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Texas Cooperative EXTENSION
The Texas A&M University System

Managing Cotton Insects

in the Lower Rio Grande Valley 2007

Contents

For recommended insecticides refer to E-7A, "Suggested Insecticides for Managing Cotton Insects in the Lower Rio Grande Valley 2007" at the following web sites:
http://insects.tamu.edu/extension/publications/index.cfm
or http://tcebookstore.org

Managing Cotton Insects in the Lower Rio Grande Valley

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

IPM Principles

The term "integrated 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 pests.

The IPM 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 pest population or plant damage level, determined through regular field scouting activities, is called an **economic threshold or action level.** Precise timing and execution of each production operation is essential. In short, pest management strives to optimize rather than maximize pest control efforts.

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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 way to help avoid pest resistance is to rotate the use of insecticide groups, taking advantage of different modes of action. In addition, do not tank-mix products from the same insecticide class. Such insecticide management practices should delay the development of resistance and also provide better overall insect control.

Insecticides with similar chemical structures affect insects in similar ways. For example, pyrethroids (including esfenvalerate, bifenthrin, cyfluthrin, cyhalothrin, deltamethrin, zeta-cypermethrin 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.irac-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 IRAC numbering system is used in the Suggested Insecticides for Cotton 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, "Field Guide to Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton," Texas Cooperative Extension.)

Biological control is the use of predators, parasites and disease to control pests. Important natural enemies in cotton include minute pirate bugs, damsel bugs, bigeyed 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 University 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 pest 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 existing 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 utilized in these studies. There are currently no economic thresholds established for augmentative releases of *Trichogramma* for bollworm/tobacco budworm control in cotton. Furthermore, parasite mortality from insecticides used to control other pests in or around parasite release areas would be a major factor adversely affecting the success of augmentative releases.

Research has shown that releasing large numbers of lacewing larvae (30,000 and more per acre) can reduce bollworm infestations below damaging levels. However, these release rates are currently cost prohibitive because of high production costs for 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 pertaining to the utility of releasing either lady beetles or lacewings for the control of economically damaging infestations of aphids.

Because definitive information on the application of augmentation (when to apply, what density should be applied, etc.) is lacking, entomologists with Texas Cooperative Extension cannot provide guidelines for the application of 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 present 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. **When infestation is heavy, supplemental insecticide treatment may be necessary for cotton bollworm.** Bt (Bollgard®) cottons provide some suppression of beet armyworm and soybean looper, and little or no control of fall armyworm or cutworms. Recently released Bollgard® II and WideStrike® cotton varieties are more effective against all 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 on damage, not on eggs or early instar larvae.**

Crop Management

Two major types of cotton production are practiced in the Lower Rio Grande Valley:

Short-season Production

This production system relies chiefly on cultural techniques including proper varietal selection, early, uniform planting and efficiency of fertilization and irrigation. These practices shorten the production season and the time that cotton is vulnerable to insect attack. By permitting an earlier harvest this system also greatly reduces the time of vulnerability to damage by adverse, preharvest weather. Short-season cotton varieties usually require 130 to 140 days from planting to harvest if grown under optimal nitrogen and water conditions. These varieties fruit and mature more rapidly than traditional full-season varieties. Thorough postharvest stalk destruction also should be practiced to reduce overwintering boll weevil populations.

