

Chapter 13.

Insects That Affect Vegetable Crops

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SOIL INSECTS

Soil insects are a constant problem in Florida unless soils are fumigated regularly. Most annual crops are subject to attack. All plant parts from germinating seed to roots and stems of young developing plants are susceptible. Damage ranges from reduced plant vigor to plant death.

Most soil insects are relatively indiscriminate in their choice of hosts. They generally feed on seed, seedlings, or plants that are in early stages of growth. Their attack centers on the rootlets, tap root, or lower part of the plant stem. Damage occurs from tunneling, boring, and consumption of plant tissue. The plant generally dies from breakage, lodging, or damage to the vascular system, restricting upward movement of water and nutrients. Damaged tissues may also become entry points for soil-borne disease. Symptoms of soil insect attack are described best as reduced plant growth followed by leaf yellowing, wilting, and eventually death. Surviving plants often remain stunted and yield poorly.

Soil insects are generally worse on crops planted after grass or turf. However, it is difficult to sample for soil insects or predict their impact. Control measures often consist of preplant insecticide treatments in well-discd soil followed by immediate incorporation by cross discing. In furrow application or fumigation are also effective. Treatment should take place from one to three weeks before seeding or transplanting.

Wireworms

Wireworms are one of the most damaging soil insects and attack almost all types of crops. The worm (larva) ranges in size from $\frac{1}{2}$ to $1\frac{1}{2}$ inches depending on stage and/or species of which there may be several. Larvae are hard, slender, and shiny. The predominant color is yellow to yellowish-brown. Adults are known as “click” beetles.

Wireworms live from one to several years and are found throughout the root zone. Symptoms may appear suddenly, causing significant reductions in plant stand that may render the crop non-economical. Edible underground parts of peanuts, Irish potatoes, sweetpotatoes and carrots are also subject to attack. Injury can result directly in culling or provide points for pathogens leading to secondary infections and rots.

Unfortunately, no sampling plan has been developed to predict damage, and field history is usually the best guide. Flooding for at least a month in summer will virtually eliminate wireworms. Chemical control continues to be a mainstay in preventing wireworm damage. It generally consists of applying recommended soil insecticides several weeks prior to planting and taking care to plow or disc the material into the soil according to directions.

Cutworms

Cutworms are larvae of moths related to armyworms, and have always been dreaded pests of young seedlings. They may attack nearly all plant types with succulent stems. They are stout, soft-bodied and dark colored. Worms are most active at night when they feed on foliage by climbing the plant or cutting it off at the base. Subsequent losses in plant stand may render the crop uneconomical. Worms often hide during the day under trash or clods close to the soil surface often near the damaged plant, readily rolling into a ball when disturbed. Cutworms can be controlled by baits which are best applied late in the afternoon.

Mole Crickets

This pest is also nocturnal and rarely observed by day. It damages young crops by tunneling in, under, and around the root systems. Feeding on the roots can occur, but is considered secondary. The crickets are active on warm nights coupled with good soil moisture. Adults as well as immature stages (nymphs) tunnel. Tunnels just under the soil surface are about $\frac{1}{2}$ inch in diameter and resemble miniature mole galleries.

Mole crickets are controlled best by baits or applications of soil insecticides. Proper choice of insecticide and application timing are critical. Baits must be broadcast in late afternoon on moist soils when warm evening temperatures (68°F or above) are anticipated.

Lesser Cornstalk Borer

This pest attacks more than 60 known plant species in Florida. It is a particularly serious pest on corn, peanuts, soybeans, southernpeas, and various varieties of beans grown as vegetables. The female moth lays eggs on the host plant and the young caterpillar feeds first on foliage, later burrowing into the stem. The larva attaches a silken tube to the entrance hole in the stem at or just below the

soil surface and bores into the main tap root and/or stem of the plant. The small ($\frac{1}{4}$ to $\frac{3}{8}$ inch) worm is encircled by alternate bands of purple and aqua-blue, and will jump violently after careful removal from the plant stem.

Chemical control with recommended insecticides is usually successful only if applied at or just after planting time, except in peanuts where delayed applications may protect developing pegs.

Cucumber Beetle Larvae

There are several species of cucumber beetles (banded, striped, spotted) that attack field and vegetable crops. Adult beetles feed on the foliage, but the major source of damage is caused by yellowish-white fragile larvae (worms) that tunnel through roots or eat off rootlets. Often the lower part of the stalk is also riddled. The small thin worm is quite fragile and can only be dissected from the plant tissue with difficulty. The spotted or banded cucumber beetle adults feed on foliage and can transmit squash mosaic virus and bacterial wilt.

Chemical control is difficult and little can be done once the plant is infested. Therefore, insecticides must be applied at planting or shortly thereafter if problems are anticipated. Cucumber beetle larvae are worse on wet soils especially where clay content is high.

