Drought Management for Cotton Production

Introduction

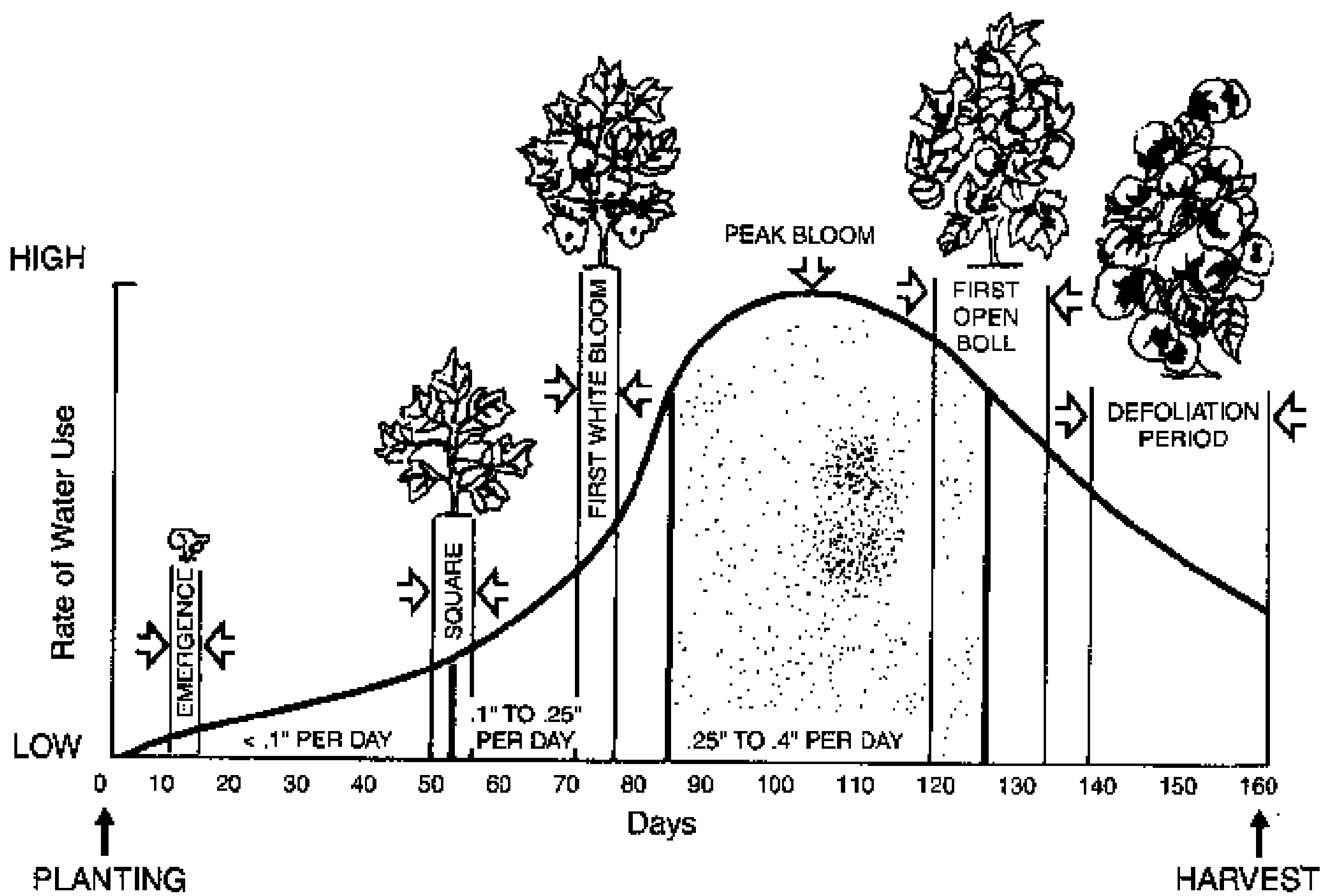
Cotton is considered one of the most drought-tolerant field crops grown in the southeastern United States. Yet it responds well to sufficient water by producing yields proportional to rainfall or supplemental irrigation. For nearly 200 years, it was grown in the Southeast almost exclusively under non-irrigated or rainfed conditions. However, growers are well aware of the need for timely rainfall in April and May to get stands established and in the summer months to sustain fruiting. A common saying among them is, "If you get rain in July, you go to the gin in September." Notable southeastern dry years in modern times include 1954, 1977, 1980, 1981, 1986, 1988, 1990, and 1993. Many cotton growers were bankrupted by drought and boll weevils during the 1920s and 1930s. Boll weevils have been successfully eradicated in most southeastern states, but droughts--such as the one in 1993--still cause disastrous cotton yields. Economic losses are significant due to the relatively high cost of growing cotton.

