

# COTTON PHYSIOLOGY TODAY

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## 1993 Crop Yields -- Explaining the Highs and Lows

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The 1993 cotton crop was one of the best and worst on record. The western half of the Cotton Belt had a good to excellent yield. In particular, the High Plains of Texas enjoyed a remarkable season. The eastern half of the Cotton Belt was a different matter. Low yields, coupled with high costs, left little or no profit margin. While most Mid-South and Southeastern growers are anxious to focus their sights on the coming season, last year deserves our attention. This newsletter will briefly describe the excellent High Plains crop and examine factors that contributed to the disappointing Mid-South and Southeast crops.

### High Plains -- Benchmark for the Future

Across the Belt, the cotton physiology recipe for a bumper crop is "combine a healthy plant with a heavy square load at first bloom." This combination allows excellent early boll set and sustained retention up the plant.

This description fit many fields on the Texas High Plains during the first half of July. With 2 million acres rotated out of cotton in 1992, a dry spring that allowed excellent seedling root development and producer attention to water and nitrogen, cotton plants were generally healthy at first bloom. The exceptions were some low rainfall, dryland fields that entered first bloom with a Nodes Above White Flower (NAWF) below 6.0 and produced only 250 to 350 lbs. per acre.

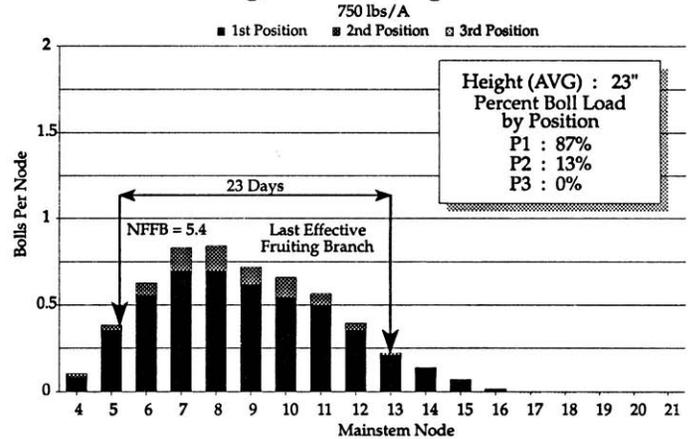
The seedling cotton did suffer from intense thrips pressure that largely disappeared prior to significant square injury. These heavy thrips populations built tremendous levels of beneficial insects. As a result, square set on 37 monitored fields averaged 96% during the first six weeks of squaring.

Cotton entered bloom on a typical calendar date (July 5 through the 15th) but cutout early (4 to 5 weeks later), in time to fully mature bolls and benefit from widespread use of harvest aids. The rest is history and a benchmark for the future: 3.4 million acres harvested with an average yield of 567 lbs.

per acre of premium quality cotton. Irrigated fields, half of the High Plains, yielded 750 lbs. per acre on average (Figure 1).



Figure 1  
Irrigated Texas High Plains

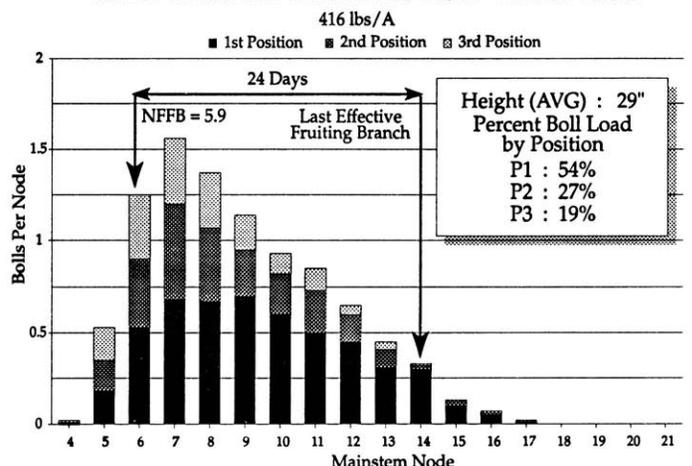


### Southeast and Mid-South -- A Complicated Story

It would be easier if the problem with the 1993 crop had one root cause. This would allow us to alter that one cause and enjoy uniform success or, if it was beyond our control, reconcile ourselves to the vagaries and whims of fortune. However, it is not that simple or straightforward. A combination of environmental circumstances, pest dynamics, management constraints and misfortune all are responsible for the crop's poor performance in these regions.

