COTTON
Management Guide

DELTA\PINE®

[Image of cotton field and cotton bolls]

[Image of farmer in cotton field]

[Image of cotton plant]

[Image of cotton field with irrigation system]

[Image of cotton bolls close-up]
Cotton has been grown in some fields so long, it is just part of history. On the other end of the spectrum, we have growers who are getting back into cotton thanks to the many advances in the cotton industry. Over the past 10 years, the industry as a whole has learned a great deal about managing this crop for increasing productivity. Deltapine® brand cotton varieties have been with the industry through all the changes, leading the way.

As a company, Monsanto is committed to providing growers value through genetics, technology, and crop management information. The development of transgenic varieties has increased the complexity of management decisions. Furthermore, advances in genetics allow growers to tailor their variety selection to take advantage of the increased yield potential, disease resistance, or other traits that fit specific fields and farms. This means a shift in management as growers are no longer managing one or two varieties across several fields and years. We now must understand the developmental status of the crop and manage for that particular situation in order to maximize potential.

Deltapine Brand COTTON MANAGEMENT GUIDE has been developed to help provide growers value through genetics, technology, and crop management information. As you read this book or refer to it in season, we hope it provides you with the information and tools necessary for you to use in growing a productive, profitable crop. For additional information, visit www.deltapine.com.
### chapter 1 PRESEASON
Management decisions made prior to and during planting

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>variety selection</td>
<td>4</td>
</tr>
<tr>
<td>Pest Management Traits</td>
<td>4</td>
</tr>
<tr>
<td>seed quality</td>
<td>5</td>
</tr>
<tr>
<td>Agronomic Traits</td>
<td>6</td>
</tr>
<tr>
<td>planting</td>
<td>6-21</td>
</tr>
<tr>
<td>Soil Temperature</td>
<td>6</td>
</tr>
<tr>
<td>Weather Outlook</td>
<td>8</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>9</td>
</tr>
<tr>
<td>Planter Preparation</td>
<td>10</td>
</tr>
<tr>
<td>Preemergence Weed Control Advice</td>
<td>10</td>
</tr>
<tr>
<td>Preseason Weed Control</td>
<td>11</td>
</tr>
<tr>
<td>Seedbed Preparation</td>
<td>13</td>
</tr>
<tr>
<td>Planting Depth</td>
<td>13</td>
</tr>
<tr>
<td>Planting Rate</td>
<td>14</td>
</tr>
<tr>
<td>Fertility</td>
<td>16</td>
</tr>
<tr>
<td>Working Through Replant Decisions</td>
<td>17</td>
</tr>
<tr>
<td>Seedling Diseases And Treatments</td>
<td>18</td>
</tr>
<tr>
<td>Nematodes</td>
<td>18</td>
</tr>
<tr>
<td>Emergence</td>
<td>20</td>
</tr>
</tbody>
</table>

### chapter 2 EARLY-SEASON
From emergence through squaring

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>plant population</td>
<td>22</td>
</tr>
<tr>
<td>monitoring growth</td>
<td>23</td>
</tr>
<tr>
<td>Growth Physiology</td>
<td>24</td>
</tr>
<tr>
<td>Root Growth</td>
<td>26</td>
</tr>
<tr>
<td>Balanced Growth</td>
<td>26</td>
</tr>
<tr>
<td>Branch Development</td>
<td>27</td>
</tr>
<tr>
<td>Square Set and Retention</td>
<td>30</td>
</tr>
<tr>
<td>Cotton Plant Monitoring</td>
<td>31</td>
</tr>
<tr>
<td>managing growth</td>
<td>32</td>
</tr>
<tr>
<td>Plant Growth Regulator Use</td>
<td>32</td>
</tr>
<tr>
<td>Fertility</td>
<td>34</td>
</tr>
<tr>
<td>Early-season Fertility Needs and Deficiency Impacts</td>
<td>35</td>
</tr>
<tr>
<td>Irrigation</td>
<td>36</td>
</tr>
<tr>
<td>Pest Management</td>
<td>38</td>
</tr>
<tr>
<td>Weed Control</td>
<td>38</td>
</tr>
<tr>
<td>Insect Control</td>
<td>39</td>
</tr>
</tbody>
</table>
chapter 3 MIDSEASON

from bloom until cutout

monitoring growth ................................................. 40
  Plant Height .................................................. 40
  Mainstem Nodes .............................................. 40
  Squaring Nodes or Nodes Above White Flower ................. 41
  Maximum Internode Distance ................................. 42
  Managing Fiber Quality ..................................... 42

plant growth regulator use ................................. 44
  Post Bloom Management of Nitrogen Fertility ............... 44
  Fertility ....................................................... 46
  Irrigation ...................................................... 48

insect management ........................................... 49
  Scouting Genuity® Bollgard II® Cotton ....................... 49
  Cotton Bollworm, Tobacco Budworm, Pink Bollworm ...... 50
  Other Cotton Pests .......................................... 51

diagnosing cotton diseases ................................... 51

midseason weed control ...................................... 53
  Postemergence Herbicide Options .............................. 53
  Hooded Sprayer and Post-directed Herbicide Options ...... 53

chapter 4 LATE- AND POSTSEASON

From cutout through defoliation; harvest and postharvest

determining and using cutout ............................. 54

managing late-season growth .............................. 55
  Defoliation .................................................. 55
  Timing Defoliation ......................................... 56
  Defoliation Materials ....................................... 58

harvesting .......................................................... 58

storing in modules ........................................... 59
  Insect Level Management .................................. 59

postharvest soil sampling .................................... 60

Interpreting and Using Variety Test Results .................. 58

sources
Decisions made during the winter and spring – whether good or bad – may affect the entire cotton production season. For that reason, considering all the options and tailoring a production program to maximize yield potential begins long before the planter is in the field. This chapter will review some of those critical decisions and practices.

**Variety Selection**

One of the first decisions cotton growers make each season is selection of which varieties they will plant. This decision has become more complex with the availability of varieties with different pest management traits. Consequently, analyzing new varieties and technologies for their fit in each field has increased in importance. The goal still remains the same – selection of a cotton product which will add the most to the bottom line through adaptation, yield, and input costs.

**Pest Management Traits**

New insect or weed management trait offerings can be alluring to growers. It is wise to evaluate any new variety or trait technology combination on a limited scale during its first year of release, unless the technological advance is so beneficial that it is worth the risk of planting a high percentage of the farm to the technology. It is important to remember that with any new variety/trait package specific management may be different than with previous products, related or not. Recommendations contained in this guide should aid in managing the new cotton product on a field-by-field basis.

When possible, it is best to choose a cotton variety with proven high yield potential within the specific geography. It is also important to consider the stability and quality characteristics of the cotton variety. Multiple cotton varieties with different maturities should be selected so cotton will not mature at the same time. Consider staggering planting dates when using the same variety.

The decision to use a given trait package should be based around several variables that are fairly common in most crop production systems.
These variables include:

- Changes in application cost and frequency associated with shifting pest pressures and inherent characteristics of the technology

- Changes in inputs due to both trait and variety shifts
  - Trait shifts
    - Control of target pests
    - Increased impact of secondary pests not controlled by trait
  - Variety shifts
    - PGR applications rates and timings may need to be adjusted
    - Fertilizer timing and amounts (due to different maturity or plant types)

- Changes in labor - labor requirements can be either increased or decreased depending on the situation. This includes labor required to hand weed, operate machinery, and generally manage the crop depending on the season.

- Change in yields - yields/fiber quality can be influenced by several factors including:
  - Improved control of target pests, both weed and insect
  - Increased yield potential of new varieties
  - Improvements in fiber quality as new higher quality products enter the market

- Risk management - as with the older trait/variety combinations, many new and emerging technologies are entering the marketplace. These new products may help to reduce a grower’s production risks and should be carefully evaluated on limited acres during the first year.

See also: Interpreting and Using Variety Test Results, page 56.

**Seed Quality**

When choosing cotton seed, check the bag for seed viability information from Standard Germination Testing. The Standard Germination Test provides the estimated percentage of seeds likely to emerge under ideal, warm growing conditions. The Standard Germination Test percentage should be at least 80% under the standard conditions. For germination testing under less than ideal conditions, the Cool Germination Test results provide an estimate for the percent of germination when planting into cooler soils (near 65°F). To obtain Cool Germination Testing information, check with your seed supplier or send seed samples in for university or private testing. The Cool Germination Test results should be at least 60%. To obtain the standard (warm) and cool germination data for the Deltapine® brand varieties that you have purchased, contact your dealer. They can obtain the germination data from the standard, cool, and state germination tests for you from Monsanto.
Agronomic Traits
Deltapine® recommends selecting varieties for each field on your farm. The selection of the variety to use in each field should be based on how well that variety will do under the specific environmental conditions, soil type, and management practices in that field. Because environmental conditions will vary, selecting a variety which has performance stability can help maintain consistent yields across different seasons/environments. Some variety traits for you to consider are in the table on the following page. This table is designed to help compile that information into an easy-to-use format. Management practices can help push varieties outside many of their normal growth patterns, but it is generally a good management practice to select a variety which offers good yield potential based on local experience. Once you complete the chart on the following page you can begin comparing your needs to products on the market.

Planting
Getting the seed in the ground at the right time requires a balancing act. Current conditions, as well as the 10-day forecast, are critical components of the planting decision. Managing a crop after it has emerged can be calendar sensitive in some ways as there are methods to encourage late-planted crops to mature earlier than normal. But planting itself should not be rushed simply because the crop is normally in the ground at a given date. Producing a late-planted crop is preferred to planting before conditions are right. And though timing is a chief component of planting, it is a concept which is based on several factors, not on the calendar.

Grower Tip | Ideal Soil Temp
Plant when soil temperatures are greater than 65°F at 8 a.m. at a depth of 4 to 6 inches for 3 to 5 consecutive days.

Soil Temperature
Cotton germination and emergence are favored when the soil temperatures are 65°F or greater. As a good rule of thumb for planting, at 8 a.m. the soil temperature should be at least 65°F at a soil depth of 4 inches or more. This represents the coolest soil temperature during the previous 24-hour period. Thus, for the minimum soil temperature to warm to 65°F, heat accumulation must have been good for the last 3 to 5 days.
## Selecting the Right Agronomic Trait for Your Operation

<table>
<thead>
<tr>
<th>Importance Ranking</th>
<th>Agronomic Trait</th>
<th>Primary Question(s)</th>
<th>Specific Need (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maturity</td>
<td>What maturity helps maximize yield potential in your area?</td>
<td>Early maturing Midseason</td>
</tr>
<tr>
<td></td>
<td>Plant Height</td>
<td>Does cotton tend to grow short or tall on your ground? Do you need a compact plant for harvest?</td>
<td>Short Medium Tall</td>
</tr>
<tr>
<td></td>
<td>Leaf Pubescence</td>
<td>Are there particular insects in your area that make smoothness important?</td>
<td>Smooth Semi-smooth Hairy</td>
</tr>
<tr>
<td></td>
<td>Storm Resistance</td>
<td>Is fall out or harvestability more of a concern?</td>
<td>Average Good Very Good Excellent</td>
</tr>
<tr>
<td></td>
<td>Fiber Qualities</td>
<td>Are there particular qualities which you need to maximize or others you should seek to limit?</td>
<td>Length Average Good Very Good Excellent</td>
</tr>
<tr>
<td></td>
<td>Micronaire</td>
<td>Low Tendency Medium Tendency High Tendency</td>
<td>Turnout Average Good Very Good Excellent</td>
</tr>
<tr>
<td></td>
<td>Disease/Nematodes</td>
<td>Does disease resistance help add to your yields?</td>
<td>Fusarium Wilt Resistance Average Good Very Good Excellent</td>
</tr>
<tr>
<td></td>
<td>Verticillium Wilt Resistance</td>
<td></td>
<td>Average Good Very Good Excellent</td>
</tr>
</tbody>
</table>

*per acre fees calculated on regional seed drop rates*
The time required for soils to warm depends on a number of factors:

- **Air Temperature** – Warm air temperatures elevate soil temperature by transferring energy through convection. Air temperature alone is a weak indicator of proper planting time.

