First Bloom to First Open Boll

Management decisions and weather conditions early in the growing season have a direct influence on boll set and yield potential. Because the eastern part of Texas has a long growing season, the cotton plant may be able to recover if fruit set is below average. In the west, however, the first 3 weeks of fruiting determine 80 percent or more of the final yield.

During this period, cotton producers need to monitor and make decisions on plant development, fruit shed, water use, nutrients, insect management and late-season disease control.

Plant development

The period of first bloom to open boll places the greatest demands on the plant. Any shortage of carbohydrates, water or nutrients at this time will reduce yield.

Through photosynthesis, plants produce the carbohydrates (sugars) that provide the energy for plant growth and development. Cotton leaves that produce more carbohydrates than they need are called "sources." These source leaves supply the carbohydrates for other plant parts, termed "sinks." Sinks include developing fruit, leaves, stems and roots.

During the first 16 days after a leaf unfurls, the carbohydrates produced by that leaf are used for its own growth. Between days 16 to 25, the leaf reaches its prime as a source and exports its carbohydrates to other developing plant parts, such as bolls. At 4 weeks old, a leaf's carbohydrate production begins to slow until about day 60, when the leaf can no longer export sugars.

During the bloom period, the most active main stem leaf is five nodes below the terminal. At this time, the leaf 13 nodes below the terminal is nonfunctional.

Young squares can support themselves with carbohydrates from the bracts (triangular leaves immediately surrounding the flower bud). However, once the boll reaches 10 days old, it demands a tremendous amount of nutrients and carbohydrates. It becomes a very strong sink.

A young boll derives most of its food from the leaf immediately below it, which is termed the subtending leaf (Table 6.1). If the subtending leaf of a 4- to 7-day-old boll is shaded – for example, because of cloudy weather or a thick stand – the boll may shed from lack of carbohydrate supply.

Of the final weight of the boll, the subtending leaf contributes 50 percent and the nearest main stem leaf 35 percent. The remaining 15 percent comes from leaves elsewhere on the plant.

By the time a boll reaches peak carbohydrate demand, it is usually buried in the canopy and

Table 6.1. Carbohydrate sources to a first-position fruit.

1st Position Fruit Stage	Major Food Sources	Function of Stem Leaf	Function of Main Subtending Leaf
Pinhead Square	Bracts	Unfurling	Microscopic
Large Square	Bracts + Main stem leaf	Source	Unfurling
Small Boll	Bracts + Main stem leaf + Subtending leaf	Source	Source
Medium Boll	Bracts + Subtending leaf	Declining	Source
Large Boll	Leaves at top of plant + Subtending leaf	Declining	Declining

Source: D. Oosterhuis et al. 1990. Leaf Physiology and Management. Cotton Physiology Today. National Cotton Council Physiology Education Program Newsletter 1 (8): 1-6.

the leaves surrounding it are in dense shade. Bolls in this position must rely on leaves farther away at the top of the plant for carbohydrates.

Water stress, cloudy weather and nutrient deficiencies can all decrease photosynthesis and therefore reduce the carbohydrate-supplying power of the plant.

First bloom is a good time to evaluate the overall status of the plant. At 7 to 14 days after first bloom, check square retention and the number of nodes above white flower (NAWF). NAWF at early bloom will vary, depending on management and the level of stress encountered by the crop. NAWF provides a good estimate of the potential boll sites.

Studies conducted in the Coastal Bend indicate that crops produce average yields if they retain 60 to 70 percent of first- and second-position fruit (squares, flowers and bolls). Table 6.2 shows potential management guidelines for cotton production in the Coastal Bend based on fruit retention.

Drought, disease and pests can reduce terminal growth and NAWF at early bloom. Insects that remove squares, such as cotton fleahoppers and Lygus bugs, may actually increase NAWF at early bloom.

To determine NAWF, count the nodes above a first-position white flower. If the NAWF count at early bloom is below seven, the plant may reach cutout prematurely unless the plant stress is relieved. Much of the dryland production in the western part of Texas enters early bloom at this stage.

To maintain growth, producers must carefully manage inputs. An NAWF count above 10 at early bloom may indicate reduced fruit retention or rank growth. You will need to monitor the fields continually to determine the proper management strategies.

A rapid decline in NAWF can be good or bad. It may signify excellent boll retention and high demands for nutrients and water. However, it may also indicate severe drought stress, which should be alleviated with irrigation where possible.

