DIURNAL LEAF WATER POTENTIAL FOR VARIOUS WATER SUPPLY AMOUNTS

R.M. Seymour, Kater Hake, W.M. Lyle and M.H. Stutler
Texas A&M University
Lubbock , TX

Abstract

Data from the first year of a 3 year project to look at the use of leaf water potential as an irrigation scheduling device are presented and discussed. The study is directed at irrigation scheduling with limited water supply.

Introduction

Using the xylem pressure potential of a plant or leaf water potential (LWP) to schedule irrigations has been a method recommended by several cotton agronomists (Browne 1987, Johnson and Kerby 1988, Grimes and Cantrell 1980). Grimes et al. (1987) and Stegman et al. (1976) conducted studies to establish the differential in LWP associated with climatic parameters, and normalized cotton LWPs according to climatic conditions. Meron et al. (1987) and Turner and Long (1980) looked at the procedures for taking the LWP in the field.

Use of LWP for irrigation scheduling usually assumes an adequate water supply for applying peak water use amounts for cotton. However, in the High Plains of Texas, cotton must be deficit irrigated due to water supply limitations. Pre-season and early season irrigations fill the rootzone to provide some compensation for the water supply limitations. Another irrigation technique which improves the water use efficiency of limited water supply is frequent, light irrigations with irrigation equipment that has high efficiency of application. Studies of LWP measurement as an irrigation scheduling tool for high frequency, deficit irrigation regime are limited and have not looked directly at the effects of limited water supply on long term LWP. This paper will look at some preliminary data measuring LWP for a high frequency, deficit irrigation situation on two soil types in the Texas High Plains.

LWP is used for scheduling irrigations by taking the daily minimum LWP watching for a critical value to be reached. When that critical value is reached, an irrigation is applied. Using relationships of LWP with climatic factors the time to reach the critical value can be estimated ahead so that advanced scheduling is possible. However, fields that have been irrigated with limited water at set frequencies may have a different critical value for triggering an irrigation than a field with adequate water supply. The purpose of this study will be to develop LWP measurement as a useful alternative irrigation scheduling tool for high frequency deficit irrigation, and to determine whether the LWP measurements should be interpreted differently for such an irrigation regime.

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Materials and Methods

A diurnal set of leaf water potentials of cotton plants was measured at two locations in the High Plains of Texas for several treatments of irrigation supply amounts. A pressure chamber was used to measure cut leaf water potential. Leaf potential readings from four leaves for each water supply amount were taken approximately hourly.

The two locations were chosen for their difference in soil type. The AgCARES site had an Amarillo fine, sandy loam while the Halfway site had a clay soil. Diurnal readings were taken at the AgCARES site on August 9, 1996, and the Halfway readings were taken 5 days later on August 14, 1995.

Irrigation amounts were controlled by a slightly different protocol at each location. At the AgCARES site irrigations were applied at regular intervals throughout the growing season once the first irrigation began in late June unless there was significant rainfall to make irrigation unnecessary for a particular interval. A center pivot irrigated this site every 3.5 days from mid-June through late August. Water requirement was based on a modified Penman calculation of evapotranspiration (ET) less any rainfall measured on the site. The center pivot had sections of outlets along the mainline where flow was reduced to simulate limited water supplies. Pivot movement was set to water 1.25, 1.0, 0.75, 0.5 and 0.25 of the water requirement calculated for the crop.

The Halfway site was watered using a linear move irrigation system that also could be set up to apply varying amounts of water in plots. The plots used for this study were watered at a constant interval of 3 days throughout the growing season with water amount limits of 0.1, 0.2 and 0.3 inches/day. The 0.1, 0.2 and 0.3 inches/day limitations correspond approximately to 1.2, .8 and .4 of the estimated water requirements. The different irrigation amounts represented different limitations on water supply availability.

The four leaf water potential readings taken each hour for each water supply amount were averaged, and diurnal readings for the different water supply amounts were compared.

Results and Discussion

Figures 1 and 2 show the diurnal readings taken at the AGCARES and Halfway sites, respectively. Comparing these two graphs there are some obvious differences found at the two locations. Probably the foremost differences are a difference in the beginning LWP first thing in the morning and the magnitude of the LWP at the two sites. Initial LWP were lower at the AgCARES site than at the Halfway site, and the LWP ranged from a maximum of -7.7 bars to a minimum of -26 while the Halfway site readings ranged from -10 to -27.5. Maximum day and minimum night temperatures were less than 3 degrees F different for the two days the readings were taken. Growth stage and fruit load differences at the two sites may have had an effect on the plants ability to recover, but AgCARES had more of a fruit load and was further in its growth stage in general than similar water availability treatments at Halfway. This would suggest that the AgCARES' LWP would be lower, but in fact the contrary occurred and the Halfway data was more negative in general.

Difference in recovery LWP early in the day may have resulted from differences in soil moisture contents at the two sites. Data on soil moisture was not available for the AgCARES site so a comparison of this parameter could not be made.

