# Emergence to First Bloom



Cotton plants grow in an orderly manner, producing new nodes, internodes, leaves and squares from meristems (growing points) over the course of the season. The plant growth stage of cotton from emergence to first bloom requires 7 to 9 weeks.

The growth rate of cotton vegetation follows an S-shaped curve pattern (Figure 5.1). Recently emerged seedlings grow slowly until the squares (flower buds) reach the match-head stage (3/16 inch in diameter). Then the growth speeds up substantially.

During this period, growers need to continue monitoring plant development; control insects, weeds and diseases; and make decisions on the use of water, fertilizers and plant growth regulators.

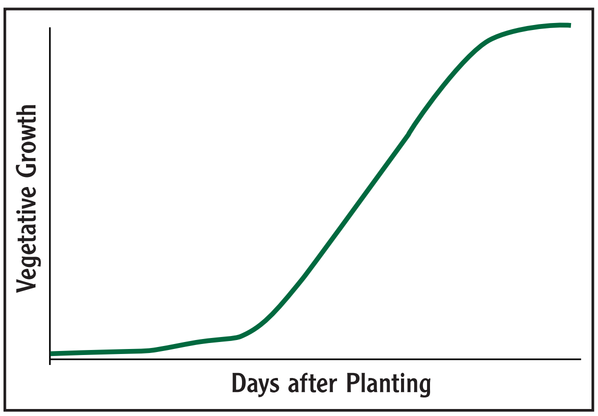


**Figure 5.1. Vegetative growth curve for cotton.**

## Plant development

Cotton plants grow slowly at emergence (the lag phase) because of the plants' limited leaf area, cooler temperatures early in the season and pests.

The first leaves that emerge are the cotyledon or seed leaves, the only leaves on the plant that grow directly opposite each other. Cotyledon leaves are primarily storage tissues; they have minimal ability to produce photosynthates (food).

If both cotyledons are lost within the first week after emergence, plant maturity will be delayed because the leaves do not have time to transfer their stored nutrients to other plant parts. After the cotyledons emerge, the plant develops main-stem or true leaves. Later in the season, subtending leaves develop on fruiting branches, which are critical to boll set and boll fill.

Through the process of photosynthesis, leaves produce carbohydrates that the plant uses to survive, grow and produce fruit. A leaf's ability to produce carbohydrates is closely related to its age. Leaves that are 16 to 25 days old are prime producers and exporters of carbohydrates to other parts of the plant. After this age, they become less able to supply photosynthates. A 60-day-old leaf is unable to supply food reserves for developing fruit.

During the early stages of plant development, the roots grow faster than the plant parts aboveground. A young taproot may extend 6 inches into the soil by the time the first true leaf is visible. Soon after the first true leaf appears, the roots begin developing an extensive lateral system.

Roots grow where moisture, oxygen and temperature are optimum. As these three factors decline, root growth slows and, as a consequence, the plant takes up less water and nutrients.

To provide more oxygen to the roots, producers using conventional tillage systems (clean tillage) can aerate the soil with shallow cultivation. This can break up any crusting that has developed and speed surface drying. Because drier soils are usually warmer, aeration can also warm the soil.

Minimum or conservation tillage systems do not offer this option, but the surface residue left by these systems usually minimizes soil crust formation. Root channels and increased organic matter in minimum tillage systems also promote better soil aeration.

## Insect control

Before the reproductive stage, the primary insect pests of cotton are the thrips complex (*Thrips* spp., *Frankliniella* spp., etc.) and the aphid complex (cotton aphid, green peach aphid and cowpea aphid).

Thrips are a concern in most cotton-producing regions of the state, except for the Lower Rio Grande Valley and the Southern Rolling Plains. In these two areas, thrips are a problem when cold, wet weather is present for an extended period or when weather conditions slow vegetative growth, leaving the terminal vulnerable to injury for a longer period.

Thrips and aphids delay plant maturity. However, the cotton plant can compensate for poor growing conditions early in the season. This ability has made thrips and aphid control somewhat controversial in Texas cotton, because treatments are often made but untreated cotton does as well as treated cotton. In the eastern part of the state, the growing season is not a limiting factor, and the cotton has time to recover from reduced early-season growth.

