Better Growing

By Julie C. Escalera
PhD Candidate
University of California, Riverside
Department of Environmental Science, Soil and Water Science

Soil Moisture Technology and Irrigation Management

Water management plays a critical role in the productivity of an avocado tree. Water plays a key role in photosynthesis; helps create amino acids, proteins, vitamins, hormones and enzymes for the tree; delivers salts and minerals to roots and leaves; cools the leaves of trees and helps prevent leaf wilt, tip burn and leaf drop that can reduce fruit production. Despite water's importance to grove productivity, a recent water use survey of California avocado growers indicated that only 50 percent of growers use some type of soil water monitoring technology to determine when to irrigate their orchards.

Determining when to irrigate your avocado grove is difficult to do visually or by feeling the soil with your hands. In avocado, symptoms of overwatering can mimic symptoms of underwatering — both exhibit droopy leaves and decreased growth thus making it difficult to determine the source of the problem simply by looking at the tree.

Some growers feel the soil to determine water needs, but this technique does not often give a clear picture of irrigation management needs. While soil has the ability to retain moisture based on its unique texture, organic matter, porosity and aggregation, soil also has the ability to change spatially within your orchard. For instance, a soil type located on hill slopes will be different than a soil type located on level ground. To further complicate irrigation management, a soil's water holding properties change with depth making it impossible to know, without the proper tools, what is going on underneath the first couple of inches of soil. Even if your soil looks dry, it could be saturated a few inches down. In fact, in field studies we have observed that some growers have been over-irrigating their trees, which can lead to root rot and low soil oxygen that inhibits root growth.

To prevent this from happening, soil monitoring equipment is essential. Soil moisture technologies have been proven to manage growers' site-specific water requirements by estimating the amount of moisture available in the soil — determining if there is a water shortage that can reduce yields or if there is excessive water application that can result in water logging and root rot. Consistent measuring of soil moisture can build a history and knowledge of each irrigated acre that is invaluable for future planning and management. The method you choose will vary by cost, ease of use and accuracy.

Soil Moisture Technology

Gravimetric

Gravimetric moisture is the amount of moisture in a soil on a dry weight basis and is a direct measurement of soil water content. Measuring gravimetric water content does not require any specialized equipment, just a scale and an oven that can reach a temperature of approx. 220°F (105°C). A grower can dig a small hole to the depth of interest in the rootzone, typically within less than 2.5 feet from the surface (0.8 meters) where avocado roots are present in a mature tree. Remove a small soil sample approximately between 0.5 to 1-oz., weight it and place it in a kitchen oven at 220°F for 24 hours. Once dry, the soil is weighed and the difference between the pre-oven-dried soil (the moist soil) and the oven-dried soil is the amount of water in the soil on a weight by weight basis. One drawback is this method does not account for soil matrix potentials. However, taking consistent readings can help a grower track moisture trends in the root zone. This method is free and accurate, however, it is labor intensive and takes a day or so to determine results.

Tensiometer

Tensiometers measure the soil moisture tension or suction. Sometimes they are referred to as a "dummy root" because they mimic the energy that a root must put forth to extract water from the soil. A tensiometer is a long plastic tube with a porous ceramic cup on one end and a vacuum gage on the other. When placed in the soil, moisture from the surrounding soil is drawn into or out of the ceramic cup and the vacuum gage measures the pressure difference. A zero reading indicates your soil is saturated. Alternately, a (higher) negative number indicates your soil is on the drier end. For example, a tensiometer reading of -50 centibars (cbars) indicates more soil moisture than a reading of -80 cbars. Though inexpensive, tensiometers require routine maintenance and proper installation is essential. Good soil contact with the ceramic cup is difficult to maintain especially if the instrument is disturbed. In addition, the installation location is critical, especially when difference in soil tex-

Soil Moisture Technologies Summary			
Type	**Advantages**	**Disadvantages**	**Cost range**
Gravimetric	-Accurate -Low costs	-Labor intensive -Destructive sampling -Time consuming	-None
Tensiometer	-Continuous readings -Low costs -No calibration needed	-Maintenance required -Correct placement is difficult -Not reliable under very dry soil conditions	-$65+
Gypsum Block	-Continuous readings -Can take reading on the drier range	-Accuracy reduced in sandy soils -Data logger required -Requires calibration	-Probes $35+ -Data logger $300+
Dielectric Sensors (TDR)	- Continuous readings -No maintenance needed -Accurate measurement over a large range	-Expensive - Requires calibration -Computer software required	-Software $100+ -Data logger $300 - $800+ -Sensors $100 - $300+
Dielectric (Capacitance)	- Continuous readings -No maintenance needed -Accurate measurement over a large range	-Expensive - Requires calibration -Computer software required	-Software $100+ -Data logger $300 - $800+ -Sensors $100 - $300+
Neutron probe	-Most accurate	-Most expensive option -Computer software needed -Special training for radioactive handling	-System $4000+

ture, soil type and topography are considered. (For more information on tensiometer placement, see "Optimizing Irrigation Management through Soil Water Monitoring" on page 12.)

Gypsum Blocks

Gypsum blocks are electrical resistance blocks that use gypsum, or some similar material, to measure soil moisture between two electrodes. The gypsum block allows moisture to move in and out as the soil becomes more saturated or dries out. When more moisture is absorbed by the block it lowers the resistance reading indicating a more saturated soil. The blocks are cheap and easy to replace but require a data logger in order to get the readings. In addition, the blocks eventually dissolve and need to be replaced.

Dielectric Sensors

There are two types of dielectric sensors: time-domain reflectometry (TDR) and capacitance. Both measure the dielectric constant of the soil. A dielectric is a material that does not readily conduct electricity — in this case the surrounding soil is the dielectric.

TDR sensors use time-domain-reflectometry. TDR measures the time a small electric pulse will travel from one electrode to another. As the moisture increases, the time the electric pulse takes to travel slows down. The reading can be influenced by soil texture, gravel content, incidental metal pieces, chemistry and salt. This method is highly accurate, though expensive, and usually reserved for research.

Capacitance sensors are two electrodes that are separated by a dielectric (soil). An oscillating frequency is applied between the sensors, which are influenced by the moisture in the surrounding soil. The resulting feedback frequency can be used to determine soil moisture content. As with TDR, this method is accurate but expensive and used primarily for research.

Neutron Probe

Neutron probes work by sending out neutrons from a probe inserted in the soil. The instrument takes a reading of how the neutrons move through the soil, which can then be related to soil moisture content. Calibration is required to get accurate results. This method uses radioactive material that requires specialized training and certification. In addition, neutron probes are the most expensive option.