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Making Sense out of Stalks

What Controls Plant Height and How it Affects Yield

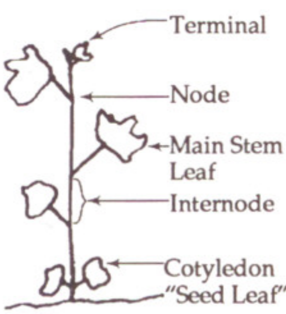
Kater Hake, Tom Burch and Jack Mauney

Plant size at harvest can be a useful tool to reflect back on the growing season and evaluate yield limitations. Simple evaluations such as main-stem growth can clue a producer into production problems that may or may not be improved upon. The ability to interpret these tools requires an understanding of plant growth because many factors can influence plant development. The producer must use his deductive reasoning to identify yield limitations within a field.

A complete field evaluation requires shovels, detailed records and plant mapping to document the season-long growth and fruit retention. In this article we will focus on the utility of simple elements of plant mapping. These include plant height, node spacing and total nodes.

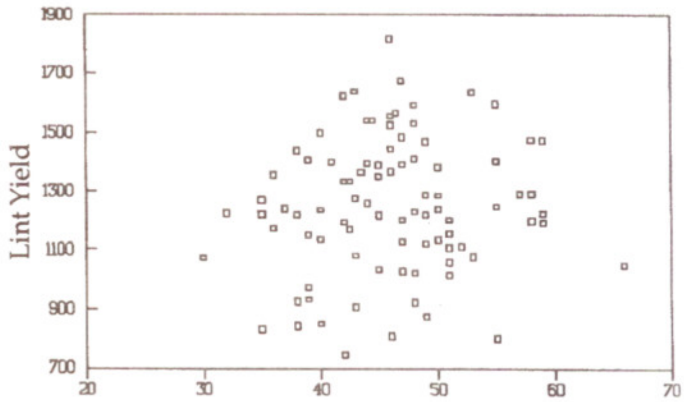
Height and Yield

Cotton plants increase in height by 2 simultaneous mechanisms, the addition of new blocks to the top of the plant and elongation of these blocks. Nodes and internodes are the physiological terms for the building blocks that add height to cotton plants. Nodes are the main-stem joints where leaves and branches arise. Internodes are the spaces between nodes that elongate (see drawing). Final plant height reflects this growth due to addition and elongation during the entire season.



For maximum yield plants must reach a certain height to provide sufficient squares and leaves. The graph to the right shows the relationship between yield and plant height for one variety grown in many different locations and different years. A wide range of plant heights can support a low yield, but as the yield level increases, plant height has to be within a narrowing range. Stated more simply, there are a thousand ways to produce a 1-bale/acre crop, a hundred ways to produce a 2-bale crop but only a few ways to produce a 3+ bale yield. Locations that produce a plant less than 40" tall limit yield potential due to stress, most likely water or salinity stress. While locations that grow plants taller than the optimum 40-50" for this variety limit yield due to poor fruit set or small boll size.

Lint Yield vs. Height



(Dick Bassett ACB 1979-1988)

Ideal plant height will vary from variety to variety and region to region but, generally speaking, the shorter the growing season, the shorter the optimum plant height. Also the ideal plant height for narrow row cotton appears to be shorter than for conventional row spacing.

Causes of Short or Tall Plants

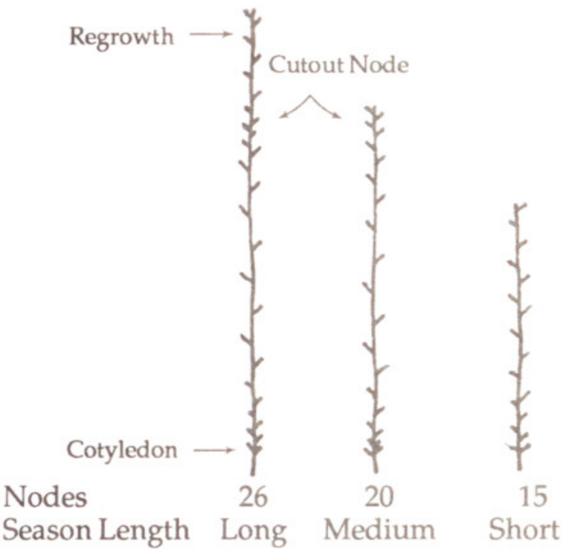
When a plant is too short or too tall for maximum yield, we look to the 3 factors that influence height for possible problems: nutrients, temperature and moisture. Excessively short plants are usually caused by moisture deficiency of some sort — either dry soil, salinity, or poor rooting. Excessively tall plants are caused by poor fruit retention in combination with moisture excess, high plant populations or ample nutrients.

