Scheduling Pima Cotton Irrigations Using Infrared Thermometers

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Abstract

Plots of pima S-6 cotton were scheduled for irrigation using the Crop Water Stress Index (CWSI). Irrigations were applied when CWSI levels reached 0.08 (wet), 0.34 (medium), and 0.68 (dry) units. The medium treatment had significantly higher lint yield. Preliminary test results indicate the CWSI can be useful in irrigation-management decisions regarding pima cotton production.

INTRODUCTION

Increasing cost, recent groundwater legislation, and decreasing supplies of water in Arizona are causing commercial cotton growers to be more water conscious if a profit is to be realized. Pima cotton is particularly susceptible to yield losses due to inadequate irrigation scheduling. Applying too much water promotes vegetative growth,and too-little water induces wilt, both resulting in yield losses. Proper irrigation scheduling balances growth to reproduction, which produces maximum lint yields.

By scheduling field plots of pima cotton at different CWSI levels, it is possible to define a CWSI critical value--that point where growth is inhibited or reduced due to soil-moisture stress. Optimum lint yield is achieved in the region with minimum applied water.

A test was designed to determine the critical value of pima S-6 cotton and the relationships between lint yields and applied water.

MATERIALS AND METHODS

Plots of cotton (pima S-6) were planted 6 May 1988 in Tucson at the Campus Agricultural Center of the University of Arizona. Three water treatments were established based on irrigation scheduling using the crop water-stress index. Four replicated plots were irrigated when their CWSI measurements reached or exceeded 0.05 (wet), 0.35 (medium) and 0.65 (dry) units. The CWSI was measured on each plot about 3 times weekly.

Initially, infrared measurements were collected from 5 random plants across the length of each plot. A vapor-pressure deficit (VPD) was collected from the center plot of the test about 1 yard above the canopy. Infrared temperature measurements were collected from the fifth leaf from the plant's top. The fifth leaf is the first fully-developed, transpiring leaf and is also used for petiole analysis. When an adequate canopy was developed, infrared measurements were taken from the east and west sides of each plot on north-south rows.

Plots were irrigated utilizing buried trickle tubing for precise water delivery. Neutron soil-moisture measurements, taken 3 times weekly, were used to determine the soil moisture deficiency in each plot. At each irrigation, the corresponding water deficiency was metered onto each plot using volumetric shutoff valves.
The test was defoliated with sodium chlorate on 29 September and 12 October 1988. Four 50-foot rows of each plot were harvested by machine on 27 October and 2 10-foot rows were harvested by hand on 19 December 1988.

RESULTS AND DISCUSSION

The effect of different levels of CWSI irrigation scheduling on the number of irrigations required to meet CWSI scheduling criteria, total water applied, and lint yield are listed in Table 1. The medium treatment, which had a CWSI at irrigation of 0.34 and a seasonally-averaged CWSI of 0.11 units, had significantly higher lint yields than the wet or dry treatments. Yield losses in the wet treatment were due to overproduction of vegetative growth, resulting in plant heights of 6.5 feet due to irrigating too frequently. Yield losses in the dry treatment were due to a high degree of water stress resulting in frequent wilting and abscission of flowers. The dry treatment was about 3 feet in height. The medium treatment had a balance in vegetative production and flowering, little wilting, and less vigorous growth resulting in plant heights of 4.5 feet. The medium treatment also required significantly less water (27.47 inches) and fewer irrigations than the wet treatment.

Figures 1, 2, and 3 are plots of the cyclical movement of the CWSI and the soil moisture content of a 3-foot profile over time for the wet, medium, and dry treatments, respectively. There was a very strong inverse correlation between the CWSI and soil moisture. As CWSI increased, the soil moisture decreased. After an irrigation, the CWSI decreased with a concurrent increase in soil moisture to near-field capacity and the cycle began again. The wet treatment required more irrigations of lesser magnitude than the medium and dry treatments. As CWSI increased, fewer irrigations--but of a greater magnitude--were required.

