch leafmines. Older larvae in leaf rolls, leaf folds or fruit are less accessible to insecticides and are more difficult to control. Insecticides may be applied to field perimeters to control early infestations.

RESISTANCE MANAGEMENT:

- The efficacy of pyrethroid insecticides (many products, 3) has declined to very low levels in research plots in Florida. Resistance to Lannate® (carbamate, 1A) has been documented in Florida.
- Applying insecticides based upon the threshold and in conjunction with cultural controls will reduce the number of applications. Chemicals of different classes should be rotated.

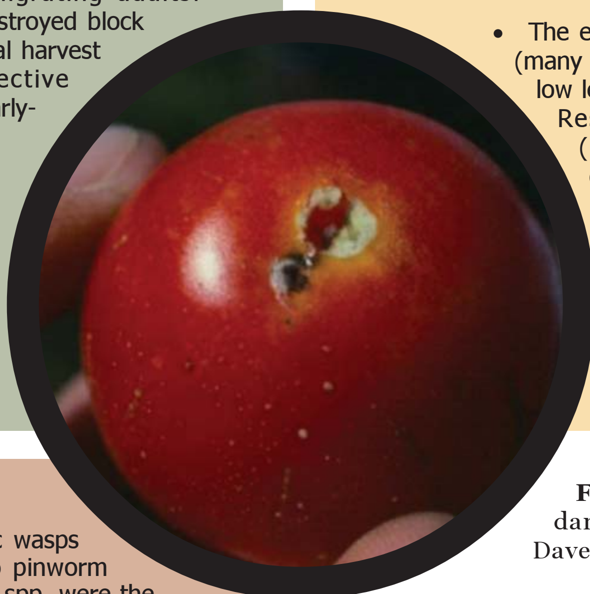


Figure 4. Tomato pinworm damage to fruit. Photograph by: Dave Schuster.

NATURAL ENEMIES:

- Of four species of parasitic wasps observed attacking tomato pinworm larvae in Florida, *Apanteles* spp. were the most abundant. Larval parasitism can reach 50%, but usually not until economic damage has occurred.
- The parasitic wasp, *Trichogramma pretiosum*, attacks eggs and can account for 10 to 90% parasitism.
- Natural enemies can be conserved by avoiding the broad spectrum pyrethroid, organophosphate and carbamate insecticides. Fewer insecticide applications and applications of new, reduced risk insecticides can also enhance biological control.

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References:

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Lin, S.Y. and J.T. Trumble. 1985. Influence of temperature and tomato maturation on development and survival of *Keiferia lycopersicella* (Lepidoptera: Gelechiidae). Environmental Entomology 14: 855-858.

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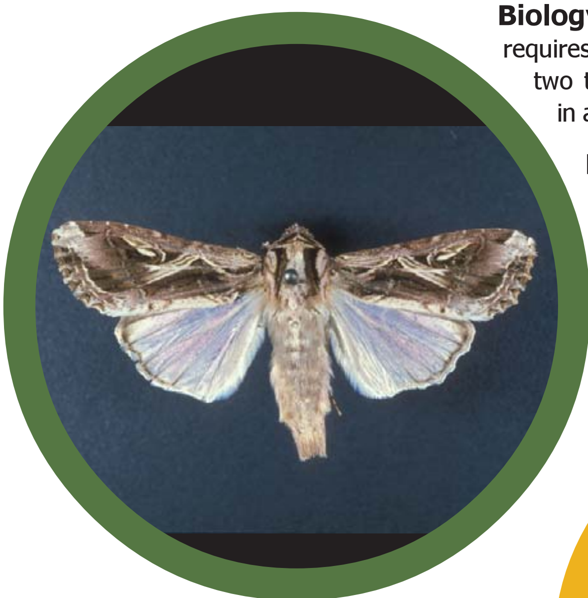
Yellowstriped Armyworm: *Spodoptera ornithogalli*



Biology & Lifecycle: The eggs hatch in about 6 days. Larval development requires about two to three weeks depending on temperature. Pupae require two to three weeks of development. Multiple generations develop each year in all parts of Florida.

Environmental Factors: Yellowstriped armyworms overwinter as pupae. Populations may be active most of the year in southern Florida. They are active in northern Florida beginning in the spring and populations are greatest in the fall.

Adult: The moth has dark forewings with white and brown markings and white hind wings. The wingspan is about 1 ½ inches **(Figure 1)**.

Larvae: The color varies from gray to black. The larva has yellow-orange stripe along each side **(Figures 4 & 5)** and a pair of black, triangular spots on the back of most segments **(Figure 2)**. The sixth larval instar is about 1 ¾ inches long.

Pupa: The brown pupa is about ¾ inch long and occurs in the soil.

Egg: Eggs are laid in masses covered with scales from the moth's body. Individual eggs are small (1/20 inch), ribbed and greenish, before turning pale pink or brown before hatching.

Host range: Yellowstriped armyworms are generalists and reproductive hosts include a wide range of crops, weeds and native plant species. Tomato and pepper are hosts.

Economic Importance: An occasional pest of tomato in Florida, primarily in the fall in northern Florida.