- **Sunlight** – Radiant heat, from a sunny day, is absorbed by the soil and warms the soil faster than air temperature alone. Consequently, sunny days result in faster soil warming even if air temperatures were equal.

- **Moisture** – Moisture at the surface will cool the soil as it evaporates. Consequently, wet soils require more energy (sunlight and/or high air temperatures) to warm than drier soils.

- **Texture and Color** – Soil texture and color affect how rapidly soils warm. Sandy soils hold less water and warm up faster than clay soils. Light-colored soils reflect more light than dark soils and, therefore, dark soils heat faster. Notice that if the soil texture is not uniform, there can be differences in emergence.

- **Ground Cover** – Fields with high levels of crop residue or trash will warm more slowly than fields with minimal ground cover. This is due to the conservation of moisture at the soil surface.

**Weather Outlook**

Degree days (DD60s) describe cotton’s potential for growth and provide an excellent evaluation tool for planting conditions. Research has shown that when the number of DD60s accumulated in the 5 days following planting is less than 10, planting conditions are very unfavorable and yield potential of the crop can be reduced. In addition, the stress caused at this point can mean changes in your management program to compensate for uneven stands and weak or diseased plants.

The 5-day outlook on DD60s is currently available in many areas of the Cotton Belt. Using this method in conjunction with soil temperature and moisture contents is key to reliability.
Cotton can suffer chilling injury whenever the soil temperature falls below 50°F, and the severity of injury increases the longer seeds are exposed to the cold. The crop is most susceptible to chilling injury:

- during the first couple of days after planting
- when the seed is initiating water uptake (imbibition)

Imbibition is a sensitive period because moisture content increases from 6 to 10 percent to approximately 50 percent within 5 hours, half of this moisture increase is during the first 30 minutes. Temperatures as low as 50°F do not appear to adversely influence seed vigor. However, low temperatures will increase seedling disease pressure, potentially resulting in a loss of seedlings. If temperatures are below 42°F at this time, the seed will die. Therefore, the minimum temperature at seed depth in the first 6 hours after planting is especially important.

The first 2 to 4 days after planting is when the radicle begins to emerge from the seed, with warm temperatures leading to more rapid emergence. The adverse effect of cool temperatures during this period is cumulative and yield reduction can be related to chilling hours below 50°F (DD<50). Injury at this stage impacts the emerging seedling’s capacity to manufacture proteins, which can ultimately limit yield potential.

Because planting into cool soils is risky and can have such negative effects, delayed planting is preferred to planting under questionable soil conditions. Through careful and intensive management, it is possible to achieve an early-maturing crop with high yield potential in most growing areas of the U.S. without having an early planting date. In those areas with short growing seasons, there is a compromise between negative effects of planting under less than optimal conditions and questions of the season’s length allowing the crop to mature.

**Soil Moisture**

Planting into moisture is critical, if irrigation will not be used to aid in germination. Cotton seeds easily absorb moisture from fairly dry soil and begin the process of germination. If the seed has softened, there must be adequate moisture to continue the process of germination or the young cotton seedling will die. The challenge is to insure there is enough water for germination and throughout emergence of the seedling.

At the same time, cotton is susceptible to water-logged soils. This is because cotton seeds contain a high percentage of oil, making them sensitive to low soil oxygen. For this reason, good drainage (either through beds, deep tillage or other means) is important to improve soil oxygen supply at the seedling depth. This is especially important in heavy soils which naturally have a higher water holding capacity, and in turn, less oxygen.
Planter Preparation
Cotton seed should be planted 0.75 to 1.5 inches into the soil depending on the soil texture and available moisture. The seed should be placed where moisture is available for germination. In coarse soils the seed should be placed in the moisture and in heavier clay soils the seed should be placed just at the moisture. Planter depth should be set in the field once the soil texture and moisture depth is determined. Planting too shallow will result in poor seed-to-soil contact and too deep can cause a skippy stand and delayed emergence. To confirm seed depth and spacing, check the planting by digging behind the planter after 50 to 100 feet of row.

The following planter parts should be checked, cleaned, fixed or replaced if needed:
- Drive trains
- Shaft bearings
- Sprocket bearings
- Sprocket teeth
- Opener blades
- Disc openers

Also be sure to check the down pressure of the closing wheel. If soils are dry, down pressure should be increased to help bring water to the seed. If soils are wet, down pressure should be decreased to avoid soil compaction around the newly planted seed. Clean and check all seals in the vacuum system. To calibrate, follow instruction in the owner’s manual. Finally, follow appropriate planting speeds to maintain uniform planting.

Preemergence Weed Control Advice
The use and adoption of cotton varieties containing Genuity® Roundup Ready® Flex remains a very important part of cotton production across the Cotton Belt. Glyphosate-resistant weeds have presented many management challenges and will likely remain an issue into the foreseeable future. One set of tools that can help manage this issue are preemergence herbicides. As you consider herbicide technology for fields on your farm, careful consideration should be given to all available components of the weed control system. This includes transgenic traits, appropriate tillage, and the proper use of all herbicides including preemergence herbicide products. The following are a few considerations when evaluating preemergence herbicides for use on your farm.
Benefits of Preemergence Herbicides

- Improved weed control and reduced early-season weed interference.
- Often provides wider window for postemergence herbicide application.
- Additional mode of action may prevent weed shifts and weed resistance from developing.
- Preemergence herbicides sometimes control weeds (velvetleaf, nutsedges, hemp sesbania, prickly sida, etc.) that are difficult to manage with postemergence herbicides.
- Preemergence herbicides may provide control during period when postemergence herbicide effectiveness may be reduced by drought stress.

Watchouts for Preemergence Herbicides

- Early-season cotton injury may delay earliness and reduce yield.
- May preclude preplant options to other crops if cotton stand fails.
- Increased production costs.
- Without optimum rainfall, weed control benefits of preemergence herbicides may not be realized.
- Residual premergence herbicides increase the selection pressure on weeds.
- Weeds may escape preemergence herbicides and require additional postemergence control measures.

Preseason Weed Control

Weed control can differ significantly by area, weed spectrum, soil type, equipment and most recently by planting herbicide-tolerant varieties. Regardless of the method chosen, the benefits of effective weed control are evident in higher yields from reduced competition and better grades from a reduction in harvested trash. With the introduction of Roundup Ready® and Genuity® Roundup Ready® Flex cotton, reliance on glyphosate in single mode of action postemergence programs dramatically reduced the number of other herbicides used, which in turn has led to an increase in the incidence of glyphosate-resistant weeds. With the development of glyphosate-resistant weeds, effective weed management prior to planting has become a critical success factor for achieving maximum yield potential. With limited in-crop herbicide options to control emerged resistant weeds, starting weed free is critical. Regardless of which crop technology growers use, any weed control system in cotton should include different products with multiple modes of action, specifically products with residual activity.
Growers should start with a clean seedbed by either using tillage or burndown herbicide application to control emerged weeds. As some growers struggle to control herbicide-resistant weed populations, one option for control is tank mixing herbicides with different modes of action. As weed populations become more difficult to control, it is recommended that a season-long weed management program be established including herbicide applications throughout the growing season including preplanting, early postemergence and layby.

When dealing with tough to control weeds, a spring burndown program is one of the most effective ways to start the season with a clean field. It is recommended that a burndown program includes glyphosate at 0.75 lbs ae/A, plus dicamba at 8 fl oz/A, plus flumioxazin at 2 oz/A. A residual herbicide with the active ingredient fomesafen, fluometuron, or diuron should also be applied preemergence.

**Preseason Herbicide Options**
- glyphosate
- flumioxazin
- paraquat
- fluometuron
- prometryn
- diuron
- pyrithiobic-sodium
- pendimethalin
- 2,4-D
- trifluralin
- fomesafen
- dicamba
- glufosinate

**Roundup Ready PLUS® Weed Management Solutions**
A centralized resource for staying informed about weed resistance by combining the knowledge of weed scientists, academics, agronomists and industry partners.

Visit roundupreadyplus.com to find local herbicide recommendations.
Seedbed Preparation

There are regional differences in the details of preparing the field for planting, with some areas rowing up in the fall, some waiting until just before planting, and others planting flat with no bed preparation. Primary reasons for the differences involve timing for planting in the spring, retention of moisture and soil conservation.

Whatever differences lie in the type of bed or timing of the preparation, the importance for starting with a clean, weed-free field crosses all geographies. Strategies to reach that objective vary in some areas with residual herbicides preferred in some and not others.

Planting Depth

It is commonly accepted that the optimum planting depth is between 0.75 and 1.5 inches. Precise planting depth varies with soil type and with wind (to insure that seedling root systems do not dry out, planting depths may be deeper in high wind areas). Soil crusting potential should also be considered.

Grower Tip

Weed control choices made at this point need to have a season-long approach:

Species: What species of weeds are present? (Proper identification of weeds in each field is critical).

Herbicide Tolerance: Which herbicide-tolerant variety are you planting and which technology(s) does it contain? Depending on the answer to this question, many weed scientists suggest using a different classes of preplant herbicides to ensure the highest probability of achieving adequate weed control.

Timing: Which preemergence herbicide should you use and should it be used alone or in combination with cultivation? Can residual herbicides be “layered” overtime into the field as needed early in the season?

Equipment: Do you have the proper equipment needed to apply the product you are considering? Have you checked and calibrated your equipment? Have you repaired or replaced worn or damaged parts? Post-directed applications need to be applied accurately to prevent possible in-field and off-target crop damage. All applications should be as uniform as possible for the best efficacy.

Rotation: Will you be rotating this field to another crop next season? If yes, choose products carefully as the use of some residuals can carryover and have negative effects on grain crops.
Planting Rate

Planting rate is a decision that has far reaching effects, some of which cannot be modified after the seed is in the ground, except by replanting. If the exact planting rate is questionable, erring on the side of a high density is better than planting too few seeds.

In figuring seeding rate, seed per acre or seed per row foot are the preferred methods as they translate well from variety to variety. A more traditional figure of pounds per acre does not account for differences in seed size, which can be significant between large- and small-seeded varieties. You should set your seeding rate based on desired final stand. The chart below provides information on determining the final stand after emergence.

Seeding rates do vary from state to state, but the range is generally from 3 to 5 seed per row foot for 30- to 40-inch rows depending on local conditions. The target is generally 35,000 to 60,000 plants per acre.

Several local conditions can generally influence the need to adjust cotton planting populations depending on management system/style, variety characteristics, projected weather patterns, and planting date. Some of these specific conditions include:

1. Early planting - A challenge of early planting is often on the ability to establish and maintain an adequate stand in the face of seedling disease, cold weather, and generally difficult establishment conditions. In the case of early planting into adverse conditions, populations should be increased to compensate for potential losses.

Effect of Final Plant Density on Relative Yield (suitable for 30- to 40-inch rows)

![Graph showing the effect of final plant density on relative yield.](image-url)

2. **Late planting and/or dryland production** - This scenario includes any case where earliness is at a premium. Cotton planted behind wheat or in the last quarter of the planting cycle falls generally into this category. In cases where earliness is required, planting higher populations, in combination with aggressive in-crop management can help make the crop earlier while maintaining adequate yield potential. Having more plants in the field allows a relatively high level of yield accumulation in shorter periods of time as compared to less dense stands. This ultimately allows for an earlier crop to be harvested.

3. **Planting on “growthy” soil types** - Highly productive soils that have demonstrated the need for aggressive growth control in the past can often benefit from decreasing the planting populations versus the previous experience. Fewer plants generate less competition for resources and thereby usually require less growth control.

