



# COTTON PHYSIOLOGY TODAY



## Planting and Replanting Decisions

**Bill Robertson, Sandy Stewart, and Randy Boman**

As May approaches, cotton planting is generally 25% complete across the Belt. California and Arizona lead the way as their five year (2001 to 2005) estimated plantings the first of May is 74% and 65%, respectively according to USDA-NASS <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1048>. Cotton planting in Texas will range from as early to as late as any other state in the nation. Regardless of the location, producers have one thing in common: they push the limits on getting the planters in the field. Extension Cotton Specialists preach that planting early does not necessarily result in earliness. The first field planted is not necessarily the first field ready for harvest.

Since the optimum soil temperature for cotton germination is near 85°F, it is understandable that soil temperatures of 60°F to 65°F can lead to stand failure. Cold weather slows cotton growth, increasing its vulnerability to fungal pathogens which grow well at 65°F. The coldest soils are fine textured, poorly drained, flat planted light colored soils. Cotton germinates slowly in these soils. The presence of sodium and other salts in these soils will slow germination even more. Cotton germination is very sensitive to salts, especially when soil calcium is low. When planting into cold soils, it is imperative to use the highest quality seed. As seed size decreases, seed quality becomes more critical when planting in marginal conditions.

A question that is common this time of the season deals with making replant decisions. Many factors must be considered. First it is important to know what is in the field. This may not be evident for a few days after a storm if evaluating hail damage. Nonetheless, it is important to evaluate the population, uniformity, and health of the existing stand. Establishing the occurrence of skips greater than three feet in length, especially when this occurs simultaneously in adjacent rows, is critical. The calendar date is also important. A thin stand will most always look better at the end of the planting window. The ability of cotton to adapt and maintain yield potential at lower plant populations is often underestimated. Most Extension recommendations state, "If the decision to replant is diffi-

cult, then there are probably enough plants to keep the stand." To find more information to assist in making this decision, search for "cotton replanting decisions" on your computer web browser. Information from your local or neighboring state's Cooperative Extension Service can be used to assist in this tough decision.

Predictive DD60 Accumulation for Five Days Following Planting	Outlook for Planting
<10	Very poor
11 – 15	Poor
16 – 25	Marginal
26 – 50	Good
>51	Very good

Close attention to planting recommendations may prevent having to become familiar with the replanting recommendations. Most Extension Specialists recommend that planting be delayed until: 1) mid-morning soil temperatures in the rooting zone exceed 60°F at a 6" planting depth or 68°F at a 2" planting depth; 2) the five-day forecast calls for dry weather and a minimum of 25 DD60s; and 3) low temperatures are forecast to remain above 50°F for the following 5 days.

Search "local temperatures" on the web browser to select any number of sites that offer current, short, and long-range forecasts. Extension Cotton Specialists may also provide a local Planting Forecast. Contact the local Extension Agent for more information regarding recommendations. ■

### Additional Resources:

Cotton Root Disorders

<http://pestdata.ncsu.edu/cottonpickin/disorders>

Cotton Nematodes - Your Hidden Enemies

<http://lubbock.tamu.edu/cottoncd/west/docs/nematodes/nematodebrochure.pdf>



*Cotton seedlings subjected to chilling temperatures (A) compared to seedlings not chilled (B) during imbibition from a study conducted by Hopper and Burke. Note the absence of normal taproot growth of the seedlings in A. Seedlings in A and B were exposed to the same temperature (86°F) with the exception of the first six hours of imbibition in which seedlings in A were exposed to chilling temperatures of 40°F.*

**Photos:** N. Hopper and J. Burke

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## Cotton Stand Establishment

Dave Guthrie, Paul Brown, Tom Burch, and Will McCarty

*Updated and Reprinted by Bill Robertson*

The need to establish a healthy stand of cotton is the first step toward a successful season. Cotton is biologically ill-equipped to withstand the environmental uncertainties encountered during its first weeks of life. The first hurdle has been crossed successfully when cotton actually begins to grow the first true leaf. Scientific advances and technological improvements have enhanced the potential to obtain a healthy and uniform population of seedling cotton plants. Nonetheless, lack of attention to detail or overconfidence is a formula for failure.

It is important to understand how cotton's growth habits and physiological challenges associated with germination and emergence complicate planting decisions. By understanding the interaction between the environment and the biology of stand establishment, management approaches can be developed that enhance seedling health.

### Seed Quality

The cotton seed industry has developed rigid quality control programs to deliver high quality seed. These quality standards have helped to eliminate low quality planting seed that arises due to cotton's indeterminate growth patterns.