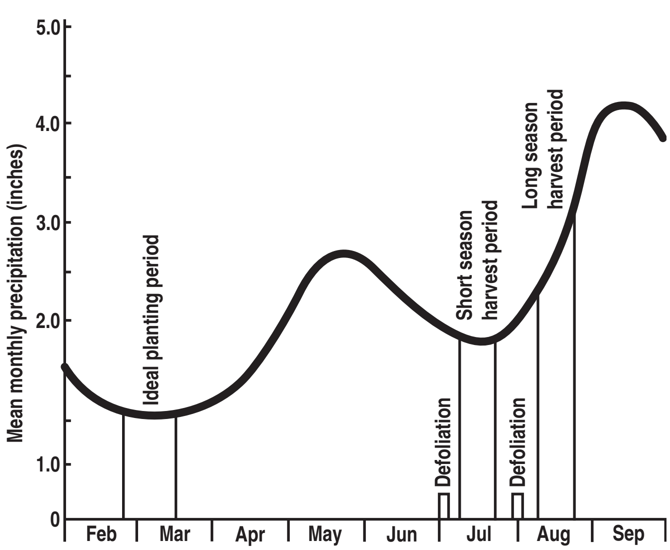
The first 30 days of blooming are critical for an optimum, early boll set. The earliness factor in short-season production can be completely lost where damaging populations of insects occur as the first squares are formed. Heavy loss of early squares to overwintered boll weevils also may detract from short-season production. The boll weevil and the bollworm/tobacco budworm complex should be controlled with insecticides when they occur in damaging numbers. Because of the early maturity and quick fruiting of short-season cotton, field scouting should be intensified to determine pest population levels and damage as well as beneficial insect abundance. Plant growth and fruiting rates also should be monitored to allow early detection of potential problems.

Full-season Production

The full-season production system has been practiced in the Lower Rio Grande Valley for many years. This system uses slower fruiting, indeterminate, full-season varieties grown with higher nitrogen inputs (greater than 30 pounds per acre) and abundant irrigation. The result is a long-season production period of 140 to 160 days from planting to harvest. This system requires higher inputs and has proven to be a profitable method of cotton production in past years. However, production costs have increased greatly in recent years in the Lower Rio Grande Valley. Increasing nitrogen fertilizer and amounts of irrigation water adds extra expense, prolongs the fruit development and delays maturation. These factors expose the cotton to high populations of late-season pests such as the boll weevil, bollworm, tobacco budworm and whiteflies. A major production cost is the multiple applications of insecticides to protect the crop throughout the longer fruiting period. Consequently, high yields must be obtained to offset these high production costs. The probability of crop loss from delayed harvest because of adverse fall weather conditions is greater under this production system.

Full-season cotton varieties can be grown under a short-season production regime where soil types and rainfall allow. Early planting in combination with reduced nitrogen (30 pounds or less) and water levels, where applicable, result in a somewhat shorter production period. Nitrogen required for cotton production depends on the previous crop planted, nitrogen recycling, fall precipitation and soil types.

Figure 1. Mean monthly precipitation for the Lower Rio Grande Valley showing the short-season harvest period and the long-season harvest period (N. L. Namken and M. D. Heilman, USDA, Weslaco, TX).



Monitoring Cotton Growth and Fruiting Rate

After moisture, the most important factor in development of squares and bolls is temperature. Researchers have devised a way to describe and measure the relationship between cotton development and temperature — the heat unit concept or DD60 (degree days using 60 degrees F). Heat units measure the amount of useful heat energy a cotton plant accumulates each day, each month, and for the season (see Table 1).

Several systems have been developed to calcuate heat units, but the most universal approach is to use the formula ((Degrees F Maximum + Degrees F Minimum) ÷ 2) - 60.

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

Table 1. Growth and fruiting rate of the cotton plant.

Development period	Calendar days		Accumulated heat units from planting*	
	Avg.	Range	Avg.	Range
Planting to emergence	7	5 to 10	109	59 to 159
Emergence of:				
first true leaf	8	7 to 9	166	127 to 205
sixth true leaf	25	23 to 27	463	321 to 608
pinhead square	29	27 to 30	517	378 to 663
1/3-grown square	43	35 to 48	752	508 to 996
Square initiation to:				
bloom	23	20 to 25	924	719 to 1129
Bloom to:				
peak bloom	18	14 to 21	1280	977 to 1582
full-grown boll	23	20 to 25	1383	1091 to 1674
open boll	47	40 to 55	1939	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			

*Calculated by the formula:

$$DD\text{-}60 = \frac{\text{High daily temperature + low daily temperature}}{2} - 60$$

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=150/2=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.

Table 2. Cotton yield estimate chart (bales lint per acre).