If NAWF remains above 10 or increases rapidly, a more significant problem may exist. This indicates that there are not enough bolls to prevent additional terminal growth. You will need to respond immediately to avoid rank growth and delayed maturity.

The plant continues to add squares and develop bolls at early bloom. The ovary (where the seed develops) is compound in domesticated cotton. A Pima cotton ovary averages three to four carpels (sections) or locules (locs) per boll. An upland cotton ovary averages four to five locs per boll.

The number of locs is determined early in square formation (3 weeks before flower opening). Although the number is strongly influenced by genetics, environment also plays a role. Most studies indicate that the carbohydrate status of

Table 6.2. Management guidelines based on plant mapping at early bloom. Corpus Christi, TX.

	Fruit Retention at First and Second Position Fruiting Sites	
Factors Affected	**Below 60%**	**Above 70%**
Yield potential	Below average	Above average
Potential for rank growth	Higher	Lower
Need for Pix®	Higher	Lower
Need for nutrients	Lower	Higher

Source: J.A. Landivar and J.H. Benedict. 1996. Monitoring System for the Management of Cotton Growth and Fruiting. Bulletin B-2. TAES, Corpus Christi. 16pp.

the plant influences the relative formation of four or five loc bolls. Moisture stress plays a relatively minor role. Factors such as shading and limiting resources produce bolls with fewer locs.

A cotton flower opens in the morning and then sheds its pollen. Cotton is generally considered a self-pollinating plant (if there are no insects, 95 to 99 percent of the flowers are self-pollinated). Cotton pollen is sensitive to moisture and can rupture upon contact with water (rainfall or irrigation) within 30 to 60 seconds.

The cotton fibers begin to elongate from the surface of the ovule (unfertilized seed) and can elongate for a few days even if the ovule is not fertilized. The unfertilized ovules are called motes.

Fiber initiation is sensitive to temperature. Hot weather during initiation produces shorter fibers, fewer seeds per boll, smaller seeds and smaller bolls. An average seed has 13,000 to 21,000 lint fibers, and the average loc has six to nine seeds.

Young seeds produce hormones that increase the flow of nutrients and carbohydrates to them. Bolls that produce fewer than 10 to 15 seeds are not strong sinks and are ultimately shed. High temperatures are the major cause of low seed counts.

As the fiber is lengthening and the seed expanding, the boll wall enlarges. The boll reaches maximum size and fiber reaches its maximum length in about 20 days. A lack of potassium or water can limit boll size, seed size and fiber length.

During the remainder of boll development, micronaire, maturity and strength are determined. Cellulose is laid down in winding sheets around the inside of the cotton fiber. Warm weather favors cellulose deposition and may increase micronaire values. Cool weather reduces cellulose deposition and can reduce micronaire values.

Fiber strength is related to the average length of the cellulose molecules deposited inside the cotton fiber. The longer the cellulose chains, the stronger the fiber. Genetics controls about 80 percent of strength development, although environment does have some influence. Excessive weathering and over-ginning can weaken fiber.

Seed quality is determined in the later stages of development. Seeds reach maximum size 4 weeks after pollination. After day 25, the embryo begins to accumulate protein and oil. The same factors that decrease the maturity of the fibers also lower seed quality.

Fruit shed

Square and boll shed are common and can be attributed to numerous factors. Large squares, blooms and medium to large bolls are generally resistant to environmental shed. Small boll shed may be an important natural process by which the plant adjusts its fruit load to match the supply of inorganic and organic nutrients.

Shedding is controlled by a series of plant hormones that regulate growth, fruiting, flowering and abscission. Boll retention declines throughout the boll-loading period as the overall nutrient "sink" demand increases.

Boll position also influences boll retention. First-position sites (bolls closest to the main stem) have a higher retention rate. Because of shading, pest pressure, light, water and nutrient availability, bolls located at second and third positions are less likely to be retained.

Although these second- and third-position bolls contribute more to yield in the eastern part of Texas because of the longer growing season, the first-position bolls generally contribute the most to the overall yield.

Water

The plant's water use increases dramatically during the stage from first bloom to open boll. Measured as evapotranspiration (water lost from the soil and the plant), water use can be as high 0.4 inches per day or 2.8 inches per week (Figure 6.1).