Because cotton exhibits indeterminate growth, there is a potential for a wider range in seed quality than that encountered in determinate crops such as small grains or corn. The distinct and narrow reproductive stage of determinate crops insures greater consistency in the quality of the harvested seed. While their determinacy does not guarantee high quality, it does increase the uniformity within a seed lot, which simplifies quality control procedures. Boll development in cotton may span as much as five to six weeks. Conditions such as moisture, mineral nutrition, and carbohydrate supplies vary, particularly in rain-fed or humid regions. Mature seed in the rainbelt also may be subjected to wetting and drying cycles which stimulate germination processes in the seed. These reactions produce free fatty acids, which can be used as an indicator of reduced seed quality.

Seed quality can be highly variable over years and even between fields on the same farm. This variability is highly dependent upon weather patterns, particularly rainfall from the time bolls begin to open and the seed is in the shed. Seed companies have attempted to overcome this limitation by concentrating their seed production in multiple regions with more predictable environments and by intensive management. There is no region that is incapable of producing high quality seed. Stringent quality control procedures are necessary to identify and preserve high seed quality. Seed companies take pride in their ability to provide high quality planting seed to their customers.

Once this high quality seed is identified and isolated, seed treatments are applied to protect the seed from pests encountered during storage and the initial stages of stand establishment. Optional seed treatments are available for the management of one or more pests, including early-season insects, seedling disease, or nematodes. Seeds are also color-coded to help differentiate variety technology traits. The actual seed costs, technology fees, and assorted optional seed treatments

can represent a significant investment prior to planting a single seed. This magnifies the importance of doing things right the first time.

Questions frequently arise on the need for additional hopper-box and/or in-furrow fungicide treatment. No absolute answer is possible due to the host of variables that influence seedling disease. Variables include: moisture, drainage, aeration, temperature, overall pest pressure and the affects of crop protection materials. The desired level of protection sought will depend on the potential for early season stress, the importance of achieving specific plant density targets and management philosophy.

### Physiology of Germination

Seed quality improvements help, but they do not ensure stand establishment. The physiology of germination can be disrupted by environmental conditions encountered within the first day following planting.

Germination is an exceedingly complex series of events which must be tightly coordinated in order for a seed to transform itself into a photosynthetically active plant. During this short time period, metabolic pathways are switched on which convert stored materials into structural components. These processes rely on the ability of the seed to continually supply and expend energy until the cotyledons begin functioning as photosynthetic factories. Environmental disruptions can affect multiple metabolic systems, which can cause seedling death, or result in seemingly permanent developmental and performance handicaps. This complex series of events can be divided into two general phases.

### Water Absorption

The first phase (imbibition) begins when the cotton seed is exposed to water. Water moves from the surrounding soil into the seed through a physical and chemical process. This process is driven by differences in surface area, moisture content, and an electrical charge between the seed and soil. The seed is composed of cells, each with a wall made of cellulose. The large surface area and low moisture content of the seed draws water from the surrounding soil into the seed. The moisture content of the seed can increase from 10-12% to 40-80% in less than 12 hours after planting. It is not necessary for the seed to be alive for this initial swelling to occur. The same principal is at work when a paper towel or sponge is used to pickup a spill. This rapid absorption of water stimulates the breakdown of storage lipids (fat-like molecules) into free fatty acids. The conversion to free fatty acids is irreversible and is partly responsible for low quality seed which results from mature, open bolls being exposed to field weathering.

This physical absorption of water initiates two physiological events that must occur in unison to complete the first phase of germination. First, membranes within the cells must undergo a transition from being dry and disorganized, where they are inactive, to an organized state, where their function is vital to the germinating seedling. Second, the contents of the seed must redissolve into metabolically useful forms.

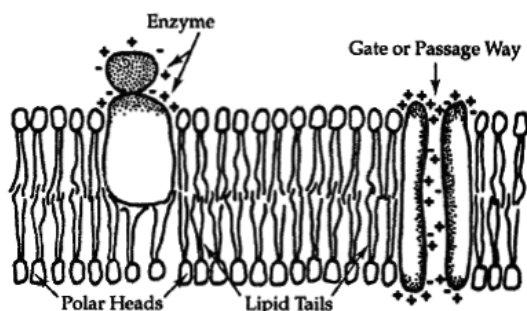
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## Pivotal Role of Membranes

The importance of this transition is best comprehended by understanding membrane function. Membranes can be thought of as barriers, micro-factories and gatekeepers. The complex array of physiological processes that occur simultaneously within a cell each require a unique mix of reaction machinery - enzymes, reactants (sugars, amino acids, fatty acids, etc.) and environmental conditions (pH, electric charge, catalysts, temperature) - to make products necessary for life. The cell is able to accomplish these multiple tasks by creating compartments within the cells called organelles. Each compartment behaves as a semi-autonomous unit, a condition that remains as long as the integrity of the compartments is maintained. This is one function of membranes, to maintain the integrity of these sub-cellular compartments as well as the integrity of the cell itself.

