Chapter 13:

Recurring Questions About COTMAN

Fred M. Bourland, N. Philip Tugwell, Thomas A. Kerby, N. Ray Benson, and Diana M. Danforth

Principles of COTMAN™ are robust and apply to most cotton growing conditions. Yet, some recurrent misunderstandings have plagued COTMAN since its conception. Most of the misunderstandings and questions have been associated with 1) the *Target Development Curve* (TDC), 2) physiological and seasonal cutout, 3) plant stress, and 4) the utility of COTMAN data.

Target Development Curve

Does the Target Development Curve represent optimal cotton growth?

Use of the term "target" has caused much confusion, because "target" suggests the establishment of a goal or optimum. The TDC does not necessarily establish the optimal or best growth pattern for a specific growing situation. Instead, the TDC simply establishes a standard for comparisons. The standard was based on long-established principles of cotton plant growth as summarized in Chapter 3. Actual crop development curves may, and often do, deviate from the TDC. Actual crop growth curves that deviate from the TDC only suggest that the pace of crop development is different than the accepted standards reported for cotton growth and development. Deviations from the TDC should not be viewed as a definite change in potential yield.

Since the Target Development Curve was developed in Arkansas, is it applicable to other cotton-growing regions?

Although the TDC was developed in Arkansas, it is not tailored to fit any specific growing situation. Since the TDC is simply a standard, there is no need to establish different standards for various cotton-growing regions or conditions. In the absence of disease and/or water stress, heat unit (HU) requirement for squaring node development is fairly standard. Expected (as well as optimal) growth patterns are not the same for different growing regions or conditions. Certainly, growth patterns for water-stressed and well-watered cottons will differ greatly. Comparison of plant development to the TDC can be used to interpret plant response in each situation.

Does the Target Development Curve represent a growth curve for maximum cotton yield?

Cotton plants mimicking the TDC should produce cotton in a highly efficient, short-season production manner. Maximum yield could be attained by a growth curve above the TDC (i.e., start fruiting earlier, higher apogee of curve, and/or longer, effective flowering period). However, production costs and risks associated with such a growth curve would often be greater than with plants following the TDC. With a three-day vertical and a six-day horizontal flowering interval, a cotton plant may potentially produce 16 flowers on main-stem fruiting branches in less than 21 days and may produce additional flowers on fruiting branches arising from vegetative branches. Assuming 40,000 uniformly developed plants per acre and a 20-day effective flowering period, cotton has a yield potential of over five bales per acre. Therefore, high and efficient cotton yields are possible with a crop having 20 days of effective flowering. Plant mapping data show that the development of nine to ten effective fruiting branches (i.e., main-stem nodes bearing a fruiting branch with a harvestable boll) is common in U.S. Mid-South cotton. Since cotton plants require at least 24 days to develop this plant structure, growers are producing plants with increased ability to compensate for fruit loss and for variation among plants.

Should there be different Target Development Curves for newly developed fast-fruiting cultivars?

Some have suggested that the TDC should be different for newly developed “fast-fruiting” cultivars. However, many of the newly developed cultivars (with the advent of *Bt* cotton and boll weevil eradication) are less determinate and tend to be later maturing than the most popular cultivars being grown when COTMAN was developed. It should also be noted that the growth parameters summarized by Tharp in 1960 were established on cultivars that predated breeding efforts to develop short-season cultivars and even predated development of old standards such as “Stoneville 213” and “Deltapine 16.” Varieties express only minor differences in node development as well as vertical and horizontal flowering intervals. Variation in early- and late-maturing varieties is usually attributed to node number of the first fruiting branch (lower is more determinate) and/or the slope of the NAWF curve (steep descent associated with early maturity and this is usually a function of fruit retention).

Why is Target Development Curve based on days after planting rather than on heat units after planting?

