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PEAK BLOOM

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Peak bloom is one of the most recognizable periods in cotton development. Fields may become blanketed with white blooms as boll loading accelerates to a maximum. This landmark developmental stage signals that a shift is occurring in the crop's biology and your management priorities. This newsletter will profile the crop at peak bloom and outline some management considerations that can affect performance and profitability.

Peak bloom provides the first opportunity to see the light at the end of the tunnel. Prior to this developmental milestone, the crop only hints at its promise. Heavily fruited plants where bolls displace squares bode well for commercial success. The opposite also is true — nagging concerns begin to turn into genuine disappointment with the passage of this phase. While poor square set may be alarming and a call to immediate action, once poor boll set is apparent, earliness is lost and yield recovery is difficult. While it is well to remember that the production season isn't over until its baled up — it is true that the crop first shows its hand at peak bloom.

Shift in Development

Peak bloom occurs when the flowering rate reaches a maximum. At early bloom some plants have not yet begun to flower while others are at the first position on the first fruiting branch. The rate increases once the remaining plants begin to flower and the blooms progress up the stalk and out the various fruiting branches. The flowering rate could increase geometrically if square set was perfect and competition between and within plants were nonexistent. However, under field conditions the various constraints limit stalk growth, fruiting site production and square retention. The bloom rate achieves a maximum that is determined by the availability of needed resources, such as moisture, light, carbohydrates and mineral nutrients; then the rate subsides, sometimes quite rapidly as cutout approaches.

The productivity of any given field and the profile of growth up to and beyond peak bloom will vary because each season and field is unique. Soil types, fertility, rainfall patterns, irrigation capabilities, plant population, variety and pest pressure are just a few of the interacting factors that help determine field performance.

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The observable outcome of these interactions can be a profusion of white flowers at one extreme or an almost imperceptible spike in flowering at the other. This range in the intensity and duration of the peak has physiological and management implications that will be discussed later.

Fields that have been intensively managed and have excellent boll retention during bloom display several characteristic features as peak bloom passes. Chief among them is the complete cessation or major reduction in terminal growth. An earlier newsletter on the transition from vegetative to reproductive growth (Negotiating the Path to Peak Bloom, Vol. 5, No. 5, June 1994) described the shift in crop development from first bloom to peak bloom. During this 3-4 week time frame, the vegetative growth rate reaches a maximum that may exceed 4-5 inches per new internode. As more squares reach the bloom stage, the plant's and soil's resources are diverted to boll growth. Growth of the vegetative terminals (shoots and roots) slows as boll loading progresses. Very heavy boll loading demands may suspend terminal growth until significant boll maturation occurs.

A second feature is a decline in square and boll retention. The high prebloom vigor associated with non-stressed conditions supports rapid vegetative development to produce large numbers of fruiting sites. The importance of fruiting branches is underlined by research findings and production guidelines that associate maximum potential productivity with nodes above white flower (NAWF) targets at early bloom. NAWF targets at early bloom range from 7-10 depending on region.

Production of additional fruiting sites initially offsets the progression of flowering early in the bloom period. But as loading continues, their demands suppress the growth of additional sites while limiting the retention of the remaining sites. Boll and square retention routinely declines in a rapidly loading field.

Physiological Demands of Boll Loading

It was mentioned earlier that the plant and soil resources available for boll loading are tested by the arrival of peak bloom. Plant requirements for three classes of nutrients — water, minerals and carbohydrates — exhibit peaks at or near peak bloom. A shortage of any one of these nutrients can alter the profile of peak bloom and limit final field performance.

Water use measured as evapotranspiration (ET) — the amount of water lost through soil evaporation plus plant transpiration — can exceed $^1/_3$ inch per day during peak bloom. It has been noted in several studies across the Belt that maximum water use occurs during peak bloom. A review of the varied roles that water plays to the cotton plant helps to illustrate how peak demand coincides with peak bloom.

The combination of high temperatures and day length increase the heat load on a cotton plant. The leaf area index (LAI) has achieved full canopy closure increasing the transpiration surface. The photosynthetic output of the plant is at its highest due to the high population of leaves at or near full productivity. Plus, the large population of bolls creates a high demand for carbohydrates produced during photosynthesis. Gas exchange between the atmosphere and the leaf chloroplasts, crucial to photosynthesis, depends on open stomates. This combination of large surface area, high photosynthetic production and high heat load creates the highest ET experienced during the season. In light of these circumstances, it is not surprising that severe drought stress at peak bloom is most damaging to final yield.

Bolls are primary sinks for most **mineral nutrients**. The requirement for nitrogen and potassium is high at peak bloom when the simultaneous development of many bolls increases demands on the plant's and soil's reserves. Nitrogen is vital to seed development as a component of storage proteins as well as enzymes. Potassium is central to carbohydrate metabolism and also serves as an electrolyte used to maintain turgor pressure within cells. Among other things, maintenance of turgor pressure enables fibers to develop their full elongation. It is notable that this high demand for mineral nutrients coincides with a period when root growth is declining. When coupled with the high ET and soil water depletion, temporary nutrient deficiencies can limit boll retention and development. This high demand from an uncertain supply route is at the root of strategies to supplement fertilization through foliar treatments.

