

## PLANT AND FIBER DEVELOPMENT

Upland cotton (*Gossypium hirsutum*) is a perennial, tropical plant that has been bred and adapted for annual crop production in temperate climates. Cotton develops on a somewhat predictable schedule, although water and temperature stresses may have profound effects on growth rate.

Plant monitoring and mapping help determine if the plant is growing and fruiting normally. Assuming a lack of moisture stress or injury from one of many potential above or below ground pests, plant growth is primarily influenced by temperature. Plant development proceeds approximately according to a heat unit model which uses 60° F as the base temperature. In this system, heat units are referred to as DD-60s and are calculated based on an average daily temperature °F minus 60° F. The formula is listed below.

$$\frac{\text{Max } ^\circ\text{F} + \text{Min } ^\circ\text{F}}{2} - 60 ^\circ\text{F} = \text{DD-60s}$$

For example, a day with a maximum of 86° F and a minimum temperature of 70° F produces 18 DD-60s,  $[(86^\circ + 70^\circ / 2) - 60^\circ = (156^\circ / 2) - 60^\circ = 78^\circ - 60^\circ = 18 \text{ DD-60's}]$ . Temperatures above 93° F should be entered in the formula at only 93° F since growth probably does not increase at higher temperatures. Current and historical heat unit accumulations for numerous locations across the state can be referenced at the website for the Georgia Automated Environmental Monitoring Network via the UGA cotton web page at [www.ugacotton.com](http://www.ugacotton.com). For numerous locations across the state, this Network website allows calculation of current heat unit accumulation and comparison with data from recent years.

The following chart estimates growth rate based on accumulated DD-60s. Because growth and development are dependent on many factors in addition to temperature, these numbers are only approximations. A detailed discussion of cotton plant growth and development can be found in UGA Extension Bulletin #B1251 at <http://pubs.caes.uga.edu/caespubs/pubcd/B1252.htm>.

		<u>DD-60's</u>	<u>Days</u>
From Planting to:	Emergence	50	4 to 14
	Pinhead square	550	35 to 45
	First bloom	940	55 to 70
	Peak bloom	1700	85 to 95
	First open boll	2150	115 to 120
	Harvest	2500 to 2700	140 to 160

### **Plant Growth Monitoring**

Monitoring cotton growth rate gives an index of vigor and should usually be initiated by the 8 to 10 leaf stage. Because of the variability of row profiles and cultivation practices, plant height

should be measured from cotyledons to the terminal bud, not from the ground up. Cotyledons are the pair of seed leaves first observed after emergence. They are attached to the mainstem directly opposite each other. By general agreement across the Cotton Belt, the node at the point the cotyledons are attached is counted as Node 0.

The first true leaf is Node 1 and should be visible in the terminal within 7 to 10 days after emergence. Subsequent mainstem leaves will emerge at approximately 3-day intervals (4 days under cool conditions). These leaves occur singly at each node and the stem area between each leaf or node is called the internode. Fruiting branches (FB) normally begin to develop at node 5 to 7 from one of the two tiny buds in the leaf axil or point at which the mainstem leaf is attached. Fruiting branches develop a fruiting bud or square with a subtending leaf at 6-day intervals (possibly 7 to 9 day intervals under stress conditions) at one to three or more positions along the branch (referred to as FB1 for first position, FB2, etc.). The subtending leaf is a major source of photosynthate for the square, which flowers after about 21 days, and the boll, which develops and matures over a 6-week period after flowering. Vegetative branches (usually 2 or 3 per plant) develop at nodes or mainstem leaves below the first FB and sometimes from the second bud adjacent to a FB if the FB is injured. The goal for FB1 square retention at early bloom should be 80 percent. Experience in Georgia and in many other environments suggests that extremely high early retention rates may actually limit yields by limiting vegetative growth and total fruiting sites.

Cotton plants usually develop 21 to 23 nodes but an aggressive variety such as DP 555 BG/RR may develop in excess of 25 nodes or mainstem leaves in long growing seasons with adequate moisture and/or moderate boll loads. Nodes beginning with numbers 5 to 7, and up to 20 to 22 potentially develop fruiting branches on which harvestable bolls develop. Cutout usually occurs when fewer than 5 nodes or mainstem leaves remain above the uppermost white flower (NAWF) at the first position (FB1). Boll retention in the top 2 to 3 nodes is usually very low since the plant is normally in cutout due to boll load, water, and/or nutrient stress.

Research indicates the crop can be defoliated when the uppermost, harvestable green boll is 4 nodes above the uppermost cracked boll (NACB-4) without sacrificing yield and quality. When NACB is 5 or more, some yield or quality may be lost. Looking at this question from a different angle, a boll is sufficiently mature after accumulating about 750 DD-60s.

### **Plant Selection and Sampling for Monitoring Purposes**

Usually, 20 normal plants should be counted/measured from each field beginning at the 8 to 10 leaf stage and on a weekly basis for maximum learning and database establishment. However, "short-cut" sampling where 8 to 10 plants or measurements are checked may be more practical for growers, county agents, and consultants.

Avoid plants with:

- ✓ Damaged terminals
- ✓ Spacings not like field average or plants next to skips or in clumps. Select the dominant plant in hill-dropped cotton
- ✓ 20 percent taller or shorter than field average.

**Note:** The following values are approximate and not well-defined by Georgia research:

1. Plant Height (inches). Measure only from cotyledons to terminal bud.
2. Height/Node Ratio (HNR). Average plant height divided by total mainstem nodes = HNR or Vigor Index (inch/node).