4. **High input, high yield environments** - These production environments require the most aggressive decision making, management inputs, and carry somewhat higher risk. In this scenario we generally plant populations on the high end of a spectrum for a region. These fields are typically irrigated and are very aggressively managed with PGRs, fertility, and irrigation applications. All of these factors influence the likely outcome of a crop in any field, but in this environment, having relatively high numbers of surviving plants establishes the yield potential early in the season. This management style requires relatively high populations be planted as compared to the scenarios described earlier. It also carries somewhat more risk but can be managed as long as those risks are acknowledged up front starting with planting rates and continuing with in-season management decisions.

Setting a target final stand can be accomplished by figuring a targeted seed per foot or plants per acre. Seeding rates can be adjusted by slightly lowering them as the weather conditions and forecast move toward the ideal, which can be achieved under irrigation and high temperatures.

### Seed Drop Rates for Desired Plants Per Foot of Row

<table>
<thead>
<tr>
<th>Seed per ft</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>row width</td>
<td>Actual pop. @ 2 seed/ft</td>
<td>Required drop rate @ 75% survival</td>
<td>Actual pop. @ 2.5 seed/ft</td>
<td>Required drop rate @ 75% survival</td>
<td>Actual pop. @ 3 seed/ft</td>
</tr>
<tr>
<td>30”</td>
<td>35,000</td>
<td>47,000</td>
<td>43,500</td>
<td>58,000</td>
<td>52,000</td>
</tr>
<tr>
<td>36”</td>
<td>29,000</td>
<td>39,000</td>
<td>36,000</td>
<td>48,500</td>
<td>43,500</td>
</tr>
<tr>
<td>38”</td>
<td>27,500</td>
<td>36,500</td>
<td>34,500</td>
<td>46,000</td>
<td>41,000</td>
</tr>
<tr>
<td>40”</td>
<td>26,000</td>
<td>35,000</td>
<td>33,000</td>
<td>43,560</td>
<td>39,000</td>
</tr>
</tbody>
</table>

15
Another decision to be made at planting time is plant spacing: drilled versus hill drop. Both systems have advantages, and fields planted to populations generally yield similarly regardless of plant spacing as long as adequate plants emerge and contribute to yield.

The advantage that hill drop systems provides is mainly in “pushing power” where difficult emergence condition are expected. Multiple seeds, for example 3 per hill with hills 12 inches apart, are somewhat better able to break soil crusts and establish viable plants in difficult conditions. The disadvantage to hill drop is that in each hill one plant usually emerges later than the first to emerge and becomes relatively nonproductive.

Drilled plantings provide uniform spacing of plants and avoid some of the issues observed in hill drop planting. Both systems can be utilized successfully in many environments. Careful evaluation of local conditions at planting time can help make this decision.

**Fertility**

Starting with and providing adequate fertility levels throughout the season is important to insure proper vegetative and reproductive growth during the entire season. While certain nutrients, especially nitrogen and potassium, are important to healthy crop development, specific fertility levels vary by several factors including soil type and irrigation or water use/availability. Consequently, management is dependent on soil tests results preseason, with petiole sampling potentially taking a critical role later in the season. *(fertility is covered in more detail in later chapters)*

**Important Nutrients Required by Cotton**

<table>
<thead>
<tr>
<th>Element</th>
<th>Nutrient</th>
<th>Estimated amounts needed units/bale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Nitrogen</td>
<td>45-60</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
<td>20-25</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
<td>40-45</td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
<td>7-9</td>
</tr>
<tr>
<td>Mg</td>
<td>Magnesium</td>
<td>10-14</td>
</tr>
<tr>
<td>S</td>
<td>Sulfur</td>
<td>10-14</td>
</tr>
<tr>
<td>Micronutrients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Boron</td>
<td>~1</td>
</tr>
<tr>
<td>Zn</td>
<td>Zinc</td>
<td>~4</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
<td>~10</td>
</tr>
<tr>
<td>Fe</td>
<td>Iron</td>
<td>~4</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
<td>~0.75</td>
</tr>
</tbody>
</table>
Working Through Replant Decisions

A producer should consider all options prior to replanting a crop. The existing plant population, uniformity of the stand, and potential yield must be considered. The following are tips to help growers decide when to replant and when to leave a cotton stand as is.

Question the Poor Stand—Why is the stand not optimal? Was a planter not calibrated or was seed planted too deep or shallow for field conditions? Were seedling diseases or insects responsible for the lost stand? Was soil moisture too high or low at planting? Knowing the answers to these questions could prevent a second loss if the decision to replant is made.

Evaluating the Existing Stand—If a crop stand has been diminished due to injury (mechanical, chemical, disease, insect, etc.) the health of the remaining plants should be assessed. Different areas of a field should be sampled to determine crop damage, especially if the injury does not appear to be uniform. To assess a cotton crop, count the number of living plants (or plants that will recover) and calculate the stand in 10 locations.

Deciding Whether to Replant—Once population and uniformity have been determined, the decision needs to be made whether to leave the existing stand, replant, or fill in. Additionally, determine if the entire field or portions of the field justify action. Filling in skips by replanting portions of the field, or spot planting, is only recommended if performed within 14 days of the original planting date.

Unlike many other row crops, cotton has unique growth habits that can make up for losses in stand. According to Mississippi State University, if plant distribution is fairly uniform, yields can remain fair with plant populations as low as 20,000 plants per acre (or one plant per row foot). For the Southeast and Midsouth regions, replant may be justified if in 80 feet of row there are at least 13 skips of 3 feet in length.

Determine the Replant Cost—The cost of replanting a field must also be factored into the replant decision. If your crop has failed, check with your seed dealer or company representative to talk about replant costs as in some situations seed and technology fees may be refunded.

Estimate the following costs for replanting: cost of seed, fuel, machinery, labor, and pesticide applications (this may include a burndown to kill existing stand). Add these costs together and deduct from the anticipated profit for the replanted cotton crop. (*Remember, late-planted cotton may reduce yield potential.*)

Making the Final Decision—To determine whether or not to replant, carefully consider the stand count of the injured crop, what replanting will costs, and how late replanting will take place in relation to the region’s planting window. And always remember the rule of thumb that has worked well for many years: When in doubt, don’t.
Seedling Diseases and Treatments

Early-season environments can favor the development of seedling disease. Because you cannot always be sure what kind of early season you will have, using a seed treatment is essential. Deltapine® brand seed provides the industry’s leading treatment for the control of broad-spectrum of early-season seedling diseases, insect and nematode pests with Acceleron® Seed Treatment Products. The benefits of buying treated seed and using an in-furrow fungicide can be seen during emergence and grow off, but the payoff is often also seen at harvest.

Modern seed treatment combinations are designed to provide multiple benefits to the cotton seed and seedling. Several components are included in most treatments and are often available alone or in other combinations. The common components in most seed treatments include:

- **Fungicides** - This portion of a treatment package includes various products aimed at the control of seed and seedling disease. Fungicidal components may include various classes of chemistry and are on the seed to control disease pests such as pythium, fusarium, and rhizoctonia.

- **Insecticides** - These treatments are primarily targeted at insect control very early (0-24 days) after seedling cotton plants emerge. The neonicotinoid insecticides are currently the primary members of this group. Thrips and aphids, along with very early fleahopper and Lygus control are the primary goals with seed treatment insecticides.

- **Nematicides** - Several new and emerging compounds are currently used or being developed for nematode control/suppression when used as seed treatments. Several species of nematodes are targeted with these products including the primary pests of reniform and root-knot nematodes across the cotton belt.

Nematodes

High populations of plant-parasitic nematodes can cause major losses in cotton and increase plant susceptibility to diseases. Plant-parasitic nematodes have been identified in every cotton-producing state, and continue to be a problem for cotton producers especially in the Southeast and Midouth regions.

The presence of certain nematode species can vary according to environmental conditions, soil types and actively growing plants. Nematodes feeding on root cells reduce the plants ability to uptake water and nutrients. Damage caused by root feeding can further injure a plant by allowing fungal and bacterial pathogens to enter into the plant and cause disease complexes.

Root-knot and reniform nematodes are becoming an increasing problem in cotton. Even though differences in symptoms occur between each species, laboratory testing should be
conducted to verify the type. Knowing the nematode species will also help determine what crop rotation options may help suppress the population.

Symptoms of nematode feeding are most noticeable when environmental conditions cause plant stress. For all nematode species, common aboveground symptoms include wilting by midday and stunting of growth. Common belowground symptoms include swollen roots, galls on roots (root-knot nematode), lack of fine roots, minimal root branching and necrotic lesions. Nematode damage is rarely uniform within a field, and is typically more visible in areas with sandier soils.

In many regions, nematodes are perceived as an increasing problem among cotton producers. Current trends in cotton production may be contributing to higher nematode populations, these practices include limited use of crop rotation, reduced tillage, and less use of soil-applied insecticides.

To confirm the presence of nematodes, soil and root samples must be taken and submitted to a nematode testing facility. Treatment recommendations can be made after test results confirm the nematode species and approximate population density. Refer to university recommendations for treatment thresholds.

**Nematode Sampling**

If nematodes are a current problem or suspected problem, a definitive sampling procedure should be used. Samples should be collected around the edges of symptomatic areas near the plant’s root zone when soils are not overly wet or dry. In cotton, nematode populations are easiest to detect when bolls begin to open. In fields with a history of nematode problems, samples can be taken in the fall so appropriate management strategies can be determined prior to planting. Samples should be placed in a plastic bag to inhibit drying, kept cool and handled with care to avoid killing nematodes before they reach the lab. When mailing samples, overnight shipment when possible. Sampling procedures may vary by testing facility, contact your local laboratory for specific sampling guidelines.
Nematode Control

Nematicides can be used to protect young seedling roots for 4 to 6 weeks. Other nematode control options are centered on reducing crop stress. The following agronomic practices may help growers manage potential nematode infestations.

- Fertilize according to soil test recommendations. Healthy plants are less susceptible to nematode damage.
- Maintain good weed control as weeds can also be a host plant for nematodes.
- For certain nematode species, rotating to a non-host crop can reduce populations. Rotate to corn or resistant soybean varieties when reniform nematodes are present.
- Chemical nematicides may be an option; however, application timing may not be convenient and may require extra safety precautions.

To protect young cotton plants, chemical options include: fumigants, soil-applied insecticides, seed treatments and foliar applications. Control options may vary from state to state.

Seed treatments may be a good option for nematode control due to ease of application, compatibility with other insect-controlling seed treatments and traits, and ability to target specific areas of a field. Monsanto continues to test and evaluate seed treatment nematicide options that will provide producers protection against these organisms.

Emergence

Monitoring emergence is important because it can be a signal of a problem if cotton is not emerging on schedule. For almost all varieties it takes about 50 DD60s from planting to emergence. The actual time of emergence can be defined in a number of different ways, but the day you can first “row” the cotton is a good guideline. “Rowing” the cotton refers to the time you can look down the seedbed and see a row of cotton without too much difficulty. It also corresponds very closely to the time at which there is enough of a stand that you would not consider replanting.

If a cotton field does not begin emerging after 50 to 60 DD60s, the cause of the problem should be investigated. There are many reasons why a field fails to emerge on schedule, but planting too deep or into inadequate or excess moisture are common reasons. The following chart of questions is designed to help in troubleshooting.
Questioning Slow Emergence

Temperature

- Is the temperature in the field the same as at the thermometer?
  - If not, you may have an incorrect estimate of DD60s.
- Did the soil temperature at the seed depth fall below 50°F?
  - If so, your crop may have sustained chilling injury.

Seed Depth

- Check the depth of the seed.
- Seeds planted deeper than 2 inches may be unable to emerge.

Moisture

- Under what moisture conditions has the field been since planting?
  - The soil in the area adjacent to the seed needs to remain moist. Saturated soils will often prevent emergence, as will drought.

Seedbed

- Has a crust formed?
  - Crusting of the soil surface can prevent seedling emergence. If the problem is severe, cultivation and possible replanting may be necessary.