Final plant mapping information is available from several Mid-South and Southeast fields. While they are not intended as definitive, they illustrate two distinctive trends. The first (Figure 2) is representative of a number of Mid-South and Southeast locations. Significant features of this boll loading pattern are good-to-excellent early boll retention and total fruiting branch

Figure 2  
Mid-South/Southeast Low Yield 1993



productivity, followed by a rapid decrease in retention and productivity above node 12. This boll loading pattern typifies fields with early maturity but lower yields.

At this point, it may be apparent that Figures 1 and 2 resemble each other yet produced quite different yields. Several factors help to explain this apparent discrepancy. Remember that each final map describes an average plant for the field. High Plains fields have about 50% more plants per acre than Mid-South fields. This means that if the final maps were identical, the High Plains fields would yield about 50% more all things considered equal. Also, bolls produced on High Plains cotton varieties are normally larger than many Mid-South varieties, particularly this year when High Plains bolls were fully mature while seed set was low in Mid-South bolls. Finally, the relative contribution to total boll load from first position bolls (P1), normally about 15-20% larger than bolls further out fruiting branches, was dramatically higher on the High Plains (87% vs. 54%). In short, larger bolls and higher plant populations enabled these Texas producers to harvest a bumper crop. This also illustrates why plant mapping data needs to be regionalized and system specific in order to be relevant.

A second low yielding pattern emerged in many fields and is depicted in Figure 3. First position boll retention never exceeded 40%, total fruiting branch productivity never reached 1 boll per node and no distinct cutout was observed. Additionally, the contribution to the total boll load by P1 sites was less than 50%, and 14 fruiting branches were required to set 95% of the crop that amounted to less than a bale -- a thoroughly forgettable crop.

## Early Season Delays

Early season field preparation and planting were marred by wet and, in many instances, cool conditions. Days suitable for fieldwork were reduced by rain, and temperatures averaged 2° to 5° less over the same time frame. Delays in getting started were not offset by favorable weather for stand establishment or grow off. Low temperatures, hurried field preparation and low soil oxygen levels from saturated soils retarded root development. Plant monitoring data indicates that square initiation was delayed about 0.5 node resulting in additional developmental delays. The delayed start, and slow grow off, produced a more variable, less vigorous crop. The stage was set for more trouble.

Areas of the Southeast, including North Carolina and Virginia, were less affected by these delays. Fields that escaped packing rains and associated herbicide injury after planting emerged and grew off rapidly. This excellent early season weather held except for atypically frequent and widespread hail storms over much of northeastern North Carolina. On the other hand, areas of Georgia were severely drought-stricken with late and uneven emergence and development.

## Square to Bloom

Conditions varied by region across the Southeast. North Carolina and Virginia square retention during this time frame is normally excellent (>90%) and followed this pattern last season. Square retention problems that did arise in the Southeast were attributed to plant bugs and budworms for the most part.

Drought conditions began to prevail across the Southeast as bloom approached. Vegetative growth slowed and fewer nodes were added to the terminal. This resulted in plants that went into bloom with low NAWF which predisposes the crop to premature cutout and reduced yield.

Missouri and other North Delta cotton regions followed this same trend: excellent square retention, developing drought and NAWF values between 5 and 7 at early bloom. These conditions, reflected in Figure 2, give high initial boll retention but inadequate horsepower to sustain boll loading and higher yields.