White-fringed Beetles

This insect is a pest of crops grown in the western and northern part of the state where over 360 species of plants including field and vegetable crops are attacked. The adult beetle is about $\frac{1}{2}$ inch long and is grey in color with faint white stripes on the sides. Adults feed on the leaves but the critical damage is caused by the grub-like legless larvae which are about $\frac{3}{8}$ to $\frac{1}{2}$ inch long and feed below the soil surface on the stem and taproot. Adults are unable to fly but can spread $\frac{1}{4}$ to $\frac{3}{4}$ mile per year by walking or be spread by human activities.

Control is almost impossible and infested fields are often abandoned. Rotation is of little value with so many hosts. Chlorinated hydrocarbon soil insecticides provided control but with their removal from the marketplace, the white-fringed beetle could become a terrible pest.

White Grubs

White grubs are occasional pests of vegetable and field crops. As with the mole cricket, damage results from tunneling and secondarily from root feeding. The grub is identified by the brown head, six prominent legs, white smooth shiny body that is purple to black at the rear end where gut contents show through the skin. Most all vegetables, field or cultivated plants may be attacked, especially when following grass, turf or sod. Adults are known as May or June Beetles and are nocturnal, doing little

damage themselves. Most species have a one-year life cycle culminating in late spring emergence of adults.

Recommended controls include crop rotation away from corn, control of grass weeds, flooding which should be done in August when most eggs have hatched, and discing, which combined with bird predation greatly reduces grub populations. Insecticidal control when problems are anticipated is similar to that for wireworms: pre-plant application thoroughly disced in. It is important to keep records on field history for several years in order to combat this pest effectively.

FOLIAGE AND STEM FEEDERS

All chewing insects feeding on foliage will be considered in this section, although the armyworms and tomato pinworms feed on fruit as well, especially in their later stages. Sucking insects will be considered in the next section, regardless of where they feed, although most feed on foliage except for stinkbugs which prefer developing seed or fruit. Chewing insects specializing on fruit and seeds will be considered in the last section.

Foliage feeders are primarily beetles and caterpillars although grasshoppers could also be considered in this category. Adult and larval beetles may both feed on above-ground plant tissue, although in cases like white-fringed beetle or cucumber beetle, most damage is done underground by the larvae (see soil insects). Caterpillars are widely recognized as foliage feeders, but the adult forms (moths, butterflies or skippers) do not damage plants. Beetles and caterpillars feed with horizontally opposed mandibles as do grasshoppers, but leafminer larvae have two downward-curving mouth-hooks that work in and out in unison. Foliage feeders and their damage usually become quite obvious, so a great deal of attention and control effort is devoted to them, sometimes more than is warranted by actual economic impact.

Caterpillars or Worms

Armyworms

Armyworms are so named for of their habit of attacking plants in large numbers. They may seem to appear all at once, feed and then more or less disappear all at once. The stripes and coloration of these caterpillars are highly variable; however, they can generally be identified by a white or light colored inverted "Y" mark on the front of the head.

The adult moth lays a mass of eggs covered with fuzzy, buff, brown or light-colored scales. Hatchlings often congregate on the underside of the foliage, scraping away all but the clear upper cuticle, giving the leaf a "window-pane" appearance. Older larvae disperse and may often

enter fruit crops like tomato and pepper. Full-sized caterpillars will reach 1 to 1½ inches in length when grown.

There are four major species of armyworms in Florida discussed in subsequent sections.

Fall Armyworm

The fall armyworm varies in color from light tan to green to black. It has three yellow hair lines down the back from head to tail. On the sides next to the yellow lines is a wider dark stripe and next to it an equally wide, somewhat, wavy yellow stripe blotched with red. The name refers to the appearance of the worm in the fall further north, but in Florida it may appear at almost any season. The insect cannot overwinter in any section where the ground freezes and thus migrates from warm winter areas every spring.

Fall armyworm is primarily a grass feeder and corn (including sweet corn) is a favorite host. However, it will sometimes attack other crops including fruiting vegetables, especially sweet pepper, where it rapidly moves from foliage to fruit. Sweet corn is attacked in all stages and control must often be intensive, especially from silking through harvest. Pheromone traps are available to assist in monitoring.

Beet Armyworm

The adult is relatively small for an armyworm (wing-span 1 inch) the front wing being light brownish grey with indistinct lines and the hind wing white. Egg masses usually number 50 to 75 eggs. Larvae are generally green, mottled with white spots, 1 to 1¼ inch long at maturity, often a small black spot above the 2nd pair of true legs. Generation time is about 25 to 35 days, depending on temperature. Young larvae tend to congregate in leaf whorls and emerging foliage where they spin loose webbing. Principal damage in fruiting vegetables, especially pepper, is from fruit feeding by older larvae. Populations tend to migrate within crops and regions where they are constantly exposed to similar insecticides so insecticide resistance is common. Pheromone traps are available to assist in monitoring. Selective insecticides can be used preferentially to avoid negative impact on beneficial insects, but should be applied before worms are more than ½ inch long.