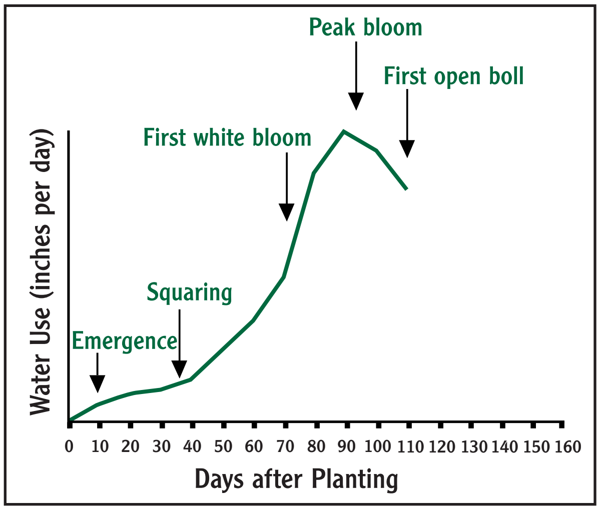

Figure 6.1. Water use for cotton up to first open boll.

Because the soil is the storage site for water available to the plant, the primary factor in determining water-holding capacity is soil texture.

The more surface area per unit volume of soil, the more water it can hold (Table 6.3). Sand particles have the largest diameter and the least surface area per unit weight. Therefore, sand retains the least water. Clay particles have the most surface area and thus retain the most water.

The total amount of water available to the growing crop is determined by the texture of each soil zone in the effective rooting depth. Rooting depth is affected by both chemical and physical soil characteristics.

Once blooming starts, cotton prefers frequent, low-volume applications of water rather than large, less frequent amounts. This strategy minimizes the degree of water stress between rain or irrigation and thus increases fruit retention.

In the western part of Texas, very few producers have the irrigation capacity to satisfy crop demands (0.3 to 0.4 inches per day). Table 6.4 shows the relationship between irrigation water supply and a crop water demand of 0.3 inches per day.

Because center pivot irrigation systems are so prevalent in west Texas, irrigation studies have focused on making these systems more efficient and on optimizing production with limited irrigation. Low energy precision application (LEPA) irrigation systems (circle rows, dragging socks in alternate furrows, furrow diked) will extend water because of increased application efficiency.

Research indicates that cotton responds very well to high-frequency deficit irrigations, even with amounts as low as 0.20 to 0.25 inch applied every 2 days (Table 6.5). When irrigation capacities are above 0.2 inch per day, the frequency of irrigation is not as critical.

Table 6.3. Inches of water held per foot of soil depth.

	Clay loam	Loam	Sandy loam	Loamy sand
Textural Class	Inches of Water Held Per Foot of Soil Depth			
Field capacity	4.8	4.2	3.6	2.4
Permanent wilting point	2.4	2.1	1.8	1.2
Plant available water	2.4	2.1	1.8	1.2

Table 6.4. Relationship between irrigation water supply and crop water replacement when water use is an average of 0.3 inches per day. GPMA is gallons per minute per acre.

Irrigation, GPMA	1	2	3	4	5	6
Irrigation, inches/acre/day	0.052	0.104	0.155	0.207	0.259	0.311
% water replacement	17	34	52	69	86	104

Table 6.5. Cotton lint yield using LEPA irrigation at three irrigation capacities and three frequencies of application. Halfway, TX. 1995-1997.

Irrigation Capacity		Seasonal Irrigation	1 Day Frequency	2 Day Frequency	3 Day Frequency
Inches per Day	Gallons/Minute Per Acre		Pounds of Lint per Acre		
0.1	2	4.6	917 b	980 a	922 b
0.2	4	6.7	1142 a	1120 a	1110 a
0.3	6	7.1	1165 a	1142 a	1187 a

Values in a row followed by the same letter are not statistically different.

Nutrient management

Cotton requires most of its nutrients during the fruiting stage. During this time, bolls are heavy consumers of nutrients, and any shortage will reduce yield (Figure 6.2). Nitrogen fertilizer should be applied before first bloom.

Growers can use irrigation systems to deliver nitrogen and other nutrients to the crop. This method is used extensively in west Texas, where center pivot irrigation comprises 50 percent of the acreage, and soils are very sandy.

Under most conditions, soil-applied nutrients are adequate to meet crop demands. However, in some situations, foliar fertilization can increase yields. Foliar feeding may be useful in exceptional years when there is a very high boll set (above 70 percent) and not enough nitrogen was applied or in seasons when high rainfall has leached the nitrogen below the root zone. Keep in mind, however, that foliar fertilization increases yield only when there is a nutrient deficiency.

