Better Growing

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Optimizing Avocado Irrigation Management Practices Using Soil Moisture Sensing

Introduction. Irrigation scheduling is one of the most critical management decisions that affects avocado tree growth, fruit yields and profitability. It is an effective tool to enhance water use efficiency and productivity which not only may result in water and cost savings but also may assist in sustainable future expansion of the avocado industry. Importantly, avocados are very sensitive to overwatering and underwatering and long-term tree health is affected by proper irrigation management. Avocados for the most part are grown in coastal California where weather patterns are erratic, and a fixed irrigation schedule can easily lead to improper irrigation management.

Understanding the effects of irrigation events on soil water content provides critical insight for farmers about the present growing environment, the frequency and duration of irrigation events needed, and to maintain adequate soil moisture for avocado trees. There are instances where irrigation events occur too often and for far longer periods than required to reach field capacity (the amount of soil water content held in the soil after excess water has drained away following an irrigation event) in avocado orchards. There are also instances where irrigation events occur improperly, and more frequent irrigations or a greater amount of water in some events could improve soil water conditions for healthy tree growth. A soil moisture sensor is a proven and useful irrigation tool that can provide answers to the following critical questions:

- What is the water status of the soil early in the irrigation season?
- When is the right time for the first and subsequent irrigation events?
- Is the soil profile full after each irrigation event?
- What is the length of irrigation time?
- Should the irrigation practice be changed?

Soil moisture sensors appear to be the most adopted irrigation scheduling tool in California avocados. Nearly 46% of growers who responded to our recent avocado irrigation management survey reported using soil moisture sensors as the key decision-making irrigation tool (Fig. 1). It needs to be noted that avocado growers also use plant observations and calendars in combination with other irrigation tools including soil moisture, CIMIS (California Irrigation Management Information System; https://cimis.water.ca.gov/), and the avocado irrigation scheduling calculator (http://avocadosource.com/tools/irrigationcalculator.asp).

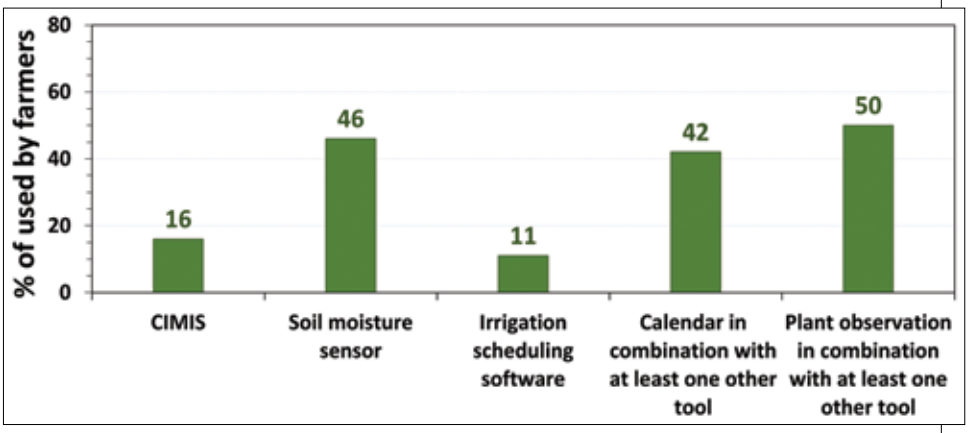

Fig. 1. The percentage of farmers who use different irrigation scheduling tools in their avocado orchards. Results are obtained from our recent avocado irrigation management survey completed by 62 California avocado farmers.

Soil moisture sensor selection. An extensive range of soil moisture sensors/probes have already been commercialized and are available to use in avocado orchards. They determine the real-time soil water potential (tension) or volumetric water content and are dominated by a small number of technologies including granular matrix or gypsum block sensors, tensiometers, time domain reflectometry (TDR) sensors, and Frequency Domain Reflectometry (FDR) or capacitance sensors (Table 1 and Fig. 2). Some commonly used soil moisture sensors can be combined with various telemetry devices to access the data through cloud-based data storage applications. Data is automatically uploaded by radio or cell phone communications to cloud-based computer servers and is accessible through apps on smartphones and tablets. These communication advancements greatly improve the convenience of accessing data and can be configured to provide timely alerts when trees require irrigation.

