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Seed Quality and Germination

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The rare occurrence of volunteer cotton plants growing around gin yards and along the roadside reminds us of the difficulty of cotton seedling establishment. Unlike corn or alfalfa, cotton makes a poor weed. Unless growers prepare an optimum environment and plant vigorous, high quality seed, cotton doesn't grow. In this article we will discuss many of the factors necessary for obtaining a healthy stand of cotton seedlings.

Seed Germination

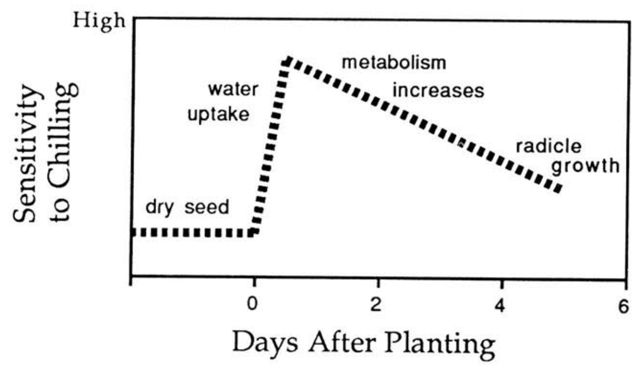
The mechanism of seed germination involves complex timing of water absorption, membrane reorganization, metabolic restructuring, and cell expansion. The complete details of germination are overwhelming and of little use in management decisions, but several critical stages **are** extremely amenable to producer control.

Seed Hydration

The first stage of germination is water uptake. Water only moves to the seed in the **liquid** phase from soil in firm contact with the seed. In fact, the seed starts out so dehydrated (-1000 bars) that it can dry the surrounding soil. Once a sandy soil starts to dry, it looses its water conducting abilities. In sandy fields, dry soil around the seed can lead to stand failures unless the seed is in excellent contact with the surrounding soil. Certainly you have found seeds that didn't germinate but were lying loose in what appeared to be moist soil. Good seed-to-soil contact is critical especially in sandy soils, regardless of initial moisture content. One key to good seed-to-soil contact is a properly functioning press wheel. This includes alignment, suspension, free rolling, and wheel cleanliness. Although seed-to-soil contact can also be obtained with surface compaction, this is a less desirable practice due to increased seedling impedence and potential for crusting.

Chilling Injury

As the seed soaks up moisture, it transforms from a living, non-growing state to a growing organism. This transformation occurs as the cell membranes restructure themselves, providing separation and organization to molecules that become mobile in the cell fluid or sap. Since functional membranes are stable sheets of oil, low temperatures harden them, disrupting their fluidity and integrity. Cotton is a tropical plant and sensitive to chilling. An example of chilling injury is when a banana (another tropical plant), chilled in the refrigerator, turns black and rots due to membrane disruption and the subsequent mixing of cell constituents. Soil temperatures of less than 50°F cause chilling injury to cotton. If this occurs at the most sensitive stage, when the seed is soaking up water, it often dies after the root tip or radicle has pushed out a half inch or does not develop a normal tap root. Chilling within the first 5 days after planting often results in weak plants with delayed maturity and reduced yield. The following graph depicts the relative sensitivity of cotton to chilling injury. Dry seed are highly tolerant to chilling, but as soon as it is placed in moist soil it begins soaking up water and enters its most sensitive stage. Since the temperature of shallow planted cotton seeds can fluctuate widely, planting should be avoided when the temperature is forecast to drop below 50°F anytime during the first few days after planting.



