Predicting Water Requirements of Avocados

Determining the water requirements of plants falls into three broad categories of technology - plant-based, soil-based and weather-based. Many of these technologies are proven and have been in use for years. Others are more experimental and have not been tested fully. The following will be a discussion of the various methods and some comments on their applicability to commercial agriculture.

Plant-based

A characteristic of all these methods is that they are measuring the main player in production - the plant. The other characteristic they have is that by the time the plant starts to give measurable signals of stress, it is often an indication that some production loss has occurred, as well. The methods include:

1. pressure chamber (pressure bomb, Schollander pressure chamber); measures plant water tension by applying a comparable air pressure to a leaf or stem
2. stem flow gauge; measures the temperature differential along a trunk which relates to water stress
3. porometer; measures the ability of a leaf to transpire
4. infrared thermometry; measures canopy temperature which is affected by rate of transpiration
5. visual symptoms; wilting, leaf curling - the cheapest method, but the most expensive in the long run.

Most of these techniques are valuable for scientific use, but have had little application in commercial agriculture, partly because of their cost and labor requirements. Another reason for their lack of use by commercial agriculture, specifically citrus, is that they are not well adapted to mature trees, such as with the stem flow gauge and infrared thermometry.

Soil-based

Soil-based methods monitor some aspect of soil moisture which, depending on the method, requires some correlation to plant water use. Some of the methods are well understood and inexpensive, others are expensive, inaccurate, inappropriate or not well researched. Some of the techniques allow multiple site readings while others require a device to be left in place. Some measure soil water directly, like oven-drying, and others measure some other parameter which is associated with water content, such as electrical conductance. Some are affected by salts or soil iron content and others have limited value in the desired soil moisture range. Some, like tensiometers and gypsum blocks, give a reading from a porous material which comes to equilibrium with soil moisture, while many others use the soil directly as the measured media. This is an important distinction since discontinuities in the soil caused by rocks or gopher holes can affect readings when the soil is used to carry a signal. Also, times have changed and some of the old techniques have been improved. For example, gravimetric oven-drying can now be done by microwave, considerably speeding up the process; tensiometers can now be found in portable models, with larger water reservoirs, with digital readout, and solid-state forms, making them more convenient to use; and new models of gypsum blocks can now give readings in the wetter range (15 - 20 cbar), giving them a broader spectrum of readings. There are quite a number of devices on the market and the following chart will shed some light on their differences.

Method	Cost	Ease of Use	Accuracy	Reliability	Salt-affected	Stationary
Gypsum block	L	H	H	H	L	YES
Tensiometer	L	M	H	M	L	YES
Portable tensiometer	M	M	H	M	L	NO
Solid-state tensiometer	M	H	H	H	L	YES
Time domain reflectometer	H	M	H	H	M	NO/YES
Neutron probe	H	L	H	H	L	YES

Feel (soil probe)	L	H	H	H	L	NO
Gravimetric (oven)	L	M	H	H	L	NO
Conductance	L	H	M	M	H	NO/YES
Capacitance	M	H	M	H	M	NO/YES
H, high; M, medium; L, low						

As with any tool, the value of these devices increases with use and familiarity. Even though several of these are listed as stationary devices, by placing them in representative positions in the orchard, they can accurately reflect the rest of the orchard. Several of the devices are listed in the table as being both stationary and portable, this is because there are various models that can act one way or the other. The "Ease of Use" category in the table indicates not just the ease of reading the device, but also the maintenance required for it. Of all these tools, only the tensiometers measure soil moisture in a way a plant might experience it. The tension on the gauge is an indication of the energy that a plant would need to extract water from the soil.

Weather-based

Weather-based techniques of irrigation scheduling measure the driving force of plant water loss - the various factors of temperature, humidity, day length, wind and solar radiation. The assumption made is that a freely evaporating surface of water is similar to the transpirational loss from leaves of a well-watered crop. Historically, standard evaporation pans have been used to measure plant water use on a daily or weekly basis. The pan value is standardized to other sized pans with a correction factor so that pans can be interchangeable in providing a reference evaporation value. Non-standard pans, such as a child's wading pool can be used as well, but the correction factor then needs to be determined specifically for that pan. Once the reference evaporation value is determined, then a crop factor, or Kc, is applied which corrects the evaporation value for water use of the crop. For mature avocados, a Kc of 0.7 will give a good approximation of that crop's water loss, while for a field crop multiple Kc's are used to account for the changes in the crop's growth. More can be learned about this weather-based method from several U.C. publications.

Other than a pan, an atmometer can be used. This is an instrument which has a porous cup at the end of a reservoir which evaporates water like a pan. But instead of having to battle birds, bees and coyotes drinking out of the pan, the atmometer is relatively more maintenance-free. Finally, calculated values of water-loss can be used, such as are generated by the California Dept. of Water Resources' CIMIS network, Fox Canyon Groundwater Management Agency or privately purchased weather stations.