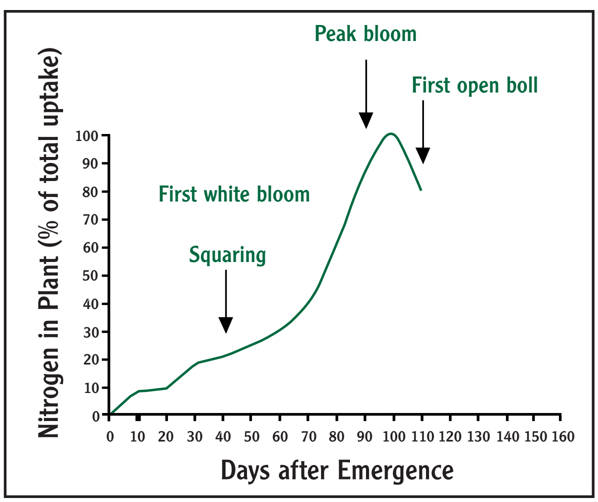

Figure 6.2. Percent nitrogen in plant up to white bloom.

To increase yield, at least three applications totaling 15 pounds of actual N are usually required. Make applications at early bloom and then on 7- to 14-day intervals if the cotton is not under stress.

To avoid injuring the leaves, use feed-grade or low-biuret urea. A typical rate on irrigated cotton is 3 pounds of urea per gallon of water (equivalent to 1.38 pounds of actual nitrogen per gallon) and for dryland, 1.8 pounds of urea per gallon of water (equivalent to 0.84 pounds of actual nitrogen per gallon).

Each application should deliver a minimum of 5 pounds of actual nitrogen per acre. The urea solution will break down quickly, releasing ammonium. Because this ammonium is converted to ammonia, which is toxic to plant tissue, use the solutions immediately. Do not let the mixture stand overnight or serious plant injury could occur.

Insect management

Insects that attack cotton in this growth stage include boll weevils, bollworms/tobacco budworms, beet armyworms, pink bollworms, aphids, *Lygus* spp., stink bugs, whiteflies and spider mites.

In areas without boll weevil eradication programs, boll weevils are a key pest around which all management tactics revolve. The need for treatments for lepidopterous pests (bollworm, tobacco budworm, pink bollworm and beet armyworms) will vary from year to year. Whiteflies, *Lygus* spp., stink bugs, spider mites and aphids can also occasionally cause problems.

Insect monitoring is critical at this time of the season because the plants probably will not compensate for any bolls lost after the first 2 weeks of bloom. Fields should be checked every 3 to 5 days during the blooming period.

Base treatment decisions on the value of the crop, the level of damage caused by the insect and the cost of control. Keep in mind that published thresholds are starting points to help in making decisions.

Boll weevils

When scouting for boll weevils, evaluate the squares. Boll weevil adults and larvae feed on developing pollen in flower buds and seed in bolls. Check the field margins near boll weevil habitats as well as the rest of the field.

Treat the fields when 15 to 20 percent of fruiting forms are damaged. When assessing damage, be sure to pick green squares and bolls. Squares damaged by boll weevils will not shed until 5 to 7 days later. Square shed is primarily a response to boll weevil larvae reaching the second instar (first molt) stage. Picking yellow or flared squares (bracts folded open) will overestimate the damage by this pest.

For complete control, repeat insecticide applications at 5-day intervals over a 30-day period. The insecticide may have to be applied in shorter intervals if fruit damage does not decrease and fresh evidence of damage is present between the 5-day applications.

Because the insecticides used for boll weevils (organophosphates and pyrethroids) have a severe impact on natural enemies, producers must be alert for other pest outbreaks. Natural enemies have little effect on in-season populations of boll weevils. Once squares have shed, fire ants in the eastern part of the state will feed on boll weevil larvae and pupae.

Bollworm/tobacco budworm

These two pests are considered together because their population dynamics and damage to cotton are identical. When scouting for bollworms/tobacco budworms, look for larvae and evaluate green squares. Adult moths are attracted to flowering cotton, and larvae feed on all stages of the fruiting forms.

In much of the state, treatment is begun if eight to 12 small (less than 1/4 inch) larvae are found per 100 plants and 5 to 10 percent of green squares are damaged. In the Rolling Plains and High Plains, thresholds are based on 5,000 small (less than 1/4 inch) larvae per acre and 5 to 10 percent damaged green squares.

When many larvae (more than 15 per 100 plants, or 10,000 larvae per acre) are found, you cannot afford to wait for plant damage to appear. Adjust thresholds depending on the ability of the person searching to find small larvae.

