

MEASURING CROP WATER STATUS IN ORCHARD CROPS

What is a Pressure Chamber, a.k.a. "Pressure Bomb"?

Simply put, the pressure chamber is just a device for applying air pressure to a leaf (or small shoot), where most of the leaf is inside an air-tight chamber but a small part of the leaf stem (the petiole) is exposed to the outside of the chamber through a seal. The amount of pressure that it takes to cause water to appear at the cut surface of the petiole on the outside of the chamber tells you how much tension the leaf is experiencing on its water: a high value of pressure means a high value of tension and a high degree of water stress. The units of pressure most commonly used are the Bar (1 Bar = 14.5 pounds per square inch).

Figure 1 with inset shows three different types of pressure chambers. Presently, there are two manufacturers of pressure chambers, PMS Instrument Company and SOILMOISTURE Equipment Corporation. Both manufacturers have websites describing their equipment. Typical prices range from roughly \$1400 for the "manual Pump-up" model in the middle and as high as \$4400 for the "gas pressured console" on the right in Figure 1. The gas console shown in the inset costs about \$2000 - \$2800 depending on specific features.



Figure 1. Three commercially available pressure chambers for measuring midday stem water potential in walnut.

What is measured with the pressure chamber?

In simplest terms, the pressure chamber can be thought of as measuring the "blood pressure" of a plant, except for plants it is water rather than blood, and the water is not pumped by a heart using pressure, but rather pulled with a suction force as water evaporates from the leaves. Water within the plant mainly moves through very small interconnected cells, collectively called xylem, which are essentially a network of pipes carrying water from the roots to the leaves. The current model of how this works is that the water in the xylem is under tension, and as the soil dries, or for some

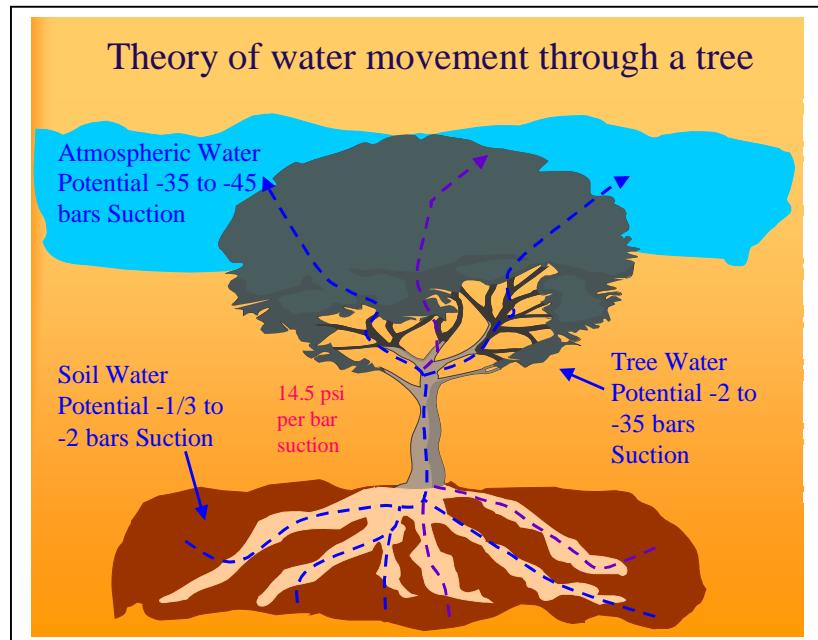


Figure 2. Illustration of the Soil-Plant-Atmospheric Continuum and the scientific theory behind using a pressure chamber and midday stem water potential to quantify water stress in walnut.

other reason the roots become unable to keep pace with evaporation from the leaves, then the tension increases. Under these conditions you could say that the plant begins to experience "high blood pressure". Figure 2 provides a conceptual illustration of the soil-plant-atmospheric continuum and what the pressure chamber is measuring.

Because tension is measured, values are reported as negative numbers. An easy way to remember this is to think of water stress as a "deficit:" the more the stress, the more the plant is experiencing deficit water. The scientific name given to this deficit is the "water potential" of the plant. The actual physics of how the water moves from the leaf within the pressure chamber to the cut surface just outside the chamber is more complex than just "squeezing" water out of a leaf, or just bringing water back to where it was when the leaf was cut. In practice, however, the only important factor is for the operator to recognize when water just begins to appear at the cut end of the petiole. Refer to Figure 3 below for an illustration of how midday stem water potential is measured.

Midday stem water potential levels vary depending on the orchard crop and the level of water stress in the orchard. In almonds, prune, and olive midday stem water potential may range from -6 to -8 bars tension, when trees are under little or no water stress. In contrast, almond, prune, and olives trees under severe water stress may show midday stem water potential levels of -30 to -35 bars tension. In walnut, midday stem water potential may range from -2 to -4 bars tension in trees under little or no water stress. Walnut trees that consistently show midday stem water potential levels of -2 to -4 bars may be at risk of too much water and poor aeration in the root zone. Highly water stressed walnuts will show midday stem water potential levels between -12 and -16 bars.



Figure 3. How to measure midday stem water potential in the field with a pressure chamber. Left to right: 1) Select about five or ten trees representative of the orchard and use these trees for routine evaluation of water stress; 2) approximately weekly cover a leaf on each tree for about ten minutes, by covering the leaf with a bag the leaf ceases to transpire water and equilibrates with the water tension in the rest of the tree; 3) prepare the pressure chamber for use while the leaves equilibrate inside the bags; 4) after ten minutes, one tree at a time, cut the covered leaf from tree with leaf remaining inside bag and insert it into pressure chamber; and 5) apply pressure to the chamber and watch for sap to exude at cut surface of walnut leaf petiole, record pressure (stress level) on gage when sap appears. It should take about 10 minutes to put the bags on the leaves and to wait for the leaves to equilibrate and about 10 to 20 minutes to complete the midday stem water potential measurements after the bagged leaves have reached an equilibrium with the rest of the tree.

Some Sources of Pressure Chamber Equipment

Note: This is a partial list and endorsements of specific products and suppliers are not intended by listing these providers of water management tools.

Pressure Chambers:

2. PMS Instrument Company
1725 Geary Street SE
Albany, OR 97322 USA
Phone: (541)704-2299
Fax: (541)704-2388
info@pmsinstrument.com
<http://www.pmsinstrument.com>
3. Soil Moisture Equipment Corp.
Catalog Request
801 S. Kellog Ave.
Goleta, CA 93117
Phone: (805)-964-3525
Fax: (805)-683-2189
<http://www.soilmoisture.com>