Recent research has shown that cotton is extremely susceptible to thrips damage before squaring. By the time producers notice damage (crinkled leaves, leaf margins curling upwards), the economic damage has been done.

Control of thrips may be justified when the plants have about as many thrips as true leaves. In areas with a history of frequent, high thrips populations, producers should consider using seed treatments or in-furrow, at-planting insecticides.

The only exception to the use of in-furrow insecticides may be in a West Texas dryland production system. Moisture is usually the limiting factor, and any yield increase from thrips control may not justify the cost of the insecticide.

The aphid complex rarely causes economic damage before blooming. However, damage from aphids can be severe during cool, wet weather when the cotton plant is developing slowly.

Because no thresholds have been established for early-season aphids, growers should base their treatment decisions on the health of the crop.

## Weed control

In general, weed control is critical during the first 6 weeks of the season. Because every production region has its own specific weed problems, each area addresses weed management from a different perspective.

Although having a few weeds in a field generally has little effect on production and harvesting, having many weeds can cause severe problems. Every crop has a critical period, or a maximum period, when weeds can be tolerated without affecting final crop yields (Figure 5.2).

The critical period for cotton is the first 10 weeks after planting. In Figure 5.2, the upper line (—▲—) shows that if weed competition ends at 4 weeks, little yield is lost. The lower line (—●—) indicates that the longer the weed-free period, the higher the yield.

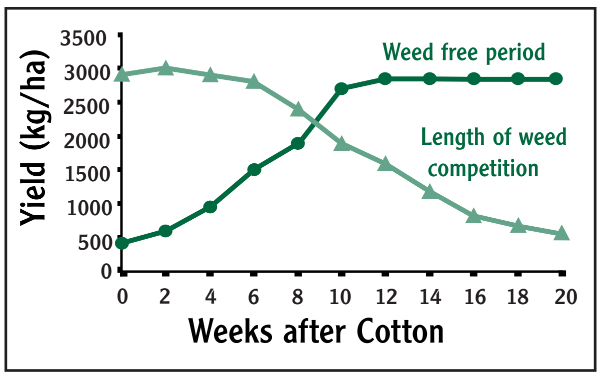


**Figure 5.2. Affect of length of weed competition on seed cotton yields.**

In general, crops are more sensitive to weed competition under conditions favoring high yields. If conditions are good for the crop, they are good for the weeds and so competition is greater. To reduce early-season weed growth, most producers use preplant incorporated herbicides in combination with preemergence products at planting.

However, weed management has changed rapidly as growers have adopted minimum tillage/conservation tillage practices and transgenic herbicide-resistant cotton varieties. In 1999, Texas growers planted more than 2.28 million acres of Roundup Ready™, 340,000 acres of stacked gene (transgenic insect and weed combined) and 150,000 acres of BXN® varieties.

Although many producers continue to use some soil-applied herbicides in concert with the new technology, many others are only using the postemergence system.

Producers using herbicide-resistant varieties must be aware of these systems' limitations. For example, when sprayed over the top of cotton, glyphosate-type herbicides (Roundup®, Touchdown®, etc.) must be applied before the fifth true leaf emerges. Beyond that stage, producers should use equipment such as hooded and post-directed sprayers, which minimize the herbicide's contact with the cotton plants.

If growers fail to follow the label instructions, yield can be reduced substantially. Unfortunately, the effects of glyphosate injury cannot be seen on the vegetative portions of the plant; it is evident only by the absence of bolls. Beyond the tolerant five-leaf stage, applying glyphosate over-the-top postemergence will induce the plant to shed flowers and small bolls because the plant produces little or no pollen.

Growers electing not to use soil-applied herbicides generally will need to apply glyphosate type herbicides at planting or postemergence at the one- to two-true-leaf stage, followed by an application at the five-true-leaf stage. In fields with a history of severe weed problems and/or in situations where it is difficult to make timely glyphosate applications (large acreage, bottomlands, labor problems, etc.), growers should use soil-applied herbicides.

In making early-season weed-control decisions, producers must also consider harvesting efficiency, reduced crop value and weed seed production. Because of the complex interactions among the factors that influence competition between weeds and the crop (light, water, nutrients, weed species, etc), predicting yield losses is less reliable early in the growing season, when weeds can be controlled most effectively.