Southern Armyworm

The southern armyworm is also considered a climbing cutworm. The front wing of the relatively large adult is streaked with cream, grey, light brown and black and the hind wing is white with some dark on margins. Eggs are laid on the underside of leaves in large masses covered with a felt-like mat of body scales, and hatch in about 3 to 4 days. The mature worm is dark with two rows of dark triangles along the top above a yellow line inter-

rupted by a dark spot behind the 3rd pair of legs. The head is light-brown with faint, net-like markings. Southern armyworm feeds on a number of weed species such as pigweed (*Amaranthus*) from which they can move into a wide range of broadleaf crops, tomato being a favorite. It is common in south and central Florida but only an occasional pest in north Florida where the yellow striped armyworm is more prevalent.

Yellow-striped Armyworm

The adult yellow-striped armyworm is similar to the southern armyworm and the larva also has two rows of triangular black spots along the side but with a white line passing through. Below the dark spots is a bright orange stripe, often with white stripes inside. The head-capsule is dark brown to black in front separated from a lighter brown area on the side by a white, inverted "V". Habits are also similar between the two species, and both are fairly susceptible to insecticides although they may be difficult to control completely in a dense canopy.

Loopers

Loopers may be devastating pests of many vegetable crops as well as some field crops. They get their name from the looping hump-back motion caused by the first three pairs of slender "true legs" moving the head and thorax forward, followed by the three pairs of fleshy "pro-legs" bringing up the club-shaped rear end. Non-looping caterpillars generally have another two pair of prolegs in the middle of the abdomen that loopers lack.

Cabbage looper and soybean looper are the worst pests of the group. Cabbage looper attacks crucifers as well as lettuce, spinach, beet, pea, celery, parsley, potato, and tomato and soybean looper attacks peanut, pea, cotton, sweetpotato, tomato and tobacco. Larvae are difficult to distinguish: both are green with light, longitudinal stripes, but the adult cabbage looper has a light mark on the forewings resembling a figure eight whereas the light mark on the soybean looper's forewing does not. The larval stage lasts for two to four weeks and pupation occurs in a loose cocoon attached to leaves of the host plant. There are usually three to four or more generations per year.

Control of loopers is often more difficult than for most species of caterpillar, probably due to resistance to many commonly-used insecticides. Also, loopers move quickly to protected parts of the plant after a spray. Therefore, thorough spray coverage of the plant is important. Proper insecticide selection is also necessary since many standard worm control agents will not control loopers. It is also important to detect loopers while they are still small, since like the beet armyworm, they become extremely difficult to kill after they get larger.

Diamondback Moth

Adults are small, greyish narrow-winged moths with three, yellowish diamond shaped markings down the back. Eggs are laid singly or in groups of two or three on the leaf underside of cabbage or other cole crops. Feeding of the tiny green larvae causes "windowpaning" or small holes in the leaves as the larvae mature. Pupation occurs in a loose, net-like cocoon attached to the leaf surface.

High populations can be devastating to cole crops. Damage from low to moderate populations may be confined largely to the wrapper leaves in cabbage but may be a greater concern in non-heading types. Diamondback moth has developed resistance to many commonly used insecticides, especially pyrethroids but also to *Bacillus thuringiensis* particularly the traditional "*kurstaki*" strains. Insecticides employing different modes of action should be rotated when insecticidal control is required. Biological control agents include the ichneumonid wasps *Diadegma* and *Microplitis*.

Hornworms

Hornworms are characterized by a horn-like projection on top of the rear end of the body. The worms grow quite large (3 to 4 inches) and can consume large amounts of foliage within a short of time. The worms attack solanaceous crops (tobacco, tomatoes, eggplant, pepper and potatoes).

Adults are large hawk or hummingbird moths (5 inch wingspan) that lay greenish eggs slightly smaller than a BB shot, one at a time, on the leaves of the host plant. Often, they are heavily parasitized by minute *Trichogramma* wasps, many of which can emerge from a hornworm egg. Caterpillars feed for three to four weeks before pupating in the ground. They are easy to control with Bts (*Bacillus thuringiensis* biological insecticide) or other recommended insecticides if spray coverage is adequate.

Bean Leafroller

This caterpillar attacks beans and can be easily recognized by the characteristic damage. Young larvae notch and roll back a portion of the leaf margin giving it a flap-like look. As the larva grows, the folds along the leaf edge also become larger. The mature caterpillar is approximately 1½ inches in length, predominately green with several yellow stripes running longitudinally along the body. The head capsule is prominent and the body is constricted just behind the head giving the worm a "small necked" or "pinched" look. Control is rarely necessary but easy to obtain with recommended materials and proper application.

Tomato Pinworm

Tomato pinworm is similar to leafminer in its initial attack, although the mine later becomes blotchy in shape rather than serpentine. Feeding is restricted to tomatoes,

eggplant and potatoes in contrast to the leafminer which feeds on a wider range of crops

The pinworm is a small, yellowish-grey or green, purple-spotted caterpillar, no more than ½ inch long when grown. It tunnels through the leaf but does not leave a trail of fecal material like the leafminer since it comes to the entrance to make depositions. It often rolls and ties the leaf tips together which leafminers never do. It may leave the mine to start another or attack the fruit. Fruit injury begins under the calyx and can initiate a rot. The larva drops to the soil or litter to pupate and several generations of the moth pest can be expected each year.