The results of our avocado irrigation management survey demonstrated that avocado farmers dominantly adopted tensiometer and watermark soil moisture sensors. However, some other sensors such as AquaSpy, Sentek, CropX, Hortau, Meter, and GroundWorx are also used in avocados (Fig. 3). Different types of soil moisture sensors have different accuracies, depending on the sensing technology used and

Fig. 2. A demonstration of commercialized soil moisture sensors.

Table 1. A summary of commercialized soil moisture sensors.

Technology	Measurement (key parameters)	Manufacture
Granular matrix	Soil water potential	Metergroup, Irrometer
Tensiometer	Soil water potential	Hortau, Irrometer, Metergroup
TDR	Volumetric moisture content (and soil temperature and salinity)	Acclima, Campbell Scientific, Metergroup, Environmental Sensors, Spectrum Technologies
FDR or Capacitance	Volumetric moisture content (and soil temperature and salinity)	AquaCheck, AquaSpy, Metergroup, Sentek Technologies, Spectrum Technologies, CropX

Table 1. A summary of commercialized soil moisture sensors.

Fig. 3. Various soil moisture sensors used in California avocado orchards (Acclima, Watermark, and tensiometer soil moisture sensors and telemetry devices (a & b), CropX soil moisture probe (c), and Metergroup Teros 54 soil moisture probe (d)).

the property of the soil. For instance, the readings of electromagnetic sensors tend to have larger errors in soil with higher clay content. The salinity of soil and/or irrigation water is another factor that can increase sensor error.

While considering the sensors that might work best for your own orchard depending on soil properties and cost (a wide range of less than $100 to more than $300 per sensor plus datalogger/telemetry components and yearly data subscription costs), it is also critical to learn where and how to install and maintain the sensors, and how to interpret and use the data of soil moisture sensors for irrigation management. Most soil moisture sensors have sufficient accuracy, and if properly installed in the right place, they may provide high quality useful data to answer the critical questions mentioned before.

Location of soil moisture sensors. The proper location of a soil moisture instrument within the active root zone is quite important. Given the high spatial variability of soils in avocado orchards on hillsides and seasonal changes in root distribution and – frequency, both within the orchard and around the trees, – the accuracy and representativeness of soil water measurements can be strongly affected.

In selecting the best location for placing a soil moisture instrument, one must consider at least two factors: first, the representativeness of its placement within the orchard, and second, the location around the avocado tree itself. Within the avocado orchard, the ideal situation for instruments is in a homogeneous area that is representative of the orchard as a whole, considering both trees and soil (use soil sampling and/or soil survey tools such as http://websoilsurvey.sc.egov.usda.gov to map you soils on the orchard). Having one soil moisture probe per irrigation block could be very beneficial for the effective monitoring of the entire avocado orchard. In addition, around the selected trees, the sensor should be placed at a soil depth and distance from the tree trunk where the highest concentration of root activity is located. The direction, as in-the-row or between-the-rows, should also be considered, particularly as it relates to the irrigation method being used. Drip irrigation tends to concentrate roots within as many soil wet bulbs as there are emitters, and micro-sprinklers (usually one per avocado tree)

California Avocado Commission 2025 Meeting Schedule

The California Avocado Commission encourages growers to engage with Commission Board members and staff by attending meetings throughout the year. Below is the current Commission meeting schedule for 2025, which is subject to change. As indicated below, some Commission meetings are in-person only. Please visit the grower website, CaliforniaAvocadoGrowers.com, for the most up-to-date information.

February 20, 2025 – CAC BOARD MEETING
- Location: Hilton Garden Inn, Temecula

March 25-27, 2025 - CAC ANNUAL MEETINGS (IN-PERSON ONLY)
- March 25, 2025 – South Coast Winery
- March 26, 2025 – Museum of Ventura County
- March 27, 2025 – SLO Farm Bureau

June 4-5, 2025: CAC BOARD MEETING (IN-PERSON ONLY)
- Location: Pasadena

August 14, 2025 – CAC BOARD MEETING
- Location: Ventura County

September 2025 – CAC FALL GROWER MEETINGS (IN-PERSON ONLY)
- Dates TBD – Three separate meeting dates with locations in Riverside/San Diego County, Ventura County and San Luis Obispo County

October 9, 2025 – CAC BOARD MEETING
- Location: Orange County

November 20, 2025 – CAC BOARD MEETING
- Location: Orange County

concentrate roots in a larger wet bulb, often located between the trees and within the row. The soil moisture sensor should be set up somewhere between the tree and micro-sprinkler, not very close to the tree nor very close to the micro-sprinkler.