Pests

- Are there disease or insect pests preventing the crop from emerging on schedule?
  - Seed rot can prevent germination or emergence and seedling disease can kill young plants as they emerge. Early-season insects can prevent emergence or damage seedlings as they emerge. Treat with the recommended product for your area.

Chemical Inhibitors

- Is there a herbicide problem from last year or earlier this year?
  - Monitoring herbicide use during the season and from season-to-season is critical. Elevated herbicide rates can prevent cotton emergence.
- Is there some other residual soil chemical (for example, starter fertilizer or salts) causing a problem?
  - Salts and excess fertilizer can have negative effects on emergence.
chapter 2  EARLY-SEASON

Entering early-season, there are many important topics that come to mind. In looking at crop development and growth during this period, begin looking at the season's total potential. Management decisions need to be made with this in mind, whether determining stand, monitoring node development or controlling pests.

Plant Population

One of the first things to do early-season is to determine plant population so management can be tailored appropriately. There are a number of different methods for estimating plant population or density, all of which involve counting the number of cotton plants in a certain distance of row. One method, which closely corresponds to our seeding guideline is determining the average number of plants per foot, and then using the table on the following page to convert those values to plants per acre. This method is beneficial because it does not require the measurement of a certain distance which varies with row spacing, but it does require the use of this table.

Once you determine final population, you need to begin tailoring your management practices in each field to the population present. The accompanying chart provides some general guidelines on growth and development as related to population as well as some of the management practices which may be considered.

Grower Tip | Skip Row Planting

Skip row planting does not follow the same method; however, skips can be ignored and the crop managed based on solid planting.
Comparison of the Effects of Low and High Plant Densities on Cotton Growth and Development

<table>
<thead>
<tr>
<th>Effects of Low Densities</th>
<th>Effects of High Densities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushier plants with more vegetative branches</td>
<td>Taller, more compact (narrower) plants</td>
</tr>
<tr>
<td>Earlier fruiting, but delayed maturity</td>
<td>Delayed fruiting on the plant</td>
</tr>
<tr>
<td>Greater verticilium wilt susceptibility</td>
<td>Lower verticilium wilt susceptibility</td>
</tr>
<tr>
<td>Increased drought tolerance</td>
<td>Decreased drought tolerance</td>
</tr>
<tr>
<td>Delayed cutout</td>
<td>Earlier cutout</td>
</tr>
<tr>
<td>Decreased picker efficiency</td>
<td>Increased picker efficiency</td>
</tr>
</tbody>
</table>

Estimate of Plant Population Per Acre

<table>
<thead>
<tr>
<th>Row width (in.)</th>
<th>Average Number of Plants Per Foot</th>
<th>Plants Per Acre in Thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>30</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>32</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>36</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>38</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>40</td>
<td>26</td>
<td>33</td>
</tr>
</tbody>
</table>
Monitoring Growth

After stand establishment, it is necessary to monitor the growth rate of cotton to determine whether or not a cotton field is making acceptable progress. Although growth and development will vary from area to area, the rate of development is related to degree days and should be fairly constant. When growers and consultants monitor and record DD60s, they make more accurate estimations of growth and development deviations from acceptable growth in their fields.

DD60s are a measure of the energy available for growth. Solar radiation is the ultimate source of energy for cotton growth through photosynthesis and although DD60s do not measure the amount of solar radiation available, they are an excellent estimate of the expected growth stage, based solely on temperature. This equation is accurate whenever the minimum temperature is greater than the lower threshold (60°F).

Certain events in the growth of cotton occur at a set number of DD60s after planting. Although there is some minor variability between varieties, most varieties are similar enough that a table of growth stages as related to DD60s can be developed. Remember that varieties will vary slightly, and environmental conditions (such as water stress and fertility levels) will also impact growth.

Growth Stages Indicated By Accumulation of DD60s and Days

<table>
<thead>
<tr>
<th>Stage</th>
<th>Number of Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>From planting to emergence</td>
<td>AVERAGE 7, LOW 4, HIGH 10, DD60s 50-60</td>
</tr>
<tr>
<td>From emergence to first fruiting branch</td>
<td>24, 21, 27, 300-340</td>
</tr>
<tr>
<td>From emergence to first square</td>
<td>32, 27, 38, 425-475</td>
</tr>
<tr>
<td>From emergence to first white bloom</td>
<td>55, 50, 60, 825-875</td>
</tr>
<tr>
<td>From emergence to peak bloom</td>
<td>90, 85, 95, 1385-1435</td>
</tr>
<tr>
<td>From emergence to open boll</td>
<td>110, 105, 115, 1700-1750</td>
</tr>
<tr>
<td>From emergence to 60% open bolls</td>
<td>140, 135, 145, 2180-2230</td>
</tr>
</tbody>
</table>
Growth Physiology

Since solar radiation provides the wellspring of energy for plant growth, understanding how energy is allocated, especially in a season with low levels of sunlight, is important because PGR management plans can help focus the plant’s energy. The accompanying illustration can be used as a basis for understanding the way in which the plant normally channels that energy.

A Conceptual Model: Illustrating the Relationship Between Photosynthetic Supply and Demand

As the illustration shows, solar radiation is captured by leaves, bracts, stems and boll walls. The greater the intensity of solar radiation and as leaf area and fertility increase, the more energy (also called photosynthate) is available to produce carbohydrates which then flows into the reserve tank. At the bottom of the energy photosynthate reserve tank there is an outlet that is open all the time letting energy continuously leak out. That is because normal plant respiration demands energy to keep the plant alive.

Once squaring begins, carbohydrates are used to fuel vegetative and reproductive growth at the same time. The successful cotton producer manages vegetative growth to enhance energy for boll development. The cotton supply and demand diagram has two outlets on the sides of the reserves tank which represent the consumption of energy for these types of growth. The amount of energy to flow through these outlets is dependent on the size or age of either the vegetative component or the size of the reproductive component.

As the season progresses from first bloom, the boll load increases demands for carbohydrates. As boll demand increases, the level of photosynthate in the reserve tank decreases, and eventually falls below the outlet for vegetative growth. When this occurs there is no energy available for continued vegetative growth and cutout (cessation of vegetative growth) occurs. While this is the normal progression, there are exceptions when boll retention and development are below normal due to insect damage, weed competition, or poor weather. If boll retention is low, more carbohydrates are available for vegetative growth. This often increases the need for additional PGR management to avoid excessive vegetative growth. (See section on plant growth regulators.)
Root Growth

Because roots perform the important functions of water and mineral absorption, as well as provide the plant anchor, management decisions should be made with consideration given on the effect it will have on rooting depth. Some of the factors impacting root growth and development include:

**Planting Conditions** - Poor early root development resulting from chilling injury can continue to cause problems throughout the season with diminished feeding capacity and limited yield potential.

**Water and Nutrients** - Controlled water and nutrient applications, encourage good root development and growth. Excessive water and nutrients can lead to shallow rooting with drought and deficiencies resulting in excessive root growth, both of which can negatively impact productivity of the aboveground parts of the plant.

**Compaction** - Soil compaction presents another problem to effective root function and development. With restricted root development, the frequency of irrigation impacts yield as the harmful effects of a shallow root system can be overcome by frequent applications of small volumes of water. To minimize compaction, it’s advisable to stay out of wet fields. Subsoiling prior to planting may be needed to improve root development.

**Oxygen** - Soil oxygen is necessary for root growth. Another key to oxygen reaching the root zone is good field drainage. Drainage keeps soil from saturating (which fills the soil air spaces with water).

**Soil pH** - Root development is also affected by soil pH, with normal growth occurring between pH levels of 5.5 to 8. Outside these ranges, root development is restricted.

Grower Tip | Root Systems
A root system reaches its maximum depth at first flower.

**Balanced Growth**

The cotton plant attempts to balance growth between below- and aboveground parts. This is called the root-to-shoot ratio. The root-to-shoot ratio differs at various stages of growth and is influenced by environmental conditions. To understand the root-to-shoot relationship, it’s important to know roots supply the plant with the moisture and nutrients which enable growth. Shoots, or aboveground growth, supply the carbohydrates needed for continued root growth.
Research shows that root length and biomass reaches maximum at 1,000 DD60s or approximately one week after first flower. Peak vegetative dry weight reaches its maximum at approximately 1,530 DD60s. In the intervening 530 DD60s, fruit and vegetative dry weight increase dramatically, but total fine root length decreases to only 47 percent of its peak value. Root and vegetative growth is extremely sensitive to and slowed by initial boll set as competition for carbohydrates increases. Once flowering begins, root development cannot overcome prior development problems.

Water stress shifts growth from shoots to roots and low solar radiation shifts growth from roots to shoots. Shoot damage, whether through environmental factors like hail or mechanical like poor post-directed herbicide applications, will slow root growth until the plant can recover. Similarly, root pruning will slow shoot growth until root growth recovers. Most growers and consultants are aware that cultivations damage roots and slow shoot development. We are probably less aware that shoot damage retards root development.

Branch Development

Branch development and leaf arrangement on the cotton plant is a complex process governed by both genetic and environmental factors. The accompanying drawing illustrates the various plant parts. The cotyledons are seed leaves and are exactly opposite one another and at the same height. New nodes develop above the cotyledons at a 3/8ths of a turn difference in stem placement. This arrangement provides for minimal self shading of lower leaves as new nodes develop. By the fourth to eighth node fruiting branches begin to develop.

Both vegetative and fruiting branches produce a series of nodes. Vegetative branches are branches of the main stem and have a leaf associated with each new node. Fruiting branches are differentiated by each node terminating with a leaf and a fruiting position (square or boll attached to the fruiting branch by a short stem called a peduncle). Early nodes of vegetative branches have only leaves, but if the branch is well developed, fruiting
branches can be initiated from them just like the main stem. Fruiting branches can grow from well-developed vegetative branches after several nodes. However, these fruiting branches are weak and generally produce only one fruiting position.

After cotton begins fruiting, most new branches will be fruiting branches. These branches will initially develop at a rate of approximately one every 50 DD60s, or one every 2.5 to 3 days during warm weather. As the season progresses and resources are diverted to bolls, it may take 5 to 10 days per new node. When cut-out occurs, new node development stops.

Monitoring the number of fruiting branches above a first position square (squaring nodes) is a good measure of vigor and may be related to yield. At first square, the value of this measurement is zero and increases to its maximum at first bloom. When a plant has eight or nine fruiting branches above a first position square this indicates normal growth. If lower than 7, yield may be reduced from premature cutout due to plant stressors. The most common type of stress would be lack of water.

Grower Tip | Node Development
Varieties vary slightly in node development, but most produce new nodes at the rate of one for every 50 DD60s for most of the season, almost linear in appearance. As cut-out approaches, the rate of new node production decreases dramatically and finally ceases.

Grower Tip | Low vs. High Populations
Low plant populations can lower the node of the first fruiting branch one node.

High plant populations, abnormally hot or cold temperatures, and insect damage can raise the node of the first fruiting branch as much as three nodes.
Square Set and Retention

After about 350 to 450 DD60s, which is usually 30 to 45 days after planting, cotton begins to produce squares (flower buds) which have the potential to become a boll. Squares are usually subjectively described by their size – pinhead, matchhead, small, medium and large – and entomologists and agronomists frequently differ on when a square is large enough to be considered a square. From a plant monitoring view, many people like to define the minimum size a square needs to be as that time when the actual flower bud, not including the bracts, is 1/8 inch in diameter. From a total cotton management standpoint, this is too long to wait, because the square at that stage has been susceptible to shed.

Not all squares on a cotton plant make it to open bolls, as square retention on the very first fruiting branch is typically less than the three to four branches above it. There is also typically only 25 to 60 percent retention of first position squares on fruiting branches 10 through 12. When first position square retention in the top five fruiting branches falls below 80%, this can be a cause for concern due to insect damage or lack of moisture.