Control is difficult due to the protected feeding habits of the pest inside the leaf and fruit. Pheromones that attract males are available to assist in monitoring and may also be applied to the crop to control egg-laying by confusing the male in his search for the female and thereby disrupting the mating process. Insecticides directed at the larvae must be correctly selected, timed and applied for satisfactory results. If left unchecked, severe infestations may result in whole fields looking as though they had been sprayed with "weed killers".

Beetles

Mexican Bean Beetle

The Mexican bean beetle is a pest of snap beans, lima beans, and cowpeas. The adult beetle is ¼ to ⅓ inch long and marked with 16 black spots on a bronze-colored background. It looks like a large lady beetle which in fact it is, being the only member of that family that feed on plants. The yellow larvae are about a inch long when fully grown and have rows of long, branched, black-tipped spines growing from their back.

Both the adult and larvae feed on the foliage and prefer to do so from the underside of the leaves. The pests usually feed in large numbers and the leaves take on a characteristic "lace-like" skeletonized appearance. Heavy infestations may cause total plant defoliation with the desperate beetles turning even on the pods and stems.

Colorado Potato Beetle

The Colorado potato beetle is a key pest of potatoes, does well on eggplant, and can survive on tomato, tobacco, pepper or even cabbage. The adult has a hemispherical body marked with alternate black and yellow stripes running lengthwise (five of each color on each wing cover) and is about ⅜ of an inch long. Yellowish-orange eggs are laid in batches of about one dozen on the underside of the leaves. The smooth, hump-backed larvae are pink to red in color with two rows of small black spots on either side and three pairs of well-developed legs. They reach ½ inch in length when fully mature. Both the adults and larvae feed by chewing the leaves and terminal growth of the host plant. Larvae usually feed in groups.

Control is becoming difficult with both contact and stomach poisons in most potato growing areas of the U.S. They are susceptible to the tenebrionis strain of Bt (*Bacillus thuringiensis*) and also to the systemic insecticide imidacloprid. Care should be used in selecting insecticides and in obtaining proper coverage.

Flea Beetles

These are flea-sized (about $\frac{1}{16}$ inch) beetles with enlarged hind legs enabling them to jump when disturbed, hence the name. They are usually bronze, brown or black with many color variations including striped. Foliage-feeding by the adult gives the plant a "shot hole" appearance and they can also trench the leaf surface. Eggs are too small to be easily seen and are usually laid in the soil or plant crevices. The white delicate worm-like larvae are only $\frac{1}{8}$ to $\frac{1}{4}$ inch long when fully grown and feed on plant roots, underground stems or tubers. Control is usually not necessary but accomplished without difficulty by proper selection and application of insecticides.

Leafminers

Leafminers are particularly damaging pests of bean, pea, celery, carrot, crucifers, cucurbits, okra, potato and tomato but also attack many other row crops. The adult is a small fly about the size of an eye gnat. The female punctures or "stipples" the leaves with her ovipositor to lay eggs in the leaf tissue or to feed on sap. The yellow maggots grow to about $\frac{1}{10}$ to $\frac{1}{8}$ inch long just prior to exiting the leaf to pupate on the ground. The maggots feed on the chlorophyll tissue leaving a winding trail or pattern through the leaf. The pest is protected within its tunnel since the upper and lower epidermis is not fed upon. The tunnel is clear with the exception of a trail of black fecal material left behind as the maggot feeds. Generations in Florida are continuous for much of the year.

Leafminer injury is quite visible to the grower but healthy plants can usually tolerate considerable damage without undo loss of vigor and yield. However, heavily damaged leaves will often drop, due in part to entry of pathogenic fungi and bacteria into old mines. Fortunately, populations are generally prevented from reaching truly damaging levels by a number of parasitic wasps that attack leafminers in Florida. Wasp larvae develop on or in the leafminer larva or pupa, and pupation occurs in or near host remains. The wasp stings the host and injects a paralyzing venom in species developing externally. The host ceases to feed and the parasitoid egg or larva is visible through the leaf epidermis. Larvae developing internally are solitary, and after several days of development may be seen inside their leafminer host by using a hand lens against strong light.

Chemical control is difficult due to the feeding habits inside the leaf of the host plant. Care must be taken in application and timing of insecticidal sprays if the pest is

to be controlled. Insecticides should be selected to specifically target the leafminer rather than broad-spectrum materials which are of limited use and decimate beneficial insects including those that attack leafminer.

Mites And Sucking Insects

Members of this group generally injure above-ground plant parts by removal of plant sap or cell contents with their needle-like mouthparts or stylets. Sap removal may debilitate the plant by removing nutrients and water. Many sap feeders produce honey dew which serves as a substrate for sooty mold which can cover the leaves and inhibit photosynthesis. Thrips and mites remove cell contents and can cause leaf injury and fruit scarring. Saliva injected during feeding contains enzymes and other substances that may produce toxic responses in plants, producing discolorations, necrosis or growth abnormalities on leaves, stems. Finally, many pests in this group are capable of transmitting plant viruses.