Bolls per 10 feet of row	Row spacing in inches 10	20	30	38	40
20	0.58-0.75	0.30-0.38			
30	0.87-1.1	0.44-0.56			
40	1.2 -1.5	0.58-0.75	0.39-0.50	0.31-0.39	0.31-0.40
50	1.4 -1.9	0.72-0.93	0.46-0.60	0.36-0.60	0.36-0.47
60	1.7 -2.2	0.88-1.1	0.59-0.75	0.47-0.59	0.47-0.56
70	2.0 -2.6	1.0 -1.3	0.68-0.87	0.53-0.69	0.51-0.65
80		1.2 -1.5	0.77-1.0	0.61-0.79	0.58-0.75
90		1.3 -1.7	0.87-1.1	0.68-0.88	0.65-0.84
100		1.4 -1.9	0.97-1.2	0.76-0.98	0.72-0.93
110		1.6 -2.0	1.1 -1.4	0.84-1.1	0.80-1.0
120		1.8 -2.3	1.2 -1.5	0.92-1.2	0.88-1.1
140			1.4 -1.7	1.1 -1.4	1.0 -1.3
160			1.5 -2.0	1.2 -1.6	1.2 -1.6
180				1.4 -1.8	1.4 -1.7
200				1.5 -2.0	1.5 -1.9

Prepared by Travis Miller, Extension agronomist, and Jesse Cocke, Jr., retired Extension entomologist.

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, growers can determine the insecticide applications for the season by calculating the daily heat units (DD60s) from cutout. The termination of insecticide applications depends on the insect pest and the number of DD60s that have accumulated.

Fields that have accumulated 325 DD60s are safe from plant bugs (*Lygus* and *Creontiades* species); fields accumulating 350 DD60s are safe from boll weevils and first and second instar bollworm/tobacco budworm larvae; and fields accumulating 475 DD60s are safe from stink bugs.

Early fruiting is desirable and facilitates early crop maturity. Frequent monitoring gives a good indication of crop set. Often, problem fields can be detected early if growth and fruiting habits are accurately monitored. The cause of a problem may not be immediately evident; however, early detection of problems is critical to minimizing losses.

Growers who make frequent boll counts can base their pest management decisions on realistic projected yield estimates in relation to dollar inputs. To make cotton square and/or boll counts, mark a 10-foot segment of row, count the squares and/or bolls in that distance and use Table 2 to calculate the estimated yield per acre.

Generally, 140,000 to 180,000 bolls per acre on a field count were required to produce a one-bale yield of cotton lint based on a 27-variety average in 1979. The two figures in the yield estimate represent varieties with small and large boll sizes. Several boll counts taken at random in a field will give a more accurate estimate of boll set and yield potential than one count alone.

Early Stalk Destruction and Field Clean-up

Early harvest and stalk destruction are among the most effective cultural and mechanical practices for managing overwintering boll weevils if done on an areawide basis. These practices reduce habitat and food available to the boll weevil, pink bollworm, bollworm and tobacco budworm. Shred cotton stalks after harvesing at the earliest possible date and do not allow stubble regrowth or volunteer seedlings to remain within fields or surrounding 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. It is illegal to leave cotton in fields during the fall and winter months in the Rio Grande Valley and some counties to the north. This cotton provides the boll weevil with a host plant on which reproduction occurs throughout the year. Boll weevil infestations which are allowed to develop during the winter may be extremely difficult to control during the following season. If a thorough stalk destruction program is not carried out, the benefits of the pest management program can be reduced significantly.

2, 4-D amine applied at 1 pound 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 required 10 to 14 days later to achieve total stalk destruction. For more information see the publication SCS-2003-10 "Cotton Stalk Destruction with Herbicides" at *http://lubbock.tamu.edu/cottoncd/*, under the Eastern Region.

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 in their area they should call the local Texas Boll Weevil Eradication Foundation office or contact the Foundation at 325-672-2800.

