Cotton Pests

Cotton Pest Terminology

adulticide - A chemical, usually an insecticide, that is targeted toward the adult stage.

aphicide - An insecticide that is active against aphids.

beat cloth - A square (typically 3 feet by 3 feet) or rectangular piece of usually light-colored cloth or synthetic sheeting (i.e., Tyvek material) with dowels at opposite ends; used to assess insect populations by catching them when plants are beaten or shaken over the device, which is normally unrolled and placed on the ground between rows. Also called a shake cloth or ground cloth.

beet armyworm - (*Spodoptera exigua*) An armyworm species whose damage to cotton is characterized by leaf skeletonizing by early instars feeding in groups, often associated with webbing and frass. Later instar larvae may feed on squares and bolls and are difficult to control with insecticides; eggs

are deposited in masses; adults are migratory and do not overwinter in the Carolinas.

beneficial arthropods - A general group of insects and their cousins (predatory mites and spiders) that either consume (predator) or live within (parasite) the host insect.

bloom tag - The dried brown cotton bloom that sticks to the tip (or, at times, off to one side) of the young boll; more frequent in dry weather; sometimes provides a refuge under which young bollworms or tobacco budworms develop protected from beneficial insects and insecticides. Inexperienced scouts sometimes tend to oversample young bolls having a bloom tag. The sampling of bloom-tagged bolls should be carried out in proportion to their percentage of the total boll population.

blooming out the top - A cotton growth state characterized by the presence of first-position blooms almost entirely in the upper canopy of the cotton plant. This occurrence may indicate premature cutout of the crop. Often called bumblebee cotton when this condition occurs abnormally early on short, stressed cotton.

blooms - Large, showy, off-white flowers that arise from buds

(squares) and typically last only one day, becoming pinkish on the second and brown on subsequent days; they usually fall from the new, developing boll on days three to five. Cotton blooms are at times attractive sites for bollworm egg deposition, western flower and other thrips, and fall armyworms. Blooms in the tops of cotton plants (blooming out the top or bumblebee cotton) often indicate very dry weather or that the crop is cutting out.

boll weevil - (*Anthonomous grandis*) A small brownish to grayish weevil that survives the winter as an adult and invades cotton in the spring to infest one-third grown cotton squares, causing fruit abortion via feeding or egg punctures; completes life cycle within fallen squares in 2 ½ to 3 weeks.

bollgard cotton - A cotton variety that has been genetically altered to express an endotoxin (Bacillus thuringiensis) that is active against some caterpillar pests, such as tobacco budworms, bollworms, and European corn borers. Also called Bt cotton.

bollgard II cotton - A cotton variety that has two "stacked" (or "pyramided") genes that each encode for the expression of separate endotoxins (*Bacillus thuringiensis*; Cry1Ac and Cry2Ab proteins) that are effective against a wide spectrum of caterpillar pests and offer enhanced activity against bollworms, compared to Bollgard.

bollworm - (*Helicoverpa zea*) The larval or caterpillar stage of the corn earworm moth. Also called soybean podworm and tomato fruitworm, depending upon host.

bract - The three modified leaves at the base of the cotton fruit. Bracts typically surround developing squares, affording some protection to bollworms and other pests from beneficial insects and insecticides; must be opened to reveal developing square when monitoring fruit for damage.

brown stink bug - (*Euschistus servus*) A brownish, medium-sized member of the stink bug family (Pentatomidae) that usually undergoes a generation on hosts, such as corn and other grass species, before moving into cotton, often during boll formation. Feeding by adults

and large nymphs with needle-like stylets, often on bolls of all sizes, causes small, rounded, dark spots on the exterior carpel wall; feeding can transmit hardlock organism, resulting in unharvestable bolls and low-quality lint. Brown stink bugs are more difficult to control with pyrethroids than green stink bugs. This species' life cycle (egg to adult) typically takes 40 days.