Prior to the end of the second week of bloom, there is not enough of a boll load for physiological stress (lack of carbohydrate supply) to be a factor in square retention. Extended periods of cloudy weather during squaring, very early bloom, or severe cold or drought stress cause physiological shed. Therefore, physiological shed is not usually an important factor early in the season, but it is important to focus on other reasons. If shedding is not caused by temperature, clouds or moisture, then it is most likely caused by insects and corrective measures should be employed.

Insects can cause square damage or shed. Reduced bollworm sprays in Genuity® Bollgard II® cotton fields may allow plant bugs to survive. Yield and earliness benefits of transgenic cotton would be reduced if plant bugs are allowed to damage squares. Thus, it is critical to maintain a thorough full-season insect and square retention scouting program to achieve full benefit from this technology.
Cotton Plant Monitoring

**Early-season:**
- **Plant Population** – Establishing an adequate stand usually ranging from 30,000 to 50,000 plants per acre, is important because it effects plant growth and development and management will need to change accordingly.
- **Plant Height and Total Mainstem Nodes** – Both height and mainstem nodes are important growth parameters to measure in determining current growth rate and stage. Growth rate in the form of height-to-node ratio is the change in plant height divided by the change in total nodes over a given period of time.
- **Early-season Fruit Retention** – Retention needs to be monitored. Any excessive losses, greater than 25% early in the season should be investigated. Whether loss is due to insects or environmental conditions, corrective actions needs to be implemented immediately to help stop the loss and to maintain other fruiting sites on the plant and future management decisions need to consider the possible delay in maturity.

**Midseason:**
- **Current Vegetative Growth** – Keeping close tabs on vegetative growth and fruit development is extremely important during this time so that excessive vegetative growth does not occur. Several tools, including a slide rule, help determine whether current growth is excessive and give plant growth regulator rates to match the plant size to help slow growth if needed.
- **Fruit Retention** – First position fruit retention is important to keep track of and to determine any problems associated with insects, fertility, or other environmental factors. A large loss of fruit from one particular area of the plant may indicate micronaire problems at the end of the season.
- **Nodes Above White Flower (NAWF)** – NAWF is a very quick and effective way to determine how far the crop is from cutout (NAWF of five or less). At the initiation of bloom, nodes above white flower should be around 8, more means that growth is excessive, less means that the crop may be heading towards an early cutout. NAWF should decrease by about one every week.

**Late Season:**
- Any problems with yield, fiber quality, and micronaire can often be addressed by looking at final plant map information and locating areas of fruit loss which can then be correlated back to a particular time period during the growing season.
- **Nodes Above Cracked Boll** – When the first position cracked boll is within 4 nodes of the top of the plant (or the uppermost harvestable boll), defoliants should be applied.
- **Plant Height and Total Mainstem Nodes** – The above information along with plant height and total nodes will be the final record of all growth activity and stresses imposed on the crop for that year.
Managing Growth

There are several management options to choose from which can either stimulate plant growth or slow growth. Because each of these management practices needs to be tailored to the specific season, environment, and variety, a discussion of the components and the ways in which they can best be used is in order.

Focusing Growth with PGRs

Cotton plants are perennial plants that are grown and manage as annuals for crop production. Consequently, getting the plant to focus on reproductive growth is one of the most important areas of management.

Both vegetative and reproductive growth play important roles in final yield. Vegetative growth may sometimes be considered a negative when striving for high yield, but it is important to remember that a plant must add leaves to add more squares. It is important to monitor plant height to a desired internode length (usually an average of 2 inches). Certain varieties with aggressive vegetative growth may require higher rates of PGRs (6 to 12 oz) as early as the 8 to 10 node stage.

Conditions which should signal attention to possible applications include:

- Cotton rotated with corn
- Late-planted or late-maturing cotton
- Tall, vigorous, indeterminate cotton varieties
- Fields in which cotton tends to grow rank
- Thick stands
- Fields with high nitrogen availability, high application rates
- Fields to be first defoliated and harvested
- Fields with low square retention
- Irrigated fields

Plant Growth Regulator Use

The use of plant growth regulators (PGRs) can be a valuable tool in managing growth and controlling the distribution of vegetative and reproductive growth. Determining when to apply PGRs and at what rate can be difficult, so it’s important to understand how the products work.
The Plant Growth Regulator Guide (Slide Rule) can be used to help determine the rate of plant growth and if a PGR application is needed. By factoring in the average number of mainstem nodes for a field and the internode distance between the 4th and 5th mainstem node a growth rate can be determined (Very Slow, Slow, Normal, High or Very High). By inputting the average plant height for a field and the growth, the slide rule will suggested PGR rate.

**Recommended Mepiquat Use Rate***

- 55 inches
- 45 inches
- 35 inches

*4.2% formulation of Mepiquat Chloride

PGRs have a number of effects on cotton growth and development. One of the most important effects is the reduction of internode elongation which can lead to cotton plants that are shorter and more compact. This can lead to carbohydrates being freed up for boll and square development.

Efficacy of plant growth management depends primarily on the concentration of PGR in the cotton plant. As PGR rates increase, the concentration in the plant increases. This is why applying too much to small plants may result in unacceptable levels of stunting. As cotton plants get larger, the amount of PGR required to give an effective concentration in the plant also increases. If a plant is very large when normal rates are applied, the concentration will be insufficient to provide good growth control. This is why, especially with vigorous varieties, it is important to evaluate the growth rate of the crop and apply appropriate mepiquat chloride rates to adjust growth, if it has become excessive.
Because determining when and how much PGR needs to be applied can be complicated, there is a simple — yet highly accurate — method of monitoring cotton growth. The procedure involves determining the length of the most recent mature, fully-expanded internode which is between the fourth and fifth node from the terminal of the plant. The term “maximum internode distance” (MID) refers to this measurement.

**Pentia® Plant Regulator**

**APPLICATION RATES AND TIMINGS EFFECT ON PLANT HEIGHT***

* 2009, 2010 trials in Lorenzo, TX. Plant height response averaged over all varieties tested.

**Determining Normal Growth**

- Select random plants throughout the field to get a good representation
- Grip the mainstem between the fourth and fifth node from the top
- Early in the season, before flowering begins, if you can place three fingers (2 inches) between these nodes, then vegetative growth is potentially too rapid and altering management (Plant growth regulator, irrigation, insect control) should be a consideration.
- Later in the season (after flowering begins), internode growth between two and three inches is optimal. Internode growth less than two inches is an indication of stress on the plant. If internode growth is more than three inches, then growth is too rapid, and changes in management are suggested.
Fertility
Growers usually apply nitrogen and potassium fertilizers prebloom. But since squaring, bloom, and boll development are the times when cotton makes the largest fertility demands, a second fertilizer application is recommended where split applications are possible or a petiole test indicates additional requirements. Growers are urged to exercise caution avoiding rates in excess of 100 pounds of nitrogen which may lead to excessive growth. The petiole nitrate-nitrogen level prior to flowering can be influenced as much by temperature as by soil nitrogen supply and is not considered a reliable measure until after flowering.
## Early-season Fertility Needs and Deficiency Impacts

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Needs/Application</th>
<th>Impact of Deficiency</th>
</tr>
</thead>
</table>
| **Nitrogen** | Needs are highest during square set and bloom. Can be applied at planting, side-dressed through third week of bloom or foliar applied | • Young leaves yellow or become pale green. As leaves age they develop shades of redness or brown, dry out and shed  
• Stunting of the plant  
• Reduced fruit set |
| **Phosphorous** | Dependent on good liming program, must be placed in rooting zone | • Stunted plants  
• Smaller leaves, dark green in color  
• Delayed fruiting and maturity  
• Reductions in lint yield and inferior fiber properties |
| **Potassium** | Needs are high during boll fill. Subsoil levels are important, related to pH level, can be foliar applied | • Stunted plants  
• Veins of leaves redden before the discoloration spreads to the outside  
• Edges of leaves curl downward  
• Bolls are small and immature, may fail to open  
• Reductions in yield, fiber strength, and micronaire |
| **Boron** | In mixed fertilizer or preemerge herbicides, common in limed fields | • Abnormal shedding of squares and young bolls  
• Darkening of boll base  
• Small, deformed bolls that do not fluff normally  
• Terminal death and shortened internodes  
• Petioles display dark green ring  
• Leaves thicken, are dark green and hard to defoliate  
• Poor response to nitrogen and potassium |
| **Sulfur** | Soil applications are more effective than foliar. If planting behind peanuts that received gypsum, applications are not always needed. | • Symptoms appear first in new leaves as persistent yellowing of new leaves and reddening of petioles  
• Severe cases can result in symptoms throughout the plant  
• Early diagnosis is critical because deficiencies after flowering starts to impact yield and late application cannot help recover that lint |
| **Calcium** | Supplied through liming to meet high needs | • Deficiencies are seldom seen as low pH and aluminum toxicity limit growth first |
| **Magnesium** | Supplied through liming to meet high needs, deficiencies most likely on sandy soils | • Appears first as purpling or reddening of lower leaves, veins remain green  
• Premature leaf shed |
Irrigation

In fields with irrigation as an option, prebloom water management involves providing adequate water in order to obtain maximum growth, but not so frequent as to be wasteful or to reduce root growth. It is important to note that water needs during the first 30 days of growth are minimal, but then increase dramatically until peak bloom.

Depending on the region, cotton acres may receive moisture from only precipitation (dryland) or may receive additional moisture from irrigation by sprinkler, furrow, or subsurface drip irrigation systems. To efficiently irrigate a cotton crop, it is important to understand critical growth stages and peak water use timing.

Monitoring plant growth, moisture availability, and tracking accumulated heat units can help in determining the appropriate time to irrigate. Like many other crops, cotton development is strongly influenced by temperature and the amount of heat units accumulated after planting (HUAP). Tracking the HUAP can help assess cotton development and when to begin irrigation. The growth stage associated with the accumulated heat units can vary according to the variety selected for the region. According to the University of Georgia, the first square typically develops at about 550 HUAP, followed by the first flower at about 950 HUAP. The optimum timing for the first irrigation is typically between the occurrence of the first square and first flower. At this time, water requirements for the plant increase. The most critical time for moisture availability through the life of a fruiting site is during square development, as water stress can cause a cotton plant to shed squares. If moisture is limited, the squares are competing for energy with the demand put on the plant from a growing boll population.

Pivot Irrigation—When using pivot irrigation, rates should be applied equivalent to the evapotranspiration (ET) losses. Approximately 1 inch or less of water should be applied per irrigation. Greater amounts can cause problems if heavy rainfall occurs soon after an irrigation takes place.

Surface (Furrow) Irrigation—Supplying water with surface irrigation has the least upfront costs, but water efficiency can vary as much as 30 to 90%, depending on the crop and soil type. Approximately 2 inches should be applied per application. With surface irrigation systems, it is important to start irrigating soon enough to get across the field before stress occurs. Surface irrigation systems typically need water applied in 8 to 10 day intervals depending on accumulated precipitation. Drainage is especially important when surface irrigation is used, for optimum surface water flow, fields should be sloped 0.15 to 0.3% and drains and ditches should be periodically cleaned out.
Deficit Irrigation—Deficit irrigation is a common practice in areas with limited water supply. Deficit irrigation is a method of applying less water than the daily evapotranspiration (ET) of the plants. Deficit irrigation assumes that the plants will also use any stored water. By limiting irrigation to the right amount, the cotton crop can continue to fruit without the risk of encouraging rank growth.

Low Energy Precision Application (LEPA)—When water is limited many growers are using different types of Low Energy Precision Application (LEPA) irrigation systems to increase water efficiency. LEPA irrigation systems can reduce losses from evaporation by applying water down into the crop and closer to the soil surface. Different LEPA irrigation systems include circular rows, furrow diking, or dropped sprinklers with low pressure nozzles. Modifying older high pressure sprinkler systems to utilize LEPA methods can increase water efficiency as much as 20 to 40%. LEPA irrigation systems can increase efficiency as cotton responds well to high-frequency deficit irrigation even when less water is applied.