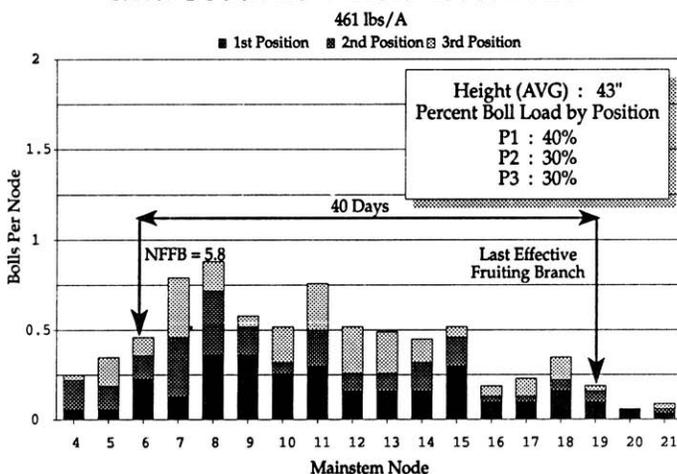
This period in the Mid-South, more than any other, has drawn the attention of many experts. Many lower Mid-South fields experienced very low (less than 25%) P1 retention on the first 3 or 4 fruiting branches. This is reflected in the final map data of Figure 3. Second (P2), third or higher positions (P3) contributed whatever yield these lowest fruiting branches produced. This trend continued up to node 9.

## Why Such Low Square Retention?

A chief point of contention has become, why such low retention? Was it the weather or was it a result of insect pressure? At this point, we need to understand

Figure 3

### Mid-South Low Yield 1993: Pattern 2



Boll loading patterns of problem fields in the Mid-South and Southeast help describe the crime scene and provide clues to help identify suspects. To narrow the list down and enable us take corrective actions in the future, let's trace the season's events from field preparation until harvest.

that we cannot at this late stage establish cause and effect. Late season mapping, while valuable, cannot distinguish if a missing site was lost during the square or early boll stage. The best we can offer now are considered opinions. This lack of precision with postmortems could be virtually eliminated with a few timely, in-season plant monitoring efforts.

The chief limitation in our investigation is our inability to narrow down the time of fruit abortion. Cotton fruiting forms are susceptible to loss over more than 40 days as a square and young boll. Scouting reports and weather data help sort out this confusion, but we still must rely on deductive reasoning rather than hard evidence.

The weather argument is supported by a cloudy period in late June prior to bloom when plants had several P1 squares on the earliest fruiting branches. Also, rainfall amounts during this time may have saturated some soils causing plant stress. Gossym/Comax simulations suggest some late June to early July square abortion may have occurred, but height-to-node ratios (HNR) and growth rates (GR) were high, indicating sufficient carbohydrate supply for growth.

Experimental data and experiences from other cotton growing regions do not support the hypothesis of physiological square shed prior to the development of a boll load. Square shed in June and early July 1993 is far more likely the result of either undetected and/or uncontrolled insect feeding.

However, low boll retention at harvest may also reflect young boll abortion. Poor seed set can also reduce boll retention and will be discussed later.

## **Bloom Period**

The arrival of bloom signaled the beginning of hot and dry conditions in the Mid-South and Southeast. Following the passage of a weather system in late June, widespread rainfall was not recorded until the first week of August. During July and August, temperatures averaged 2° to 5° higher than normal across the regions. Daytime highs routinely exceeded 90°, and 95° or higher was recorded on more than 30 days.

Nighttime low temperatures were also abnormal. Dew points measure the temperature when the relative humidity reaches 100%. Dew points are excellent indicators of nighttime lows as further cooling is offset by the energy released to the atmosphere as water vapor is converted to liquid. Dew points were approximately 5° higher than normal during the bloom period.

Plants are able to regulate their daytime leaf temperatures through the process of transpiration. With sufficient water, leaves operate their own evaporative coolers. Leaves have thousands of minute pores called stomata that regulate the passage of gases and liquids between the plant and the atmosphere by opening and closing. Stomata opening is controlled by a number of factors including light, water status and carbon dioxide

levels. Under well-watered conditions, temperatures rise and liquid water in the stomata is converted to water vapor. This phase change requires an input of energy which is supplied by the leaf tissue. When the vapor escapes through the open stomata, it carries this energy with it, which cools the leaf. Daytime leaf temperatures can be modulated to below 90° F even when air temperatures exceed 100° if they have enough water.