Damage from the piercing-sucking group is often underestimated since the wounds they make are not apparent to the eyes of the observer. Frequently, the pests of this group are quite mobile and fly before they are seen. These pests are particularly bothersome in dry weather since they account for added strain on plants which are already short of moisture.

Overall plant symptoms caused by either severe or constant attack are characterized by distorted leaves, overall loss of plant vigor (in spite of adequate moisture and nutrition), spotting of leaves, eventual yellowing of the plant or some of the leaves, and in some cases, loss of foliage and death. In the case of fruit or pods the piercing-sucking group causes off-color spots or wart-like growths on tomatoes, etc; pod drop on soybean, bean and pea; and curvature of the fruit on okra and others.

Aphids or Plant Lice

Aphids or plant lice are common plant pests that are usually present to some degree in every crop. There are numerous species of these insects and hardly any plant escapes their attack. They may be particularly severe pests of vegetables and field crops.

The aphids come in various sizes ($\frac{1}{16}$ to $\frac{1}{8}$ inch long) and colors (brown, yellow, pink, or black). They feed by thrusting their sharp hollow beaks in among the plant cells and sucking out juices from the phloem. They can produce copious amounts of honey dew resulting in appearance of black sooty mold on leaves and other plant parts. Saliva is injected during feeding that may cause the foliage to become twisted, curled or cupped downward. Large numbers of aphids may cause plants to gradually wilt, turn yellow or brown and die.

Aphids are the most important agents in the dissemination of plant viruses such as tobacco etch virus, (TEV), potato virus Y (PVY), pepper mottle virus (PMV) that are mainly problems in solanaceous crops, or watermelon mosaic virus (WMV), zucchini mosaic virus (ZMV), and cucumber mosaic virus (CMV) that are problems mainly in cucurbits and cucumber mosaic virus which attacks a large number of plant families. The aphid mouthparts act like a dirty needle, acquiring and inoculating the virus rapidly, often just by testing or “probing” the plant. Thus, the aphids that colonize the plant are not the only culprits, and insecticides do not act quickly enough to stop the transmission.

Aphid females reproduce asexually, giving birth to live young which develop rapidly to reproductive age. Thus, populations increase rapidly. Under favorable conditions the adults remain wingless aphid factories, but under crowded conditions winged forms develop which disperse effectively, moving viruses with them.

Aphids have many natural enemies such as ladybeetles, aphid lions, hover flies, and tiny parasitic wasps that convert them to dry, brown mummies. These beneficial insects are capable of suppressing aphid populations if present in sufficient numbers before the aphids get a foothold. If insecticides are required, short-term control of aphids with foliar sprays is possible if a few precautions are observed. It is necessary to select a recommended material for their control, but even more so, a thorough coverage of all the plant surfaces is mandatory. Aphids prefer the undersurface of the leaves and young developing buds as feeding sites. Thus they are protected from much of the insecticidal spray unless these places are covered. Even a few females left uncontrolled can quickly lead to new populations. One item in favor of the grower is that the aphids do not lay eggs, which generally is a life stage that protects the insect from insecticides. Therefore, a single well-delivered spray will often kill all of a population, and the grower will be free of the pest until re-infestation occurs from new migrations of winged females. Another option if damaging populations are anticipated is soil-applied systemic insecticides which translocate to the leaves and may provide long-term protection.

Leafhoppers

Leafhoppers are pests that attack nearly all cultivated plants as well as many wild hosts. The majority of adults vary in size from $\frac{1}{20}$ to $\frac{1}{4}$ inch but a few will reach $\frac{1}{2}$ inch in length. Most are wedge-shaped individuals, broad at the head and pointed behind. They are often brilliantly colored: green, yellow, blue, red, and may have solid, striped, spotted or banded color patterns. However, many are somber colored such as brown, tan, grayish or black.

When leafhoppers are abundant on any crop, the plants show a lack of vigor, growth is retarded and, in most cases, the leaves have a somewhat whitened, mottled appearance, or turn yellow, red or brown. This condition is due to the

sucking out of the sap by the hoppers which feed mainly on the underside of the leaves.

The feeding of certain species of leafhoppers produces a burning effect on the plants, and causes the tips to wither and die as if scorched by bright sunshine, heat, or drought. In walking through fields which are infested, large numbers of these insects will hop or fly for short distances ahead of the observer.

Several species transmit plant viruses, although the leafhoppers take longer to become infective than do aphids but remain infective all their lives. Thus, insecticidal control may be a more viable option to slow transmission. The adults lay eggs in the plant stem, buds or leaves, which hatch into wingless nymphs. The nymphs feed in the same manner as the adults. They suck and inject toxins into the plants which are poisonous to the tissues, particularly around their feeding punctures.

Control, if required, can usually be accomplished by proper spraying of the crop with a recommended insecticide.