Damage: Larvae hatch from the egg mass and begin feeding on the leaves before moving to fruits **(Figure 3)**.

Figure 1. Yellowstriped armyworm adult female. Photograph by: John Capinera.

Figure 2. Black triangular spots are visible on this larvae. Photograph by: Lyle Buss.

Figure 3. Larvae and feeding damage. Photograph by: Skip Choate.

Actual Size:

Largest larvae is 1¾ inches.

Monitoring

Scouting: Frequent monitoring of once or twice weekly is needed to detect the presence of egg masses or small larvae. Inspect 6 plants for eggs and larvae for every 2 ½ acres.

Action Thresholds: Pre-bloom, 1 larva per 6 plants
Post-bloom, 1 egg or larva per field

Prepared by: Dr. Joe Funderburk

Yellowstriped Armyworm:
Spodoptera ornithogalli

CULTURAL CONTROLS:

Start Clean: Tomato and pepper fields should not be planted near or adjacent to old, infested fields.

Field Manipulations: Fields should be destroyed immediately after final harvest by applying a foliar herbicide to destroy infested plants and by deep disking to destroy pupating larvae.

Volunteer plants and weed hosts should be destroyed during the summer off season by frequent disking.

CHEMICAL CONTROLS:

- This is an occasional pest that infrequently requires control. Spray tomatoes and peppers when numbers of larvae exceed the action threshold.
- Numerous insecticides are effective in controlling the small larvae. Larger larvae are difficult to control with insecticides.
- Reduced-risk insecticides should be employed to conserve beneficial organisms.

RESISTANCE MANAGEMENT:

- Insecticide resistant populations have not been documented.
- Rotate different classes of insecticides.

NATURAL ENEMIES:

- Numerous parasitic wasps and flies attack the larvae.
- Numerous generalist predators feed on the eggs and larvae.
- A nuclear polyhedrosis virus is highly pathogenic to the larvae.

Figure 4. Note yellow-orange stripe on the larvae. Photograph by: James Castner.

Figure 5. Yellow-striped army worms can be distinguished from other armyworm species by the single yellow-orange stripe on each side that runs the length of the larvae. Photograph by: Skip Choate.

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References:

Capinera, J. L. 2005. Yellowstriped armyworm, *Spodoptera ornithogalli* (Guenee) (Insecta: Lepidoptera: Noctuidae) UF/IFAS Pub. EENY-216, http://creatures.ifas.ufl.edu/veg/leaf/yellowstriped_armyworm.htm.

Heppner, J. B. 1998. *Spodoptera* armyworms in Florida (Lepidoptera: Noctuidae). Florida Dept. Agric. Cons. Serv., Div. Plant Industry, Entomol. Circ. 390.

Sweetpotato/Silverleaf Whitefly: *Bemisia tabaci*

Biology & Lifecycle: Biotype B of the sweetpotato whitefly in Florida is also known as the silverleaf whitefly. Adults prefer the undersides of leaves, especially the upper canopy. Females produce about 160 eggs, on the undersides of leaves. Upon hatching, the 1st instar nymph or "crawler" moves about the leaf in search for a place to insert its needle-like mouthparts into the plant to suck up plant phloem. Large quantities of sweet liquid waste or honeydew are excreted by nymphs which supports the growth of black sooty mold fungi. Complete development takes from 2.5 to 7 weeks over a temperature range of 93 to 61°F.

Environmental Factors: Present year round in south Florida, although highest populations occur in spring. Up to 21 generations per year in southwest Florida and 15 generations in north Florida, where freezing temperatures will kill host plants. Whiteflies oversummer on abandoned and volunteer crops and on weeds such as primrose willow (*Ludwigia* spp.).

Adult: About 0.8 mm (1/32 inch) long with two pairs of white wings held roof-like over the cream colored body **(Figure 1)**. The white color is due to a covering of powdery wax. Males are generally a bit smaller than females.

Nymphs: Only the 1st instar (0.3mm) has tiny legs and antennae, later instars are immobile. Clear to whitish with two yellow patches on the posterior end **(Figure 2)**. Red eye spots develop in the final 4th instar/"pupa". Nymphal appearance depends somewhat on host leaf surface, flat with few spines on smooth leaves, more rounded with more spines on hairy leaves.

Host Range: Over 500 host plant species in over 74 plant families including most broadleaf agronomic and vegetable crops and many ornamentals such as poinsettia and hibiscus. Pepper harbors lower populations than tomato or other solanaceous crops.

Damage: Heavy populations are debilitating due to sap loss and buildup of sooty mold. Feeding by nymphs on leaves causes tomato irregular ripening (TIR), where fruit do not color uniformly and exhibit areas of green or white tissue internally **(Figure 4)**. An average of 0.5 nymphs per leaf during fruit maturation may be sufficient to induce TIR.