Seasonal Water Demand Curve for Cotton

![Seasonal Water Demand Curve for Cotton](source: Sansone, C. et al. Texas Cotton Production Emphasizing Integrated Pest Management. Texas AgriLife Extension Service.)
**Weed Control**

Growers should start with clean seedbed by either using tillage and/or a burndown herbicide application to control emerged weeds. In areas with glyphosate-resistant weeds, it is recommended that an at planting tankmix include glufosinate, plus a residual herbicide such as diuron, fluometuron, or fomesafen at labeled rates.

For early in-season weed control, glyphosate may be tankmixed with an acetanilide herbicide or an encapsulated acetochlor herbicide such as Warrant® Herbicide. Other options are provided in the box below. Always read and follow product labels and application directions. Be sure to scout fields before and after any in-crop herbicide application to monitor herbicide efficacy or potential resistant weed populations.

**Early Postemergence Herbicide Options**

- glyphosate
- acetochlor
- metolachlor
- pyrithiobac-sodium
- trifloxysulfuron
- guizaloflop
- fluazifop
- Clethodim

**Pest Management**

**Insect Control**

Early-season pests, such as thrips and aphids, can have negative impacts on early-season square retention as plant bugs and thrips can cause square shed.

Boll weevil eradication and cotton varieties with Genuity® Bollgard II® technology have changed the landscape of insect control. One of the largest benefits of eradication and Genuity Bollgard II technology is the increased prospect of well-planned integrated pest management systems. There are possible shifts in insect spectrum and populations as one or more insect species are controlled. Control measures should be considered when pests reach local economic thresholds.
Insects Which Damage Young Cotton

<table>
<thead>
<tr>
<th>Timing</th>
<th>Insect</th>
<th>Type of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling</td>
<td>Cutworms or Grasshoppers</td>
<td>Seedling stems cut off at base</td>
</tr>
<tr>
<td></td>
<td>Aphids or Whiteflies</td>
<td>Deformed or “cupped” cotyledon or initial true leaves with honeydew present</td>
</tr>
<tr>
<td></td>
<td>Thrips</td>
<td>Deformed or “cupped” cotyledon or initial true leaves</td>
</tr>
<tr>
<td></td>
<td>Armyworms, Cabbage loopers</td>
<td>Ragged holes in leaves</td>
</tr>
<tr>
<td>Emergence through Square</td>
<td>Spider mites</td>
<td>Discolored, reddened or mottled leaf appearance, some webbing on underside of leaf</td>
</tr>
<tr>
<td></td>
<td>Cotton leaf perforator</td>
<td>“Shot-hole” appearance in leaves, horseshoe larvae present</td>
</tr>
<tr>
<td></td>
<td>Armyworms</td>
<td>Leaf surface eaten away with veins remaining (“skeletonized”) with numerous small larvae present</td>
</tr>
<tr>
<td></td>
<td>Plant bugs (lygus), Cotton fleahoppers</td>
<td>Blackened or “blasted” squares</td>
</tr>
<tr>
<td></td>
<td>Beet armyworm</td>
<td>Hollowed squares with circular holes of entry</td>
</tr>
<tr>
<td></td>
<td>Boll weevil</td>
<td>Tiny feeding sites with bright orange to yellow excrement present, small wart-like egg-laying sites</td>
</tr>
</tbody>
</table>

Diseases Affecting Young Cotton

**Fusarium spp.** – Fusarium can develop at soil temperatures around 70° F and symptoms will decline at temperatures at 82° F. Fusarium can infect young cotton seedlings, while symptoms such as stunting, yellowing and loss of leaves may not occur until later in the season. Immediate signs of severe seedling infection include: cotyledon and leaf wilting and dropping off the plant, leaving a bare stem.

**Rhizoctonia spp.** – May occur when soil temperatures are 70-80° F. A good indicator of an infected seedling is the presence of dry reddish-brown lesions girdling the stem (soreshin) at the soil line. If the seedling survives, the stem will be weakened and plant growth may be stunted. Discoloration is usually limited to the outside layer of the main root and hypocotyls, while the infected stems will remain dry and firm. Sandblasting can make a seedling more susceptible to infection.
As bloom and boll growth begin, the relationship between photosynthetic supply and demand is altered to favor reproductive growth at the expense of vegetative growth. To manage this change for increased productivity, monitoring the crop's growth and development, and controlling inputs and pests are critical.

Monitoring Growth
This section brings together all the various plant monitoring measurements and observations that provide clues as to the correct input management. Weighing any or all of them helps when determining whether or not to alter management inputs. There are several measurements utilized to make sure growth and development are occurring normally and a combination of these measurements is suggested. During bloom, growers and consultants should continue to record height and mainstem nodes, nodes above white flower (NAWF) counts, square retention and maximum internode distance on a weekly basis.

Plant Height
Height of the mainstem is one of the most common cotton measurements and it can be useful in making management decisions when combined with other information. Generally at first bloom or shortly thereafter, cotton is growing at its maximum rate. A growth rate of about 1 inch per day is the upper limit of acceptable growth. Growth more rapid than this indicates an alteration in management is needed and using mepiquat chloride may be beneficial.

Mainstem Nodes
Development of mainstem nodes is also close to its maximum rate near first bloom. There should be a new mainstem node about once every 2.5 to 3 days – or approximately one every 40 to 50 DD60s. Water availability and carbohydrate production are the main influencers of mainstem node development. More important than the number of mainstem nodes on a given day is whether or not the number of days or DD60s between new nodes is increasing. If this is not occurring, or vegetative growth is not slowing, by the third or fourth week after bloom, an investigation is warranted.
Squaring Nodes or Nodes Above White Flower (NAWF)

The maximum number of fruiting branches prior to bloom, or the maximum NAWF, is an excellent indication of vigor. NAWF is effective because it directly corresponds to energy absorption by the reproductive and vegetative demands of the plant. This measurement monitors the difference between the rate squares reach bloom and the rate new vegetation and nodes are produced.

As NAWF declines, nodes are being produced slower than first fruiting position squares reach bloom. This value ranges from 5 to 10 with 8 and 10 nodes being most common when stress has not been a significant factor. Values of 7 or less at first bloom indicate low vigor and using a PGR is not recommended until the stress is alleviated as noted by NAWF values increasing to normal range. If the value is closer to 10 and/or does not decline at a rate of about 1 node per week, vigor is high and using a PGR may be beneficial. NAWF of 5 indicates the plant is entering cut-out.

Average Number of Squaring Nodes by Days After Planting

**Maximum Internode Distance (MID)**

As mentioned previously, the maximum internode distance (MID - the distance between the 4th and 5th nodes from the terminal) is the most sensitive, available measure of current vigor. It encompasses all effects current inputs are having on growth. It also reflects the current relationship between carbohydrate supply and demand. After first bloom, if this distance exceeds approximately 3 inches, current growth is vigorous and needs control. If it is less than 2 inches, growth is limited and may need investigation. In some situations, cotton having a MID under 2 inches may be a perfectly normal response to retention, PGRs, and environment.

**Managing Fiber Quality**

As cotton bolls begin to grow, fiber cells on the seed coat begin to elongate. These cells continue elongation for 3 weeks, starting with the day of flowering. Stress during this time will reduce fiber length. The following 3 weeks, a layer of cellulose is deposited daily on the inside of the cotton fiber. This is called secondary wall thickening and directly corresponds to fiber strength and micronaire. Stress during this second phase of fiber development can have detrimental effects on fiber quality.

Micronaire management requires thorough understanding of the causes of high and low micronaire. High micronaire is a common problem in many parts of the U.S. that is highly related to year and environment and the maturity of the fiber; and related to variety to a lesser degree. Low micronaire, though not as common a problem as high micronaire, still affects many growers each year. Low micronaire levels are related primarily to insufficient carbohydrate levels to adequately mature the cotton fibers. Mature fiber has relatively higher micronaire while immature fiber has low micronaire.

Micronaire can vary due to boll maturity by field, but also by the location of the boll on the plant. Bottom bolls have relatively higher micronaire and upper less mature bolls have lower micronaire. Fiber from the bolls is blended at harvest to establish micronaire for the field/variety. For this reason, harvest termination and in-season crop management along with localized weather conditions can influence crop micronaire measurements.

Remember, higher yielding crops are generally higher micronaire crops while crops terminated prematurely either by weather or harvest aids tend to have lower micronaire.
Micronaire is a measure of fiber weight per unit length and the reading is used as an indicator of fiber fineness which also relates to the maturity of the fiber. Fiber fineness and diameter is greatly impacted by environmental conditions, but is also highly genetic. If fiber development is terminated prematurely, finer fibers will result in low micronaire. Conversely if environmental conditions are good, fibers will continue to mature, resulting in coarse fibers with high micronaire.

Factors Affecting Micronaire

<table>
<thead>
<tr>
<th>Cause of High Micronaire</th>
<th>Cause of Low Micronaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good early-season boll set followed by poor mid to late-season boll set.</td>
<td>Middle and lower 1st position fruit loss</td>
</tr>
<tr>
<td>A preponderance of 1st position bolls at the expense of 2nd and 3rd position bolls.</td>
<td>Premature application of harvest aid chemicals which stops lint development.</td>
</tr>
<tr>
<td>Warm weather between 3 and 6 weeks after 1st bloom with poor fruit retention during this time.</td>
<td>Cool and/or cloudy weather between 3 and 6 weeks following the first bloom with good late fruit retention.</td>
</tr>
<tr>
<td>Short fiber caused by water stress during the 3 weeks following 1st bloom, followed by good weather for the next 3 weeks.</td>
<td>High levels of boll rot which affect the older, 1st position.</td>
</tr>
</tbody>
</table>
Plant Growth Regulator Use

As discussed in Chapter 2, PGR effectiveness depends on a number of different factors. During the first few weeks of bloom, response to PGRs may be at a maximum. If applications are delayed, growth control is reduced. PGRs can be used throughout the season (according to label) to manage high vegetative growth and focus development on square and boll set.

If the bottom crop is lost early- or midseason, it is important to encourage reproductive development rather than vegetative growth. This is also the case for late-planted cotton to continue to push for maturity. In these situations, you want to continue producing high levels of energy, but focus that energy to progress the crop toward harvest.

Fertility

During bloom, reasonably accurate estimates of cotton nutritional status can be obtained by the use of petiole sampling, and many states have specific guidelines for this. There are a limited number of conditions that can make the interpretation of results difficult, but if moisture conditions have been close to normal during the past 2 to 3 weeks, the results should be accurate.

Nitrogen

Nitrogen is in high demand at bloom and sufficient nitrogen in the soil and plant is required to obtain high yields. Vigorous varieties have the ability to maintain vegetative growth longer than many other varieties; therefore, close nitrogen management is important. The accompanying figure depicts petiole sufficiency level of nitrate-nitrogen for cotton.

Post Bloom Management of Nitrogen Fertility

In general, the optimal system for nitrogen fertilization in cotton consists of supplying approximately 20 to 30% of the seasonal total before bloom, 60 to 75% of the remaining total during boll development and supplementing with foliar applications as boll load or plant needs indicate. In practice, this ideal goal is a desirable, but may be difficult to achieve.

Total nitrogen is frequently applied in a single preplant application. Since cotton uses less than 33% of it’s seasonal nitrogen prior to bloom, single preplant applications may not be
the best approach to nitrogen fertilization. Single preplant applications are subject to nitrogen loss through denitrification or leaching through the soil profile, which can be a concern in rainy seasons or irrigated fields.

If heavy boll loads develop, there may not be enough available nitrogen to support the total fruit load. It will be important to monitor fields which had total nitrogen applied preplant and have received higher than normal rainfall. This is even more critical for fields with lighter soil types.