Whiteflies

There are three species of whitefly that may commonly attack vegetables in Florida, the greenhouse whitefly, the bandedwing whitefly and the silverleaf whitefly. Adults are tiny, moth-like insects approximately $\frac{1}{32}$ inch long that inhabit and feed on the undersurface of leaves by penetrating the tissue and removing plant sap with their piercing-sucking mouthparts. The white color is attributed to the secretion of wax on the body and wings.

The greenhouse and bandedwing whiteflies fold their wings flat while at rest or feeding, whereas the silverleaf whitefly holds its wings roof-like at an angle. Silverleaf whitefly is by far the most common and damaging of the three. The name refers to symptoms caused by feeding of nymphs on squash.

Female silverleaf whiteflies deposit their eggs on the underside of leaves where they are usually clustered in groups. The number of eggs laid by a female in her lifetime ranges from approximately 50 to 400, with an average of about 160. The eggs are very small, about $\frac{1}{125}$ inch long and $\frac{1}{250}$ inch diameter. Each egg is attached by a stalk to the leaf and is somewhat elliptical in shape, tapering towards the unattached end. Newly laid eggs are smooth and whitish-yellow. As the eggs approach hatching in about five to seven days, they turn brown.

The pest goes through four nymphal instars, ranging in approximate size from $\frac{1}{95}$ inch as first instars and/or crawlers, to $\frac{1}{40}$ inch as fourth instars. The immature stages are thin and flat, elliptical in shape, and clear or creamy-yellow in color. In most infestations, all stages of the life cycle are present. At the end of the nymphal cycle,

it enters into what is commonly referred to as the pupal stage. The pupa has two conspicuous red eyes and the body is raised or convex in shape. It is yellow in color and about 1/35 inch long.

The nymphal stages are sedentary, with the exception of the crawler, which after hatching moves a very short distance. Once a feeding site is selected the nymphs do not move. They suck juices from the plant with their piercing-sucking mouthparts. The nymphs are located on the undersides of the leaves and can become so numerous that they almost cover the entire undersurface area.

As the life cycle progresses from stage to stage, molting occurs and the cast skins (particularly from the pupae) remain on the leaves. These structures are empty, silver in color, and resemble small fish scales on the leaves.

The silverleaf whitefly currently is known to attack over 500 species of plants representing 74 plant families. They have been a particular problem on tomato, members of the squash and cucumber family, eggplant, okra, beans, peanut, gerbera daisy, hibiscus and many other ornamental plants. The poinsettia is a favored host and suffers color loss and leaf damage in a recognizable pattern.

Feeding damage by both nymphs and adults results in the accumulation of honeydew on the leaves, with subsequent growth of sooty mold. Other forms of damage include the removal of plant sap, vine, leaf, and plant breakdown, chlorotic spots, yellowing, leaf shedding, silencing of squash foliage and abnormalities of fruiting (Fig. 13-1). In Florida, silverleaf whitefly is a vector of tomato mottle virus (ToMoV) and tomato yellow leaf-curl virus (TYLCV) and bean golden mosaic virus (BGMV) in bean. These viruses have narrow host ranges compared to the aphid-borne viruses mentioned above. At least a few hours of feeding are required for the whitefly to become infective which it remains for life. Therefore, insecticidal control may be effective in slowing virus spread. However, foliar insecticides are of limited value and systemic insecticides applied to the soil are generally more effective. There are many natural enemies of whiteflies that may provide effective biological control in the absence of broad-spectrum insecticides.

Stink Bugs

Stink bugs can be recognized by the offensive odor they produce when disturbed. One species or another will attack almost all vegetable and field crops. Stink bugs, like all other insects with piercing-sucking mouthparts, remove plant juices and inject toxins which result in limp wilted leaves or groups of wilted leaves connected to a common fed-upon stem.

The southern green stink bug is probably the most common of all the stink bugs in Florida. It is a large flat-

tened, shield-shaped, bright green colored bug about $\frac{2}{3}$ of an inch long. The nymphs are smaller, wingless and have small red, black and white markings on their backs. This pest may become a serious threat to soybean, cowpea, and other beans. They prefer to feed on young developing pods which causes them to drop or form hardened, knotty areas or to produce stunted and distorted seeds. Feeding injury on tomato results in hard, flattened, light-colored areas surrounding a tiny puncture.

The brown stink bug is similar to the green variety except that it reaches only $\frac{1}{2}$ inch in length as an adult and is buff or brown in color. They attack plants in the same manner and cause the same damage as the green stink bug does. Normally the green species outnumbers the brown, but there are times when they occur in reverse populations.

The leaf-footed plant bug is identified by the lower part of the hind legs which are flat and somewhat leaf-shaped. They are approximately $\frac{5}{8}$ to $\frac{3}{4}$ of an inch long and are brown with a narrow white band running across the back. They normally are solitary in their attack, but often several will be found on one plant causing wilting symptoms. The big-legged or big-footed plant bug is the largest of the group, closely related to the leaf-footed bug. It is dark grey to black, and adults are 1 to $1\frac{1}{2}$ inches long. The hind legs are enlarged and appear to be swollen. They are not generally bothersome, and occur more as solitary pests.

