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TENSIOMETERS FOR IRRIGATION SCHEDULING IN A FLORIDA CITRUS GROVE

JACK CREIGHTON
U.S. Department of Agriculture
Soil Conservation Service
517-A 8th Avenue West, Palmetto, FL 34221

DAVID A. SLEEPER AND CALVIN HUBBARD
U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 638, Wauchula, FL 33873

Additional Index Words. irrigation water management, trickle irrigation.

Abstract. **Many growers have expressed distrust in the use of tensiometers for irrigation scheduling in citrus [Citrus sinensis (L.) Osb.] groves. Our observations, however, show that tensiometers are reliable indicators of soil moisture conditions within the citrus root zone and are an accurate method for scheduling irrigation. Observations were made at six tensiometers stations on an eight year old orange grove with a spray emitter type trickle irrigation system and a uniform soil type. Six, eighteen and thirty-six inch (15, 46 and 91cm, respectively) length tensiometers were used. With few exceptions, the tensiometer data from all six stations revealed similar information. Under the conditions found at this grove, the 6 inch depth tensiometer provided the best information for irrigation scheduling. It was necessary to have tensiometers both inside and outside the wetted area of the irrigation system in order to assess the effects of rainfall.**

Funding for this project was provided by the Southwest Florida Water Management District. The authors wish to express appreciation to Larry and Bruce Durrance of Bowling Green for their cooperation in supplying the grove which made this study possible.

The two key questions about irrigation which every grower must answer are: "When is it time to start irrigation?" and "When is it time to stop irrigation?" These are difficult questions to answer in a precise way. Crop water budgets, evapotranspiration estimates and other scheduling methods are good planning tools which give the growers valuable information. However, these methods fail to give clues as to whether the schedule is working or not and rely on the grower being able to recognize when adjustments need to be made.

Citrus growers need a more precise way of determining when to start and stop their irrigation systems. The ethics and economics of water conservation convince most growers that over-irrigating is not desirable. On the other hand, the purpose of having supplemental irrigation is to ensure good yields by applying sufficient water to the crop when needed.

Soil moisture availability has been a common way of assessing the crop water status in many crops for many years. Several reliable scientific tools exist to measure soil moisture (2), however, many require a high degree of skill to operate and are time consuming to set up and read. In addition, some of these tools cost many hundreds and even *thousands of* dollars and are thus too expensive for most growers. To satisfy the criteria of being reliable, inexpensive and easy to use, our list of tools then consisted of tensiometers and electrical resistance/gypsum blocks.

Our limited experience with gypsum blocks over the past two years on both flatwoods and low knoll transitional sites (which are transitional between flatwoods and ridge citrus sites) showed that in sandy soils these instruments did not respond in the range of soil moisture content needed for crop production. Therefore, we confined our investigation to tensiometers.

Although tensiometers have been around for many years, to the best of our knowledge, very few Florida citrus growers use tensiometers to assist in irrigation scheduling. Many citrus growers are suspicious of the reliability of tensiometers. We are not able to determine from our talks with growers whether the problem in using tensiometers was with the instrument itself, the specific site conditions, or with the techniques used to install and maintain the tensiometers. Clearly, many of those who had tried tensiometers had a negative opinion about their usefulness.

Our main objective in this study was to assess whether tensiometers are reliable, practical tools which provide useful irrigation scheduling information in a Florida citrus grove. In order to meet our main objective, we first had to answer a few simple but specific questions. What do the tensiometers read before and after an irrigation? What depth should the tensiometers be set at in order to get an overall picture of the available soil moisture in the root zone? Should tensiometers be placed inside and outside the wetted area? And how consistent are tensiometers from one station to another?

Materials and Methods

A trial site was selected in the summer of 1987. The site selection criteria were many. Of major importance was to find a site with a uniform soil, trees of uniform growth and of bearing age, and a spray emitter type trickle irrigation system which was well designed and carefully installed and maintained. In addition, the site selected was to be owned and managed by a person respected by his peers as a knowledgeable irrigator. The grove selected was in southern Polk county, a major citrus producing area.

The grove occupied 20 acres and was 8 years old during the time the observations were made. The tree spacing was 15 ft by 27 ft with 108 trees per acre. Within the rows the tree canopies were touching and had formed a hedgerow. The trees were the early season cultivar 'Hamlin' on bittersweet (C. aurantium L.) rootstock. Auger borings at the site showed that the active root zone ranged from 28 to 33 inches from the surface.

The irrigation system was designed and installed according to the U.S. Dept. Agr. Soil Conservation Service (SCS) standards and specifications. The irrigation system was established prior to the trees being planted and fertigation was practiced since the trees were initially set out.

