Texas A&M AgriLife Extension

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Managing COTTON INSECTS in Texas

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Suhas S. Vyavhare
Assistant Professor and Extension Specialist
Texas A&M AgriLife Extension Service, Lubbock

David Kerns
Professor, IPM Coordinator and Extension Specialist
Texas A&M AgriLife Extension Service, College Station

Charles Allen
Professor, Associate Department Head and Extension Specialist
Texas A&M AgriLife Extension Service, San Angelo

Robert Bowling
Assistant Professor and Extension Specialist
Texas A&M AgriLife Extension Service, Corpus Christi

Mike Brewer
Associate Professor
Texas A&M AgriLife Research, Corpus Christi

Megha Parajulee
Professor, Faculty Fellow, and Regents Fellow
Texas A&M AgriLife Research, Lubbock

The Texas A&M University System

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The objectives of this publication are to 1) describe economic arthropod pests of cotton in Texas, including their associated damage to crop growth stages, 2) describe the various sampling methods for these pests, and 3) list the management tools for each pest regarding action thresholds.

Use the control recommendations in this publication as a guide. Every cotton field differs in terms of soil, microclimate, surrounding cropping patterns, and farmer input. The adage "one size fits all" does not apply to cotton pest management. The information given here will help stakeholders manage cotton insect pest problems for maximum profits with minimal inputs, and preserve and improve the cotton agroecosystem.

Contents

Texas ranks first in cotton production in the United States, using about half of the country's cotton acres to produce half of the total crop. Cotton is the leading cash crop in the state and is grown on about 5 million acres annually (Fig. 1).

Cotton production in Texas occurs in the following regions: the Panhandle, South Plains, Permian Basin, Trans-Pecos, Rolling Plains, Blackland Prairies, Winter Garden, Coastal Bend, and Lower Rio Grande Valley (Fig. 2). The South Plains is the largest cotton-producing area with acreage exceeding 3 million in some years. Approaches to cotton production vary from one region to another because of differences in climate, harvest techniques, irrigation requirements, pest pressure, soil types, and variety selection.

For each region, a unique group of insect pests damages cotton, making the crop vulnerable to attack throughout the crop season. Therefore, frequent and careful scouting for insect pests and beneficial insects is critical for successful cotton production.

Figure 1. Cotton plant.

Pest Management Principles

The term Integrated Pest Management (IPM), a philosophy used in designing disease, insect, mite, and weed pest control programs, helps avoid economic losses from pests, optimize production and environmental sustainability, and minimize risks to human health. Systems based on IPM principles encourage the intelligent integration of compatible and ecologically sound combinations of pest suppression tactics, including:

- Cultural control such as manipulating planting dates and stalk destruction, variety selection, fertilization, and irrigation timing
- Biological control such as conservation of existing natural enemies
- Host plant resistance
- Field scouting as the basis for treatment decisions to keep pest populations below economically damaging levels

Major factors to consider when using insecticides include:

- Efficacy of product
- Protection of natural enemies of cotton pests
- Possible resurgence of primary and secondary pests after applications
- Development of insecticide resistance in pest populations

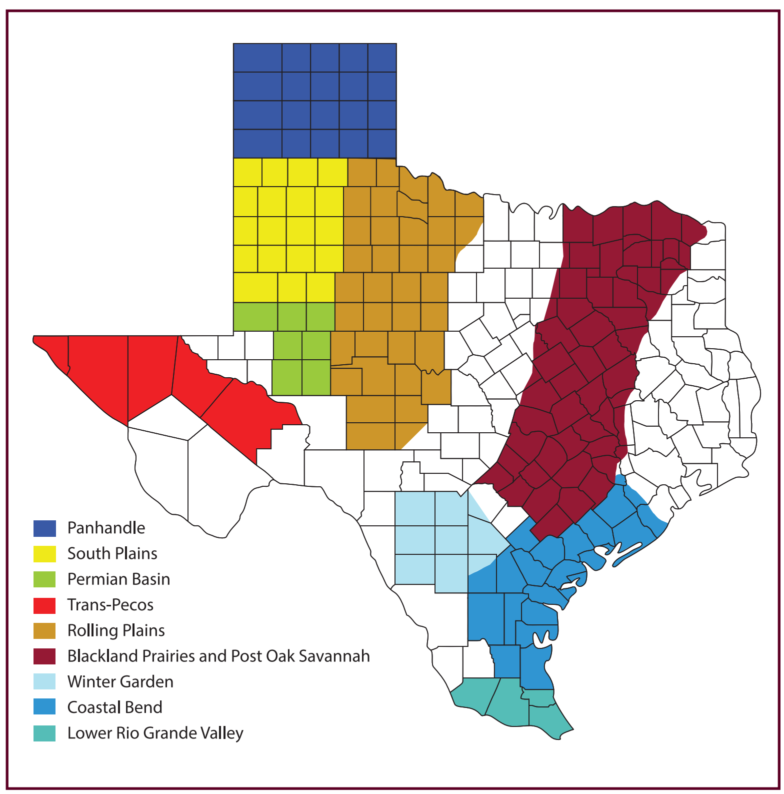

Figure 2. Major cotton growing regions in Texas.

Using multiple pest suppression tactics allows growers to control pests at a low cost, preserve natural enemies, and slow the development of pest resistance to insecticides and insect control traits. Applying insecticides at the proper rates and only when necessary, as determined by frequent field inspections and economic thresholds, helps prevent economic losses that pests can cause.

The integrated pest management concept assumes that pests will be present to some degree and, at low levels, do not cause significant economic losses. The first line of defense is to use effective agronomic practices and cultural methods to produce the crop in ways that are unfavorable for pest problems to develop. Use appropriate insecticides only when pest populations reach levels that cause crop damage and losses greater than the cost of the treatment. This potentially injurious population or plant damage level, determined through regular field scouting, is the economic or action threshold. In short, pest management strives to optimize rather than to maximize pest control efforts.

Recent developments have significantly impacted managing pests in cotton. The availability of transgenic, insect-resistant traits in cotton has reduced the incidence of damaging populations of caterpillar pests. Eradication programs have eliminated the boll weevil from all but far South Texas and the pink bollworm throughout Texas. And, neonicotinoid seed treatments have greatly decreased the pest status of thrips and other early-season cotton pests.

Because of these technological breakthroughs, the use of foliar insecticides in Texas cotton is down by two-thirds since 2000 and cotton yields have increased by 50 percent. Predictably, the lower threat level reduced growers' reliance on field scouting for insects and also affected the frequency that trained scouts have to conduct effective scouting programs at the field level.

Current insect-related threats to the cotton system are pest resistance to insecticides and transgenic technologies, and the potential introduction of invasive pests. Transgenic technologies and neonicotinoid seed treatments have recently become targets of environmental and food safety groups.

Insecticide Resistance Management

The Insecticide Resistance Action Committee (IRAC) defines insecticide resistance as an inherited change in the sensitivity a pest population has to an insecticide, "reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species" (see http:www.irac-online.org/about/resistance/). Reliance on insecticides that act the same way can cause pests to develop resistance to the entire class of insecticides. This phenomenon applies to transgenic traits as well.

To delay resistance, growers should use IPM principles and integrate other control tactics into their insect and mite control programs.

One strategy to avoid or delay resistance development in pest populations is to rotate insecticide groups to take advantage of different modes of action. Tank-mixing products from the same insecticide class is not recommended. The combination of insecticide rotations and tank mixtures with insecticides from different IRAC classes reduces the chance of selecting individual pests that are resistant to certain classes of insecticides. These practices may delay the development of resistance, provide better control of target pests, and enhance the long-term sustainability of cotton production systems.

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

IRAC has developed an insecticide mode of action classification system that provides an IRAC number on the insecticide label (see http://www.irac-online.org/). Insecticides with the same number have the same mode of action. This system makes it relatively easy for producers and consultants to determine different modes of action among the insecticides in order to rotate their treatment selection among the insecticide classes and slow the development of resistance in pests.

Resistance to transgenic traits slows when two or more effective traits are incorporated into a cotton variety. This strategy selects for individuals in an insect population that have resistance to more than one transgenic control element at the same time, which is very rare.

Biological Control

Weather, inadequate food sources, and natural enemies can hold insect and mite infestations below damaging levels. Biological control relies on parasites, pathogens, and predators to help control pests. Recognizing the impact of these natural control factors and, where possible, encouraging their action is a key IPM component.

Natural enemies in cotton include assassin bugs, big-eyed bugs, collops beetles, damsel bugs, ground beetles, lacewing larvae, lady beetles (or ladybugs), minute pirate bugs, spiders, syrphid fly larvae, and a variety of tiny wasps that parasitize the eggs, larvae, and pupae of many cotton pests. Avoiding the use of broad-spectrum insecticides until they are needed helps conserve existing populations of natural enemies and prevents the development of economically damaging pest infestations. Selecting insecticides that are more toxic to the target pests than they are to natural enemies minimizes the impact insecticides have on natural enemies.

Bt Transgenic Cotton

Bt cotton is genetically altered by inserting genes from a common soil bacterium, *Bacillus thuringiensis,* to make proteins that are toxic to specific groups of insects. For example, currently available Bt traits in cotton specifically target caterpillar pests such as beet armyworm, cotton bollworm, and tobacco budworm. Conventional or non-Bt cotton does not produce such insecticidal proteins and is more vulnerable to worm damage.

Since its introduction into US agriculture in 1996, Bt technology has developed from a single-gene trait to multi-gene trait packages. The first-generation Bt cotton (Bollgard) had a single Bt gene that produced (expressed) Cry1Ac. The second-generation Bt technologies, such as Bollgard II, TwinLink, and WideStrike, produce two Bt toxins. The most recent third-generation Bt technologies (WideStrike 3, Bollgard 3, and TwinLink Plus) are three-gene trait products.

Table 1. Bt technologies currently available in cotton

Bt technologies	Proteins expressed
Second generation	
Bollgard II	Cry1Ac + Cry2Ab
WideStrike	Cry1Ac + Cry1F
TwinLink	Cry1Ab + Cry2Ae
Third generation	
WideStrike 3	Cry1F + Cry1Ac + Vip3A
Bollgard 3	Cry1Ac + Cry2Ab + Vip3A
TwinLink Plus	Cry1Ab + Cry2Ae + Vip3Aa19

Cotton varieties with third-generation Bt technologies have excellent activity against cotton leaf perforators, loopers, pink bollworm, and tobacco budworm, and good activity against beet armyworm, cotton bollworm, fall armyworm, and saltmarsh caterpillar. Some situations may require supplemental insecticide treatment for bollworm and fall armyworm. Recommended economic thresholds used to trigger insecticide applications on Bt cotton are the same as those used for non-Bt cotton but should be based on larvae larger than ¼ inch.

Scouting

Regular field scouting is crucial to any pest management program because it is the only reliable way to determine whether pests have reached the economic threshold. More than just "checking bugs," scouting determines insect density and damage levels by using standardized, repeatable sampling techniques. It also monitors beneficial insect activity, diseases, fruiting, plant growth, and weeds as well as the effects of pest suppression practices.