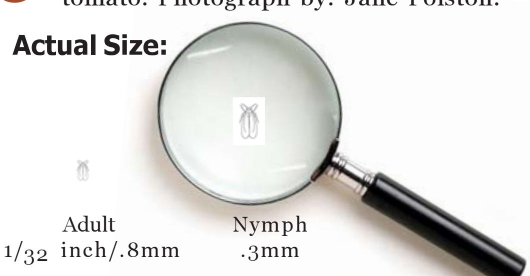
The sweetpotato whitefly is **the** key pest of tomato, primarily as a vector of the geminivirus, *Tomato yellow leaf curl virus* (TYLCV). TYLCV causes severe stunting, chlorosis, cupping and puckering of leaves, and flower abortion. Little fruit is set above the point of initial infection. The earlier the infection, the greater the impact on yield. Losses of up to 90% may be sustained if plants show symptoms within the first month after transplanting **(Figure 3)**.

Figure 1. Infestation of adults on the underside of a weed. Photograph by: James Castner.

Figure 2. Immobile 2nd or 3rd instar nymph. Photograph by: David Schuster.

Figure 3. TYLCV symptoms on tomato. Photograph by: Jane Polston.

Actual Size:



Monitoring:

Scouting: Monitor incoming adults with yellow sticky cards and by observing adults by gently inverting upper leaves. Count nymphs on the terminal leaflet of leaves below the 6th node counting from the top.

Action Thresholds: 0.5 nymphs per terminal leaflet or 1 adult per leaf or plant for TIR.

There is no set threshold for TYLCV because incidence depends on the portion of adults carrying the virus.

Prepared by: Dr. Phil Stansly

Sweetpotato/Silverleaf Whitefly: *Bemisia tabaci*

CULTURAL CONTROLS:

Start Clean: Transplants must be free of whiteflies and virus.

Field Manipulations: Newly planted crops must be located distant from older plantings that may serve as a source of virus and whiteflies.

Residues from spring crops should be removed and volunteers controlled during at least two months prior to fall planting.

Mulch: Reflective (aluminized) mulch may be used to repel whiteflies during the first weeks of plant development.

TYLCV infected plants early in the crop cycle should be removed from the field, after being sprayed with an insecticide effective against adults, to prevent dispersal of infected whiteflies.

NATURAL ENEMIES:

- Whiteflies have many effective natural enemies, including parasitic wasps (*Encarsia* and *Eretmocerus* spp.), tomato bugs (*Engytatus = Cyrtopeltis* spp.), ladybeetles (*Nephaspi* and *Delphastus* spp.), lacewings (*Chrysoperla* and *Ceraeochrysa* spp.) and mites (*Amblyseius swirskii*).
- Natural enemies are responsible for the low whitefly populations observed in weeds and can help control whitefies in field crops if broad spectrum insecticides are avoided. Mass release of certain natural enemies has also proved effective in greenhouse crops.

CHEMICAL CONTROLS:

- Drenches of systemic "neonicotinoid" insecticides (4A*) such as imidacloprid (Admire Pro®), thiamethoxam (Platinum®) and dinotefuron (Venom®) before and immediately following transplanting provides early season control that is essential for most tomato production in Florida.
- Foliar sprays of spiromesifen (Oberon®; 23*) and the insect growth regulators buprofezin (Courier®; 16*) and pyriproxyfen (Knack®; 7C*) should be applied according to the nymphal threshold.
- Soaps, oils, pymetrozine (FulFill®; 9B*) and broad spectrum insecticides, alone or tank-mixed with products such as endosulfan (cyclodiene; 2A*), organophosphates (several products; 1B*) and pyrethroids (numerous products; 3) should be applied according to the adult threshold. The latter three groups are best used toward the end of the crop.

RESISTANCE MANAGEMENT:

- Foliar applications of neonicotinoids should not be made 6 weeks following soil drenches of the insecticides. Other products of different chemical classes* should be rotated.

* IRAC insecticide classification system
See Appendix 5

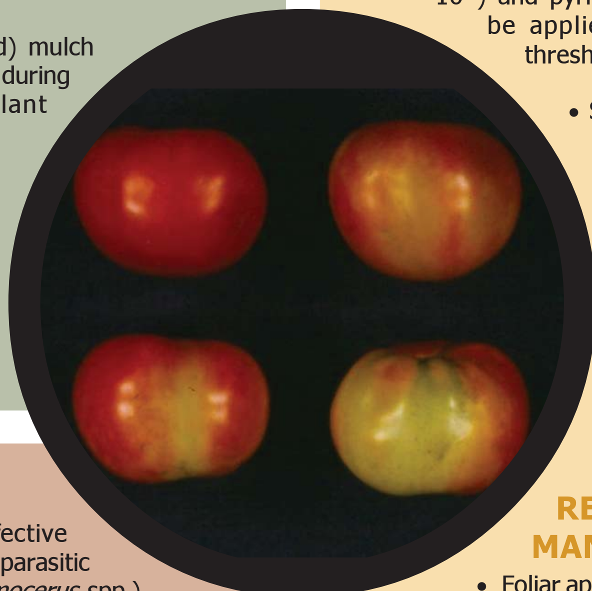


Figure 4. Tomato Irregular Ripening (TIR) external symptoms. Photograph by: Dave Schuster.

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References:

Capinera, J.L. 2001. Handbook of Vegetable Pests. Academia Press, San Diego, CA.