Drought is rated by far the greatest cause of disasters of cotton and other crops in the Southeast by the Federal Crop Insurance Corporation. Much research has been devoted to more efficient water use. The reversal of cotton's migration to the irrigated valleys of the West indicates the increasing cost of water and the volume of natural rainfall. Therefore rainfed cotton production, an enterprise not without risk, appears once again to be economically feasible here. However, the water available from rainfall and supplemental irrigation to produce profitable yields will ultimately determine the success of southeastern cotton in the post-boll weevil eradication era.

Cotton Water Needs

Drought before bloom can reduce the number of fruiting branches produced by first bloom. However, drought is rarely severe enough to cause fruit shed before bloom in the Southeast because of the relatively low water demands that squares development exerts on the plant. As the crop begins to bloom, it must begin filling bolls. This process causes the plant's demand for water to rise dramatically as more and more bolls are produced as shown in Figure 1. Drought will not only slow down plant development but will cause the plant to shed small bolls and squares due to this increased demand for water. Drought following bloom has the greatest effect on cotton yield and lint quality.

Figure 1. Rate of Water Use in Relation to Plant Development



Irrigation

Cotton is an excellent candidate for irrigated land particularly in areas that frequently have drought periods during July 1 through Aug. 20 and on coarse-textured, sandy land. During peak blooming, cotton will use about 0.3 to 0.4 inch of water per day. Irrigated cotton yields have been from zero to more than 800 pounds per acre greater than non-irrigated yields, with the most frequently reported increases being in the 200 to 400 pounds per acre range.

The following procedure is suggested for 900 to 1,200 pounds per acre yields: Before first bloom irrigate with 0.75 to l.0 inch of water whenever wilting of plants is observed by midday. Continue applying 0.75 to 1.0 inch of water at the first sign of drought stress before first bloom. It should be recognized that abundant moisture magnifies vegetative growth problems when excessive nitrogen is available, insect control is insufficient or both. After first bloom, irrigate as needed to supply the quantities of water listed in Table 1. Rain gauges should be used to measure the water received from rain and the amount supplied by irrigation.

Table 1. Cotton Irrigation Schedules Suggested for High Yields

	900 to 1,200 lb/A		1,300 to 1,600 lb/A	
	In./Week	In./Day	In./Week	In./Day
Week beginning at 1st bloom	**1.0**	**0.15**	**1.5**	**0.22**
2nd week after 1st bloom	**1.5**	**0.22**	**1.5**	**0.22**
3rd week after 1st bloom	**2.0**	**0.30**	**2.5**	**0.36**
4th week after 1st bloom	**2.0**	**0.30**	**2.5**	**0.36**
5th week after 1st bloom	**1.5**	**0.22**	**2.5**	**0.36**
6th week after 1st bloom	**1.5**	**0.22**	**2.0**	**0.30**
7th week after 1st bloom	**1.0**	**0.15**	**2.0**	**0.30**
Weekly quantities should be increased to compensate for runoff.				

Examine the crop during the seventh week (900 to 1,200 pounds) and eighth week (1,300 to 1,600 pounds) to determine if irrigation should be continued. Additional irrigation may be needed if hot dry conditions are predicted and the plants are experiencing wilt.

Irrigation intervals can be determined by dividing the quantity per day for a period into one-half to two-thirds the available moisture-holding capacity of the upper 2 feet of soil in fields. For example, if the available moisture capacity of the soil is 0.7 inch per foot and the quantity per day is 0.3 inch, the interval between irrigations or following rain that brings soil moisture to field capacity would be:

$$\frac{0.66\% \text{ x } 2 \text{ ft x } 0.7 \text{ in./ft}}{0.3 \text{ in./day}} = 3.08 \text{ or } 3 \text{ days}$$

Intervals for most of the season will be three to four days for coarse-textured sand, four to six days for more productive loamy sand and sandy loam, and five to eight days for fine-textured sandy loam or "clay." A four- to six-day interval will fit a majority of the situations.