Table 2. Relative efficacy of Bt traits against caterpillar pests

Pest	Bollgard (Cry1Ac)	Bollgard II (Cry1Ac + Cry2Ab)	Widestrike (Cry1Ac + Cry1F)	TwinLink (Cry1Ab + Cry2Ae)	Widestrike 3 (Cry1Ac + Cry1F + Vip3A)	Bollgard 3 (Cry1Ac + Cry2Ab + Vip3A)	TwinLink Plus (Cry1Ab + Cry2Ae + Vip3Aa19)
	1996	2003	2005	2013	2014	2017	2017
Bollworm	4	2.5	4	2.75	2.5	2*	2*
Tobacco budworm	1	1	1	1	1	1	1
Pink bollworm	1	1	1	1	1	1	1
Beet armyworm	2	2	2	2	1–2*	1–2*	1–2*
Fall armyworm	2.5	2	1	2	1	1–2*	1–2*
Soybean looper	1	1	1	1	1	1	1

1 = Complete control
2 = Rarely requires oversprays
3 = Sometimes requires oversprays
4 = Frequently requires oversprays
*Incomplete data

Growers or crop consultants should check fields at least once and preferably twice a week to determine what species are present, their density, and the amount of damage. Most pests can be monitored visually by thoroughly checking whole plants or plant terminals. However, some pests, such as plant bugs (for example, the verde plant bug), are more reliably sampled using a beat bucket, drop cloth, or sweep net (Figs. 3, 4, and 5).

Beat bucket sampling method

- Tilt a 2.5- or 5-gallon white or black plastic bucket toward the plants.
- Grasp the plant stems of two or three representative plants (depending on plant size) and bend them into the bucket.
- Vigorously shake the plants against the side of the inside of the bucket.
- Hit the outside of the bucket several times to knock the bugs to the bottom and quickly inspect the inside of the bucket to count pests.
- Count the adults first because they can fly from the bucket and may be missed during scouting.
- Keep a running total of the number of plants shaken and the adults and nymphs of the insect being monitored.
- Shake a minimum of 40 plants to get an estimate of the number of insects per plant.

Figure 3. Beat bucket sampling.

Drop cloth sampling method

- Use an off-white or black cloth specific to the row spacing (such as 36 × 42 inches on 40-inch rows).
- Staple a thin strip of wood, approximately 1-inch wide, to the short sides of the cloth.
- Select a random site in the field and spread the drop cloth on the ground in the row-middle from one row to the next.
- Vigorously shake the plants in 2.5 feet of row on both sides of the cloth.
- Count the insects that fall into the cloth, including any insects that fall at the base of the plants. This total gives the number of insects per 5 feet of row.
- Repeat the process in at least 16 locations in the field (sampling 60 feet of row).
- 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.

Figure 4. Drop cloth sampling.

Sweep net sampling

- Use a standard 15-inch canvas sweep net with a handle. One sample should consist of 50 sweeps across a single row of cotton. However, if you pick up too much plant material in 50 sweeps, reduce the sweeps to 25 or less.
- 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.
- Keep the net moving to prevent adults from flying out.
- After each set of sweeps, count all the insect stages in the net.
- Go through the sample slowly, counting insects, inspecting each leaf, and watching closely for adults flying from the net.

Figure 5. Sweep net sampling.

Sampling predatory insects

Knowing how many predatory insects and spiders are present helps make pest-management decisions, especially for aphids and caterpillar pests. Also, sampling can identify fields at risk of pest outbreaks due to a lack of predators.

The beat bucket method provides the most rapid and accurate estimate of the presence of predators. The sampling method is similar to the steps discussed above:

- Grasp the stem of a single plant near its base and, while holding the bucket at a 45-degree angle, 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, rapidly beat the plant against the side of the bucket 12 to 15 times for 3 to 4 seconds so that the predators get shaken from the plants and fall to the bottom of the bucket.
- Remove the plant, take one step, and sample a second plant. Take another step and sample a third plant down the row.
- After sampling the third plant, record the number of damsel bugs, lacewing larvae, lady beetles, pirate bugs, and spiders in the bottom of the bucket.
- Remove and examine leaves and bolls from the bucket to be sure to record all predators. Tap the bottom of the bucket, so predators that are playing dead begin to move and become apparent.

For an accurate estimate, take 34 beat bucket samples per field (3 plants per sample × 34 samples = 102 plants). Divide these samples into 3 to 4 locations per field. Since beat bucket sampling takes more time (about 45 minutes per field), sample when predator information is most useful for making pest management decisions. For example, sampling for predators once at first bloom and again 2 to 3 weeks later yields information for managing mid- and late-season caterpillar pests.

Early-Season Pests (Emergence to the first one-third-grown square–about 1/4 inch in diameter)

Thrips

The most common species of plant-feeding thrips in Texas cotton include flower thrips, onion thrips, and western flower thrips.

Thrips are slender, straw-colored insects about 1/15 inch long, with piercing-sucking mouthparts (Fig. 6). Adults are winged and capable of drifting long distances in the wind. They attack leaves, leaf buds, and very small squares, causing a silvering of the lower leaf surface, deformed or blackened leaves, and loss of the plant terminal (Fig. 7). 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 seedling cotton plants are growing slowly. Rain, blowing sand, wind, residual herbicide damage, and seedling diseases can worsen thrips damage.

Under favorable growing conditions, cotton can sometimes recover completely from early thrips damage. In areas in which seedling

Figure 6. Adult thrips.

Figure 7. Young cotton leaves damaged by thrips feeding.

emergence typically occurs under warm conditions, thrips are usually of minor concern.

Figure 8. Sampling for thrips.

Figure 9. Immature thrips.

Management and Decision Making

Insecticide seed treatments have become an industry standard. Seed treatments usually provide thrips control until the two-to-three-true-leaf stage. In areas with a history of frequent, heavy thrips infestations, consider using systemic insecticides in addition to treated seed. Foliar sprays are often applied too late to prevent damage, and research shows that applying foliar sprays after significant thrips damage occurs does not increase yields.

Growers who may need to use post-emergence sprays should:

- Scout fields twice a week as the cotton emerges.
- Begin inspections once the cotton reaches about 50 percent stand emergence.
- Randomly select 25 plants from four regions of the field and inspect them, looking for adult and immature thrips.
- Look carefully through the terminal growth, picking it apart with a pencil lead, toothpick, or another pointed object, uncurling all of the leaves (Fig. 8). Thrips often hide in tight locations, especially during rainy, windy conditions.
- Look at the tops and undersides of each leaf, paying particular attention to the area where the leaf veins intersect the central leaf vein.

Thrips can migrate in large numbers from adjacent weeds or crops, especially as small grains dry down, causing significant damage in just a few days. Pay attention to immature thrips (Fig. 9), because their populations can increase rapidly through in-field reproduction as seed treatments become ineffective. Thrips development, from egg to adult, takes from 2 to 3 weeks. Infestations at the cotyledon and one-leaf stage often reduce yield more than later infestations.

Chemical Control and Action Thresholds

Preventive in-furrow or seed treatments usually provide adequate thrips control until the second true-leaf stage. However, under adverse growing conditions, a foliar treatment may still be necessary. Base the decision to apply an insecticide on the number of thrips present and the stage of plant development. As plants add more leaves, the number of thrips per plant needed to justify an insecticide application increases. Treat fields from cotyledon to first true-leaf stage when one or more thrips per plant are present. Resistance to neonicotinoids has been confirmed in thrips species in other parts of the Cotton Belt, but, so far, not in Texas.

Table 3. 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.

Figure 10. Click beetle.

Figure 11. Adult darkling beetle.

Figure 12. False wireworm larva.

Figure 13. Wireworm stem girdling.

Wireworms

Wireworms (click beetle larvae) and false wireworms (darkling beetle larvae) are cotton pests in the Texas High Plains (Figs. 10 and 11).

The larvae of these species are very similar, and it is difficult to distinguish wireworms from false wireworms. They are hard-bodied, smooth-skinned, elongated, cylindrical, and up to 1¼ inches long. Creamy white to yellow or light brown, their heads are typically darker with small true legs clustered near the head and no abdominal prolegs (Fig. 12). They move by slowly pulling themselves with their legs while dragging their bodies. Wireworm larvae are soil-dwellers, and you will not see them unless you remove them from the soil. They feed on decaying vegetation, roots, seeds, and other subsurface plant parts.

Wireworm attacks on cotton (including wireworms and false wireworms) tend to be most severe following grain crops (especially sorghum), in fallow or weedy ground, or in reduced-tillage systems. Overwintering larvae inflict the most damage as they become active in the spring. However, darkling beetle adults have been known to girdle or clip seedling cotton off at the soil surface much like a cutworm (Fig. 13).

Figure 14. Christmas-tree-like growth from subsurface wireworm feeding on the plant terminal.

The larvae damage cotton by feeding on the root, hypocotyl, and cotyledon of plants before the plants emerge from the soil. Root feeding can kill plants but usually results in stunting. The most severe damage occurs when the hypocotyl is severed, killing the plant and reducing the stand. Larvae also feed on the growing point of the plant, causing a loss of apical dominance. These plants often have a Christmas tree appearance after they emerge (Fig. 14).

Figure 15. Stand loss due to wireworms.

Figure 16. Cotton fleahopper adult.

Figure 17. Cotton fleahopper nymph.

Figure 18. Cotton fleahopper nymph.

Figure 19. Blasted square.

Management and Decision Making

In the spring, growers, scouts, and consultants should look for darkling beetles and their damage from planting to the four- to five-leaf stage. Darkling beetle adults can enter cotton fields from corn, pastures, sorghum stubble, or weedy areas. These beetles are a threat only if they cut off the seedling plants, reducing the stand (Fig. 15).

Chemical Control and Action Thresholds

Minimize wireworm infestations through clean cultivation and clean fallowing. Infestations are most severe in no-tillage or reduced-tillage situations, particularly following alfalfa, cover crops, or grain. Planting shallow and under warm conditions often allows cotton seeds to germinate quickly so plants can outgrow wireworm injury potential rapidly.

Treat wireworm larvae preventively. Insecticidal seed treatments are the most effective way to prevent wireworm damage. Treat for darkling beetle adults only when they are present in large numbers, plant clipping is evident, and unacceptable stand reduction is probable.

Cotton Fleahoppers

The cotton fleahopper adult is about 1/8 inch long, with piercing-sucking mouthparts and a flattened body (Fig. 16). Adults are active flyers; they readily flit within the cotton canopy when disturbed, which makes insect sampling a challenge. Their eggs are not visible because the adult inserts them into the cotton plant stem.

Adults are pale green to gray-green; nymphs are lighter-colored with reddish eyes (Figs. 17 and 18). Nymphs are very small and often confused with other plant bugs such as the verde plant bug and lygus bugs. Small black dots on the hind tibiae (fourth segment of the leg) distinguish late instar cotton fleahopper nymphs from other common plant bug nymphs.

In both the adult and nymphal stages, cotton fleahoppers suck sap from the tender portions of the cotton plant, including small squares. Pinhead size and smaller squares are the most susceptible to cotton fleahopper damage. Fleahopper feeding causes squares to die and turn dark brown. These "blasted" squares dry up and fall from the plant, leaving a characteristic scar on the fruiting site (Fig. 19).

When fleahoppers are abundant, heavy square loss can cause poor boll set and reduce yield. The first 3 weeks of squaring are the most sensitive to cotton fleahopper feeding, particularly in dryland cotton production.

The yield-cotton fleahopper relationship shifts with plant stage, water stress, weather, and cultivar sensitivity. Early squares are at high risk when large populations migrate into cotton from healthy stands of wild hosts that survived mild winter conditions. Yield reduction and development delays tend to be more pronounced in water-stressed cotton. Cotton fleahoppers can be more plentiful in vigorously growing cotton under good rainfall and irrigation, but their damage is less severe.

Scouting and Decision Making

There are two recommended scouting methods for cotton fleahoppers: terminal inspection (Fig. 20) and beat bucket sampling (Fig. 3). Table 4 provides action thresholds for terminal inspection, and action thresholds for beat bucket sampling are in development.

