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Square Retention

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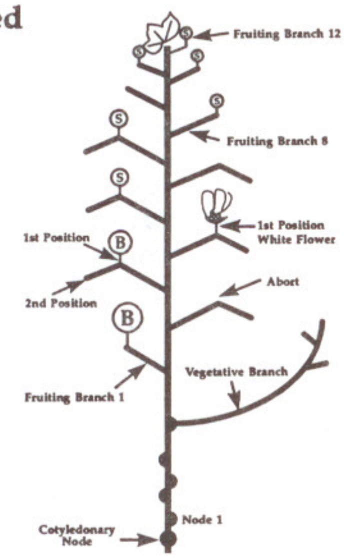
Making cotton "fruit" and setting early squares has become a call to arms for many growing regions. This issue will discuss the causes of fruiting, the effect square shed has on plant growth and quality, and how to manage cotton that has suffered from fruit shed.

Scientists and producers have long sought a magical chemical or management practice that would make cotton square. An increase in the relative amount of fruit does occur when plants suffer from water or nitrogen deficiency or have been treated with Pix. However, these differences are not the result of increased square production, but rather increased boll retention at lower nodes (Pix), reduction in leaf size (Pix or water deficit) and reduction in new leaf development (N deficiency), making bolls and squares more prominent.

Cotton has an internal mechanism to regulate the initiation of squares. Squares will appear at every new mainstem node following development of the 1st fruiting branch. The node location of the 1st fruiting branch is controlled by variety and the environment surrounding the plant during the first weeks after emergence. After the first 3 weeks of plant growth, the only possible manipulation of square numbers is through protection and sustained plant growth — new mainstem nodes and thus, new squares.

Patterns of Fruit Shed

Although patterns of fruit shed vary from one region or variety to another, some general comments can be made regarding the timing and location of shed. First position squares typically have a 60% chance of surviving to harvest compared to 30% for 2nd positions and 15% for 3rd position squares.



- **Fruiting branches 1 and 2:** Immediately after emergence, the mainstem bud — located between the cotyledons — forms microscopic nodes and internodes. Lateral buds, which occur at each node, give rise to branches. Early in the plant's development, lateral buds only produce vegetative branches, but later develop the ability to form fruiting branches. This transition is not always abrupt, therefore the first fruiting branch is weak. This first branch has poor boll retention and seldom produces 2nd and 3rd fruiting positions on the branch.
- **Fruiting branches 3 to 8** are the most robust on the plant and may account for ¾ of the yield. By the 3rd fruiting branch, the mainstem has solidly switched to the production of fruiting branches. Since 1st and 2nd position squares (fruiting branches 3 to 8) appear on the plant prior to significant boll set, they seldom shed due to physiological reasons and may exceed 95% retention in the absence of insects. Boll retention on fruiting branches may reach 90% at the 1st position and 50% at the 2nd position. Although bolls are more likely to shed during their first 2 weeks, lower set bolls flower when the plant is generally most healthy and the weather moderate. Regardless of variety or growing region, fruiting branches 3 to 8 constitute the bulk of the yield unless insects remove squares or stress limits boll retention (excessive shading, water deficit or cloudy weather).
- **Fruiting branches 9 to 15** produce the top crop in the Southeast, Mid-South and Far West but may be non existent on the High Plains. Within this node range, square retention suffers from competition with developing bolls and increasing insect populations. Boll retention is often low unless bolls set at nodes 1 to 8 are few or small in size. A combination of healthy plants (non-stress without excess height accumulation), along with favorable weather (moderate temperature with clear skies), also promotes boll retention on fruiting branches 9 to 15.

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Also In This Issue

- **Fruiting branches 16 to 20** generally develop after the plant cuts out and begins to regrow. Although square retention in this zone can be high (due to the lack of competition with developing bolls), boll retention, boll weight, and fiber quality are reduced due to deteriorating weather and late season insects. Outside of the Southern Desert (Arizona and Southern California) these branches seldom contribute to yield.