Frequent scouting can make treatment decisions easier. By scouting every 3 to 4 days, growers have a better estimate of damage and population changes.

Management decisions for cotton varieties that contain the *Bacillus thuringiensis* (Bt) insecticidal protein gene are similar to those for conventional cotton. Thresholds remain the same except that producers should wait for larger larvae (longer than 1/4 inch) to develop. Bollworms have a greater tolerance for the protein, so the cotton may have to be treated if bollworm populations are high. Transgenic varieties control about 90 percent of the bollworms and 95 to 99 percent of the tobacco budworms.

Survival is higher in blooming cotton because less insecticidal proteins are present in blooms compared to squares and bolls.

Producers have many choices of insecticide, depending on the product efficacy, pests present, impact on natural enemies and cost. Tobacco budworms are generally less susceptible to the pyrethroid class. They can be monitored with pheromone traps, and kits are available to help differentiate between the two species.

The introduction of boll weevil eradication programs and Bt cotton has renewed interest in using natural enemies. Studies in the Blacklands have shown that up to 90 percent of the eggs and small larvae never reach the fourth or fifth instar, the most damaging stages of bollworm/tobacco budworm complex (Table 6.6).

The disappearance can be attributed to weather (rainfall and high winds) and predators removing the eggs and first instar larvae. Important predators include minute pirate bugs, insidious flower bugs, big-eyed bugs and damsel bugs. Other predators, such as lacewing larvae, hooded beetles, fire ants and lady beetles, also have an impact.

The egg parasite, *Trichogramma*, has a limited impact (Table 6.6), and larval parasites are relatively unimportant.

Beet armyworms

Beet armyworms are an occasional pest usually associated with mild winters (absence of prolonged freezing temperatures), late planting, delayed crop maturity, drought, weather conditions that favor long-distance migration and high use of insecticides before bloom. There is a greater chance of beet armyworm problems developing when they are present before bloom.

Thresholds are higher for this pest because it feeds primarily on leaves. However, the larvae will feed on all stages of fruit.

Treatment decisions are made when 20,000 small larvae are found per acre and 10 percent of the plants are infested. Lower the thresholds to bollworm/tobacco budworm levels when the beet armyworm larvae shift to feeding on fruit.

Beet armyworms are difficult to control. Insecticide control for this pest is more expensive than for bollworm/tobacco budworm.

Pink bollworms

Pink bollworms are an economic problem in the Trans-Pecos Valley region. Larvae prefer 15- to 20-day-old upland cotton bolls. Pima cotton bolls are susceptible to damage until the bolls are 35 to 40 days old. Because of the length of susceptibility to pink bollworms, scouting for them must extend later into the season than for any other pest.

During the growing season, pink bollworm management includes using pheromone traps, pheromone mating disruption and insecticides. Begin monitoring at seedling emergence and continue throughout the season. Once plants start flowering, monitor also for blooms that are rosetted (the petals are webbed together by small larvae).

Table 6.6. Mortality of egg and first instar larvae in unsprayed cotton fields. Thrall, TX.

Year	Percent Parasitism	Percent Disappearance	Total Mortality
1991	8.1	71.6	79.7
1992	5.6	79.7	85.3
1993	0.3	89.8	90.1
1994	6.7	61.0	67.7
1995	6.2	80.5	86.7

Thresholds are based on selecting 10-day-old bolls (those with a diameter the size of a quarter) and examining the inside of the carpel wall for the entrance wart (small growth) and mines of small larvae. Inspect the lint and seed also for small larvae.

Begin treatments when 10 to 15 percent of the bolls in upland cotton are infested and when 5 to 10 percent of the bolls in Pima cotton are infested. This treatment in upland cotton should stop when the last harvestable boll is difficult to cut with a sharp knife. Treatment ends in Pima cotton when 70 percent of the bolls are open.

Pink bollworms have been controlled in the rest of the state with cultural practices that emphasize stalk destruction. In the Trans-Pecos/El Paso Valley, problems can be reduced by irrigations in late winter, cultural practices that promote early crop maturity and crop termination by September.

Bt cotton is highly effective against pink bollworm and has reduced the significance of this pest in Far West Texas. The introduction of the transgenic technology and boll weevil eradication has resulted in the creation of a pink bollworm suppression program.

Aphids

Aphids are an occasional problem late in the season in the eastern part of the state. In West Texas, aphids are a key pest with distinct population increases regardless of any management practices applied to the cotton (Figure 6.3).