Experience over the past decade soundly indicates 900 to 1,200 pounds per acre or better yields can be expected with the above seven-week irrigation scheduling technique. Although there have been several reports and many feel that more water is needed for higher three-bale-plus yields. Rainfall-irrigation-yield histories from several locations with water supplies of 14 to 16 inches during the first seven to eight weeks of blooming show yields of 1,300 to 1,600 pounds per acre.

Growers with intensely managed production programs that are already harvesting two-bale yields and are striving for three-bale-plus yields on part of their crop may want to increase the amount of water supplied by irrigating to provide the quantities of water listed on the right side of Table 1 on a trial basis. This will provide four inches more during the seven-week period than is suggested for two-bale yields.

Irrigation Efficiency. One factor that has not received much attention is the efficiency of the irrigation system in delivering water. Non-uniform water application by an irrigation system may cause uneven growth patterns in a field. Worn nozzles on the irrigation system may need to be replaced to correct the non-uniformity problem. Another option may be to change the type of sprinkler packages on the center pivot.

You have several options when determining what type of nozzles to use when retrofitting an old--or purchasing a new--center pivot system. All of the water that is emitted from a nozzle does not reach the soil surface. Water is usually lost due to evaporation, wind drift and crop canopy losses. The ratio of the water that reaches the ground to the water that leaves the nozzle is called water application efficiency (WAE). Placing the most efficient type of nozzle on a system will make a difference in the amount of water that enters the soil.

A study was conducted in Georgia in 1992 evaluating different nozzle types on a peanut grower's center pivot irrigation system. The system was equipped with three different nozzle types to determine the water application efficiency of different nozzles. They were:

1. Conventional low-angle, impact-type sprinklers (IMPACT).
2. Low-pressure spray nozzles on drops at truss rod height (LDN).
3. Low-pressure spray nozzles on drops at about 18 inches above ground (LEPA).

Table 2 shows the WAE for each package. The study shows that the LDN and LEPA nozzles were 13 and 15 percent more efficient than the IMPACT nozzles during daytime conditions, respectively. There was more effect on WAE of impact-type sprinklers for day versus night conditions than the other sprinkler packages demonstrated. This water savings could be beneficial, if the irrigation water supply is marginal.

Table 2. Summary of Water Application Efficiency for Three Sprinkler Packages

	IRRIGATION EFFICIENCY	
TYPE OF SPRINKLER PACKAGE	DAY	NIGHT
Low-Angle Impact on Top of Pivot (IMPACT)	77%	82%
Spray Nozzles on Drops at Truss Rods (LDN)	90%	93%
Spray Nozzles on Drops 18" Above Ground (LEPA)	92%	93%

Water Conservation. When center pivot systems are operated on soils with relatively low water infiltration rates or on undulating soils, a significant amount of water runoff can result. Excessive runoff can also occur after a large rainfall. Runoff results in additional irrigation costs, uneven water infiltration throughout the field, and soil erosion. A water-saving technique called furrow diking may be beneficial in conserving water. Furrow diking is an interrow tillage technique which forms small dikes in the furrow approximately every 5 feet. The small dikes restrict rainfall or irrigation water from flowing to a different location in the field. Furrow diking has been extensively investigated in cotton on the rolling plains and high plains of Texas. Increases in cotton lint yields have ranged from 11 to 16 percent when alternate rows are diked and from 32 to 36 percent when all rows are diked. Based on rainfall records, dikes are expected to increase yields in 17 out of 20 years in these areas of cotton production. Diking has been demonstrated in Georgia with limited success in irrigated fields. A drawback of diking in the Southeast is that the plant height is greater than in Texas. Texas growers are able to remove the dikes before harvest, which eliminates picker bounce. A system of removing dikes would probably make diking acceptable in the Southeast.

Management Alternatives

Cultivars. Full-season varieties have a more indeterminate type of growth that makes them more likely to "rebound" when a serious drought is relieved. If enough time remains after drought relief, then full-season varieties often can make a top crop. Full-season varieties are a good choice for droughty soils as long as they can be planted on time.

Short-season varieties often load up quickly and cut out early due to drought. Cut-out due to drought seems to be more "permanent in nature" the shorter the maturity of the variety.

