

E-5
5-08



Managing Cotton Insects

in the Southern, Eastern and
Blackland Areas of Texas
2008

Contents

	Page
Pest Management Principles	3
Insecticide Resistance Management	3
Biological Control	3
Bt Transgenic Cotton	4
Crop Management	4
Monitoring Cotton Growth and Fruiting Rate	4
Early Stalk Destruction and Field Cleanup	5
Stalk Destruction Laws	6
Management Decisions	6
Scouting Decisions	6
Early-season Pests	7
Thrips.....	7
Aphids.....	8
Cotton Fleahopper	8
Overwintered Boll Weevil.....	8
Mid-season and Late-season Pests	9
Boll Weevil	9
Bollworm and Tobacco Budworm	9
Aphids.....	11
Occasional Pests	11
Cutworms.....	11
Creontiades Plant Bug (<i>Creontidas signatus</i>).....	12
Tarnished Plant Bug (<i>Lygus</i> spp.)	12
Beet Armyworm	13
Spider Mites	13
Fall Armyworms.....	13
Cabbage Looper, Soybean Looper, Cotton Leafworm	14
Stink Bugs	14
Grasshoppers.....	14
Other Pests	15
Systemic Insecticides for Early-season Pests	15
Limitations of Systemics	15
Advantages of Systemics	15
Ovicides	15
Microbial Insecticides	15
Protecting Bees from Insecticides	16
Policy Statement for Making Pest Management Suggestions	16
Endangered Species Regulations	16
Worker Protection Standard	16
Additional References	17

For recommended insecticides, refer to E-5A, "Suggested Insecticides for Managing Cotton Insects in the Southern, Eastern and Blackland Areas of Texas 2008" at the following web sites:

<http://insects.tamu.edu/extension/publications/index.cfm>

or <http://AgriLifebookstore.org>.

Managing Cotton Insects in the Southern, Eastern and Blackland Areas of Texas

R. D. Parker, M. J. Jungman, S. P. Biles and D. L. Kerns*

A committee of state and federal research personnel and Extension specialists meets annually to review cotton pest management research and management guidelines. These guidelines are directed toward maximizing profits for the Texas cotton producer by optimizing inputs and production.

Pest Management Principles

The term "pest management" applies to a philosophy used in the design of insect, mite, disease and weed pest control programs. It encourages the use of the most compatible and ecologically sound combination of available pest suppression techniques. These management techniques include: cultural control, such as manipulation of planting dates and stalk destruction; crop management practices, such as variety selection and timing of irrigation; biological control, involving conservation of existing natural enemies; host plant resistance; and the wise use of selective insecticides and rates to keep pest populations below economically damaging levels.

Major factors to be considered when using insecticides include protecting natural enemies of cotton pests, possible resurgence of primary pests, increased numbers of secondary pests following applications and pest resistance to insecticides. Therefore, insecticides should be applied at the proper rates and used only when necessary, as determined by frequent field inspections, to prevent economic losses from damaging pests.

The pest management concept rests on the assumption that pests will be present to some degree in a production system, and that at some levels they may not cause significant losses in production. The first line of defense against pests is prevention through the use of good agronomic practices or cultural methods which are unfavorable for the development of pest problems (discussed below). Properly selected control measures should be taken only when pest populations reach levels at which crop damage suffered could result in losses greater than the cost of the treatment. This potentially injurious population or plant damage level, determined through regular field scouting activities, is called an **economic threshold or action threshold**. Precise timing and execution of each production operation is essential. In short, pest management strives to optimize rather than maximize pest control efforts.

Insecticide Resistance Management

Experience has shown that reliance on a single class of insecticides that act in the same way may cause pests to develop resistance to the entire group of insecticides. To delay resistance it is strongly recommended that growers use IPM principles and integrate other control methods into insect or mite control programs. One strategy to help avoid pest resistance is to rotate the use of insecticide groups in order to take advantage of different modes of action. In addition, do not tank-mix products from the same insecticide class. Such insecticide management should delay the development of resistance and also provide better overall insect control.

Insecticides with similar chemical structures act on insects in similar ways. For example, pyrethroids (including esfenvalerate, bifenthrin, cyfluthrin, lambda cyhalothrin and tralomethrin) all act on an insect's nervous system in the same way. Other types of insecticides such as organophosphates (methyl parathion, dicrotophos) or carbamates (thiodicarb) also affect the insect's nervous system but in a different way than do the pyrethroids.

The Insecticide Resistance Action Committee (IRAC) has developed a mode of action classification system that is based on a numbering system (see <http://www.irc-online.org/>). This system makes it simpler for producers and consultants to determine different modes of action among the insecticides. Insecticides with the same number (e.g., 1) are considered to have the same mode of action. Producers should rotate among different numbers where appropriate to delay resistance. The objective of successful insecticide resistance management is to prevent or delay the evolution of resistance to insecticides. The IRAC numbering system is used in the Suggested Insecticides for Cotton Insect Management publications to assist producers with their choices.

Biological Control

Insect and mite infestations are often held below damaging levels by weather, inadequate food sources and natural enemies such as disease, predators and parasites. It is important to recognize the impact of these natural control factors and, where possible, encourage their action. (See E-357, "Guide to the Predators, Parasites, and Pathogens Attacking Insect and Mite Pests of Cotton," Texas AgriLife Extension Service.)

Biological control is the use of predators, parasites and disease to control pests. Important natural enemies in cotton include minute pirate bugs, damsel bugs, big-

* Extension Entomologist, Extension Agent-IPM, Extension Agent-IPM, and Extension Entomologist, The Texas A&M System.

eyed bugs, assassin bugs, lady beetles, lacewing larvae, syrphid fly larvae, spiders, ground beetles and a variety of tiny wasps that parasitize the eggs, larvae and pupae of many cotton pests.

Biological control includes the conservation, importation and augmentation of natural enemies. It is an environmentally safe method of pest control and is a component of integrated pest management programs in cotton. The Texas A&M System is fully committed to the development of pest management tactics which use biological control.

Existing populations of natural enemies are conserved by avoiding the use of insecticides until they are needed to prevent the development of economically damaging pest infestations. Insecticide impact can also be minimized by using insecticides that are more toxic to the target pests than to the natural enemy. Classical biological control is the importation of natural enemies from other countries. This method has been effective where an exotic pest has entered Texas without its incumbent natural enemies, or to augment natural enemies of native pests.

Augmentation involves the purchase and release of natural enemies on a periodic basis. The most notable commercially available natural enemies include the egg parasite *Trichogramma*, and the predators lady beetles and lacewings. Although the control of both bollworms and tobacco budworms by the release of commercially reared *Trichogramma* wasps is theoretically possible, researchers have not been able to consistently achieve the level of parasitism necessary to reduce infestations below economically damaging levels. Multiple *Trichogramma* releases at high rates ranging from 50,000 to 150,000 parasitized eggs per acre were used in these studies. There are currently no economic thresholds established for augmentative releases of *Trichogramma* for bollworm/budworm control in cotton. Furthermore, parasite mortality from insecticides used to control other pests in or around parasite release areas would limit the effectiveness of augmentative releases.

Research has shown that releasing large numbers of lacewing larvae (30,000 or more per acre) can reduce bollworm infestations below damaging levels. However, these release rates are currently cost prohibitive because of the high production cost of rearing lacewings. The release of lacewing eggs has been less successful and there is little information on the efficacy of releasing adult lacewings in cotton. There is even less information about releasing either lady beetles or lacewings for the control of economically damaging infestations of aphids. Because there is too little information about augmentation (when to apply, what density should be applied, etc.), entomologists with the Texas AgriLife Extension Service cannot provide guidelines for augmentation as a management tool in cotton.

Bt Transgenic Cotton

Bt cottons are insect-resistant cultivars and one of the first such agricultural biotechnology products to be

released for commercial production. Insect resistance in the Bt cottons was engineered by the introduction of a bacterial gene that produces a crystalline toxin, which, in turn, kills feeding larvae of several cotton pests.