Membranes are composed of fat-like lipid materials as well as water-soluble (polar) materials such as certain proteins and phosphorous containing compounds. The membrane orients itself into a bilayer, like two slices of bread, so that the polar heads of the molecules face toward water soluble material and the tails face toward each other on the inside of the membrane. Membranes function as cellular barriers because their lipid core repels water. Functional membranes do not readily mix with the dissolved cellular constituents. This separation prevents wholesale, disruptive mixing between and within cells. On the other hand, some molecules must pass through membranes to be used in another part of the cell or plant. Membranes accomplish this regulation in the flow of materials through shunts or gates which utilize specific enzymes. The enzymes assist the movement of some materials and prevent the transfer of others. One membrane passage might transport sugar molecules, another may transport specific amino acids. Much like a lock and key, the appropriate molecule unlocks the gate allowing passage.

### Model of Membrane Structure



Finally, membranes also contain enzymes to make new compounds. These enzymes are ideally placed because they may have access to different metabolic environments which allow them to transform and transfer molecules between compartments.

### Chilling Injury

In order to become functional, membranes must reconfigure themselves from a disorganized to an organized state. When cotton seeds are dry, membranes are not complete, having pores or discontinuous regions. When seeds are hydrated, the membranes orient themselves into these bi-layers. During the transition, these membranes must change their shape. If this transformation does not occur, cellular and subcellular integrity is compromised. Temperatures below 50°F inhibit this re-configuration into functional membranes. Simultaneously, the

stored cellular material begins to redissolve as moisture enters the cells of the seed. If the membrane remains discontinuous, the separation between and within cells is lost. This can cause the direct death of a seedling due to loss of necessary materials, or it can encourage the growth of disease organisms that utilize these lost sugars etc., for their growth.



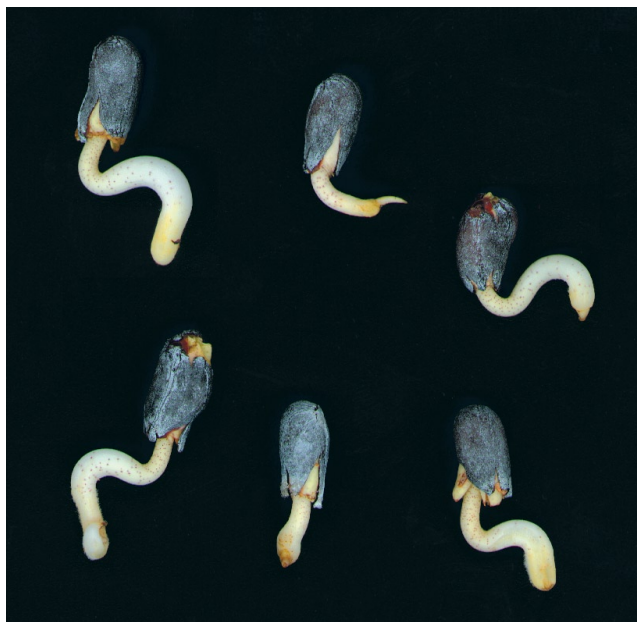
*This picture is a close-up view of a seedling injured by chilling. The root tip meristematic tissue is dead, which results in the brown color. In many cases, the root tissue behind the dead root tip will be enlarged. Presumably, this results from a buildup of food reserves mobilized to the root meristematic tissue for growth. However, with a dead tip, these materials are not used and, therefore, accumulate.*



*The two seedlings in this picture show normal root development. When the two groups are compared, it may be noted that seedlings injured by chilling are often short with thickened hypocotyls and radicles, dead root tips, and show some signs of lateral root growth.*

**Photos:** N. Hopper and J. Burke

*The six seedlings pictured below depict various morphological responses to chilling injury.*



## Cell Division Begins

The second phase of germination begins when the young, tap root (radicle) grows beyond the outer surface of the seed. Cells must divide and elongate to enable the radicle to penetrate into soil, while the young shoot must pull the seedling leaves (cotyledons) through to the surface where they can begin to capture sunlight and manufacture their own sugars to sustain further growth.

Until the cotyledons become photosynthetically active, seedling growth is completely dependent on reserves stored in the seed for building blocks and energy sources. Cotton seeds contain about 16% oil that can be converted into fatty acids for production of carbohydrates used as energy sources. Protein content may range up to 25% in cottonseed, a portion of which is converted into amino acids, which are transported to the growth points for production of structural proteins and enzymes. The young seedling must have both sufficient reserves of these proteins and oils, plus the metabolic machinery, to convert these storage materials into useable reactants.