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 manipulation 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 cotton acreage in 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 foundation 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 threshold" or treatment level. 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 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 with the use of standardized, repeatable sampling techniques. Scouting also should 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 in making decisions regarding the need to apply an insecticide for these pests. Also, monitoring densities of predator 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 predators 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 studies have shown that 34 beat bucket samples (3 plants per sample or 102 plants/field) will most often accurately estimate densities of pirate bugs and spiders, which are key predators of bollworms, tobacco budworms and other caterpillar pests (Table 3). Samples should be taken from three or more locations across the field to obtain a more realistic predator density estimate for the entire area. 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 boom and again 2-3 weeks later, can provide information for using predator densities in mid- and late-season pest management decisions for caterpillar pests.

Refer to E-357, "Guide to the Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton" (see p. 15 to order) for information on identifying common predatory insects and spiders in cotton.

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 normally would occur throughout the cotton production season.

Table 3. 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.

	3-plant sample unit		5-plant sample unit	
Key predator group	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

Early-season Pests

Early-season is the first few weeks of the season from plant emergence to first 1/3-grown square (see drawing below). Major early-season pests include overwintered boll weevils, fleahoppers and sometimes sweetpotato whiteflies.

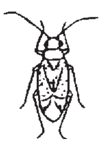
Cotton Square Diameter

1/16-inch	3/16-inch	1/4-inch
Pinhead	Matchhead	1/3-grown

Scouting and management of early-season insect pests are extremely important, particularly in a short-season production system. Loss of early squares may prolong the length of the growing season required to obtain adequate fruit set.

Silverleaf Whitefly

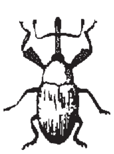
Refer to the discussion under Mid-season and Late-season pests.



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 host weeds when cotton begins to square. Both adults and nymphs suck sap from the tender portions of the plant, including small squares. Squares are susceptible to damage from the pinhead size through the 1/3-grown stage.

Management and decision making. After cotton begins producing the first small squares (4- to 6-leaf stage), examine the main stem terminal buds (about 3 to 4 inches of plant top) of 25 randomly selected plants at each of four or more locations across the field. **During the first 3 weeks of squaring, 15 to 25 cotton fleahoppers (nymphs and adults) per 100 terminals may cause economic damage.** As plants increase in size and fruit load, larger populations of fleahoppers may be tolerated without economic yield reduction. Care should be taken not to apply insecticides early in the blooming period as this will result in destruction of beneficial insects, possibly inducing an outbreak of bollworm and tobacco budworm.



Overwintered Boll Weevil

The adult boll 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 boll 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 a significant weevil infestation than cotton planted later in the season or fields farther away from good overwintering habitat.

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 Foundation at 325-672-2800.

However, producers should still follow good management practices to aid boll weevil eradication. In addition, producers can help with eradication by doing the following:

- Avoid planting cotton in small fields that are difficult to treat (e.g., 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 boll weevil-punctured squares.

Mid-season and Late-season Pests

Mid-season is the 6-week fruiting period following the appearance of the first 1/3-grown squares. Proper crop management and frequent field inspection of 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.

Silverleaf Whitefly

Silverleaf whitefly (SLWF), *Bemisia argentifolii*, formerly known as sweetpotato whitefly, has been a pest of cotton in the Lower Rio Grande Valley since 1990. Its life cycle begins as a yellow-orange, cigar-shaped egg laid on end in groups or clusters usually on the undersides of leaves. A small, nearly clear crawler stage emerges from the egg, finds a suitable place on the leaf, and inserts its proboscis into the tissue and begins to feed. The scale-like immatures continue to feed, molt and grow as immobile insects until they emerge as adults. The entire life cycle of SLWF lasts from 12 to 30 days, or longer, depending on temperature. On cotton, in the heat of the summer, SLWF can complete its life cycle in about 2 weeks. Because of its short life cycle and a high reproductive rate, SLWF can build large populations over a relatively short period.