BXN cotton - A cotton variety that has been genetically altered to tolerate the herbicide Buctril (bromoxynil).

calyx - Outer protective covering of the flower bud (square); the leaf-like green segment also called sepals.

canopy - The foliage of a cotton crop; said to be closed when plant growth of adjacent rows closes over and shades row middles; direct sunlight penetration between rows constitutes an opened canopy.

carbamates - A class of chemicals, usually insecticides, that inhibits cholinesterase, resulting in unregulated nerve-ending activation and paralysis in insects (e.g., Temik, Sevin, Larvin).

carpel wall - The thick outer walls of the boll. If insects (e.g., bollworms, green stink bugs) penetrate them, they may cause damage to

locks (see definition) or may cause boll rot, translating into lost yield or lower lint quality.

caterpillar - The immature damaging stage of a butterfly or moth. Larva is the general term for immature stages of moths (caterpillars), flies (maggots), beetles (grubs), and others.

cotton aphid - (*Aphis gossypii*) The aphid species most commonly associated with outbreaks on cotton in the Southeast; has many generations per year and is often resistant to various classes of insecticides; typically subject to heavy mortality via predation and parasitism; also called the melon aphid.

cotyledon - In dicotyledonous plant species, the initial growth stage characterized by the presence of "seed leaves." These leaves were initially contained in the seed and provide food for seed germination.

cumulative threshold - The point at which consecutive scouting assessments of sub threshold levels of the same species justify treatment.

cutout - Final stage of cotton plant growth before boll opening; characterized by the predominance of more mature fruit, general absence of squares and blooms, and cessation of new terminal growth. According

to more recent terminology, cotton is approaching cutout at five nodes above white bloom and is generally considered to be cutout at three nodes above white bloom. Cotton blooming out the top is considered cutout.

defoliant - A harvest-aid material applied to the cotton plant to accelerate leaf drop in preparation for harvest (see defoliation).

defoliation - The loss of leaves from the cotton plant; may be damaging and happen prematurely (i.e., soybean loopers consuming cotton plant leaves before cutout or leaf loss caused by a potassium deficiency) or naturally (the predictable loss of leaves of all deciduous plants).

egg - A single cell or ovum from an ovary; the first stage of an insect or mite; may be deposited singly (e.g., bollworm) or in a mass (e.g., European corn borer).

European corn borer - (*Ostrinia nubilalis*) A recent pest of cotton in the Southeast where corn is planted, this boring caterpillar passes its initial two generations on corn,

potatoes, wheat, and various weed species in North Carolina; the third and a partial fourth generation can be damaging to cotton, primarily because the pest bores into medium to large bolls and to a lesser extent into stems; female moths deposit small, fish scale-like egg masses deep within the plant canopy and on the underside of cotton leaves. Egg masses are difficult to find.

fall armyworm - (*Spodoptera frugiperda*) A migratory species; larvae hatch from egg masses often deposited in the upper third of the cotton plant, often on the underside of leaves but also in the terminal area; small larvae typically etch the bracts of medium and large bolls before penetrating the carpel walls, often at the base of the boll. Fall armyworm larvae are also often associated with blooms. Medium to large established larvae are difficult to kill with insecticides.

foliar feeding - On cotton: (1) leaf consumption, usually by caterpillars; (2) the feeding of nutrients, such as nitrogen-containing fertilizer, to the cotton plant via a liquid applied to the foliage.

frass - A term applied to insect feces, the shape of which is sometimes used in family- or species- level identification; also called fecal pellets or droppings.

fruit - Refers to cotton squares (or flower buds), blooms, and bolls; reproductive parts of the plant.
Cotton fruit is susceptible to a wide range of insect pests.

fruiting branch - Lateral branch of a cotton plant, typically arising from the fourth through eighth node and higher on the plant; has fruiting position at each node; sympodium or reproductive branch.

fruiting position - Any main stem, vegetative branch, or fruiting branch location on which fruit is either present or aborted.
fungicide - A material used to control or kill fungi.

green stink bug - (*Acrosternum hilare*) A large green member of the stink bug family (*Pentatomidae*) that usually undergoes a generation on wild hosts, such as elderberry and wild cherry, before moving into cotton, often during boll formation. Feeding by adults and large nymphs with needle-like stylets, often on bolls of all sizes, causes small, rounded, dark spots on the exterior carpel wall; feeding can transmit hardlock organism, resulting in unharvestable bolls and low-quality lint. This species' life cycle (egg to adult) typically takes 30 to 35 days.

herbicide - A material used to kill weeds. In cotton the material usually is characterized by (1) timing: "PPI" (prior to planting and

