Quantification of Pecan Water Stress For Irrigation Scheduling

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Introduction

When water stress of a plant can be numerically quantified, the relationships among water stress levels, yield, water use efficiency, and product quality can be measured and defined. The relationships can then be used to assist farm managers in irrigation scheduling to achieve optimum production for the amount of water applied. The crop water stress index (CWSI) numerically defines water stress where 0.00 units represents a non-water-stressed condition to 1.00 CWSI units which represents a total water stressed condition (Idso et al., 1981). The CWSI is based on the relationship between the canopy temperature (measured with an infrared thermometer) of a well watered plant in full sunlight and the atmospheric water content. The technique has been successfully used to schedule irrigations of cotton, wheat, pecans, table grapes, and apples at the commercial level in Arizona.

In 1986, University of Arizona extension and research personnel began investigating the use of the CWSI to assist in farm pecan orchard management decisions and to characterize the relationships among varying levels of CWSI irrigation scheduling values, pecan production, water consumption and product quality (Garrot et al., 1987; Garrot et al., 1988; Garrot et al., 1989). This manuscript presents results of the fourth year of the five year study.

Materials and Methods

Sixteen rows of an 80 acre pecan orchard planted in 1967 on 15 X 30 foot spacings, thinned to 30 X 60 foot spacings in 1986, and thinned to an average 40 X 60 foot spacings in 1988 containing from 15 to 28 'Western Schley' trees per row was used as a test site. The sixteen rows were randomized into four replicates of four irrigation scheduling treatments throughout the field. Three of the four treatments were scheduled for irrigations at CWSI values representing little to moderate water stress, while the fourth treatment was irrigated following standard grower practices and monitored with the CWSI. All other cultural aspects were in accordance with standard grower practices.

Two sites, about one-third of the way from each end of the field were used for infrared measurements in each plot. Infrared measurements were taken with an Everest Interscience Inc. Model 112 infrared thermometer with a 15 degree field of view. The average of two readings taken from ground level looking up to the northeast and northwest on the sunlit side (south exposure) at both sites of each row were used to calculate the CWSI to schedule irrigations. CWSI measurements were collected on the average of twice weekly, between 1100 and 1500 hours (MST), and only when skies were clear. Atmospheric moisture status (vapor pressure deficit, VPD) was measured in full sunlight about 6 feet above ground level between rows with an aspirated psychrometer at 15 minute intervals. An applied CWSI baseline with a slope of 0.50 (kPa) and intercept of -0.86 with an upper limit of 4.0 degrees C was used to calculate the CWSI (Garrot et al., 1988).

All plots were machine harvested by the grower on January 9, 1990. Three subsamples (one pound each) of each row were analyzed for nut quality by the grower. CWSI irrigation scheduling values, pecan yields, water applied, water use efficiency (WUE), number of irrigations applied, % growth increase, yield efficiency (pounds per square inch), % leaf nitrogen (dry weight), nuts per pound, % saleable kernel, and % inedibles were measured for each plot and reported.

Results and Discussion

The relationships among different CWSI irrigation scheduling values, pecan yield, water applied, WUE, and total number of irrigations required are presented in Table 1. Highest yield was attained by the grower (G) at an average CWSI at irrigation of 0.14 units. The wet (W) treatment also averaged 0.14 units at irrigation, but yielded less and required more water than the grower treatment. We believe moderately reduced yields in the wet treatment were due to moderately overwatering, which also had been shown to reduce yields previously (Garrot et al., 1988). Water use of the grower treatment, which had the highest yield, was 60 inches, which closely matches the use measured in 1986 (56 inches) and 1987 (54 inches). However, in 1988, which was a very hot year, highest yields required 78 inches of water. Results from four years of this study indicate that to attain highest yields, water use of the same pecan orchard can vary 44% depending on environmental conditions encountered. Increasing CWSI and water stress lowered yields, although WUE increased with higher stress. As in prior years, even moderate overwatering or CWSI above 0.14 units has decreased pecan yields (Garrot et al., 1988; Garrot et al., 1989).

Highest CWSI values significantly reduced % increase in growth and nuts per pound as in previous years of this study (Table 2). Nuts from the 0.41 CWSI treatment are about 25% smaller than both the wet and grower treatment (0.14). The lack of difference in the nuts per pound between the wet and the grower indicates moderate overwatering does not affect nut size as drastically as moderate underwatering of the medium treatment (M) at 0.28 units. As in prior years of this study, the range of water stress induced had no significant effect on nut quality (Table 3).

Summary

The crop water stress index has been a viable tool to measure the effects of water stress on pecan production and quality. Highest yields are attained when irrigations are scheduled when the CWSI nears 0.14 units. Increasing water stress even moderately (CWSI = 0.28) reduces pecan yields, pecan size, and tree growth, although water use efficiency increases. The range of water stress induced in this test did not affect pecan quality. The four years of results show that to achieve highest yields, size, and growth, water use of the same orchard can vary 44% depending on the climate. The University of Arizona will continue its efforts to better define the relationships among pecan yields and quality and irrigation scheduling with the crop water stress index.

Literature Cited

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Table 1. Effect of CWSI irrigation scheduling on pecan yields, total water applied, WUE and total number of irrigations required in 1989.

Trt	CWSI*	lb/ac	lb/tree	Water applied	WUE lb/ac/in	Total # irr
W	0.14 c	1023.5	56.40	65	15.7	13
M	0.28 b	928.7	51.17	40	23.2	8
D	0.41 a	945.7	52.10	35	27.0	7
G	0.14 c	1200.5	66.15	60	20.0	12

*Means followed by different letters are significantly different at the 0.05 level.

Table 2. Effect of CWSI scheduling on % increase in growth, yield efficiency, % leaf nitrogen, and number of nuts per pound in 1989.

Trt	CWSI*	% Growth increase	Yield Efficiency (lbs/in^2)	% N dry wt.	Nuts/lb.**
W	0.14 c	4.92 A	0.29	2.3	66.5 C
M	0.28 b	2.96 B	0.28	2.3	71.3 B
D	0.41 a	3.12 B	0.29	2.4	76.2 A
G	0.14 c	4.50 A	0.34	2.3	66.0 C

* Means followed by different letters are significantly different at the 0.05 level.
** Means follows by different letters are significantly different at the 0.01 level.

Table 3. The effect of CWSI irrigation scheduling on overall nut quality in 1989.

Trt	CWSI*	% Good	% Amber	% Saleable kernel	Inedible
W	0.14 c	50.0	2.20	52.2	4.5
M	0.28 b	50.1	3.25	53.4	2.7
D	0.41 a	51.3	2.40	53.7	2.6
G	0.14 c	49.7	3.15	52.8	3.8

Means followed by different letters are significantly different at the 0.05 level.