Figure 4 is a plot of the relationship between CWSI at irrigation and the cotton lint yield for the 4 replicates of each treatment. The relationship was curvilinear with highest yields occurring at CWSI values between 0.30 and 0.36 units. That area was the critical value region and representd optimum timing of irrigation. The plots in the test were irrigated within hours of the scheduled irrigations. If water has to be ordered in advance, a lower CWSI value should be used so that the CWSI approaches 0.34 units the day the water arrives.

The test will be repeated in 1989. The College of Agriculture and the University of Arizona will continue efforts to better-define the relationships between pima cotton lint yields, irrigation scheduling, and plant water use.

Table 1. 1988 Campus Agricultural Center - Field K; CWSI Irrigation Scheduling Test

Cultivar: Pima S-6 (Lot #88-17)
Planted: 5/6/88
Defoliated: 9/29/88 and 10/12/88
1st Pick: 10/27/88 by machine
2nd Pick: 12/19/88 by hand

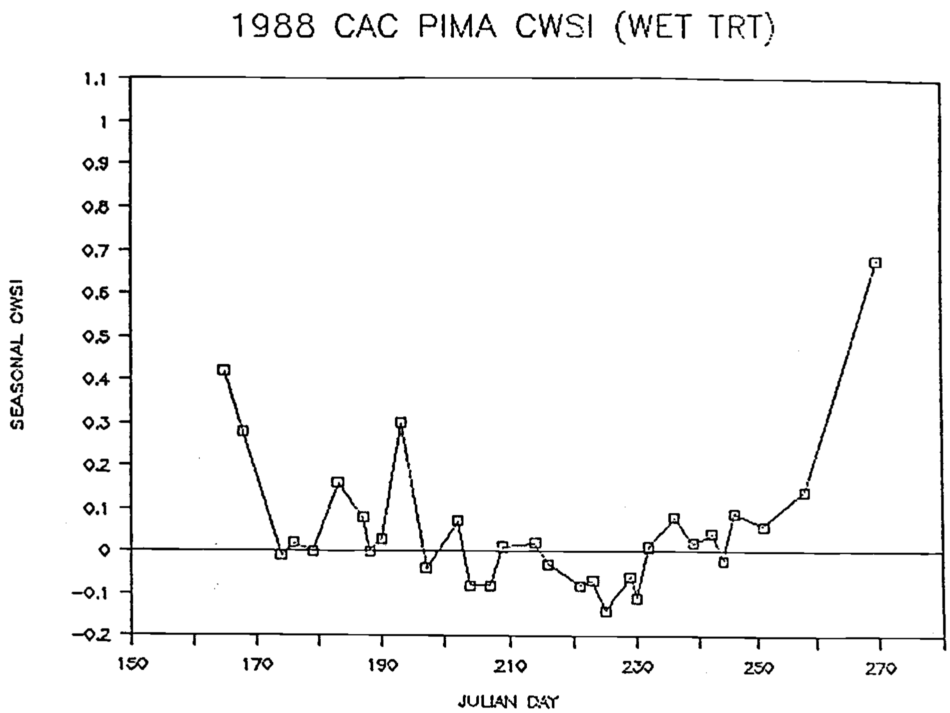
TRT	CWSI At Irr Av *	Seas CWSI Av *	# of Irr. App. **	Inches Water App. * ***	Lint Cotton lb/ac *
Wet	0.08 c	0.03 c	8	36.34 a	1258 b
Medium	0.34 b	0.11 b	6	27.47 b	1516 a
Dry	0.68 a	0.25 a	4	18.53 c	1206 b

* Numbers followed by the same letter are not significantly different at the 0.01 level using Waller Duncan K-Ratio T-Test.

** This is the number of irrigations applied to meet the CWSI scheduling criteria and does not include a pre-irrigation, or 3 establishment irrigations totaling 5.75 inches.