The spray emitters were of one piece construction with a 360 degree spray pattern. The emitters were set on twelve inch risers which were set directly in the polyethylene lateral lines. The laterals were parallel with the tree row, on top of the ground and were within a foot of the tree trunk. Emitters were spaced one per tree and were offset four feet from the tree trunk. The emitters had a discharge rate of 8.4 gallons per hour (gph) with a standard deviation of 0.9 gph at 15 pounds per square inch pressure. The spray pattern of the emitters covered a diameter of 10 feet.

The soil was identified as a Zolfo fine sand (f.s.) (Sandy, siliceous, hyperthermic grossarenic Entic Haplohumod) and was very uniform throughout the grove. Zolfo f.s. is commonly found in the flatwoods ecological community. Zolfo f.s. usually occurs on low knolls within the flatwoods and therefore occupies a slightly higher position on the landscape than other flatwoods soils. The site was moderately well drained and the seasonal high water table was not expected to be within 36 to 42 inches from the surface at the wettest season. A 30% depletion of the available soil moisture as recommended by Smajstrla et al. (3) was chosen as the starting point for the irrigation cycles. Soil characterization data used to calculate the available waterholding capacity and the tension at which 30% depletion would occur was obtained from published characterization data (1).

Six stations were selected within the grove for tensiometer installation. Each station consisted of two sets of six, eighteen and thirty-six inch tensiometers. One set was located inside and the other outside the emitter's wetted area (Fig. 1). The tensiometers were prepared and installed according to the manufacturer's procedures during the summer of 1987. The tensiometers were located under the tree canopy three feet from the tree trunk and in line with the tree row. Those tensiometers inside the wetted area were located one foot away from the emitter.

The tensiometers used were commercially obtained. Vacuum gauges were selected which had a set screw allowing all tensiometers, regardless of length of tube, to be set to zero. This was important in order to eliminate erroneous readings produced by height of the column of water in the different lengths of tube. Water levels in the tensiometers were replenished as needed throughout the trial.

The date and amount of rainfall were recorded from a rain gauge at the site each time the tensiometers were read. A record of dates and duration of irrigations was kept by the grower and confirmed by a flow meter.

Data were collected daily from 3 September to 21 October 1987 (49 days) except for weekends. From 21 October 1987 to 8 March 1988, readings were taken infrequently. Readings were intensively taken again during the spring from 8 March to 13 April 1988 (37 days). It was felt that frequent readings were necessary because of the

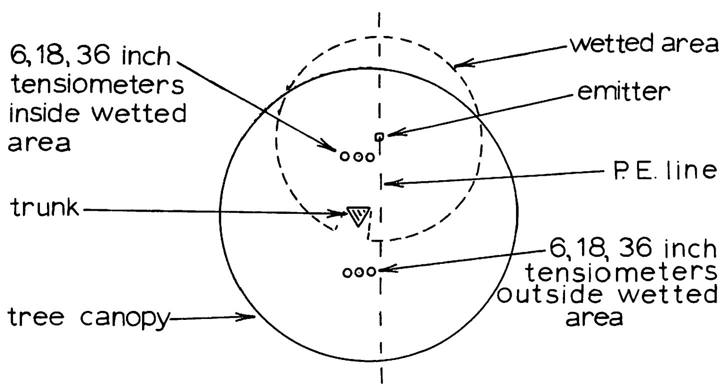

Fig. 1. Tensiometer locations.

rapidly changing soil moisture conditions and the frequent shallow irrigations. All readings were taken in the early afternoon. The spring and fall data sets were very similar but more irrigation events took place during the spring and therefore the spring data are presented in this paper.

Results and Discussion

Tensiometers were found to be very responsive to changing soil moisture conditions. The effect of rainfall on the tensiometer readings during the first 14 days of the observation period is shown in Figure 2. As the rain infiltrated the soil, the soil moisture increased and the tensiometer readings decreased. After day 14, without rainfall to replace moisture used by the crop, the 6 and 18 inch tensiometers showed the gradual depletion of soil moisture. The 36 inch tensiometers showed a relatively constant soil moisture (never exceeded 14 centibars). The 36 inch tensiometers were just below the root zone and therefore these tensiometers may not reflect direct soil moisture extraction. In addition, the capillary redistribution of soil water from deeper depths appears to have been occurring.

The tensiometers showed a much different pattern of soil moisture extraction inside the wetted area (Fig. 3). After day 14, when rainfall ceased, the irrigation cycles began. The tensiometers inside the wetted area reflected removal by evapotranspiration and replacement by irrigation.

The shallower tensiometer showed a more rapid rate of soil moisture depletion than the deeper tensiometers (Figs. 2 and 3). The difference in soil moisture removal rate is most apparent outside the wetted area during dry periods when the tensiometer readings at the three different depths became widely separated (Fig. 2). Outside the wetted area the 36 inch tensiometers did not reflect any soil moisture depletion. Direct measurements of the water table were not made during this study, however, the data is consistent with the expected upward flux from a water table approximately 70 inches from the surface.