For terminal inspection:

- As the first squares appear (approximately four- to six-leaf stage), examine the main stem terminal (about 3 to 4 inches of the plant top) of 25 plants in at least four locations across the field. Sample more sites in fields larger than 80 acres.
- Scout fields for cotton fleahoppers weekly. Cotton fleahoppers move into cotton in early summer as noncrop host plants mature and become dry. Under wet spring conditions conducive to the rapid buildup of cotton fleahoppers in alternate hosts (such as cutleaf evening primrose, horsemint, silverleaf nightshade, and woolly croton), shorten the scouting intervals to every 3 to 4 days, especially as the alternate host plants begin maturing or undergo drought stress.
- When approaching a plant to sample, watch for adults that might fly from it. Cotton fleahoppers move quickly. Adults may fly away and immatures often hide within the plant canopy when disturbed.

Terminal inspection is applicable to all cotton production regions of Texas, and action thresholds are available (Table 4).

Beat bucket sampling is another sampling method for cotton fleahoppers. This sampling procedure is under development. Based on studies from South Texas, the beat bucket method is more effective in sampling for nymphs and more consistent for inexperienced users than the terminal inspection method. However, research to validate

Figure 20. Plant terminal inspection.

Table 4. Cotton fleahopper action thresholds

<table>
<tr><th>Region</th><th>Fleahoppers</th><th colspan="2">Cotton growth stage</th></tr>
<tr><td>Blacklands</td><td>10–15 per 100 terminals (terminal inspection)</td><td colspan="2" rowspan="3">During squaring</td></tr>
<tr><td rowspan="2">Coastal Bend
Winter Garden
Lower Rio Grande Valley</td><td>15–25 per 100 terminals (terminal sampling)</td></tr>
<tr><td>In development: 20–40 adults and nymphs per 100 plants (beat bucket sampling)</td></tr>
<tr><td rowspan="5">Panhandle
South Plains
Permian Basin
Rolling Plains
Trans Pecos</td><td rowspan="5">25–30 per 100 terminals (terminal inspection)</td><td>Week of squaring</td><td>Square set</td></tr>
<tr><td>1st week</td><td>< 90%</td></tr>
<tr><td>2nd week</td><td>< 85%</td></tr>
<tr><td>3rd week</td><td>< 75%</td></tr>
<tr><td colspan="2">After 1st bloom, treatment is rarely justified.</td></tr>
</table>

thresholds based on the bucket sampling method is currently incomplete. Thus, at this time the bucket sampling method is recommended only as a means to detect cotton fleahopper infestations.

Chemical Control and Action Thresholds

Depending on the region, thresholds range from 10 to 30 cotton fleahoppers per 100 plants (Table 4). Preliminary studies indicate beat bucket thresholds will be higher. A range of 20 to 40 adults and nymphs per 100 plants is being tested in South Texas (Table 4). In some regions, combine insect density with square-set during the first 3 weeks of squaring.

After first bloom, fleahopper control is rarely justified. Insecticides applied during early bloom can result in outbreaks of aphids, bollworms, and tobacco budworms because of the destruction of predaceous insects and spiders. Avoid using broad-spectrum insecticides after the second week of squaring.

Figure 21. Cotton bollworm larval colors.

Figure 22. Cotton bollworm moth.

Figure 23. Tobacco budworm moth.

Figure 24. Cotton bollworm egg.

Mid-Season and Late-Season Pests (Remainder of the Production Season after First One-Third-Grown Square)

Bollworm and Tobacco Budworm

Bollworm and tobacco budworm larvae look very much alike and cause similar damage. Full-grown larvae are about 1½ inches long and vary in color from pale green, pink, or brownish to black, with longitudinal stripes along the back (Fig. 21).

Bollworm and tobacco budworm moths are attracted to and lay eggs in cotton with lush new growth (Figs. 22 and 23). Moths usually lay single eggs on the tops or undersides of young, tender, terminal leaves in the upper third of the plant. However, in transgenic Bt cotton, moths frequently lay eggs on blooms, drying petals of blooms (bloom tags), or other tissues deeper in the canopy. Larvae survive better because these Bt cotton tissues have lower concentrations of Bt protein toxins.

Tobacco budworm and bollworm eggs are pearly white to cream color and about half the size of a pinhead (Fig. 24). They can be confused with looper eggs (which are flatter), can have a blue greenish-white tint, and are usually laid singly on the undersides of leaves.

Bollworm and budworm 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 (Figs. 25 and 26). Small worms are most vulnerable to insecticides when they are in the upper third of the plant.

Moths sometimes deposit eggs on squares, bolls, stems, and lower parts of the plant when cotton plants are stressed and making little new growth, or during periods of high temperature and low humidity. Detecting eggs and controlling small worms is more difficult when the eggs are deposited in the lower plant canopy.

Budworms are typically less numerous than bollworms, and, in recent years, have rarely reached damaging levels. With the increased adoption of transgenic Bt cotton, insecticide sprays for bollworm and tobacco budworm control have become much less common in Texas, particularly in West Texas.

Scouting and Decision Making

In Bt cotton, search the entire plant for tobacco budworm and bollworm larvae and injury. A proper sample includes squares, white blooms, pink blooms, bloom tags, and bolls. Reduce the scouting intervals to 3 to 4 days during periods of increasing bollworm egg-laying, especially during peak bloom. The presence of eggs alone should not trigger treatment since hatching larvae must first feed on the cotton plant to receive a toxic dose.

Terminal and Square Inspection Method

- Divide the cotton field into four or more manageable sections, depending on the field size.
- Examine 25 plant terminals (upper third of the plant), selected at random from each quadrant, for small larvae and eggs. Also, from each quadrant, examine 25 half-grown and larger green squares as well as small, medium, and large bolls for bollworms and bollworm damage.
- Keep track of the number of undamaged and damaged squares and bolls (Figs. 27 and 28). Select fruit at random and do not include flared or yellow squares in the sample.
- Pay attention to bloom tags and petals stuck to small bolls; they will often hide larvae that burrow into the tip of the boll.

Whole Plant Inspection Method

- Divide the cotton field into four or more manageable sections, depending on the field size.
- Make whole-plant inspections of five randomly chosen groups of three adjacent cotton plants in each section. Look in every square, bloom, and boll.
- Thoroughly inspect dried blooms or bloom tags attached to small bolls.
- Count the number of undamaged and damaged fruit and calculate the percentage of damaged fruit.

Chemical Control and Action Thresholds

Thresholds in Bt cotton fields are based on how many worms survive to late first- or second-instar larval stage, not on newly hatched larvae or the presence of eggs. Since newly hatched larvae must feed on the plant for the Bt toxin to be effective, base treatment decisions on damaged fruit and the presence of larvae.

Budworms are more resistant to certain insecticides (for example, pyrethroids) than are bollworms, but more sensitive to the Bt toxins

Figure 25. Cotton bollworm.

Figure 26. Cotton bollworm.

Figure 27. Cotton bollworm damage.

Figure 28. Cotton bollworm damage.

in transgenic cotton. Aphids and other secondary pests may increase when broad-spectrum insecticides targeted at budworms or bollworms disrupt natural control. When secondary pests are present during a budworm or bollworm outbreak, use a selective insecticide to help prevent a secondary pest outbreak. Insecticides in the diamide, oxadiazine, and spinosyn classes are more selective than the pyrethroid and carbamate classes. (See the list of suggested insecticides on page 31.)

Table 5. Bollworm and tobacco budworm action threshold based on boll damage

Cotton stage	Action threshold (both Bt and non-Bt cotton)
Emergence to	
Before bloom	≥ 8 worms (≥1/4 inch) per 100 plants or when populations threaten to reduce square retention below 80 percent
After boll formation	≥ 6% damaged squares and/or bolls and worms are present

Fields that have accumulated 350 DD60 (degree days 60) beyond 5 NAWF (nodes above white flower) are no longer susceptible to first or second instar bollworm/tobacco budworm larvae. Action threshold should be adjusted according to yield potential and production system (dryland vs. irrigated).

Aphids

In Texas, three species of aphids feed on cotton plants as secondary pests: the cotton aphid, the cowpea aphid, and the green peach aphid (Figs. 29, 30, and 31). Cotton aphids are the primary aphid species of concern in cotton. Their color varies from light yellow to dark green or almost black. They are not shiny and can occur anytime during the growing season. The cotton aphid and the cowpea aphid are the only species that establish sustainable, reproductive colonies during most of the growing season. Common on seedling plants, the cowpea aphid is shiny black with white patches on its legs. The nymphs of the cowpea aphid are ash-gray. Green peach aphids are light green or pink and can occur on cotton seedlings early in the growing season.

Figure 29. Cotton aphids.

Figure 30. Cowpea aphids feeding on weedy kochia.

Figure 31. Green peach aphid adult.

Figure 32. Cotton aphid colony on the underside of a cotton leaf.

Figure 33. Leaf curling from cotton aphid infestation.

Figure 34. Honeydew accumulation on leaves.

Aphids have piercing-sucking mouthparts and those that infest cotton have two protrusions (cornicles) at the back of the abdomen. Aphid adults can be winged or wingless. The immatures or nymphs look like the adults but are smaller. They are usually found on the undersides of leaves, on stems, in terminals, and sometimes on fruit (Fig. 32). They suck phloem sap and its sugars from the plant, robbing it of energy otherwise used for growth or fruit production.

Heavy and prolonged infestations can cause leaves to curl downward (Fig. 33), older leaves to turn yellow and shed, squares and small bolls to drop off, and smaller bolls to develop, resulting in incomplete fiber development.

Late in the season, honeydew excreted by aphids can drop on fibers in open bolls. A black, sooty fungus sometimes develops on honeydew deposits during wet periods. The honeydew-contaminated lint from such bolls is stained, sticky, and of lower quality, making it difficult to harvest, gin, and spin the fiber (Fig. 34).

Natural controls such as parasites, pathogens, predators, and unfavorable weather can keep aphid populations below damaging levels. But, cotton aphid populations can increase when treatments with nonselective insecticides for other pests destroy their natural enemies.

Figure 35. Aphid colony on the plant terminal.

Scouting and Decision Making

Scout fields infested with cotton aphids twice a week since aphid numbers can increase rapidly (Fig. 35). From plants across the field, sample 60 leaves divided among the top, middle, and lower portion of a plant to determine actual infestation levels.

Chemical Control and Action Thresholds

Table 6. Aphid action threshold

Cotton stage	Action threshold
Prior to first cracked boll	40–70 aphids per leaf*
After first cracked boll	10 aphids per leaf**

*Higher the yield potential (>1000 lbs lint/acre), lower the threshold
**Where rainfall is not likely to wash honeydew from the lint

Figure 36. Southern green stink bug adult.

Figure 37. Green stink bug adult.

Figure 38. Brown stink bug adult.

Figure 39. Conchuela stink bug adult.

Figure 40. Conchuela stink bug nymph.

Figure 41. Boll wall warts.

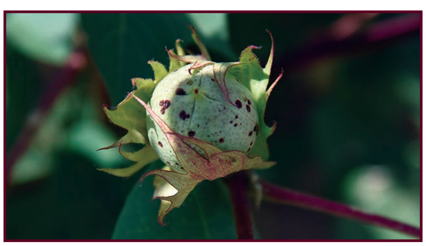

Figure 42. External signs of stink bug feeding.

Figure 43. Lint staining caused by stink bug feeding.

Stink Bugs

Several stink bug species feed on bolls in Texas cotton fields. In South and East Texas, the primary stink bug species is the southern green stink bug, followed by the green stink bug, and brown stink bug (Figs. 36, 37, and 38). They are strong flyers and can move into cotton from corn, grain sorghum, soybeans, and various alternate hosts. In West Texas and the Winter Garden region in South Texas, the conchuela stink bug is the most prominent species (Figs. 39 and 40). Its populations develop on mesquite and then move to cotton and grain sorghum.

