# IRRIGATION MANAGEMENT THAT OPTIMIZES YIELD AND CONSIDERS EARLINESS

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## Abstract

Soil and plant based measurements of crop water status were used to evaluate varietal responses to four contrasting soil moisture regimes in 1996 and 1997. Premature irrigation cut off resulted in significantly more extraction of residual soil moisture and higher accumulated crop stress mid- and late-season. Extending the irrigation termination date beyond optimum timing, determined by a computer simulation module, resulted in greater numbers of unharvested bolls, which corresponded closely with numeric decreases in cotton yield for these treatments. An accumulated stress bar day concept is proposed that uses average weekly pressure chamber readings summed daily from post bloom through defoliation. Accumulated stress bar days in 1996 and 1997 showed a correlation with yield of $R^2$ = 0.950 and 0.945, respectively. Percent allowable depletion did not correlate well with crop water stress and measured by the pressure chamber. This paper demonstrates the value of using measurements of leaf water potential to schedule irrigation events in the San Joaquin Valley.

## Introduction

In a typical San Joaquin Valley (SJV) cotton production year, more than 80 percent of the water needed to optimize crop yield, comes from farm irrigation water deliveries. Recent Federal legislation known as the Central Valley Project Improvement Act has resulted in reduced water supplies for most of the SJV agricultural crops including Pima and Upland cottons. This recent legislation will result in both reduced water deliveries for the CVP contractor and increased unit costs for supplemental irrigation water transfers. Reduced supplies and increased costs to growers will translate to a change in cotton irrigation economics and the subsequent field water management practices that accommodate these changes.

Future agricultural water deliveries will be closely linked to seasonal rainfall, regional snowpack, and reservoir storage levels, while more expensive groundwater supplies will be utilized in water deficit years. For optimum cotton production, Acala varieties have been shown to use between 26 and 28 inches of water using surface irrigation methods in most years. Considerable interest and difficulty exists however, in determining a final irrigation date for cotton.

Growers often use historic calendar dates to schedule the final irrigation. This method can be very accurate in some years but does not consider the maturity of the crop, and does not rely on the collection of soil depth and available soil water information. This method can lead to underirrigation leading to excess crop stress and yield reduction or overirrigation and problems associated with low crop stress. This study was conducted to evaluate the impact of a range of soil moisture regimes on current cotton cultivars having varied maturity classes. Furthermore, this study will evaluate the current methods for scheduling irrigation events and consider a basic computer module that may improve upon current irrigation scheduling methods. A computer irrigation module (Munier et.al. 1994) was developed for the field that used soil and crop perameters for estimating the optimum irrigation termination date for cotton.

## Materials and Methods

These trials were conducted at the University of California West Side Research and Extension Center in Five Points, CA from 1995 to 1997. A randomized complete block design was used having four replicates with irrigation regime as the main effect. Three common SJV Acala varieties GC510, Maxxa, and PHY33 representing determinate, moderately determinate, and moderately indeterminate plant types were evaluated as subplots. Irrigation treatments were imposed based on estimated optimum irrigation termination parameters identified by the CCM irrigation termination module. Module inputs included nodes above white flowers at a specified time, rooting depth, and soil water availability. Computer generated estimates of crop water use, heat unit accumulation, and boll maturity were made using historic data sets established by the University of California. Once an optimum irrigation termination date was identified for the season, two early termination treatments, and one delayed termination treatment was added to the estimated optimum treatment.

Plots were 280 feet by 12-40 inch rows with four adjacent rows planted to each of the three varieties. Four row guard rows per irrigation plot were used to minimize the possibility for lateral soil moisture transfer between adjacent irrigation treatments.

Each field was preirrigated in January with adequate moisture to produce an eight-foot soil profile at field capacity. The crop was planted April 23, 1996 and March 31, 1997. Neutron probe access tubes were installed to eight feet on two of the four Maxxa replicates for each irrigation treatment. A Cambell-Pacific 503 Hydroprobe was used to determine volumetric soil water content at 7- to 10-day intervals throughout the growing season. Neutron probe calibration was conducted independently at each site for each year of the study. A nine inch reading was made to represent soil

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moisture storage at the one foot depth while an 18 inch reading was used to represent second foot soil moisture, 12 inch increments were used thereafter to represent corresponding depths to eight feet for soil moisture content.

