Cotton growth related to plant's water status

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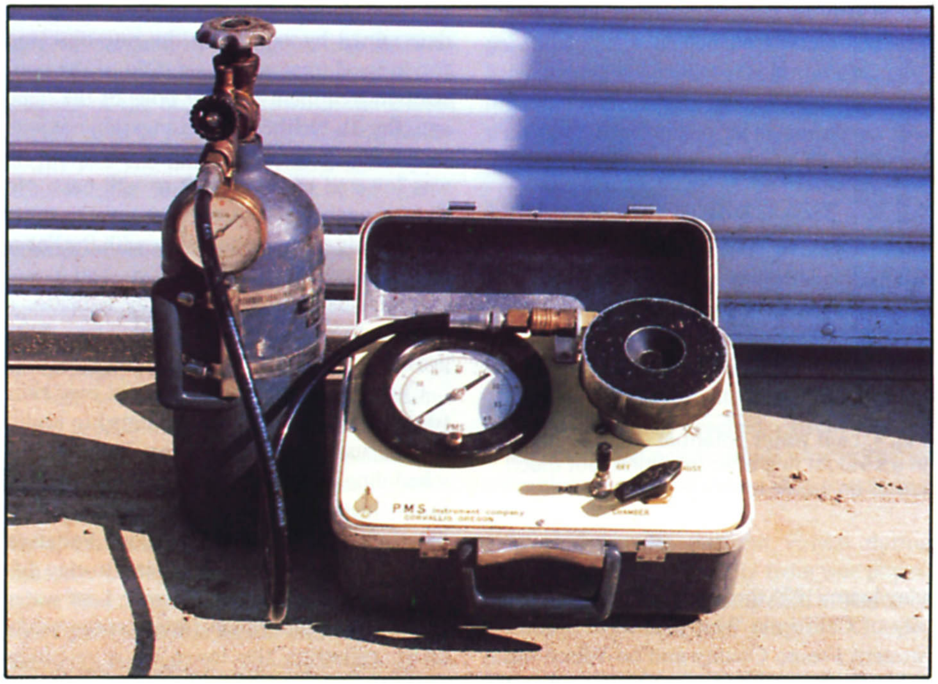
Leaf water potential may be a better guide to irrigation timing than soil water status.



Portable pressure chamber for measuring leaf water potential is small enough to be hand-carried to measurement site.

Leaf and intact petiole are inserted into underside of chamber lid and subjected to negative pressure.

Cotton irrigation scheduling varies greatly in arid and semiarid regions, where large differences occur in soil water-retention and transmission properties. Compact soil zones may restrict root growth and extension and substantially reduce the plant's ability to use stored soil water. On the other hand, a shallow water table in or near the potential root zone may contribute water to the growing plant. Therefore, measurements of soil water content may not always be useful in scheduling irrigations. Because the plant reflects its total environment, a measurement on the plant to determine its water status will sometimes be a better indication of when irrigation is needed.

The water status, or leaf water potential, of vascular plants can be measured with a pressure chamber. Water present in the conducting tissue (xylem) of a transpiring plant is subjected to negative pressure, with the pressure becoming more negative as water stress increases. Equipment required for measuring leaf water potential is commercially available at a reasonable cost and is sufficiently portable to be hand-carried to a measurement site.

Primary features of the apparatus are the pressure chamber, gauge, and control valve, and a small nitrogen gas tank that provides the pressure. To avoid sampling leaves of different physiologic age and exposure history, we select the youngest fully expanded leaves, usually on the fourth readily visible node down from the terminal. The petiole and attached leaf are cut from the plant, leaving about 7 to 9 cm of petiole from the cut to the base of the leaf. Once the petiole is severed, water withdraws within the xylem vessels, because the external pressure is several times that inside the system. After the initial cut, any further trimming of the petiole would introduce an error into the measurement and

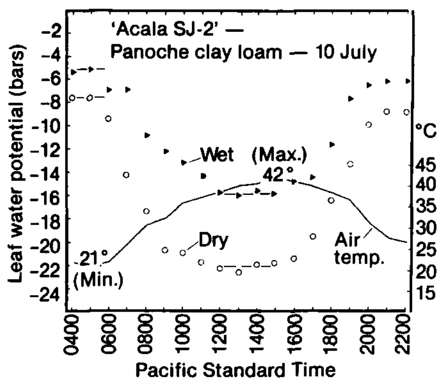


Fig. 1. After sunrise, leaf water potential declines rapidly until solar noon, then begins recovery after 2.5 to 3 hours.

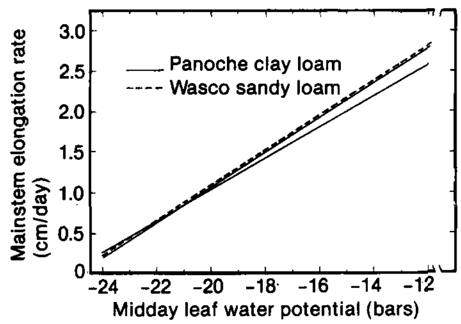


Fig. 2. Cotton mainstem growth declined uniformly with declining leaf water potential on contrasting soils.

