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Irrigation Management in California Avocado Groves

I recently gave a talk on Phytophthora root rot management at the California Avocado Society seminar series. During that talk, I stressed the importance of proper irrigation management for managing Phytophthora. Inevitably, the question came up at each seminar location: "What is proper irrigation management?" There is no one-size-fits-all recipe for irrigation management; however, there are a series of principles that you can follow to figure out the proper irrigation management for your grove.

How much water does an avocado tree need?

To understand how much water your avocado trees need, you need to know the evapotranspiration (ET) rate — the total water consumption based on evaporation and transpiration through the plant — for your location. You can calculate this in multiple ways. Many weather stations will provide you with an estimate of ET for your location. You also can use the California Irrigation Management Information System (CIMIS; www.cimis.water.ca.gov), which has a network of weather stations around the state – as well as a spatial network based on satellite data – to estimate ET for the areas between stations.

For the purposes of this article I will use CIMIS station number 198, located in Santa Paula in Ventura County. For 2018, CIMIS station 198 recorded a total ET of 53.99 inches. For uniformity and comparison from site to site, CIMIS stations use a grass field as their reference plant, so the 53.99 inches of ET reference (ET_o) is based on the water that was transpired through the grass as well as what was lost from the surface due to evaporation.

Avocados use less water than grass, so to correct for this difference a crop coefficient is applied — usually 0.85 for mature avocado trees. Thus, the ET for the crop (ET_c) is the ET_o (53.99) multiplied by the crop coefficient (0.85), which in this example equals 45.89 inches or about 3.8 acre-feet. Young avocado groves will have proportionally less water use than mature groves.

When using ET_c to determine your trees' irrigation needs it's important to remember that ET changes based on the weather conditions. Referring back to the Santa Paula example, monthly ET ranged from 2.48 inches in December to 6.87 inches in July. This variation needs to be taken into account when designing your irrigation system and your system should be designed to supply enough water to meet the maximum ET you expect to experience at your location when your trees are mature.

When should you irrigate your trees?

ET only tells you part of the story — how much water your trees are using. But how do you know when to apply water to meet their needs? The answer can be found under your feet, in the soil.

Every soil has a certain water holding capacity, which can be measured using soil moisture sensors. For a comprehensive review of soil moisture sensors please see "Using Soil Moisture Sensors to Improve Irrigation Efficiency" in the Fall 2015 issue of *From the Grove*. Briefly, soil moisture sensors tell you how much water is in the soil. This will either be measured as the percentage of the total volume of water held at saturation (volumetric water content) or as soil tension (a measure of how "difficult" it is for plant roots to extract moisture from the soil). For the purposes of discussion in this article, I will use soil tension, which is measured by tensiometers, the most common soil