Carbohydrates (sugars) produced during photosynthesis are used both as an energy source and building blocks in a cotton plant. The metabolic conversion of sugars and other sugar-derived materials produces energy needed to support maintenance respiration of established plant organs and new tissue, including seeds and vegetation terminals. Other metabolic routes transform these sugars into an array of building blocks used in fiber development (cellulose), enzymes (amino acids) and membranes (fatty acids), etc.

Carbohydrate demands can outstrip the plant's ability to supply them during rapid boll loading, particularly with an aging canopy. Leaf productivity declines with age. Peak bloom may arrive 90 days after planting. By this time, many leaves within the canopy are more than 40 days old and relatively unproductive. With little new vegetative growth, the crop's ability to support boll growth is declining rapidly. Additional boll loading is further strained by the high demands of older, retained bolls that are still developing. Carbohydrate uptake is highest in bolls that are less than 30 days old.

It becomes apparent that the demand for carbohydrate peaks in established (retained) bolls at roughly the same time that the bloom rate reaches a maximum, all supported by an aging, less productive canopy. This perhaps best explains why the bloom rate does not increase to infinity. The flowering profile including peak bloom is dependent, at least in part, on the boll loading pattern.

Crop Status at Peak Bloom

As suggested by the previous discussion, the degree to which cotton responds to the demands of peak bloom is strongly influenced by field conditions encountered earlier in the season. Prior environmental stresses, insect pressure and management decisions will impact the onset, intensity and duration of peak bloom. The multitude of interactions makes for an extremely dynamic situation where appropriate management responses are conditioned by prior history and future scenarios.

A cotton crop growing under non-stressed conditions can produce astronomical yields in an extremely short period of time. There are several recent examples. The Mid-South produced record yields from late May planting dates in 1991. The Texas High Plains enjoyed remarkable success during 1993 when weather patterns were favorable. Virginia, just this side of the cotton North Pole, produced the highest yields of any rain-fed region in 1994.

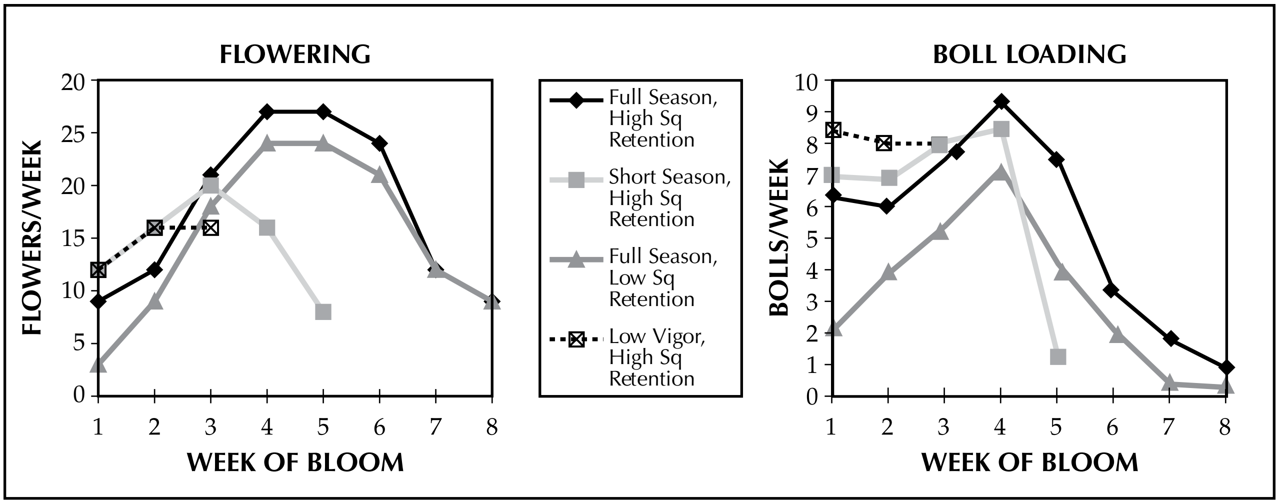
What were the common features from these record-setting years? Each region enjoyed favorable prebloom environmental conditions with high square retention rates followed by timely rainfall and contained insect pressure during bloom that allowed rapid boll loading. To recreate these textbook examples, a production target for Early Bloom would include NAWF = 7-10 (depending on region) and 1st position square retention >80%. Adequate moisture would be available during the effective bloom period to replenish water lost to evapotranspiration. Insect pressure would be minimized through appropriate control measures.

Varied Profiles

As indicated earlier, each field's passage through peak bloom is distinct and may not behave according to the books. A peak bloom management strategy should be tailored to each field. Four possible field scenarios follow based on plant monitoring data from several regions across the Belt. Appropriate management considerations will then be reviewed.

