# 2. THE COTTON PLANT

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Successful cotton production depends on an integrated management strategy that recognizes and adapts to the unique characteristics of the crop. The development of vegetative growth and fruiting forms is highly related to temperature if adequate moisture is available. The relationship between cotton development and temperature is best described by DD-60s. The equation for determining DD-60s is:

**(°F Max + °F Min Temp)/2 - 60 = DD-60s**

For example, if today's high and low temperatures were 80°F and 60°F, then the formula would give this answer: (80°F + 60°F)/2 - 60 = 10 DD-60s.

Cotton will produce a node about every 50 DD-60s or approximately every three days if moisture is adequate. This rate of growth will slow once the plant begins to bloom and fill bolls.

## PERENNIAL GROWTH HABIT

In its native habitat, cotton is a perennial that does not die in the fall. Instead, the plant becomes dormant during periods of drought and resumes growth with the return of favorable rainfall. This characteristic is partially responsible for cotton's reputation of being a dry-weather crop. During periods of drought in North Carolina, a cotton plant will continue to grow the most mature bolls and abscise (or drop) the remaining boll load. This trait enables cotton to produce some yield even during severe drought years.

Along with this favorable drought-avoidance trait comes the undesirable feature of regrowth and the harvesting problems regrowth may create. Unlike annual crops that die following seed production, cotton will continue growing until environmental conditions become unfavorable. This trait is shown when cotton continues adding leaves and unharvestable bolls until a killing frost occurs. This second growth presents some producers with defoliation challenges while inducing others to delay harvest in the hopes of realizing additional yield. The consistent and reliable heat needed to continue to contribute significantly to yield rarely occurs past the middle of October in North Carolina.

## FRUITING

Another growth characteristic associated with cotton's perennial nature is its indeterminate fruiting habit. Rather than flowering during a distinct period following vegetative growth, cotton simultaneously produces vegetation and fruiting structures. A cotton fruit begins as a small flower bud or "square" that flowers about 21 days after it reaches the size of a pinhead (just visible to the naked eye). The new bloom is white the first day (pollination occurs on the first day) and turns red by the second day. Cotton normally will flower for up to eight weeks in North Carolina. This characteristic allows the crop to compensate partially for earlier periods of unfavorable conditions. However, this longer fruiting period requires continued attention to pest management and complicates harvest timing decisions.

Squares that bloom by about August 15 to 25 in the northern part of the state and about August 20 to September 1 in the southern part of the state should have a reasonable chance of maturing, depending on heat unit accumulation during the fall and when first frost occurs. These bolls should be full-sized by about mid to late September if we have a reasonable chance to harvest them. A boll needs about two weeks of decent weather after it becomes full-sized to mature (increase in micronaire). It takes at least six weeks or 750 DD-60s after the last harvestable bolls are set before the crop can be terminated without reducing overall lint yield and quality. Nine hundred DD-60s are usually needed from white bloom until a boll is fully mature. Although maturity is minimal at 750 DD-60s, overall lint quality is not seriously affected because the relative proportion of bolls set last is usually small.

## TROPICAL ORIGINS

The third distinguishing characteristic of cotton results from its tropical origins. Cotton is adapted to regions where temperatures range from warm to hot. Grown as an annual crop in the United States, it is often necessary to plant cotton before the onset of consistently favorable temperatures. While cotton struggles to emerge from the soil and grow, diseases, weeds, and insects adapted to our environment can damage the crop. When several pests are present simultaneously, especially when accompanied by chemical stress, crop development may be severely retarded. Earliness, normally our best indicator of high yields, strongly depends on favorable environmental conditions during the early season. Cool and wet conditions during the early part of the growing season adversely affect cotton development.

Cotton varieties grown in North Carolina are all day-length insensitive, unlike soybeans. Because of this insensitivity, only early varieties should be planted once we approach the end of our planting period. Maturity is primarily related to how early the plant begins to produce fruiting branches, in other words, from which node the cotton initiates fruiting. Early varieties will start fruiting around the fourth or fifth node, while late varieties will start fruiting higher up the plant.

## LINT QUALITY

The price received by cotton producers is determined by both the quantity and quality of the harvested lint. While the nonfood nature of cotton may persuade newcomers of the crop's tolerance of harvesting delays, experienced growers recognize the value of timely harvests that preserve the maximum lint quality. Lint exposed to wet weather will become discolored, a reason to discount the ginned lint. Because of cotton's prolonged fruiting habit, some weathering of lint exposed to the elements is unavoidable. Green leaves resulting from incomplete defoliation or excessive regrowth also can cause grade discounts. Growers should concentrate on developing a harvest preparation strategy that retains as much lint quality as possible. This strategy can increase a grower's net return by several cents per pound.