The TDC establishes a standard for main-stem nodal development relative to *days after planting* (DAP) and does not attempt to model or predict plant development. Initiation of fruiting might be more closely synchronized with the curve if nodal development were charted by *days after emergence* (DAE). Yet, charting by DAE rather than DAP would disregard a major plant develop criterion, namely, days required to emerge. Slow emergence is usually indicated by SQUAREMAN growth curve occurring to the right of the TDC. Also, an even better fit to a standard curve might likely occur if the development were charted by heat unit accumulation. Again, COTMAN is not modeling plant development—a fit to a curve would not provide any diagnostic function. Comparison of main-stem nodal development by DAP to the TDC provides a dynamic evaluation of plant development throughout effective flowering.

Physiological and Seasonal Cutout

What is the difference between physiological and seasonal cutout?

End-of-season decisions in COTMAN are based upon the maturation of the last effective population of bolls. The flowering date of the last effective population of bolls is determined by either the plant’s ability to set and mature a population of bolls (physiological cutout) or by simply running out of time at the end of the season (seasonal cutout), whichever comes first. Physiological cutout is related to the carrying capacity of the plant. As boll load increases relative to the plant’s carrying capacity, white flowers progress toward the plant apex. We have determined that physiological cutout is identified by NAWF=5 (white flower occurring within 5 nodes of the plant apex). Flowers retained after NAWF=5 often result in bolls that produce less lint and are of poorer quality than bolls set lower on the plant.

The only time that physiological cutout does not identify the flowering date of the last effective flower population is when boll maturation is limited by late-season weather. The latest possible cutout dates have been determined for various cotton growing locations by assigning each location a harvest completion target date (primarily based on historical weather data). From various experiments, we know that 850 heat units (DD60s) are required from flower to mature a boll. Using long-term daily averages for heat unit accumulations, latest possible cutout date was defined as the last date from which a person can expect to achieve 850 HU prior to harvest completion target date (i.e., harvest completion date minus 850 HU). Obviously, neither boll weevil eradication nor *Bt* cotton changes the weather, and thus they have no effect on the latest possible cutout date.

Does NAWF=5 signal physiological cutout for all cotton varieties?

Identification of NAWF=5 as a signal of physiological cutout was simultaneously determined by the University of Arkansas group and Dr. Tom Kerby’s group in California during the early 1990s. At the time, neither group knew that the other was working on the concept, and each group used different approaches. Finding the same conclusion independently in contrasting environments with contrasting varieties increased our confidence. Since then, the validity of NAWF=5 for identifying physiological cutout has been proven throughout the Cotton Belt over multiple years in nearly all conceivable insect pest situations with all classes of cotton varieties.

In certain circumstances, is NAWF=4 a better signal of physiological cutout than NAWF=5?

The only time that NAWF=4 becomes a better signal of cutout than NAWF=5 is when cotton has experienced severe plant stress. Such stress typically causes short plant structure and small boll load. Conditions that may incite such stress include prolonged drought, competition among plants (as found in ultra-narrow row cotton), hard pans, root-knot nematode, nitrogen deficiency, etc. In such cases, flowers occurring at NAWF=4 tend to have proportionately more value. However, plants under such stress require very few days to progress from NAWF=5 to NAWF=4. Thus, changing physiological cutout to NAWF=4 has little practical value.

Can date of physiological cutout be estimated by a one-time examination of plants?

Date of physiological cutout is typically determined by the interpolation of 2 points of NAWF that encompass NAWF=5 (i.e., dates that are above and below NAWF=5). One-time examination of plants seldom will provide an accurate measurement of physiological cutout. A greater danger of a one-time examination is that the user may be measuring second growth. In this case, physiological cutout date has already occurred, and the user will be monitoring flowers that will not contribute to profitable yield.

Should physiological cutout be re-defined since boll weevil eradication and *Bt* cotton permits maturation of the "top crop?"

Boll weevil eradication and *Bt* cotton will have no effect on the physiological capacity of the plant. As its name implies, physiological cutout (NAWF=5) is a plant-based, physiological phenomenon. The validity of NAWF=5 as a signal of physiological cutout has been confirmed in several tests with *Bt* cotton and in environments void of boll weevils (including eradication zones). Since normally growing plants are unable to maintain and mature populations of bolls derived from flowers after NAWF=5, injury to the late fruit by boll weevils or the bollworm/budworm complex will not adversely affect yield of *Bt* (or non-*Bt*) cotton grown with or without boll weevils.