The toxin in Bollgard® cottons has excellent activity against tobacco budworm, pink bollworm, cotton leaf perforator and European corn borer, and good activity against cotton bollworm, saltmarsh caterpillar and cabbage loopers. **Under heavy infestation pressure, supplemental insecticide treatment may be necessary for bollworm.** Bt cottons (Bollgard®) provide some suppression of beet armyworm and soybean looper, and little or no control of fall armyworm or cutworm. Recently released Bollgard® II and WideStrike® cotton varieties are more effective against all of the mentioned caterpillar pests, except cutworms. In all cases, economic thresholds used for Bt cottons should be the same as those used for non-Bt cottons, **but should be based on larvae larger than 1/4 inch and damage, not on eggs or early instar larvae.**

Crop Management

The short-season cotton production system is crucial in reducing insect damage. This system includes cultural practices such as: 1) early, uniform planting of cotton varieties which bloom and set bolls early, mature rapidly and are ready to harvest 130 to 150 days from planting (refer to county cotton demonstrations for varieties that have performed well in your area); 2) optimum use of fertilizer and minimum irrigation; and 3) early, complete stalk destruction. These practices shorten the time that cotton is vulnerable to insect attack, minimize potential damage from adverse weather, and allow more time to prepare land for the next crop. Failure to implement these cultural practices will increase the probability of late-season insect pest outbreaks, increase the need for insecticides and cause larger populations of overwintering pests to develop. (See Early Stalk Destruction and Field Cleanup, p.5).

The first 30 days of blooming are critical for early boll set. The earliness factor in short-season production can be lost when damaging populations of insects occur as the first squares are formed. Loss of first squares to overwintered boll weevils also will detract from short-season production. To ensure early fruit set, scout fields to determine pest population levels and plant damage, as well as beneficial insect numbers and cotton fruiting rate. Use chemical insecticide only when it can be justified. Insecticides may destroy natural enemies of cotton insect pests, causing increased numbers of bollworms, tobacco budworms, spider mites and cotton aphids.

Monitoring Cotton Growth and Fruiting Rate

Knowing when a cotton crop is near cutout can help producers make effective end-of-season decisions. To estimate cutout, monitor the number of nodes above white flower (NAWF) during the bloom period. To

determine NAWF, count the number of nodes above the upper most first position white flower on a cotton plant. The last node counted on a plant will have a leaf equal to the size of a quarter.

NAWF will range from 5 to 10 at first bloom, depending on the amount of soil moisture available to the plant before bloom. Other factors affecting NAWF include soil compaction, diseases and fruit retention.

When the average NAWF value of 5 is reached, the field is considered to be cut out. The flowers produced after NAWF is equal to 5 contribute less to yield because the bolls are smaller and boll retention is reduced.

Once the date of cutout (NAWF = 5) has been reached, termination of insecticide applications for the season can be determined by calculating the daily heat units (DD60s) from cutout. The heat unit concept or DD60 (degree days using 60 degrees F) is the measure the amount of useful heat energy a cotton plant accumulates each day, each month, and for the season. The plant must accumulate a specified level of heat units to reach each development stage and to achieve complete physiological maturity. Several systems have been developed to calculate heat units, but the most universal approach is to use the formula $((\text{Degrees F Maximum} + \text{Degrees F Minimum}) / 2) - 60$.

The termination in the potential need of some insecticide applications depends on the insect pest and the number of DD60s that have accumulated. Fields that have accumulated 325 DD60s are considered safe from plant bugs (*Lygus* and *Creontiades* species); fields accumulating 350 DD60s are considered safe from boll weevils and first and second instar bollworm/tobacco budworm larvae; and fields accumulating 475 DD60s are considered safe from stink bugs.

To monitor fruiting rates, fields should be examined weekly or bi-weekly. During each visit, mark a point on a row and count 100 consecutive 1/3-grown or larger green squares; record the number of row feet required to gain that count. Later in the season when there are fewer squares, count 100 consecutive bolls, both green and open. Record the number of row feet required to make this count. To estimate the number of squares and/or bolls present per acre, divide the number of row feet counted into the number of row feet per acre (13,068 on 40-inch rows, 13,756 on 38-inch rows, 14,520 on 36-inch rows and 17,424 on 30-inch rows) and multiply by 100. Row feet per acre also can be obtained by dividing 522,720 by the row spacing in inches.

Early Stalk Destruction and Field Cleanup

Early harvest and stalk destruction are among the most effective cultural and mechanical practices for managing overwintering boll weevils if done on an area-wide basis. These practices reduce habitat and food available to the boll weevil, pink bollworm, bollworm and tobacco budworm. Shred cotton at the earliest possible date and do not allow stubble regrowth or volunteer seedlings to remain within fields or surround-

Growth and fruiting rate of the cotton plant

Development period from	Days per event ¹	Cumulative days from emergence	Accumulated heat units (DD 60's planting required) ²
Planting to emergence	4 to 10	7 to 9	59 to 159
Emergence to:			
first true leaf	7 to 9	7 to 9	127 to 205
sixth true leaf	23 to 27	23 to 27	321 to 608
pinhead square	27 to 30	27 to 30	378 to 663
Pinhead square to:			
matchhead square	9 to 10	36 to 40	
1/3-grown square	12 to 16	39 to 46	508 to 996
1/3-grown square to:			
first white bloom	12 to 16	51 to 62	719 to 1129
first open boll	52 to 76	91 to 122	1857 to 2021
Fully matured two-bale/acre crop			2500 to 2900
Boll development:			
Fiber length established:		first 21 to 30 days	
Fiber micronaire and strength determined:		second 20 to 60 days	
96% boll set period:		first 4 weeks bloom	
95% mature bolls:		129-163 days from planting	

¹ The rate of development is influenced by variety, planting date, weather, soil type and nutrient status.

² Calculated by the formula:

DD 60 = (high daily temperature + low daily temperature/2) - 60

For each day in which the result is a positive number, heat units are accumulated. For example, if the high for the day is 90 and the low is 60, then $90 + 60 = 150$ divided by 2 = 75; $75 - 60 = 15$; so 15 heat units would be accumulated for the day. This total would be added to those accumulated each day since planting to get accumulated heat units.

ing field margins or drainage system banks. Particular attention should be given to the destruction of green or cracked bolls and other plant debris left at the ends of rows following stripper harvest. Cotton present during the fall and winter months is illegal in the Rio Grande Valley and most counties in the Lower Coastal Bend, South Texas and the Blacklands (refer to "Cotton Pest Regulations" available from the Texas Department of Agriculture). This cotton provides the boll weevil with a host plant on which reproduction occurs throughout the year. Weevil infestations that are allowed to develop during the winter may result in extremely high populations during the following season. If a thorough stalk destruction program is not carried out, the benefits of the pest management program will be reduced significantly.

2,4-D amine applied at 1 to 1.5 pounds of formulated product in 10 gallons of water per acre provides excellent control of cotton stalks when applied immediately after harvest or shredding. A second application is usually necessary to control seedlings and any remaining live stalks. For more information see the publication SCS-2003-10 "Cotton Stalk Destruction with Herbicides," at <http://lubbock.tamu.edu/cottoncd/> under the Eastern Region.

Stalk Destruction Laws

Upon request and petition of Texas Cotton Producers, the Texas Legislature passed the Cotton Pest Control Law in an effort to combat the boll weevil and pink bollworm. This law, which is enforced by the Texas Department of Agriculture, requires producers in a regulated county to culturally manage pest populations using habitat manipulations by planting and destroying cotton within an authorized time period. Appointed producers, who are members of local pest management zone committees, have established a series of cotton planting and stalk destruction deadlines for all producers in each regulated county.