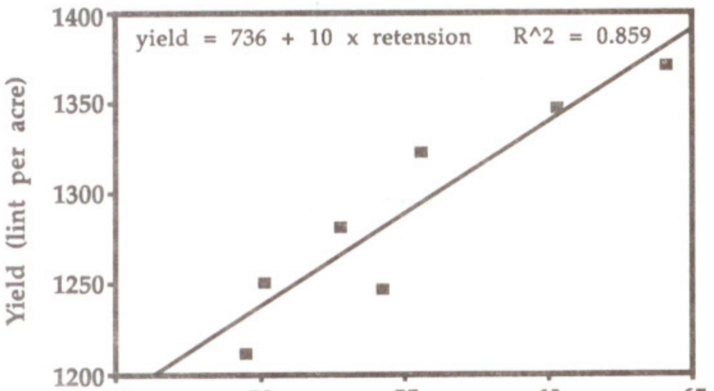
Square Retention and Profit

Entomologists and agronomists agree that boll retention is important for yield but some disagree as to what extent squares should be protected from insects. Not only are short term considerations involved (chemical costs and maturity delay) but also long term considerations (insect resistance and development of secondary pests). Clearly, opinions such as "protect every square out there" or "there's all the time in the world for compensation" are extreme; the middle ground that considers both short term and long term profitability is the wisest for producers.

The need to retain early squares fluctuates depending on the year (see section 'When is Early Shed Most Damaging?'); in general, a gradual increase in the benefits from early square retention has occurred in the U.S. due to changes in varieties and management. Five to ten years ago, 50% retention at the 1st position was acceptable. Yield potential now has increased while the growing season has shortened; therefore, 60 to 70% boll retention at the 1st position may be required to optimize yield. Varieties and management have improved such that boll retention can go higher. Each square now has a greater chance of becoming a boll and is thus more valuable.

New varieties and management have enhanced boll retention. Using plant map data from Tom Kerby, 86% of the varietal yield improvement for new Acala varieties grown under non-disease conditions can be explained by boll retention at nodes 6 through 10 (see figure below).

SJV Acala Yields under Non-Wilt Conditions



In the Mid-South and San Joaquin Valley, 1991 plant mapping demonstrated that high levels of boll retention can be achieved and record yields produced despite late starts and short seasons. In 29 monitored San Joaquin Valley cotton fields, 1st position boll retention averaged 70% of the bottom 10 fruiting branches last year versus 63% average in previous years.

Plant Response to Early Square Shed

Plant response to early square shed is dependent on previous plant growth and the degree of shed. For example, hand pruning studies have demonstrated that removing 2 early squares per plant, followed by favorable conditions for square retention, does not result in measurable change in yield, plant growth or maturity. However, removal of the 4 earliest squares results in a series of plant responses:

- Flowering is delayed.
- Vegetative growth is promoted resulting in taller plants with greater total square and bloom production.
- Retention of mid- and late-season bolls is increased.
- Crop maturity and boll opening is delayed.

Under certain conditions these plant responses may be desirable because they allow a larger plant that is less prone to premature cutout during long growing seasons. This is the reason that varieties with a higher node of the 1st fruiting branch yield better than varieties with low fruiting branches under long, hot growing seasons (Kittock, Hofman and Clark, 1986). However, time is lost with delayed squaring. In addition, most growing areas suffer adverse weather during the end of the bloom period. Sacrificing bolls at the beginning of the season to allow enhanced boll retention later, when the weather, plant and insect conditions often deteriorate, can be highly risky.

Whether the above plant responses alter yield depends on the delay in boll opening and the season length (fall heat unit accumulation). Even though plants can add new blooms up the mainstem rapidly, 2.5 to 3.5 days during early bloom, the time interval between boll opening is considerably longer, 5 to 10 days up the mainstem. This difference results from the more rapid heat unit accumulation during mid-summer as compared to the fall. As boll opening shifts later into the fall, cool temperatures retard the opening process and prolong the exposure of open bolls to wet conditions. In the rainbelt, a loss of yield and grade (both color and trash) invariably results from a protracted, lengthy boll opening period that pushes harvesting operations into periods of inclement weather.

When terminal damage occurs in the 4 to 9 node stage, such as from thrips, plant bugs or early season worms, the effect on plant growth is similar to loss of the first 4 squares. Loss of the terminal forces the plant to essentially start over using vegetative branches to compensate for the loss of the mainstem. The first 3 to 4 nodes on a vegetative branch usually do not bear fruiting branches, and thus the start of flowering is delayed.

When is Early Shed Most Damaging?

Clearly, early fruit shed is most harmful when cotton is planted late or when the growing season is short. Time for recovery is not available and the key fruiting branches, 3 to 8, become even more critical.

Non-irrigated cotton also appears to be more sensitive to early shed because mid-season drought can greatly reduce the window for setting bolls. Where the window or time available to set bolls is narrow (late planting, short season, or adverse weather during bloom), retaining a high proportion of the squares that will bloom during that window is critical; retaining squares that will bloom outside of that window is less important. If a field does not have blooms when conditions are favorable for boll retention (moderate temperature, adequate soil moisture, clear skies), all the effort to produce a crop is wasted.