Crop Stage	Vigor Index (Height/Node Ratio)		
	Normal	Stressed	Vegetative
Seedling Cotton =	0.5 to 0.75	-	-
Early Squaring =	0.75 to 1.2	0.7	>1.3
Large Square-1st bloom	1.2 to 1.7	<1.2	>1.9
Early bloom =	1.7 to 2.0	<1.6	>2.5
Early bloom + 2 weeks	2.0 to 2.2	<1.8	>2.5

3. Nodes Above White Flower (NAWF) at first position on fruiting branch (FB1):

<u>Growth Stage</u>	<u>NAWF</u>
Early Bloom	7 to 10
Peak Bloom	7 to 8
Cutout	<5

4. Ideal Plant  
 Height = 44 to 50 inches  
 Total Nodes = 22 to 24  
 HNR = 1.8 to 1.9  
 First Fruiting Branch = node 6  
 Fruiting Branches = 12 to 14  
 Boll Retention = 67 percent or 8 to 10 FB1 bolls  
 Cutout = begins node 18 to 20

Managing the crop according to information obtained by plant monitoring is not yet possible due to lack of enough baseline data and environmental control under Georgia conditions. Generally, when monitoring indicates the plant is stressed or growing abnormally, the cause should be determined and corrected as soon as possible. Timely soil, petiole, and tissue analysis can detect nutrient deficiencies or excesses. Of course, water stress can only be relieved by timely rain or irrigation. Stress may also be caused by herbicide injury, disease, nematode injury, soil compaction, and temperature extremes.

Mepiquat containing products (Pix, Mepichlor, Topit, Mepex, Mepex Ginout, Pentia, Stance, etc.) can be used to regulate excess vegetative growth. If excessive vegetative growth is due to fruit loss, the cause of fruit loss should be detected quickly, especially if related to insects. Other causes of fruit loss may include cloudy weather, heat/drought stress, heavy boll load, and cutout. Maximum yields can be obtained by optimizing growth conditions through proper management.

## **Fiber Quality and Development**

A cotton fiber is a single cell that generates from the surface of the seed and elongates resembling a hollow tube. Fiber quality issues in Georgia gained significant attention concerning the 2003 crop. In light of these concerns, during the summer of 2004 several mills and merchants indicated their unwillingness to purchase cotton grown in Georgia. Concerns about the quality of Georgia cotton have persisted. While in any given year, due to environmental conditions light spot grades, short staple, and high micronaire may be encountered, the current situation seems to revolve around short fiber content. Short fibers are those that possess an individual fiber length of 0.5 inch. There is no direct measure of short fiber content with current HVI classing technology. Fiber length uniformity is an indirect indicator of short fiber content where as uniformity decreases short fiber content increases. Classing data for the past several years in the southeast indicate that the uniformity of Georgia cotton is lower than other states in the region.

Fiber length uniformity is a calculation determined by dividing the average fiber length by the average of the upper half fiber lengths (staple). This is difficult to comprehend, but in essence, the uniformity index reflects how many short fibers are present. Short fibers lower yarn strength, reduce spinning efficiency, limit the use of lint for certain yarns, and increase imperfections in yarn. Uniformity can be influenced significantly by variety, boll feeding bugs, weathering of the open crop, and ginning. Relative comparisons of crop quality can be made by examining the Statewide Cotton Variety Testing data as well as other sources. The effects of boll feeding bugs on yield is well documented and we continue to learn about their effects on overall fiber quality. Weathering problems are aggravated by the limits of our harvest capacity, the interference of peanut harvest with cotton harvest, and our reluctance to push the crop toward rapid defoliation, boll opening, and harvest. Ginning can also have a profound affect on fiber uniformity. Excess heat (drying) and lint cleaning can result in breakage of fibers and reduce uniformity.

The two most important stages of development are fiber elongation and “thickening.” Elongation occurs primarily during the first 20 days after flowering, while thickening (internal deposition of cellulose within the fiber) occurs from about 15 to 20 days after flowering and continues for about 30 days (until 45 days after flowering). Inside the “tube,” rings or strands of cellulose are layered each day, intertwining and providing strength to the fiber.

The measure of elongation is staple, and the measure of internal fiber thickness is micronaire, often abbreviated as mike or sometimes mic. Variety, weather patterns, and boll feeding pest control play a role in determining fiber length and micronaire. Micronaire reflects the internal surface area or fill of the cotton fiber; that is, the thickness of the rings/layers formed within the cell. High or low micronaire generally corresponds to thicker or thinner deposits of cellulose, respectively. High micronaire (above 4.9) is usually associated with moisture or heat stress. Such conditions reduce boll set or boll size and concentrate carbohydrate production in fewer or smaller bolls, increasing cellulose deposition within individual fibers and increasing micronaire. Conversely, if stresses such as early frost or premature defoliation (from whiteflies, rain scald, etc.) curtail the development of bolls, low mic (below 3.5) may result. Low micronaire penalties are uncommon in Georgia, although a few early harvested bales in 1999 were docked for low micronaire because of late season whitefly damage, rain scald, and premature defoliation.

Certain varieties have a tendency towards high mic. In fact, because high micronaire means a slightly thicker and probably heavier fiber, cotton breeders recognize that elevated micronaire is

often a quick step to higher yield. High micronaire generally means coarse fibers which have reduced spinning efficiency, and has implications concerning dye uptake.

Fiber quality is influenced by numerous factors, including weather, management, variety, and ginning. Both length and micronaire are influenced by environmental conditions. WHEN stress occurs determines the characteristic most affected.