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COTTON STAND ESTABLISHMENT

Dave Guthrie, Paul Brown, Tom Burch, Will McCarty

Most growers arrive at cotton planting decisions with a mixture of anticipation and a hint of apprehension. A new season provides the opportunity to start either with a clean slate, or behind the eight ball if stand problems develop. Experienced growers recognize how important stand establishment is to season long development and performance. This newsletter will discuss germination and emergence, and how management decisions can influence early season cotton development.

The need to establish a healthy stand of cotton should not be taken lightly. Cotton is biologically ill-equipped to withstand the environmental uncertainties encountered during its first weeks of life. Producers often breathe a sigh of relief when their cotton actually begins to grow that first true leaf. Scientific advances and technological improvements have improved the prospect for a healthy and uniform population of seedling cotton plants. Nonetheless, lack of attention to detail or overconfidence are formulas for failure.

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

Cotton Seed Production

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 results from cotton growth patterns.

Because cotton possesses an indeterminate growth habit, there is a potential for a wider range in seed quality than encountered in determinant 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 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, an indicator of reduced seed quality.

Seed quality in the rainbelt may be highly variable over years or even between fields on the same farm. Seed companies have attempted to overcome this limitation by concentrating their seed production in regions with more predictable environments and by intensive management. There is no region that is incapable of producing high quality seed, if quality control procedures cull seeds that have been exposed to excessive weathering.

Once this high quality seed is identified and isolated, seed treatments are applied to protect the seed from fungal pathogens encountered during storage and the initial stages of stand establishment. Depending on the specific treatment, fungicides may provide contact and/or systemic protection.

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 do not insure stand establishment. The physiology of germination can be disrupted by environmental conditions encountered within the first days following planting.

Germination is an exceedingly complex series of events which must be tightly coordinated in order for a dormant seed to transform itself into a photosynthetically active plant. During this short time period, new 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 seed-

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ling 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 begins when the cotton seed is exposed to water. Water moves from the surrounding soil into seed through a physical and chemical process. This process is driven by differences in surface area, moisture content and 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 soil into the seed surrounding. The moisture content of the seed can increase from 10-12% to 40-80% in less than 12 hours. 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 resulting from mature, open bolls exposed to field weathering.

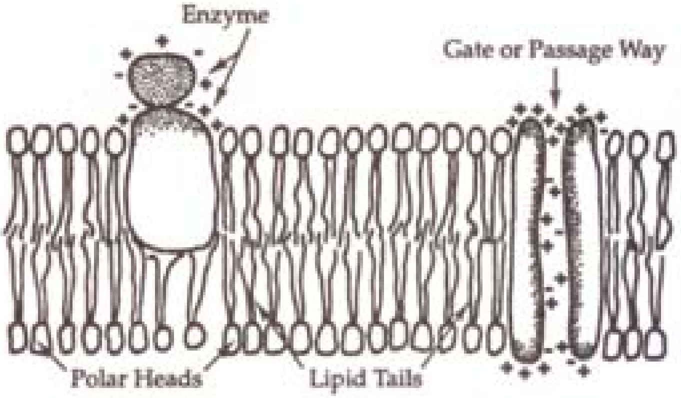
This physical absorption of water initiates two physiological events that must occur in unison to complete the first phase of germination. First, membranes within the cells must undergo a transition from a dry environment, where they are inactive, to a wet environment, where their function is vital to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

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 material as well as water-soluble (polar) materials such as certain proteins and phosphorous containing compounds. The membrane orients itself into a bilayer like 2 slices of bread (Figure 1) 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 specific amino acids. Much like a lock and key – the appropriate molecule unlocks the gate allowing passage.

Figure 1.
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 allows them to transform and transfer molecules between compartments.

Chilling Injury

However, in order to become functional, membranes must reconfigure themselves from a dry to a wet environment. When cotton seeds are dry, membranes are not complete, having pores or discontinuous regions. When wet, they orient themselves into these bi-layers. During the transition from dry to wet, these membranes must change their shape. If this transformation does not occur, cellular and subcellular integrity is compromised. Temperatures below 50°F inhibit this reconfiguration 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.

Cell Division Begins

The second phase of germination begins when the young, tap root (radical) 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 push 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 new 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°during this second phase, membrane fluidity and activity is impaired which 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 spell doom to cotton.

Research data and grower experience suggest that seedling stress can permanently cripple crop performance. Late emerging seedlings which 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 are not well understood, avoidance of these conditions is commercially desirable.

Managing the Planting Season

Several management objectives are incorporated into successful planting strategies. Most important is a recognition 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 60-65°F (depending on temperature determination method); (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 until emergence.

Despite chronic complaints and good-natured ribbing, **weather forecasting** is much improved. Reasonably good five-to-seven-day temperature forecasts are available from the National Weather Service and other sources such as weather channels. Some states provide regular weather-based advisories during the planting season to assist growers with decisions pertaining to planting. Contact your local extension office to determine if advisories are available in your area. Following these advisories decreases the likelihood, but does not eliminate the possibility, that a fast moving cold front will make an unwelcome appearance in a given production region. Fortunately, the extreme sensitivity of cotton to chilling injury is relatively brief. Once these susceptible periods have concluded, plant resiliency to cool temperatures improves. Rainfall predictions are less certain. However, rainfall's potential negative impact on stand establishment is lessened if not accompanied by a cold front.

Extremely precise **planting equipment** can be used to create a physical environment that favors seed germination and emergence. Uniform seed-soil contact enhances the absorption of water from the surrounding zone. Planting coulters and discs can improve aeration and minimize soil crusting by temporarily decreasing soil density . Engineered improvements in planting equipment can adjust the depth of seed and distance between adjacent plants or hills.

Beds can be constructed to improve soil drainage, aeration and warming. Bedding land is particularly beneficial on tight or fine-textured soils with poor drainage. **Seed depth** should be monitored carefully. Deep planting weakens seedlings. If surface crusting is common, emergence may not occur and the stand may be lost. In the rainbelt, planter depth may need to be adjusted between ½-1 inch, balancing the soil's tendency to dry out and its likelihood of forming a deep crust. **Crop rotation** helps build soil organic matter which reduces crusting. **Hill dropping** 3-4 seeds per hill can be an effective means to improve emergence of cotton on land that tends to crust.

Wrap Up

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

For additional reading on the planting season, refer to the following issues of Cotton Physiology Today:

- Balancing Plant and Crop Performance, April 1993, Vol. 4, No. 3
- Late Planted Cotton, June 1991, Vol. 2, No. 7
- Seed Quality and Germination, March 1990

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

About the Authors

Paul Brown is Extension Specialist-Biometeorology with the University of Arizona in Tucson. Tom Burch is Extension Cotton Specialist with Louisiana State University in Baton Rouge, and Will McCarty is Extension Cotton Specialist with Mississippi State University at Starkville.

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