## Disease control

Seedling diseases are a factor early in the season. Watch for fungal diseases, leaf spots and bacterial blight.

Applying in-furrow fungicides can protect the seedlings longer than using seed treatment fungicides alone, but you must make the decision to use them at planting. Producers must ensure that growing conditions are optimum and take management steps to help dry and warm the soil.

Cotton may develop minor leaf spots that can be caused by several different species of fungi (*Alternaria* spp., *Cercospora* spp., *Rhizoctonia* spp., *Stemphyllium* spp.). Although the symptoms vary, these organisms generally cause circular concentric lesions similar to a target spot.

Bacterial blight (*Xanthomonas campestris* pv. *malvacearum*) is also known as angular leaf spot, vein blight or black arm. This organism affects all above-ground parts of the cotton plant at any stage of its growth. Although the disease is seedborne, the pathogen can overwinter in crop residue.

If bacterial blight attacks, angular spots first appear on the leaves as water-soaked areas. The spots later turn dark brown to black and are covered with a glazed film. Often the surrounding tissue becomes yellow, giving a halo effect.

The size of bacterial leaf spots is limited by leaf veins, causing the angular shape. Infected leaves shed from seedlings and older plants. Occasionally, a black, water-soaked area occurs along a large vein in a leaf.

Plowing under the stubble immediately after harvest and rotating crops will help reduce inoculum in the field. Although you can use resistant or tolerant cotton varieties, there are many races of the pathogen. A variety resistant to one race may be susceptible to others.

## Plant development

Growers must begin monitoring the crop early and continue throughout the growing season until harvest. Before bloom, plant development depends primarily on temperature.

**Node development:** A new node, which is the point along the main stem at which a vegetative or fruiting branch arises, develops every 50 DD60s. Early in the season, a cotton plant can accumulate 50 DD60s in 3 to 10 days, depending on the temperature.

Through early bloom, the number of nodes on a plant is a good indicator of its age. Node development is not affected by environmental stresses at this stage, making it a valuable index to the plant's development.

At the base of each node are two buds designated the first and second axillary buds. At the first five to seven nodes, the first axillary buds are vegetative (producing leaves and stems). The cotton plant will establish a root system and an adequate vegetative structure before it starts fruiting.

The plant usually starts to flower at the seventh node. At that time, the first axillary bud starts to produce fruit. The second axillary bud remains dormant. Fruit initiation (development of the first flower buds) can be delayed by cool temperatures, high plant populations and high pest densities. Plants very rarely revert to producing vegetative branches after a plant starts to produce fruiting branches. Hormones (plant chemicals) prevent other vegetative meristems from growing below nodes six or seven.

If insects or hail damages the plant terminal, one or more of the lower vegetative meristems will begin growing to produce new main stems. This is how plants damaged early in the season recover to produce a crop, even though it will mature late. Table 5.1 shows a time line of square progression to open flower.

Unlike nodes, the internode (the portion of stem between the nodes) is very sensitive to environmental and plant conditions, making the length of the internodes a reliable indicator of plant growth. A long internode (more than 3 inches) indicates favorable growth conditions and

**Table 5.1. Time line of fruit formation of a cotton plant.**

| Days Before Bloom | Bud Height (25 mm=1 inch) | Comments |
|---|---|---|
| 40 | Microscopic | Square initiation can occur, as early as the 2$^{nd}$ true leaf expansion. Hot, spring weather induces 4-bract squares. Cool or very hot weather delays square initiation. |
| 32 | Microscopic | Lock number determined, carbohydrate stress decreases number of locks from 5 to 4. |
| 23 | 2 mm, Pinhead | Ovule number determined, carbohydrate stress decreases potential seed number |
| 22 | 2 mm, Pinhead | Pollen cells divide |
| 19 | 3 mm, Matchhead | Pollen viability reduced by night temperatures > 80 $^{o}$F |
| 5 | 13 mm | Square starts to expand rapidly |
| 3 | 17 mm | Fibers begin to form |
| 0 | Flower opens | Pollen sheds and fibers start to elongate. Extremes of humidity or water disrupt pollen function. |
| +1 | Fertilization of ovule | Ovule now called seed |

the potential for excessive growth. A short internode (less than 1.5 inches) shows that the plant was stressed when that internode was developing.