McAuslane, H.J. 2000. Sweetpotato whitefly B biotype, *Bemisia tabaci* (Gennadius), or silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring (Insecta: Hemiptera: Aleyrodidae) UF/IFAS EENY-129, http://creatures.ifas.ufl.edu/veg/leaf/silverleaf_whitefly.htm.

Q biotype is visually indistinguishable from the B biotype and is resistant or tolerant to many of our commonly used insecticides.

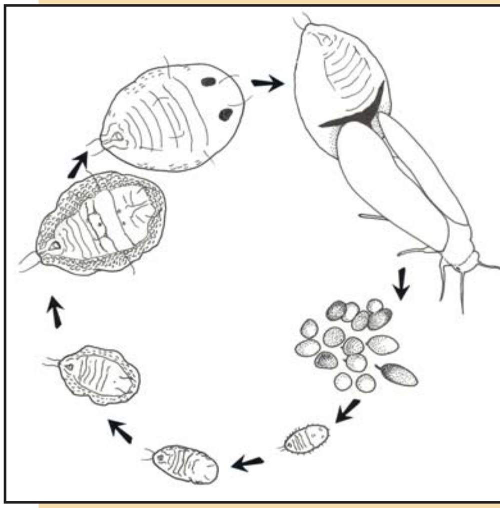

Figure 1. Lifecycle of the whitefly. Drawing by: Jane Medley.

For additional information on biology and control information, a good source is Dr. Lance Osborne's website at http://www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm. It includes a number of documents that contain information from Florida and other states.

Figure 2. Whitefly adults should be collected when sampling. Photograph by: UF/IFAS.

Why is the Q biotype of whiteflies important?

While B out-competes Q in the absence of insecticides, Q out-competes B in the presence of many insecticides, and Q can transmit TYLCV at least as efficiently as B. The major problem facing growers is that Q is resistant or tolerant to many of our commonly used insecticides, including the nicotinoids, the pyrethroids and the insect growth regulators Knack® and Courier®. Thus, if both biotypes are present and we spray heavily, we are selecting for the Q biotype. This makes spraying as little as possible and following resistance management recommendations even more critical, including rotation of chemicals and the inclusion of a **crop-free period** into the production cycle.

What should growers do?

If your current whitefly pesticide program is working, continue using it! If you are having great difficulty controlling whitefly, you may want to consider some other options. Oberon® is effective on Q; thus, if you are targeting nymphs, this would be an alternative to Knack® and Courier®. Oberon® is also effective on adults, although it is slow to act. Venom® (Valent) is a nicotinoid that has been more effective on Q in greenhouse trials than have other nicotinoids. It is labeled on tomatoes as a foliar spray or drench. This should be a "last resort" treatment. It is recommended that this **NOT** be used on crops where nicotinoids have already been applied this season. Recent work in ornamentals has shown control with a combination of Agri-Mek® and a pyrethroid. Another combination that could be trialed is a combination of Agri-Mek® and oil. Soaps, oils, Prev-Am® and similar materials should still be useful, but remember good coverage is critical.

Submitting Samples for Q-biotype Testing

Growers are cautioned **NOT** to immediately begin changing their pesticide program if they feel their current one is working. If you feel you are having problems controlling whitefly, it is recommended that you submit samples for Q testing.

- A minimum of 20 adults should be sampled from different plants.
- Try and carefully collect leaflets with whitefly adults and put them into a baggie.
- Put them in the freezer to slow them down and then transfer them to vials of 95% ethanol with a cotton swab or artist's paintbrush.
- Do not crush the whitefly.
- Be sure to label the vial, but use a code so that you will know where the sample came from but the identity of the farm will not be known. You can also request a code from Dr. McKenzie.
- Vials should be kept out of heat and carefully packaged and sent via priority mail or overnight to the following address:

Dr. Cindy L. McKenzie
Subtropical Insects Research
2001 South Rock Road
Ft. Pierce, FL 34945
Phone: 772-462-5917
Fax: 772-462-5986
cmckenzie@ushrl.ars.usda.gov

If you are unable to sample, please give your local county extension agent a call and they will try to help.

Prepared by: Dr. Cindy McKenzie

Management of Whiteflies, TYLCV and Insecticide Resistance:

Economic importance:

The sweetpotato whitefly is ***the*** *key pest of tomato, primarily as a vector of the geminivirus, Tomato yellow leaf curl virus, TYLCV. Pepper may act as an asymptomatic host of the virus.*

INTRODUCTION:

Tomato yellow leaf curl virus (TYLCV) threatens commercial tomato production fields was identified in 1997 in south Florida. The disease spread north rapidly and TYLCV was first identified in north Florida and south Georgia in the Fall of 1998. TYLCV is transmitted by adult silverleaf whiteflies (*Bemisia tabaci* Biotype B = *Bemisia argentifolii*). TYLCV is not trasmitted through seed or by mechanical transmission. The presence of other cultivated or wild hosts of silverleaf whitefly (i.e., cotton) during summer may lead to additional whitefly migration to tomato. During late spring, summer, and early fall, growers need to monitor whitefly populations very closely and follow recommendations in this Fact Sheet. TYLCV has a broad host range from several plant families including Solanaceae (tomato, tobacco), Malvaceae (cheeseweed), and Fabaceae (common bean, lentil).

