WATER USE AND WATER USE EFFICIENCY OF COTTON PRODUCTION SYSTEMS IN WEST TEXAS

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Abstract

Lack of an adequate water supply to meet the evaporative demand of the growing cotton crop represents the major limitation to maximizing yield of cotton production in Texas. On the Texas High Plains where nearly 70% (3.5 million acres) of the states total (5+ million acres) cotton acreage exists, water supply-demand relationships are even more strained than in most other areas of the state. The precipitation received during the frost-free period represents only 25% of the evaporative demand. Water storage in the soil system is dependent upon both soil texture and depth considerations. Soil texture varies from clay-loams in the northern area to loamy-sands in the southern zones of the High Plains region. Plant available water ranges from 2.5 inches per foot of depth in the clay-loams to less than 1.0 inch per foot in the loamy-sands. Soil depth ranges from less than 3 feet to slightly over 4 feet across most of the area. The greatest problem with soil water supply is the lack of winter precipitation to recharge the profile between crop seasons. More than 7 out of 10 years the area does not receive adequate precipitation from November through May to completely refill the profile for the cotton crop to use.

Crop water use is dependent upon the prevailing atmospheric demand and the amount of crop leaf area. Leaf area intercepting radiation is the primary evaporation site. Row spacing, plant density and plant size can influence leaf area distribution. Leaf area development is fairly slow until the plant begins fruit development. Each square is associated with a leaf. Row spacing and plant density determines the amount of radiation interception and therefore the crop water use in relation to the potential evaporation rate. Stomatal conductance controls the rate of water vapor loss to the atmosphere per unit transpiring leaf area. Stomatal conductance is subject to genetic control but strongly influenced by prevailing environmental conditions.

In West Texas, cotton production is highly dependent upon how efficiently the total water supply is used by the growing cotton crop. Minimizing the waste of bare soil evaporation has great potential to increase crop water supply. Traditional 40-inch rows rarely achieve canopy closure even under well-irrigated conditions. Narrow rows (30 inch) and even ultra-narrow rows (15 or less) increase the degree of ground cover at all plant ages and reduce bare soil evaporation and increase crop water use. Yield increases of 15-18% are consistently observed from 30-inch rows compared to 40-inch row spacing at equivalent water supplies. An additional 8 to 12% yield advantage is frequently observed from ultra-narrow row systems when properly managed. However the additional risks associated with ultra-narrow row production may offset the potential yield gains. In addition the absolute requirement for ground cover prior to planting ultra-narrow row cotton in West Texas requires 4-5 inches of additional water above the cotton crop requirements.

About 10 years ago (late 80's) a production system was developed that maximizes irrigation water application efficiency. This system termed LEPA (low energy precision application) is based on a center pivot equipped with drop lines instead of sprinkler heads. The drop lines apply the water directly to the ground eliminating evaporation of the droplet through the air. Coupled with circular rows and alternate row application, less than 50% of the ground surface is wetted each irrigation. The volume-frequency of application must be adapted to crop type, stage of growth and soil textural conditions determining infiltration rates. For cotton on the loam to sandy loam soils, we believe that prior to flowering a large volume-low frequency application approach is best. Once fruit development begins we recommend a lower volume-higher frequency approach. For instance prior to flowering a typical approach would be to apply 1.0-1.5 inches per revolution. The frequency would depend on the water use rate of the crop. After flowering has begun, during fruit development, the goal is to reduce the intensity and duration of stress between application intervals. Lower volumes at greater frequency achieves this goal. Depending on irrigation water supply the frequency can be in the 2-4 day range. We recommend that no less than 0.5 inches be applied per revolution during this growth phase, so frequency will again be determined by irrigation water supply.

The development of the LEPA system also allows the application of fertilizer solutions through the water without fear of leaf burn from the salts. We have determined that cotton production on the Texas High Plains is maximized when a ratio of 5 pounds Nitrogen per inch of total water supply is available from planting through peak flower (about the fourth week of flowering on the High Plains). The nitrogen supply through the water results in greater fruit retention and larger bolls due to more seed per boll. Applying nitrogen through the irrigation water allows the producer to manage the nitrogen supply as the crop develops within the limits of the water supply and increase water use efficiency.

We have recently begun to evaluate the application of a nutrient blend consisting of $N:P_2O_5:SO_4$ through the water. Due to the calcareous nature of our soils, applied phosphorus is rapidly immobilized and precipitated as insoluble $Ca_3(PO_4)_2$. Multiple applications of P_2O_5 through

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:569-570 (1999)
National Cotton Council, Memphis TN

the growing season offer the opportunity to minimize phosphorus deficiencies delaying maturity of the fruit, especially the seed. Comparison of fertigation versus soil applications of P_2O_5 indicate benefits can be attained within a given phosphorus level. We are also evaluating the $N:P_2O_5$ ratios. To date we have found that as the $N:P_2O_5$ ratio increases to $5N:3P_2O_5$, both yield and quality increase. The $5N:3P_2O_5$ ratio produces the greatest yield due to more seed per boll and higher micronaire of the fiber. We are continuing the ratio evaluation. Fertility management through the irrigation water provides an opportunity to maintain an adequate nutrient supply throughout the fruit production period which increases both retention of fruit and fruit size resulting in significant increases in yield and therefore water use efficiency.

In order for cotton production in Texas to maintain a reasonable level of profit, yields must increase within the limits of the current production inputs. Water is the primary yield constraint at present. In the short term (next 10-15 years) management strategies designed to reduce the waste of the existing water supply offer the greatest opportunity to increase yield. Nutrient supply represents the next most promising area. Nutrient management through the irrigation water supply using the LEPA concept offers the opportunity to further enhance yield and water use efficiency while managing costs.