IRRIGATION TECHNOLOGY

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Abstract

Plant stress resulting from lack of an adequate water supply throughout the growing season represents the single greatest limitation to attainment of genetic yield potential of essentially all crop plants. Plant water stress occurs when the soil water supply is inadequate to meet the crop water demand defined by atmospheric conditions. The volume of water contained in the root zone defines soil water supply. Soil texture determines the water holding capacity (volume of H_2O/volume of soil) of the soil system. Rooting depth and density determine how much of the total soil volume can be extracted. The daily crop water consumption (transpiration) is determined by the evaporative demand the atmosphere and the crop size and structure (leaf area and light interception).

Annual precipitation across the Cotton Belt ranges from over 60 inches in the southeast to less than 10 inches in the southwest. Over 60% of the annual precipitation occurs during the summer growing season across most of the Belt except for the Far West.

Cotton production is possible in the western half of the Cotton Belt only with irrigation and yields exceed 1000 pounds/acre. Texas and Oklahoma represent the transition area between the Rainbelt (east) and the Irrigated Belt (west) and yields are low and highly variable from year to year. Irrigation, especially supplemental irrigation, is used to not only increase yields by providing more total water to the crop but also to stabilize yields from year to year. Both surface and groundwater sources of irrigation water are used in most irrigated areas except for the large irrigated area on the Texas High Plains where a depletable source of groundwater is being utilized. Both surface and groundwater sources of irrigation water are being challenged more each year by urban and industrial requirements.

The cotton plant is a woody, indeterminate perennial and as a consequence seed production (the site of lint production) is not important to its survival as a species. Both the production of fruiting sites and the retention of young fruit are sensitive to plant water stress. If the growing season is long, short periods of moderate water stress have little impact on final yield. However, in nearly every environment growing season length is limited for one or more reasons (insect dynamics, harvest weather, etc.)

Tremendous progress has been made over the past 50 years in irrigation system design and development. We initially transported irrigation water in open ditches and used siphon tubes to deliver the water to the individual rows. Less than 50% of the irrigation water was used effectively due to large losses from seepage, evaporation and nonuniform distribution. Improvements were rapidly made in both conveyance systems and application systems using gated pipe and surge valves. The application efficiency of a well designed and operated row water system using a surge valve can approach 80%. Row watering is relatively low cost from a capital investment perspective but more labor intensive than other systems. A large amount of crop acreage is not amenable to surface flooding due either to soil texture or slope constraints. Sprinkler irrigation was used in these areas to apply irrigation water. Sprinklers required a greater capital investment and initially suffered from high-pressure requirements for uniform distribution and high evaporative losses. Improvements in sprinkler technology written the past 10 years has resulted in the LEPA system which stands for Low Energy Precision Application. This system drops water right at the ground surface to eliminate evaporation of the droplet as it passes through the air. The application is made to alternate furrows to reduce soil surface evaporation. The water is uniformly distributed with line pressure of less than 10 psi. The application efficiency of this system exceeds 95%. Center pivots or linear move systems allow low volume, high frequency applications of water which greatly reduce the opportunity for stress to occur between water application.

In order to completely eliminate soil surface evaporation and to allow for more uniform and controlled water application to the root zone, buried drip has been gaining popularity. This system is very capital intensive but almost eliminates labor. Drip irrigation requires a high level of management but results in higher yields and/or less water use.

Both the LEPA system and the drip system provide the opportunity to apply more than just water to the crop through the system. Most of the fertilizer and many of the pesticides can be applied through the system ,again reducing costs of production.

In the development of any irrigation system a thorough understanding of the interaction between water supply and evaporative demand must be developed. We commonly use the relationship between water supply expressed as gallons per minute per acre (GPMA) and evaporative demand to determine the acreage that can be irrigated properly to maximize production. Each 1.0 GPMA will replace 0.056 inches per day of evaporation. The potential evaporation rate is defined by atmospheric conditions including absorbed radiation and vapor pressure deficit. The lower the relative humidity of the air the greater the evaporating power of the atmosphere. The daily crop water use is a fraction of the potential evaporation rate. The fraction approaches 1.0 as

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:14-15 (1998)
National Cotton Council, Memphis TN

the crop grows and develops leaf area. When the crop absorbs more than 90% of the incident radiation, the daily water use is equal to the evaporating power of the atmosphere. In most of the western half of the Cotton Belt the potential evaporation exceeds 0.30 inches per day from 80 through 110 days of age, the period of maximum growth rate of the fruit load.

Irrigation scheduling must be designed and implemented to minimize the risk of yield -reducing plant water stress occurring throughout the life of the plant. Three approaches have been used over the past 25 years. The first technique used was based on soil water supply. The technique was site specific, labor intensive and required special equipment and careful interpretation. The second approach was to monitor the water status of the plant itself. Most of the above-mentioned limitations existed. The third approach which is rapidly gaining in use is the estimate of daily crop water use based upon measured weather parameters and calculating potential evaporation rates, then multiplying by a crop coefficient. No perfect system exists, and much is still dependent upon individual attitudes.