Scheduling Irrigations on Cotton Based on the Crop Water Stress Index

Donald J. Garrot, Jr., Delmar D. Fangmeier and Stephen H. Husman

Abstract

The Crop Water Stress Index (CWSI) was used to schedule irrigations on drip irrigated cotton research plots in Tucson and on eight acre furrow irrigated fields at the Marana and Maricopa Agricultural Centers. Scheduling irrigations when plots reached 0.30 CWSI units resulted in highest yields with 1403 lbs/acre cotton lint using 33.8 inches of water. The Marana and Maricopa fields yielded 1322 lb/acre on 28 inches and 1767 lb/acre on 58 inches of water, respectively.

Introduction

Typical irrigation scheduling techniques have relied on indirect methods to determine when a crop needs to be irrigated. These methods included soil moisture measurements, estimated evapotranspiration, crop color, crop growth patterns, and fixed schedules. Direct indications of plant water stress have required difficult measurements of leaf water potential, leaf transpiration rates or stomatal resistance.

Recently the U.S. Water Conservation Laboratory in Phoenix developed a promising technique using infrared thermometry. The technique, termed the Crop Water Stress Index (CWSI), uses infrared measurements of crop canopy temperature and the absolute air moisture content (vapor pressure deficit) above the crop. A well-watered nonstressed crop has a CWSI value near zero, while a nontranspiring water stressed crop's CWSI value is near one.

When plots of cotton (DPL 61) in a 1985 drip irrigation test at Maricopa (where plots were irrigated 130% (wet), 100% (medium), and 60% (dry) of Erie's consumptive use value of 41.2 inches every other day) were monitored using the Crop Water Stress Index (CWSI) as an indicator of plant water stress, a highly linear correlation (r=0.997) between the seasonally averaged CWSI and the cotton lint yield by treatment was measured.

A CWSI average value of 0.15 units (wet) correlated to the highest yield of 1545 lb/ac of cotton lint. Higher CWSI average values resulted in lower lint yields where a maximum CWSI average value of 0.26 units for the dry treatment yielded 843 lb/ac of cotton lint.

The linear correlation between seasonally averaged CWSI and lint yields indicated a straight line relationship. However, when the data were plotted, a leveling effect in yield could be observed when CWSI values were lower than 0.15 units.

A similar linear relationship (r=0.991) was also measured in 1985 at Marana on a 10 acre field planted with two different cotton cultivars (DPL 90 and DPL 41). They were scheduled for irrigation with the CWSI and irrigated using a linear move equipped with furrow drop lines and overhead boom-mounted sprayers.

The lowest seasonally averaged CWSI value measured was 0.09 units yielding 1648 lb/ac of cotton lint, and the highest seasonally averaged CWSI value was measured at 0.22 units yielding 1166 lb/ac cotton lint.

To determine if yields leveled off, increased, or decreased at seasonally averaged CWSI values of less than 0.15 units, a drip irrigation test was designed where plots would be scheduled for irrigation using the

Crop Water Stress Index at 0.0 units (wet), 0.15 units (medium), and 0.30 units (dry). Results should indicate the CWSI value at which irrigations should be scheduled to obtain maximum cotton lint yields.

In addition, eight acre bulk cotton fields at Marana and Maricopa were scheduled for irrigation when their CWSI values neared 0.15 units.

MATERIALS AND METHODS

Plots of cotton (Deltapine 90) were planted May 5, 1986 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 0.0 (wet), 0.15 (medium), and 0.30 (dry) units. Plots were irrigated utilizing buried trickle tubing for precision water delivery.

Neutron soil moisture measurements were used to determine the soil moisture deficiency in each plot at each irrigation. The corresponding volume of water was metered onto each plot using volumetric shutoff valves. The CWSI and soil moisture measurements were taken on each plot on the average of three times weekly when skies were clear.

Bulk fields planted April 15 and 17 at the Marana and Maricopa Agricultural Centers were furrow irrigated laser leveled fields having a slight slope (about 0.015%). To obtain high irrigation efficiencies, both fields were irrigated using high furrow flow rates for short periods of time.