**Petiole Sampling:**

- Petiole sampling should typically begin at least one week before first bloom and continue weekly until the first open boll.
- It is best to take at least 25 to 35 samples from a representative areas in the field.
- Petiole samples should be taken from the first full-sized mainstem leaf from the terminal, pulling the leaf off at the mainstem. This is usually the fourth vegetative leaf from the top of the mainstem. Separate the leaf blade and leaf stem (petiole). Discard the leaf blade and submit the petioles to your local county or state office for analysis and recommendations.
- Since local sampling techniques may vary, check with your county extension office or consultant for sampling instructions.

When petiole tests indicate a need for foliar applications of nitrogen:

- Urea is the most common foliar nitrogen material applied to cotton because it is inexpensive, easily absorbed by the leaf, and has a low potential for leaf injury.
- The rate of uptake by the leaf is dependent on the rate of urea applied, temperature and the condition of the leaf surface. Healthy, actively growing cotton and warm temperatures favor uptake.
- Research has shown that approximately 30% of the urea is absorbed during the first hour and 70% within 24 hours. It is important to use “Feed Grade” or low biuret urea and to avoid applications to stressed cotton.
- Typical rates of foliar urea range from 10 to 15 lbs of urea (5 to 7 lbs of actual nitrogen) applied in 10 to 15 gallons of water. It may be necessary to buffer the urea solution if pH is above 7. Applications should be made within 2 to 3 hours of mixing the urea to avoid possible leaf burn due to ammonium toxicity. Applications made either early in the day or late in the evening are best.
Potassium

Potassium is also required in large quantities after first bloom, and the demand for potassium can actually exceed nitrogen demand during this time. Petiole samples collected for nitrogen monitoring can also serve as the basis for building a potassium fertilization program.

Since potassium is critical for boll formation, factors which effect boll retention also impact petiole potassium levels. People joke that potassium deficiency can be controlled by reducing the boll load, but there is an element of truth to that statement. If petiole potassium levels remain high, especially when cotton is grown on a soil which is marginally adequate in potassium, then serious concerns about the boll load may be warranted.

Grower Tip | Nitrogen
Nitrogen management utilizing split applications can help promote adequate availability during bloom.
Petiole Potassium Sufficiency Levels: Based on Number of Days After First Bloom

Source: Cotton Production Manual. 1996. University of California, Division of Agriculture and Natural Resources. pg 57.

Petiole Nitrate-Nitrogen Sufficiency Levels for Cotton Versus Day After First Bloom

Source: Cotton Production Manual. 1996. University of California, Division of Agriculture and Natural Resources. pg 56.
Irrigation

Management of water during bloom changes from maintaining water availability for rapid vegetative growth, to maintaining reproductive growth. Growth control can be accomplished by increasing the irrigation interval slightly to increase water stress. It is possible that since water use is greater during bloom, irrigation intervals can remain the same, and water stress level will increase naturally.

The water budget method is an accurate method of estimating irrigation dates and many state extension services have publications documenting its use. Several of the values needed differ by soil type. You can get the specific water holding capacity, rooting depth, allowable depletion, and daily water use by cotton from your local Farmers Services Agency or the local extension service.

For fields in which cotton growth may be stimulated by excess rain or irrigation, PGR management and accurate nitrogen fertilization is critical. Please refer to those sections in this book.

Growing Tip | Irrigation

Irrigation can delay crop maturity so management of water and PGRs late in the season are vital to get a mature crop to harvest.

Calculating Irrigation Dates

<table>
<thead>
<tr>
<th>Water holding capacity</th>
<th>example: 1.6 inches per foot of soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>X rooting depth</td>
<td>3 foot rooting depth</td>
</tr>
<tr>
<td>= total water available</td>
<td>4.8 inches available</td>
</tr>
<tr>
<td>X allowable depletion</td>
<td>.60 60% depletion</td>
</tr>
<tr>
<td>= amount used prior to irrigation</td>
<td>2.9 inches used before irrigation</td>
</tr>
<tr>
<td>÷ daily use</td>
<td>.3 inches used daily</td>
</tr>
<tr>
<td>Irrigation interval</td>
<td>9.6 (irrigation needed every 9-10 days)</td>
</tr>
</tbody>
</table>
**Insect Management**

Controlling insects has long been a priority for cotton growers. The use of thresholds and insecticides has help to change the face of cotton production, two other forces - boll weevil eradication and transgenic varieties have also changed the industry.

The use of varieties containing Genuity® Bollgard II® cotton offers growers enhanced protection from Lepidopterous pests—helping protect the bolls by controlling most leaf- and boll-feeding worm species (i.e. tobacco budworm, pink bollworm and cotton bollworm). Using Genuity Bollgard II cotton can provide greater yield protection. The advanced dual-gene system of Genuity Bollgard II cotton allows a wider spectrum of worm control with fewer sprays. Decreasing the number of insect sprays can conserve beneficial insect populations and reduce flaring of other pest infestations, such as aphids and spider mites.

**Scouting Genuity® Bollgard II® Cotton**

Because Genuity Bollgard II cotton has different efficacy levels for different worm species, good scouting and identification are critical components of every insect control program.

*Identifying problem caterpillars* – The number of eggs and newly hatched larvae do indicate pressure, yet they do not necessarily indicate that control measures are needed. Because caterpillars are susceptible to Genuity Bollgard II cotton, and must feed for a short time prior to being controlled by the *B.t.* toxin, it is more important to monitor young larvae than egg lay. Identifying escapes is complicated, but most authorities agree that larva of 1/4 inch in length that appear healthy have good chances of survival.

*Modified whole plant search* – Inspecting the terminal squares and blooms is suggested in scouting for worms on cotton with Genuity Bollgard II cotton technology. The nodes above and below the white bloom are the primary target area for scouting since most surviving bollworm larvae feed on pollen from newly bloomed bolls. This leads to larval survival being closely associated with newly bloomed bolls and bloom tags. In addition to that area, all bolls beneath this area should be scouted outwardly for fall armyworm bract etching.

---

**Grower Tip | Insect Monitoring**

Insects not controlled by Genuity® Bollgard II® need to be monitored more closely than before, because any coincidental control obtained when spraying for worms is absent.
Insects Impacting Cotton During Bloom

<table>
<thead>
<tr>
<th>Insect</th>
<th>Effect of Genuity® Bollgard II® Technology</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco budworm</td>
<td>Control</td>
<td>• Holes in bloom base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Circular holes in bolls with frass (excrement) present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tunneling in terminal</td>
</tr>
<tr>
<td>Pink bollworm</td>
<td>Control</td>
<td>• Rosetted petals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Holes through boll, carpel walls and seeds</td>
</tr>
<tr>
<td>Cotton bollworm</td>
<td>Sprays may be needed in some situations</td>
<td>• Holes in bloom base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Circular holes in bolls with frass (excrement) present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tunneling in terminal</td>
</tr>
<tr>
<td>Beet armyworms</td>
<td>Suppression</td>
<td>• Holes in bloom base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Circular holes in bolls with frass (excrement) present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skeletonized leaves</td>
</tr>
<tr>
<td>Fall armyworms</td>
<td>Little activity</td>
<td>• Holes in bloom base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Circular holes in bolls with frass (excrement) present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tunneling in terminal</td>
</tr>
<tr>
<td>Lygus (plant bug), stinkbugs</td>
<td>None, reduced coincidental control</td>
<td>• Blooms are disfigured, twisted and coarse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Small depressions in bolls</td>
</tr>
<tr>
<td>Boll weevil</td>
<td>None, reduced coincidental control</td>
<td>• Soft, dark area on boll with cream colored grub inside boll</td>
</tr>
</tbody>
</table>

Source: G. T. Bohmfalk, Texas Agricultural Extension Service; Blake Layton, Mississippi State Cooperative Extension Service

**Cotton Bollworm, Tobacco budworm, Pink Bollworm**

Heliothine pests are the target of Genuity® Bollgard II® cotton technology. Worm populations can be present from early bloom through late season, with the strongest generations coming during boll fill, the most damaging time of the year. Bollgard® technology was first judged solely on its efficacy during this period, using the transgenic varieties as a risk management tool. However, seasons during which budworm and bollworm populations are low have indicated that the in-plant protection also provides economic benefit while populations are below normal threshold levels.
Genuity® Bollgard II® cotton has varying efficacy against worms other than the ones mentioned on the previous page. Use state guidelines or consultant recommendations for monitoring and control of insect pests that are not controlled.

**Other Cotton Insect Pests**

Plant bugs and boll weevils can cause serious yield loss during early bloom. Thus, it is critical that they are monitored and controlled when necessary. In addition to normal field scouting, monitoring percent retention of bolls in the top five first positions can be a valuable tool in the management of plant bugs.

**Diagnosing Cotton Diseases**

The primary disease concern as the season progresses is a group of diseases generally referred to as boll rot. Boll rot may become a problem in high moisture or humidity environments and in conjunction with excessive insect damage, high plant populations and rank growth.

**Diplodia spp.** – This fungus attacks the bracts. Given sufficient moisture, Diplodia spp. can enter the boll base through the peduncle, carpel wall or developing cracks at sutures between the carpels. Rapid spread is possible, producing a mat of black filaments and spores which turn the boll black.

**Xanthomonas spp.** – Symptoms are first observed as small round water-soaked lesions that are noticeable on the upper and lower surfaces. Lesions appear to be angular due to the restrictions by veins within the cotton leaf. Other parts of the cotton plant may become infected following the production of secondary inoculum. The systemic spread of infected leaf petioles, stems and branches may form black cankers (“Blackarm” lesions) that can cause portions of the plant to die above the canker. Older boll lesions can appear sunken and dark brown or black. Symptoms will be most severe with high humidity and warm air temperatures.

**Alternaria spp.** – This disease infects cotton leaves, bracts and bolls. Initially, the fungus produces red lesions on the lower leaves where spores germinate and create small (.004 to 0.4 inches in diameter) circular gray-brown to tan spots with purple margins. When mature, the lesions may dry and fall out leaving a hole in the leaves. Spore production can increase in humid conditions resulting in the appearance of a black sooty substance. Stem lesions begin as small sunken spots, later developing into a canker.
Verticillium Wilt – This disease is caused by *Verticillium dahlia*, a soil-borne fungal pathogen. The pathogen can enter through the roots and grows into the plant’s vascular system causing light brown discoloration in the vascular bundles. Foliar symptoms include necrotic lesions on the leaf surface, bottom up plant wilting, and interveinal chlorosis (yellowing). Light to dark brown discoloration may be present on stem and branches which interfere with water and nutrient uptake. Symptoms typically occur late in the season (August or September) post bloom and boll formation stages. The fungus may survive in the soil for long periods of time as microsclerotia. There is no effective control of verticillium wilt. To reduce yield losses, tolerant cotton varieties may be planted or crop rotation may help to reduce the inoculum and disease pressure in the soil.

**Grower Tip | Boll Rot Prevention**

Treatments for established boll rot are largely ineffective, so preventative cultural practices, such as reducing humidity in the canopy by reducing rank growth and late-season irrigations, during the season are encouraged. Well scheduled defoliations may also be beneficial.
MIDSEASON WEED CONTROL

Postemergence Herbicide Options
In addition to preemergence herbicides, post applications of Roundup® brand agricultural herbicides are a valuable tool for mid season weed control. Fields planted with Genuity® Roundup Ready® Flex varieties can receive an over-the-top applications of Roundup® brand agricultural herbicides to control grasses and broadleaves up to seven days preharvest. These applications should be mixed with additional herbicides to provide control of glyphosate-resistant weeds.

Hooded Sprayer/Post-Directed Herbicide Options
Even with a good residual program, tough-to-control weeds may emerge in-season and necessitate a post-direct and/or under hood application. Several herbicide options are available for post-directed weed control applications. It is important to include a surfactant or crop oil concentrate with post-directed herbicide applications. MSMA may be included with treatments to increase activity.