Stink bugs have piercing-sucking mouthparts and damage cotton by piercing the bolls and feeding on the developing seeds. Stink bug infestations can cause substantial economic losses through reduced yield, loss of fiber quality, and increased control costs.

Although stink bugs favor medium-sized bolls, they can feed on any size boll. Although stink bugs may feed on bolls 25 or more days old, bolls of this maturity are relatively safe from yield loss. Their feeding on young bolls (less than 10 days old) usually causes the bolls to shed. In larger bolls, stink bug feeding often results in dark spots about 1/16 inch in diameter on the outside of bolls. These dark spots do not always correlate well with the internal damage—callus growths or warts (Fig. 41) and stained lint. There may be several spots on the outside of a boll without internal feeding damage being present (Fig. 42). Damage to the internal boll wall is a good indication that lint and seed are affected. Excessive stink bug feeding causes reduced yield, stained lint, poor color grades, and reduced fiber quality (Fig. 43). In addition to direct damage, stink bug feeding can transmit plant pathogens that cause boll rot.

Scouting and Decision Making

Stink bugs are difficult to scout, especially in tall, vigorous cotton. Adults tend to aggregate, and the distribution of stink bugs within a field may be highly concentrated, particularly along field margins. Use any of the sampling techniques such as visual inspection, drop cloth, and sweep net for scouting. However, recent research by entomologists at the University of Georgia and Clemson University suggests that decisions to treat for stink bug infestations are best made based on the percentage of bolls with evidence of internal damage (warts or stained lint associated with feeding punctures). To use this technique:

- Remove about 10 to 20 bolls, one inch in diameter (about the size of a quarter), from each of four parts of the field, avoiding field edges.
- Break open the bolls by hand or cut them with a knife. Look for internal warts on the boll walls and stained lint on the cotton locks.
- Check bolls with visible external lesions first to determine if the internal damage threshold has been met because bolls with external lesions are more likely to also be damaged internally.

Once the cotton has reached 450 DD60 (degree days 60) beyond cutout (five nodes above the white flower), sampling and treating for stink bugs may no longer be necessary since bolls produced after this point will not become fully mature or contribute significantly to the crop yield. However, it is possible that this value may shift slightly due to factors such as boll shading, variety, and water stress.

Chemical Control and Action Threshold

Based on boll sampling, treat cotton with an insecticide when stink bugs are present and 20 percent or more of the quarter-size bolls have internal warts or stained lint. Use recommended insecticides to control southern green, green, and conchuela stink bugs. Brown stink bug populations in the Coastal Bend of Texas have shown some resistance to pyrethroids.

Verde Plant Bug

Verde plant bugs are cotton pests primarily in coastal South Texas and Mexico. Adult verde plant bugs are elongate, about 1/2 inch long. They have well-developed wings lying flat on the back, red eyes, prominent antennae that extend out from the body, and red striping in early instars (Fig. 44).

Figure 44. Verde plant bug.

The verde plant bug life cycle (egg, nymph, and adult) and overwintering habit is similar to the cotton fleahopper. It is found on many alternative hosts, including annual seepweed, *Chenopodium,* pigweeds, and sorghum, commonly seen on maturing heads. Migration to cotton occurs as these wild hosts decline and, depending on cotton planting time, coincides with bloom.

Economic yield decline from the verde plant bug is usually from injury to young bolls during early to mid bloom when mild winters favor egg overwintering and spring populations on wild hosts, and when the environment favors the introduction of cotton boll rot by the insect. The verde plant bug feeds on large squares and bolls up to about an inch in diameter. Feeding injury causes a combination of dropped mature squares and very young bolls as well as internal boll damage, including damage from cotton boll rot. Feeding injuries and plant symptoms associated with boll-rotting organisms look the same as those caused by stink bugs.

Figure 45. Beet armyworm.

Figure 46. Beet armyworm moth.

Figure 47. Beet armyworm damage.

Figure 48. Beet armyworm.

Scouting and Decision Making

Scout for verde plant bugs when they are first detected until the last harvestable bolls are more than 20 days old or 450 heat-units (degree days 60) after cutout (five nodes above white flower). Because the verde plant bug is an internal boll feeder, also inspect bolls for internal injury similar to that caused by stink bugs. Use these two measurements to evaluate boll risk.

Use a beat bucket to sample for verde plant bug through late bloom of cotton:

- At each sampling site, bend the upper part of 40 plants into the bucket and shake them.
- Count the dislodged nymphs and adults inside the bucket.
- Adjust the total to a count per 100 plants and compare it to the treatment threshold. If small nymphs dominate the sample, a hatch is in progress and the population may increase rapidly. Consider this result in evaluating risk, adjusting the threshold, or increasing the sampling frequency.

Chemical Control and Action Threshold

Treat for verde plant bugs when, using the beat-bucket method, you find more than 20 to 25 bugs per 100 plants.

Beet Armyworm

Both beet armyworm (Figs. 45 and 46) and yellow-striped armyworm moths lay eggs on leaf surfaces in masses covered by a whitish, velvety material. Young beet armyworms hatch, "web up," and feed together on leaves. The damaged leaf or leaves (Fig. 47), called hits, turn tan and are distinctive and easily seen when walking through fields—a quick way to determine if the field has a beet armyworm infestation. After a few days, small beet armyworms disperse and become solitary in their feeding habits.

In early-season infestations, the larvae feed on leaves and terminal areas (Fig. 48), skeletonizing leaves rather than chewing large holes in them. 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 lower optimal plant stand limits.

Damaging infestations sometimes develop late in the season. These infestations are more prone to feed on terminals, squares, blooms, and bolls. Several factors can contribute to beet armyworm outbreaks:

- Mild winters (the absence of prolonged freezing temperatures)
- Late planting
- Delayed crop maturity
- Heavy early-season, broad-spectrum insecticide use
- Continued hot, dry weather conditions
- Prebloom presence of beet armyworms
- Conducive weather conditions for long-distance migration

Additional characteristics of high-risk fields are:

- Sandy and droughty fields
- Skip-row planting
- Fields with skippy, open canopies
- Drought-stressed plants and fields infested with pigweed

The likelihood of a substantial outbreak increases as more of these factors occur in a given location. Control may be justified when beet armyworms begin to damage the fruit, especially bolls. Beet armyworms longer than ½ inch may be difficult to control, so early detection of populations helps improve control.

Scouting and Decision Making

Conduct general observational scouting to detect armyworm hits on a 5- to 7-day schedule throughout the growing season. Because infestations within a field may be spotty, scout to determine the need for and the area of the field requiring control. It is not uncommon for only a portion of a field to require treatment.

Once you detect armyworm hits, conduct more extensive scouting. Using the whole plant inspection method described on page 13, thoroughly inspect 10 to 20 plants from three to four locations throughout the field. Carefully scout weedy areas of the field, especially those infested with pigweed, since beet armyworms are strongly attracted to pigweed and may move from pigweed onto cotton. Migration of the worms from pigweeds to cotton is more of a problem in fields treated with a herbicide to kill the pigweed. Bt cotton varieties usually control beet armyworms effectively.

Action Threshold

Table 7. Beet armyworm action threshold

Table 7. Beet armyworm action threshold
>10% infested plants with 15 larvae/100 plants

Occasional Pests

Grasshoppers

The most common grasshopper species in Texas cotton are the lubber grasshopper, differential grasshopper, and migratory grasshopper (Fig. 49). Lubber grasshoppers move quite slowly and travel by feebly walking and crawling over the soil surface. They most commonly damage presquaring cotton, while the other winged and more agile species invade large-bloom to open-boll stage cotton as pastures dry down.

Figure 49. Adult differential grasshopper.

Depending on the conditions in a particular year, early in the spring, populations may be high in pastures, rangeland, and other noncrop areas. Large populations of winged grasshoppers occasionally occur mid-to-late summer.

Usually, grasshoppers feed on cotton foliage without causing much damage. But, they can be very destructive to seedling cotton and

Figure 50. Grasshopper damage.

Figure 51. Grasshopper nymph.

Figure 52. Adult lygus bug.

Figure 53. Lygus bug nymph.

Figure 54. Adult lygus bug.

destroy stands during large outbreaks, especially at the field edges. Grasshoppers rarely damage older cotton.

Scouting and Decision Making

Treat when unacceptable stand loss or severe defoliation (more than 30 percent) is evident and grasshoppers are present (Fig. 50). Control damaging infestations early while the grasshoppers are small, wingless, and still in crop border areas (Fig. 51). In many cases, field edge treatments can stop the damage.

Lygus Bugs

There are three predominant species of lygus in Texas cotton: the western tarnished plant bug, the tarnished plant bug, and the pale legume bug. The western tarnished plant bug is the most common species in the western half of Texas, and the tarnished plant bug dominates in the eastern half of the state. These species are similar in appearance, biology, and the damage they cause. In this publication, we will call them lygus and discuss them as a single pest.

Lygus bugs feed on cotton terminals, squares, flowers, and small bolls. Adults are ¼ inch long, have a conspicuous dark-colored triangle in the center of the back, have wings, and vary from pale green to yellowish brown with reddish brown to black markings (Fig. 52). Nymphs (immatures) are uniformly pale green with red-tipped antennae; late instars have four conspicuous black spots on the thorax and one large black spot near the base of the abdomen (Fig. 53). The nymph's wings are not developed, but they can move rapidly and are difficult to detect in cotton foliage. It is easy to mistake small nymphs with aphids, cotton fleahoppers, and leafhopper nymphs, but their broader shape, quick movements, larger size, and the specific characteristics discussed above help differentiate them.

Lygus bugs prefer legumes to cotton and usually occur in large numbers in alfalfa, potato fields, or on wild hosts such clovers, dock, mustard, pigweed, Russian thistle, vetches, and wild sunflower. Lygus bugs are attracted to succulent growth (Fig. 54). In cotton, their feeding causes:

- Deformed bolls
- Dirty bloom (damaged anthers in blooms) and puckered areas in petals
- Shedding of squares and small bolls
- Stunted growth
- Small black spots or small, dark, sunken lesions on the outer surface of the developing bolls that can penetrate the boll carpel wall and damage developing seeds or lint

Scouting and Decision Making

The abundance of lygus bugs in relation to the fruiting condition of the cotton plants determines the need for control measures. Inspect fields for lygus bugs at 4- to 5-day intervals throughout the fruiting period.

Before peak bloom, using a sweep net is the most accurate way to sample for lygus. After peak bloom, a drop cloth is best. How to use beat bucket, drop cloth, and sweep net sampling are discussed in the scouting section of this guide on pages 5 and 6. Research in Arizona and California indicates that the western tarnished plant bug may be more difficult to control with insecticides and may require using higher labeled rates of suggested insecticides.

Chemical Control and Action Thresholds

Table 8. Lygus action threshold

	Sampling method	
Cotton stage	**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	2–3 per 6 ft-row with unacceptable square set	15 per 100 sweeps with unacceptable square set
After peak bloom	4–6 per 6 ft-row with unacceptable fruit set the first 4-5 weeks	15–20 per 100 sweeps with unacceptable fruit set the 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 recommended, 3-foot sampling area, sample 2 rows. Recommended after peak bloom. Stop sampling and treating when NAWF = 5 + 350 DD60's.

*In West Texas, insecticide applications for lygus are rarely needed in prebloom cotton as lygus generally stay in roadside weeds and vegetation until cotton begins flowering.