At Marana, about 45 gpm/furrow was delivered for 70-90 minutes, which applied about three inches of water over the 600 foot run. At Maricopa, about 90 gpm/furrow was delivered for about 75 minutes, which applied about four inches of water over the 800 foot run. Moisture measurements were taken before each irrigation, while CWSI measurements from the four corners of each field were collected three times weekly.

Four 50-foot rows of each plot were harvested by machine in Tucson on November 6, 1986. The Marana field was picked on October 15 and November 24, 1986 and the Maricopa field was picked on December 4 and 29, 1986.

RESULTS AND DISCUSSION

The effect of CWSI irrigation scheduling on lint yield, total water applied, and number of irrigations scheduled, including the preplant, over the three locations are listed in Table 1. The dry treatment, which had a CWSI at irrigation of 0.30 and a seasonally averaged CWSI of 0.17, had significantly higher lint yields with the lowest water applied and fewest number of irrigations. This correlates well with previous results, which indicated highest yields should be attained at a seasonally averaged CWSI near 0.15 units. Lower seasonally averaged CWSI values did significantly decrease yields and required more applied water and total number of scheduled irrigations. This shows that some crop stress increases lint yields.

Table 1. Effect of CWSI irrigation scheduling on cotton lint yields, total water applied, and number of irrigations at three locations.

Location	TRT	Av. CWSI at Irrigation*	Seasonally Av. CWSI*	Lint Yield* (lb/ac)	Total Water* (in)	# of Irr.
Tucson	Wet	0.10 b	0.06 b	1178 c	48.5 a	22
	Med	0.21 ab	0.10 ab	1290 b	37.4 b	12
	Dry	0.30 a	0.17 a	1403 a	33.8 b	8
Marana	-	0.18	0.09	1322	28.0	10
Maricopa	-	0.21	0.11	1767	58.0	12

**Numbers followed by the same letter are not significantly different at the (.05) level using Waller Duncan K-Ratio T-Test.*