*** Includes pre-irrigation, establishment, and applied water to meet CWSI scheduling criteria.

Figure 1


1988 CAC PIMA CWSI (WET TRT)
SEASONAL CWSI
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
150
170
190
210
230
250
270
JULIAN DAY

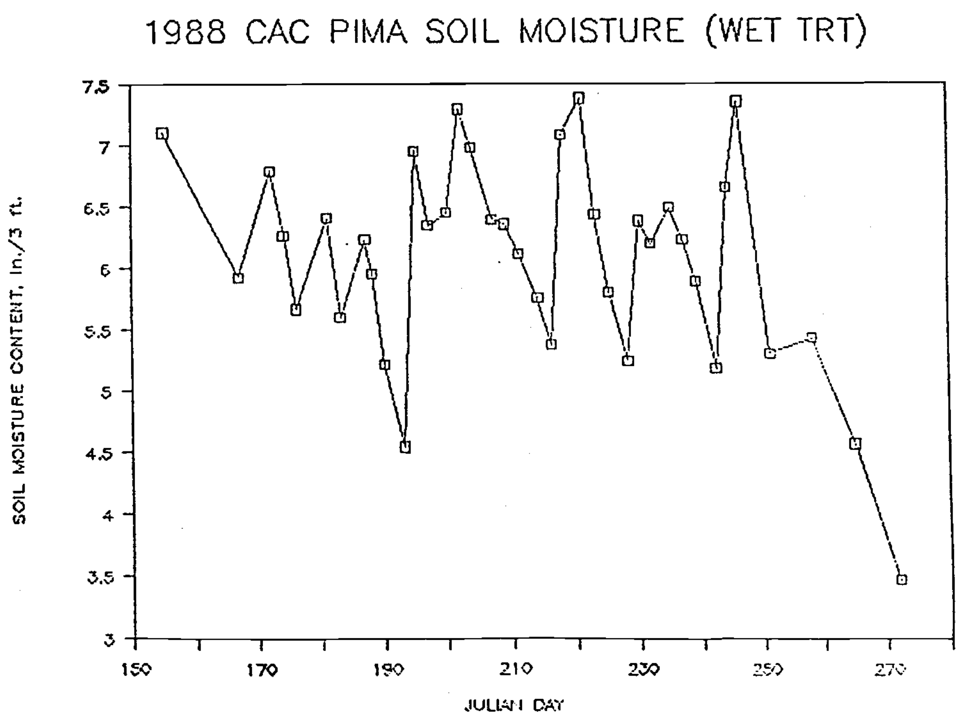
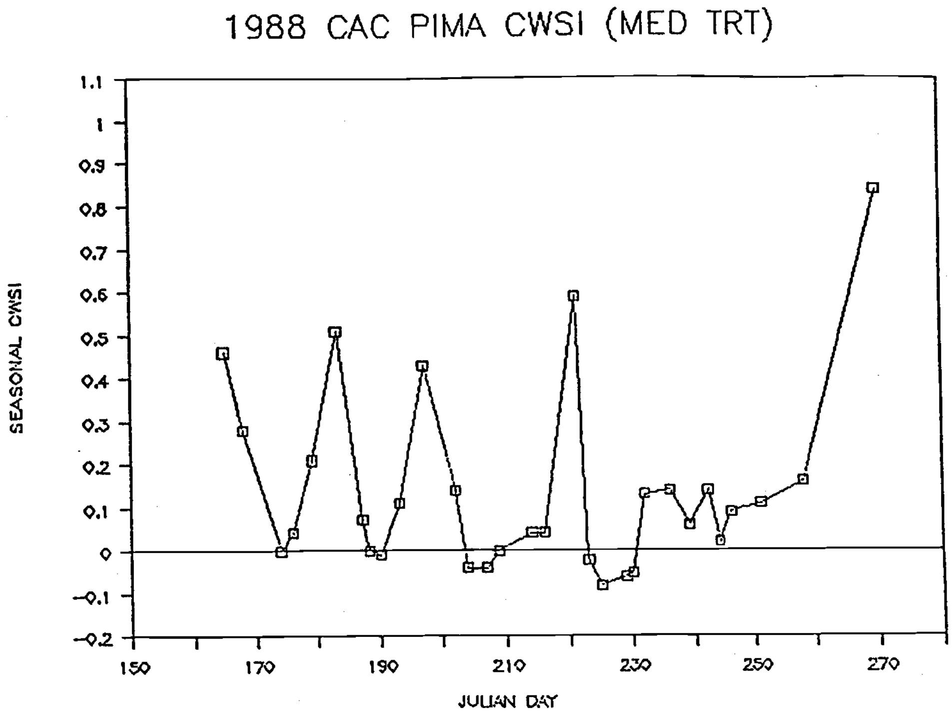