There is usually little difference in performance of different maturity groups affected by severe and prolonged drought which is not relieved by rain in time to allow cotton to "rebound." Occasionally, short-season varieties outperform full-season varieties when the timing of a prolonged drought favors an early variety. In any case, success with full-season varieties requires timely planting, especially on droughty soils which cannot be irrigated.

Tillage and Residue Management. Many soils in the Southeast form hardpans which restrict root growth. Any restriction in root development can increase the severity of a drought. You should dig up roots to ensure that the taproot is developing straight downwards. Roots that turn sideways are an indication that your tillage system is not providing a good environment for root development. Plants with roots turned sideways will not be able to use water deep in the soil and will suffer from drought earlier than plants that have good root systems. Tillage that eliminates compaction problems or hardpans will allow the root to develop downwards to obtain moisture from a greater depth of soil. This will permit the crop to pass through short periods of drought during the season without stunting or severe fruit shed. Where irrigation is available it will make irrigation scheduling less critical.

Underrow subsoiling and bedding will disrupt hardpans that are problems especially in sands and loamy sand soil that does not have enough silt or clay to be sticky, gummy or slick when wet. Most hardpans are located between the depths of 8 to 12 inches. Their presence and depth can be determined by probing the soil with a "T"-shaped steel rod about 30 inches in length with a point at the bottom of the "T". If the operation is performed about two weeks before planting, any rain that occurs will be conserved. At planting this will allow the beds to be conditioned and the dry soil removed allowing seeds to be planted in firm moist soil. In conservation tillage, underrow subsoiling will accomplish the same goals.

No-till and reduced tillage systems are increasing in the Southeast. Research in North Carolina suggests that in dry years reduced tillage systems will outperform conventional tillage systems. Conversely the same studies show that in wet years conventional tillage outperforms reduced tillage. Studies conducted on silt loam soils that do not respond to subsoiling in north Alabama have shown that no-till cotton planted into a small grain cover crop can yield as much as conventional cotton. In these Alabama studies no-till cotton without a cover did not yield as well as no-till cotton with a cover or conventional cotton in dry years. The reason for higher yields associated with cover crops in dry years is thought to be due to one or more of the following factors: increased infiltration of rainfall, less evaporation of moisture, increased organic matter, and reduced compaction.

Cultivation. Excess cultivation can dry out soil and increase problems related to drought. Cultivating too deeply (more than 1 to 2 inches depending on the size of cotton) can prune roots and reduce the plant's ability to extract moisture. Excess cultivation and cultivating too deeply are more of a problem as the plant gets larger and begins to square.

Cultural Practices. Low plant populations (preferably two plants per foot and not more than three or four) will generally yield more than higher plant populations under drought conditions. When making replant decisions you should keep in mind that low plant populations do well in the Southeast especially in dry years. Avoid high plant populations on sandy, droughty fields.

Fertilization. While sufficient levels of nutrients help plants withstand water shortages, the uptake of nutrients--especially of nitrogen (N) and potassium (K)--is reduced by drought stress. Fertilization should be based on soil tests and realistic yield expectation to avoid excess fertilizer costs when drought reduces yield. In addition, high nitrogen rates in drought years often cause regrowth and defoliation problems when drought-stressed crops receive rain between cut-out and harvest.

Reasonable soil-applied N and K rates are advisable since supplemental foliar applications can be used to correct mid-to-late-season deficiencies. These are best determined by petiole testing. However, petiole nitrate and potassium tests are less reliable as drought stress intensifies since nutrient uptake decreases. Therefore, during periods when drought stress induces wilting by noon, supplemental foliar applications are not usually recommended even though petiole tests show deficient levels of these nutrients.

Pest Management. Seedling diseases can be nonlethal and still have a detrimental effect on the root system of a cotton plant. Root systems that are weakened by diseases can not extract as much moisture as healthy root systems during dry weather. Seedling diseases usually do not cause problems unless the soil is both cool and wet; sandy, droughty soils are less likely to have economic levels of seedling disease pressure.

Drought can have a major impact on insect pressure. Drought will usually reduce budworm, bollworm, and European corn borer pressure because the drought-stressed plants are less attractive and these insects have a harder time getting established during drought. Frequent and diligent scouting for these pests may result in fewer applications in dry years.