Spider Mites

Two species of mites commonly feed on cotton plants in Texas: the twospotted spider mite and the carmine spider mite. These two species are difficult to distinguish from one another. Carmine spider mite females are red; twospotted spider mites are greenish. When conditions are suitable for initiating diapause (dormancy), female twospotted spider mites may also be red. Because the damage they inflict and their biology and ecology are similar, we will discuss them as one pest for this guide (Fig. 55).

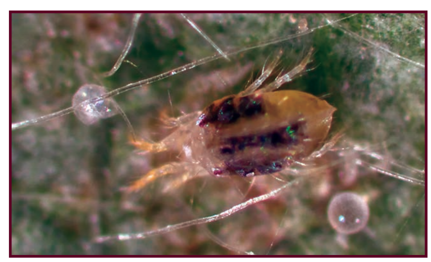

Figure 55. Twospotted spider mite.

Spider mites can infest cotton at any point in the growing season, but cotton is most susceptible to injury from spider mites during fruiting periods and when the crop suffers water-deficit stress. Spider mites infest the underside of leaves (Fig. 56).

Figure 56. Twospotted spider mite infestation on the underside of a cotton leaf.

Infestations most often develop in hot spots in fields, near grain crops, and at dusty field margins. Spider mite infestations are often made worse by broad-spectrum insecticide applications that target other pests. High winds or equipment from infested crops nearby can move mites from one location to another.

They feed by piercing plant cells with their mouthparts and sucking the liquid contents of the cells. Damaged leaves develop white or yellowish specks, called stipules. Specking damage is Phase I damage. As feeding increases and the mites persist, the damage spreads, leaves develop a reddened appearance (Phase II damage), and eventually turn brown. This damage affects cotton photosynthesis, which appears to decline sharply at Phase II, or about 20 mites per leaf. Spider mites also infest bracts of squares and bolls, causing the bracts to desiccate (dry up). Heavy and prolonged spider mite infestation can prematurely defoliate cotton plants. Spider mite injury can reduce cotton yield, fiber quality, and seed.

Management and Decision Making

Hot, dry weather favors spider mite infestations. Conversely, high relative humidity and precipitation deter spider mite infestations by washing them off leaves and creating conditions that favor disease outbreaks. Since spider mite outbreaks tend to develop on field borders adjacent to spider-mite-infested weeds or other crops, managing weeds along field margins often prevents the mites from migrating into cotton. Avoid excessive nitrogen fertilizer because spider mite outbreaks occur more frequently in fields fertilized with higher than necessary nitrogen rates. Spider mite populations often develop where dust from roads blows onto cotton plants, possibly interfering with natural enemy efficiency.

The spider mite treatment threshold has not been fully worked out, but the following formula provides general guidelines for treatment. Before bloom, scout cotton for leaf damage to protect it from spider-mite-induced defoliation. After bloom, protect leaves responsible for boll filling from spider mite damage until 650 to 750 DD60s beyond cutout or NAWF + 5. Because spider mite populations are often clumped together, particularly along field edges, spot treating infested areas often prevents spread and can be cost-effective. Consider alternatives to pyrethroids for managing pests such as bollworms and lygus. Also, consider selective insecticides such as neonicotinoids for aphid control when mites are present. Maximize insecticide coverage when treating for mites. Drop nozzles and high spray volumes can significantly enhance mite control.

Table 9. Spider mite action threshold

Treat when 40% or more of the plants show noticeable leaf damage and the mite population is growing.
Spot treat problem areas and field edges when infestations are relegated to small areas. Stop sampling and treating when NAWF = 5 + 650-750 DD60s.

Fall Armyworms

There are two host strains of fall armyworms: the rice strain and the corn strain. The rice strain is associated with rice, Bermudagrass, and other pasture grasses. The corn strain is the predominant fall armyworm on corn, sorghum, and cotton. Other than feeding habits, these strains are indistinguishable without using molecular identification techniques (Fig. 57).

Figure 57. Fall armyworm.

Fall armyworm moths (Fig. 58) lay their eggs in masses (Fig. 59), and, unlike beet armyworms, the larvae quickly disperse from the egg mass (Fig. 60). First and second instar larvae are difficult to distinguish from other armyworm species and bollworms. Fall armyworm larvae are usually greenish-brown with a white line below the top of the back, a brownish-black stripe above the midline, and a pale stripe with a reddish-brown tinge below. Their most distinctive characteristic is a prominent, white inverted “Y” on the front of the head (Fig. 61). Black hairs on their bodies distinguish them from beet armyworms. Because bollworms also have hairs on their bodies, this characteristic may lead to confusion between small fall armyworms and small bollworms. Fall armyworm larvae also have four large spots that form a square on the upper surface of the last body segment. When larvae are large, these spots help differentiate fall armyworms from bollworms.

Figure 58. Fall armyworm moth.

Figure 59. Fall armyworm egg mass.

Depending on the strain of fall armyworm, damage to cotton may be nonexistent to severe. Although rare, rice strain larvae have been seen dispersing from pastures into cotton where they fed exclusively on grassy weeds. The corn strain larvae, however, can do extreme damage to cotton. Fall armyworms that feed on cotton are typically more damaging than other armyworm species because they tend to feed on fruiting structures, especially bolls. However, they do not feed as voraciously on fruit as bollworms do and their populations develop more in grain crops such as corn and grain sorghum in preference to cotton.

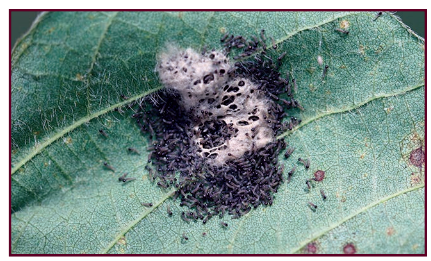

Figure 60. Fall armyworm egg hatch.

When abundant in prebloom cotton, fall armyworms may cause defoliation, but the greatest damage comes from topping the plants—branches cut off and stalks almost severed. The most damaging populations of fall armyworms are those that occur during boll filling. Because fall armyworms quickly disperse away from the egg mass, which is often inside the plant canopy, it is not uncommon to find small larvae individually feeding on squares, bolls, and bloom tags, much like a bollworm. Because, like bollworms, they are cryptic (hidden/concealed) feeders, they are easy to miss and often first noticed feeding in blooms.

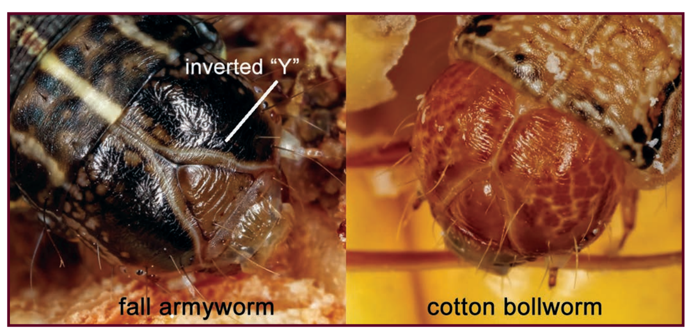

Figure 61. Prominent inverted Y on the head of the fall armyworm.

Occasionally, fall armyworms will feed in fairly high numbers on Bt cotton blooms. In these cases, the blooms may not have produced high enough levels of Bt toxins to kill them. There have been some instances where these larvae have completed their entire life cycle feeding exclusively on Bt cotton blooms without causing significant boll damage or pollination issues.

Management, Scouting, and Decision Making

Currently, planting Bt cotton is the most effective way to control fall armyworms. Third-generation Bt cotton with three toxins (Bollgard 3, WideStrike 3, and TwinLink Plus) develop lower fall armyworm populations compared to second-generation Bt cotton. However, areas with heavy fall armyworm pressure may occasionally require treatment. Large acreages of cotton, particularly in the South Plains and Panhandle, are still planted in varieties that do not contain the Bt genes. These fields may become infested with fall armyworms.

Field monitoring is essential in Bt cotton because fall armyworm populations may develop, particularly on blooms and, late in the season, on stressed cotton with compromised Bt toxin production. Thresholds in Bt cotton fields are based upon surviving second and third instar larvae and not upon newly hatched larvae. Because newly hatched larvae must feed on the plant for the Bt toxin to be effective, delay decision making until you can determine how many larger larvae (worms) are surviving.

Small fall armyworms are difficult to distinguish between bollworms and budworms. Unless you find these larvae feeding in a mass, include them with the bollworm and budworm counts. To detect fall armyworm populations and make management decisions, inspect whole plants using the techniques described above for bollworm and tobacco budworm.

Chemical Control and Action Thresholds

When you detect larger, distinguishable worms, note whether they are bollworms, budworms, or fall, beet, or yellow-striped armyworms because control tactics for these species will differ.

Bollworms and budworms are often controlled with pyrethroids. But, pyrethroids are weak against armyworms, which are typically controlled with a variety of insecticides that tend to be weak against bollworms. If you have mixed populations of armyworms and bollworms, use tank mixes of insecticides to achieve adequate control and prevent damage.

Because of the similarity in damage and difficulty in distinguishing small fall armyworm larvae from bollworms, include them along with bollworm and budworm counts and base your treatment decisions on the cumulative total of caterpillars counted.

Other Pests

Cutworms

Several species of cutworms infest cotton. The adult cutworm is a robust brown to gray moth (Fig. 62). When disturbed, cutworm larvae curl up into a C-shape and regurgitate. The larvae are often shiny or glossy and always have four pairs of prolegs (Fig. 63).

Cutworms usually cut off seedling cotton plant stems at the soil surface. The resulting stand reduction may be more visible at field margins and in low-lying, weedy areas. On rare occasions, cutworm damage can be severe enough to require replanting.

In no-till or limited-till situations, cutworms can establish on existing vegetation and move to emerging cotton seedlings when that vegetation dies. Reduce the risk of cutworm attack by destroying all existing vegetation 3 to 4 weeks before planting.

Chemical Control and Action Threshold

Treat for cutworms if infestations threaten to reduce the stand below 35,000 plants/acre (on an avereage 2.68 plants/row foot with 40-ich row spacing) in a field or part of a field.

Figure 62. Cutworm moth.

Figure 63. Cutworm larva.

Saltmarsh Caterpillar

The larval stages of the saltmarsh caterpillar and the banded woolly bear are called woolly bears because of the long hairs covering their bodies. They are dark-headed, woolly, yellow, gray, black, or reddish-brown (some with rusty red and black bands) (Fig. 64 and 65). We will discuss both species as saltmarsh caterpillars because of their similar appearance, biology, and the damage they inflict.

The saltmarsh caterpillar is a problem on the edges of fields and where alternate host plants are available. Early in the growing season, large populations can develop in outbreak years, destroying plant stands along the field edges.

Treating isolated areas within a field or along the field borders effectively controls saltmarsh caterpillars and reduces their spread across fields.

Figure 64. Saltmarsh caterpillar.

Figure 65. Saltmarsh caterpillar.

Cotton Square Borer

The adult cotton square borer is a slate or bluish-gray butterfly. It has two large black spots on each wing with smaller reddish-orange spots above these at the back edge of the hind wing. There are usually two or three thin tails that mimic antennae on the hind wing (Figs. 66 and 67). The larval stage is a velvety, light green, slug-shaped worm (Fig. 68).

The adult begins laying eggs early in the spring. They take about 6 days to hatch; then the small larvae feed on cotton squares for around 20 days.

Figures 66 and 67. Adult cotton square borer.

Figure 68. Cotton square borer larva.

Figure 69. Adult cotton stainer.

Figure 70. Cotton stainer nymph.

Figure 71. Adult whitefly.

The presence of adult butterflies is usually the first indication of cotton square borer activity. However, hollowed-out squares with almost perfectly round entrance and exit holes are another sign. Unlike bollworm or tobacco budworm damage, there is no frass (the excrement of insect larvae) present with cotton square borer damage. Insecticide treatment for cotton square borer control is almost never necessary in Texas.