Soil moisture data triggers irrigation events. The major pitfall of the soil-based irrigation norms using soil moisture probes is that irrigation scheduling is carried out according to the properties of the soil, while the water status of the plant is not taken into consideration. An assumption is made that the plant would not stress if soil water content at the effective root zone is kept within the recommended ranges of soil water content, usually field capacity and 50% depletion of easily available water. If the sensor is not in the right place or the avocado root system is not healthy, the measured soil moisture will not truly assess the tree moisture status.

Avocado growers who schedule irrigation based on soil water balance could use a depth of up to 24 in. (called irrigation depth and is recommended to monitor water drained below effective crop root zone of avocado trees), where more than 70% of roots are found. Data from the sensor installed at 8 - 12 in. depths could be considered as a good indicator for irrigation management. For instance, those who read the in-field soil water potential from tensiometer and/or watermark sensors may trigger irrigation when soil water potential reaches between – 20 (20 if it is called soil water tension) and – 40 centibar (cb) at the shallow depth. In order to provide adequate water, irrigation is normally started when the soil dries to -25 cb for sandy soils, or to 40 cb for clay soils. These numbers could be considered greater in late fall through winter when temperature is low, and the water and heat stress are not likely potential issues. This provides optimal water availability that does not restrict plant growth. The amount of available water remaining in the soil profile at this given time determines the need for irrigation.

An interpretation of soil moisture data from avocado orchard case studies. Half-hourly soil water tension (potential) at 12 in. depth was measured using watermark sensors in two avocado sites, site A with a sandy loam soil texture and site B with a silty loam soil texture (Fig. 4). The data demonstrates that the soil water was maintained within the optimal range in both sites A and B due to the frequent irrigation events, while there was room to optimize irrigation management practices in these avocado sites. For instance, a moderate water stress could have occurred in mid-June 2022 at site A, when the soil water tension exceeded 70 cb, due to a late irrigation event. Also, scheduling a light irrigation event in mid-February 2023 at site A could benefit avocado trees. Even though considerable precipitation occurred in winter 2023, there was no rain event between late January through February 20, 2023, at this site, and consequently, the soil water tension exceeded 100 cb for a short period of time until new precipitation occurred in late February.