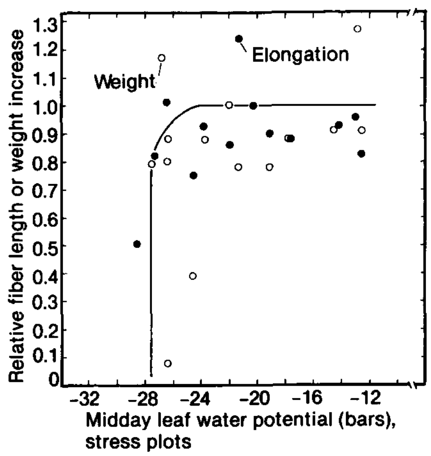


Fig. 3. Fiber growth was not affected by water stress until minimum leaf water potential decreased to -27 to -28 bars.

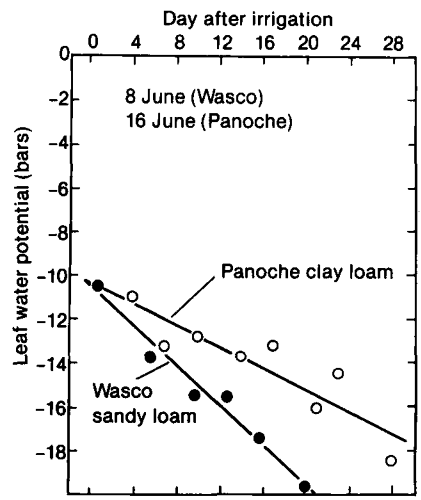


Fig. 4. Leaf water potential declines nearly in a straight line after irrigation, but much faster on sandy loam.

should be avoided. Also, any leaf drying that occurs before the measurement makes the readings too low.

We find that immediate measurement gives good results with cotton, but if this is not possible, leaves should be wrapped with moist cheesecloth or tightly sealed in a vapor-proof plastic bag (exhaling into the bag will help minimize vapor loss). Leaves are sealed inside the pressure chamber with the petiole extending above the chamber top through a rubber stopper that is pressure-sealed into the underside of the chamber lid. The chamber is pressurized until water in the xylem is forced back exactly to the cut petiole surface. At this point, pressurization is stopped and the reading is taken from the gauge. The balance pressure now matches the negative pressure of the plant system. We find that the average of readings from three to five leaves is adequate to characterize a sampling site.

We conducted a three-year field study on cotton (*Gossypium hirsutum* L.) in the San Joaquin Valley. The tests were on Panoche clay loam (1975 through 1977) at the University of California West Side Field Station in western Fresno County and on Wasco sandy loam (1975 and 1976) at the U.S. Cotton Research Station in Kern County. Both soils allow deep root development, and water extraction is commonly observed in mid- or late-season at depths of 1.5 meter for the Wasco soil and 2 meters for the Panoche soil. This study was done to establish the relationship of cotton vegetative and fiber growth to leaf water potential (Ψ_l) and to assess this measurement's effectiveness for scheduling irrigations.

Typical variation in Ψ_l during the day is shown in figure 1 for contrasting soil water conditions. Leaf water potential is greatest before sunrise, then it declines rapidly, reaching a minimum at about solar noon. Values are relatively constant for the next 2.5 to 3 hours, after which recovery begins. We chose to relate cotton growth to the minimum values observed at and following solar noon, because treatment differences were greatest at minimum leaf water potential, measurement time is convenient, and the values are relatively stable in this climatic region for a day-to-day comparison.

Cotton mainstem growth is greatest from about 20 June to 20 July. After this, the boll load becomes heavy, and vegetative growth slows. To eliminate variation associated with the stage of plant development, only mainstem elongation rates from the maximum growth period were used. Mainstem growth was most rapid after stress was alleviated by irrigation. A linear reduction accompanied declining Ψ_l until little or no growth was observed at about -24 to -25 bars (fig. 2). Contrasting soils gave the same results.

The effect of declining leaf water potential on fiber elongation and weight increase was determined by expressing the rate observed for stressed treatments as a ratio of the non-stressed treatment rate for bolls of the same age (fig. 3). Neither fiber elongation nor wall thickening was reduced until minimum Ψ_l was lowered to about -27 to -28 bars. No fiber growth was observed at greater stress levels. This response contrasts with the linear decline in vegetative growth as leaf water potential declined and possibly indicates a preferred photosynthate sink for fiber growth.

Changes in leaf water potential over time for contrasting soils were examined to evaluate the usefulness of this measurement for scheduling irrigations. Figure 4 shows only slight fluctuations of Ψ_l from a straight line function of time since irrigation. Variation from the line reflects normal day-to-day differences in evaporative demand. Leaf water potential declines much faster on the sandy loam, reflecting the lower water-retention capacity.

In this study treatments that varied timing of the first irrigation of the growing season showed best results when leaf water potential was allowed to decline to about -16 bars just before the irrigation. This degree of stress slows growth slightly. After substantial root extension and plant conditioning, yields were optimum when midseason irrigations were scheduled at midday leaf water potentials of -18 to -20 bars. At peak bloom, results may be improved by irrigation at -18 bars, since the plant is more sensitive to yield loss from excessive stress at this stage.

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