Plants were thinned to a stand of 41,000 and 34,000 plants per acre at first true leaf in 1996 and 1997, respectively. Nutrition, insect, and defoliation management were optimized both years of the study. As a result of extremely high pest populations in 1995, only the 1996 and 1997 data were summarized. In-season plant mapping was conducted every two weeks until peak bloom with a final plant map occurring in early September each year. Nodes above cracked boll were evaluated at the time of the final plant map. Plant height, total node number, fruiting node number, and height to node ratio were evaluated at each plant map with nodes above white flower monitored following first bloom.

Each of the four row treatments were spindle picked and weighed in harvest trailers and 5 to 7 lbs. subsamples collected for each plot to determine lint turnout and HVI fiber quality parameters.

## Results and Discussion

A large soil moisture reservoir was available to cotton plants at this location, figures 1 and 2. Estimated soil water extraction for the driest irrigation treatment ranged from 19.2 in 1996 to 18.9 inches in 1997, (Table 1). This accounts for approximately 72 and 79 percent of total seasonal crop water needs at this site in 1996 and 1997, respectively. The additional water applied with the second irrigation reduced this total deficit of soil water in the 8-foot profile at season's end. Similarly, soil water content at season's end increased as applied in-season water increased.

Leaf water potential readings conducted each season were found to vary dramatically throughout the season, increasing after an irrigation event, and declining over time, Figures 3 and 4. Because of the linear decline of midday leaf water potential following irrigation, (Grimes, et.al. 1974), we established an average value between each reading that represented that time period, typically seven days. Accumulated stress bar days were calculated using averages and multiplied by the number of days between readings, thereby, establishing a stress bar day for each plot monitored. This relationship was then evaluated together with plot yield, Figure 5. Each year a high correlation was observed between stress bar days and yield, with a $R^2 = 0.950$ and 0.945 when a quadratic function was used to model this relationship.

Because of the high correlation observed between accumulated LWP and yield, an attempt was made to test the correlation of allowable soil water depletion with LWP. This test provided mixed results. Well-watered, late termination irrigation treatments correlated poorly while early termination treatments showed more robust relationships between LWP and percent allowable depletion (%AD) between LWP and % AD decreased, (Figure 6). The driest treatment having the most stress late season and highest % AD showed a $R^2 = 0.55$ and 0.89 when relating the two factors. The poor relationship between LWP and %AD under well-watered conditions provides us with a strong argument in favor of using plant based rather than soil based methods alone, to determine proper irrigation schedules in SJV cotton. The value of soil moisture monitoring may be best used in determining irrigation water volumes needed once a threshold LWP reading has been reached. Extensive tests and alternative methods of estimating soil water depletion should continue to be studied. Estimates of accumulated allowable depletion will also be tested with this data set to evaluate their continued value.

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Table 1. Applied water and estimated soil water extraction at the WSREC Irrigation Trial in 1996 & 1997.

| | | Applied Water | Soil Water extracted | Total |
|---|---|---|---|---|
| 1996 | T1 | 7.3" | 19.2" | 26.5" |
| | T2 | 12.8" | 16.3" | 29.1" |
| | T3 | 17.8" | 15.1" | 32.9" |
| | T4 | 20.9" | 12.5" | 33.4" |
| 1997 | T1 | 4.8" | 18.9" | 23.7" |
| | T2 | 11.5" | 19.6" | 31.1" |
| | T3 | 15.9" | 15.3" | 31.2" |
| | T4 | 18.9" | 12.4" | 31.3" |

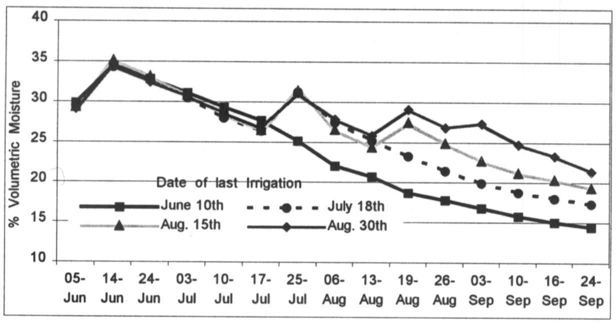


Figure 1. Average % volumetric soil moisture from an 8 foot Profile at the WSREC Irrigation Trial in 1996.