Cells in a developing internode stop elongating between the fourth and fifth node from the terminal (the dominant, upper main stem part of the plant). The fifth internode from the terminal is the last fully mature internode and is the best indicator of plant vigor.

**Fruiting:** Once fruiting begins, growers have to make many more management decisions. Squares form at the first axillary bud after the first fruiting branch develops. The location of the node is determined by the cotton variety and environmental conditions during the first weeks after emergence.

After the first 3 weeks of plant growth, the only way to increase the number of squares is to protect against pests and to sustain plant growth, which produces sites for additional fruiting branches and adds fruiting sites to existing branches. Under optimum growing conditions, a new fruiting site will develop every 3 to 5 days moving up the plant (vertical fruiting interval) and every 5 to 7 days moving horizontally along the fruiting branch (horizontal fruiting interval).

The objective at early fruiting is to retain the most squares possible. Because of the different weather characteristics and pest problems across Texas, the optimum number of squares retained differs by region.

In West Texas, fruit initiation usually occurs during warm temperatures and sunny days. The goal in that region is to have 90 percent square set in the first week of squaring, 85 percent in the second week and 75 percent in the third week up to first bloom.

This goal is more difficult to reach in the eastern part of the state because of pest problems and environmental stresses (cool temperatures and cloudy conditions).

## Fruit shed

Fruit shed is unavoidable in the life of a cotton plant (Figure 5.3). It is caused by environmental, physiological and pest influences. Although growers generally view it as detrimental, some fruit shed is necessary, especially when the plant is adjusting its fruit load to accommodate growing conditions.

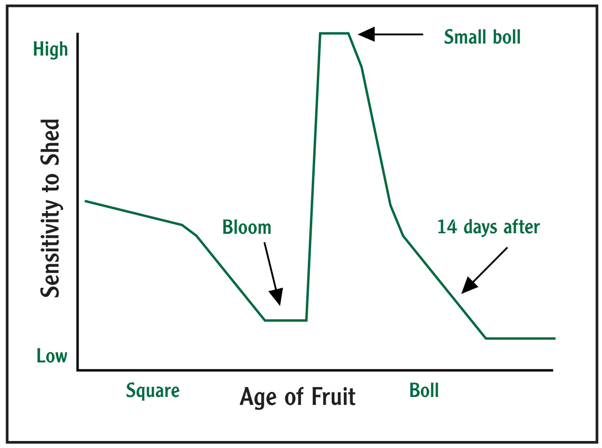


**Figure 5.3. Fruit age sensitivity to shed.**

Fruit shed is most harmful when cotton is planted late or during short growing seasons. Nonirrigated cotton has a higher risk of shedding because mid-season drought substantially reduces boll set.

A plant's response to fruit shed varies with local conditions and can vary from field to field. The most obvious symptoms are delayed flowering and increased vegetative growth. If fruit loss occurs early, more mid- and late-season bolls are often retained, but crop maturity will be delayed.

Under certain conditions, these plant responses can be favorable because they produce larger plants that are less prone to premature cutout during longer growing seasons. However, time is lost with delayed squaring, and the weather is unfavorable in most growing regions in Texas at the end of the bloom period. Consequently, in Texas, early fruit set is critical to successful production of high-quality cotton.

## Insect control

Insects have the greatest effect on square retention early in the season. The primary insects attacking cotton during emergence to first bloom are thrips, cotton fleahoppers, *Lygus* spp., boll weevils, the bollworm/budworm complex and beet armyworms.

Thrips become less of a problem as fruiting begins. At that time, the major insect pests are the plant bug complex (cotton fleahopper and *Lygus* spp.) and boll weevils.

Plant bugs affect small squares by feeding on the pollen grains or developing ovules (seeds). Once the fruit is damaged, the plant sheds it. This shedding is a way for the cotton plant to conserve carbohydrates.

Growers should base their plant bug treatment decisions on the presence of the pest and on fruit retention.