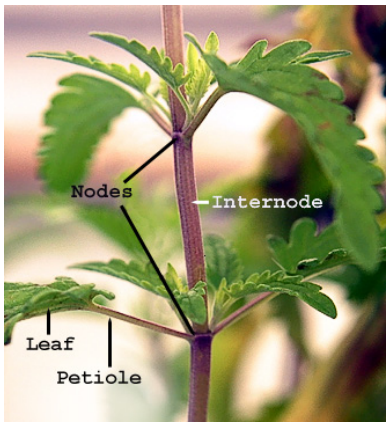
incorporated), “pre” (prior to plant emergence from soil), and “post” (after plant emergence); or by (2) application type: “broadcast” (applied evenly over an area), “banded” (applied over a portion of the total area), or “directed” (targeted at a specific area), usually toward the base of the cotton plant.

insect growth regulator - A compound, either natural or synthetic, that influences insect growth and development (e.g., Dimilin affects boll weevil grub integument formation during shed, resulting in deformed pupae and adults or premature death). Often referred to by its acronym, IGR.

insecticide - A material that kills insects.

instar - Stage of nymph (e.g., stink bug) or larva (e.g., bollworm) between molts.

internode - The portion of the main stem between nodes; in cotton it is often used as an indicator of growth, i.e., a greater internode length indicates faster growth and the possible need of a growth regulator capable of slowing growth, such as Pix.



label - A legally binding document affixed to every pesticide container outlining the product's constituents, amount of active ingredients, primary uses, precautions, and Worker Protection Standard (WPS) information.

larva - The immature stage of an insect with four distinct metamorphic stages (e.g., cabbage looper: egg, larva [caterpillar], pupa, and adult).
larvicide - A compound that kills the larval stage of insects.

lay-by - A final, typically post-directed herbicide application designed to eliminate or suppress weeds through harvest time.

liberty Link cotton - A cotton variety that has been genetically altered to tolerate the herbicide Liberty (glufosinate).

light trap - A device consisting of at least an ultraviolet light (which

is attractive to a number of night-flying insects) and a collection container. Used to monitor the timing and relative abundance of selected insect species (e.g., bollworm and European corn borer).

lock - The major, individual, internal section of a cotton boll in which seed and lint development take place; four or sometimes five locks per boll are typical.

match-head square - Early stage of growth when the flower bud (excluding the outer bracts) reaches approximately the size of a large kitchen match head.

migratory - A term applied to an insect species that undergoes long-range movement, sometimes hundreds of miles (e.g., fall armyworms do not overwinter in the Carolinas but rely instead on annual, long-range, northward movement by consecutive generations "hopscotching" from the southern United States). It can also refer to shorter, more localized flights or transport (e.g., the migration of thrips from alternative hosts to cotton).

mites - A group of small, active, non-insect arthropods, some of which are predators of other mites and small insects (e.g., thrips); most species are plant feeding. The two-spotted spider mite (Tetranychus

urticae) is the predominant mite on cotton in the Southeast, typically more of a problem under hot, dry conditions, and damages cotton plants by rasping mostly lower leaf cells; populations are often reduced by naturally occurring fungi, particularly under humid conditions.

miticide - A material that kills mites.

multipest threshold - The point at which the combined effects of subthreshold levels of two or more pests justify treatment.

naturalites - A class of fermentation products called spinosads derived from an ascomycetous fungus, which is active against Lepidoptera and selected members of other insect families and some mite species.

node - A point, usually along the main stem, at which lateral vegetative and fruiting branches arise.

nodes above cracked boll - Term applied to the number of mainstem nodes from the highest first position cracked boll to the plant terminal (often used as a method of assisting with measurements of cotton readiness for defoliation).

nodes above white bloom - Term applied to the number of mainstem nodes from the last developed first-position white bloom to the plant terminal; used as a measure of plant growth (e.g., to assist in growth regulator assessments or as an index of degree of "cutout"). All plants will not have a first-position white bloom.

organophosphates - A class of organic, phosphorus-containing insecticides that inhibit cholinesterase, causing excess nerve activation, paralysis, and eventual death; some insecticides in this class with a high phosphorus content (e.g., methyl parathion) may delay cotton crop maturity if applied at an early stage; abbreviated OP.

ovicide - A material that kills the egg stage of an organism.

parasite - An organism that lives wholly off and often feeds within another organism (called a host); with most insect species, insect parasites usually kill their hosts and are referred to as parasitoids.

Pheromone trap - A trap that uses either a natural or, more typically, a synthetic insect sex attractant pheromone; these traps are usually species specific.

Pinhead square - In practice, this misnomer most often applies to

match-head squares. Pinhead squares are just visible to the naked eye.