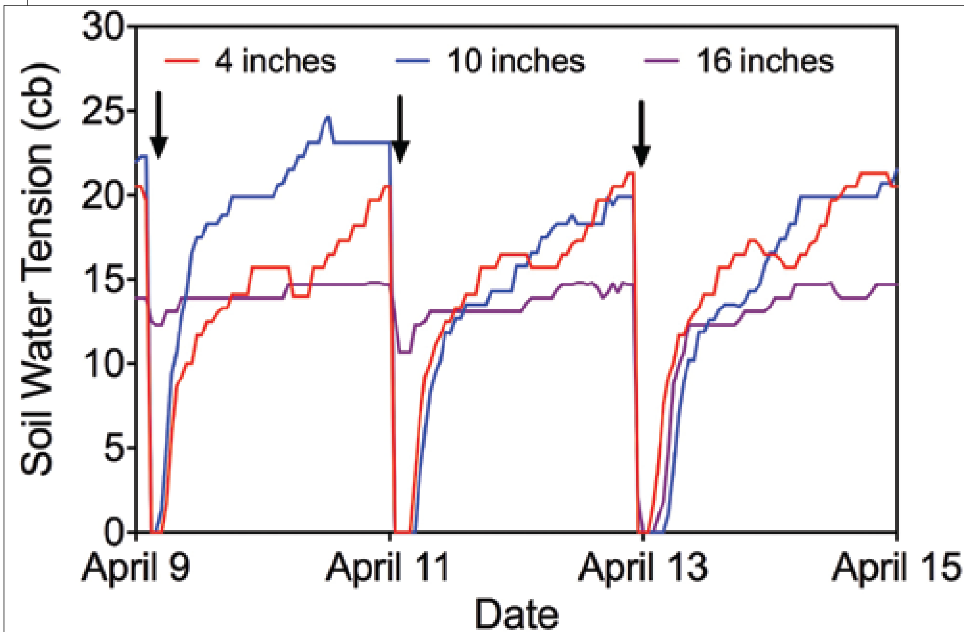


Figure 1. Soil water tension readings from a block at Pine Tree Ranch, Santa Paula, for a week during April 2018. Note how the 4- and 10-inch sensor readings drop to 0 cb after each irrigation (arrows), then the soil quickly drains and reaches field capacity (about 10 cb). However, the 16-inch sensor only dropped to 0 cb after the April 13 irrigation. This indicates that the prior two irrigations were not long enough to fully wet the soil profile. Also notice how the 16-inch sensor tends to stay at about 14 to 15 cb between irrigations, indicating that there is little root activity at that depth. Most of the water is being taken up at shallower depths as indicated by the drying (increasing soil water tension values at 4- and 10-inches) between irrigations.

moisture sensor available.

When a soil is saturated, a tensiometer will read 0 centibars (cb) — your tensiometers should never read 0 cb except for a brief period after irrigation or a saturating rain (Figure 1). As the soil becomes drier and the plant roots have to work harder to extract moisture the readings will increase. A dry soil will likely be in the 60 cb range for many of the soils that we grow avocados on. In general, you should try to manage your irrigation such that your tensiometers read between about 10 to 20 cb right after irrigation (when the soil is at field capacity; Figure 2) and don't exceed 60 to 80 cb before the next irrigation.

How long it takes for your tensiometers to move from wet to dry depends on the soil texture, tree size and canopy health, temperature and relative humidity, and whether or not your grove is well mulched. Coarse textured soils (sand) will dry out more quickly than fine textured soils (clay). If you're new to using tensiometers, or you're using them in a new location for the first time, it is important to look at them often (every 2-3 days). By reading your tensiometers often, you will begin to understand the dynamics at play within your grove and how quickly your soils dry out under different conditions.

Figure 3 shows the general relationship between soil water depletion (horizontal axis) and tensiometer readings (vertical axis) for various soil types and is a good starting point for calculating when to irrigate your trees. Soil water depletion is the percentage of water in the soil between saturation and the permanent wilting point. You don't want your trees to experience saturated

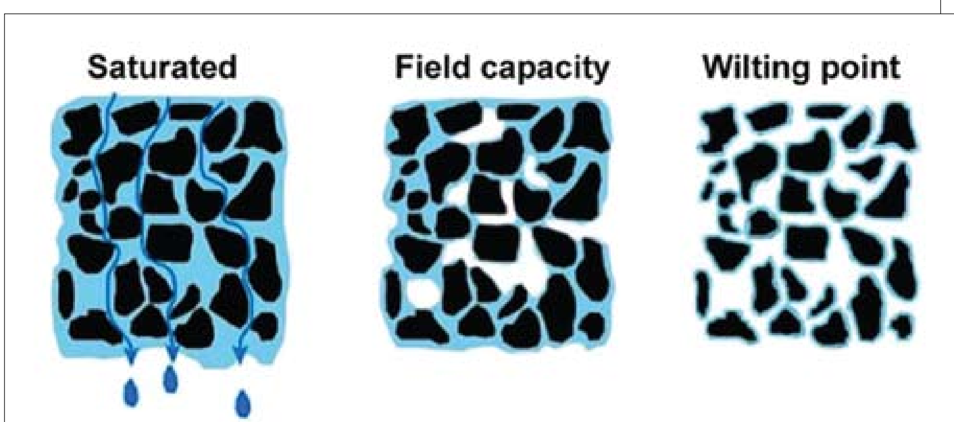


Figure 2. An illustration of the three phases of soil moisture — saturated, field capacity and the permanent wilting point. At saturation (0 cb), all of the soil pores are filled with water, but the water is held weakly and the large pores will empty by gravity. At field capacity (about 10-20 cb), the large pores have drained and filled with air, but the smaller pores remain water filled and no more drainage will occur by gravity. At permanent wilting point (>100 cb, will vary by soil type), the water remaining in the soil is held very tightly to the soil particles by adsorptive forces and the plant roots are unable to overcome these forces to extract more water.