During the spring phase of the trial it was decided that irrigation was to be based on the tensiometer readings. Currently, irrigation management practices from the Florida Institution of Food and Agricultural Sciences define the spring flowering and fruit set period as a critical

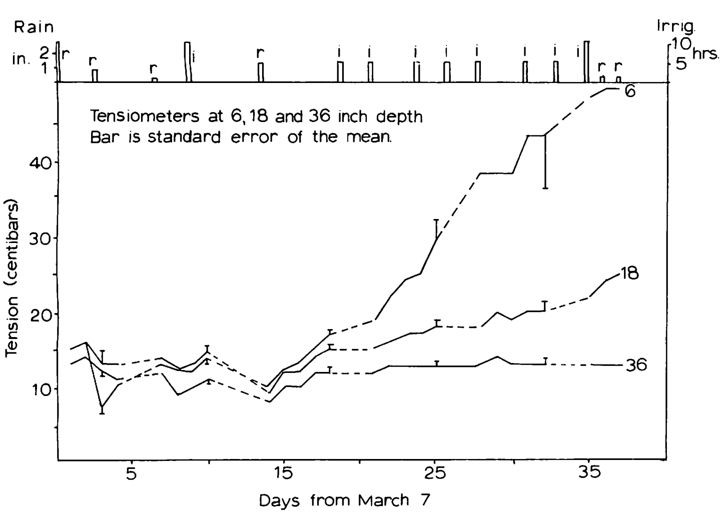

Fig. 2. Average tensiometer readings outside the wetted area.

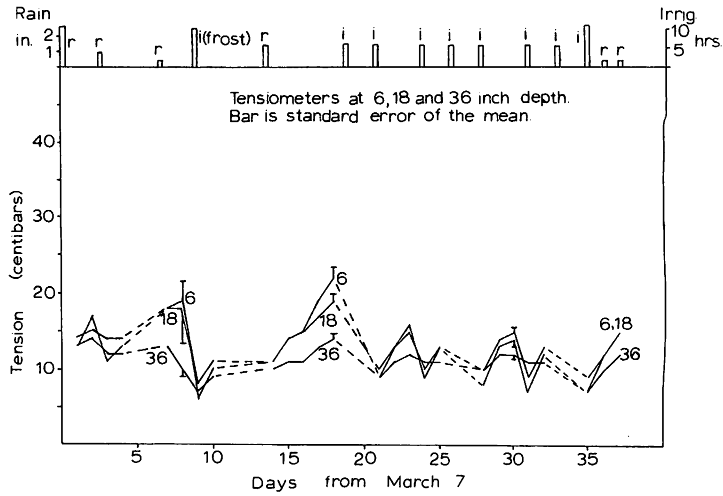

Fig. 3. Average tensiometer readings inside the wetted area.

time in which to avoid crop moisture stress (3). Soil moisture is generally not allowed to be depleted as much in the spring as during other times of the year. A 30% depletion level of the available soil moisture was used in this study. Based on the soil moisture characterization data from the University of Florida Soil Characterization Laboratory (1), the available soil moisture in a Zolfo fine sand would be 30% depleted when the tensiometer readings reached 15 centibars.

Moisture was depleted by the trees after rainfall or irrigation (Figs. 2 and 3, respectively). Since the 6 inch depth was the first to be depleted, it was chosen to be an indicator of when to irrigate. The choice of using the depth was also based on observing that in the fall period, the level of moisture at this depth generally corresponded to the growers decisions as to when to irrigate. In the spring, the trees responded well and showed no visible signs of stress when irrigations were started when the 6 inch tensiometers read 15 centibars.

In spray emitter systems, where water and fertilizer are applied to a relatively small area, roots may proliferate and dry this area at a faster rate than outside the wetted area. The tensiometer readings inside the wetted area may indicate irrigation is needed while tensiometers outside the wetted area may show moisture is readily available (Fig. 4,

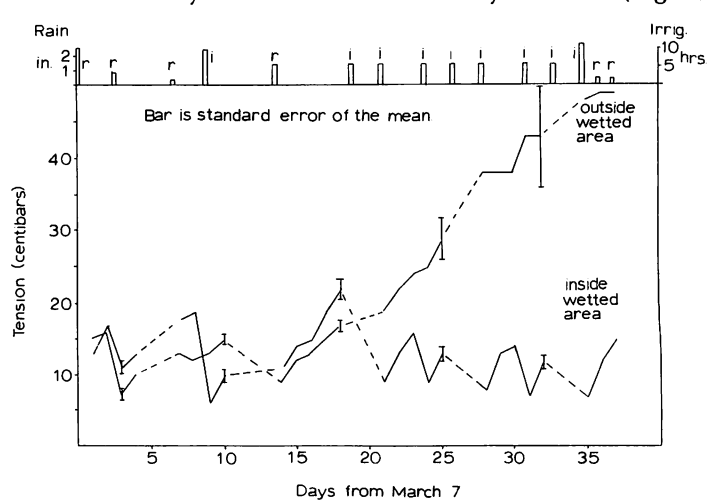

Fig. 4. Average tensiometer readings at the 6 inch depth outside and inside the wetted area.