In general, if a field consistently produces plants that are too tall then high density (greater than 60,000 plants/acre) should be avoided because dense plants will be harder to manage. These fields that produce tall plants have the greatest yield potiental if managed with an early boll load because maximum yield occurs when we establish an early boll load and then remove all stress giving the plant ample water, nutrients and warmth. To focus further on yield limitations requires a closer examination of the internode spacing on the main stem.

Also In This Issue

Although final plant height is determined by both the number of main-stem nodes and the internode elongation between those nodes, only the severest stress will markedly reduce node development. A stress that cuts plant height by 50% may only decrease node number by 10%. The elongation of internodes is a sensitive indicator of the intensity and timing of stress, because an internode only has one opportunity to elongate. If stressful conditions exist during that period, that internode will remain pinched even after the stress is relieved. Under non-stress conditions, and especially with poor boll retention, internodes can be up to 5 inches long, while internodes elongating under stress conditions are often less than 1" long.

Healthy plants typically show internodes approximately 1-2 inches long at the bottom of the plant. Above that, when a healthy plant gets into squaring, internodes are typically 3-4 inches long. At the top of the plant, internodes gradually become smaller and smaller due to cutout. The following figure shows typical node spacing for a long-season crop with a second boll set, a medium season cotton and short season cotton.



Causes of Compressed Internodes

Causes of internode compression (less than 1 inch) at the bottom of the plant include seedling diseases, cool temperatures, and carbohydrate or phosphate deficiencies. Pinched internodes in the middle of the plant are often due to water stress from root pruning or dry soil. Since internodes elongate at about the same time as adjacent squares appear, the location of pinched internodes on the plant can be used to estimate when in relation to squaring that the stress occurred. For example if most of the plants had pinched main-stem internodes near the first fruiting branch we might suspect a severe water stress at the time of first square.

Some types of stress reduce internode elongation all season long. Nematodes, soil compaction and salinity are frequent examples. Soil salinity reduces all of the internodes because water availability is decreased all season long, by the presence of salts. Additionally, plants grown in saline soils must expend energy to exclude toxic salts out of the roots. This energy cost delays plant development and further reduces plant height. Soil compaction reduces plant height by limiting water uptake and the "bonsai" effect. Just like bonsai trees, if cotton roots are restricted in volume, hormonal communication will cause the shoot to match in height the reduced size of the root system. The effect of nematodes on plant height is similar to salinity with both a decrease in water uptake and carbohydrate drain. Nematode pressure builds during the season and plants are often severely affected during boll filling which destroys fiber quality.

Causes of Excessive Regrowth

The extent of late season growth after cutout also can be used to evaluate management problems. An ideal cotton plant at harvest would have mature cotton bolls right to the top. This would imply that vegetative growth and fruiting were perfectly matched to the season length, i.e., we set fruit to utilize the full complement of warmth, nutrients and moisture available. We experience excessive regrowth when we do not set fruit long enough to utilize the season length, such as the regrowth that often follows premature cutout — a problem in long growing seasons. Premature cutout can be caused by mid to early season water stress, too high a rate of PIX, or insufficient N fertilization. Other causes of excess regrowth, besides premature cutout, include late irrigation or rain. Late season insect problems can result in excessive vegetative growth, where the plant never goes into cutout.

Yield and Total Nodes

Total main-stem nodes that accumulate reflect the length of the growing season and the yield potential inherent in that growing season. Cotton seedlings start with only the cotyledonary node and develop main-stem nodes only after emergence. This contrasts with beans and grains that have several pre-formed nodes in the seed and explains cotton's long lag-phase between emergence and first true leaf. Heat unit models accurately predict node accumulation until boll set, at which time carbohydrate demand by the bolls decreases nodal development. A new node will develop in approximately 55 heat units (DD60's).

Large numbers of nodes do not insure a large yield, but only insure that the producer will have time to mature a mediocre crop even with severe insect pressure or plant stress. Long growing seasons give us the opportunity for large yields and the security of harvesting at least mediocre yields despite adverse fruit setting conditions. On the contrary, 3+ bale yields are occasionally produced from total nodes of 15-20 but only if weather and insects cooperate with timely and precise management. Three plus bale yields typically require a season long enough to produce 20 to 25 nodes. Taking a close look at the plant can allow growers to identify production limitations, and push their yields up to the limit that the weather allows.

Causes of Poor Defoliation

Kater Hake and V.T. Walhood

Across the Cotton Belt, growers experience fields that defoliate poorly. Whether these same fields also suffer quality loss depends partially on seed cotton moisture. We can harvest middling cotton from poorly defoliated fields if the plant is very dry. This unfortunately is a rarity in most regions. For a successful defoliation, three components must be put together properly; the Plant Status, the Weather, and the Chemicals. If any one of these is outside of an optimum range then poor defoliation will result. The following list of causes of poor defoliation may help growers identify problems in their own fields.