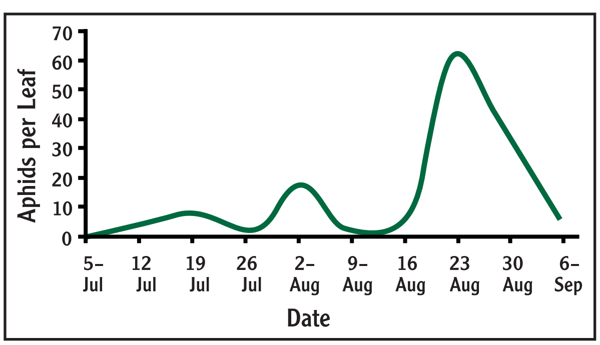

Figure 6.3. Seasonal increases for cotton aphid. Chillicothe, TX. 1994.

In the eastern part of the state, most aphid outbreaks during the blooming period are caused by insecticide use and a resultant drop in natural enemy populations. In West Texas, late-season aphid outbreaks can occur as a result of reduced temperatures, adequate moisture and low light intensity.

Aphids reduce yields during the blooming period by becoming a "sink" for the carbohydrates produced by the plant, leaving fewer carbohydrates available to the plant and thus producing smaller bolls. The aphid parasite *Lysiphlebus testaceipes* and predators such as lady beetles, green lacewings and predatory bugs help control most aphid outbreaks. The insect pathogen *Neozygites fresenii* is a fungus that can help reduce populations in the eastern part of the state.

When deciding whether to treat for aphids, inspect a total of 60 leaves evenly divided among the top, middle and lower portions of the plant. Delay insecticidal control until there are more than 50 aphids per leaf. Although cotton can tolerate low populations (fewer than 50 aphids per leaf) for long periods, it is very sensitive to high populations (more than 100 aphids per leaf). At this level, make treatment decisions quickly to avoid yield loss.

Lygus spp.

Lygus spp., also known as plant bugs, damage large squares and small bolls. These insects have sucking mouthparts and prefer to feed on developing pollen and seeds.

Damage to squares is characterized by yellow staining before abscission. Damage to blooms results in black anthers (the part of the bloom containing the pollen) and puckered areas in the petals. Boll damage is often characterized as small black spots or small, sunken lesions. The black spots will extend through the boll wall and cause stained lint.

In East Texas, the primary species is the tarnished plant bug (*Lygus lineolaris*); in the west, the primary species is the western tarnished plant bug (*Lygus hesperus*). The western tarnished plant bug is generally harder to control and requires higher rates of insecticides.

Treatment decisions for *Lygus* spp. are some of the most difficult to make because of the difficulty of finding the insects. Thresholds in the eastern part of Texas are based on using a sweep net and finding 20 to 30 per 50 sweeps and the presence of damage. In the west, thresholds are based on using a beat sheet and finding two adults or nymphs per 3 feet of row and the presence of damage.

The goal during the blooming period is to maintain adequate fruit set (60 percent of the first position fruit retained). *Lygus* spp. is attracted to succulent growth. Natural enemies are ineffective for this pest.

Stink bugs

Stink bugs generally move into cotton after grain harvest, primarily on bolls up to 25 days old. The damage on bolls is very similar to that caused by *Lygus* spp., with small black spots on the outside and damage to developing seed on the inside. If bolls are growing rapidly, stink bugs and *Lygus* spp. bugs can produce a small growth or "wart" inside the boll wall.

Thresholds are based on finding one stink bug per 6 feet of row and damage. Some areas are shifting to a threshold based on injury to 10-day-old bolls. Bolls 10 days old are opened, and when 20 percent have stink bug injury, insecticidal control is necessary.

Brown stink bugs are difficult to control with pyrethroid insecticides and require a higher rate with the organophosphate class. Natural enemies are ineffective against this pest.

Whiteflies

Like aphids, whiteflies have sucking mouthparts and reduce yields by feeding on the carbohydrates produced by the plant.

In the Lower Rio Grande Valley, the primary whitefly is the silverleaf whitefly, sometimes called the sweet potato whitefly. This whitefly can also transmit a viral disease that has been a problem in other countries and states but has not yet caused problems in Texas.

Thresholds are based on sampling the underside of the fifth leaf from the terminal. Consider treatment when the number of adults reaches five to 15 per leaf, or immature populations (nymphs and pupae) average 1 per square inch.