Cotton fleahoppers damage squares only up to $^{3}/_{16}$ inch in diameter. Threshold levels for this pest are lower in the eastern part of Texas than in the west. In the east, thresholds (10 to 15 fleahoppers per 100 plants checked) are lower because these insects migrate constantly from other host plants, giving producers less time to react to increasing populations. Furthermore, high square retention is more difficult because of adverse weather.

In the west, thresholds (25 to 30 per 100 plants checked) are higher because cotton fleahopper populations develop slowly, giving producers more time to react to developing problems. In years when alternate hosts are abundant (those with mild winters and above-average winter and spring rains) and cotton fleahopper populations are high in those host plants, producers in West Texas should consider using the thresholds from the eastern part of the state.

Growers should use these numbers in combination with square retention. Consider square retention when treatment decisions are difficult to determine.

For example: In the eastern part of the state, if populations are 10 cotton fleahoppers per 100 plants and the square set is 90 percent in the second week of squaring, producers should not treat but should monitor the field again in 4 days. If populations are 10 per 100 terminals and the square set is 70 percent in the second week of squaring, producers should apply an insecticide.

The rationale for this is that fruiting rates should be in the 80 percent range. A 10 percent fleahopper infestation is a borderline case that does not always require treatment. However, if square set is below 75 percent, then a 10 percent fleahopper infestation may be damaging.

Some cotton varieties are much more sensitive to cotton fleahoppers than are other varieties. Smooth-leaf varieties generally have fewer cotton fleahoppers than hairy-leaf varieties, but the smooth-leaf varieties are more sensitive to cotton fleahopper damage.

However, the disadvantages of hairy-leaf varieties outweigh the advantages. Hairy-leaf cotton contains more trash at harvest, requiring more intensive ginning to remove the particles from the lint. It also attracts more egg deposition by the bollworm/tobacco budworm complex and higher populations of cotton aphids and whiteflies. Consequently, most Texas producers grow smooth-leaf varieties.

Natural enemies, particularly spiders, can reduce populations of plant bugs, especially early in the season. However, cotton fleahopper populations can overwhelm natural enemies in cotton before bloom. Parasites have little effect on plant bug populations.

*Lygus* spp. rarely reach damaging levels until after blooming starts. However, growers should begin monitoring them early in the season. Use a drop cloth or sweep net to count these insects because they are difficult to find on the plant.

When deciding whether to treat for *Lygus* spp., consider square retention targets during the first 3 weeks of squaring. Thresholds early in the season are one per 3 feet of row or 10 per 50 sweeps combined with square retention.

Damage by *Lygus* spp. is similar to cotton fleahoppers, except that the *Lygus* spp. complex can damage all sizes of squares. Natural enemies have little to no impact on overall *Lygus* spp. populations.

Boll weevil treatment decisions are also made during this growth period. Boll weevils damage squares by feeding on developing pollen and seeds. Adults feed on developing pollen, and the females lay eggs in squares and small bolls. After the larvae hatch, they feed on the squares, causing them to shed.

Before boll weevil eradication, producers in Texas were highly successful in using a combination of tactics to control boll weevils:

- Planting shorter-season cotton (mature bolls in less than 130 days)
- Shifting to stripper-harvested cotton
- Using desiccants
- Controlling overwintered boll weevils
- Controlling early-season pests for earlier fruiting and stalk destruction

In the Rolling Plains, uniform delayed planting shifted the start of fruiting until after the majority of boll weevils emerged from overwintering sites.

Overwintered boll weevils should be controlled for two reasons:

- When boll weevils are absent for 14 to 30 days, the development of damaging populations can be delayed, and cotton can set fruit.
- Insecticide treatments made before bloom do less harm to the natural enemies that are important in controlling late-season pests such as bollworm/tobacco budworm and cotton aphids.

Most cotton production regions in the state are involved in boll weevil eradication programs. The Texas Boll Weevil Eradication Foundation begins treatments based on trap catches and crop phenology, or stage (matchhead size square or 3/16 inch in diameter).

As of March 2002, the northern Blacklands and a small part of the Trans-Pecos production region have not begun boll weevil eradication. In those areas, treatment decisions are made on the basis of trap catches, crop phenology (matchhead size square or 3/16 inch in diameter) and previous field history of boll weevil populations at early bloom.