Plant bugs - Small, active, dark brown bugs with piercing-sucking mouthparts. The mouthparts make tiny needle-like holes in small squares, causing darkening and abortion. At high population levels, terminal feeding may result in unusual upper growth (crazy cotton) and loss of apical dominance; late in the season, high levels of plant bugs can also damage larger squares, blooms, and small bolls.

plant growth regulator - A substance applied to cotton plants that affects growth or aging (e.g., Pix and Prep); abbreviated PGR.

plant map - A precise, prescribed manner of recording, or mapping, cotton plant growth that shows the location and stage of fruit by its position on each node of all vegetative and fruiting branches. Plant maps are often used to determine nodes above white bloom, nodes above cracked boll, and fruit retention and to compartmentalize and compare fruit retention on selected horizontal or vertical zones of the cotton plant. Modified mapping systems are available that focus on particular vertical zones of cotton, such as first position only.

point sampling - A scouting method that relies on randomly selecting a prescribed number of sites or points within a cotton field for intensive

scouting of a predetermined number of plants or feet of row (best suited to uniform fields).

postemergence-directed - Herbicide placement after seedling emergence directed to the base of cotton plants; better control if cotton has grown significantly taller than weeds (e.g., Bladex).

postemergence over the top - Herbicides applied directly over the canopy of both cotton and weeds; sometimes represents a salvage treatment following inadequate PPI or preemergence weed control; some compounds may cause maturity delays and yield reductions (e.g., Cotoran).

predator - An organism that kills and consumes another (its prey); a number of small predator insects can provide significant natural control of several pests.

preemergence - A term most often referring to broadleaf herbicides applied at or after planting but before seedling emergence; "pre" herbicides (e.g., Zorial).

preplant incorporated - Refers mostly to grass and small-seeded broadleaf herbicides (but also some other weed species such as

nutsedge) applied and incorporated before planting; PPI herbicides (e.g., Treflan).

pupa - The compact, often protected, resting stage of an insect preceding the adult stage (bollworms overwinter in the pupal stage under the soil surface).

pyramided genes - See stacked genes.

pyrethroids - A class of insecticides characterized by very low mammalian toxicity and high insect control at low usage rates.

random sampling - A scouting method that relies on continuous inspections throughout most of a cotton field; better suited for regions with variable soils within fields.

rank - A term signifying tall, vegetative cotton growth; often a result of late planting, excessive nitrogen fertilizer, fertile soils, or excessive moisture. Rank growth often renders cotton plants more attractive and susceptible to late-season insects, more susceptible to boll rot, and more difficult to defoliate.

refugia - In cotton insect management, an area used to maintain the

production of susceptible insect populations. A refugia is a crop or host area that is left untreated with an insecticide or type of technology so that adults that are resistant to the chemical or chemical class in question will have a high probability of mating with the higher number of refugia-produced, susceptible adults, thus producing susceptible offspring. For example, to preserve the effectiveness of Bt cotton, a certain acreage of non-Bt cotton must be set aside to produce enough Bt-susceptible adult bollworms and tobacco budworms to mate with a high enough proportion of the Bt-produced resistant individuals to maintain a population of budworms and bollworms susceptible to Bt cotton.

restricted entry interval - The mandatory period of time a person must wait between application of a chemical and entry to the treated area.

Roundup Ready - Trademark term applied to varieties that have been genetically altered to be tolerant to the herbicide glyphosate.

sample - The portion of a population collected in a prescribed manner upon which a judgment is made about the entire population.

scout - An individual trained to collect information about cotton insect and plant populations; scouts are not responsible for interpreting

data or providing recommendations.

scouting - The procedures followed by a scout.

skeletonizing - A type of insect damage characterized by insect feeding on leaf areas between veins; it can result in a lacy appearance to the leaf.

soybean looper - (Pseudoplusia includens) A light-green, defoliating caterpillar; migratory adults overwinter in the southern United States or Caribbean basin and typically arrive in the Carolinas in late summer or fall.

square - The flower bud of a cotton plant with a central corolla containing the pollen anthers and sepals and surrounded by three (or sometimes four) bracts; squares are often a preferred site of insect feeding, e.g., plant bugs, boll weevils, bollworms.

square retention - The proportion of squares, usually expressed as a percentage, retained by the cotton plant (often employed early in the growth of a cotton plant as an index of plant development).