Scouting fields on a regular basis is critical to making timely applications. Glufosinate may be applied ONLY UNDER A HOOD for Genuity Roundup Ready Flex varieties.

<table>
<thead>
<tr>
<th>Postemergence Herbicides</th>
<th>Post-Directed Herbicides</th>
</tr>
</thead>
<tbody>
<tr>
<td>• glyphosate</td>
<td>• fluometuron</td>
</tr>
<tr>
<td>• pyrithiobac sodium</td>
<td>• prometryn</td>
</tr>
<tr>
<td>• promaethryn</td>
<td>• diuron</td>
</tr>
<tr>
<td>• MSMA</td>
<td>• flumioxazin</td>
</tr>
<tr>
<td>• encapsulated acetochlor</td>
<td>• glufosinate (under hoods only)</td>
</tr>
<tr>
<td>• flumetsulam + S-metolachlor</td>
<td></td>
</tr>
<tr>
<td>• pyrithiobac sodium</td>
<td></td>
</tr>
</tbody>
</table>
Determining and Using Cutout

Cutout is a gradual change over 1 to 2 weeks during which vegetative growth ceases. It is the time when blooms currently on the plant have a small chance of surviving to harvestable bolls. Estimating the time over which cutout occurs can be helpful in crop management.

The best method of estimating cutout is to monitor the number of nodes above the highest first position white flower (NAWF). When this value declines to 4 or 5, cutout has been reached. The figure on the following page illustrates the typical relationship between NAWF and weeks after first bloom.

NAWF declines by about one node per week for every week after first bloom. However, the rate of decline may be affected by the use of PGRs, available moisture, or other factors. If stressed prior to bloom, NAWF may be 7.0, but if it rains, that value may stay near 7.0 for several weeks. Typically 4 to 5 weeks of effective bloom are required to produce a high-yielding crop.

Grower Tip | COTMAN
COTMAN Cotton Management Expert System Software indicates that NAWF 5 plus 350 DD60s provides for economical termination of insecticide applications.

While NAWF is helpful in establishing the onset of cutout, monitoring the decline of NAWF is beneficial in management. Cotton fields which are growing with too much vigor this late in the season will end up rank, will not follow this normal rate of decline, and may be subject to problems such as excessive boll rot.

This means vegetative growth is not being reduced by the developing boll load, and an investigation into cause, and possible changes in management are required.
When Cutout is Reached: Once NAWF Reaches 4 or 5 (usually 3-5 weeks after bloom)

Managing Late-Season Growth

At this point in the season, growth management options are limited. Fertility and PGR programs have stopped as they will no longer be effective or economical. However, in areas where irrigation is utilized, water stress can be used late in the season to manage regrowth and hasten boll maturity. Due to a fortunate difference in sensitivity to water stress between vegetative growth and boll development, periods of substantial water stress late in the season can be tolerated with little or no effect on yields. This may be especially true for vigorous varieties or delayed crops where the control of late-season vegetative growth is beneficial. It is also possible that reducing irrigation frequency late in the season will lower the humidity in the lower canopy, thus reducing boll rot.

Defoliation

While defoliation does not necessarily mature a crop, a good harvest aid program can help mature crops at the peak of quality. The way a crop has been managed with fertility, PGRs, water, etc. affects defoliation. While defoliation practices differ by region, the timing of harvest aid programs and the components which need to be considered are common.
Water Stress Level: Influence of Water Stress Level on Photosynthesis, Mainstem Growth and Boll Development in Cotton

Timing Defoliation
Growers can use scientific means of timing defoliation in tandem with information on the number of acres harvesting equipment can cover daily to help stagger harvest rather than defoliating entire farms at the same time. The foremost means of determining crop readiness is nodes above cracked boll (NACB). Timing defoliation with NACB can help maximize yields and quality.

Conditions Favoring Good Defoliation
- Warm, sunny weather
- Mature plants
- Low moisture and nitrogen levels
- Cessation of leaf growth and development
- Programs based on current environment

Steps to follow in using NACB:

- Take a sample from plants that have a first position boll in the process of opening (cracking).
- Count that node as “0” and count all the nodes above that node (fruiting branch) until the node with the last harvestable boll. DO NOT count nodes all the way to the terminal.
- If the uppermost harvestable boll is a second position boll, add “2” to the NACB value. This is because a second position boll is the same age as a first position boll 2 fruiting branches higher on the plant.
- Since growth and maturity are not uniform in most cotton fields, it is best to sample the area that is least mature since it will set guideline for harvest aid timing. A total of 20 plants randomly selected from the least mature area of a cotton field should be examined.

Research indicates that there is no yield or micronaire loss by defoliating at 4 NACB. Losses were less than 1% when fields were defoliated at NACB between 4 and 5. These relationships are illustrated in the accompanying figure.

**Relationship Between Relative Yield and Reduction in Micronaire (as Related to Defoliation at Differing Nodes Above Cracked Boll)**

![Graph showing relationship between relative yield and reduction in micronaire](source: Cotton Production Manual. 1996. Univ. of California. Pub. 3352. p.553)
Defoliation Materials

Selection of the most efficacious harvest aid chemicals depends on many factors – both within the plant and related to the weather.

For good defoliation to occur, cotton should be low on moisture and nitrogen. This balance is exceedingly difficult to reach since, in the case of nitrogen, this depends on application rate and boll load. When nitrogen fertilizer was applied, the total boll load was not known, only anticipated. Some growers use petiole testing for nitrate-nitrogen late in the season to schedule fields for defoliation. This method allows fields to be ranked in a relative order so the field which will be ready first can be prioritized for defoliation.

Weather also has a major impact on defoliation. Defoliants and desiccants are herbicides that when applied at appropriate rates will help prepare cotton for harvest. The weather, especially the temperature, has a large impact on the efficacy and performance of the defoliant. As temperatures increase, the activity of most defoliants also increases. Local experience is the best indicator of which defoliants will work best in each field.

Harvesting

Pickers and strippers need to be well-maintained before, during, and after the harvest season. Entering the season with well-prepped machinery can save valuable time that might otherwise be spent trying to fix mechanical problems during harvest. Along this line, close inspection of equipment is suggested and any parts that appear to be worn or damaged be replaced before harvest. Proper alignment is also conducive to clean harvest as trash in the lint will be minimized.

In terms of timing of harvest, it is important that the crop is both open and free of leaves, weeds and other extraneous material. Harvesting cotton dampened with dew can cause problems with equipment and fiber quality. Consequently, testing seed cotton with a moisture meter is suggested.

Grower Tip | Testing for Moisture

In testing for moisture, if no meter is available, North Carolina State University recommends biting the seed, as dry seeds will crack indicating moisture is low enough to be harvested.
Storing in Modules

Only dry cotton with very little trash should be stored in modules. Monitoring temperatures inside the module for the first 5 to 7 days will alert growers to problems as rapid and continuing rises in temperature of 15 to 20°F indicates high moisture and the need for immediate ginning. It is recommended that ginning be expedited when temperatures inside modules reach 110°F. Other suggestions include:

- Building modules in areas free of gravel, stalks and other debris.
- Place modules in areas that are well-drained and accessible.
- Position modules so that trucks can load the module straight.
- Protect modules with weather-proof tarps.
- Inspect modules following adverse weather.
Insect Level Management

The benefits of early harvest stalk destruction are well-documented as being among the most effective cultural and mechanical practices when it comes to managing overwintering insects. The key pests affected by early harvest and stalk destruction are the boll weevil, pink bollworm, tobacco budworm, and cotton bollworm as their habitat and food sources are destroyed.

It is recommended that growers:

- Shred stalks at the earliest possible date.
- Do not allow stubble, regrowth, or volunteer seedlings to remain in fields or the immediate area.
- Pay particular attention to destroying green or cracked bolls at row ends (especially a factor with stripper harvest).
- Consider adding insecticides into phosphate defoliants (combinations of chlorate and some insecticides can cause potential fire hazards).
- If you are in an area with mandated stalk destruction deadlines, success depends on strict adherence.

Postharvest Soil Sampling

If a nematode problem is suspected, an aggressive sampling program is recommended, with actions following up if the problem is confirmed. But because nematodes are not visually detectable, treatments that are not based on samples could be wasteful. At the same time, fields in which nematode infestations are lowering yields and economic potential must be tended to in a timely manner. Nematode sampling is best accomplished in the late summer or fall as populations are easier to detect and more reliable estimates are made.

Tips on collecting and handling samples:

- Ensure representative sampling by taking samples within the row in areas with different cropping histories or soil textures.
- Use a guideline of one sample consisting of 20 to 30 cores, taken at depths between 6 and 12 inches, to represent 10 acres of each soil type or cropping history. Cores should be mixed thoroughly and approximately one quart placed in a plastic bag.
- Keep samples cool and prevent dryout.
- Get samples to testing lab with overnight service if possible.
Interpreting and Using Variety Test Results

As the number of varieties available to cotton growers increases, growers have more and more options. Variety selection may be the most important decision made during the growing season. The initial investment in seed has a huge influence on ability to yield, as well as drought tolerance, insect resistance, crop quality and other factors that add up to profit at the end of the season.

The difference in yields from private tests and university test has been the object of discussion. While genetics in a variety may be superior to those of another variety, overall management and environmental conditions account for a large percentage of a variety’s performance as they enable you to obtain the potential.

Reviewing results at different test locations and the rankings of varieties at each is complicated because the environment at each location is different. This difference, called variety environment interaction, can be large or small depending mainly on the weather and crop management. The maturity of each variety also can make this interaction larger. Since each variety cannot be managed separately, the management system for the variety trial has to be selected that can be an average for the entire test. This system favors some varieties and hurts others.

What about the official variety tests? A grower must look at the statistical significance to see if differences are meaningful. When looking at data, you can have more confidence in an analysis run at the 0.05 level of significance (LSD) than at 0.10. When looking specifically at lint yields, an LSD of about 100 lbs or less can be useful in selecting a variety. LSDs of more than 100 lbs gives you little useful information due to non-uniform conditions within the test.

How to use variety tests to select those varieties that are right for you:

- Review as many public and private tests within your growing area as possible.
- Check the statistical reliability of each test.
- Determine the management system and variety used in each test.
- From several valid tests, select the top 5 or 6 consistent yielding varieties with the characteristics you need.
- Refer to on-farm variety tests, like Deltapine® New Product Exposure (NPE) tests.
- Don’t put all of your eggs in one basket. Plant several varieties. If you are unsure about a new variety, then plant limited acreage of that particular one.

The bottom line is to plant varieties in which you have confidence.
The information presented in this book was compiled from a variety of sources and publications.


Monsanto Company is a member of Excellence Through Stewardship® (ETS). Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto’s Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. This product has been approved for import into key export markets with functioning regulatory systems. Any crop or material produced from this product can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for this product. Excellence Through Stewardship® is a registered trademark of Biotechnology Industry Organization.

_B.t. products_ may not yet be registered in all states. Check with your Monsanto representative for the registration status in your state.

_Individual results may vary_, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible.

**ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.** Roundup Ready® crops contain genes that confer tolerance to glyphosate, the active ingredient in Roundup® brand agricultural herbicides. Roundup® brand agricultural herbicides will kill crops that are not tolerant to glyphosate. Warrant® Herbicide is not registered in all states. Warrant® Herbicide may be subject to use restrictions in some states. The distribution, sale, or use of an unregistered pesticide is a violation of federal and/or state law and is strictly prohibited. Check with your local Monsanto dealer or representative for the product registration status in your state. Acceleron®, Bollgard II®, Genuity Design®, Genuity Icons, Genuity®, Respect the Refuge and Cotton Design®, Roundup Ready®, Roundup® and Warrant® are trademarks of Monsanto Technology LLC. Deltapine® is a registered trademark of Monsanto Company. All other trademarks are the property of their respective owners. ©2013 Monsanto Company. 030513SS/CMB