The battle against pink bollworms has been extremely successful. Because farmers have adhered to authorized planting and stalk destruction deadlines over the past years, pink bollworm populations in most of the state have been reduced to levels that don't cause major economic damage. In addition, all of the cotton acreage in the state of Texas is now in the boll weevil eradication program. If producers or others have questions about boll weevil control and the impact on stalk destruction in their area they should call the local Texas Boll Weevil Eradication Foundation office or contact the state Foundation office at (325) 672-2800.

Management Decisions

Control measures are needed when a pest population reaches a level at which further increases would result in excessive yield or quality losses. This level is known as the economic (action) threshold. The relationship between pest level, amount of damage, and ability of the cotton plant to compensate for insect damage is greatly influenced by crop phenology and seasonal weather. The economic threshold is not constant but varies with factors such as the price of cotton, the cost of control, and stage of plant development.

When a cotton field is properly scouted, accurate and timely decisions can be made to optimize control efforts while minimizing risk. Fields should be inspected every 3 to 7 days using the scouting procedures described in this guide for the various pests.

Scouting Decisions

Regular field scouting is a vital part of any pest management program because it is the only way reliable information can be obtained to determine if and when pest numbers reach the economic threshold. Scouting should involve more than just "checking bugs." Scouting determines the insect density and damage levels through the use of standardized, repeatable sampling techniques. Scouting should also include monitoring plant growth, fruiting, weeds, diseases, beneficial insect activity, and the effects of implemented pest suppression practices.

Scouting for predators. Predatory insects and spiders can sometimes maintain densities of bollworms, aphids and other pests below economic levels. Knowing the densities of common predators can be important when deciding whether to apply an insecticide for these pests. Also, monitoring densities of predators can alert the producer to those fields that are at risk of pest outbreaks because of low predator densities.

The number of predatory insects and spiders in cotton can be rapidly and accurately determined by the beat bucket method. This method requires less time than using a sweep net, drop cloth or visually searching the plant, and can accurately estimate predator densities. The beat bucket method uses a common white, 5-gallon plastic bucket or pail about 14 inches deep and 10 inches in diameter. To use the beat bucket, carefully approach the sample plant and grasp the stem near the base of the plant. While holding the bucket at a 45-degree angle to the ground, quickly bend the plant into the bucket so that the terminal and as much of the plant as possible are inside the bucket. Still holding the stem near the base of the plant, rapidly beat the plant against the side of the bucket 12 to 15 times during a 3- to 4-second period. This dislodges predators from the plant so that they fall into the bottom of the bucket. Quickly take one step, sample a second plant, and then another step, and sample a third plant down the row. Banging the side of the bucket with the hand will knock down predators crawling up the side of the bucket while sampling. After the third plant is sampled, record the number of bollworm predators (pirate bugs, spiders, big-eyed bugs, lacewing larvae) and others of interest (lady beetles, etc.) captured in the bucket. Remove and examine any leaves and bolls that fall into the bucket to be sure all predators are visible for recording. Tapping the bottom of the bucket can sometimes encourage predators that are playing dead to begin moving and become apparent. The bucket must be kept clean so that the predators are easily seen.

Research has shown that 34 beat bucket samples (3 plants per sample or 102 plants/field) will, in most situations, accurately estimate densities of pirate bugs and spiders, which are key predators of bollworms, tobacco budworms and other caterpillar pests (see table below). Samples should be taken from three or more locations across the field. This will provide a more realistic predator density estimate for the entire field. Weekly sampling for predators is not as important as weekly sampling for pests because predator densities do not change as rapidly as do pest densities. Sampling predators once at first bloom and again 2 to 3 weeks later can provide information for using predator densities in mid- and late-season pest management decisions for caterpillar pests.

Scouting for pests. The following general discussion briefly reviews the insect pests of cotton. (For more detail see B-933, "Identification, Biology and Sampling of Cotton Insects.") The insect pests are discussed as they




Number of beat bucket samples and total sampling time needed to estimate densities of key predator groups at a mean density of 0.5 per plant or all key predators at 1.5 per plant for 3 and 5 plants sampled per beat bucket sample.

Key predator group	3-plant sample unit		5-plant sample unit	
	Samples required	Time to take samples (min)	Samples required	Time to take samples (min)
Pirate bug adults	34	30.2	16	19.3
Pirate bug nymphs	60	52.9	38	44.9
Spiders	30	26.7	20	23.9
Lady beetles	45	39.8	52	61.3
All key predators	17	23.4	14	23.3

normally would occur throughout the cotton production season. Growers should check fields at least once and preferably twice a week to determine the species present, the pest density and the amount of damage. Most pests can be monitored by visually checking the terminal and by making whole plant inspections. However, some pests, such as plant bugs (*Lygus* spp.) at certain stages of cotton development, are more reliably sampled using a drop cloth. The drop cloth method uses an off-white or black cloth measuring 36 x 42 inches (on 40-inch rows). Small insects are usually better seen on a black drop cloth than a white one. Staple a thin strip of wood, approximately 1 inch wide, to each short side of the cloth. Select a random site in the field and unroll the cloth from one row over to the next row. Mark off 18 inches on each row bordering the cloth and vigorously shake all the plants within that area. Two 1.5-row-foot sections (3 feet total) will be sampled simultaneously for insects. Count the number of *Lygus* bug adults and nymphs that fall on the cloth. Repeat the process in at least 20 locations in the field (60 feet of row sampled). If the results show that populations are close to threshold levels, or if the field is very large (more than 100 acres), sample more areas to increase confidence in the results.

Early-season Pests

The period from plant emergence to first 1/3-grown squares requires about 5 to 6 weeks. The 1/3-grown square is approximately 1/4 inch in diameter. Major pests during this crop development period include thrips, cotton fleahoppers, plant bugs and overwintered boll weevils.

Cotton Square Diameter		
1/16-inch	3/16-inch	1/4-inch
		
Pinhead	Matchhead	1/3-grown



Thrips

Thrips are slender, straw colored insects about 1/15 inch long, with piercing and sucking mouthparts. Adults are winged and capable of

drifting long distances in the wind. Thrips attack leaves, leaf buds and very small squares and may cause a silvering of the lower leaf surface, deformed or blackened leaves, terminal loss and square loss. Under some conditions, heavy infestations may reduce stands, stunt plants and delay fruiting and maturity. Thrips damage is most evident during cool, wet periods when small cotton is growing slowly. Thrips damage often is further compounded by plant damage resulting from rain, wind, blowing sand and diseases. Under favorable growing conditions, cotton can sometimes recover completely from early thrips damage. In many areas thrips are considered minor cotton pests. Thrips problems are more prevalent in areas with large winter wheat acreages. Research has demonstrated that cotton varieties with hairy leaves are less injured by thrips than smooth-leaf varieties.

Management and decision making. In areas with a history of frequent, heavy thrips infestations, the use of systemic insecticides should be seriously considered. Research has shown that the application of foliar sprays after significant thrips damage has occurred generally does not result in increased yields. Where postemergence sprays are to be used, fields should be scouted as often as twice a week as cotton emerges. Thrips can migrate in heavy numbers from adjacent weeds or crops, especially small grains, and cause significant damage within a few days and prior to the appearance of true leaves.

Early infestations often reduce yield more than later infestations. Thrips often infest the folded small leaves of the plant terminal and are difficult to count unless the terminal area is dissected. This is especially true during rainy, windy conditions. The decision to apply insecticide should be based on the number of thrips present and the stage of plant development. The number of thrips per plant to use as a treatment level increases as plants add more leaves. One thrips per plant should be used as the treatment level from plant emergence, through the cotyledon stage, to the first true leaf. Inspections should begin once cotton has reached approximately 50 percent stand emergence.