stacked - Using two or more genes in a cotton variety for expression of similar characteristics (Bollgard II will use two Bt genes to express different endotoxins for caterpillar control) or dissimilar characteristics (Bollgard gene plus Roundup Ready gene for herbicide tolerance to Roundup herbicide).

stacked genes (or pyramided genes) - Two or more genes inserted into the plant's DNA that express similar (though enhanced) activity (e.g., two genes that encode for separate Bacillus thuringiensis endotoxin expression in the same variety, such as in Bollgard II or Widestrike, or two genes that express different activities in the same variety, such as Bollgard caterpillar resistance plus Roundup Ready glyphosate tolerance).

starter fertilizer - Fertilizer placed close to the seed, usually at planting; also called "pop-up" fertilizer.

sweep net - A sturdy net composed of a 15-inch (standard size) rigid wire support and a heavy-duty cloth bag used to "sweep" across the upper canopy of cotton plants to assess insect populations.

systemic - A pesticide that is taken up through the roots or leaf tissues into the cells of the cotton plant (as opposed to remaining on the

surface), often in concentrations high enough to cause a biological change (e.g., a systemic might be an at-planting soil insecticide taken up by cotton seedling roots and transported through the plant's vascular system to suppress or kill leaf-feeding thrips, or it might be Roundup herbicide absorbed into the vascular system of weeds and translocated to the root zone in high enough concentrations to kill the weed).

terminal - The dominant, upper mainstem part of a cotton plant containing three to four expanding leaves and developing squares; if they are all retained, the number of squares typically is identical to the number of leaves; also called "apex."

threshold - The point at which an action is taken; often applied to insects. (Most thresholds are action thresholds; an action is taken when a level or number of eggs or caterpillars is reached. It can also be an economic threshold, which takes the commodity value and treatment cost into consideration.)

thrips - Tiny, active insects of the order Thysanoptera, which move in high numbers primarily into seedling cotton, often because their alternative hosts are drying up.

tobacco budworm - (*Heliothis virescens*)

A caterpillar pest of primarily squares and bolls; a close relative of the corn earworm. It undergoes three to four generations annually and often is the predominant species of the bollworm/budworm complex in June in the Carolinas. Midsouth populations of tobacco budworms have developed resistance to all major classes of insecticides.

transgenic cotton - Cotton that has been genetically altered by recombinant DNA techniques to express tolerance to either herbicides (e.g., Roundup Ready, BXN) or insect pests (e.g., Bollgard against tobacco budworms).

vegetative branch - Lateral branch on a cotton plant that does not have a fruit at each node; fruiting branches, however, can develop from vegetative branches. Vegetative branches have a terminal and often develop fruiting branches, especially under low plant populations.

vegetative growth - General term for undesirable cotton plant growth, typified by lack of fruit; often tall and rank.

VIP cotton - A cotton variety that has been genetically altered to

express an endotoxin that is produced during the vegetative stage of bacterial growth (Vip3A protein) and is effective against a wide spectrum of caterpillar pests. These varieties offer enhanced bollworm control, compared to Bollgard, but low activity against the European corn borer.

weed map - A simple diagram, typically developed in the fall, of a field or field portion showing the location of predominant, economically important weeds; used in planning weed management programs.

whitefly - A small, white-winged insect with piercing-sucking mouthparts; damages cotton both directly via its sap-feeding and indirectly via voiding honeydew, resulting in "sticky cotton," a ginning and milling problem.

widestrike cotton - A cotton variety that has two "stacked" (or "pyramided") genes that each encode for the expression of separate endotoxins (Bacillus thuringiensis; Cry1Ac and Cry2Ab) that are effective against a wide spectrum of caterpillar pests and offer enhanced activity against bollworms when compared to Bollgard.

windowpaning - See skeletonizing.

Boll Weevil (Anthonomous grandis grandis Boheman)

Identification

The adult boll weevil is a brown to grayish- brown beetle. The body is covered with short, fine hair, giving it a fuzzy appearance. There is considerable variation in size from slightly more than 1/8 inch to almost ½ inch in length. The boll weevil's snout is approximately half as long as its body. It is slightly curved and has chewing mouthparts on the end. Immature stages are found inside squares and bolls. The boll weevil egg is seldom seen since it is deposited inside a square or boll. The larva is a small, legless grub with a brownish head and chewing mouthparts. This grub varies in size from very small to ½ inch in length. The pupal or "resting" stage of the boll weevil is 3/8 to ½ inch long and cream colored with eyes and an obvious snout.

