

Using Plant Based Measurements to Refine Irrigation Scheduling in Walnut

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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 your 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. 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 10 minutes before sampling, you can allow it to equilibrate with the water potential in the stem. Then, you can cut off the leaf at midday (1-3pm) 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 walnut tree being somewhere near -3 to -5 bars depending on environmental conditions. A mildly stressed walnut tree might have a midday stem water potential of -5.5 to -7.5 bars. A moderately stressed walnut tree might have midday stem water potential readings in the -8 to -10 bar range. Walnuts with readings more negative than -11 bars will generally show signs of water stress such as leaf yellowing and drop. Note that the values for a fully watered walnut tree (-3 to -5 bars) are much different than those for prune or almond where a fully watered baseline would be in the -7 to -9 bar range.

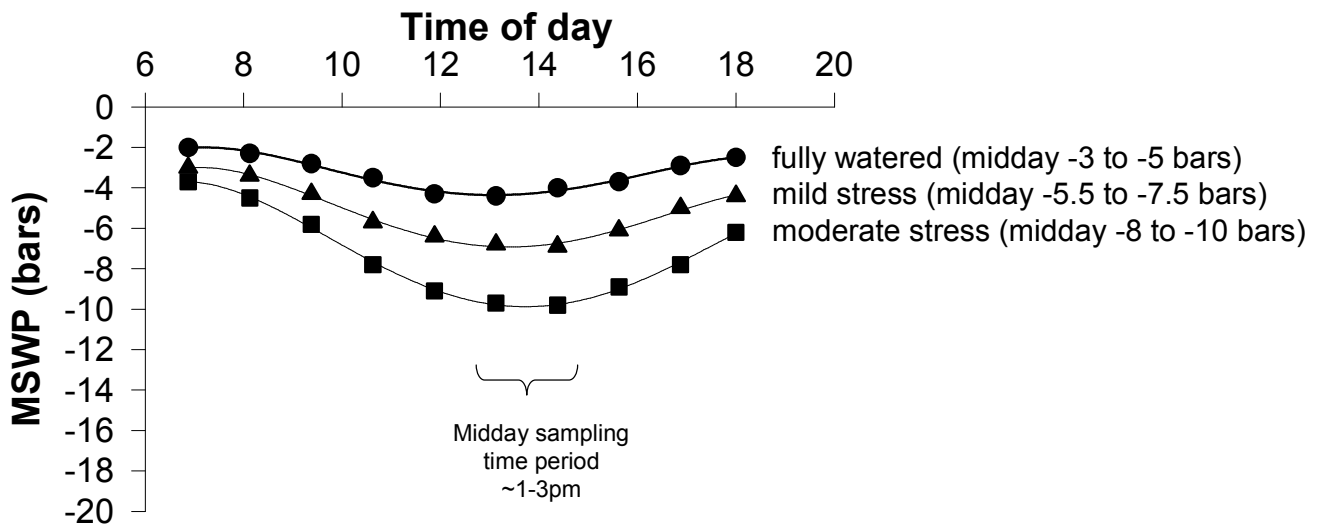
Procedure to measure midday stem water potential

- 1) Readings should be taken approximately weekly between 1 and 3 pm.
- 2) At least 10 minutes before taking readings, place mylar bags over mature, lower canopy shaded leaves on approximately 10 trees per orchard. With walnuts, the terminal leaflet is normally used. The number of trees to sample depends on accuracy desired, soil/irrigation variability in orchard etc.
- 3) Remove leaves from tree one at a time and immediately place in pressure chamber (leaving leaf inside the plastic bag)
- 4) Pressurize slowly 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 water potential reading as well as time, temperature and relative humidity and move on to next tree.

Midday stem water potential values are influenced by both temperature and relative humidity. The table below gives values of midday stem water potential (in bars) for a fully watered walnut tree under varying conditions of temperature and relative humidity. This value is known as the fully watered baseline.

Temperature (°F)	Air Relative Humidity (RH, %)						
	10	20	30	40	50	60	70
60	-3.8	-3.7	-3.6	-3.5	-3.3	-3.2	-3.1
65	-4.0	-3.9	-3.7	-3.6	-3.5	-3.3	-3.2
70	-4.2	-4.1	-3.9	-3.7	-3.6	-3.4	-3.3
75	-4.5	-4.3	-4.1	-3.9	-3.7	-3.5	-3.3
80	-4.8	-4.6	-4.3	-4.1	-3.9	-3.7	-3.5
85	-5.1	-4.9	-4.6	-4.4	-4.1	-3.8	-3.6
90	-5.6	-5.2	-4.9	-4.6	-4.3	-4.0	-3.7
95	-6.0	-5.7	-5.3	-4.9	-4.6	-4.2	-3.9
100	-6.5	-6.1	-5.7	-5.3	-4.9	-4.5	-4.0
105	-7.2	-6.7	-6.2	-5.7	-5.2	-4.7	-4.2
110	-7.8	-7.3	-6.7	-6.2	-5.6	-5.0	-4.5
115	-8.6	-8.0	-7.3	-6.7	-6.0	-5.4	-4.7
120	-9.5	-8.8	-8.0	-7.3	-6.5	-5.8	-5.0

Stem water potential varies throughout the day based on solar radiation, temperature and relative humidity. The figure below shows the normal daily pattern of stem water potential for fully watered mildly stressed and moderately stressed walnuts on a normal summer day in the Sacramento Valley. Midday measurements are used as the standard because that is the time that the water potential is relatively constant for several hours.