Thrips Action Threshold

Cotton stage	Action threshold
Emergence to	
1 true leaf	1 thrips per plant
2 true leaves	2 thrips per plant
3 true leaves	3 thrips per plant
4 true leaves	4 thrips per plant
5-7 leaves or squaring initiation	Treatment is rarely justified



Aphids

Three species of aphids, or plant lice, feed on cotton plants: the cotton aphid, the cowpea aphid and the green peach aphid. Cotton aphids range from light yellow to dark green to almost black and is the most common aphid in cotton, particularly during mid- and late season. The immature or nymphal stage looks like the adult stage, only smaller. Most adults do not have wings. Cowpea aphids are shiny black with white patches on the legs and are common on seedling plants. Green peach aphids range from pale yellow to green. Winged migrant forms have a yellowish-green abdomen with a dark dorsal blotch. Aphid infestations can occur from plant emergence to open boll. Aphids usually are found on the undersides of leaves, on stems, in terminals and sometimes on fruit. Heavy and prolonged infestations can cause leaves to curl downward and older leaves to turn yellow and shed. Late in the season, honeydew excreted by the aphids can drop on fibers of open bolls. A black, sooty fungus sometimes develops on honeydew deposits. Fiber from such bolls is stained, sticky and of lower quality, resulting in difficult harvest, ginning and yarn spinning.

Management and decision making. Natural control by unfavorable weather, predators, parasites and pathogens can be effective in holding populations below damaging levels. Sometimes aphid numbers increase to moderate or heavy levels and then decline for no apparent reason. Although high populations can develop prior to bloom, most economically damaging infestations develop later in the season during the blooming period. Fields should be scouted twice per week since rapid increases in aphid numbers can occur in a short time. A total of 60 leaves divided between the top, middle and lower portion of the plant should be sampled from plants across the field to determine infestation levels.

Aphid Action Threshold

Cotton stage	Action threshold
Prior to first cracked boll	50 aphids per leaf
After first cracked boll	10 aphids per leaf



Cotton Fleahopper

Adult fleahoppers are about 1/8 inch long and pale green. Nymphs resemble adults but lack wings and are light green. They move very rapidly when disturbed. Adults move into cotton from weed hosts when cotton begins to square. Both adults and nymphs suck sap from the tender portion of the plant, including small squares. Pinhead size and smaller squares are most susceptible to damage.

Management and decision making. The decision to apply insecticide should be based upon the number of fleahoppers present and percent square set. As the first small squares appear (approximately 4- to 6-leaf

stage), examine the main stem terminal buds (about 3 to 4 inches of plant top) of 25 plants at each of at least four locations across the field. More sites should be sampled in fields larger than 80 acres. As plants increase in size and fruit load, larger numbers of fleahoppers may be tolerated without yield reduction. When plants are blooming, fleahopper control is rarely justified. In addition, insecticides applied early in the blooming period may result in outbreaks of bollworms and tobacco budworms because of the destruction of predaceous insects and spiders. Use suggested higher application rates only when infestations are severe.

Cotton Fleahopper Action Threshold

Region	During the first 3 weeks of squaring:
Blacklands	10-15 per 100 terminals
Others	15-25 per 100 terminals



Overwintered Boll Weevil

Emerging overwintered boll weevils usually move relatively short distances from hibernation sites and usually are confined to small areas in fields adjacent to good overwintering habitat. Overwintered weevil emergence begins during early spring and generally peaks during late May and early June. However, significant emergence can continue into early July in some years. The adult weevil is about 1/4 inch long, grayish brown, and has a prolonged snout with chewing mouthparts at its tip. The presence of two distinct spurs on the lower part of the first segment of the front leg will distinguish the boll weevil from other weevils with which it might be confused.

Weevil colonization in cotton is closely related to the fruiting of the plant, with the greatest numbers of overwintered weevils entering cotton fields after squares are present. Therefore, the extent of overwintered weevil infestation depends on the size of the emerging weevil population and the availability of squaring cotton. Thus, early-planted cotton and fields adjacent to ideal overwintering habitat are much more likely to have significant weevil infestation than cotton planted later in the season or fields farther away from good overwintering habitat. In areas where a uniform delayed planting date is recommended, volunteer cotton should be destroyed as early as possible.

Management and decision making. All of the cotton acreage in Texas is now in the boll weevil eradication program. If producers or others have questions about boll weevil control in their area, they should call the local Texas Boll Weevil Eradication Foundation office or contact the state Foundation office at (325) 672-2800. However, producers should still follow good management practices to aid boll weevil eradication. In the Rolling Plains, uniform planting of cotton on a community-wide basis after mid-May will often significantly reduce weevil infestations. When fruiting cotton is not

available for feeding, the life span of newly emerged weevils is relatively short. Therefore, delayed, uniform planting of cotton increases suicidal emergence of overwintered weevils. In addition, producers can help with eradication by doing the following:

- Avoid planting cotton in small fields that are difficult to treat (i.e., surrounded by trees or buildings occupied by people or livestock).
- Make boll weevil eradication personnel aware of all cotton fields.
- Give boll weevil eradication personnel access to all cotton fields.
- Ensure that pheromone traps are kept standing and operational.
- Promptly alert eradication personnel of any field detections of live boll weevils or weevil-punctured squares.

Mid-season and Late-season Pests

Mid-season is the 6-week fruiting period following the appearance of the first $\frac{1}{3}$ -grown squares. Proper crop management and frequent field inspection for pests and beneficials will eliminate unnecessary insecticide applications during this period. The major concern during this period is ensuring adequate fruit set and preserving beneficial insect populations.

Late-season is the remainder of the production season when the major concern is boll protection. Monitoring boll set may aid in making spray decisions in the late-season period. Boll protection is of primary concern as long as bolls which will be harvested are immature. Heavy irrigation and high rates of fertilizer prolong cotton plant growth and increase the chance of late-season insect damage.

Bollworms, tobacco budworms and boll weevils are the principle insect pests in mid- and late-season. A major goal of a well-planned pest management program (although not always achieved) is to avoid having to treat for bollworms and tobacco budworms. Naturally occurring parasites and predators and certain weather conditions often suppress bollworm and budworm populations. For this reason, chemical control for the boll weevil at this time of year should be avoided if possible. If a satisfactory fruit set occurred during the first 30 days of blooming, higher numbers of weevil-damaged squares can be tolerated. However, if fruiting is delayed, additional insecticide applications may be necessary to protect smaller bolls that are expected to mature. Fewer boll weevil-damaged bolls can be tolerated if cotton is to be picked instead of stripped

Boll Weevil

Recently emerged adults feed on squares or bolls for 4 to 8 days before mating and laying eggs. Adult weevils puncture squares or bolls both for feeding and egg laying. Egg laying punctures can be distinguished from feeding punctures by the presence of a wartlike plug

which the female places over the feeding site after she has deposited an egg in the cavity. The female deposits an average of 100 eggs during her life span of about 30 days.

Eggs hatch into larvae, or grubs, within 3 to 5 days under midsummer conditions. Grubs transform into pupae within the square or boll in approximately 7 to 11 days. Adults emerge 3 to 5 days later. The time required for development from egg to adult under summer field conditions averages 17 days, with a complete generation occurring in 21 to 25 days.

Punctured squares flare open and usually fall to the ground within a week. Small bolls that are punctured may also fall to the ground, but larger bolls remain on the plant. When direct sunlight and hot, dry conditions cause fallen squares to dry out rapidly, large numbers of weevil larvae do not survive.

Boll weevil populations reach the highest level late in the growing season. As cotton plants mature and the number of squares is reduced, the percentage of boll weevil-damaged squares becomes an unrealistic indicator of damage because boll weevils are competing for squares. As square numbers decrease, boll weevils may cause more damage to small bolls.

Management and decision making. All of the cotton acreage in Texas is now in the boll weevil eradication program. Producers should continue monitoring the plants for boll weevils and boll weevil damage. If boll weevils or boll weevil damage is found, producers should contact their local Texas Boll Weevil Eradication Foundation office or contact the state Foundation office at (325) 672-2800.

Bollworm and Tobacco Budworm

Bollworm and tobacco budworm larvae are similar in appearance and cause similar damage. Full-grown larvae are about $1\frac{1}{2}$ inches long and vary in color from pale green, pink or brownish to black, with longitudinal stripes along the back.