Whiteflies are sucking insects, and their damage ranges from stunting, reduced growth and reduced plant vigor during the early-season to reduced plant vigor, honeydew deposits on open cotton lint (sticky cotton), and premature defoliation during the mid- and late-seasons. Honeydew attracts black sooty molds that stain lint and reduces quality. Experience in the Lower Rio Grande Valley has shown that in the heaviest infestations, yield reductions can be severe with losses of more than 500 pounds of lint per acre. Viral disease transmitted to cotton by SLWF has been a severe problem in some countries, but has not been a problem in Texas.

Management and decision making. Sampling for SLWF is generally conducted by examining the underside of the third leaf from the top of the plant and counting adults, and/or counting immatures on the underside of the fifth leaf from the top. **Currently, thresholds for whitefly treatment in cotton are not set. However, adult SLWF populations that have been observed to cause damage have ranged from 5 to 15 adults per leaf. Immature populations of 1 per square inch maintained for at least 6 weeks have been shown to cause yield losses of approximately 20 pounds per acre.**

Cultural controls have provided one of the best approaches to SLWF management in the Lower Rio Grande Valley and form the foundation for effective integrated management of this pest. Management of SLWF in cotton actually starts with winter and spring vegetables and planting of the cotton. Winter and spring vegetables provide the largest source of SLWF populations infesting cotton. Management of the pest on these crops and separation of cotton from these source populations play key roles in reducing potential problems in cotton. Timely destruction of vegetable crop residue that harbors active SLWF populations is one of the simplest methods of lowering poten-tial levels of SLWF infestations in nearby cotton fields.

Host plant resistance is another key element of managing SLWF in cotton. In general, smooth-leafed varieties have far fewer whiteflies than hairy-leafed cotton varieties. Yield data from tests conducted in the Lower Rio Grande Valley show that higher yields can be achieved if smooth-leafed varieties are grown when SLWF are a threat to the crop.

Several species of naturally occurring parasites and predators will attack SLWF and can aid in the management of infestations. However, these beneficials must be preserved to have maximum impact on SLWF populations. Applications of broad spectrum insecticides decrease the role of beneficial insects in managing SLWF. The impact of beneficials also can be easily overwhelmed by the presence of a large source population nearby.

Tests conducted in the Lower Rio Grande Valley during the last several years have shown that insecticidal control of SLWF populations is achievable, but is most efficacious and cost effective when used as part of an integrated management program. Insecticides alone have been found to be ineffective, or cost prohibitive, when populations are large and other management strategies are not being employed. Insecticidal control is not an effective stand alone strategy for management of this pest.

Boll Weevil

Adult boll weevils puncture squares or bolls for feeding and egg laying. Egg-laying punctures can be distinguished from feeding punctures by the presence of a wart-like 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 (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. Recently emerged adults feed on squares or bolls for 4 to 8 days before laying eggs. 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 in about 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 boll 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 are 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. 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 Foundation at 325-672-2800.

Bollworm and Tobacco Budworm

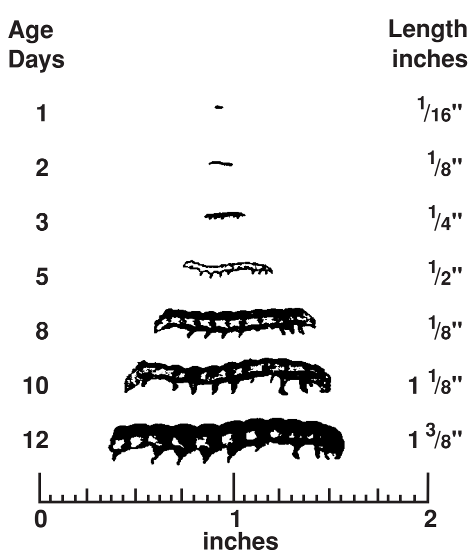
Bollworm and tobacco budworm larvae are similar in appearance and cause similar damage. Full grown larvae are about 1 1/2 inches long and vary in color from pale green to pink or brownish to black, with longitudinal stripes along the back.