Cold Temperatures and Emergence

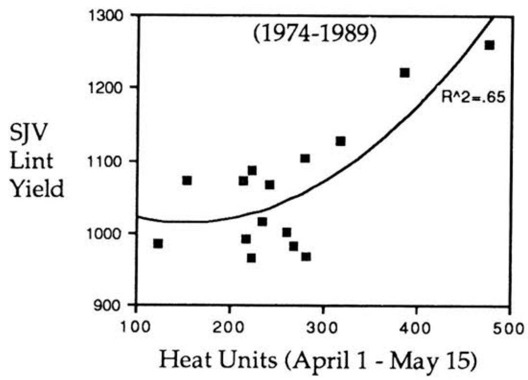
Since the optimum soil temperature for cotton germination is near 85°F, producers frequently observe that soil temperatures of 60 to 65°F can lead to stand failure. Cold weather restricts cotton growth, increasing its vulnerability to fungal pathogens, which grow well at 65°F degrees. These general rules describe soil warming and provide some guidance for improving soil temperature:

- Sandy soils warm up faster due to the lower water content. Soil water has a high heat capacity and acts as a thermal buffer.
- Due to water's high heat capacity, surface soils that are well drained warm faster than waterlogged soil.
- Beds warm faster than flat planted cotton due to improved, air to soil contact, angle to the sun and surface drainage.
- Dark colored soils tend to warm up faster because they are more efficient absorbers of sunlight.

The coldest soils are fine textured, poorly drained, flat planted, light colored soils, such as some alkali soils. Cotton germinates slowly in these soils not only due to the cooler temperatures, but also the presence of salts and sodium. When planting into cold soils, it is imperative to use the highest quality seed as measured by cool germination test.

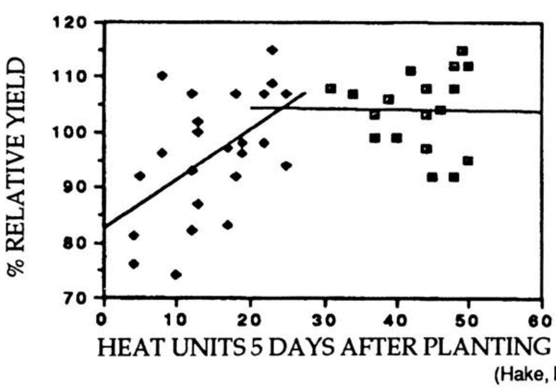
Spring Temperature and Yield

The overriding importance of warm temperatures on obtaining healthy stands and yield is demonstrated by data from Mississippi and the San Joaquin Valley. The relationship of heat unit accumulation during the seedling stage and yield has been shown to be correlated in Mississippi. George Cathey reported at the 1985 Beltwide Cotton Conference that, when he divided the season into 2-week segments, the only time period to have a significant correlation between heat units and yield was a 2-week period in May. This period generally coincides with the seedling stage of the cotton plant in Mississippi. The following figure relates the San Joaquin Valley average yield to the total number of heat units received from April 1 through May 15. If this region gets off to a warm start, as it did in 1987 and 1989, growers have to rent parking spaces for all their extra modules.



(Kerby, Keeley 1990)

Growers with sufficient planter capacity can utilize this knowledge to increase yield by planting when the weather is warming. The following figure shows one grower's yields versus the observed heat units for the 5 days after each field was planted. Yield was decreased 10% by planting into a cool spell. When the 5-day accumulated heat units were above 25, yield was not limited by temperature.



(Hake, Kerby 1985)

Soil Aeration

After cotton seeds soak up moisture and the membranes reorganize, the seedling starts to mobilize nutrients out of the folded cotyledons. The stored cotyledonary nutrients are rich in oil and must be converted to sugars and proteins for new root and shank growth. This conversion requires oxygen and is the reason that oil seeds, such as cotton, have a high oxygen requirement. This oxygen requirement for cotton germination limits the optimum moisture level around the seed because water restricts soil aeration or oxygen movement. Poor aeration is of major concern on clay soils, especially when the seed is planted into mud. A good rule of thumb is that cotton on fine textured soils should have firm seed-to-soil contact on ½ to ⅔ of the seed surface to allow sufficient area for oxygen uptake as well as water uptake.