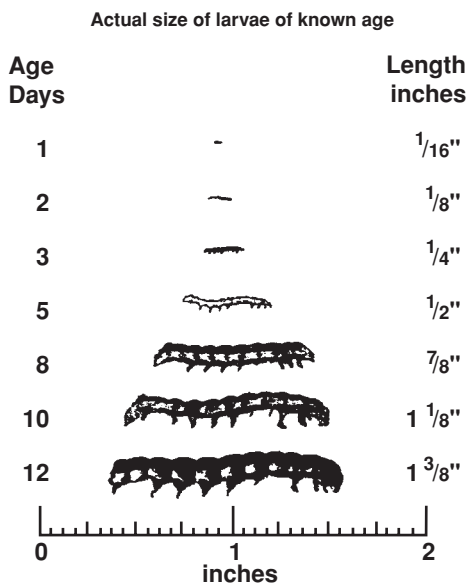
Tobacco budworm and bollworm moths are attracted to and lay eggs readily in cotton that is producing an abundance of new growth. Moths usually lay single eggs on the tops of young, tender terminal leaves in the upper third of the plant. Eggs are pearly white to cream color and about half the size of a pinhead. These should not be confused with looper eggs, which are flatter and usually laid singly on the undersides of leaves. Eggs hatch in 3 to 4 days, turning light brown before hatching. Young worms usually feed for a day or two on tender leaves, leaf buds and small squares in the plant terminal before moving down the plant to attack larger squares and bolls. **When small worms are in the upper third of the plant, they are most vulnerable to natural mortality and to insecticides.**

Sometimes moths deposit eggs on squares, bolls, stems and, in general, lower parts of the plant. This may occur when cotton plants are stressed and making little new growth, or during periods of high temperature and low humidity. Detection of eggs and control of small

worms are more difficult when eggs are deposited in these locations.

Budworms are generally more resistant to certain insecticides than bollworms. Budworms are less numerous than bollworms early in the crop season and rarely reach high numbers until mid- to late-season. With the use of insecticides that are less effective towards budworms relative to bollworms, the percentage of budworms in the infestation increases with each additional application because of selection pressure. Aphids and other secondary pest infestations may increase following bollworm/ budworm sprays, especially when pyrethroids are used.

Bollworm/Budworm Identification



Management and decision making. Cotton fields should be scouted carefully every 3 to 5 days during periods of predicted moth egg-laying activity. In fields with fewer than five squares per row foot (approximately 67,000 per acre), bollworm populations often collapse and cease to be a problem.

Eggs and newly hatched worms are usually found in the plant terminals and indicate possible outbreaks. Natural mortality agents such as weather and predators frequently control these pests before any damage occurs. Once worms have grown to larger than 1/2-inch long, natural and insecticidal control are less effective. Insecticides applied to control 1/2-inch long worms are only moderately effective.

Frequently, examination of the upper third of the plant (leaves, stems, squares, blooms and bolls) is all that is needed to make a sound management decision. However, when eggs are being laid all over the plants

or when 60 percent or more of the bolls are mature, whole plant counts should be used. Mature, unopened bolls are firm, cannot be dented when pressed between the thumb and forefinger, and cannot be cut easily with a sharp knife.

Terminal/Square Inspection Method. Divide the field into four quadrants and examine 25 plant terminals, selected at random from each quadrant, for small larvae and eggs. Also, from each quadrant, examine 25 one-half grown and larger green squares for bollworms and bollworm damage. Squares should be selected at random and flared or yellow squares should not be included in the sample. If previous insecticide applications have eliminated natural enemies (see guidelines for scouting for predators on p. 6), fewer bollworms/tobacco budworms can be tolerated before economic damage occurs.

Terminal Inspection Method: Bollworm and Tobacco Budworm Action Threshold

Cotton stage	Natural enemies	Cotton type	
		Non-Bt	Bt
Before bloom	present or absent	15-30% damaged squares and worms are present	
After 1st bloom	present	8-12 small worms per 100 terminals and 5-15% damaged squares/bolls*	Use whole plant inspection method
	absent**	4-5 small worms per 100 terminals with eggs present and 5% damaged squares/bolls	

Fields that have accumulated 350 DD60s beyond 5 NAWF are no longer susceptible to first or second instar bollworm/tobacco budworm larvae.

If two or more key predators (see discussion under Scouting Decisions) are found for each small worm, control measures may not be needed or a microbial insecticide may be considered.

*If worm numbers are high, it may not be appropriate to wait until the damage threshold of 5 to 15 percent square damage is reached.

**Eliminated by broad-spectrum insecticide application after first bloom.

Microbial insecticides may be considered during the squaring period through the first 10 days of blooming if infestations average 12 or fewer small (less than 1/4 inch) bollworms per 100 terminals. Unlike conventional insecticides, microbial insecticides do not destroy predators and parasites (see Microbial Insecticides, p. 15).

Whole plant inspection method. Divide the cotton field into four or more manageable sections depending upon field size. Make whole plant inspections of five randomly chosen groups of three adjacent cotton plants in each section. Count the number of eggs, worms and

key predators encountered and estimate the number of eggs, worms or key predators per acre using the following formula:

$$\text{Worms, eggs or key predators per acre} = \frac{\text{No. eggs, worms or key predators counted}}{\text{No. of whole plants checked}} \times \text{No. of plants per acre}$$

$$\text{Plants per acre} = \frac{\text{Row feet per acre}}{\text{Row feet examined}} \times \text{Plants counted}$$

$$\text{Row feet per acre} = \frac{522720}{\text{Row spacing in inches}}$$

The number of plants per acre is calculated from counts of plants on at least 10 feet of row in four locations in the field. The number of row feet per acre (see Monitoring Cotton Fruiting Rate) divided by the number of row feet examined multiplied by the number of plants counted equals the plants per acre.

A range of treatment thresholds is provided under both the terminal and whole plant inspection methods because many factors in addition to density of larvae determine the need to treat with insecticides for bollworms/budworms. One of these factors is the number of predatory insects and spiders which feed on bollworm/budworm eggs and small larvae. If previous insecticide treatments have eliminated these beneficial insects, then a lower treatment threshold should be considered. However, if two or more key bollworm predators are found for each small worm, control measures may not be needed or a microbial insecticide may be considered (see Microbial Insecticides, p. 15). The number of bollworm/budworm eggs can also be considered along with worm densities in making treatment decisions. The treatment threshold will also vary according to the ability of the individual scout to locate small larvae, the age structure of the infestation, the stage of crop growth, the percent fruit set, the cost of insecticide treatment, the duration of the infestation (1 to 2 weeks vs. 3 to 4 weeks), the type of production system (high input/high yield or low input/low yield) and the market value of the crop.

Bt transgenic cotton management. Research trials evaluating the Bollgard® transgenic Bt gene technology have determined it to be highly effective against tobacco budworms. Bollgard® cottons are also effective against cotton bollworm, but under heavy pressure from this species, insecticide treatment may be needed. Recently released Bollgard® II and WideStrike® cotton varieties are more effective against tobacco budworm and bollworm. However, under extreme environmental conditions or heavy insect pressure, they may still need to be treated.

The entire plant should be searched for tobacco budworm and bollworm larvae and injury. A proper sample includes squares, white blooms, pink blooms, bloom tags and bolls. Scouting intervals should be reduced to 3 to 4 days during periods of increasing

bollworm egg laying, especially during peak bloom. Treatment should not be triggered by the presence of eggs alone. Hatching larvae must first feed on the cotton plant to receive a toxic dose.

As with non-Bt cotton, a range of treatment thresholds is provided since many factors in addition to density of larvae and square damage determine the need to treat Bt cotton with insecticides. Many of these factors are the same as those listed above for non-Bt cotton. As in non-Bt cotton, predators and parasites are very important in reducing the numbers of eggs and larvae and they complement the control provided by these varieties.

The use of a non-Bt cotton refuge is a requirement for planting Bt cotton and is an important component of resistance management.