Stink bugs are often overlooked in plant inspections due to their cryptic coloration, and habits of feeding deep in the plant foliage. They can be controlled if necessary with the proper spray material applied with thorough coverage.

Thrips

Thrips have been considered in the past as nuisance pests to most vegetable crops, although the onion thrips has always been a serious pest of onions. However, in the last several years two species, western flower thrips in the north and melon thrips in the south, have become pests of a serious nature on some crops.

Thrips are tiny (about $\frac{1}{16}$ inch long as adults) and slender. They live in flowers, on tender leaves and leaflets. Adults of most thrips pests are yellow except for the tobacco thrips and the onion thrips which are dark brown to black. Adults are active when disturbed and move quickly. The wingless larvae are cream or white in color. Larvae develop through a stage known as the prepupa which does not feed but drops to the ground and pupates.

Mouths of thrips are unique in being intermediate between the chewing and the piercing-sucking type and in having only one mandible which tears open the cells so that the exuded fluid can be sucked up. Thrips inhabit the

blooms of many plants and it is not known if they inhibit pollination. Feeding on young fruit may result in scarring and russetting; feeding on foliage can cause scarring, distortion and upward curling and if severe, dessication. Egg-laying in young tomato and pepper fruit by western flower thrips causes dimpling that may throw fruit out of grade. Finally, western flower thrips, the tobacco thrips and the onion thrips transmit tomato spotted wilt virus (TSWV) which can be a very serious problem in a wide range of crops including tomato, tobacco, pepper and peanut. The virus is acquired by the larvae but transmitted by the adult.

A number of beneficial insects feed on thrips and may contribute to their control, notably the minute pirate bug. Insecticidal control is difficult, especially of the two most damaging species, melon thrips and western flower thrips. Broad-spectrum insecticides will often flare thrips populations, presumably by killing off natural enemies. If chemical control is necessary, care must be taken in selecting specific insecticides and in obtaining thorough spray coverage.

Spider Mites

Although there are several species of spider mites which attack vegetables, the red spider mite and the two-spotted spider mite are the most common. The red spider mite is often referred to as the “red spider”, the red mite, or the red spider mite.

Spider mites are favored by hot dry weather which also aggravates injury by stressing the plant. Leaves become blotched with pale yellow, reddish-brown spots ranging from small to large areas on both upper and lower leaf surfaces. If infestation is severe, leaves become pale and sickly in appearance, gradually die, and drop off the plant. Before death the leaves look as though they have been dusted with some sort of powder which is caused by numerous molted skins of the mites coupled with a depletion of leaf chlorophyll.

Spider mites may be whitish, green or red, depending upon age and species. Adults are about $\frac{1}{60}$ inch long. Mites are more closely related to spiders than to insects and generally have eight legs except when just hatched when they have six legs like insects. Males are oblong in shape while females are more round.

Spider mites live on cell sap which they draw by piercing the leaf with two sharp, slender lance-like stylets. Almost all types of crops are subject to attack by some species of spider mite. The mites are also severe pests of plants grown inside or in greenhouses. Those that attack vegetables spin webbing on the plant surface, and also to migrate by spinning a long strand of silk and ballooning on the wind. The first outbreak of mites in a field generally occurs around barns, fences, trees or some obstacle in the field acting as a windbreak.

Spider mites reproduce rapidly under favorable conditions, and control can be difficult. Biological control with predaceous mites that can be purchased commercially is a viable option but must be initiated before populations have a chance to build up. In accessing the need for chemical control, consideration should be given to the age structure of the population. Numerous nymphs compared to adults signals a population likely to increase, whereas numerous adults may signal a declining population, especially if a disproportionate number of males is present. If chemical control is deemed necessary, care must be taken to select an appropriate miticide and thoroughly cover the plants. In Florida, a second application must be applied from five to seven days following the first, to kill mites that were eggs at the first spray. If more than five to seven days are allowed to pass after the first application, new females will have matured and laid eggs again. Therefore, a second spray kills the nymphs before they reach maturity and lay eggs which in turn would provide for a new generation.

INSECTS THAT CONSUME SEEDS, PODS OR FRUIT

This group of insects constitutes probably the most dangerous of those discussed. A plant, particularly one possessing good health and vigorous growth often can overcome attack by soil and foliage feeders, and piercing-sucking types. Most plants (if the foliage is not consumed) can also stand quite a bit of foliage loss before actual seed, pod or fruit loss occurs. However, if the final product is fruit or seed and that is attacked, serious economic loss can be incurred. Therefore, insects that infest fruits, pods, ears, etc. are given special attention by the grower since even small damage will cause fruit to be culled. To further complicate the situation, attack of fruiting structures usually comes late in the crop cycle when time, money and labor expended on the crop is at a maximum.

Corn Earworm

The corn earworm is also called the cotton bollworm, tomato fruitworm, and soybean podworm. It attacks most vegetables and field crops. Although it also feeds on foliage, it becomes the most damaging when it bores into or attacks developing fruit, ears, and pods which are its preferred food.