## SUMMARY OF PLANT DEVELOPMENT

Seedling leaves, or cotyledons, appear on the day of cotton emergence. True leaves will appear seven to 10 days later. After 30 to 35 days of vegetative growth, the first square (flower bud) will be formed on a fruiting branch arising from the axil (node) of the fifth to seventh true leaf. This important event marks the visible beginning of reproductive growth. The plant will normally continue to produce additional fruiting branches in an orderly manner up the main stem. Fruiting branches are distinguished by their zigzag appearance where a leaf and flower bud are formed at each angle. Each fruiting branch may produce several squares. However, more than 90 percent of the harvestable bolls will be found at either the first or second position on a fruiting branch. When plant populations are high, 90 percent of the harvestable bolls may be found at the first position on the fruiting branch.

North Carolina cotton normally produces between 12 and 15 of these fruiting branches. Research in North Carolina indicates that bolls produced at the first position of fruiting branches arising from nodes six through 10 have a 50 to 70 percent chance of becoming harvestable bolls (assuming they are retained and are protected from insects). Boll-set at position one declines at higher fruiting branches. Bolls produced on fruiting branches arising from nodes 18 or higher have less than a 10 percent chance of finding their way into the picker basket. The same trend is followed at position two except that boll-set peaks at 20 to 30 percent at nodes six to 10 and then declines.

The progression of cotton fruiting can be followed by estimating the interval between the appearance of cotton flowers up the main stalk and out each fruiting branch. The vertical fruiting interval, or VFI (the interval between appearance of white flowers at position one on adjacent fruiting branches), is approximately three days (50 DD-60s). The horizontal fruiting interval, or HFI (the interval between appearance of white flowers at positions one and two on the same fruiting branch), is approximately six days (100 DD-60s). For example, in Figure 2-1, the boll closest to the stalk on the lower branch is about nine days older than the white bloom on the second position of the upper branch (three days up and six days out). The same principle can be used throughout most of the plant to map when and where boll loading occurs. Due to boll load, this relationship can begin to break down for nodes and fruiting sites developed following peak bloom.

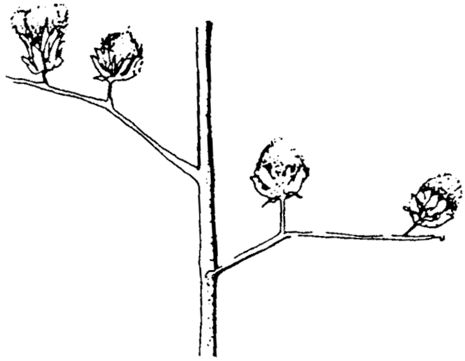

***Figure 2.1. Section of a main stem showing two adjacent branches.***

This process can be used to record and frequently identify the causes of fruit loss, such as water stress, insect damage, rank growth, cloudy weather, and prolonged periods of rain. Growers can then use this information in refining their management strategies.

## PLANT MONITORING

Plant monitoring techniques, such as monitoring nodes above white bloom and plant mapping, have received a great deal of attention in the past few years. These techniques require a certain amount of time and energy but can tell us a lot about our cotton crop and how the crop should be managed. This section is divided into three subsections called prebloom, the bloom period, and the boll-opening period (postcutout).

Tables 2-1, 2-2, and 2-3 (at the end of this chapter) are examples of mapping sheets for use during prebloom, the bloom period, and the boll-opening period (postcutout), respectively. This plant monitoring method involves mapping only first positions of fruiting branches. Fruiting sites on vegetative branches and second or higher positions of fruiting branches are ignored.

## PREBLOOM

### *Determining the Onset of Fruiting (Node of First Fruiting Branch)*

When the cotton plant has about five or six true leaves, you should be able to detect pinhead squares in the terminal (top of the plant). By counting the number of main stem true leaves (ignore cotyledons) when a majority of the plants have a pinhead square, you can determine the node of the first fruiting branch. Well-managed early season varieties should begin fruiting on node five or six with an occasional plant fruiting at node four. Full-season varieties usually start fruiting about a node higher. As the plant grows larger, the leaves below the first fruiting branch will shed, and vegetative branches may develop from these lower nodes.

When determining the first fruiting node of older cotton, you will have to count the "notches" if the lower leaves have been shed. Do not count the cotyledon notches. The shedding of cotyledons will leave two notches directly across from each other just above the soil surface. The notches you are interested in are those that were formed by true leaves above the cotyledons.