Whole Plant Inspection Method: Bollworm and Tobacco Budworm Action Threshold based on a Plant Population of 40,000 to 60,000 Plants per Acre

Cotton stage	Worm size	Cotton type	
		Non-Bt	Bt
Before bloom	All	15-30% damaged squares worms are present	
After boll formation	≤ ¼ inch	10,000 worms/acre	Do not treat
	>¼ inch	5,000 worms/acre	4,000-8,000 worms/acre or 8-12 worms/100 plants, with 5-15% damaged fruit

Fields that have accumulated 350 DD60s beyond 5 NAWF are no longer susceptible to first or second instar bollworm/tobacco budworm larvae.

If two or more key predators (see discussion under Scouting Decisions) are found for each small worm, control measures may not be needed or a microbial insecticide may be considered.

Aphids

Aphids are a common pest of mid- and late-season cotton; refer to the early-season section, p. 7, for a full description and for management and decision making information.

Occasional Pests



Cutworms

Cutworms may damage cotton during the seedling stage, and control will be necessary if stands are threatened. The action threshold is a matter of judgment. Keep fields as weed-free as possible 6 weeks before planting to minimize cutworm problems. Destroy (with tillage or herbicides) cover crops at least 6 weeks before planting. Band applications over the drill is recommended for insecticide sprays. If the ground is dry, cloddy or crusty at the time of treatment, control may not be as effective as in moist soil.



Creontiades Plant Bug (*Creontiades signatus*)

Plant bugs feed on cotton terminals, squares and small bolls. *Creontiades signatus* (Distant) adults are 1/4 inch long, narrow-bodied and light green. The insect goes through several molts or instars (nymphs). Differences between *C. signatus* and cotton fleahoppers make identification between these two pests easier. *C. signatus* is generally bigger than a cotton fleahopper, with the smallest *C. signatus* nymph about the size of a large cotton fleahopper nymph. The antennae of nymph and adult *C. signatus* are longer than the length of their body, while the antennae of nymph and adult fleahoppers are approximately half the length of the insect body. Nymph and adult *C. signatus* are light to dark green, while nymph and adult fleahoppers are grayish green-colored insects. Both *C. signatus* and fleahopper nymphs have red eyes. Young nymphs of *C. signatus* have a red stippling on the antennae, but this usually is not observed after the third instar. In addition, adults of *C. signatus* have a reddish band on the pronotum (segment behind the head).

Damage from *Creontiades* species in cotton can be square and small boll loss. A characteristic clear yellow liquid (frass) is often left on the fruiting structure where *Creontiades* have fed. Squares and small bolls may suffer damage ranging from just surface feeding and boll malformation to complete fruit loss.

Management and decision making. The need to control this bug is determined by the insect abundance. Inspect fields at 4- to 5-day intervals during the fruiting period. Take 50 sweeps at each of the four locations in the field by sweeping a 15- to 16-inch net across the top of one row in such a way that the top 10 inches of the plants are struck. The action threshold for *Creontiades* has not been fully evaluated.

Creontiades Action Threshold

Cotton stage	Action threshold
During the 1st 4 or 5 weeks of fruiting	15-25 bugs per 100 sweeps with unacceptable fruit set

When harvestable bolls exceed 10 days old, treatment should not be necessary.

Tarnished Plant Bug (*Lygus spp.*)

The tarnished plant bug is one of several *Lygus* species that feeds on cotton terminals, squares and small bolls. Adults are winged, vary in color from greenish to brown, and are 1/4 inch long. Immature tarnished plant bugs are called nymphs. They are light green; late instars have four conspicuous black spots on the thorax and one large black spot near the base of the abdomen. The nymph's wings are not developed, but nymphs can move rapidly and are difficult to detect in cotton foliage. Small nymphs may be confused with aphids, cotton fleahoppers and leafhopper nymphs. Plant bugs prefer legumes to cotton and usually are found in large numbers in areas of alfalfa production or areas providing

wild hosts, such as clovers, vetches, mustard and dock. Lygus bugs are attracted to succulent growth; their feeding results in shedding of squares and small bolls, stunted growth and boll deformation. Damage to blooms appears as black anthers and puckered areas in petals.

Management and decision making. The need for lygus bug control is determined by their abundance in relation to the fruiting condition of the cotton plants. Fields should be inspected for lygus bugs at 4- to 5-day intervals.

Prior to peak bloom, the most accurate means of sampling lygus is with a sweep net. Always use a standard cloth or canvas sweep net with a diameter of 15 inches. One sample set should consist of 50 sweeps across a single row of cotton. However, if you are picking up too much plant material in 50 sweeps, you may want to reduce the number of sweeps to 25 or less. These tips can help:

- Walk briskly down the row and swing the net in front of you perpendicular to the row.
- Strike the plants so that the lower edge of the rim strikes the plants about 10 inches from the top.
- Keep the lower edge tilted slightly ahead of the upper edge.
- Keep the sweeps far enough apart that you do not sweep plants that have already been jostled by the net.
- Sweeps that are too closely spaced may cause lygus fly to drop from the plants and be missed.
- Keep the net moving to prevent adults from flying out.
- After each set of sweeps, count all the lygus bugs in the net, including nymphs.
- Go through the sample slowly, looking at each leaf and watching closely for adults flying from the net.
- Be sure not to confuse lygus with scentless plant-bugs which are similar in appearance.

After peak bloom, the most accurate method of sampling lygus is with a drop cloth. See page 7 for the discussion on how to construct and use a drop cloth.

Lygus Action Threshold

Cotton stage	Sampling Method*	
	Drop cloth	Sweep net
1st two weeks of squaring	1-2 per 6 ft-row with unacceptable square set	8 per 100 sweeps with unacceptable square set
3rd week of squaring to 1st bloom	4 per 6 ft-row with unacceptable fruit square set	15-20 per 100 sweeps with unacceptable fruit set first 4-5 weeks
After peak bloom	4 per 6 ft-row with unacceptable fruit set the first 4-5 weeks	15-20 per 100 sweeps unacceptable fruit set first 4-5 weeks

*Sweep net—standard 15-inch net, sample 1-row at a time taking 15-25 sweeps. Recommended before peak bloom.

Drop cloth—black is recommended; 3-ft sampling area, sample 2-rows. Recommended after peak bloom.

Cease sampling and treating when NAWF = 5+ 350 DD60's.



Beet Armyworm

Beet armyworm eggs are laid on both leaf surfaces in masses covered by a whitish, velvety material. Young beetle armyworms “web up” and feed together on leaves, but eventually disperse and become more solitary in their feeding habits. Early-season infestations feed on leaves and terminal areas. Occasionally they destroy the terminal, causing extensive lateral branch development and delayed maturity. Early-season insecticide applications may be warranted when plants with undamaged terminals approach the lower optimal plant stand limits of two plants per row. Larvae skeletonize leaves rather than chewing large holes in them. Damaging infestations sometimes develop late in the season when beetle armyworms also feed on terminals, squares, blooms and bolls. Several factors can contribute to these late-season beetle armyworm outbreaks. These factors are: mild winters (e.g., absence of prolonged freezing temperatures); late planting; delayed crop maturity; heavy early-season organophosphate or pyrethroid insecticide use; prolonged hot, dry weather conditions; presence of beetle armyworms prior to bloom; and weather conditions that support long-distance migration. Additional characteristics of high risk fields that consistently appear to fit a pattern for developing beetle armyworm problems are: sandy and droughty soils; skip-row planting; fields with skippy, open canopies; drought stressed plants; and fields infested with pigweed. The likelihood of a heavy outbreak increases as more of these factors occur in a given location. However, when beetle armyworm populations are high all fields are susceptible. When beetle armyworms begin to damage the fruit, control may be justified. Infestations usually are spotty within a field, and careful scouting is necessary to determine the need for, and field area requiring, control. Beetle armyworms longer than 1/4 inch may be difficult to control.