Biology

The adult boll weevil spends the winter in hibernation, called "diapause," without food and returns to cotton in the early spring the following year. Overwintering quarters usually consist of fence rows, broadleaved plant litter along creek bottoms, ditch banks and other protected, wooded areas near cotton fields. In the spring overwintered boll weevil adults concentrate in early-planted fields nearest overwintering habitat where cotton is squaring. Adult boll weevils feed

on tender growth in plant terminals if the young cotton does not have squares. In the early season, boll weevils colonize localized spots and do not generally invade the entire field.

The boll weevil is a pollen feeder; its survival is diminished without squaring cotton, although adult boll weevils emerging from overwintering quarters may subsist on other plants for short periods (e.g., an average of 18 days on yellow woolywhite in the Rolling Plains area). After adult weevils feed on cotton for 3 to 7 days and mate, they lay eggs in squares that have reached at least the "one-third grown stage" (approximately ¼ inch in diameter). Egg laying may occur in smaller squares; however, sufficient feeding material is not available for a high percentage of larvae to develop to the adult stage. Late in the season eggs may be laid in small bolls, but squares are preferred.

It takes the eggs 2.5 to 5 days to hatch into the grublike larva that feeds inside the square or small boll. After larval development begins the infested square turns yellow, bracts open or flare and the fruiting form falls off the plant. The larva feeds for 7 to 14 days before pupating inside the square or small boll. During the next 4 to 6 days the pupal stage changes into an adult boll weevil. The newly developed adult eats its way out of the square or small boll and feeds on other fruiting forms for about 5 days. During this time the weevil mates and females begin

to lay eggs. The entire cycle takes 16 to 18 days under ideal conditions. Six or seven generations may be produced each year with each female having the capability of laying approximately 200 eggs.

Evidence of Infestation

Although adult boll weevil feeding causes little damage, it indicates the presence of weevils and that egg laying will soon follow. There are distinct differences between feeding and egg-laying punctures.

As weevils feed, a small cavity is formed at the site of feeding. If a female weevil determines that the feeding site is suitable for egg laying, she enlarges the cavity slightly and inserts her ovipositor (egg-laying tube) to deposit a single egg in the cavity. When the ovipositor is withdrawn, she secretes a sticky substance that covers the cavity. This sticky secretion hardens to form a wart-like protuberance that can be easily seen and felt. Feeding punctures usually have no sticky covering and therefore no wart-like protuberance.

Nature of Damage

Most of the damage is due to larval development inside fruiting forms. Feeding larvae eventually cause cotton squares and small bolls to shed or damage developing lint in larger bolls. Heavily infested cotton

may produce much foliage but few mature bolls.

Cotton Fleahopper (Pseudatomoscelis seriatus [Reuter])

Identification

The adult cotton fleahopper is approximately 1/8 inch long. It is flat with an elongated, oval outline and prominent antennae. The body usually is yellowish-green, although it may be white or yellow with minute black hairs and spots on the upper surface. After feeding, the immature stage is pale green with prominent, often reddish eyes. Other parts of the body also may be reddish. Cotton fleahopper eggs are yellowish-white, about 1/30 of an inch long and are inserted under the bark of small stems.

Biology

The cotton fleahopper overwinters in the egg stage, primarily in wild hosts such as woolly croton (Croton capitatus), cutleaf evening primrose (Oenothera laciniata), showy sundrops (Oenothera speciosa), wooly tidestromia (Tidestromia lanaginosa), spotted [horsemint]

beebalm (Monarda punctata), lemon [horsemint] beebalm (Monarda citriodora) and silverleaf nightshade (Solanum elaeagnifolium). At 80° F., eggs hatch in about 11 days, and the young nymphs feed on tender vegetation. They usually molt five times and require 14 to 15 days to mature into the reproductive adult cotton fleahopper. Usually there are six to eight generations per year. Of these, only one to three occur in the cotton field. Early in the spring, fleahoppers build up large numbers on alternate weed hosts. As these hosts mature and become less succulent, the cotton fleahopper searches for more preferred hosts. If cotton is present, fleahoppers colonize in it and feed on leaf and fruit buds. Some fleahoppers stay in cotton fields as long as cotton plants are lush and succulent.