A trap index (Table 5.2) has been developed in the Coastal Bend production region to help producers decide whether to treat overwintered boll weevils. The index is based on the use of six to eight traps evenly spaced around fields of 50 to 300 acres. It calculates the average number of boll weevils captured per trap each week and adds these averages together for the 6 weeks before the development of the first 1/3 grown square (1/4 inch in diameter).

**Table 5.2. Trap index for overwintered boll weevils for the Coastal Bend cotton production region.**

| Trap Index | Decision |
|---|---|
| Fewer than 1 boll weevil/trap | Do not treat. |
| 1 to 2.4 boll weevils/trap | Do not treat unless damage and/or adult weevils are found in the field. |
| More than 2.4 boll weevils/trap | Treat just before first 1/3 grown square and again 4 to 5 days later. A third application may be necessary in some fields. |

Several insecticide applications may be needed if traps show continued movement into the field from overwintered sites (wooded or brushy areas).

Natural enemies play a limited role in controlling boll weevils. Parasites of third-instar larvae also play a minor role. Although effective parasites are present in Mexico, they cannot survive Texas winters. Therefore, annual periodic releases are necessary. Rearing these boll weevil parasites is costly and so releasing parasites is cost prohibitive for producers.

Predators such as the red imported fire ant have a greater effect than do parasites, but these are limited to the eastern production region. In the west, the main reason for boll weevil deaths is the desiccation of larvae in aborted squares. This is important in nonirrigated acres but less important where irrigation is available.

Plant breeders and entomologists have identified plant characteristics that provide some protection of the fruit from boll weevils. Cotton characteristics such as frego bracts (small, twisted bracts that expose the flower bud), red plant color, okra leaf characteristics and leaf hairiness provide a level or resistance or tolerance to the boll weevil. Problems with adequate yield (red color), susceptibility to other insects (okra leaf and frego bract) and harvesting concerns (leaf hairiness) have limited the use of these characteristics in new varieties.

Other potential fruit-feeders in cotton before bloom are the bollworm/tobacco budworm complex and beet armyworms. These rarely cause economic damage before blooming. The thresholds for these pests are high early in the season because few of them survive to feed on developing fruit.

Treatment decisions for caterpillar pests are made when 15 to 25 percent of the squares are damaged. To determine this, pull 100 green squares from different areas of the field and count the damaged ones.

When making insect management decisions early in the season, also consider natural enemies. Conserving natural enemies is the most cost-effective way to control insects. Start managing the natural enemy populations early so that enough remain later in the season to attack pest populations.

Multiple applications of insecticides reduce natural enemy populations. Try to maintain an adequate square set while limiting the effects of insecticide use on natural enemies.

The importance of setting early squares cannot be overemphasized. As cotton moves closer to first bloom, producers should place more emphasis on maintaining natural enemies. Table 5.3 shows how reducing insecticide rates can provide control of pests and still conserve natural enemies.

## Water, fertilizers and plant growth regulators

During this growth stage, decisions on water, fertilizers and plant growth regulators become important. Water use increases dramatically, from less than 1 inch per week to 2 inches per week at first bloom (Figure 5.4).

**Table 5.3. Impact of changing insecticide rates to conserve natural enemies. Mitchell Co., TX. 1985.**

| Treatment | Rate (oz/ac) | % Fleahopper Control | % Square Set | Predators/Acre | Bollworm Larvae/Acre |
|---|---|---|---|---|---|
| Untreated | | 0 | 68 | 52,500 | 4,000 |
| Orthene® 75 S | 2 | 93 | 81 | 47,750 | 3,750 |
| Orthene® 75 S | 4 | 94 | 79 | 16,500 | 13,250 |

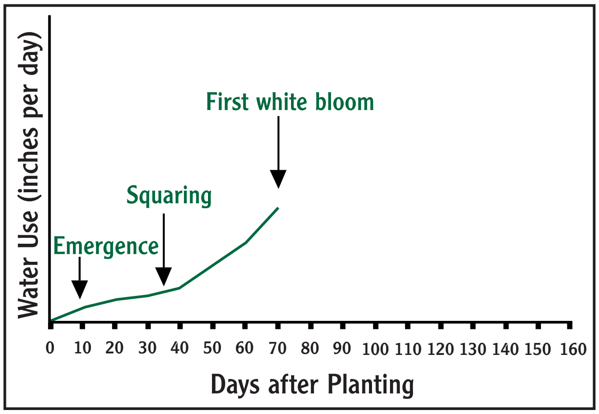


**Figure 5.4. Water use for cotton up to first bloom.**

Producers with adequate water should start making management decisions soon after the first bloom appears. The goal is to avoid any water stress early in the season and to have a full soil water profile as the plant reaches peak bloom (usually 3 weeks after bloom for most regions of Texas).

