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Texas Agricultural Extension Service

Water Management Strategies for Cotton

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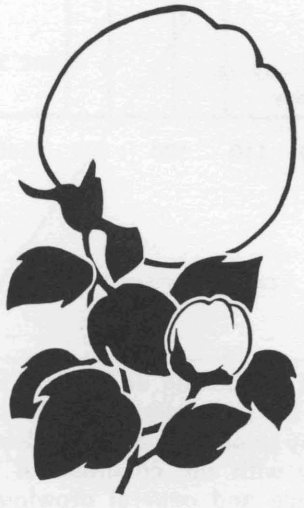

Water is the most limiting factor in cotton production throughout the state. Cultural practices are typically directed toward enhancing the retention and storage of rainfall in the soil. The ability to irrigate affords producers an opportunity not only to meet the water needs of the crop but also to manage growth and length of the fruit setting period. Declining water supplies, high energy costs, varietal changes, new production systems (i.e., narrow row spacings) and other changes necessitate utilization of the most efficient water management techniques to produce acceptable yields of high quality fiber.

Cotton Growth and Development

Managing crop water supplies requires an understanding of plant growth and development, especially the critical stages when insufficient water can result in slowed growth and fruit shedding. During the vegetative growth stages, all available carbohydrates are directed toward root and shoot development. Typically during this stage, root growth exceeds top growth by a wide margin. By the onset of fruiting a relatively large root system is in place to anchor the plant and supply it with soil nutrients and water.

As the plant enters the reproductive phase, the flow of carbohydrates is gradually shifted to developing fruit. Bolls constitute the strongest "sinks" and in time, the bulk of the carbohydrates produced by the leaves are directed into the bolls. As a result, new vegetative development and root growth are slowed. The reduced ability of the root system to expand and provide needed nutrients and water leads to a reduction in plant growth and the production of new fruiting sites. The level of fruit shedding increases as the plant enters the "cut-out" phase.

Crop Water Use Patterns

Seasonal water use for adequately watered cotton varies from about 24 inches on the Texas High Plains, which has a short growing season, to over 40 inches in Arizona which has an extended growing period characterized by high temperatures and low humidity conditions. Figure 1 illustrates the typical seasonal water use pattern for cotton.

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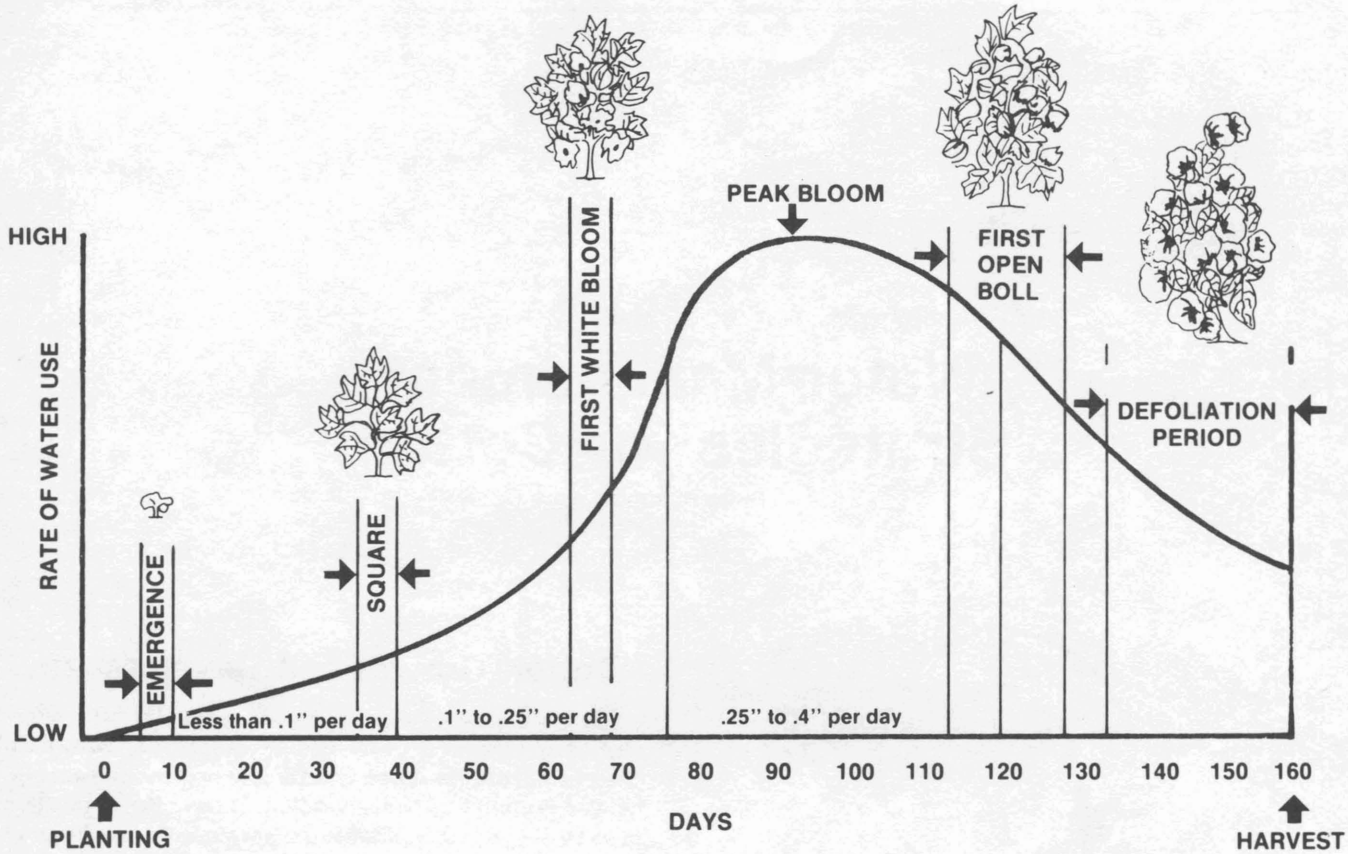