Soil Impedence and Crusting

Soil impedence or resistance, determines the success of the last stage of germination, that is, expansion of the root and shank. Soil impedence determines how hard the seedling shank must pull on the cotyledons to raise them above the soil and how twisted the root tip must grow. Although some soil impedence is beneficial for shedding the seed coat or cap, severe impedence such as associated with alkali crust can restrict the plant's ability to emerge. The longer the cotyledons are underground, the greater is the susceptibility to seedling diseases.

Management tools to minimize crust formation:

- Rotate crops to build soil organic matter for improved aggregation.
- Avoid surface compaction. Compact soils form tighter crusts.
- If thick crusts do set up, use the lightest weight equipment that will break the crust to avoid compacting soils.
- Avoid deep planting which aggravates seedling disease development and weakens seedlings.
- Use modern planters which are designed to leave a fracture line for seedling shanks to break through.
- Consider hill dropping, where 3 - 4 seeds are placed together, on severe crusting soils in the rainbelt.
- High vigor seed also increases stand success when crusts are thick.

Uniform Stands Increases Yield

Uniform plant spacing is another key component of stand establishment. Non-uniform stands increase both, the number of whip or weed plants (which bear few bolls due to crowding) and the number of bushy wide plants (which require extra growing days to compensate for skips). Bob Metzer, Extension Cotton Agronomist in Texas, has compared double-disc planters to sweep opener planters for the last 3 years. He attributes the consistent higher yield (85 lbs lint per acre) with the double-disc opener to the more uniform seed placement both down the row and to the moisture. Non-uniform stands are more common now that hand thinning has become too expensive.

Salts and Sodium

Cotton planted in saline or sodic spots emerges slowly, partially due to the colder temperature of light colored, fine textured soils, but also due to the high sensitivity of cotton seedlings to sodium and other salts.

Research has shown that cotton germination is very sensitive to salts, especially when soil calcium is low. Under these conditions, seeds fail to germinate or are severely delayed.

Ammonia Toxicity

Another chemical damaging to cotton seeds and seedlings is ammonia. If ammonia-producing fertilizers such as urea, UAN-32 or anhydrous are placed close to the seed, an unacceptable risk of stand failure occurs. Ammonia toxicity is aggravated in high pH soils which convert more of the ammonium (NH_4+) into the toxic ammonia (NH_3). Damage from ammonia to cotton seedlings occurs as a root tip burn and is quantifiable by the ammonia/ammonium content in the tissue.

Seed Quality

The "ideal" seed bed would be moist and warm, with firm seed-to-soil contact on at least the lower half of the seed, and sufficient soil cover to avoid excess drying. Once the radicle or root tip has emerged from the seed, stand failure due to soil drying is rare. Under these conditions, we would have successful stands even with lower quality seed. But we always experience adverse planting conditions in some part of the Cotton Belt. For this reason, planting high quality seed should be the standard practice. And when adverse weather is likely, planting only the highest quality seed will increase the chance of obtaining a healthy stand instead of a costly replant.

Germination Tests

The standard germination test (warm germ) is conducted under temperature and moisture conditions favorable for germination and development of seedlings. Because of these favorable conditions this test is often called the seed viability test. Seed that do not germinate under these conditions are essentially dead seed. To perform this test, seeds are rolled inside moist towels and placed into a laboratory germinator. The temperature inside the germinator is either a constant 86°F or alternating day/night of 86/68°F. Towels are unrolled at 4, 8, and 12 days to count normal seedlings. The minimum acceptable germination in most instances under these very favorable conditions is 80%. This minimum percentage is printed on the bag as the "Percent Germination".

Cool Test

The cool germination test is conducted at 64.5±1°F, the lower germination temperature for cotton. Since this temperature is at a critical breakpoint for cotton seedling development, slight deviations from this temperature may result in highly variable measurements. The cool germination is evaluated once at 7 days after planting. Only seedlings with a root (actually root and hypocotyl) of 1.5 inches or longer are counted. The percent includes only the strong vigorous seedlings and is reported as "Percentage Cool Test Germination". The cool test is run on delinted, fungicide treated seed, while the warm test may be conducted on seed at any stage after ginning.