On the other hand, when high temperatures are accompanied by drought, the result can be devastating to plant productivity and the health of the leaf. Increases in leaf temperatures cannot be held in check as stomata close in a survival mechanism to prevent further desiccation. The uncontrolled rise in temperatures exceed the optimums for necessary physiological processes, decreasing productivity and accelerating leaf aging. The plant is no longer functioning at peak efficiency due to the higher temperatures.

A second major disruption due to heat and drought also diminishes the plant's productivity. Carbon dioxide from the air is depleted in the leaf during photosynthesis as carbohydrates are produced. Open stomata allow the leaf to replenish its supply of this needed gas to continue growth. When the stomata close, gas exchange and photosynthesis ceases. Additionally, the photosynthetic machinery in effect reverses itself by consuming oxygen and producing carbon dioxide as carbohydrates are broken down. This poorly understood process, referred to as photorespiration, may be biologically necessary but it does consume carbohydrates that are needed for boll filling and terminal growth.

High nighttime temperatures compounded these problems. Unlike the day when stomata are open, at night evaporative cooling ceases and leaf and air temperatures are similar. The higher dew points in 1993 and resultant nighttime lows increased the plant's maintenance respiration at a cost of carbohydrates that could have been available for boll filling. In short, the reduced food supplies resulting from less daytime photosynthetic productivity were consumed by the plant as it spun its metabolic wheels.

This reduced supply of food reduces terminal growth and the plant's carrying capacity. Premature cutout is the likely outcome of this stress during bloom, particularly when coupled to the prebloom stresses mentioned earlier. Prebloom stresses that reduced NAWF at bloom, coupled with weather extremes during bloom, were largely responsible for the low yields in non-irrigated fields in the North Delta and much of the Southeast.

## **Late Season**

Two situations enabled some producers to avoid the devastation of premature cutout. Irrigated fields were able to partially offset the temperature effects if irrigation was applied early and frequently enough. Alternately, those fields with the most troubling fruit shed

were less impacted by the bloom stress as boll demand was lower. Irrigation or timely rainfall allowed these fields to continue square production.

Both situations enabled growers to continue boll loading which helped revive field productivity in some regions. However, higher insect pressure, particularly from beet armyworm and boll weevil, necessitated more frequent and costly control measures. For example, the beet armyworm annihilated areas of Alabama and the Mid-South.

### **Boll Size/Seed Per Boll**

Boll size in 1993 was reduced by up to 20% or more in many Mid-South fields. This helps to explain why boll counts, although somewhat reduced, failed to account for the yield reductions found at harvest. Reductions in boll size are partly due to the unusually high numbers of P3 bolls found in fields with low P1 retention. These bolls, found further out the fruiting branches, average about 20% less size than P1 bolls.

There is, however, another factor that contributed to smaller boll size in 1993. Seed counts per boll were reduced by 10 to 20% in fields where this was monitored. Nighttime temperatures above 80°F have been associated with pollen sterility which will reduce pollination and

seed set. While these temperature extremes were not recorded in the Mid-South and Southeast regions during 1993, reduced pollination may have contributed to fewer seeds per boll. Additionally, the reduced carbohydrate supply to the developing bolls also is associated with reduced seed set as the plant is unable to satisfy all the young seeds' food demands.

### **Wrap Up**

Crop performance is the result of a combination of factors. The Texas High Plains had excellent early, mid and late season weather conditions. Those growers who had irrigation capabilities were able to respond to this favorable weather with timely water and nitrogen. Plus it helped to have excellent square retention. Mid-South and Southeast producers were confronted by a host of weather and pest problems. Square retention suffered, NAWF suffered, seed set suffered and yields suffered. Without irrigation, in-season management options to sustain NAWF and seed set are more limited. However, square retention is another matter. This coming season may not bring foul weather, but pest pressure is assured. Maintaining a heavy square load at first bloom is possible. Plant monitoring once squaring begins is fundamental to this formula for success.

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