Nature of Damage and Evidence of Infestation

The cotton fleahopper feeds on anthers of small squares and sucks sap from leaf buds. This feeding causes squares to die and turn brown, resulting in a "blasted" appearance. When fleahoppers are abundant, heavy fruit loss may occur on preflowering plants. The cotton fleahopper prefers terminal bud clusters including young leaves and tiny squares. The piercing, sucking habit of nymphs and adults interferes with normal growth patterns in cotton. Feeding punctures stimulate the plant to produce shorter main stem internodes, more nodes and spindly

branches or “suckers” from the lower parts of the plant. The fleahopper injects saliva when feeding, but its effects are only local. There is no evidence that fleahoppers transmit plant diseases or toxic substances other than digestive enzymes.

Crop Monitoring (Scouting)

Integrated pest management evolved as several control techniques in harmony to keep pests below damaging levels. Experience shows that it is better to manage pests by using multiple suppression tactics rather than a single one. This includes using natural controls such as predators, parasites and pathogens and cultural strategies in combination with well- timed insecticide applications in an integrated approach. Along with the development of this multitactical management system is an increased awareness of "in-field" insect and plant dynamics.

This awareness is a result of constant crop monitoring of pests and beneficial insects and their effects on the cotton plant. This is the basis of *cotton scouting*.

Cotton scouting, or crop monitoring, is not a suppression tool itself but rather a means of gathering information on pests which will aid in management decisions.

There is more to cotton monitoring than just checking for insects. It involves proper identification, a determination of pest and beneficial insect densities and their effects on the cotton crop as a whole. Insect numbers fluctuate a great deal. In cotton fields pests can increase to a point where, if not suppressed, they will cause economic damage to the crop. This pest density is called an *economic threshold* and is illustrated in figure 3.

The economic threshold is determined by research and practical experience. It has been approximated for most cotton pests but may vary with the area in which the crop is grown. For current information on the economic thresholds of cotton pests in your area, contact an Extension entomologist or your county Extension agent or refer to the *Management of Cotton Insects* series appropriate for your region.

Since evaluating the economic threshold involves observing a pest population that is truly dynamic and rises and falls periodically, there

must be some method of systematic sampling on a regular basis. Sampling in cotton usually is done once or twice a week. Sampling results should be recorded in an easy-to-understand method (figure 4). Frequently, during peak insect activity, fields must be scouted or monitored more than twice a week. It is also critical to monitor the effects of other factors such as *weather, disease, herbicidal injury*, etc.

Insect populations often are concentrated in certain areas of a field. Insects are not distributed uniformly in the field and do not infest all fields in an area. Large areas of the field must be covered each time. Scouting aids in determining the kinds of insects present, their location, relative abundance and distribution in the field and numbers of insects or amount of insect damage to the plants. Scouting only near turn rows and field margins is inadequate for determining insect infestation. To cover the field completely, walk a field in a "zigzag" pattern crossing it diagonally from one corner to another or walk it in-a wide arc taking samples from several plants (figure 5). The pattern followed should allow adequate sampling throughout the field, including the center, the sides and corners. Sampling pattern should be determined by the shape and size of the field. Avoid sampling in the same area of the field on successive sampling days.

The numbers and kinds of insects in a field usually are determined with

reasonable reliability by examining squares and leaves from the terminal or entire plant or by sweeping the top part of a plant. Samples also may include any insects in the blooms, the rate at which squares are being set, the blooming rate, observable damage to bolls and the growth rate of plants. Determine any "natural" excessive square or boll shed when making an evaluation. Remember to consider the effect the weather has on the crop when evaluating fruit loss.

The part of the plant examined in a sample varies with the insect pest being sampled. Many insect infestations are assessed by taking "square" samples and determining the percent damaged by the particular insect. Other insects may be found primarily on terminal buds, so the terminal may be the best sampling unit. Taking leaf samples and counting the number of insects present or the amount of leaf damage provide infestation information for many leaf-feeding species. Sample plant bugs and other insects by using an insect sweep net. Black light traps and pheromone traps are *survey tools* useful for estimating the relative density of some insects in the area.

Take samples or count samples from the bottom, middle and top

portions of the plants. Taking all the samples from the top can give an inaccurate count and let insect infestations concentrated on the lower parts of the plants go undetected. This is especially true for bollworms and tobacco budworms and their eggs, which are sometimes laid lower on plants in the hotter part of the season.