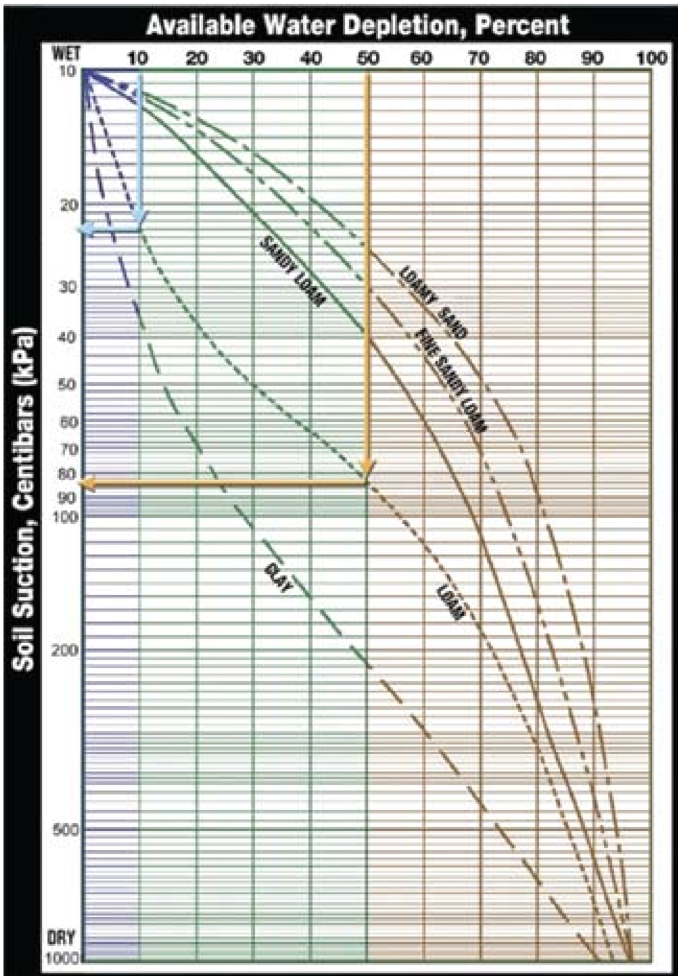


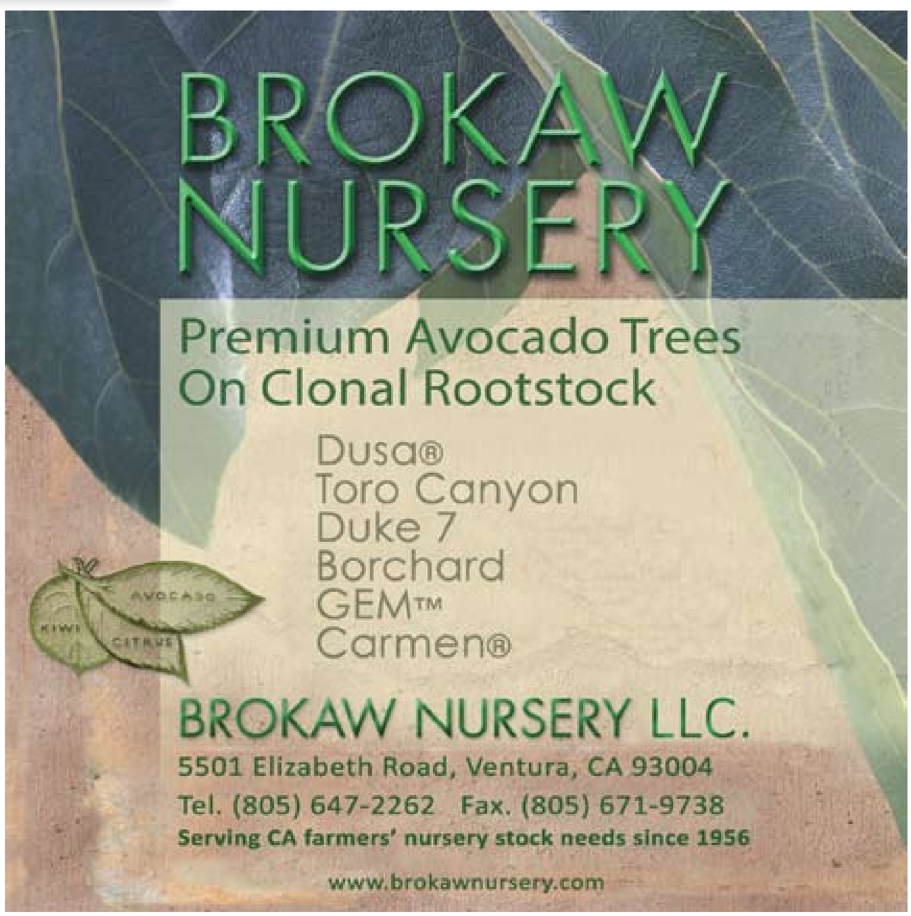
Figure 3. A graph showing the relationship between available water depletion (horizontal axis) and soil suction (tensiometer reading; vertical axis) for different soil types. The greater the available water depletion, the dryer the soil (left to right on the graph). As soil dries, the soil suction increases (top to bottom on the graph). Figure courtesy of Irrometer, www.irrometer.com.

conditions (0-10 percent depletion) or very dry conditions where it is difficult for the tree to extract water (>50 percent depletion).

How many soil moisture sensors do you need?

Determining how many soil moisture sensors you need is quite easy and is directly correlated to variability. If you have a well-designed irrigation system with good distribution uniformity (≥ 85), your grove is flat with one uniform soil type, and your trees are a uniform size and age, you need two sensors. You need to have at least one pair of sensors in each soil type in your grove and in a representative block for each different aspect (north, south, east, west). For groves on hills, it's also a good idea to have sensors at the top and bottom of slopes to be sure your system is not overwatering the downhill trees and underwatering the uphill trees. Lastly, you will want a pair of sensors in blocks of different age trees since young trees have different water requirements than mature trees.

A pair of sensors is composed of two separate sensors placed at a shallow and deeper depth. I like to see sensors placed at about 4 inches and 12 to 16 inches. You can add additional sensors in between if you want, but they're not critical. The shallow sensor will tell you when to turn on your irrigation. It also lets you know when, during your irrigation set, the water has begun moving into the soil profile. The deeper sensor tells you when you have fully wetted the soil profile. When your deeper sensor reaches your target reading (e.g., 10 cb) you can turn your system off. If you are doing a leaching irrigation to move salts below the root zone, leaching begins when your deeper sensor reaches your target reading.