In other parts of the state, the primary whitefly is the banded wing whitefly. It is not as damaging as the silverleaf whitefly, and thresholds have not been set.

Cultural controls are very important for whiteflies. In the Lower Rio Grande Valley, winter and spring vegetables provide the greatest source of silverleaf whiteflies. The simplest way to lower potential populations is to destroy vegetable residue before planting cotton.

Natural enemies, including parasites and predators, play an important role in reducing both silverleaf and banded wing whitefly populations. Conserving natural enemies by limiting early season insecticide applications and planting smoothleaf cotton varieties can help reduce populations.

Using insecticides to control silverleaf whitefly is difficult and expensive. New growth regulators and pyrethroid and organophosphate combinations are effective. Banded wing whiteflies are easier to control with the pyrethroid and organophosphate combinations and with high rates of some of the organophosphates.

Spider mites

Spider mites are another sucking insect affecting photosynthesis. Problems usually occur during hot, dry conditions and after extensive use of insecticides. Spider mite thresholds have not been developed in Texas.

Spider mites infest the undersides of leaves, where they remove sap from the plant and cause the leaves to discolor. Mites may also infest the bracts of squares and bolls, causing the bracts to desiccate (dry out) and squares and small bolls to shed.

Insecticidal control is expensive. Begin treatment when you find mites, and damage is evident. Many spider mite populations start on field margins, especially next to dusty roads. Treating field margins can be effective.

Cultural control measures such as conserving natural enemies and managing irrigation will minimize the impact of this pest.

Late-season disease problems

Diseases to watch for in this period include cotton root rot, nematode damage, verticillium wilt, fusarium wilt, bronze wilt, leave spots, cotton rust and angular leaf spot.

Cotton root rot

During the blooming and boll fill period, two major disease problems become evident – cotton root rot and nematodes. Cotton root rot, also known as Phymatotrichum root rot or Texas root rot, is a disease caused by the fungus *Phymatotrichopsis omnivora*, which causes rapid wilting and death of the plant.

Unlike Fusarium or Verticillium wilt, this fungus causes a root rot. Brownish strands of the fungus can be found on the outer surface of the root. The infection progresses so quickly that dead leaves remain attached to the plant. The fungus is soil borne and is widespread throughout all cotton production areas of Texas except for the High Plains.

In Blackland soils, wilt may begin to appear 40 to 55 days after emergence. The disease kills plants in circular areas ranging from a few square yards to an acre or more.

Cotton root rot tends to occur in alkaline, calcareous soils. However, in these soil types, the fungus does not occur in all fields. Within a field, the fungus spreads in somewhat circular patches ranging from a few square yards to an acre or more. The fungus survives almost indefinitely as small, resistant, seed-like structures called sclerotia.

Management is very difficult and largely ineffective. The fungus remains in the affected areas, and continued planting of susceptible crops expands the affected area. However, the expansion is not permanent and will shrink in subsequent years by rotating crops and plowing deeply.

No data exist on the effects of conservation or reduced tillage on cotton root rot. Producers should try mapping large areas where root rot occurs and develop rotation schemes using nonsusceptible crops to avoid growing cotton in these areas in consecutive years.

Nematodes

Nematode injury also becomes evident during this growth period. Root knot nematodes are a problem primarily in sandy soils, and they are a major yield-limiting factor in the High Plains. In heavier soils, reniform nematodes are a problem. They are the major nematode in the Lower Rio Grande Valley.

Nematode-infected plants are stunted and wilt under drought stress several days before noninfected plants. Symptoms of the root knot nematode are swellings and galls on the roots. Reniform nematodes produce no remarkable root symptoms, but in addition to stunting the plant, infection may also result in reddish leaves that resemble potassium deficiency. The presence of nematodes may increase the severity of the fungus Fusarium wilt.

Because nematodes are not evenly distributed within a field, affected areas will not expand significantly during the growing season. Tillage operations can redistribute nematodes through a field, but the spread will not be evident until the next year.

If you suspect a nematode infestation, sample the soil while the plants are still in the field. If nematodes are found, crop managers should begin making plans to manage nematodes for the next growing season either with crop rotation or the use of nematicides (products used to control nematodes).

Verticillium and fusarium wilt

Two soil-borne diseases are caused by fungi that cause the plants to wilt but do not cause a root rot. They are Verticillium and Fusarium wilt. Both cause browning of the vascular system that can be seen by examining a cross-section of the stem, as well as stunting. The foliage becomes yellow, dies and falls off.