Figure 1. Rate of water use in relation to cotton development.

From planting to square initiation (a period of about 40 days) evapotranspiration (ET) is generally less than 0.1 inches per day. Plant water requirements are low due to the limited leaf area. Most of the water used is extracted from the top foot of soil. The bulk of the water loss during this period is due to evaporation.

Water use (ET) increases to 0.1 to 0.3 inches per day during the square to early bloom stage (40 to 75 days after planting). The leaf canopy and roots are developing rapidly. Transpiration now exceeds evaporation. Moisture extraction occurs mainly from the top 2 feet of soil although the taproot and some feeder roots extend to deeper depths.

From early bloom to the opening of the first bolls (usually 75 to 120 days after planting), ET values of 0.25 to 0.35 inches per day are common. ET values may exceed 0.4 inch per day during the peak bloom period. The plants have attained their maximum leaf canopies and root densities. Moisture is being extracted from the entire soil profile.

Following the opening of the first bolls until crop termination, ET generally declines from about 0.25 inches per day to as little as 0.1 inches. Actual water use will vary with the condition of the plant, soil moisture status and general growing conditions. If regrowth occurs during periods of ample moisture and warm temperatures, ET levels can increase dramatically, thereby rapidly depleting soil moisture reserves which could have been utilized by subsequent crops.

Stress Sensitive Periods

Fruit production, retention and shedding are closely related to availability of soil moisture. Production is optimized with an available moisture status that allows uninterrupted development of fruiting positions while avoiding excessive vegetative development on the one hand, or fruit shedding on the other. In many cases, it has been a common practice to allow cotton to "stress" before applying the first irrigation in order to slow vegetative growth, force root system expansion and enhance early fruit development. However, recent studies have shown that even moderate stress prior to the first irrigation may impede the development of fruiting sites and can ultimately reduce yields.

Numerous trials have been conducted to assess the effects of moisture stress at different times during the bloom period on lint yields. The results of one such study conducted in California are shown in Figure 2. As might be expected, moisture stress during the peak flowering period had the most pronounced negative effect on yield. However, stress either early or late in the blooming period also resulted in significant yield reductions.

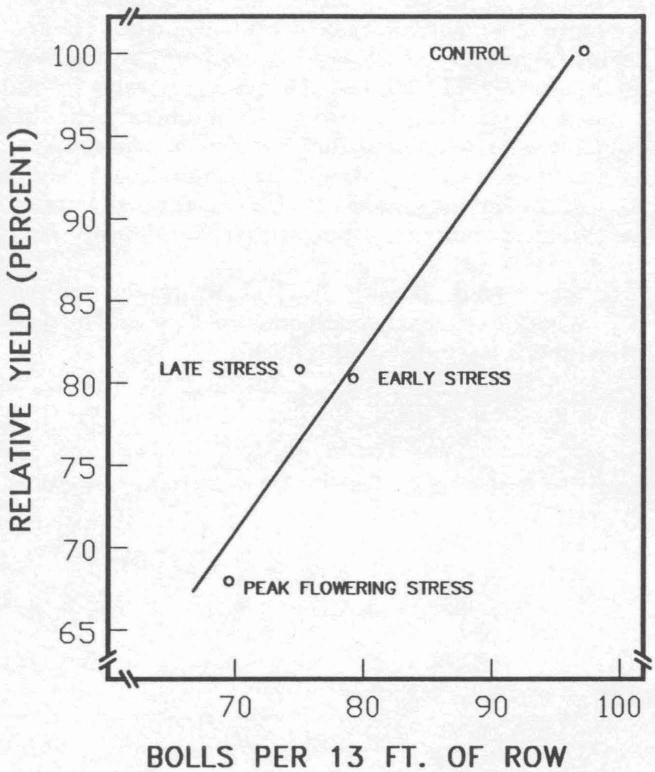

Figure 2. Relative lint yield and boll production associated with different stress conditions during flowering. (Grimes and El-Zik, 1982.)