### *Factors Affecting the Onset of Fruiting*

Several factors alone or combined can influence the onset of fruiting. Low plant populations can lower the node of the first fruiting branch by as much as one node. High plant populations, cool temperatures (night temperatures below 60°F) during the weeks after emergence, thrips damage, or unusually high temperatures (nights remaining above 80°F) can raise the node of the first fruiting branch by as much as three nodes. Nitrogen stress also can raise the node of the first fruiting branch, although this change is rare because nitrogen requirements are low prior to fruiting, and preplant nitrogen applications almost always supply enough nitrogen to avoid delayed fruiting. If one or more of these factors have delayed squaring, then no visible square scar should be present. If visible square scars or black squares are present at nodes five or six, then the cotton is not delayed in squaring but is shedding squares.

### *Implications of Delayed Fruiting*

Cotton that begins fruiting higher on the plant is more likely to grow rank, particularly if early squares are not retained. Retaining early squares and bolls becomes more important when cotton begins to fruit higher on the plant than normally. These fields should be monitored closely for fruit retention and the potential need for Pix applications to control plant height. Delayed fruiting increases the likelihood of a positive response to Pix. In addition, in-season nitrogen applications should be weighed carefully. Nitrogen application above recommended rates may further delay the crop and add to the potential for a rank crop.

### *Determining Fruit Retention*

When the cotton plant has about five or six true leaves, you should be able to detect pinhead squares in the terminal (top of the plant). From this time through first bloom, it may be helpful to determine fruit retention using plant-mapping techniques. You should map plants from several areas of the field, and map at least 20 plants per field. The more plants you can map per field, the more accurately your mapping program will reflect the true fruiting pattern of the field. The percentage of fruit retention is determined by dividing the number of fruit by the number of fruiting sites. The resulting number is then multiplied by 100. For example, if you mapped 20 plants and came up with 75 fruit and 90 fruiting sites, the fruit retention would be 83 percent.

$$\text{\% fruit retention} = \frac{\text{(number of fruit)}}{\text{(number of fruiting sites)}} \times 100$$

*Example*: $$\text{\% fruit retention} = \frac{75}{90} \times 100 = 83\%$$

### *Causes of Early Square Shed*

When squares are formed but then shed, a visible scar remains. Square shed prior to bloom can be caused by several factors, including insect damage; cloudy, cool weather; or water-saturated soils. However, it is often difficult to distinguish early season square shed due to insect damage from square shed due to weather conditions. Because weevils have been eradicated in North Carolina, our fruit retention prior to bloom is usually very high, unless plant bugs are present. When square retention is lower than desired (below 80 to 90 percent), try to determine the possible cause. But don't be too quick to blame poor retention on plant bugs, unless sweep net numbers indicate otherwise.

Unnecessary spraying for plant bugs is not only a waste of money, but it will also kill beneficial insects that in turn may result in a higher likelihood that the cotton will need to be treated for caterpillars. Unnecessary spraying also can cause aphid and spider mites to flare.

Cool, cloudy weather (below 55°F at night) has been observed to cause square shed because of decreased photosynthesis. Water-saturated soils (often combined with cloudy weather) can cause square shed. Although drought conditions can cause shedding of small-to-medium-sized squares later in the season, square shed before bloom caused by drought stress is fairly rare. Other insects, including caterpillars and plant bugs, can cause square loss. One should not assume early square shed is entirely caused by weather conditions without first closely examining the insect situation in the field.

### *Significance of Early Fruit Retention*

Square retention before bloom can have an effect on how the plant grows for the remainder of the season and on how the field should be managed. Fields with low early square retention are more likely to grow rank and have delayed maturity. Therefore, fields with low early square retention are more likely to respond to Pix applications. Because fields with low early square retention tend to grow rank, use nitrogen judiciously to minimize rank growth and the potential for boll rot. Scouting for insects should be intensified to avoid further excessive fruiting losses.

## THE BLOOM PERIOD

Cotton normally blooms for seven or eight weeks. Stresses associated with drought, nematodes, and fertility can shorten the bloom period significantly. The bloom period also can be lengthened by poor fruit retention or excess nitrogen (with adequate rainfall). Plant mapping, as discussed under the Prebloom section, can be beneficial during the bloom period. In addition, monitoring the movement of first-position white blooms up the stalk during the bloom period gives us some insight into the condition of the crop.

### *Nodes Above White Bloom (NAWB)*

Counting the nodes above white bloom (NAWB) is relatively easy during the bloom period. This technique involves locating the highest first-position white bloom on a plant and counting the nodes above that bloom. Each node above the highest first-position white bloom should be counted if the main stem leaf associated with the node is larger than a quarter. You will have to look for plants with a white bloom in the first position because not all plants have one at any given time.