Tobacco budworm and bollworm moths are attracted to and lay eggs in cotton that is producing an abundance of new growth. Moths usually lay eggs singly on the top of young, tender terminal leaves in the upper third of the plant. Eggs are pearly white to cream colored 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, on lower portions of the plant. This may occur when cotton plants are stressed and have little new growth or during periods of high temperatures and low humidity. Detection and control of eggs and small worms are more difficult when eggs are deposited in these locations.

Tobacco budworms are less susceptible to certain insecticides than bollworms, but are less numerous than bollworms until mid-July. Once applications of certain insecticides are used to control bollworms and tobacco budworms, the percentage of tobacco budworms in the population increases with each additional application due to selection pressure. Aphid and other secondary pest infestations may increase following bollworm/tobacco budworm sprays, especially when pyrethroids are used.

Figure 2. Actual size of bollworm larvae of known age (reared 85° F).



Management and decision making. A major objective of a well-planned IPM program is to avoid having to treat for bollworm and tobacco budworm. Naturally occurring parasites, predators and, to a certain extent, weather conditions often suppress bollworm and tobacco budworm populations.

Examine 100 green squares for worms and worm damage, and 100 plant terminals for eggs and small worms. Examine a few plants in each field for eggs, worms and worm damage on lower leaves, stems and fruiting forms.

Prior to initial chemical application. Fields should be scouted at least once a week. Fields should be divided into four quadrants and 25 green squares (1/2-grown or larger) should be selected at random in each quadrant. If fields are larger than 100 acres, additional scouting sites should be added to the sample.

Before bloom the economic threshold is reached when larvae (worms) are present and 30 percent of the green squares are damaged by the larvae (worms).

After bolls are present, the economic threshold has been reached when 10 small larvae (less than 5 days old) are present and 10 percent of the green squares have been damaged by larvae.

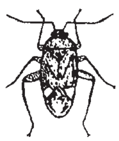
After initiation of insecticide applications. The fields should be checked closely 2 to 3 days following the first application. **The economic level has been reached when bollworm eggs and 10 small larvae (less than 5 days old) are found per 100 plants (5,000 larvae per acre) and 5 percent of the squares and small bolls have been injured by small bollworms or tobacco budworms.** If control has not been obtained, another application will be necessary immediately.

Bt transgenic cotton management. Research trials have determined the Bollgard® transgenic Bt gene technology 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 most effective against tobacco budworm and bollworm; but, 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. **Treatment with foliar insecticides for bollworm should be considered when 10 larvae *larger than* 1/4 inch per 100 plants (5,000 larvae per acre) are present and 5 percent of the squares or bolls are damaged by larvae.**

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.



Plant Bugs (*Creontiades signatus*)

Plant bugs, a general term for insects in the family Miridae, feed on cotton terminals, squares and small bolls. *Creontiades signatus* (Distant) is a plant bug that has become more common in the lower Rio Grande Valley. 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. **A tentative threshold when mostly squares and small bolls are present is when plant bug counts exceed 15 to 25 bugs per 100 sweeps in fields where plants failed to retain squares and set bolls. This occurs normally during the first 4 to 5 weeks of fruiting. Where the last bolls expected to be harvested exceed 10 days old, further protection against this insect is unnecessary. This threshold may change in the future as more is learned about the biology of this insect.**

Occasional Pests

Aphids

Two species of aphids, or plant lice, feed on cotton plants: the cotton aphid and the black cowpea aphid. Cowpea aphids are shiny black with white patches on the legs and are common on seedling plants. Cotton aphids range in color from light yellow to dark green to almost black. The immature or nymphal stage looks like the adult stage, only smaller. Most adults do not have wings. 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 younger leaves to curl downward, older leaves to turn yellow and shed, squares and small bolls to shed, and bolls to open pre-maturely, resulting in incomplete fiber development.

Honeydew excreted by the aphids can drop on fibers of open bolls. A black, sooty fungus sometimes develops on honeydew deposits during wet periods. Fiber from such bolls is stained, sticky, of lower quality and difficult to harvest and process at the mill.

Natural control by unfavorable weather, predators, parasites and pathogens can be effective in holding populations below damaging levels. In other situations, aphid numbers increase to moderate or heavy levels and then decline for no apparent reason.