Because more water is held at the same soil moisture potential for a clay soil than a sandy soil, the lower initial LWP of the Halfway site is most likely indicative of a lower soil moisture potential does not necessarily represent less soil moisture availability. Hence, it is important to consider the soil type and its soil moisture characteristic (relationship of moisture to pressure potential in the soil) in looking at the LWP in a given field. The minimum values of both locations were relatively close which means this value is probably more related to the limitations on resistance of liquid flow between plants and the soil.

The shape of the diurnal curves for all of the water availability treatments are similar. They all have the classic shape of a diurnal curve that is highest before sunrise then hits a minimum LWP during the mid-afternoon and later in the day begins to rise. There are notable differences in diurnal curves of the various water supply amounts. Keeping in mind that all of the treatments at each site had been watered at the same time and the same number of times, but with different amounts of water. There is a definite trend that the lower the water amount available the more negative the diurnal curve as a whole.

Table 1 gives some average numbers that show differences in LWP readings among water supply levels for the Ag CARES site. Average minimum LWP and average maximum LWP for each of the water supply levels were highest for the 1.25WR (1.25 of the estimated water requirement) treatment. While the 0.25WR had thelowest values for all the diurnal readings throughout the day. The lower readings of the 0.25WR indicate either lower soil water potential or greater resistance of flow between the soil and plants or a combination of these factors. The indications of this initial data are that the degree of deficit water availability a field has can influence the LWP as much if not more than differences in temperatures or the vapor pressure deficit.

These results suggest that it is important to know the available water supply and watering history of a crop when evaluating the meaning of a particular LWP. In most cases, where the LWP is being used for irrigation scheduling this will be the case, but if the LWP is being used for something besides irrigation scheduling the LWP must be interpreted in light of the water history or soil moisture potential at least. Also, when LWP is used for determining the time to terminate irrigation to finish out a cropping season, the LWP value for termination will most likely be different for different water supply availability situations. This question needs to be evaluated as the present study continues.

The Halfway site data did not have near the variation between water supply treatments. The clay soil at the Halfway site may be one reason for the similarities of data from different water supply treatments. Because clay soils have higher water holding capacities, the available waterof different treatments would be more similar for the different water supply treatments. Additionally, because all plots had received some rainfall during the season, the rainfall would minimize soil moisture differences between treatments. Table 2 summarizes the data from the Halfway site diurnal readings.

Conclusions

The results of this first year of data show a definite trend of diurnal readings to be strongly influenced by the irrigation amounts and water availability with high frequency deficit irrigation. Studies will be continued to more completely and accurately determine the effects of irrigation timing and amounts particularly high frequency irrigation for future use of LWP as a tool for making irrigation decisions.

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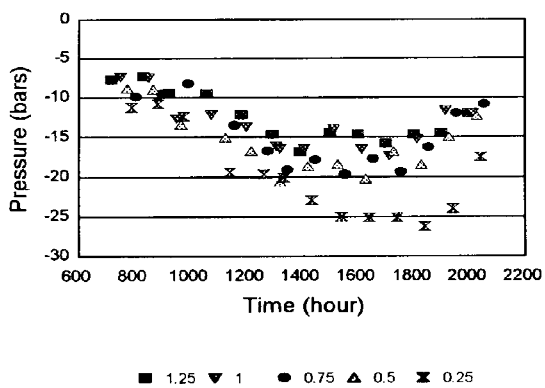

Figure 1. Diurnal LWP averages for 5 water supply limitations for the AgCARES site.

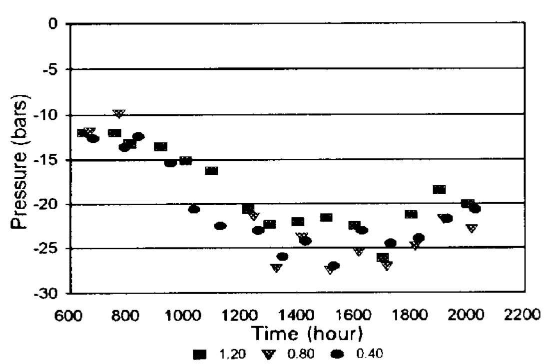

Figure 2. Diurnal LWP averages for 3 water supply limitations for the Halfway site.

Table 1. LWP maximum and minimum average readings and average of all readings taken from 1200 to 1700 hours for various water supply treatments for the AgCARES site.

Water Supply Treatment	Average of Maximum LWP(bars)	Average of Minimum LWP(bars)	Average of Readings 1200-1700 (bars)	Average of Readings 1700-2000 (bars)
1.25WR	-15.88	-7.33	-14.6	-14.3
1.00WR	-17.43	-7.40	-15.4	
0.75WR	-19.38	-8.23	-18.3	-14.6
0.50WR	-20.68	-8.86	-19.0	-15.7
0.25WR	-26.25	-10.77	-22.6	-23.2

Table 2. LWP maximum and minimum average readings and average of all readings taken from 1200 to 1700 hours for various water supply treatments for the Halfway site.

Water Supply Treatment	Average of Maximum LWP(bars)	Average of Minimum LWP(bars)	Average of Readings 1200-1700 (bars)	Average of Readings 1700-2000 (bars)
1.20WR	-26.1	-8.6	-21.8	-21.5
0.80WR	-27.5	-9.9	-25.1	-24.2
0.40WR	-27.0	-12.6	-25.2	-22.7