Cotton Stainer

The cotton stainer is a true bug (has piercing-sucking mouthparts). The head and pronotum are bright red; the remainder of the body is dark brown crossed with pale yellow lines (Fig. 69). Immature stages are smaller but resemble adults without wings (Fig. 70).

The cotton stainer damages developing bolls by puncturing seeds and causing plant sap to exude from the feeding site. The plant sap stains the lint an indelible yellow. Feeding by the cotton stainer also interferes with the bolls' natural development. In recent years, the cotton stainer has been rare in Texas cotton.

Whiteflies

Silverleaf whitefly (SLWF) and bandedwing whitefly (BWWF) are the two most common whitefly species that infest Texas cotton.

Both whitefly species are similar in appearance and basic biology. The adults of both species resemble tiny white moths with yellowish bodies, about 1/16 to 1/10 of an inch long. Their wings fold roof-like over their abdomens. The SLWF (Fig. 71) has solid white wings, and the BWWF has grayish-brown colored bands across its wings.

The nymphs are flat, scale-like insects, usually about 1/30 of an inch long (Fig. 72). The immatures feed with sucking mouthparts on the underside of leaves. Damage ranges from stunted growth and reduced plant vigor during the early season to reduced plant vigor, honeydew deposited on open cotton lint (sticky cotton), and premature defoliation during the mid and late season. Like aphid honeydew, whitefly honeydew is a food source for black sooty molds that can stain lint and reduce fiber quality. Heavy whitefly infestations can severely reduce cotton yield.

Scouting

To sample for whiteflies:

- Examine the underside of at least 30 key leaves (leaves located at the fifth node down from the terminal) and note how many leaves are infested with at least three adults.
- Use a hand lens to examine a quarter-sized area on the underside of the leaf between the main middle vein and one of the main lateral veins.
- Note how many hand-lens views contain at least one large whitefly nymph (third and fourth instars).

Chemical Control and Action Thresholds

Table 10. Whitefly action thresholds

Insecticide option	Silverleaf whitefly	
Adulticide	When ≥40% of the 5th node leaves are infested with 3 or more adults	
Insect growth regulator (IGR)	When ≥40% of the 5th node leaves are infested with 3 or more adults and nymphs are present	When ≥40% of quarter-sized disks* contain at least one large nymph
Cotton stage	**Bandedwing whitefly**	
Before open bolls	50 whitefly nymphs per 5th node leaf	
After open bolls	25 whitefly nymphs per 5th node leaf	

*Quarter-sized area taken between the main middle vein and one of the main lateral veins from a 5th node leaf

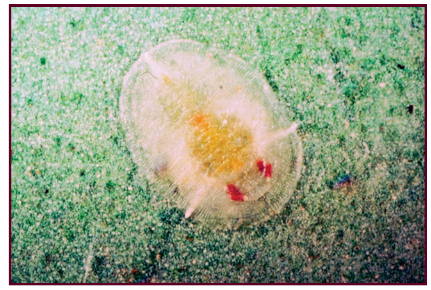

Figure 72. Whitefly nymph.

Figure 73. Adult boll weevil.

Boll Weevil

Boll weevils have been declared eradicated in the West Texas region. In 2016, the only zones in the United States to capture weevils were the Lower Rio Grande Valley and South Texas/Winter Garden zones (Fig. 73). Contact your local AgriLife Extension office or the Texas Boll Weevil Eradication Foundation (325-672-2800) for information.

Figure 74. Boll weevil larva.

Pink Bollworm

The pink bollworm has been eradicated from the southwestern United States (Figs. 74–77). Contact your local AgriLife Extension office for information.

Figure 75. Adult pink bollworm.

Figure 76. Pink bollworm larva.

Figure 77. Pink bollworm damage.

Figure 78. Lady beetle.

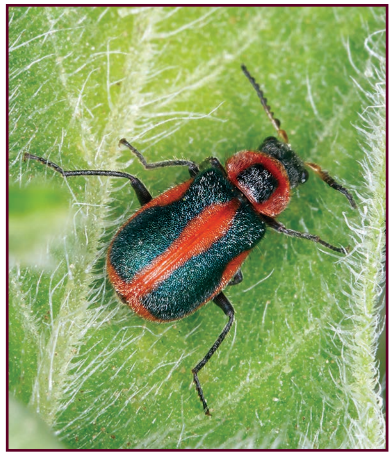

Figure 79. Collops beetle.

Figure 80. Minute pirate bug.

Beneficial Arthropods

Natural enemies such as parasites, pathogens, and predators feed on various arthropod pest species in agricultural fields and provide natural control. Conserving such beneficial organisms is an important component of IPM. Following are examples of beneficials commonly found in cotton fields.

Lady Beetles (Fig. 78)

Generalist predators: Feed primarily on aphids, caterpillars, insect eggs, mealy bugs, scale insects, spider mites, and whiteflies. Some species are plant feeders.

Collops Beetle (Fig. 79)

Adults feed on aphids, stink bug eggs, moth eggs, small caterpillars, spider mites, and whiteflies.

Minute Pirate Bug (Fig. 80)

Generalist predator: Feeds on aphids, insect eggs, leafhopper nymphs, scale insects, small caterpillars, spider mites, thrips, and whiteflies.

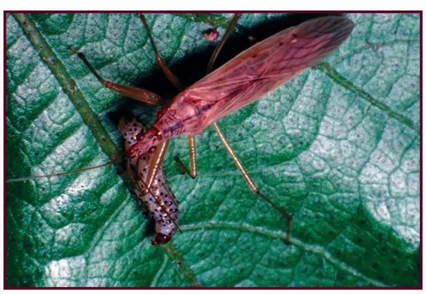

Figure 81. Damsel bug.

Damsel Bug (Fig. 81)

Generalist predator: Feeds primarily on aphids, caterpillars, insect eggs, leafhoppers, spider mites, and thrips.

Figure 82. Green lacewing.

Green Lacewing (Fig. 82)

Larvae are generalist predators: Feed primarily on aphids, insect eggs, leafhoppers, mealybugs, psyllids, small caterpillars, spider mites, thrips, and whiteflies. Depending on the species, adults are also predaceous.

Figure 83. Spined soldier bug.

Figure 84. Brown lacewing.

Figure 85. Big-eyed bug.

Spined Soldier Bug (Fig. 83)

Generalist predator: Feeds on beetle larvae, caterpillars, and true bug nymphs.

Brown Lacewing (Fig. 84)

Generalist predator: Feeds primarily on aphids, insect eggs, leafhoppers, mealybugs, mites, psyllids, small caterpillars, thrips, and whiteflies.

Big-Eyed Bug (Fig. 85)

Generalist predator: Feeds primarily on flea beetles, insect eggs, mites, small caterpillars, thrips, whiteflies, and other true bugs.

Assassin Bugs (Fig. 86)

Generalist predators: Feed primarily on aphids, caterpillars, insect eggs, leafhoppers, true bugs, and various small beetles.

Ground Beetles (Fig. 87)

Generalist predators: Feed primarily on small insects, spiders, and various other ground-dwelling arthropods. Some species feed on seeds.

Flower Flies or Syrphid Flies (Fig. 88)

Larvae are generalist predators: Feed on aphids, mealybugs, scale insects, spider mites, and thrips.

Ichneumonid Wasps (Fig. 89)

Larvae are parasitoids of beetle larvae, caterpillars, and other insects.

Braconid Wasps (Fig. 90)

Larvae are parasitoids of aphids, beetle larvae, caterpillars, and other insects.

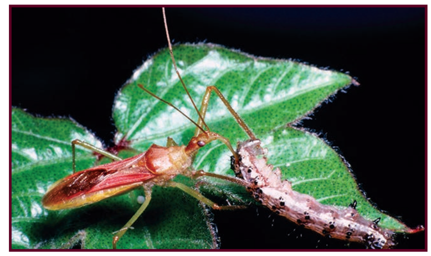

Figure 86. Assassin bug.

Figure 87. Ground beetle.

Figure 88. Syrphid fly.

Figure 89. Ichneumonid wasp.

Figure 90. Braconid wasp.

Tachinid Flies (Fig. 91)

Larvae are internal parasitoids of beetle larvae, caterpillars, grasshoppers, and other insects.

Spiders (Figs. 92 and 93)

Spiders are beneficial predators and serve a significant role in keeping populations of many insect pests in check.

Figure 91. Tachinid fly.

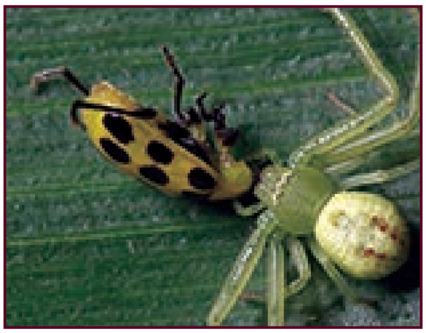

Figure 92. Crab spider.

Figure 93. Lynx spider.

Table 11. Insecticides Labeled for Control of Insect Pests of Cotton

Pest	Product Name/ Common Name	Active Ingredient/s	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval
Thrips									
Seed treatments									
	Gaucho 600	imidacloprid^	12.8 fl oz/100 lbs seed	0.375 mg AI/seed		Caution	Neonicotinoid (4A)		
	Aeris	thiodicarb + imidacloprid	25.6 fl oz/100 lbs seed	0.375 mg ai/seed + 0.375 mg AI/seed		Caution	Carbamate (1A) + Neonicotinoid (4A)		
	Cruiser 5FS	thiamethoxam		0.300–0.340 mg AI/seed		Caution	Neonicotinoid (4A)		
	Avicta Duo Cotton	abamectin + thiamethoxam		0.15 + 0.34 mg AI/seed		Warning	Neonicotinoid (4A) + Avermectin (6)		
	Avicta Elite Cotton Plus	abamectin + thiamethoxam + imidacloprid		0.865 mg AI/seed		Warning	Neonicotinoid (4A) + Avermectin (6)		
	Acceleron	imidacloprid				Caution	Neonicotinoid (4A)		
	Acceleron Elite	imidacloprid + clothianidin				Caution	Neonicotinoid (4A)		
	Acephate 97UP	acephate^	0.28–0.4 lb/100 lbs seed			Caution	Organophosphate (1B)		
At planting in furrow treatments									
	Velum Total	fluopyram + imidacloprid	14–18	0.164–0.211 + 0.237–0.305		Caution	N/A + Neonicotinoid (4A)	12h	30
	Admire Pro	imidacloprid	7.4–9.2	0.266–0.331	17.30–13.91	Caution	Neonicotinoid (4A)	12h	14
	Orthene 97	acephate^	8–16	0.487–0.974	2–1	Caution	Organophosphate (1B) + Pyrethroid (3A)	24h	21
	Acephate 90 Prill	acephate	8.9–17.6	0.5–0.99	1.80–0.91	Caution	Organophosphate (1B)	24h	21
Foliar treatments									
	Bidrin 8EC	dicrotophos^	1.6–3.2	0.1–0.2	80–40	Danger	Organophosphate (1B)	6d	30
	Acephate 90 Prill	acephate^	2.5–3.3	0.141–0.186	6.4–4.85	Caution	Organophosphate (1B)	24h	21
	Orthene 97	acephate	2.5–3.0	0.152–0.183	6.4–5.33	Caution	Organophosphate (1B)	24h	21
	Radiant SC	spinetoram	4.25–8	0.0332–0.0625	30–16	Caution	Spinosyn (5)	4h	28
	Dimethoate 4E	dimethoate^	4–8	0.125–0.25	32–16	Warning	Organophosphate (1B)	48h	14
Cutworms									
	Acephate 90 Prill	acephate^	13.3	0.748	1.20	Caution	Organophosphate (1B)	24h	21
	Orthene 97	acephate	12	0.731	1.33	Caution	Organophosphate (1B)	24h	21
	Fanfare ES	bifenthrin^	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Brigade 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Discipline 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Silencer (Silencer VXN)	lambda-cyhalothrin^	1.92–2.56	0.015–0.02	66.67–50	Warning	Pyrethroid (3A)	24h	21
	Karate/Warrior II	lambda-cyhalothrin	0.96–1.28	0.015–0.02	133.33–100	Warning	Pyrethroid (3A)	24h	21
	Baythroid XL	beta-cyfluthrin	0.8–1.6	0.007–0.013	160–80	Warning	Pyrethroid (3A)	12h	0