Symptoms of TYLCV include:

- If plants are infected at an early stage, they won't bear fruit and their growth will be severely stunted.
- Other symptoms that are typical for this disease are: yellow (chlorotic) leaf edges, upward leaf cupping, leaf mottling, reduced leaf size **(Figure 3)** and flower drop.
- Identification based only on symptomatology is unreliable, because similar symptoms can be caused by other viruses or various growing conditions.
- Proper identification of TYLCV is available at Plant Disease Clinics in Florida.

Figure 3. Note yellowing of edges, cupping and distortion of leaflets. Photograph by: Tim Momol.

CROP HYGIENE:

Field hygiene should be a high priority and should be included as an integral part of the overall strategy for managing whitefly populations, TYLCV incidence and insecticide resistance. These practices will help reduce the onset of the initial infestation of whitefly, **both biotype B and biotype Q (if present)**, and lower the initial infestation level during the cropping period.

1. Establish a minimum two-month crop free period during the summer, preferably from at least mid-June to mid-August.
2. Use a correct crop destruction technique, which includes destruction of existing whitefly populations in addition to the physical destruction of the crop.

Figure 4. TYLCV infected regrowth of fall tomatoes after doublecropped cucumbers. Photograph by: Phyllis Gilreath.

a. Promptly and efficiently destroy all vegetable crops **within 5 days of final harvest** to maximally decrease whitefly numbers and sources of plant begomoviruses like TYLCV.
b. Use a contact desiccant ("burn down") herbicide in conjunction with a heavy application of oil (not less than 3 % emulsion) and a non-ionic adjuvant to destroy crop plants and to quickly kill whiteflies.
c. Time burn down sprays to avoid crop destruction during windy periods, especially when prevailing winds are blowing whiteflies toward adjacent plantings.
d. Destroy crops block by block as harvest is completed rather than waiting and destroying the entire field at one time.

Prepared by: Drs. David Schuster, Phil Stansly, Jane Polston and Phyllis Gilreath

Reduce overall whitefly populations, both biotype B and biotype Q (if present), by strictly adhering to cultural practices.

Figure 5. Use resistant cultivars if possible. Photograph by: Charlie Vavrina.

OTHER CULTURAL CONTROL PRACTICES:

Use proper pre-planting practices:

a. Plant whitefly and virus-free transplants.
   - Do not grow vegetable transplants and vegetatively propagated ornamental plants (i.e. hibiscus, poinsettia, etc.) at the same location, especially if bringing in plant materials from other areas of the US or outside the US.
   - Isolate vegetable transplants and ornamental plants if both are produced in the same location.
   - Do not work with or manipulate vegetable transplants and ornamental plants at the same time.
   - Practice worker isolation between vegetable transplants and ornamental crops.
   - Avoid yellow clothing or utensils as these attract whitefly adults.
   - Cover all vents and other openings with whitefly resistant screening. Use double doors with positive pressure. Cover roofs with UV absorbing films.

b. Delay planting new fall crops as long as possible.
c. Do not plant new crops near or adjacent to old, infested crops.
d. Use determinant varieties of grape tomatoes to avoid extended crop season.
e. Use TYLCV resistant tomato cultivars (see additional information below for list) where possible and appropriate, especially during historically critical periods of virus pressure. Whitefly control must continue even with use of TYLCV resistant cultivars because these cultivars are able to carry the virus.
f. Use TYLCV resistant pepper cultivars (see additional information below for list) when growing pepper and tomato in close proximity.
g. Use ultraviolet light reflective (aluminum) mulch on plantings that are historically most susceptible to whitefly infestation and TYLCV infection.

Figure 6. Destroy old crops within 5 days after harvest. Photograph by: Phyllis Gilreath.

Use proper post-planting practices:

a. Apply an effective insecticide to kill whitefly adults prior to cultural manipulations such as pruning, tying, etc.
b. Rogue tomato plants with symptoms of TYLCV at least until second tie. Plants should be treated for whitefly adults prior to roguing and, if nymphs are present, should be removed from the field, preferably in plastic bags, and disposed of as far from production fields as possible.
c. Manage weeds within crops to minimize interference with spraying and to eliminate alternative whitefly and virus host plants.
d. Dispose of cull tomatoes as far from production fields as possible. If dumped in pastures for cattle feeding, the fruit should be spread instead of dumped in a large pile to encourage consumption by cattle. The fields should then be monitored for germination of tomato seedlings and, if present, they should be controlled by mowing or with herbicides.
e. Avoid u-pick or pin-hooking operations unless effective whitefly control measures are continued.
f. Destroy old crops within 5 days after harvest, destroy whitefly infested abandoned crops and control volunteer plants with a desiccant herbicide and oil.