The number of samples taken when scouting a field usually is dictated by field size and field variability. In fields of 40 acres or less, usually only two samples are made. A single sample should consist of examining at least 25 individual plants at random or all plants in a predetermined length of row (6.5 feet or 13 feet) at each site. Make a record of pests, beneficials and plant damage. The data from all samples are totaled or averaged for the field. The number of samples should increase as the field size increases. Fields between 40 and 100 acres usually have four samples taken. In fields exceeding 100 acres, a sample is added for every additional 50 acres. For specific sampling instructions refer to the Management of Cotton Insect series for your region.

Management Decisions

The decision to control cotton insects and mites with insecticides should be made with care. Use insecticides only if the economic threshold has

been reached, based on insect scouting results, the stage of plant growth and rate of fruit production. With the exception of a few microbial insecticides, insecticide applications typically depress beneficial (predator and parasite) populations that are important natural control agents. Low rates of certain insecticides such as ovicides have been less damaging to beneficial populations. Insecticidal control of one pest often affects the beneficial population suppressing another pest. The most frequent example is an insecticide applied near or at the bloom stage for boll weevil, which destroys beneficial insects that help keep the bollworm- tobacco budworm in check.

The growth stage of the cotton plant, in relation to its vulnerability to insect attack, is important to consider. One may view these susceptibility periods as "windows" in crop growth. Figure 6 illustrates these windows and their relationship, in time, with the plant's growth stages. For example, the window for the cotton fleahopper is from pinhead size square through one-third grown square. After this period the cotton fleahopper usually does not have the potential to inflict damage. Windows of key pests may overlap and make decisions more difficult and riskier. The best example of this is, again, with the boll weevil and the bollworm-tobacco budworm complex. The window for the boll weevil begins at one-third grown square and generally ends when a boll reaches 10 to 12 days of age. The

window for the bollworm-tobacco budworm begins around the one-third grown square stage and extends past and overlaps with the boll weevil window.

Research shows that the most critical period of fruit formation is in the first 30 to 40 days of blooming. The highest quality and quantity of lint is produced at this time. Thus, damage inflicted in this window can be most costly. Strategies in cotton insect management show that the boll weevil can be managed effectively in various parts of the state by altering the planting date, if practiced uniformly, or by selected insecticide applications early in the boll weevil window (first one-third grown square stage), based on field scouting information. Either of these strategies, if properly practiced in most years, neutralizes the boll weevil as a pest, allows the plant to set and hold early fruit and delays boll weevil build-up until the critical 30 to 40 days of blooming can take place. Of equal importance, this strategy has little effect on beneficials that naturally control bollworm-tobacco budworm populations.

By viewing growth of the cotton plant as a series of susceptibility windows, management decisions and scouting information can be targeted to deal with the specific major pests attacking cotton. By considering the pest within a certain window (time-frame), its damage

can be assessed relative to the growth stage and its potential to destroy harvestable fruit.

Other Insect Pest Management Practices

A field sterile of all pest insects is neither necessary nor desirable. However, do not allow harmful insects to reach numbers that will cause unacceptable losses. Keep them below the economic threshold. Excessive use of nitrogen fertilizer causes cotton plants to stay green and stimulates rank growth. The excessive, rank growth can reduce cotton yield and increase damage from the bollworm-tobacco budworm. Rank growth also makes it difficult to achieve thorough plant coverage with insecticides.

Cotton planted too thick becomes tall and "leggy" before it sets squares. This condition is often wrongly blamed on cotton fleahoppers. Maximum yields are produced when cotton is planted at a rate of two to four plants per foot of row on 40-inch rows. Current research in this area on narrow row spacings is being evaluated for use by cotton producers in various production areas.

Foliage and fruit on cotton stalks remaining in a field after harvest can supply a food source for boll weevils, bollworms, tobacco budworms

and pink bollworms that allows these pests to continue growing and reproducing. This increases the number of overwintering pests. Cut stalks and plow fields immediately after the cotton is picked or stripped.

By planting cotton at a uniform time throughout an area, many problems with boll weevils, bollworms and tobacco budworms and pink bollworms can be reduced greatly. These insect pests are attracted to the older cotton plants of early-planted cotton. Late season damage by bollworm-tobacco budworm often is greater on later planted cotton which remains green and lush longer than earlier planted cotton. Later planted cotton also may have more squares which aid in the development of high numbers of boll weevils.