Management and decision making. Scout the field by using the Whole Plant Inspection Method described in the bollworm and tobacco budworm section.

Beet Armyworm Action Threshold

Cotton stage	Feeding site	Action threshold	
Prior to 5 NAWF	Primarily leaf feeding	≥ 10% infested plants and:	
		20,000 larvae per acre	or 16-24 larvae per acre
	Obvious square, bloom and boll feeding	< 1/4 inch larvae	> 1/4 inch larvae
After 5 NAWF	Any	4,000-8,000 larvae per acre	
		8-12 larvae per 100 plants	

NAWF = nodes above white flower



Spider Mites

Spider mites infest the undersides of leaves, where they remove the sap from the plant and cause the leaves to discolor. They may also infest bracts of squares and bolls, causing the bracts to desiccate and squares or small bolls to shed. Severe infestations can defoliate the cotton plant. Mite infestations most often occur in spots and in field margins. Increased spider mite populations usually follow multiple applications of insecticides for other pests, since insecticides destroy natural spider mite predators. Mites may be moved by high winds or equipment from nearby crops which already have heavy infestations.

Management and decision making. The current action threshold for spider mites has not been fully evaluated, but is meant to act as a general guide. Prior to bloom, cotton should be protected from spider mite induced defoliation. After bloom, it is essential that the leaves responsible for boll filling be protected from spider mites. Research as demonstrated that cotton should be protected from severe spider mite damage for 650-750 DD60s beyond cutout or NAWF + 5. Because spider mite populations are often clumped in distribution, particularly along field edges, spot treating infested areas will often prevent spread and be more cost effective. Thorough coverage of the plant canopy with the miticide is essential to achieve good mite control. This may require high gallonage sprays (> 50 GPA) delivered by ground applicators. The spray should be directed into the canopy with drop nozzles.

Spider Mite Action Threshold

Action threshold
Treat when 50% of the plants show noticeable reddened leaf damage and the mite population is increasing
Spot treat when infestations are relegated to small areas.
Cease sampling and treating when NAWF = 5 + 650-750 DD60s.

Fall Armyworms

Fall armyworms have four life stages: egg, larva, pupa and adult. Eggs are very small, white, laid in clusters of 50 or more, and are covered with grayish, fuzzy scales from the body of the female moth. The eggs are difficult to find and are distributed throughout the plant on the undersides of leaves. Larvae will feed for 2 to 3 weeks and can be 1 to 1½ inches long with various color patterns depending on the food source. The larvae have five instars (stages when molting occurs). When full grown, larvae enter the soil and form the pupal stage. Adult moths emerge from pupae. Moths mate and lay eggs, thus starting the life cycle over again.

The fall armyworm overwinters in the pupal stage in the southern regions of Texas. The adult is a moth that migrates northward as temperatures increase in the spring. The adult moth has a wingspan of about 1½ inches. The hind wings are silver-white; the front wings are dark gray, mottled with lighter and darker

splotches. Each front wing has a noticeable whitish spot near the extreme tip on the males. Larval color can vary from light tan to shades of green. The head is brown or black with a prominent white line between the eyes which forms an inverted "Y." The fall armyworm larva also has four large spots that form a square on the upper surface of the last segment of its body.

Management and decision making. Small larvae are difficult to detect because they often feed on boll bracts and on the surface of bolls, hidden behind the bracts. Larger larvae are often the first to be detected while feeding in blooms. Fall armyworm infestations have been so sporadic in Texas that little is known about their ability to do damage. Observations made in the 2005 growing season indicated that fall armyworms feed on a relatively small number of bolls compared to bollworms. Thus, it takes more larvae to do as much damage as a smaller number of bollworm or tobacco budworm larvae.

The fall armyworm is inherently difficult to control with insecticides, and larvae are often found deep in the canopy in protected areas. Divide the field into four quadrants and examine 25 plant terminals, selected at random from each quadrant, for small larvae and eggs. Also, from each quadrant, examine 25 one-half grown and larger green squares for armyworms and armyworm damage. Squares should be selected at random and flared or yellow squares should not be included in the sample.

An alternative is to determine the number of fall armyworm larvae per acre. Divide the cotton field into four or more manageable sections depending upon field size. Make whole plant inspections of five randomly chosen groups of three adjacent cotton plants in each section. Count the number of eggs, worms and key predators per acre using the formula described in the bollworm section.

Fall Armyworm Action Threshold

Cotton stage	Action thresholds	
	Terminal and fruit inspection	Whole plant inspection
Prior to 1st bloom	30% damaged squares	10,000-20,000 small larvae per acre
After 1st bloom	15-25 small larvae per 100 plant terminals and 5-15% damaged squares or bolls*	

*If the number of fall armyworms is high, it may not be appropriate to wait for 5-15% damaged squares or bolls. (See bollworm section for determining the number of larvae per acre.)



Cabbage Looper, Soybean Looper, Cotton Leafworm

Moths of these species lay eggs singly, mainly on the lower surfaces of leaves. Larval feeding damage is characterized by leaf ragging or large holes in the leaves. Larvae often are killed by a disease before economic foliage loss occurs.

Management and decision making. An economic threshold for these pests has not been established. **As a general guideline, treat when 10 percent of the "key leaves" are infested with worms.** The key leaf is the third one down the main stem from the tip (usually the highest leaf on the plant).

Cabbage Looper, Soybean Lopper and Cotton Leafworm Action Threshold

Treat when 10% of the 3rd node leaves are infested.
The 3rd node is the third one down the main stem from the tip (usually the highest leaf on the plant).



Stink Bugs

Several species of stink bugs feed on squares and bolls. Feeding on bolls may cause boll shed and/or seed damage and lint staining. Stink bugs may move into cotton when other crops in the area starts to mature. Second through fifth instar stink bug nymphs and adults can damage bolls. Fourth and fifth instars can cause the same level of damage as adults.

Management and decision making. Using a drop cloth (see page 7 for drop cloth discussion), sample 6 row feet of cotton in several locations in the field. If any stinkbugs are found, small bolls should be sampled and inspected for internal injury. Stink bugs often are clumped near field margins. Spot treatment provides effective control when this situation exists.

Stink Bug Action Threshold

Drop cloth	Small bolls*
1 per 6 row ft	20% with internal injury

*Sample at least 50 quarter-sized bolls.

*Callous growth on internal boll wall and/or stained lint.



Grasshoppers

A number of grasshopper species are occasional cotton pests. They generally move into fields from adjacent fence rows, ditch banks and field margins.

Management and decision making. Damaging infestations need to be controlled early while grasshoppers are small and still in crop border areas.

Grasshopper Action Threshold

In-field	Field margin
10 per 3 row ft	20 per sq-yard

Other Pests

Yellowstriped armyworm, cotton square borer, southern armyworm, cotton leaf perforator and salt marsh caterpillar rarely cause economic damage.

Management and decision making. Economic thresholds have not been established for these pests. Control is a matter of individual judgment.

Systemic Insecticides for Early-season Pests

In areas where early-season pests such as thrips, aphids and spider mites consistently damage young cotton each year, preventive systemic insecticides are sometimes used instead of postemergence sprays. In choosing either approach to early-season pest control, key factors to consider include acreage, yield potential, available equipment and labor, knowledge of cotton pests and beneficial species, difficulties in getting a stand, drought tendencies, etc. Both the limitations and advantages of systemics used at planting should be evaluated carefully before choosing their use over postemergence insecticides.

Limitations of Systemics

- The decision to invest in systemics must be made before the severity of the early-season pest problem can be known; therefore, the net economic return is uncertain.
- If replanting is necessary, the initial systemic treatment is lost and a new treatment at additional expense is required.
- Continued pest exposure to and population selection by certain systemics may result in accelerated development of resistance to these and related insecticides.
- Excessive rates of systemics may result in increased numbers of damaging pests after the effective control period.
- Under conditions unfavorable for plant emergence, such as poor seed quality, planting too deeply, seedling disease or cool wet weather, some systemics used at planting time may contribute to further stand reduction.
- Special application equipment is required for granular systemics.