Management and decision making. Although large 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 actual infestation levels. **Insecticidal control of cotton aphids should be delayed until infestations exceed 50 aphids per leaf**.

Beet Armyworm

Beet armyworm eggs are laid on both leaf surfaces in masses covered by a whitish, velvety material. Young beet 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 plant terminal, causing extensive lateral branch development and delayed maturity. Small larvae are gregarious and skeletonize leaves rather than chewing large holes in them. As they grow, they become solitary and may eat large irregular holes in the leaves. Sometimes damaging infestations will develop late in the season when they also feed on terminals, squares, blooms and bolls. Several factors can contribute to these late-season beet armyworm outbreaks including: mild winters (no prolonged freezing temperatures); late planting; delayed crop maturity; heavy early-season organophosphate or pyrethroid insecticide use; prolonged hot, dry weather; presence of beet armyworms prior to bloom; and weather conditions that support long-distance migration. Additional characteristics of high risk fields 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 beet armyworm populations are high, all fields are susceptible. When beet armyworms begin to damage fruit, control may be justified. Infestations may be spotty within a field and careful scouting is necessary to determine the need for, and field area requiring, control. Beet armyworms larger than 1/2 inch in length may be difficult to control.

Management and decision making. Scout the field using the Whole Plant Inspection Mehod described in the bollworm and tobacco budworm section. **When infestations are mainly leaf feeding and small larvae (worm) counts exceed 20,000 larvae per acre (16 to 24 larvae per 100 plants) and at least 10 percent of the plants examined are infested, control may be warranted. If beet armyworm larvae have shifted from feeding on foliage to feeding on squares, blooms and bolls, thresholds should be lowered toward the bollworm threshold (4,000 to 8,000 larvae per acre or 8 to 12 larvae larger than 1/4 inch per 100 plants). When cotton maures and square feeding is of no consequence, thresholds should be raised to 20,000 small larvae per acre.**

Cabbage Looper

Cabbage looper eggs are laid singly, mainly on the lower surfaces of the leaves. Their feeding damage is characterized by leaf ragging or large holes in the leaves. Looper larvae often are killed by disease before economic foliage loss occurs.

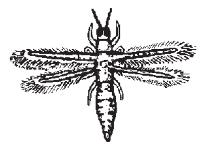
Management and decision making. No economic threshold has been established for this pest. Insecticide treatments generally are not recommended.

Cutworms

Cutworms may damage cotton during the seedling stage, and control will be necessary if stands are threatened. The economic threshold is a matter of judgment. Keep fields as weed-free as possible 3 weeks before planting to minimize cutworm problems. Destroy (with tillage or herbicides) cover crops at least 3 weeks before planting. Band application 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.

Saltmarsh Caterpillar

Saltmarsh caterpillars may attack cotton plants from the seedling stage to the fully mature crop stage. Generally, the larval stages will migrate into a cotton field from surrounding vegetation such as wild sunflowers. Some adults may emerge from within the cotton field and lay eggs in large (1 to 2 inches in diameter) clusters of cream colored masses on individual leaves. The young caterpillars will disperse from their places of hatching and spread out across the field. Some individual fields may be severely defoliated. But usually only margins of fields are attacked and little economic damage is done. Spraying for large infestations of saltmarsh caterpillars is best conducted only when the larvae are very small and more easily controlled. Once larvae reach the 1- to 2-inch stage, they are much more difficult to control. No established thresholds exist for saltmarsh caterpillars. Producers should use their best judgment about the extent of actual crop damage when determining if control is necessary.



Thrips

Thrips are a minor pest in the Lower Rio Grande Valley and rarely require treatment. Most thrips problems occur in cotton fields located in close proximity to onion fields when onion thrips migrate from maturing onion fields to cotton. Under cool, wet conditions heavy infestations might delay fruiting and maturing because of slowed plant growth and increased thrips damage. Generally, about the time thrips reach damaging numbers, favorable growing conditions negate the need for control. Inspect cotton from the cotyledons to the 4-leaf stage. If thrips are present and leaf buds are curled, spray treatment may be justified.