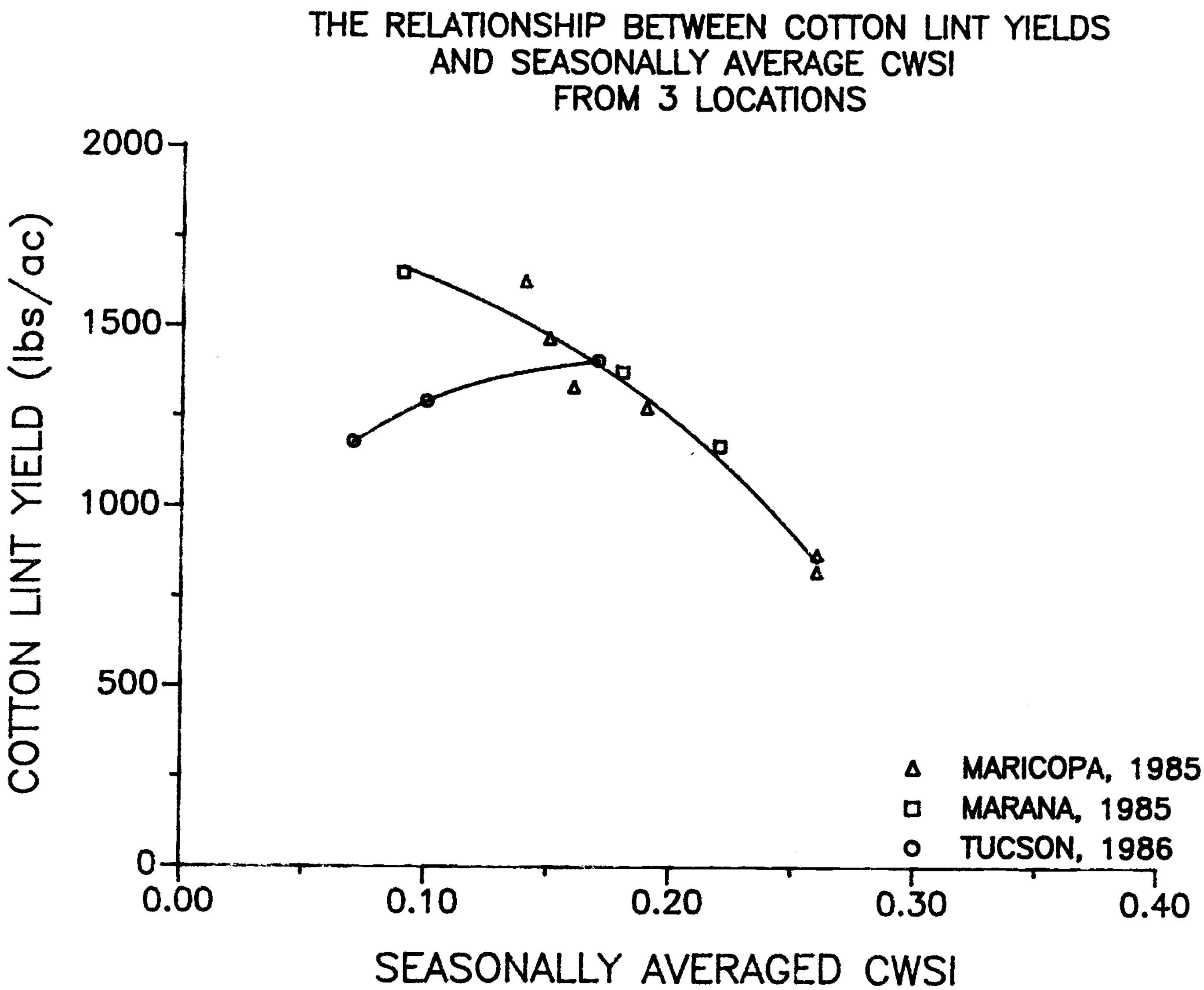
The results indicate that if CWSI irrigation scheduling were to be used on large acreages, fields should be scheduled for irrigation when the CWSI value nears 0.30 units. This value was obtained from same-day trickle irrigations. Since at the grower level there is usually a 2-4 day delay in obtaining water, irrigations should be scheduled below 0.30 units depending on the length of the delay. Cotton begins to show visible wilt at about 0.35 units.

The Marana and Maricopa fields, which were scheduled for irrigation at 0.15 units, actually had average CWSI at irrigation values of 0.18 and 0.21, respectively. These values are very near the same values as the medium treatment in Tucson which resulted in a significant reduction in yield of about 10% from the dry treatment, probably due to overwatering. Although the Marana and Maricopa lint yields of 1322 and 1767 lb/ac are about 450 lbs above county averages, higher yields using less water may be attainable if fields are scheduled at 0.30 units.

Figure 1 is a graphic representation of the relationship of seasonally averaged CWSI and cotton lint yield from the 1985 Maricopa and Marana tests and the 1986 Tucson test. There is a good correlation between the seasonally averaged CWSI and lint yields for both locations and years (Tucson 1986 r=0.97, Maricopa and Marana 1985 r=0.96).

The Tucson 1986 slope is +2137, while the Maricopa and Marana 1985 slope is -5044. The slopes of the two lines indicate that cotton lint yield decreases over twice as rapidly at CWSI values above 0.15 units (underwatered) than at lower CWSI values (overwatered). The results suggest that if optimal irrigation timing can't be met, it is more beneficial yield-wise to over-irrigate DPL 90 rather than to underirrigate.

All three tests will be repeated in 1987.


THE RELATIONSHIP BETWEEN COTTON LINT YIELDS
AND SEASONALLY AVERAGE CWSI
FROM 3 LOCATIONS
COTTON LINT YIELD (lbs/ac)
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
SEASONALLY AVERAGED CWSI
MARICOPA, 1985
MARANA, 1985
TUCSON, 1986