Management of Whiteflies, TYLCV and Insecticide Resistance:

INSECTICIDAL CONTROL PRACTICES:

1. Use a proper whitefly insecticide program. *Follow the label!*

a. On transplants in the production facility, do not use a neonicotinoid insecticide if biotype Q is present. If biotype B is present, apply a neonicotinoid **one time** 7-10 days before shipping. Use products in other chemical classes, including Fulfill®, soap, etc. before this time.
b. Use neonicotinoids in the field **only during the first six weeks of the crop**, thus leaving a neonicotinoid-free period at the end of the crop.
c. As control of whitefly nymphs diminishes following soil drenches of the neonicotinoid insecticide or after more than six weeks following transplanting, use rotations of insecticides of other chemical classes including insecticides effective against biotype Q. Consult the Cooperative Extension Service for the latest recommendations.
d. Use selective rather than broad-spectrum control products where possible to conserve natural enemies and enhance biological control.
e. Do not apply insecticides on weeds on field perimeters because this can kill natural enemies, thus interfering with biological control, and because this can select for biotype Q, if present, which is more resistant to many insecticides than biotype B.

Figure 7. Pesticide application on tomato. Photograph by: Fred Fishel.

2. Soil applications of neonicotinoid insecticides for whitefly control:

a. For best control, use a neonicotinoid as a soil drench at transplanting, preferably in the transplant water.
b. Soil applications of neonicotinoids through the drip irrigation system are not recommended.
c. Do not use split applications of soil drenches of neonicotinoid insecticides (i.e. do not apply at transplanting and then again later).

3. Foliar applications of neonicotinoid insecticides for whitefly control:

a. If foliar applications of a neonicotinoid insecticide are used instead of or in addition to soil drenches at transplanting, **foliar applications should be restricted to the first six weeks after transplanting.** Do not exceed the maximum active ingredient per season according to the label.
b. Follow scouting recommendations when using a foliar neonicotinoid insecticide program. Rotate to non-neonicotinoid insecticide classes after the first six weeks and do not use any neonicotinoid class insecticides for the remaining cropping period.

Additional Information:

Breaking the whitefly/TYLCV cycle: http://swfrec.ifas.ufl.edu/veghort/docs/tom_inst_2002_091202.pdf

TYLCV resistant pepper cultivars: http://gcrec.ifas.ufl.edu/TOMATO%202003.pdf

TYLCV resistant tomato cultivars: http://gcrec.ifas.ufl.edu/TomatoOptimized.pdf

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NEIGHBORS:

1. Look out for your neighbor's welfare.
This may be a strange or unwelcome concept in the highly competitive vegetable industry but it is in your best interest to do just that. Growers need to remember that should the whiteflies develop full-blown resistance to insecticides, especially the neonicotinoids, it's not just the other guy that will be hurt—everybody will feel the pain! This is why the Resistance Management Working Group has focused on *encouraging region-wide cooperation in this effort.*

2. Know what is going on in the neighbor's fields.
Growers should try to keep abreast of operations in upwind fields, especially harvesting and crop destruction, which both disturb the foliage and cause whitefly adults to fly. Now that peppers have been added to the list of TYLCV hosts, tomato growers will need to keep in touch with events in that crop as well.

Prepared by: Drs. David Schuster, Phil Stansly, Jane Polston and Phyllis Gilreath

WHAT IS SPDN?
Southern Plant Diagnostic Network

PEST ALERTS:

The NPDN/SPDN partners with the National IPM Centers, USDA-APHIS, USDA-CREES and the National Plant Board to produce regional and/or national pest alerts: http://www.ncpmc.org/alerts/

See Appendix 8 for a Tospovirus Pest Alert

First Detector Newsletter:

If you would like to receive the newsletter via your email, visit the SPDN website to signup:

http://spdn.ifas.ufl.edu/

Florida-specific information will also be available periodically through the Florida Plant Diagnostic Network (FPDN) website:

http://fpdn.ifas.ufl.edu/

The SPDN, coordinated by the University of Florida, is one of five regions within the National Plant Diagnostic Network (NPDN).

The mission of the NPDN is to enhance national agricultural biosecurity by assisting with the early detection of exotic, introduced pests and pathogens. This is achieved through a functional nationwide network of primarily public agricultural, Land Grant University (LGU) institutions with a cohesive, distributed system designed to quickly detect and appropriately disseminate information concerning high consequence plant pathogens, arthropods, weeds and other biological pests. The SPDN/NPDN is funded by the USDA, Cooperative State Research Education and Extension Service (USDA-CSREES).

FIRST DETECTOR TRAINING AND RESOURCES:

In order to promote the early detection of exotic pests, the NPDN has a national First Detector training program. A First Detector is anyone would potentially first notice an exotic pest problem in the field and may include Growers, County Extension Agents, Crop Consultants, Agricultural Inspectors, Master Gardeners and others involved in plant management. An effective First Detector should be familiar with 1) the normal appearance of the host and 2) the common insects, diseases, weeds and other pests associated with the host. He/she must also know how to 1) monitor for pests in the crop and 2) submit a sample of an unusual pest to their local diagnostician.

Most First Detector training sessions incorporate special topic information on high-risk pests of concern to a specific crop or geographic region.