A midday stem water potential in the -11 to -15 bar range would indicate that the trees are severely stressed and impacts on nut sizing and nut quality might be expected. Walnuts will generally die before they reach a midday stem water potential of -17 to -18 bars.

Interpretation and uses of midday stem water potential data

Mature trees (have filled in allotted space)

By keeping the midday stem water potential values near the fully watered baseline (-3 to -5 bars), 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 2 to 3 bars below the baseline (-5.5 to -7.5 bars) 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 spring until midday stem water potential falls below baseline
- Irrigate when MSWP falls approximately 2-3 bars below the fully watered baseline (~-5.5 to -7.5 bars)
 - Assures that you are not over-irrigating which can be a problem in walnuts, especially where water tables and/or confining layers are present
 - May prevent excessive vegetative growth and minimize pruning requirements
- Irrigate enough to bring MSWP back near baseline and/or soil moisture to near field capacity
- Monitor deep soil moisture with an auger, Watermark soil moisture blocks, etc.

Young trees (have not yet filled in allotted space)

For young walnut 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 spring until MSWP falls below baseline
- Irrigate when MSWP falls approximately 1 to 2 bars below the fully watered baseline to ~ -4.5 to 6.5 bars
 - Assures that you are not over-irrigating which is a major problem in walnuts, especially where water tables and/or confining layers are present
- Irrigate enough to bring MSWP back near baseline and/or soil moisture to near field capacity
- Monitor deep soil moisture with an auger, Watermark soil moisture blocks, etc.

Soil moisture measurements

Soil moisture measurements provide additional essential information. By monitoring deeper soil moisture, it is obvious when the lower profile is drying down and potential stress problems can be anticipated/avoided. Soil moisture can be monitored by several means including a soil auger, tensiometers, gypsum blocks, granular matrix sensors, neutron probe etc. Irrrometer produces a granular matrix sensor known as the Watermark that is relatively grower friendly. By installing Watermark sensors at 3 depths (depending on rooting depth but 2', 4' and 6' may work), changes in soil moisture can be observed as the season progresses. If the lowest sensor gets wetter after an irrigation, you probably are irrigating too much. If the lower sensor continually dries as the season progresses, you may need to increase irrigations slightly. Generally, a Watermark reading of 0 to 20 cbars suggests that the soil is too wet. Irrigation is usually called for when the soil moisture in the root zone reaches about 40 to 60 cbars depending on soil texture. Reading of 100 to 200 cbars suggests the soil is too dry for tree roots to access moisture.

Irrigation strategies to minimize chances of negative impacts on yields and nut quality

Start the season with a fully charged profile

- If winter rainfall is inadequate, provide irrigation in a gradual manner to fill profile
Monitor soil moisture over winter (Watermark sensors, tensiometers, or soil auger)

- This is particularly important if a water table is present
 - If deficient, start applying a few inches at a time in late Jan. and every few weeks thereafter
 - Then if rainfall occurs in late winter/early spring, you can skip future irrigations
 - If a water table is present, monitor the water level over the season and avoid bringing water level near root zone
- As season progresses:
 - Schedule irrigation based on evapotranspiration data
 - Available on the World Wide Web at <http://www.cimis.water.ca.gov/>
 - To confirm where soil moisture is, monitor with Watermark sensors, tensiometers, or soil auger
 - This is particularly important in soils with water tables and/or water penetration problems

Use midday stem water potential, as described earlier, to assure that you are not over or under-irrigating

*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/pressure-chamber.html>).

Sources for pressure chambers, relative humidity/temperature gauges, soil moisture monitoring equipment, etc.

PMS Instruments (console and pump-up pressure chamber)
 1725 Geary Street SE
 Albany, OR 97322
 Phone: (541)704-2299
www.pmsinstrument.com

Soil Moisture Equipment Company (console pressure chamber, soil sampling tubes, augers)
 P.O. Box 30025
 Santa Barbara, CA 93105
 Phone: (805)964-3525
www.soilmoisture.com

Irrrometer Company (Watermark sensors, Watermark meter, dataloggers, and tensiometers)
 P.O. Box 2424
 Riverside, CA 92516
 Phone: (909)689-1701
www.irrometer.com

Spectrum Technologies, Inc. (Watermark sensors, dataloggers, temperature/relative humidity gauges)
 23839 West Andrew Road
 Plainfield, Ill. 60544
 Phone: (800)248-8873
www.specmeters.com

Forestry Suppliers, Inc. (temperature/relative humidity gauges, soil sampling tubes, augers, Watermark sensors, dataloggers, tensiometers)
 205 West Rankin Street
 Jackson, MS 39201
 Phone: (800)647-5368
www.forestry-suppliers.com