## Impact of Stress on Emergence

Environmental stresses encountered during this phase will also impact emergence. When temperatures fall below 50°F during this second phase, membrane fluidity and activity are impaired. This inhibits the conversion of stored reserves into needed reactants. Emergence can also be hindered if oxygen levels in the soil are low due to saturated soil conditions or soil crusting. The requirement for high oxygen levels is particularly important in plants like cotton whose seeds contain high amounts of storage lipids that are utilized during germination and emergence. Oxygen is a needed reactant for chemical conversion of lipids into organic acids and sugars. If oxygen is low, the necessary raw materials for emergence may be lacking. Surface crusting also hampers emergence. Soil aeration is reduced because the sealing process prevents the passage of oxygen from the atmosphere into the soil. Secondly, the crust increases the amount of energy the seedling must expend to break through to the surface.

These three stresses frequently occur simultaneously after planting with the passage of cold fronts. Rain associated

with a cold front helps to saturate the soil and seal the surface, creating a crust. Cold air replaces the subtropical warmth and decreases the soil temperature. And finally, the embryonic seedling quickly depletes the oxygen levels. Chilling injury compromises membrane function and cellular integrity. Oxygen needed to meet the high metabolic requirements of germination and emergence is limited, and the sealed surface further inhibits germination. The metabolic demands of emergence can exhaust seedlings, particularly if initial seed quality is low. The seedlings may die prior to emergence, or be predisposed to injury or death from other stresses such as disease, thrips or phytotoxicity from crop protection products. This helps explain why cold fronts between planting and emergence can spell doom for cotton.

Research data and grower experience suggest that seedling stress can permanently cripple crop performance. Late emerging seedlings that have been monitored through the season have been shown to contribute less to yield than earlier emerging neighbors. This same inferior performance is noted in late emerging adjacent rows and in experimental plots where the late emergers do not have to compete with the superior performers. Although the physiology of these long-term effects on seedling stress is not well understood, avoidance of these conditions is commercially desirable.

## Management Summary

Several management objectives are incorporated into successful planting strategies. Most important is recognizing that cotton seed is damaged by cool and wet soils. Delay planting until: 1) soil temperatures in the rooting zone of the young seedling exceed 60°F at a 6" planting depth or 68°F at a 2" planting depth; 2) the five-day forecast calls for dry weather and a minimum of 25 DD60s; and 3) low temperatures are forecast to remain above 50°F for the following 5 days.

The physiological transformation of seed into an active seedling is complex. Cotton's genetic heritage predisposes the crop to stand failure following inclement weather. However, wise management decisions can lessen this risk. Adopting available technologies, including planting high quality seed and following weather advisories, can improve the likelihood of obtaining a healthy stand of cotton. ■

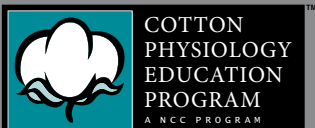
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**The National Cotton Council** of America's mission is to ensure the ability of all U.S. cotton industry segments to compete effectively and profitably in the raw cotton, oilseed and U.S.-manufactured product markets at home and abroad. The Council Headquarters are located in Memphis, Tennessee. The Council maintains close contact with national policy makers with offices in Washington DC. Member Services personnel are located across the Belt and are the eyes and ears of the organization to help the Council meet the needs of members. The Council serves as the central forum for consensus-building among producers, ginners, warehousemen, merchants, cottonseed processors/dealers, cooperatives and textile manufacturers. The organization is the unifying force in working with the government to ensure that cotton's interests are considered.

**The Cotton Foundation**, based in Memphis, Tennessee, strengthens and expands markets for U.S. cotton by fostering: innovative cotton research to find solutions to cotton problems; technology to implement those solutions; education to speed new research application; and communication to spread information throughout cotton's production and marketing chain. Foundation-supported programs, endowments and fellowships are not covered by other public or private agencies.

Based in Memphis, Tennessee, the **Cotton Board** is the oversight and administrative arm of the Cotton Research & Promotion Program, representing U.S. Upland cotton. To fund the Program, the Cotton Board collects a per-bale assessment of all Upland cotton harvested and ginned in the U.S., as well as an importer assessment for all Upland cotton products imported into the U.S. To conduct the Program, the Cotton Board contracts with Cotton Incorporated to carry out the actual research and promotion activities for U.S. producers and importers of cotton.

**Cotton Incorporated** is the research and marketing company for U.S. Upland cotton, as administered by the Cotton Board. The mission is: "To increase the demand for and profitability of cotton through research and promotion." Cotton Incorporated's World Headquarters and Research Center is located in Cary, North Carolina and its Consumer Marketing Headquarters is located in New York, New York. Supporting offices are located around the globe in Los Angeles, Osaka, Singapore, Shanghai and Mexico.



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