The worm varies in color from light green or pink to brown or nearly black. Light-colored underneath, they have alternating light and dark stripes running lengthwise on the body. The stripes are not always the same on different individuals, but there is usually a double dark line running lengthwise of the body located on the mid point of the back. The head is yellow and the legs nearly black. The skin is coarse and shows many thorn-like projections. The worm has four pairs of abdominal prolegs plus the

terminal pair, and reaches up to 1½ inches in length when fully grown. The worms are cannibalistic and usually only one or two per ear (on corn) are found. Two to three generations are produced each season.

The corn earworm is an extremely dangerous pest. Larvae bore into the fruit of the tomato and feed on the silk and tip kernels of sweet corn, ruining the ear. They also will bore into pods of bean and pea and eat the seeds. Control is dependent upon good coverage of the target plant by the spray applicator. Timing is also critical and the worms are impossible to control once they have bored into plant structures.

Pickleworm and Melonworm

These two closely related species are pests of the cucurbit group (watermelon, cantaloupe, squash, cucumber, pumpkin, and honeydew melon). The pickleworm is greenish except for the brown head and about 100 black spots on all but the oldest stage. The melonworm is also green but with two white lines down the body in all but the largest stage and no black spots. Wings of the adult pickleworm measure a little more than 1 inch across and are yellow in the center with brown margins whereas wings of the melonworm moth measure 1¾ inch across and are pearly white surrounded by a dark, narrow margin. Both moths have a bushy tuft of scales at the tip of the abdomen. The female moth lays her eggs in groups of 2 to 7 on the tender buds, new leaves, stems and underside of fruit. Melonworm larvae at first feed on leaf tissue and when they become larger many bore into fruit. The larvae push out small masses of green sawdust-like excrement from the holes in the fruit. The fruits soon rot, sour and mold after the interior has been exposed to the air by the burrows. Fruits of late season plants are severely attacked. Pupation occurs near the ground in rolled up leaves of the host plant or nearby weeds. Usually four to five generations are produced per season. Pickleworm larvae spend very little time in foliage, but head straight for the fruit, although young larvae can also be found in flowers, especially of squash.

Chemical control of the pickleworm is difficult because the caterpillar is protected once it penetrates the fruit and every effort should be made to reduce populations over the fallow period by burning or incorporating crop residues and discing to bury pupae. Squash can be used as a trap crop for cantaloupe but infested fruit need to be destroyed before the worms complete growth. Insecticidal control must be initiated before entry of the worms into fruit to be effective.

Cowpea Curculio

The adult weevil is about ⅛ to ⅙ inch long and dark in color, with a long snout. The female uses the mouthparts located at the end of the snout to drill a hole through the developing pods of peas and beans where it inserts an egg. The tiny white grub-like larvae then feed on the inside of

the seed and cause its destruction. Control, if necessary can be obtained with properly timed preventive spray programs targeting the adult.

Pepper Weevil

Pepper weevils are shiny, brownish-black or grey colored snout beetles, about ⅛ inch long. The females use their mouthparts to drill into fruit or flower buds if no fruit is available. She inserts an egg, then plugs the hole with fecal material. She may also drill into leaf buds, flower buds or fruit to feed, leaving puncture holes. The legless white, brown-headed grubs tunnel into the seed mass at the center of the pepper pods or into flowering structures to feed. Infested fruit eventually fall to the ground if not picked first. The grub is only ¼ inch long when full grown but its feeding and the fecal material left behind is enough to ruin the fruit. When the larva terminates feeding and growth it pupates in place and the adult later bores its way out leaving a small round hole.

Pepper weevil populations usually build up slowly but steadily during the season and eventually can become devastating. They are capable fliers and readily migrate from field to field, so it is imperative not to plant close to an infested field. Adults are quite long-lived and can survive for a month or more on alternate hosts. Some reproduction is also possible on nightshade. Only the adult is subject to insecticidal control. Thorough scouting is critical to detect an infestation in its earliest stages if treatments are to be effective. Pheromone traps are available to aid in monitoring. Weekly sprays are often necessary to control an established population.

Potato Tuberworm or Tobacco Split Worm

Potato tubers in the field and in storage are often riddled with slender, dirty-looking silk-lined burrows containing pinkish-white or greenish caterpillars with dark brown heads. Length ranges up to ¾ inch. The worms also attack leaves of potato, tobacco and other members of the same plant family, acting like miners by consuming palisade tissue between the upper and lower epidermis. In potato, the first generations are completed in the upper parts of the plant but later generations attack the tubers directly. Care should be taken not to leave tubers exposed in the field, to remove infested plant parts prior to harvest, to harvest thoroughly and remove all cull tubers. Stored potatoes can be saved by fumigation. Insecticidal control is difficult due to the cryptic habits of the larvae, but is possible before entry into tubers by foliar applications of appropriate insecticides at least twice at 10-day intervals.

Once the potato tubers have been invaded by the caterpillar they cannot be controlled. Potatoes must be kept in a cool storage area protected by screen or in a completely covered storage area so that the tuber moth cannot contact them.