The diagnosis of the fungus causing a wilt requires a laboratory examination. Verticillium wilt, caused by the fungi *Verticillium dahliae* and *V. albo-atrum,* occurs in Far West Texas and the High Plains.

In addition to reducing lint and seed yield, this fungus can reduce fiber quality. Symptoms become evident after the first fruiting squares occur.

Cool temperatures, excessive soil moisture and excessive nitrogen favor the disease. Because the fungus is persistent in soil, crop rotation does not help. In fields where this disease is a problem, use resistant or tolerant varieties.

Fusarium wilt, caused by the fungus *Fusarium oxysporum* f. sp. *vasinfectum*, is not a major disease in Texas. Although it has been reported occasionally in the High Plains, it is primarily a problem in acidic soils, particularly in the former cotton production areas of East Texas.

Wilting occurs rapidly with a rain that follows a dry spell. This fungus is also persistent in soil, so the best control measure is to use resistant or tolerant varieties.

Bronze wilt

Another wilting disease that can appear during this period of growth is bronze wilt (also known as sudden wilt and coppertop), a recently recognized disease that has been reported from several cotton production areas of the southeast United States. The suspected cause is a soil-borne bacterium, but this identification remains controversial.

Symptoms include stunting, wilting, a copper-colored discoloration of foliage, reddening of the stem and fruit shed. Plants may die, especially if the disease sets in early.

The disease is favored by high temperatures or drought stress followed by heavy rainfall or irrigation. It is more severe in later plantings and is randomly scattered within a field.

Diagnosis of this disease is difficult because the symptoms can resemble those caused by other factors, including premature cutout, normal senescence, nutrient depletion or other environmental stresses. Control the disease by minimizing water and fertility stress. Some varieties are apparently more susceptible to bronze wilt than other varieties (Table 6.7).

Table 6.7. Varieties in which bronze wilt has been observed.

Dyna-Gro 205	Fibermax 963*	Paymaster 1215*
Paymaster 1215 BG*	Paymaster 1215 BG/RR*	Paymaster 1218*
Paymaster 1218 RR*	Paymaster 1218 BG/RR	Paymaster 1220*
Paymaster 1220 RR*	Paymaster 1220 BG/RR*	Paymaster 1244*
Paymaster 1244 RR*	Paymaster 1330 BG*	Paymaster 1560 BG
Paymaster 1560 BG/RR	Suregrow 125 RR	Suregrow 125 BG/RR
Stoneville 132*	Stoneville 373*	Stoneville BXN 16
Texas 14		

*Varieties are no longer commercially available in the United States.
Source: *Bronze Wilt in Cotton.* **L-5412.**

Leaf spots

Although leaf spots caused by fungi can appear during this growth period, their effect on yield is generally minor. These diseases tend to be more prevalent at crop maturity and during periods of high humidity or rainy weather. Under sustained wet weather, the plants can lose foliage prematurely.

There is no control for leaf spot fungi; prevention includes plowing under crop residue and maintaining good management practices. Also, some varieties are more susceptible to late-season leaf spot fungi.

Cotton rust

Cotton rust, caused by the fungus *Puccinia cacabata*, is a problem in the Trans-Pecos area of West Texas, where it may reduce yields by as much as 50 percent.

Rust first appears as small, yellowish spots or pustules on upper leaf surfaces, bracts, green bolls and stems. These enlarge, developing orange to reddish centers. After 2 weeks, large orange pustules appear on the lower leaf surface and discharge orange spores (aeciospores). Having several lesions on a leaf may cause it to shed. The rust lesions also weaken stalks, stems and petioles, causing breakage on these parts. Broken stalks are more difficult to cultivate and harvest mechanically.

The aeciospores released on the cotton do not reinfect the plant, but are windblown to wild grama grass. The spores that originate from grama grass infect cotton, which serves as an alternate host for the fungus. Spore production on grama grass and infection of cotton occurs after a rainfall of $^{1}/_{2}$ inch or more, followed by 12 to 18 hours of high humidity.

The only effective way to control cotton rust is by applying mancozeb to the leaves before symptoms appear. Apply the chemical in June or July, before rains. One or two additional applications may be needed. There is no control once symptoms are visible.

Angular leaf spot

Angular leaf spot can also appear on foliage during this period of growth. The disease will appear and spread after periods of rainy weather. Dry weather conditions will stop its progress. Symptoms may also be seen on the bolls as round, water-soaked lesions that later turn brown or black.