On the other hand, beet armyworm and fall armyworm pressure can be higher in dry years. The likelihood of higher beet armyworm pressure increases with early-season sprays to control plant bugs, weevils, and second generation budworms. The farther south in the Southeast you are, the more likely that the increased pressure from armyworms will be more significant than reduced bollworm pressure in dry years.

Drought tends to reduce aphid numbers. However, it may be argued that aphid feeding is more damaging when water is limiting. Spider mites are generally associated with dry weather but have not had a serious economic impact on the Southeast in recent years.

Defoliation. A drought that is not relieved in time to make a top crop forces the crop to be early since the small bolls and squares are shed which compress the fruiting period into two or three weeks of effective bloom. Growers need to be aware of the effects this compression of the fruiting period has on maturity and defoliation. Early crops can usually be defoliated before the "normal" rule of thumb of 60 percent open. The only way to know for sure when defoliation is safe is to cut bolls open and examine them. You should begin examining bolls when the crop is 30 to 40 percent open in drought years. Because drought makes a crop earlier, the tendency is to wait until the crop is past the "normal" 60 percent open to ensure mature fiber. Delaying defoliation beyond that stage increases the chances of high micronaire (mike) cotton.

The section on fertilization above addresses residual N problems that often occur in drought-stressed cotton. Your cotton may look like it could not regrow but if rains return and N is available you will probably see regrowth occur quickly. Because of this regrowth potential the addition of regrowth control materials to defoliant mixtures is often a good idea. Dropp uptake is reduced by drought; growers may need to increase rates during drought.

Ginners need to be aware that drought will cause cotton to open earlier. Gins need to be started earlier in drought years to allow growers to defoliate earlier. Growers without module builders cannot defoliate if a gin is not available. This is due to regrowth that will more likely be a problem soon after the cotton is defoliated. It is also important that gins be open so that if regrowth does become a problem growers can pick through the regrowth and gin quickly.

Drought-stressed cotton that does not produce a great amount of regrowth may not need defoliation. How much regrowth occurs will vary from field to field. Drought-stressed cotton will often drop about half its leaves naturally by harvest time. If this is the case and regrowth is not severe and the cotton is dry, you should be able to harvest without defoliation. Remember that green material is easier to remove at the gin than dry material. If cotton is not defoliated, you should take care to put cotton in trailers or if modules are used, the cotton should be ginned within three days. High levels of green thrash in harvested material will cause a module to heat and increase light-spot (or lower) grades. Cotton placed in modules at questionable moisture content should be checked daily for internal temperature rise for the first five to seven days. If there is a temperature rise of 15 to 20 degrees Fahrenheit or if the temperature reaches 110 degrees Fahrenheit, the module should be ginned immediately. Nondefoliated cotton should not be placed in modules if it cannot be ginned quickly. If you are trying to decide if defoliation is justified, always pick a trailer without defoliation to see how it cleans up at the gin. When harvesting without defoliation, an oil-based spindle wetting agent is preferable to a surfactant type to reduce green stains and cause spindle twist problems.

Harvesting. Harvesting short cotton can be a little difficult if the bolls are closer to the ground than normal. Bolls close to the ground only have one chance of being picked since there are no spindles below them. For this reason, it is very important to have good sharp spindles especially at the bottom five or six rows on the drum when harvesting short cotton. Remember that these spindles are subjected to more dirt and wear and tear than spindles higher on the drum and are more likely to need replacing in a normal year. The other major differences in harvesting cotton close to the ground is that you have to put the head on the ground and go slow. Scrapping (second picking) is not likely to be justified on short drought-stressed cotton. If you intend to harvest cotton once over, you should adjust the tension and clearance of compression sheets (pressure plates or crowder plates) so that you are not leaving a significant number of bolls and tags. This will increase trash in the cotton but will allow you to harvest the maximum amount of seed cotton. A good rule of thumb is to allow a 3/4- to 1-inch clearance on early green cotton and to decrease clearance with more mature cotton. Tension should be set at about 20 pounds for larger plants with green bolls and 40 pounds for small plants with short limbs.

Make sure that stalk lifters are adjusted to lift branches up to a height where the lower bolls will come in contact with the lower rows of spindles. Get your picker's operator manual out and go over all adjustments before you go to the field.

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