1988 CAC PIMA SOIL MOISTURE (WET TRT)
SOIL MOISTURE CONTENT, In./3 ft.
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
150
170
190
210
230
250
270
JULIAN DAY

Figure 2


1988 CAC PIMA CWSI (MED TRT)
SEASONAL CWSI
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
150
170
190
210
230
250
270
JULIAN DAY

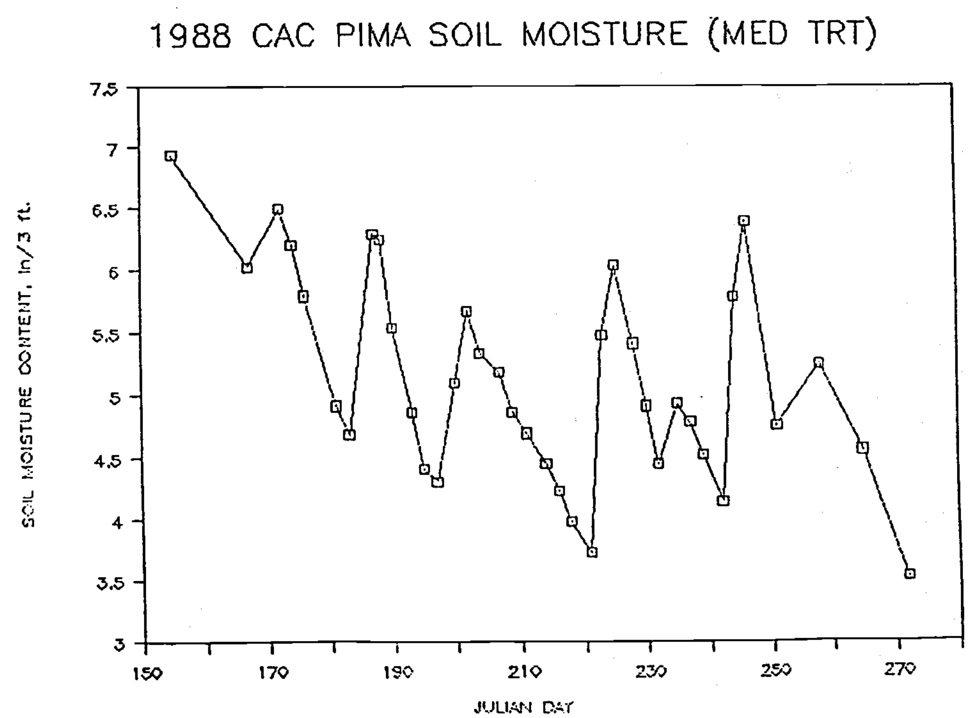
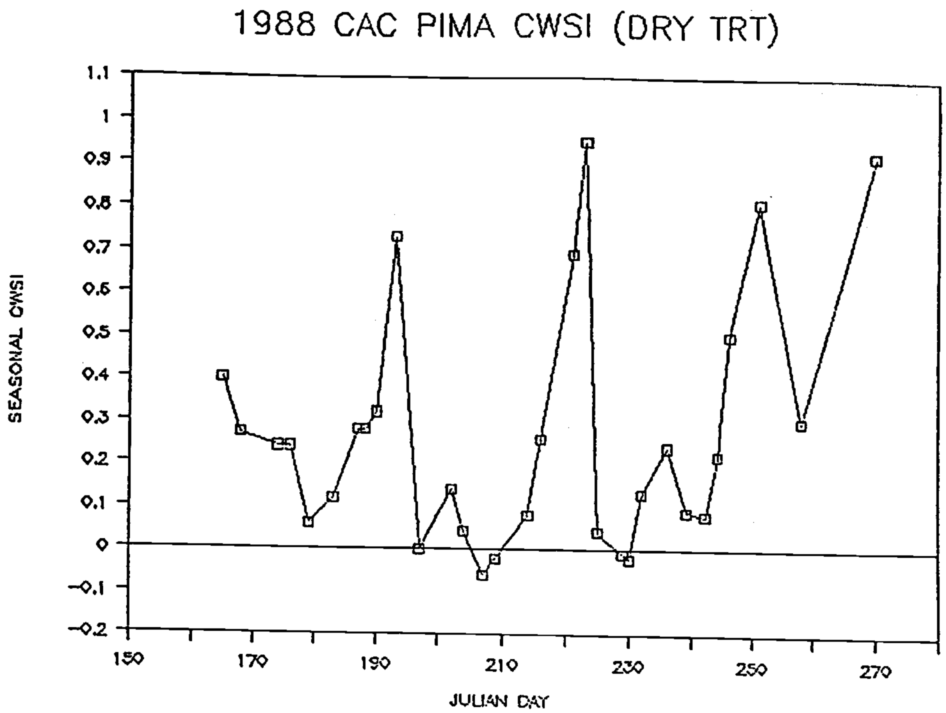
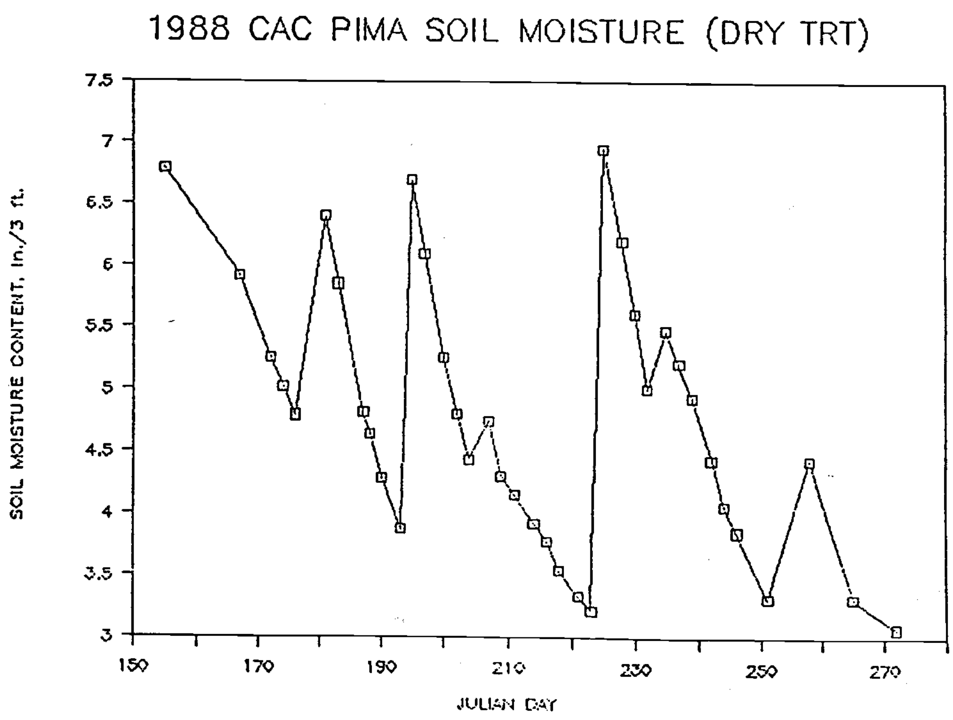

1988 CAC PIMA SOIL MOISTURE (MED TRT)
SOIL MOISTURE CONTENT, in/3 ft.
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
150
170
190
210
230
250
270
JULIAN DAY