Thrips also can be controlled by applying systemics as planter box treatments, as granules in the seed furrow or as insecticide seed treatments. Phorate (Thimet®), imidacloprid (Gaucho® Grande) and thiamenthoxam (Cruiser®) seed treatments may effectively control thrips for 2 to 5 weeks following plant emergence. Phorate and aldicarb (Temik®) granules applied in the seed furrow will control these pests for 2 to 5 weeks following planting; however, at the higher labeled rates they sometimes result in greater numbers of bollworms and tobacco budworms later in the season.

Spider Mites

Spider mites infest the undersides of leaves; 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 limited areas of fields and in field margins. Increases in spider mite populations usually follow multiple applications of insecticides for other pests, since these insecticides destroy naturally occurring spider mite predators. Mites also may be moved by high winds or equipment from nearby crops which already have heavy infestations.

Management and decision making. Treat when mites begin to cause noticeable leaf damage. Spot treatment of fields is encouraged when infestations are restricted to small areas. 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.

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 1.5 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 1.5 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 that 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.

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 damage crops. 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.

The threshold used is based on observations in Texas and other states. No threshold work has been conducted in Texas because of the sporadic infestations experienced. Based on these observations and other states' experiences, before first bloom, insecticide application may be justified when 30 percent of the green squares are worm damaged. Once bolls are present, an insecticide application may be justified when 15 to 25 or more small larvae are present per 100 plant terminals and 10 to 15 percent of the squares or bolls are worm damaged. If worm numbers are high, it may not be appropriate to wait until the damage threshold of 10 to 15 percent square damage is reached.

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 following formula:

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

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:

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

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

Treatment may be justified when counts average 10,000 to 20,000 small worms or more per acre. A range of treatment thresholds is provided under the percent and worms per acre methods because many factors in addition to density of larvae determine the need to treat with insecticides for fall armyworms. One of these factors is the number of predatory insects and spiders, which feed on fall armyworm eggs and small larvae. If previous insecticide treatments have eliminated these beneficial insects, then a lower treatment threshold should be considered. The number of fall armyworm 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 versus 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 have little effect against fall armyworms. However, Bollgard® II and WideStrike® are effective against fall armyworms.

Ovicides

These insecticides are effective at reducing 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, spiders and parasitic wasps. Natural egg control can vary greatly between fields and with time of the season. Often, high numbers of sterile eggs are found late in the growing season. These eggs fail to hatch and no larvae 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 of up to 12 per 100 plants (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 3/8-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. Good coverage is essential.

Table 4. Registered *Bacillus thuringiensis* products and labeled rates for controlling bollworm and tobacco budworm.

Product	Rate per acre (formulated material)
Dipel DF	0.5-2.0 lb
Dipel ES	1.0-6.0 pt
Javelin WG	0.5-1.5 lb

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 yield and fiber length of cotton is unclear. The importance of insect pollinators in the production of hybrid cottons is well recognized, however.

Where pollinating insects are required for flower fertilization, the crop producer, insecticide applicator and beekeeper should cooperate closely to minimize bee losses. The following guidelines will reduce 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 catagorized as "moderately toxic" or "relatively non-toxic" should be applied in late evening or early morning when bees are not foaging.
3. To prevent heavy losses of bees, don't spray any insecticide directly on colonies and avoid insecticide 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. Our 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 Cooperative Extension 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, (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 requirement 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*

Number	Title
B-933	Identification, Biology and Sampling of Cotton Insects
E-5	Managing Cotton Insects in the Southern, Eastern and Blackland Areas of Texas-2007
E-5A	Suggested Insecticides for Managing Cotton Insects in the Southern, Eastern and Blackland Areas of Texas-2007
E-6	Managing Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas-2007
E-6A	Suggested Insecticides for Managing Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas-2007
E-7A	Suggested Insecticides for Managing Cotton Insects in the Lower Rio Grande Valley-2007
L-5142	The Proper Use of Cotton Harvest-Aid Chemicals
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/*

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

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