- High residual nitrogen will universally inhibit cotton leaf drop. In fact, cotton leaves will shed naturally if leaf N drops low enough.

- Rapidly growing juvenile plants defoliate poorly. This condition can result from poor boll set or late cotton. These plants have high levels of juvenile hormones (auxins and gibberellin) that interfere with defoliation.

- Ample soil moisture retards defoliation. Sandy streaks in a field where cotton is water stressed defoliate much better than the rest of the field.

- Disease free plants often suffer poor leaf drop. Where fields have been extensively rotated to control disease we often observe poor defoliation. In regions where Verticillium wilt is prevalent, this disease increases the level of ethylene in the plant, the same compound released by the plant growth regulator PREP.

- Regrowth does not defoliate, regardless of weather. This young developing tissue does not form abscission zones (separation areas), and usually must be desiccated prior to harvest because of its high moisture content.

- Cool temperatures for 5 days following defoliation retard the activity of defoliants. Since defoliation is an active living process of cell division and development, cool weather will slow the entire defoliation process. Additionally, uptake of defoliants is decreased with cool weather. Even if the weather warms after the first 5 days we still observe poor defoliation.

- Low humidity and/or high temperatures before and during defoliation causes toughening of the waxy layer on the outside of leaves (the cuticle). Cuticles decrease the uptake of all chemicals, especially charged molecules such as Gramaxone® or chlorate. Wetting agents or cotton seed oil are often added to enhance uptake under these conditions.

- Excessive defoliant or desiccant application rates can cause leaves to die prior to abscission zone formation, with frozen leaves as the result.

- Inadequate chemical rates also can cause poor defoliation, especially under cool conditions or with rank vigorous plants.

The worst defoliation imaginable occurred not in a grower's field but at a university research station. The field had been solarized to control disease, which also released excess soil residual nitrogen. The fertilization was miscalculated, resulting in 220 of N applied in two sidedress applications. The early fall weather was hot and dry causing tough leaves on the 6 foot plants. But the defoliation was applied late when the weather was cool. It took 3 applications to kill the plant, minimal leaf drop actually occurred, but the plot did yield over 1800 lbs of lint. Bringing up one last point; we don't grow cotton to obtain an ideal defoliation but rather for lint and seed. If we do experience a "perfect" defoliation, we may have shorted our yields by not providing adequate moisture and nitrogen.

Cotton Physiology Seminar

There's something new and exciting for cotton growers at the 1990 Beltwide Cotton Conferences. It's the first physiology seminar for growers, presented as part of the new Cotton Physiology Education Program, CPEP.

This seminar, like all aspects of the CPEP, is designed to break technical topics down to the language and everyday experience of growers. It's a translation we think will mean improved crop management and increased profitability for growers across the Cotton Belt.

For the first Physiology Seminar we've enlisted the wisdom and experience of many of the Extension cotton specialists, innovative growers and consultants. They'll be presenting the latest information on two topics of widespread interest and concern among growers.

"Plant Mapping: A Tool to Increase Profitability" will offer you an overview of cotton development and growth, a look at how plant mapping allows your cotton crop to "speak" to you about its stresses and needs, how to plant map Pima, and how to use the new Plant Mapping Kits being developed by the CPEP.

"Causes of Square and Boll Shed" will examine how and why the plant sheds squares and bolls, insect problems that trigger shed, and environmental causes of shedding. Finally, a panel of leading growers and consultants from across the Belt will discuss how they use plant mapping and how they manage cotton after severe shedding.

The half-day Physiology Seminar kicks off the Beltwide Cotton Production Conference first thing Wednesday morning, January 10, 1990. A question and answer session "Breakfast with the Experts" on Square and Boll Shed, will be held the following morning, Thursday, January 11.

Several other sessions at the 1990 Beltwide should provide valuable information to growers. The Production session will start Wednesday after the Physiology Seminar and continue all day Thursday. Friday morning will start the Technical Conferences on all aspects of cotton production. Focused conferences on fertilization, morning-glory control, and HVI classing and quality should address specific grower problems. Saturday will include a full day session on cotton plant growth regulators and further sessions on cotton quality.

To attend, plan your arrival in Las Vegas no later than Tuesday night. Due to the busy Las Vegas convention season, rooms at the Riviera Hotel are limited and reservations must be made immediately. If you need a registration packet, phone the National Cotton Council offices today (901-274-9030). I look forward to meeting you at the Physiology Seminar.

The Cotton Physiology Education Program is supported by a grant from The Cotton Foundation, and brought to you as a program of the Technical Services Department, National Cotton Council.

The National Cotton Council (NCC) is the central organization representing all seven sectors of the U.S. cotton industry: producers, ginners, warehousemen, merchants, cottonseed crushers, cooperatives and manufacturers. A majority of elected delegates from each sector must approve all NCC policies, thus assuring unity of purpose and action.

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