## Nitrogen

Fertilizer requirements at this stage are much like water requirements. In much of Texas, residual nitrogen from previous crops is adequate for early-season growth until the squares appear. Research indicates that the vegetative stage requires less than 25 percent of the plant's nitrogen needs for the season.

Figure 5.5 shows that the plant has used 50 percent of the nitrogen by first bloom. After first

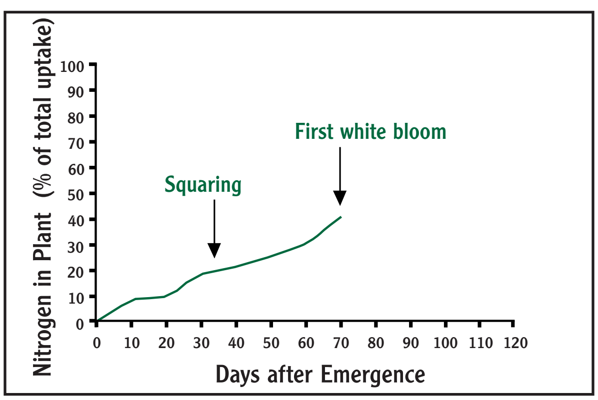


**Figure 5.5. Nitrogen uptake for the period up to white bloom.**

bloom, nitrogen uptake increases dramatically. The goal for producers is to have all the nitrogen applied before peak bloom.

Early in the growing season, nitrogen deficiency symptoms include lighter green foliage, slowed growth rate and smaller overall leaf area. In mid to late season, the symptoms are discolored, yellow to red leaves, smaller plants and reduced boll set.

Excess nitrogen also presents problems for cotton production. If there is too much nitrogen, the plant develops too much vegetative growth and becomes rank (excessively vigorous). This reduces its ability to cope with dry conditions, delays maturity, increases the incidence of boll rot and creates difficult defoliation conditions. Excess nitrogen also increases the risk of problems from cotton aphids.

If nitrogen is needed, apply it as a side-dress before the first white blooms appear. If more nitrogen is needed later, apply it without disturbing the root system (through irrigation or foliar sprays).

## Plant growth regulators

Cotton producers use plant growth regulators to slow plant growth and, therefore, improve harvest efficiency. In some parts of Texas, growth regulators also reduce boll rot.

One plant growth regulator used in cotton is mepiquat chloride (Pix® Plus, etc.). In cotton, it reduces the production of gibberellic acid, a plant hormone that promotes cell expansion.

Applications of mepiquat chloride suppress cell enlargement and promote shorter internodes; smaller, thicker, darker-green leaves; and ultimately shorter plants. This overall reduction in plant growth makes harvest more efficient and reduces boll rot in the eastern part of the state.

Because environments and management levels vary across Texas, no one approach to using plant growth regulators will work in all regions. However, for best results, make the first application of mepiquat chloride early (at the matchhead square stage) and then let growing conditions and fruit retention dictate the strategy for the remainder of the season, especially in fields that historically produce rank growth.

The strategy of making early applications of a plant growth regulator provides the best chance of success. Once a cotton plant has begun to grow rapidly, especially under irrigated or good rainfall conditions, it is difficult to slow it down. Reducing growth is difficult, costly and usually unsuccessful.

Use mepiquat chloride if the plants undergo excessive early growth caused by early-season square loss, good growing conditions and ample nitrogen fertilization. Mepiquat chloride treatments are also used on varieties that tend to produce larger, ranker plants.

Because mepiquat chloride reduces plant growth, do not apply it if the plants are already under stress. Low heat unit accumulation and water stress can reduce plant growth, and applications of mepiquat chloride during these periods can be harmful.

Once good growing conditions return, monitor plant growth to determine future use of the chemical.