A. Full season, high retention

The flowering and boll loading profile of this crop is illustrated in the accompanying figures. In this model of peak bloom there are 3 plants per foot on 40" centers. Each plant produces about 25 nodes,



18-20 of which are fruiting branches (FB). The lowest five FB produce 4 fruiting sites, with successively higher branches producing fewer sites with only first position sites for the last 3-5 branches. Roughly 70% of the 1st positions will be retained, 30% of second positions and only 10% of further removed positions. Peak bloom arrives 4 weeks after first bloom. Note the moderately large and broad peak in both flowering and boll loading. This crop can produce a three bale crop in about 40-45 days from first bloom. This model could be encountered throughout the southern half of the Cotton Belt.

Management Considerations:

Cutout is still three weeks away. Terminal growth, which has slowed, may not require additional Pix treatment. Boll retention and development are sensitive to shortages of water and nutrients. Irrigation schedules should be maintained through cutout. Tissue testing can ascertain need for additional nitrogen and/or potassium. Maintain vigilance for insect pest pressure.

B. Short season, high retention

In contrast, production areas with a shorter effective bloom period must proceed along a different production track. Plant density has increased to 4 plants per foot on 40" centers while the number of FB and sites per FB has declined. A greater proportion of the bolls are from first positions. This alters the pattern of flowering and boll loading. Peak bloom occurs within 3 weeks of first flower. The peak of the flowering and boll loading curve has narrowed. A three bale crop may be produced in 35 days from the beginning of bloom. This has implications on the boll demand and the crop's ability to meet these requirements as illustrated. Soil productivity and crop vigor must be intensively managed to satisfy the high boll demand.

Management Considerations:

Cutout follows peak bloom within two weeks. Increase management emphasis on yield protection. Terminal growth is greatly reduced, and there are no new fruiting branches. Square and boll retention declines precipitously. Follow crop closely for development of potassium or nitrogen deficiency. Induced deficiency may arise from rapid loading. Prompt foliar response to documented shortage may alleviate symptoms and enhance yields. Irrigation remains high priority until cutout. Crop susceptibility to bollworm/budworm complex begins to decline as boll population ages.

C. Full season, low retention

The previous examples were based on high retention and vigor at early bloom. In the following examples, either square retention or vigor will be compromised to describe boll loading patterns. First position square retention is poor under a full season production system. The assumptions used for this scenario are the same scenario as "Full season, high retention" except that first position square retention at early bloom is now 50% rather than >80%. Retention percentages of the remaining sites are unchanged. This pattern can be deceiving to a casual observer. There is only a minor depression in the total number of flowers because first position sites represent only a portion of the total. Peak bloom arrives in about the same length of time and follows a similar pattern albeit less intense. In marked contrast, boll loading is dampened throughout the bloom period due to the higher proportion of less favored sites 2 and above. The loss of some first position sites is not fully compensated by the remaining sites. The field may still produce 2+ bales over a long enough season.

Management Considerations:

Peak bloom is less pronounced. Management priorities remain insect control, growth regulation and irrigation. Boll loading patterns are unlikely to induce nutrient deficiency. Late maturity becomes a major consideration. Additional nitrogen should not be applied unless based on documented yield, limiting deficiency. Insect management should be maintained or heightened in recognition of crop attractiveness and susceptibility of young bolls.

D. Low vigor, high retention

This combination is frequently encountered in rain-fed areas that suffer minimal insect damage but experience prebloom drought. The crop may enter bloom with NAWF less than 7 with first position square retention >90%. In essence, the crop is at peak bloom at the onset of flowering. Boll retention can exceed 80% on first position sites under this scenario. Without continued vegetative growth, the boll load quickly reaches the crop's carrying capacity. Cutout may arrive within three weeks of early bloom. This crop can also produce 2+ bales if the crop canopy remains healthy and mineral nutrients and water are not limiting.

Management Considerations:

Crop is perilously close to premature cutout. Immediate irrigation should be considered if available. Base additional fertilizations on tissue test reports. Response is unlikely unless yield prospects are otherwise excellent. Crop rejuvenating rains may stimulate late flush of terminal growth and fruiting sites. This vegetation is rarely productive and frequently quite costly. Avoid chasing phantom bolls. Concentrate on protecting those bolls that will contribute to the bottom line.

Wrap Up

Peak bloom reflects the history of the crop, particularly its boll loading patterns. Observing the crop's passage through peak bloom helps you assess the status of the crop. Crop monitoring at this stage will alert you to developmental shifts that you must account for in your production strategies.

For additional reading on other-mid season topics, refer to the following issues of Cotton Physiology Today:

- High Temperature Effects on Cotton, Vol. 1, No. 10, July 1990
- Charting a Course to Cutout, Vol. 4, No. 6, July 1993
- Rescuing Productivity, Vol. 5, No. 6, July 1994

To obtain copies of these issues, call or write Pat Yearwood at the National Cotton Council, Box 12285, Memphis, TN 38182-0285, phone: 901/274-9030.

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