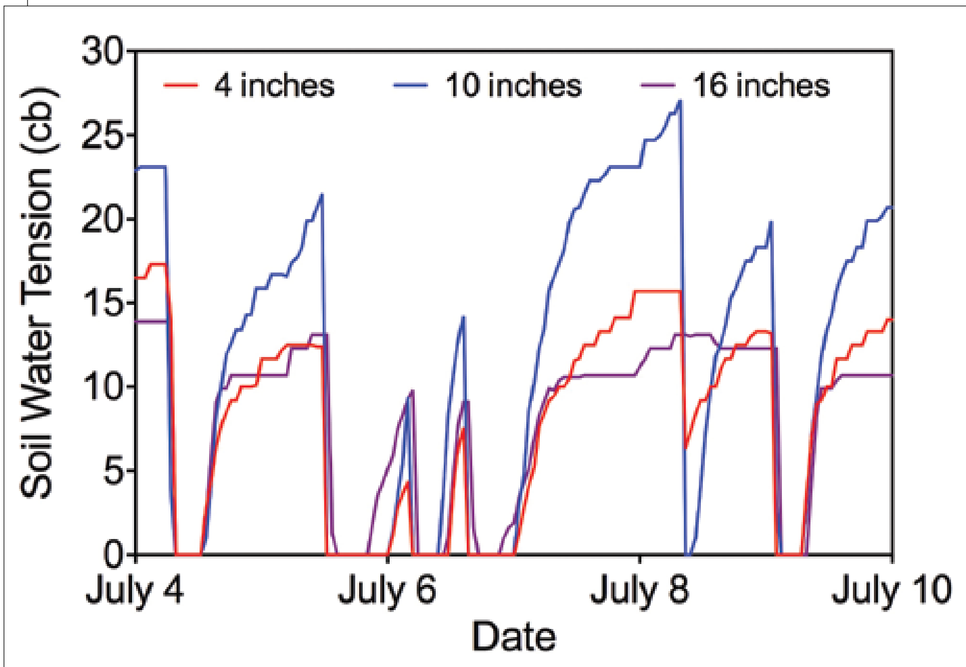


Figure 4. Soil water tension readings from a block at Pine Tree Ranch, Santa Paula, for a week during July 2018. Note the sustained irrigation that was made on July 5 (all sensors at 0 cb) prior to July 6 heat wave. Notice how in the days after the heat wave, the 4-inch sensor readings are relatively flat between irrigations. This shows that there was a partial die-off of surface roots due to the excessive heat. However, soil drying at the 10-inch depth indicates that those roots were still active and helped the trees recover following the heat wave.

Watching your soil moisture sensors on a regular basis and plotting the readings on a graph can tell you a lot about the health of your trees' root systems. In Figure 4, you can see how following the July 6, 2018 heat wave there was little root activity at 4-inches in the days following the heat wave, as indicated by the relatively stable soil tension readings. This was likely because the shallow roots died from the excessive heat.

Fundamentals of good irrigation system design

Your irrigation system should be designed to uniformly apply water over a given block. To achieve this, you should consult with a qualified irrigation design specialist when you are laying out your grove. When you are deciding how to lay out your irrigation blocks, consider your different soil types. Each soil type will behave differently so irrigation blocks should not contain a mix of soil types if at all possible. Also consider what direction a block faces if you're growing on slopes. Southern and western exposures will receive more sunlight, generally be warmer, and require more frequent irrigation than northern and eastern exposures. The same principle applies for a wind-exposed versus a wind-sheltered slope.

Utilize pressure-compensating drippers or microsprinklers to ensure uniform water distribution, especially on slopes. The Irrigation Technology and Research Center (www.itrc.org) at Cal Poly San Luis Obispo has independently tested many of the available pressure compensating drippers and microsprinklers on the market. The majority of products tested do not perform as well as manufacturers report. Be sure to use emitters that have been independently tested to perform under the conditions of your system.

How can you improve the irrigation of an existing block?

For existing blocks that may not follow the guidelines above, you can compensate for soil type and/or exposure by making adjustments to your system. First, you will need to install soil moisture sensors in the various areas of the block — different soil types, top of slope and bottom of slope, different exposures. After installing the sensors, follow the Goldilocks principle — assess which parts of your block are being overwatered, which are being underwatered and which are just right.

In the overwatered areas you can change out the microsprinklers for lower volume ones. If there are entire lines that are being overwatered, you can install valves to turn those lines off and only irrigate them every other irrigation or at some other interval. In underwatered areas, the microsprinklers can be upsized to get more water to these areas. Consider making adjustments to your underwatered areas first. The changes made to apply more water to these areas may cause a reduction in flow to your overwatered areas and correct or reduce the overwatering.

Growing avocados starts with good irrigation management. Correcting irrigation issues can go a long way to helping mitigate root rot and makes nutrient management in your grove easier. Get the irrigation right and your job as an avocado grower will be much easier and enjoyable.