These results suggest that, where possible, severe moisture stress should be avoided throughout the crop development period. Early irrigations may be justified to maintain adequate but not excessive vegetative growth. In production regions with a short growing season, late season water stress may be acceptable or even desirable in that it hastens cut-out and results in shedding of fruit that would not normally mature.

Irrigation Scheduling

The water requirements of cotton are met by the moisture extracted from the soil by plant roots. A common practice in most irrigated regions is to irrigate before planting with sufficient water to bring soil moisture reserves to field capacity. Preplant irrigation can provide several benefits including timely planting, leaching of salts and providing adequate water for early to mid-season crop growth.

The actual economic benefits of preplant irrigation are dependent on seasonal rainfall patterns. On the Texas High Plains, for example, there is a high probability that sufficient rainfall will be received to plant during the optimum cotton planting period. Consequently, in years when subsoil moisture reserves are adequate, a preplant irrigation may not be justifiable. Likewise, when available, center pivot irrigation systems can be utilized to "water-up" cotton in fields that are not pre-watered.

Determining when to apply the first summer irrigation is an important but often very difficult management decision. Typically, throughout the state, limited irrigation resources are used to supplement rainfall. Because of short water supplies, irrigation usually commences before the crop actually needs the moisture in order to water fields before severe moisture stresses occur. Consequently, scheduling irrigations to meet the moisture needs of the crop precisely are not always feasible.

Several options are available as management aids in scheduling irrigations. These include techniques based on:

Soil moisture status

- based on appearance and feel of soil
- measurements with tensiometers, gypsum blocks or neutron probes.

Plant moisture status

- based on mid-day wilting
- based on "red-line" advancement on stems
- measurements with pressure bombs
- measurements with infrared thermometers.

Soil-plant-environmental conditions

- ET models
- GOSSYM, other models.

Other

- calendar date
- water availability, seasonal conditions.

Irrigation Frequency

The number of summer irrigations and their timing has a significant influence on crop development and water use efficiency. With furrow irrigation, only one summer watering may be justifiable on the Texas High Plains whereas two or three waterings may be needed in areas with a longer growing season. As a general rule, cotton that is being watered twice during the summer produces most efficiently when the first irrigation is applied when first squares are 2 to 3 weeks old (near bloom initiation) and the second 2 to 3 weeks later. Cotton that is to be watered more than twice during the summer is generally most productive when irrigated at 14- to 20-day intervals beginning when first squares are 2 to 3 weeks old or when warranted by early season stress development.

Sprinklers, especially the low pressure center pivot and LEPA (low energy precision application) systems, afford much greater control in the amounts of water applied and frequency of applications. The LEPA systems provide additional advantages in labor, energy and water savings; optimization of water management utilizing alternate row, high frequency, deficit irrigation; and affording opportunities for chemigation.

Alternate row-high frequency-deficit irrigation with LEPA systems resulted in improved lint yields in tests conducted by the Texas Agricultural Experiment Station at Halfway. It is postulated that depositing the water in alternate furrows (rather than spraying it over the plant canopy) minimizes growth retardation due to soil and plant cooling. Frequent light irrigations provide a suitable environment for root development in the upper foot of soil where nutrients and water are concentrated and oxygen is most abundant. Gradual depletion of soil moisture reserves through deficit irrigation provides for control of plant growth and development even if rainfall amounts exceed normal expectations.

Irrigation Termination

Ideally, the last irrigation should provide just enough plant available moisture to retain and mature all the bolls that have a reasonable chance of producing lint of acceptable quality under normal growing conditions. Based on long term seasonal conditions at Lubbock, blooms set on August 10 have a 100 percent probability of producing a mature boll of cotton whereas blooms set on August 15 and 25 and September 1, respectively, have only 71, 29 and 14 percent, respectively, chance of reaching maturity. Consequently, in the Lubbock area, irrigations that bring soil moisture levels to near field capacity should be terminated by mid-August. Deficit irrigations with sprinklers could feasibly be extended until early September to minimize fruit shed.

In any given locale, the last irrigation will be dependent on seasonal conditions, soil type and the type of irrigation system being utilized.

Reference

Grimes, D. W., K. M. El-Zik. 1982.Water Management for Cotton. Univ. of Calif. Bull. 1904.

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