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Table 11. Insecticides Labeled for Control of Insect Pests of Cotton (continued)

Pest	Product Name/ Common Name	Active Ingredient/s	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval
Cutworms continued									
	Declare	gamma-cyhalothrin	0.77–1.02	0.0075–0.01	166.23–125.49	Caution	Pyrethroid (3A)	24h	21
	Mustang Maxx	zeta-cypermethrin	1.28–1.92	0.008–0.012	100–66.67	Warning	Pyrethroid (3A)	12h	14
	Mustang	zeta-cypermethrin	1.4–2.0	0.016–0.024	91.43–64	Warning	Pyrethroid (3A)	12h	14
Bollworm and **Tobacco Budworm									
	Blackhawk	spinosad	1.6–3.2	0.036–0.072	80–40	Caution	Spinosyn (5)	4h	28
	Prevathon	chlorantraniliprole	14–27	0.047–0.09	9.14–4.74	Caution	Diamide (28)	4h	21
	Radiant SC	spinetoram	2.8–8	0.0219–0.0625	45.71–16	Caution	Spinosyn (5)	4h	28
	Lannate LV	methomyl	24–36	0.45–0.68	5.5–3.5	Danger	Carbamate (1A)	72h	15
	Steward EC	indoxacarb	9.2–11.3	0.09–0.11	14–11.5	Caution	Oxadiazines (22A)	12h	14
	Fanfare ES	bifenthrin^	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Brigade 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Discipline 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Silencer	lambda-cyhalothrin^	3.2–5.12	0.025–0.04	40–25	Warning	Pyrethroid (3A)	24h	21
	Karate/ Warrior II	lambda-cyhalothrin	1.60–2.56	0.025–0.04	80–50	Warning	Pyrethroid (3A)	24h	21
	Declare	gamma-cyhalothrin	1.28–2.05	0.0125–0.02	100–62.44	Caution	Pyrethroid (3A)	24h	21
	Mustang Maxx	zeta-cypermethrin	2.64–3.60	0.0165–0.0225	48.49–35.56	Warning	Pyrethroid (3A)	12h	14
	Baythroid XL	beta-cyfluthrin	1.6–2.6	0.013–0.021	80–49.23	Warning	Pyrethroid (3A)	12h	0
Aphids									
	Sivanto 200 SL	flupyradifurone	7.0–10.5	0.0913–0.137	18.29–12.19	Caution	Butenolide (4D)	4h	14
	Carbine 50WG	flonicamid	1.4–2.8	0.044–0.089	11.43–5.71	Warning	Flonicamid (29)	12h	30
	Intruder Max 70WP/Strafer Max	acetamiprid^	0.6–1.1	0.025–0.05	26.67–14.55	Caution	Neonicotinoid (4A)	12h	28
	Bidrin 8EC	dicrotophos^	4.0–8.0	0.25–0.5	32–16	Danger	Organophosphate (1B)	6d	30
Beet Armyworm									
	Confirm 2F	tebufenozide^	4–16	0.06–0.12	32–8	Caution	Diacylhydrazines (18)	4h	14
	Prevathon	chlorantraniliprole	14–27	0.047–0.09	9.14–4.74		Diamide (28)	4h	21
	Lannate LV	methomyl	24–36	0.45–0.68	5.5–3.5	Danger	Carbamate (1A)	72h	15
	Steward EC	indoxacarb	9.2–11.3	0.09–0.11	14–11.5	Caution	Oxadiazines (22A)	12h	14
	Blackhawk	spinosad	1.6–3.2	0.036–0.072	80–40	Caution	Spinosyn (5)	4h	28
	Intrepid 2F	methoxyfenozide^	4–10	0.06–0.16	32–13	Caution	Diacylhydrazine (18)	4h	14
	Radiant SC	spinetoram	4.25–8	0.0332–0.0625	30–16	Caution	Spinosyn (5)	4h	28

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Table 11. Insecticides Labeled for Control of Insect Pests of Cotton (continued)

Pest	Product Name/ Common Name	Active Ingredient/s	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval
Grasshoppers									
	Prevathon	chlorantraniliprole	8–20	0.047–0.09	16–6.4	Caution	Diamide (28)	4h	21
	Bidrin 8	dicrotophos^	3.2	0.2	40	Danger	Organophosphate (1B)	6d	30
	Baythroid XL	beta-cyfluthrin	2.0–2.8	0.016–0.022	64–45.71	Warning	Pyrethroid (3A)	12h	0
	Mustang Maxx	zeta-cypermethrin	3.0–4.0	0.01875–0.025	42.67–32	Warning	Pyrethroid (3A)	12h	14
	Mustang	zeta-cypermethrin	3.2–4.3	0.0375–0.05	40–29.77	Warning	Pyrethroid (3A)	12h	14
Cotton Fleahopper									
	Vydate C-LV 3.77	oxamyl	8–32	0.125–0.5	16–4	Danger	Carbamate (1A)	48h	14
	Orthene 97	acephate^	4	0.244	4	Caution	Organophosphate (1B)	24h	21
	Acephate 90 Prill	acephate	4.4	0.248	3.64	Caution	Organophosphate (1B)	24h	21
	Intruder Max 70WP/Strafer Max	acetamiprid^	0.6–1.1	0.025–0.05	26.67–14.55	Caution	Neonicotinoid (4A)	12h	28
	Carbine 50WG	flonicamid	1.7–2.8	0.053–0.089	9.41–5.71	Warning	Flonicamid (29)	12h	30
	Centric 40 WG	thiamethoxam	1.25–2.5	0.0313–0.0625	12.8–6.4	Caution	Neonicotinoid (4A)	12h	21
	Alias 4F	imidacloprid^	1–2	0.0313–0.0625	128–64	Caution	Neonicotinoid (4A)	12h	14
	Bidrin 8	dicrotophos^	4.0–8.0	0.25–0.5	32–16	Danger	Organophosphate (1B)	6d	30
Plant Bugs									
	Vydate C-LV 3.77	oxamyl	8–32	0.125–0.5	16–4	Danger	Carbamate (1A)	48h	14
	Intruder Max 70WP/Strafer Max	acetamiprid^	0.6–1.1	0.025–0.05	26.67–14.55	Caution	Neonicotinoid (4A)	12h	28
	Acephate 90 Prill	acephate^	4.4–17.6	0.248–0.99	3.64–0.91	Caution	Organophosphate (1B)	24h	21
	Orthene 97	acephate	4–16	0.244–0.974	4–1	Caution	Organophosphate (1B)	24h	21
	Diamond 0.83 EC	novaluron	9–12	0.0584–0.0778	14.22–10.67	Warning	Benzoylureas (15)	12h	30
	Steward EC	indoxacarb	9.2–11.3	0.09–0.11	14–11.5	Caution	Oxadiazines (22A)	12h	14
	Carbine 50WG	flonicamid	1.7–2.8	0.053–0.089	9.41–5.71	Warning	Flonicamid (29)	12h	30
	Dimethoate 4E	dimethoate^	8	0.25	16.0	Warning	Organophosphate (1B)	48h	14
	Bidrin 8	dicrotophos^	4.0–8.0	0.25–0.5	32–16	Danger	Organophosphate (1B)	6d	30
	Alias 4F	imidacloprid^	1–2	0.0313–0.0625	128–64	Caution	Neonicotinoid (4A)	12h	14
	Centric 40 WG	thiamethoxam	1.25–2.5	0.0313–0.0625	12.8–6.4	Caution	Neonicotinoid (4A)	12h	21
Stink Bugs									
	Acephate 90 Prill	acephate^	13.3	0.748	1.20	Caution	Organophosphate (1B)	24h	21
	Orthene 97	acephate	12	0.731	1.33	Caution	Organophosphate (1B)	24h	21
	Fanfare ES	bifenthrin^	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Discipline 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14

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Table 11. Insecticides Labeled for Control of Insect Pests of Cotton (continued)

Pest	Product Name/ Common Name	Active Ingredient/s	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval
Stink Bugs continued									
	Brigade 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Bidrin 8	dicrotophos^	4.0–8.0	0.25–0.5	32–16	Danger	Organophosphate (1B)	6d	30
	Baythroid XL	beta-cyfluthrin	1.6–2.6	0.013–0.021	80–49.23	Warning	Pyrethroid (3A)	12h	0
	Mustang Maxx	zeta-cypermethrin	2.64–3.60	0.0165–0.0225	48.49–35.56	Warning	Pyrethroid (3A)	12h	14
	Mustang	zeta-cypermethrin	2.8–3.8	0.033–0.045	45.71–33.68	Warning	Pyrethroid (3A)	12h	14
	Silencer	lambda-cyhalothrin^	3.2–5.12	0.025–0.04	40–25	Warning	Pyrethroid (3A)	24h	21
	Silencer VXN	lambda-cyhalothrin	3.2–5.12	0.025–0.04	40–25	Caution	Pyrethroid (3A)	24h	21
	Declare	gamma-cyhalothrin	1.28–2.05	0.0125–0.02	100–62.44	Caution	Pyrethroid (3A)	24h	21
	Karate	lambda-cyhalothrin	1.60–2.56	0.025–0.04	80–50	Warning	Pyrethroid (3A)	24h	21
	Warrior II	lambda-cyhalothrin	1.60–2.56	0.025–0.04	80–50	Warning	Pyrethroid (3A)	24h	21
Spider Mites									
	ABBA Ultra	abamectin^	2–8	0.00469–0.01875	64–16	Warning	Avermectin (6)	12h	20
	Agri-Mek SC	abamectin	1.0–1.25	0.00547–0.00684	128–102.4	Warning	Avermectin (6)	12h	20
	Oberon 4SC	spiromesifen	3–8	0.09–0.25	42.7–16	Caution	Tetronic and Tetramic acid derivatives (23)	12h	30
	Zeal 72WSP	etoxazole	0.67–1	0.03–0.045	23.88–16	Caution	Etoxazole (10B)	12h	28
	Portal	fenpyroximate	16–32	0.05–0.10	8–4	Warning	METI Acaricides (21A)	12	14
Fall Armyworm									
	Prevathon	chlorantraniliprole	14–27	0.047–0.09	9.14–4.74	Caution	Diamide (28)	4h	21
	Steward EC	indoxacarb	9.2–11.3	0.09–0.11	14–11.5	Caution	Oxadiazines (22A)	12h	14
	Lannate LV	methomyl	24–36	0.45–0.68	5.5–3.5	Danger	Carbamate (1A)	72h	15
	Orthene 97	acephate^	16	0.974	8	Caution	Organophosphate (1B)	24h	21
	Blackhawk	spinosad	2.4–3.2	0.054–0.072	6.67–5	Caution	Spinosyn (5)	4h	28
Whiteflies									
	Intruder Max 70WP/Strafer Max	acetamiprid^	1.7–2.3	0.075–0.1	9.41–6.96	Caution	Neonicotinoid (4A)	12h	28
	Acephate 90 Prill	acephate^	8.9–17.6	0.5–0.99	1.8–0.9	Caution	Organophosphate (1B)	24h	21
	Orthene 97	acephate	8–16	0.487–0.974	2–1	Caution	Organophosphate (1B)	24h	21
	Oberon 4SC	spiromesifen	3–8	0.09–0.25	42.7–16	Caution	Tetronic and Tetramic acid derivatives (23)	12h	30
	Knack	pyriproxyfen	8–10	0.054–0.067	16–13	Caution	Pyriproxyfen (7C)	12h	28
	Centric 40 WG	thiamethoxam	2.0–2.5	0.05–0.0625	8–6.4	Caution	Neonicotinoid (4A)	12h	21
	Sivanto 200 SL	flupyradifurone	10.5–14.0	0.137–0.183	12.19–9.14	Caution	Butenolide (4D)	4h	14
	Admire Pro	imidacloprid^	1.3–1.7	0.0467–0.0611	98.46–75.29	Caution	Neonicotinoid (4A)	12h	14