The seemingly logical conclusion that higher yields can always be made with more nodes and time ("chasing a top crop") is enticing but can have severe consequences. Each time that new tools to control insect pests become available, short-season concepts of cotton production tend to be abandoned. The removal of the boll weevil and the insertion of *Bt* genes do not change the basic physiology of the plant or negate the benefits of short-season cotton production. The promise of increased yield with little additional costs invariably increases risks, costs money, and provides little or no increase in yield.

Can optimal yields be obtained if physiological cutout occurs before latest possible cutout date (i.e., plants cutout too early)?

The suggestion that optimal yields cannot be obtained if physiological cutout occurs prior to the latest possible cutout date encourages growers to add inputs with hopes of increasing yields. This approach may pay off occasionally, but the risks of disaster associated with late-season weather are always increased with delayed production. Certainly, if all fields were pushed to the latest possible cutout date, then harvest could not be completed by the target date. Numerous studies have proven that cotton plants have enough fruiting sites to make ample yield in a short-season approach. In the past century, short-season concepts of producing cotton have seemed to appear and disappear at regular intervals. In the early 1900s, early production of cotton was seen as a way to escape ravages of the boll weevil, a new pest of U.S. cotton. Using short-season concepts, yields were increased and production costs declined. When new, more effective insecticides were developed, short-season concepts were abandoned—until the insects became resistant and lessened the effectiveness of the insecticide. Each time, the return to using short-season concepts to grow cotton provided increased yields with lower production costs.

Is the latest possible cutout date for effective flowering accurate for all years?

Latest possible cutout date is an average based on long-term weather data. It predicts the latest date that a flower can be expected to have enough heat units (850 DD60s) to develop into a mature boll. Since it is an average, the absolute date for latest possible effective flowering may differ in any year. If late-season weather is warmer than usual, effective flowering may occur later than the latest possible cutout date. Conversely, if cooler conditions occur (usually from an early cold front) then effective flowering may cease prior to the latest possible cutout date. Although not verified, less than 850 HU may be needed in areas where better "quality" of late-season heat units (e.g., higher light intensity, wider diurnal temperature fluctuation) is attained.

Plant Stress

What is the difference between good and bad plant stress?

Cotton plants grow in an indeterminate fashion. They continue vegetative growth after initiation of fruiting (both squares and flowers). Consequently, maintenance of a good balance of vegetative to fruiting growth is important. Typically, stress will impact vegetative growth more quickly than fruit development. Stress may occur because of bad factors (e.g., lack of moisture, temperature extremes, lack of nutrients, hard pans, diseases, root-knot nematode, etc.) or good factors (e.g., large fruit load). The impact of the bad factors is to limit vegetative growth, which will reduce the carrying capacity (fruit load) of the plant. Plants will selectively favor the demands of increasing fruit load over the demand of the vegetative growth, causing plants to progress to physiological cutout.

Does COTMAN differentiate or signal the type of stress plants are undergoing?

Slopes of observed plant growth relative to the TDC can be used to detect plant stress. The TDC tracks typical effects of good stress on plant growth. Bad stress factors will cause a very slow ascent (flatter than TDC) before flowering or a rapid descent (steeper than TDC) after flowering. Although COTMAN does not specify the type of stress, users can typically determine the source of stress by measures of fruit retention and plant vigor and by knowledge of the incipient environmental conditions.

Can COTMAN predict plant stress?

Although COTMAN does not extrapolate growth curves beyond observed data, plant growth conditions that are vulnerable to plant stress can be identified. For example, plants with very high square retention or relatively slow main-stem nodal development (i.e., few NAWF at first flower) are very vulnerable to plant stress. Such plants may cutout prematurely if hot, dry weather is experienced.

Will plant stress managed by COTMAN influence micronaire?