When early shed combines with mid- or late-season shed, yield loss can be phenomenal. If early squares are lost, each remaining square on the plant (especially 1st and 2nd position squares) becomes more valuable. The uncanny ability of insects (boll weevils and plant bugs) to find those last remaining squares means pest management is absolutely critical.

Early shed also makes agronomic management more difficult. When early squares are lost, producers must walk that fine line with fertilizer and irrigation applications — a line between insufficiency that limits boll development or excess that leads to rank vegetative growth, delayed maturity and boll rot. When plants fruit low and retain a couple of those early bolls, management can focus on minimizing all stress, knowing that the plant will cutout due to the heavy boll load.

Managing Cotton After Early Square Shed

Regaining square activity is the first goal. Identify the cause of shed and if possible correct promptly. Monitor plant growth, especially Nodes Above White Flower, along with an indicator of growth potential such as: internode size, Height-To-Node ratio or Elongation Rate to allow timely applications of Pix if necessary (see following section on Cotton Monitoring). By the time excessive growth becomes obvious from the road, severe damage has occurred that will be costly in lost yield, maturity, boll rot and excess chemicals. Nitrogen fertilizer and irrigation levels may need to be adjusted downward to minimize maturity delay. Square shed is especially hazardous in high density fields, because a thick stand of rank growing cotton can shade developing fruit causing further square and boll shed.

Management to Promote Early Square Retention

Strive for a good stand of healthy plants by: creating ideal seedbeds, planting near the optimum time when warm dry weather is forecast, using only high vigor (cool germ) seed, and protecting against seedling disease and seedling insects in fields and regions where these occur.

Protect the crop against insects that remove early squares (thrips, plant bugs, fleahoppers and boll weevils and in some cases early boll worms). Work in Arizona (Mauney, 1984) and Arkansas (Smith, Tugwell and Maples, 1986) indicates that 90% or more of the squares shed prior to bloom are caused by insect injury. Starting at first bloom, an increasing proportion of the square shed is caused by physiological stress.

Select varieties that fruit low on the plant when planting late or in short growing seasons. The same work demonstrating benefits of high fruiting branch varieties in long growing seasons also demonstrated their adverse effect under delayed planting conditions.

Monitor square retention closely. Regardless of early season insect control strategy, plant monitoring for square shed is necessary to back up a pest management program and insure that nothing is "falling through the cracks."

Cotton Monitoring Program

A new Cotton Foundation project "Cotton Monitoring Across the Belt," funded by a grant from BASF, has been initiated to enhance our knowledge about optimum cotton growth patterns in diverse environments. This project cooperates with local Extension Agents who monitor weekly over 150 fields scattered throughout the Belt. Updated results on current crop development are available in the Farm Press publications and electronically via COTNET (NCC's electronic news service — call the National Cotton Council at 901-274-9030 for information regarding free access.) For this Beltwide effort, many of the plant mapping/monitoring techniques were standardized, updated and condensed. If you would like a copy of the latest plant mapping/-monitoring instructions and field cards, please call NCC at the same number.

Cotton Comics

Unless cotton is planted into extremely warm weather (highs in the 90's) early growth is slow and protracted, especially when compared to competing weeds. Plants are unable to regulate their own temperature and are at the mercy of the environment. Plant tissue temperature reflects the heat exchanged between the environment and the plant. The major source of incoming heat to the plant is sunlight, either directly shining on the leaves or reflecting off dry soil. Warm air is another source of heat if the air is warmer than the plant, otherwise the plant will give off heat to the cooler air. Plants also exchange heat with their surroundings by radiation. All objects, including the sky, radiate heat, the amount of which depends on the temperature. This form of heat exchange is usually minimal during the day because both the plant and its surroundings have similar temperatures and thus radiate equal amounts of energy to each other. But at night, a clear sky can be cold and the plant still warm. Under these conditions **radiational cooling** will occur. Another method by which the plant exchanges heat is evaporation. During the day, green plant surfaces **transpire**, giving off water vapor from the open **stomates**, which allows continued evaporation inside the leaf. If we look at all these methods whereby plants exchange heat, we can see why the temperature of cotton is sometimes below the air temperature and sometimes above. The temperature of non-water stress cotton is usually below the temperature of relatively dry air, due to transpiration during the day and radiational cooling at night. But if soil moisture is limiting or the air humidity near saturation, transpiration will be curtailed and the sunlit plant warmer than air.

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