Continual updates are provided for training resources available through the NPDN and SPDN by the monthly NPDN ***First Detector Newsletter.***

Various training resources are provided through the NPDN/SPDN website including: fact sheets, pest alerts, videos, powerpoint presentations and other information.

Visit the NPDN website http://www.npdn.org/ and click on the "First Detector Information" for more information. To view NPDN training, you must create an account and register through the NPDN educational site: http://cbc.at.ufl.edu/ .

Figure 1. Damage caused by the Chilli thrips, *Scirtothrips dorsalis,* a potentially significant new invasive species for both tomato and pepper production. Information (including powerpoints, video clips) are available at: http://spdn.ifas.ufl.edu/Chillithrips.htm and on the enclosed Pest alert. Photograph by: Matt Ciomperlik.

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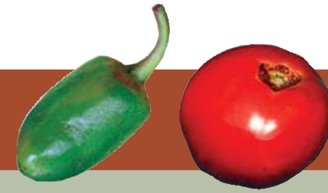

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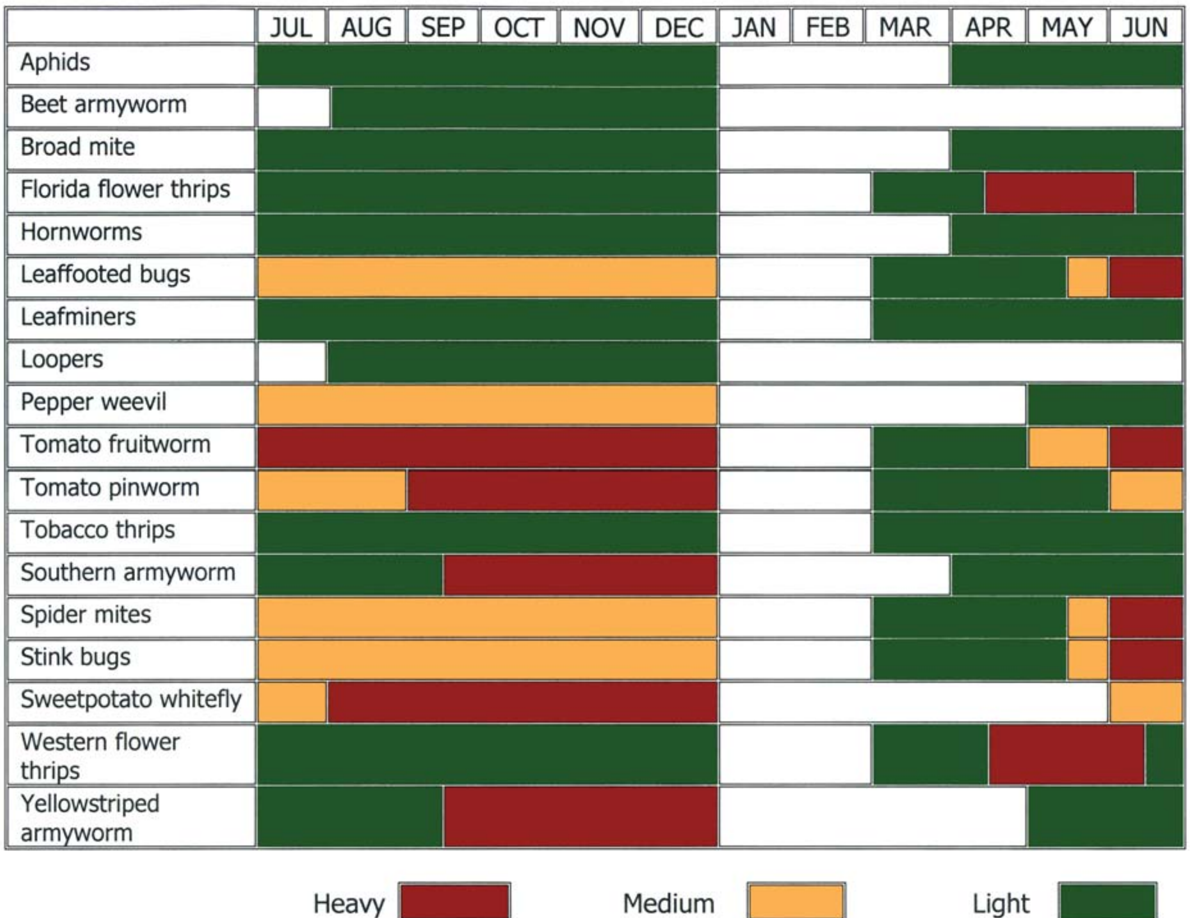