Plant stress may contribute to low or high micronaire. Chronic stress, which limits vegetative growth throughout the season, would likely limit maturation of bolls and cause immature (low micronaire) fiber. Acute stress, which effectively ceases vegetative growth and incites fruit abortion, may result in high micronaire. The specific effects of acute stress on micronaire depend upon the timing of the acute stress and environmental conditions following the acute stress. With early cutout, warm temperatures (especially at night) facilitate the flow of carbohydrates to support sustained fiber development, resulting in high micronaire. Plants that follow the normal development patterns of the TDC should produce inherent micronaire values associated with the cotton variety grown.

Utility of COTMAN Data

Why should a grower be interested in use of COTMAN?

Users of COTMAN should be able to reap the benefits (increased or equal yields with reduced costs and less risks) associated with short-season cotton production (*See* Chapters 10 and 11). It has been suggested that BOLLMAN provides opportunities to save money (i.e., reduce production costs) while SQUAREMAN provides opportunities to make money (i.e., increase yields). The advents of *Bt* cotton and boll weevil eradication have lessened the direct value of BOLLMAN in reducing cost of insect control. Yet, savings with regard to control of other insect pests still exist. More importantly, BOLLMAN provides information regarding end-of-season plant management and relative maturation of different fields. Although users can gain important information from SQUAREMAN, research is needed to be able to fully utilize the economic benefits of this information.

How much time does it require to collect COTMAN data?

Collection of BOLLMAN/NAWF data requires 16 to 23 minutes per field per week. Moving between sampling sites usually takes more time (and effort) than collection of NAWF data at one site. Time requirements for SQUAREMAN data are greater than for BOLLMAN data. As plants get larger, more time is required to collect SQUAREMAN data. Conversely, as plants progress to cutout, less time is required to collect BOLLMAN.

The cost of gathering COTMAN (SQUAREMAN and BOLLMAN) data has been estimated to be $1.65 per acre per season.

Can COTMAN data collected in different fields be compared?

COTMAN provides a very strong tool for comparing plant development in different fields. Variation in growth patterns may be associated with different planting dates, plant densities, soil types, varieties, irrigation, etc. An aberrant growth pattern is “normal” if abnormal conditions are experienced. Thus, fields showing aberrant or unusual growth patterns can be examined for contributing conditions. Comparison of relative maturity of different fields is an important attribute of COTMAN, because it assists with scheduling groups of fields for defoliation and harvest.

Is the role of second- and third-position fruit ignored by the COTMAN program?

The COTMAN program focuses on the first-position squares and bolls. First-position bolls typically account for at least 60% of yield and encompass the full range of fruit age (i.e., oldest and youngest fruit). Therefore, sampling based on first-position squares and bolls should provide correct management for all fruit. Fruit in second and third positions will directly affect the vegetative-to-fruiting balance of the plant and will be reflected in the observed COTMAN growth curve.

Can COTMAN be used to determine time and rate of mepiquat chloride?

The COTMAN curve tends to reflect, rather than detect, the effects of uncontrolled vegetative growth. By the time the curve suggests excessive vegetative growth, it may be too late to effectively control the growth. Direct measures of plant height in SQUAREMAN may be used to assist with plant growth regulator management (*See* Chapter 3).

How can COTMAN be used to time irrigation?

Undue, bad plant stress will likely occur if irrigation is delayed until the COTMAN curve reflects drought conditions. Therefore, other irrigation timing techniques should be utilized to time irrigation. Considerable research has been done to utilized COTMAN data to time to the last irrigation (*See* Chapter 11).

Can COTMAN’s utility be increased through additional research?

Considerable research is being conducted to validate and extend the utility of COTMAN. Some areas that have great potential to increase the utility of COTMAN are:

1. *Improved use of SQUAREMAN data*. At present, pre-flower COTMAN data are used to monitor square retention and nodal development. Little attention has been given to investigating possible remedial and enhancement treatments associated with early-season growth patterns.
2. *Incorporation of COTMAN into precision agriculture*. Precision agriculture provides the opportunity to greatly improve COTMAN sampling techniques so that variability in a field can be more accurately accessed and managed.
3. *Incorporation of COTMAN and remote sensing*. Some evidence indicates that remote-sensing techniques may someday be used to monitor plant growth. If a remote-sensing parameter that closely monitors NAWF can be found, BOLLMAN principles could be applied without physically monitoring fields.