Advantages of Systemics

- For the producer who is unable to check his fields regularly for pest buildups during the early-season, and therefore cannot apply post-emergence pesticides based upon actual need, systemics offer a degree of protection during the first few weeks of growth.

- Using systemics frees labor and equipment and reduces the need to make pest control decisions during the protected period.
- Systemics applied at planting often control insects more consistently than foliar sprays.
- Protection from early-season insect damage may result in earlier and more uniform maturity, which may be important during years of deficient moisture or insect buildups late in the season.
- The activity of systemics within the plant is relatively unaffected by rain and weathering during their normal period of effectiveness.
- Systemics are effective when inclement weather precludes sprayer operation.

Ovicides

These insecticides effectively reduce numbers of bollworm and tobacco budworm eggs. Because large numbers of eggs often fail to produce economically damaging worm infestations, **insecticidal control of eggs alone is not recommended.** Environmental factors such as hot, dry weather can significantly reduce field levels of eggs. Some other important natural control factors include predacious insects and spiders and parasitic wasps. Natural egg control can vary greatly between fields and times of the season. Often, high numbers of sterile eggs are found. If larval infestations exceed suggested treatment levels and large numbers of eggs are present, the addition of an ovicide to the larvicide may be justified to enhance overall control.

Microbial Insecticides

Microbial products which are natural pathogens of the bollworm and the tobacco budworm are commercially available as preparations of *Bacillus thuringiensis* (B.t.). Field studies indicate that microbials are best suited for square protection. They are slow acting and should be used only against infestations of worms during the squaring period through the first 10 days of blooming. They are not suggested for use after that point.

Microbials are effective against worm numbers up to 6,000 per acre. They do not destroy beneficial arthropods (predators and parasites), a characteristic which sets them apart from conventional insecticides. When beneficial arthropod populations are absent, other insecticides provide more consistent control.

Treat fields in which most of the larvae are not more than $\frac{1}{4}$ inch long. Infestations of larger worms should **not** be treated with microbials. Maximum effectiveness with B.t. requires precise sampling of cotton plants during the fruiting period. Sampling should be conducted at least twice a week while squares are developing. Apply microbials with ground equipment at the rate of 5 to 15 gallons of liquid per acre, or by air using 2 to 5 gallons per acre.

Protecting Bees from Insecticides

Pollination is extremely important in producing many seed crops such as alfalfa, clover and vetch. Honey bee pollination also is critical in the production of cucurbits throughout the state, and supplements native pollinators. The role of honey bees and wild pollinators in contributing to increased yields and fiber length of cotton is unclear. The importance of insect pollinators in the production of hybrid cotton is well recognized. Where pollinating insects are required for flower fertilization, the crop producer, insecticide applicator and beekeeper should cooperate closely to minimize bee losses:

1. Apply insecticides, if practical, before bees are moved into fields or adjacent crops for pollination. When bees are in the vicinity, evening applications after bees have left the field are less hazardous than early morning applications.
2. Where insecticides are needed, consider their toxicity. "Highly toxic" insecticides include materials that kill bees on contact during application or for several days following application. Insecticides categorized as "moderately toxic" or "relatively nontoxic" should be applied in late evening or early morning when bees are not foraging. For information on hazards of insecticides to honey bees, refer to the table in E-5A, "Suggested Insecticides for Managing Cotton Insects in the Southern, Eastern and Blacklands Areas of Texas-2008."
3. To prevent heavy losses of bees, do not spray any insecticide directly on colonies and prevent insecticide from drifting. Bees often cluster on the fronts of their hives on hot evenings. Pesticide drift or direct spray at this time generally results in high levels of mortality.

Policy Statement for Making Pest Management Suggestions

The information and suggestions included in this publication reflect the opinions of Extension entomologists based on field tests or use experience. These management suggestions are a product of research and are believed to be reliable. However, it is impossible to eliminate all risks. Conditions or circumstances which are unforeseen or unexpected may result in less than satisfactory results even when these suggestions are used. Texas AgriLife Extension Service will not assume responsibility for such risks. Such responsibility shall be assumed by the user of this publication.

Suggested pesticides must be registered and labeled for use by the Environmental Protection Agency and the Texas Department of Agriculture. The status

of pesticide label clearances is subject to change and may have changed since this publication was printed. County Extension agents and appropriate specialists are advised of changes as they occur.

The **USER** is always responsible for the effects of pesticide residues on his livestock and crops, as well as problems that could arise from drift or movement of the pesticide from his property to that of others. Always read and follow carefully the instructions on the container label.

For additional information, contact your county Extension staff or write the Extension Entomologist, Department of Entomology, Texas A&M University, College Station, Texas 77843-2475, (979) 845-7026.

Endangered Species Regulations

The Endangered Species Act is designed to protect and to assist in the recovery of animals and plants that are in danger of becoming extinct. In response to the Endangered Species Act, many pesticide labels now carry restrictions limiting the use of products or application methods in designated biologically sensitive areas. These restrictions are subject to change. Refer to the Environmental Hazards or Endangered Species discussion sections of product labels and/or call your local county Extension agent or Fish and Wildlife Service personnel to determine what restrictions apply to your area. Regardless of the law, pesticide users can be good neighbors by being aware of how their actions may affect people and the natural environment.

Worker Protection Standard

The Worker Protection Standard (WPS) is a set of federal regulations that applies to all pesticides used in agricultural plant production. If you employ any person to produce a plant or plant product for sale and apply any type of pesticide to that crop, WPS applies to you. The WPS requires you to protect your employees from pesticide exposure. It requires you to provide three basic types of protection: you must inform employees about exposure, protect employees from exposure, and mitigate pesticide exposures that employees might receive. The WPS requirements will appear in the "DIRECTIONS FOR USE" part of the pesticide label. For more detailed information, consult EPA publication 735-B-93-001 (GPO #055-000-0442-1) *The Worker Protection Standard for Agricultural Pesticides — How to Comply: What Employers Need to Know*, or call Texas Department of Agriculture, Pesticide Worker Protection Program, (512) 463-7717.

ADDITIONAL REFERENCES

(These publications can also be found at: http://insects.tamu.edu/extension/publications/results_all.cfm.)

Number Title

- B-933 Identification, Biology and Sampling of Cotton Insects
- E-5A Suggested Insecticides for Managing Cotton Insects in the Southern, Eastern and Blackland Areas of Texas-2008
- E-6 Managing Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas-2008
- E-6A Suggested Insecticides for Managing Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas-2008
- E-7 Managing Cotton Insects in the Lower Rio Grande Valley-2008
- E-7A Suggested Insecticides for Managing Cotton Insects in the Lower Rio Grande Valley-2008
- L-5142 The Proper Use of Cotton Harvest-Aid Chemicals
- B-1721 Cultural Control of the Boll Weevil: A Four Season Approach—Texas Rolling Plains
- E-357 Guide to the Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton
- B-6116 Texas Cotton Production — Emphasizing Integrated Pest Management (\$15.00)
Cotton Resource CD at <http://lubbock.tamu.edu/cottoncd/>

Other

Cotton Resource DVD at <http://lubbock.tamu.edu/cottondvd/>

MP-1718 An Illustrated Guide to the Predaceous Insects of the Northern Texas Rolling Plains, is available at: <http://insects.tamu.edu/extension/bulletins/17180.pdf>

The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Texas AgriLife Extension Service is implied.

Cover photo by Winfield Sterling

Produced by AgriLife Communications and Marketing, The Texas A&M System
Extension publications can be found on the Web at: <http://AgriLifebookstore.org>.

Visit the Texas AgriLife Extension Service at <http://AgriLifeextension.tamu.edu>.

Educational programs of the Texas AgriLife Extension Service are open to all people without regard to race, color, sex, disability, religion, age, or national origin.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas AgriLife Extension Service, The Texas A&M System.

Revised