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Table 11. Insecticides Labeled for Control of Insect Pests of Cotton (continued)

Pest	Product Name/ Common Name	Active Ingredient/s	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval
Saltmarsh Caterpillar									
	Prevathon	chlorantraniliprole	14–27	0.047–0.09	9.14–4.74	Caution	Diamide (28)	4h	21
	Fanfare ES	bifenthrin^	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Silencer	lambda-cyhalothrin^	2.56–3.84	0.02–0.03	50–33.33	Warning	Pyrethroid (3A)	24h	21
	Silencer VXN	lambda-cyhalothrin	2.56–3.84	0.02–0.03	50–33.33	Caution	Pyrethroid (3A)	24h	21
	Skyraider	bifenthrin + imidacloprid	3.8–6.4	0.0594–0.1 + 0.0297–0.05	33.68–20	Warning	Pyrethroid (3A) + Neonicotinoid (4A)	12h	14
	Discipline 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Baythroid XL	beta-cyfluthrin	1.6–2.6	0.013–0.021	80–49.23	Warning	Pyrethroid (3A)	12h	0
	Blackhawk	spinosad	1.6–3.2	0.036–0.072	80–40	Caution	Spinosyn (5)	4h	28
	Lock-On	chlorpyrifos^	32	0.5	4.0	Caution	Organophosphate (1B)	24h	40
	Radiant SC	spinetoram	4.25–8	0.0332–0.0625	30–16	Caution	Spinosyn (5)	4h	28
	Brigade 2EC	bifenthrin	2.6–6.4	0.04–0.10	49.23–20	Warning	Pyrethroid (3A)	12h	14
	Mustang Maxx	zeta-cypermethrin	2.64–3.60	0.0165–0.0225	48.49–35.56	Warning	Pyrethroid (3A)	12h	14
	Mustang	zeta-cypermethrin	2.8–3.8	0.033–0.045	45.71–33.68	Warning	Pyrethroid (3A)	12h	14
	Karate/ Warrior II	lambda-cyhalothrin	1.28–1.92	0.02–0.03	100–66.67	Warning	Pyrethroid (3A)	24h	21

* IRAC = Insecticide Resistance Action Committee
^ Various generics available
** No pyrethroids are suggested against tobacco budworms due to resistance
Insecticide groups 7, 10, 15, 18, and 23 are insect growth regulators
Make aerial or ground applications when wind velocity (approximately 3 to 10 mph) favors on-target product deposition. Do not apply when wind velocity exceeds 15 mph. See product labels for information on toxicity to fish and other aquatic organisms and wildlife.

Table 12. Premix Insecticide Products: The following products are available as premixes of two or more insecticides.

Product Name/ Common Name	Insecticide Active Ingredient	Formulated Rate (fl oz or oz/A)	lb AI/A	Acres Treated per gallon/lb	Signal Word	Insecticide Class (*IRAC Groups)	Re-entry Interval	Pre-harvest Interval	Primary Pests Controlled (See product label for other pests that may be controlled and specific rates.)
Skyraider	bifenthrin + imidacloprid	2.6–6.4	0.0406–0.1 + 0.0203–0.05	49.23–20	Warning	Pyrethroid (3A) + Neonicotinoid (4A)	12h	14	Plant bugs, stink bugs, whiteflies
Brigadier	bifenthrin + imidacloprid	3.8–7.7	0.03–0.06 + 0.03–0.06	33.68–16.62	Warning	Pyrethroid (3A) + Neonicotinoid (4A)	12h	14	Plant bugs, stink bugs, whiteflies, saltmarsh caterpiller
Hero	zeta-cypermethrin + bifenthrin	3.6–10.3	0.00875–0.025 + 0.02625–0.075	35.55–12.43	Caution	Pyrethroid (3A) + Pyrethroid (3A)	12h	14	Grasshoppers, bollworm, stink bugs, saltmarsh caterpillar
Besiege	lambda-cyhalothrin + chlorantraniliprole	6.5–12.5	0.0218–0.0407 + 0.0424–0.0815	19.69–10.24	Warning	Pyrethroid (3A) + Diamide (28)	24h	21	Most caterpillar pests, stink bugs
Intrepid Edge	methoxyfenozide + spinetoram	4–8	0.0781–0.156 + 0.156–0.0313	32–16	Caution	Diacylhydrazine (18) + Spinosyn (5)	4h	28	Most caterpillar pests
Leverage 360	imidacloprid + beta-cyfluthrin	2.8–3.2	0.0438–0.05 + 0.0219–0.025	45.71–40	Caution	Neonicotinoid (4A) + Pyrethroid (3A)	12h	14	Grasshopper, plant bugs, stink bugs
Bidrin XPII	dicrotophos + bifenthrin	8–12.8	0.250–0.400 + 0.063–0.100	16–10	Danger	Organophosphate (1B) + Pyrethroid (3A)	6d	30	Plant bugs and stink bugs
Athena	bifenthrin + avermectin B1	7–17	0.0416–0.101 + 0.00602–0.0146	18.29–7.53	Caution	Pyrethroid (3A) + Avermectin (6)	12h	20	Spider mites, stink bugs, plant bugs
Endigo ZC	lambda-cyhalothrin + thiamethoxam	4.5–6	0.0309–0.0378 + 0.0461–0.0553	25.6–23.27	Warning	Pyrethroid (3A) + Neonicotinoid (4A)	24h	21	Plant bugs, stink bugs, whiteflies
Gladiator	zeta-cypermethrin + avermectin B1	19	0.0255 + 0.0116	6.74	Caution	Pyrethroid (3A) + Avermectin (6)	12h	20	Spider mites, stink bugs
Velum Total	fluopyram + imidacloprid	14–18	0.164–0.211 + 0.237–0.305	9.14–7.11	Caution	N/A + Neonicotinoid (4A)	12h	30	Thrips
Fyfanon Plus ULV	malathion + gamma cyhalothrin	8.00–16.00	0.588–0.009 + 1.175–0.019	16–8	Warning	Organophosphate (1B) + Pyrethroid (3A)	2d	21	Stink bugs, plant bugs, bollworms
Cobalt advanced	chlorpyriphos + lambda-cyhalothrin	16–42	0.313–0.016 + 0.82–0.042	8–3	Warning	Organophosphate (1B) + Pyrethroid (3A)	24h	21	Stink bugs, plant bugs, bollworms
Stallion	zeta-cypermethrin + chlorpyrifos	9.25–11.75	0.020–0.20 + 0.025–0.25	13.84–10.89	Warning	Pyrethroid (3A) + Organophosphate (1B)	24h	14	Stink bugs, plant bugs, bollworms

Nozzle Selection

For adequate coverage of the target, insecticides require smaller droplets than systemic herbicides do. When choosing nozzles for insecticide applications, consider both the droplet size and the spray volume. Smaller droplets provide better coverage, but larger droplets are less likely to drift.

Air induction nozzles recommended for new herbicide technologies produce a coarser spray that is less prone to drifting. However, these nozzles can reduce insecticide penetration through dense plant canopy, resulting in a less thorough coverage. Improve penetration through the plant canopy by increasing the final volume (no less than 10 gallons per acre with a preference of 15 gallons per acre), lowering the boom to just above the plants, increasing the operating pressure, and slowing down the travel speed. Research indicates that penetration is better with hollow-cone nozzles compared to air induction nozzles when using high final volumes (15 to 20 gallons per acre). To improve aerial application coverage, increase the spray volume (about 5 gallons per acre) where practical.

Always read the label. Pesticide product labels may specify what droplet size and spray volume to use. This information will direct nozzle selection and, in turn, affect spraying equipment configuration and calibration.

Photo Credits

Max Badgley, University of California: pink bollworm adult
Jim Baker, North Carolina State University, Bugwood.org: green peach aphid adult
Apurba Barman, Texas A&M University: tobacco budworm moth
Mike Blanton, Texas A&M University: boll weevil larva
Lyle Buss, University of Florida: cotton stainer adult
James Castner, University of Florida: cotton stainer nymph
Andrew Jensen, BugGuide.net: cowpea aphids feeding on weedy kochia
David Kerns, Texas A&M University: adult thrips, beet armyworm, beet armyworm damage, Christmas tree-like growth from wireworm feeding on plant terminal, false wireworm larva, immature thrips, map of major cotton growing regions in Texas, stand loss due to wireworms, wireworm stem girdling
Xandra Morris, Texas A&M University: cotton aphid, cotton aphid colony on the underside of a cotton leaf, cotton fleahopper nymph
Pat Porter, Texas A&M University: beet armyworm, beet armyworm moth, collops beetle, cotton boll, cotton bollworm larval colors, cotton bollworm moth, cotton spraying, cotton square borer adult, cotton stripper in field, crab spider, fall armyworm, fall armyworm egg mass, ichneumonid wasp, lygus bug adult, plant terminal inspection for cotton fleahoppers, prominent inverted Y on the head of fall armyworm, saltmarsh caterpillar, sampling for thrips, twospotted spider mite, whitefly adult
Mike Quinn, TexasEntoNet: adult darkling beetle, click beetle, verde plant bug adult
Steven Roberson, North Carolina State University: green stink bug adult
Winfield Sterling, Texas A&M University: big-eyed bug, boll weevil adult, braconid wasp, brown lacewing, cotton fleahopper nymph, cotton square borer larva, damsel bug, ground beetle, lygus bug nymph, minute pirate bug, pink bollworm damage, pink bollworm larvae, spined soldier bug, whitefly nymph
Scott Stewart, University of Tennessee: fall armyworm egg hatch, cutworm larva
Michael Toews, University of Georgia: boll wall warts
Jeff Trahan, BugGuide.net: cutworm moth
Salvador Vitanza, Texas A&M University: cotton fleahopper adult, cotton square borer adult, lady beetle adult, twospotted spider mite infestation underside of cotton leaf
Suhas Vyavhare, Texas A&M University: aphid colony on the plant terminal, beat bucket sampling, beet army-worm, blasted square, Conchuela stink bug adult, Conchuela stink bug nymph, cotton bollworm, cotton bollworm damage, cotton bollworm egg, cotton field, cotton plant, differential grasshopper adult, drop cloth sampling, external signs of stink bug feeding, grasshopper damage, grasshopper nymph, green lacewing, honeydew accumulation on leaves, leaf curling from cotton aphid infestation, lint staining caused by stink bug feeding, lygus bug adult, lynx spider, saltmarsh caterpillar, sweep net sampling, syrphid fly, tachinid fly, young cotton leaves damaged by thrips
Mo Way, Texas A&M University: Southern green stink bug adult
S219 Regional Project: brown stink bug adult

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