Using these Tests

The sole purpose of these tests is to predict how a seed lot will perform in the field. Generally the warm germ will estimate the percent emergence under highly favorable conditions, while the cool germ will estimate emergence under more typical, somewhat adverse conditions. Where moisture, aeration or soil tilth — and not just temperature — limit field germination, these tests will over-estimate field emergence. In cloddy or flooded fields where seeds cannot be properly placed in contact with the soil, or when soil temperatures are low, even the highest cool germ seed will not emerge.

Minimum acceptable levels for cotton planting seed are 80% on the warm test and 50% on the cool test. BUT under adverse cool temperatures, the higher the cool germ — the better the field emergence. Because only the minimum warm germ is reported on the seed bag, growers are encouraged to ask their seedsman the specific warm and cool germ for their planting seed. Growers have used germination tests in several ways:

- Adjust seeding rates upward when planting low cool germ seed under less than optimum conditions.
- Avoid planting low cool germ, weak seed lots if the forecast is for cool weather.
- And avoid purchasing low germ seed.

Some cotton states suggest adding the warm and cool germ percentage together. Seed with a combined cool and warm germ of less than 140 would be marginal quality seed.

Carry-Over Seed

Carry-over seed refer to seed not planted the previous year. Rarely are seed carried over for more than 1 season. Due to the small 1989 crop in Texas and the early frost in the Mid-South, some cotton growers may be planting carry-over seed. If good quality cotton seed has been stored dry it will retain viability for at least 2 years. When planting carry-over seed, new warm germ and cool germ tests should be run to insure viability and vigor.

Stand Establishment and Yield

Producers are well aware of the effect of weak stands on yield and earliness. Skippy, low density stands are generally lower yielding and later maturing, because plant compensation requires time and shifts late boll maturation into unfavorable weather. Chilling injury is also deleterious because chilled plants are weak slow growers. Also non-uniform emerging fields are impossible to manage properly because variability in plant growth is perpetuated all season long. But maximum yields can be obtained with mediocre quality seed if ideal seed beds are planted and followed with warm weather. By understanding the effect of temperature, moisture, aeration and impedence on the cotton stand establishment, producers are better prepared to respond to the unusual weather patterns that currently plague much of the Cotton Belt.

Update on Cotton Physiology Education Program

Andy Jordan

Producer interest in the Cotton Physiology Education Program has been tremendous. For example, distribution of this newsletter has grown from 3,500 to 15,000, due to requests from producers and Extension Specialists. Interest in the physiology seminars has also been impressive with 550 attending the Beltwide Physiology Seminar in Las Vegas and 120 at the Fresno Physiology Seminar.

This 3-year program started in September and is designed to deliver information about cotton physiology that producers can use to improve management decisions. Copies of previous newsletters are available and can be obtained by contacting Kater Hake or Pat Yearwood at our Memphis office:

"Conservation Tillage, Narrow Row Cotton" Feb. 1990
"Plant Mapping" Jan. 1990
"Environmental Causes of Shed" Dec. 1989
"What Controls Plant Height" Nov. 1989
"Effect of Cold Weather on Yield and Quality" Oct. 1989

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About the Authors

Will McCarty is Extension Cotton Specialist for Mississippi. Gay Jividen holds the position with Cotton Incorporated of Director of Agricultural Research. Norman Hopper is Associate Professor of Seed Physiology at Texas Tech in Lubbock. Much of the information in this article was derived from the Seed Germination chapters in the Cotton Foundation reference book "Cotton Physiology". These 7 chapters provide an excellent review of all aspects of seed production, storage, and stand establishment.

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The National Cotton Council (NCC) is the central organization representing all seven sectors of the U.S. cotton industry: producers, ginners, warehousemen, merchants, cottonseed crushers, cooperatives and manufacturers. A majority of elected delegates from each sector must approve all NCC policies, thus assuring unity of purpose and action.

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