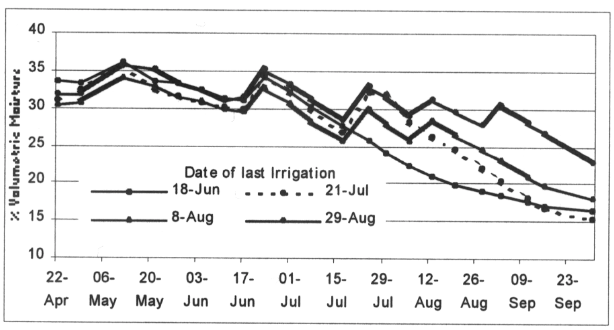


Figure 2. Average % volumetric soil moisture from an 8 foot Profile at the WSREC Irrigation Trial in 1997.

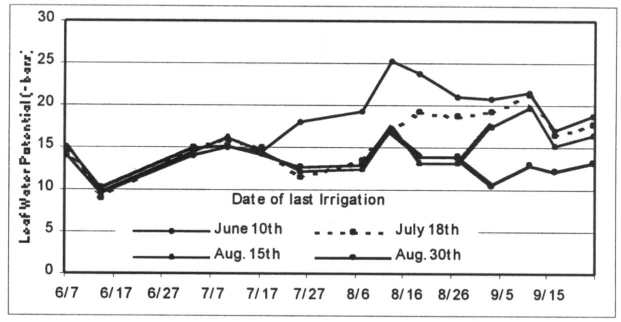


Figure 3. Leaf water potential during the growing season at the WSREC Irrigation Trial in 1996.

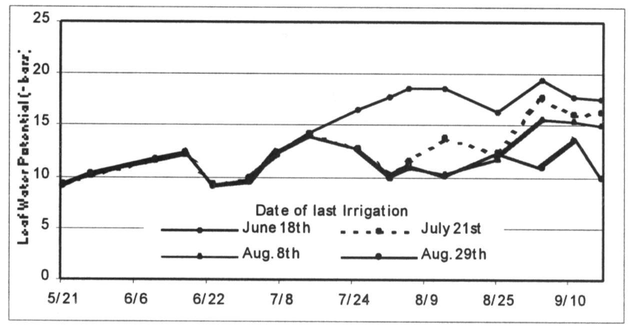


Figure 4. Leaf water potential during the growing season at the WSREC Irrigation Trial in 1997.

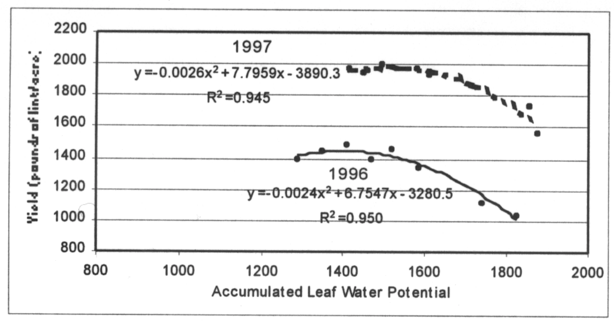


Figure 5. Correlation between leaf water potential and yield at the WSREC Irrigation Trial in 1996 and 1997.

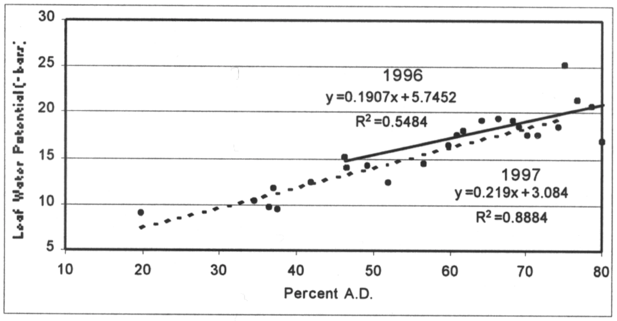


Figure 6. Correlation between leaf water potential and % allowable depletion in a treatment with one in-season irrigation in 1996 and 1997.

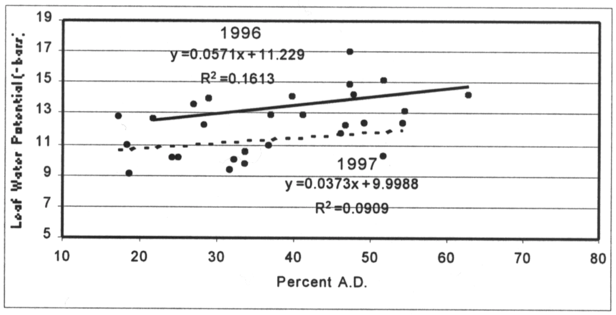


Figure 7. Correlation between leaf water potential and % allowable depletion in a treatment with four in-season irrigations in 1996 and 1997.