days 17 and 18). Therefore, tensiometers are also useful outside the wetted area. With tensiometers inside and outside the wetted area it becomes a management decision whether low tensiometer readings outside the wetted area will delay irrigation. During the dry period of this study, after the 6 inch tensiometers inside the wetted area exceeded 15 centibars, the 6 inch tensiometers inside the wetted area were used for scheduling. These tensiometers responded to the replacement of water by the irrigation system (Fig. 4). The 6 inch tensiometers outside the wetted area continued to dry and were not affected by irrigation.

Once the decision was made to irrigate, the grower irrigated for ten hours. After ten hours of irrigation, the thirty-six inch tensiometers inside the wetted area responded showing that some irrigation water had reached this depth (Fig. 3). Since the root depth was approximately 30 inches, the duration of operation needed to be decreased until water no longer moved below the root zone. Five hour irrigation durations were tried from day 20 of the spring observation time. In practice, the tensiometers could be used to determine the length of time to operate the system. However, careful observations over a number of irrigations would be needed. Our present study ended before the five hour operating time could be verified for this irrigation system.

In this study, tensiometers were consistent from site to site. The only exception was that over extended periods of no rainfall, 6 inch tensiometer readings outside the wetted area diverged (Figs. 2 and 4). This site was specifically chosen for uniform soil, tree size and irrigation. Other sites, where those characteristics vary, may have a greater variation in soil moisture and therefore tensiometer station locations will have to be selected based on additional criteria. In groves with more than one soil type or soil moisture condition the tensiometer locations may be determined by which area of the grove has the greatest economic return. This may or may not be the section with the largest field area.

Summary

1. Tensiometers always responded to changes in soil moisture regardless of whether water was added by irrigation or rainfall or whether water was removed by the crop.
2. The shallow tensiometers reflected a more rapid moisture extraction, particularly outside the wetted area where prolonged moisture depletion occurred.
3. At this site, 6 inch tensiometers were the best indicators of available moisture in the root zone and therefore could be used for scheduling on sites similar to the study site.
4. Tensiometers are useful both inside and outside the wetted area where the irrigation system applies water to a small portion of the field area.
5. Tensiometers below the root zone can indicate when excess water has been applied. Also, if the tensiometers below the root zone start drying a larger irrigation or shorter duration is needed.
6. Tensiometer stations can be placed so as to represent the irrigation needs of the grove, however, many site specific factors influence the number of tensiometer stations needed. Knowledge of the grove and the irrigation system are needed along with a well thought out irrigation water management strategy in order to adequately irrigate the crop while getting the best use from the irrigation water.
7. Tensiometers may not be the appropriate tool for all soil types, however, our experience indicates they deserve wider use in the Florida citrus industry particularly on sandy textured soils.

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Proc. Fla. State Hort. Soc. 102:72-75. 1989.

THE TEXAS CITRUS INDUSTRY—1989

JULIAN W. SAULS AND ROBERT E. ROUSE
The Texas A&M University System
Agricultural Research and Extension Center
2401 East Highway 83
Weslaco, TX 78596

Abstract. **The Texas citrus industry presently stands at 34,400 acres, which is almost half that which existed prior to the Christmas freeze of 1983. Recovery of lost acreage has been slower than anticipated, partly because of the removal of an additional 8,700 acres of trees that were initially undergoing freeze rehabilitation. Approximately 36% (12,300 acres) of present acreage has been planted since the freeze, leaving about 22,100 acres that survived the freeze.**

Overall tree density has increased to about 129 trees per acre, primarily because orchards established since the freeze are being planted at about 151 trees per acre. Grapefruit production in the 1988-89 season reached 46% of pre-freeze levels, but orange production was only 33% of previous levels. However, higher prices have resulted in a total industry value of $85.7 million, which is comparable to previous values of the Texas crop.

Approximately 4,000 acres of 'Rio Red' grapefruit have been planted, representing nearly 60% of all new grapefruit plantings and 20% of total grapefruit acreage. Approximately 60% of new orange orchards are 'Marrs' and other early varieties; 28% are navels and 12% are 'Valencia'. The ratio of acreage of grapefruit to oranges has steadily declined from 65:35 pre-freeze to 59:41 presently.