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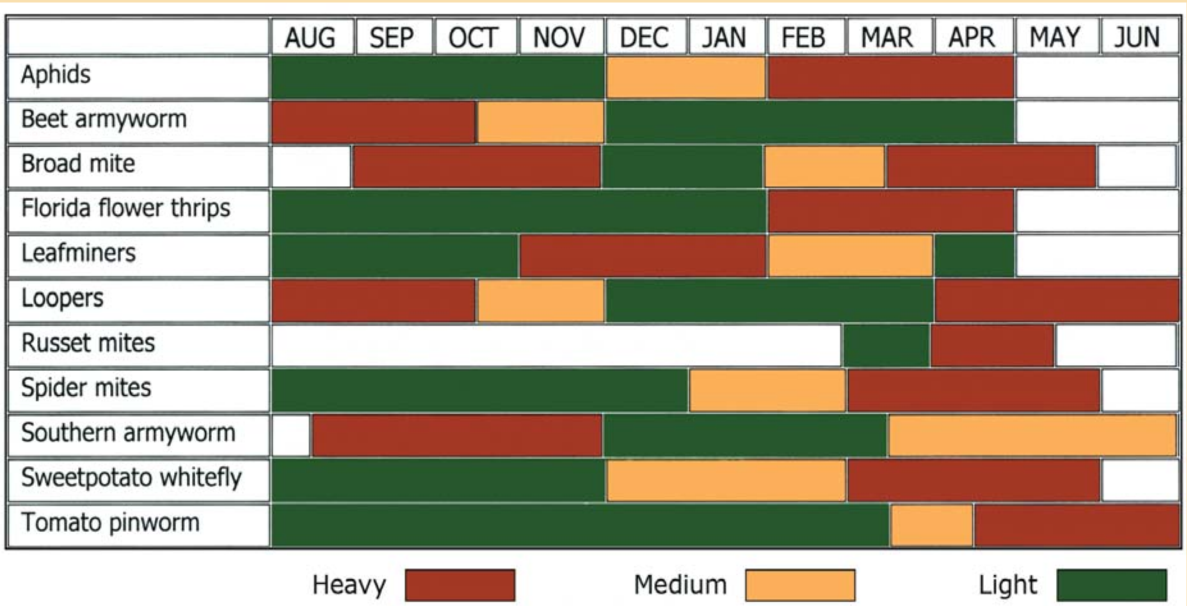

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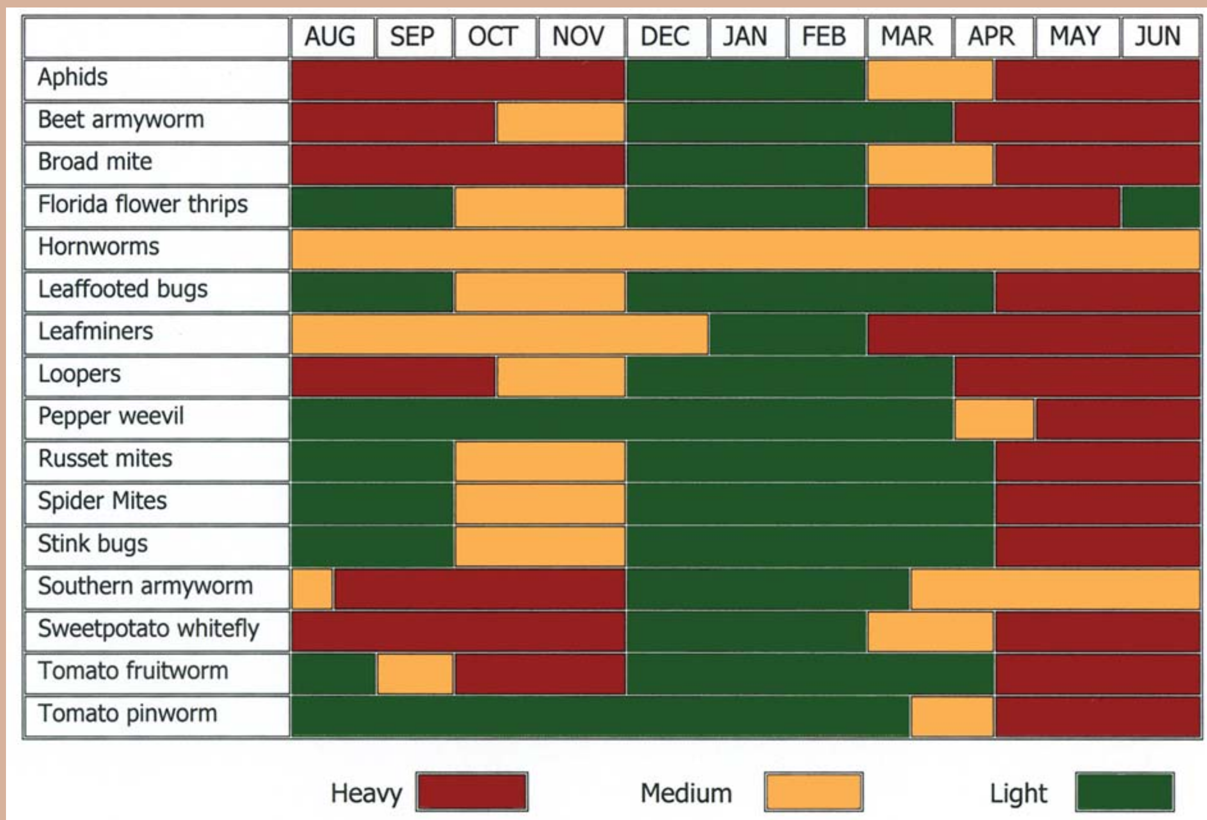

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