Validation of Protocols for Using Trunk Diameter and Tree Water Potential Measurements in Orchard Irrigation Scheduling

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Executive Summary:
Background and Justification
It has long been recognized that the plant is the best indicator of its water status but until recently, plant-based monitoring involved discrete measurements in both space and time. This procedure involves a cumbersome pressure chamber and the timely detection of critical plant water stress depends on the monitoring frequency; how much labor is allocated for this approach. Our recent work with linear variable displacement transducers (LVDTs) shows that trunk diameter fluctuations correlate well with tree water status. For mature trees, the most useful parameter than can be gleaned from trunk diameter measurements is maximum daily trunk shrinkage (MDS); the difference between daily maximum (early morning) and minimum (later afternoon) values. We believe that if protocols for using and interpreting MDS measurements can be developed, these instruments offer the promise of automated irrigation scheduling-coupling of plant-based indicator to computer/electronic irrigation controller.

Last season, we tested an MDS-based scheduling protocol for the first time in a daily irrigated, mature, commercial almond orchard. There were three irrigation treatments: the cooperating grower's ranch practice, a "control" irrigated at 150% of the ranch practice, and the MDS protocol trees. Our protocol was predicated on the assumptions that MDS indicates the presence of very mild water stress and that almond trees tolerate this mild stress without negative impacts on production. We calculated a "signal" as the MDS of the trees to be scheduled divided by the MDS of the control trees being irrigated in excess of evapotranspiration (ETc). When the MDS signal on three consecutive days exceeded 1.25, the daily irrigation rate was raised by 10%. Similarly, if the MDS signal did not reach 1.25 fo4 three consecutive days, the irrigation rate was decreased 10%.

All irrigation treatments applied water far in excess of estimated orchard ETc. The control, which received the most water, had consistently lower MDS and higher shaded LWP. A diurnal study was conducted where additional water was applied at midday to some control trees. Following the addition of the extra water, stem water potential decreased significantly. This raises questions concerning the use of control or "reference" or "baseline" values in plant-based scheduling approaches. Both the current MDS and SWP guidelines involve these values. It's possible that since soil hydraulic conductivity increases exponentially with soil water content, maintaining high soil water content at the root/soil interface by irrigating in excess of ETc may decrease flow resistance and thus, increase (make less negative) the plant water potential required to sustain a given transpiration rate.

While the validity of using control, reference, or baseline values in interpreting plant-based measurements for irrigation scheduling needs to be studied, one approach to adapting protocols where these values are used is to adjust signal "threshold" values. We believe that these values can be set such that the high stress sensitivity of MDS becomes an asset to this procedure and results in applied water being less than orchard ETc.

Objectives

1. To validate an MDS-based irrigation scheduling protocol using higher indicator signal thresholds than previously tested, and

2. to answer the question of using control, reference, or baseline values by evaluating tree water status, trunk diameter fluctuations, vegetative, and reproductive growth of trees irrigated at various rates in excess of ETc.

Procedures

The MDS validation will be conducted in a commercial, drip irrigated almond orchard on the west side of the San Joaquin Valley. The orchard contains three irrigation sets; two of which will be irrigated using our MDS protocols with signal thresholds of 2.0 and 4.0, respectively. Reference values will be calculated using a relationship between control data from 1999 and 2000 and mean daily vapor pressure deficit. Block 3 will be the normal ranch irrigation. Interior, shaded LWP will be measured each weekday on each of the 12 LVDT-instrumented trees. Almond yields and fruit parameters (individual fruit component weights (hull, shell, and kernel) and hull split percentage) will be determined at the end of the season.

Evaluating the effects of irrigation in excess of ETc on tree water status and growth will be done using the weighing lysimeter at the Kearney Agricultural Center. Blocks will receive 100, 125, 150, and 175% of lysimeter ETc. Each tree will be instrumented with a trunk mounted LVDT and at least one fruit mounted LVDT to assess vegetative and reproductive growth, respectively. Soil moisture will be monitored continuously at 10, 20, 40, and 150 cm deep in the root zone using one EnviroScan probe per tree. Shaded LWP will be monitored at least twice per week with single leaf measurements on each of the 16 trees.