### *Implications of NAWB*

NAWB should be eight to ten at first bloom, depending on variety and growing conditions. NAWB at first bloom for short-season varieties that fruit on the fifth to sixth node normally will be at the lower end of this range, while full-season varieties usually will be at the higher end of the range. Environmental stress, such as drought, cool temperatures, or nitrogen deficiency, can result in a lower NAWB at first bloom. Poor fruit retention or excess nitrogen may result in a higher NAWB at first bloom. NAWB should begin to decrease after two weeks of bloom because of fruit load. If NAWB does not begin to decrease during the third week of bloom, fruit retention should be evaluated. An increase in NAWB during the season is usually caused by insect damage. Crops with a large NAWB may be suffering from poor fruit retention caused by insect damage. Under these situations, the crop will grow rank and be late maturing if ample moisture and nutrients are available. In crops with higher than normal NAWB at first bloom or crops in which NAWB does not begin to decrease during the third week of bloom, one can expect a strong response to mepiquat. On the other hand, mepiquat may not be needed in crops with low NAWB at first bloom or in crops in which NAWB decreases rapidly during the bloom period.

NAWB should continue to decrease through the remainder of the bloom period as the plant moves toward cutout or "flowering out the top." If NAWB is decreasing too rapidly, one should attempt to identify stresses and alleviate them if possible. The most common stresses that will cause a rapid decrease in NAWB are drought and nitrogen deficiency. When NAWB is lower than normal at first bloom or decreases more rapidly during bloom than desired because of drought stress, increasing the frequency of irrigation may be beneficial. Foliar urea applications have been shown to increase NAWB and yield when NAWB is lower than desired because of nitrogen deficiency.

When NAWB has reached five, the terminal has essentially ceased growth and cutout is imminent. Less than 2 percent of the yield is set after NAWB reaches four. Cutout occurs when NAWB reaches three or fewer.

**When NAWB is higher than normal, look hard at insect-related fruit shed and consider mepiquat to control plant height.**

**When NAWB is lower than desired, avoid mepiquat use and attempt to alleviate any drought stress or nutrient deficiencies.**

## THE BOLL OPENING PERIOD (POSTCUTOUT)

### *Percent Open*

Plant monitoring during the boll-opening period can help you schedule defoliations and determine whether boll openers are justified. Table 2-3 can be used to determine the percentage of open bolls. Cotton is almost always safe to defoliate at 60 percent open, but often it can be defoliated earlier if fruiting is compact (see Chapter 12, "Cotton Defoliation"). Percent open is determined by counting the number of open and closed harvestable bolls on several plants in a field. The number of open bolls is divided by the total number of bolls (both open and unopen). For example, if you mapped 20 plants and came up with 195 open bolls and 105 closed bolls (300 total bolls), the percent open would be 65.

$$\%\text{ open} = \frac{(\text{number of open bolls})}{(\text{total number of bolls})} \times 100$$

$$\textit{Example}\text{: }\%\text{ open} = \frac{195}{300} \times 100 = 65\%$$

### ***Nodes Above Cracked Boll (NACB)***

Bolls within four nodes above a cracked boll should be mature enough for defoliation in most fields. Counting the nodes above cracked boll (NACB) is a good technique to help schedule defoliation. This technique involves counting the nodes from the highest first-position boll that has cracked open enough that lint is visible up to the highest first-position boll you plan to harvest (not necessarily the highest node on the plant). This technique gives more focus to the unopened portion of the crop and is less likely to result in premature defoliation. When NACB reaches four, there will be essentially no yield loss due to defoliation in fields with normal plant densities. A yield loss of about 1 percent would be expected when defoliated at an NACB of five, and a yield loss of about 2 percent would be expected when defoliated at an NACB of six with normal planting densities. Fields with low plant populations (less than two plants per foot of row) will set more fruit on vegetative branches and outer positions of fruiting branches, and these fruit will be less mature. In these type fields, an NACB count of three might be a better estimate for timing defoliation.

### ***Green Boll Counts***

Deciding whether Prep is needed for boll-opening is often difficult. Counting the number of mature green bolls per foot of row is helpful in making this decision. In-depth information on the number of green bolls needed to justify ethephon application is given in Chapter 12.

***Table 2-1. Prebloom Plant-Monitoring Form***

**Field** ________________________

**Date** ________________________

| Plant Number | Height (inches) | Total Nodes | Node of First Fruiting Branch | Number of Fruiting Branches | First Position Squares Retained |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| Average | | | | | |

***Table 2-2. Bloom Plant-Monitoring Form***

**Field** ______________________

**Date** ______________________

| **Plant Number** | **Height (inches)** | **Nodes Above White Bloom** | **First Position Bolls Retained** | **Fruiting Branches Below White Bloom** | **First Position Squares Retained** |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| Average | | | | | |

***Table 2-3. Postcutout Plant-Monitoring Form***

**Field** ________________________

**Date** ________________________

| Plant Number | Height (inches) | Node Above Cracked Boll | First Position Unopened Bolls | Fruiting Branches Below Cracked Boll | First Position Open Bolls |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| Average | | | | | |