Figure 3

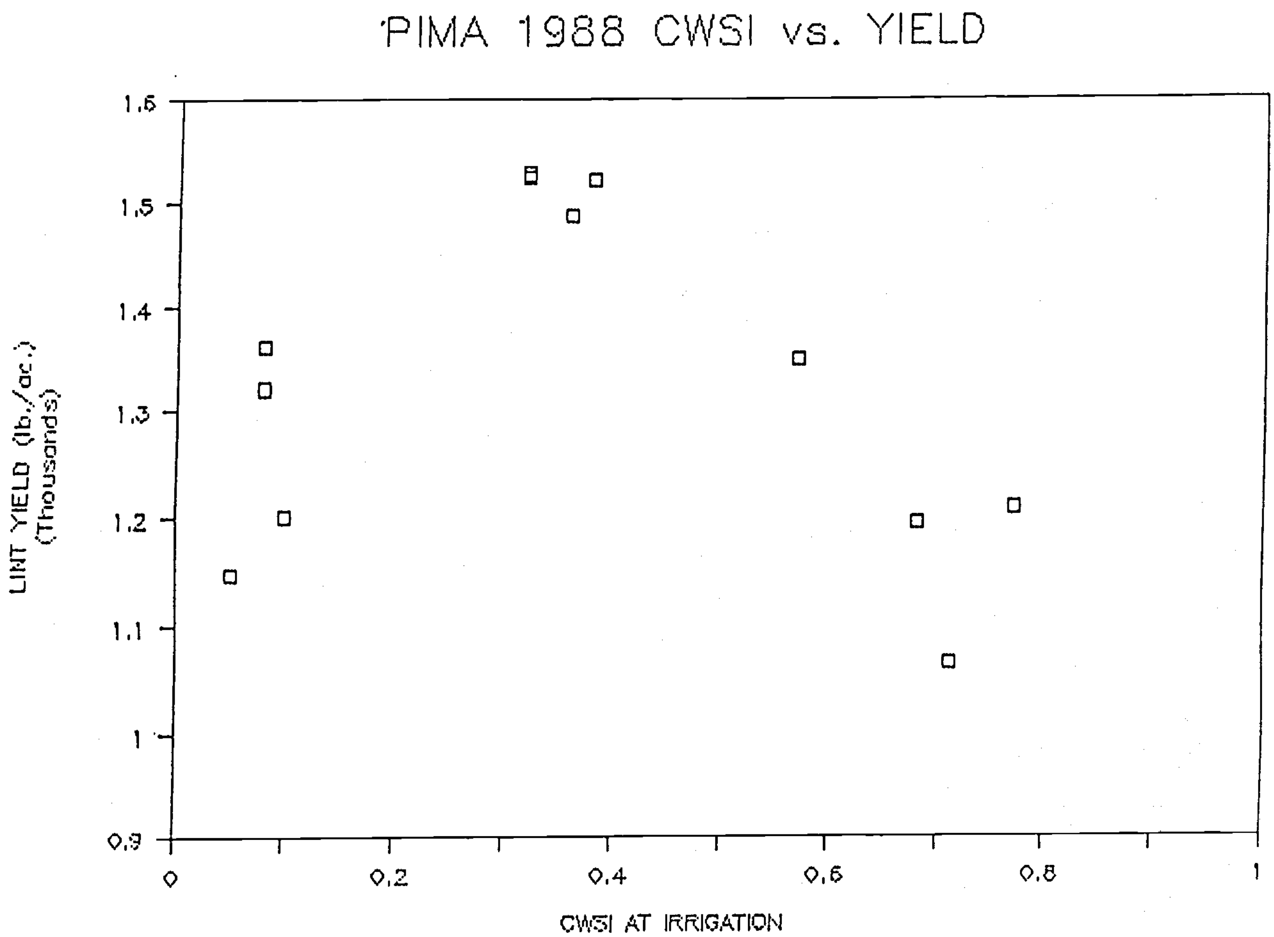


1988 CAC PIMA CWSI (DRY TRT)
SEASONAL CWSI
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
150
170
190
210
230
250
270
JULIAN DAY



1988 CAC PIMA SOIL MOISTURE (DRY TRT)
SOIL MOISTURE CONTENT, in./3 ft.
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
150
170
190
210
230
250
270
JULIAN DAY

Figure 4



PIMA 1988 CWSI vs. YIELD
LINT YIELD (lb./ac.)
(Thousands)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0
0.2
0.4
0.6
0.8
1
CWSI AT IRRIGATION