Using Midday Stem Water Potential to Refine Irrigation Scheduling in Almond

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There are several advantages to using midday stem water potential as an adjunct to monitoring soil moisture or using evapotranspiration based irrigation scheduling. Measuring soil moisture gives you an idea what is going on in only a limited volume of soil where your measurement device is placed. It can be difficult to decide where to monitor soil moisture since tree roots can be quite deep and variable depending on irrigation system design (i.e. variable roots under drip irrigation) and method of operation (i.e. deep versus shallow irrigations). Using evapotranspiration based scheduling alone can lead to problems if you do not know the soil moisture conditions at the beginning of the season, your irrigation system application efficiency is lower than you estimate, or your estimates of crop water use are incorrect. Midday stem water potential can be used as an adjunct to either soil or evapotranspiration based irrigation scheduling to help refine your irrigation scheduling. The advantage to using midday stem water potential is that it integrates soil factors for the entire tree root system as well as environmental factors giving you an accurate picture of the level of stress the tree is experiencing.

Pressure chamber basics*

Water in a plant is under tension. By bagging a leaf low on the tree at least 15 minutes before sampling, you can allow it to equilibrate with the water potential in the stem. Then, you can cut off the leaf and place it in a pressure chamber with the petiole protruding out. As you pressurize the cylinder, a point will be reached where the water will just begin coming out of the cut surface. At this point, a reading of the dial gauge will give the midday stem water potential. Since the midday stem water potential is measuring a tension, the value is normally expressed as a negative value with a fully watered almond tree being somewhere near –6 to –10 bars depending on environmental conditions. A moderately stressed almond tree might have a midday stem water potential of –10 to –15 bars.

Procedure to measure midday stem water potential

1) Readings should be taken approximately weekly between 1 and 3 pm.

2) At least 15 minutes before taking readings, place aluminum foil covered plastic bags (or Mylar bags) over mature, lower canopy shaded leaves on approximately 10 trees per orchard. The number of trees to sample depends on accuracy desired, soil/irrigation variability in orchard etc. Try to sample in a gradient across the wettest to driest areas in the orchard.

3) Remove leaves from tree one at a time and immediately place in pressure chamber (leaving leaf inside aluminum foil covered plastic or Mylar bag)

4) Pressurize until you see water just begin to come out of the cut end. If you go past the endpoint and see excessive water bubbling out, back off and re-pressurize to determine the endpoint.

5) Record reading and move on to next tree.

6) Record the time, temperature and relative humidity (if available) at the time the readings were taken. Hourly temperature and relative humidity data are also available from CIMIS-web site for CIMIS is listed at the end of this paper.

The table below gives you values for a fully watered tree under varying conditions of temperature and relative humidity. The table was developed for prunes but the values are similar for almonds.

Temperature (°F)	Air Relative Humidity (RH, %)						
	10	20	30	40	50	60	70
70	-6.8	-6.5	-6.2	-5.9	-5.6	-5.3	-5.0
75	-7.3	-7.0	-6.6	-6.2	-5.9	-5.5	-5.2
80	-7.9	-7.5	-7.0	-6.6	-6.2	-5.8	-5.4
85	-8.5	-8.1	-7.6	-7.1	-6.6	-6.1	-5.6
90	-9.3	-8.7	-8.2	-7.6	-7.0	-6.4	-5.8
95	-10.2	-9.5	-8.8	-8.2	-7.5	-6.8	-6.1
100	-11.2	-10.4	-9.6	-8.8	-8.0	-7.2	-6.5
105	-12.3	-11.4	-10.5	-9.6	-8.7	-7.8	-6.8
110	-13.6	-12.6	-11.5	-10.4	-9.4	-8.3	-7.3
115	-15.1	-13.9	-12.6	-11.4	-10.2	-9.0	-7.8

Interpretation and uses of midday stem water potential data

Mature trees

By keeping the midday stem water potential values near the fully watered baseline, you can assure that you do not get into deficit conditions. However, it is usually advantageous to allow the midday stem water potential to fall 1 to 2 bars below the baseline before beginning irrigation to assure that you are not over-irrigating. This is particularly true in areas where a water table is present.

- Do not initiate irrigation in the springtime until midday stem water potential falls below the baseline levels in table above.
- Begin irrigating when midday stem water potential falls approximately 3 to 4 bars below the baseline (-10 to -11 bars)
    - o May help to control excessive vegetative growth which is generally not desireable once trees have filled in their allotted space.
- Irrigate enough to bring midday stem water potential back near baseline (-7 to -8 bars).

By taking readings before and after an irrigation event, you can judge better adjust the timing of system operation. If you do not approach the baseline after an irrigation, you should most likely irrigate for a longer period during the next cycle.

Hull rot

Previous work has suggested that moderate water deficits during hull split may lead to a decreased incidence of hull rot. However, these studies were based on cutting-off or decreasing irrigation during certain periods rather than reaching specific levels of midday stem water potential. Therefore a study was recently conducted to more accurately assess the levels of stress needed (as measured by midday stem water potential) to have a beneficial effect on decreasing hull rot in almond. This work suggested that midday stem water potentials of -14 to -16 bars during hullsplit can lead to decreased incidence of hull rot without significant impacts on yield.

Young trees

For young almond trees, where maximum vegetative growth may be desirable to fill in the canopy rapidly, the average value of midday stem water potential should be close to the baseline. If the average is more negative than the baseline value at the temperature and relative humidity conditions

when the measurements are made, then the trees are under water stress and vegetative growth may be compromised. If trees remain more negative than the baseline, and the soil is wet, then there may be a problem with root health and/or the soil may be too wet.

- Do not initiate irrigation in the springtime until midday stem water potential falls below the baseline levels in table above.
- Begin irrigating when midday stem water potential falls approximately 1 to 2 bars below the baseline (-9 to -10 bars)
    - You want to keep young trees fairly close to the baseline to maintain maximum vegetative growth to allow trees to fill allotted space as rapidly as possible
    - By letting midday stem water potential drop below baseline before irrigating, you can assure that you are not overirrigating, which can be a major problem, especially where water tables and/or confining layers are present in soil.
- Irrigate enough to bring midday stem water potential back near baseline (-7 to -8 bars).

An Integrated approach is best

It is best to use an integrated approach combining evapotranspiration data to estimate water application amounts (see http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp for an overview of using an evapotranspiration based approach), soil based monitoring, particularly at 6 foot depth or so to see if lower profile is wetting or drying as season proceeds, combined with pressure chamber measurements to refine irrigation scheduling. Deciding when to start irrigating in the spring is a critical decision that is best made using a combination of soil and plant based measurements.

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*For a more detailed explanation of how a pressure chamber works, see **The Pressure Chamber, a.k.a. "The Bomb"** by Ken Shackel available on the UC Fruit and Nut Research and Information Center web page (http://fruitsandnuts.ucdavis.edu/crops/pressure-chamber.shtml).

Evapotranspiration data is available from the California State Department of Water Resources CIMIS program (http://wwwcimis.water.ca.gov/cimis/welcome.jsp)

Plant pressure chambers are available from:

PMS Instruments in Albany, Oregon (http://pmsinstrument.com/)
Soil Moisture Equipment Corp.in Santa Barbara, California (http://www.soilmoisture.com/)

Watermark soil moisture sensors are available from:

Irrometer Company in Riverside, California (http://www.irrometer.com/)