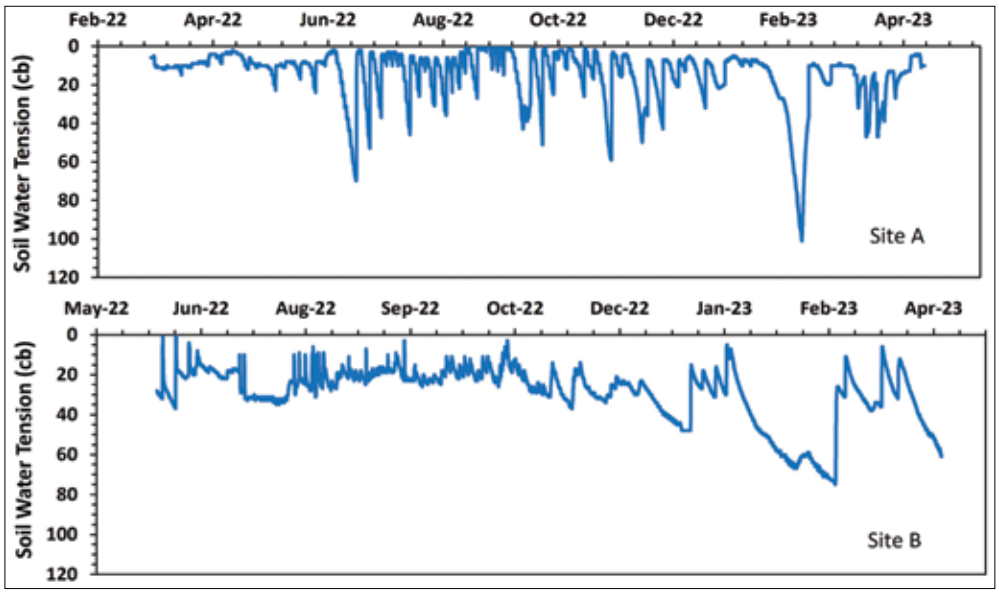

Fig. 4. Half-hourly soil water tension (centibar) measured using watermarks at 12 in. depth in two different avocado orchards over nearly a 12-month period. Sites A and B have sandy loam and silty loam soil textures, respectively. Soil water tension at field capacity (FC) at site A and B is approximately 12 and 20 cb, respectively. Both sites have micro-sprinkler irrigation systems with a flowrate of 9.5 and 7.4 gallons per hour (per tree).

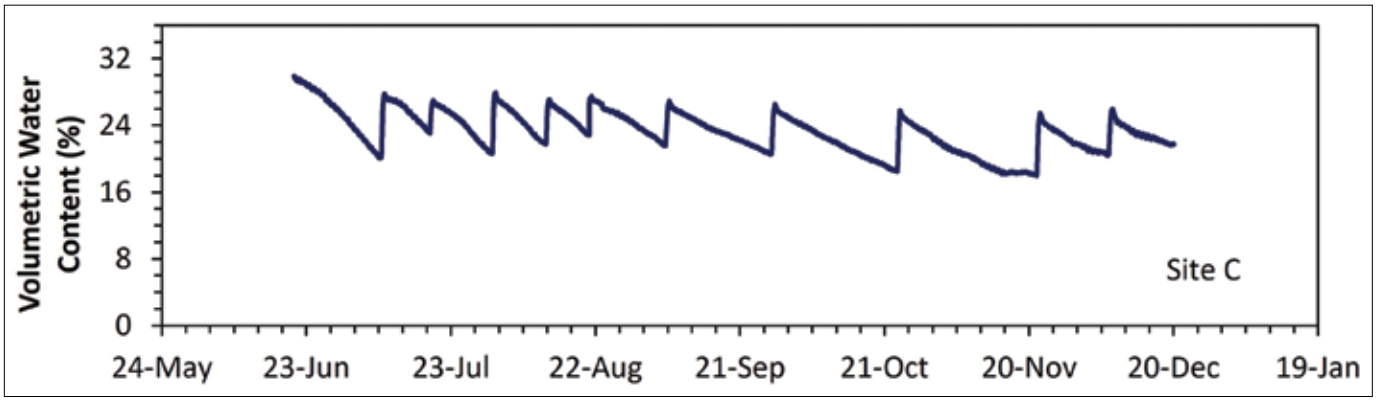

Fig. 5. Half-hourly soil volumetric water content (%) measured using CropX soil moisture sensor at 8 in. depth in an avocado orchard over a six-month period. The site has a loamy soil texture. Soil water content at field capacity (FC) at site C is approximately 28%. The site has a micro-sprinkler irrigation system with a flowrate of 7.9 gallons per hour (per tree).

Site B was occasionally overirrigated during the summer but again one irrigation event in mid-February 2023 could have been recommended for this avocado site as well, to maintain soil water status at a desired level in the late flower bud development growing phase. The soil moisture data indicates that less frequent irrigation events at site B and shorter irrigation runs at site A could be considered in the summer period to improve irrigation efficiency.

A good example of proper irrigation scheduling in avocado orchards is what happened in a 6-month period at site C (Fig. 5). The loamy soil of this site has high water holding capacity and the grower scheduled 10 irrigation events between mid-July and mid-December in the 2023 season. As a result of proper irrigation management at this site, the volumetric soil water content at the effective root zone was maintained at an average of 23.5% over the period. No considerable overirrigation or potential water stress was observed, as soil moisture was adequately maintained throughout the study period.

A few last comments. We need to keep in mind that adopting soil moisture sensors and effectively using them to fully obtain the benefits and optimize irrigation scheduling in avocado groves could be time consuming. Making a habit of having them in avocado groves and looking at their data is likely the most critical step of the adoption process. One might be disappointed about the accuracy and the effectiveness of this tool in the beginning, or even find soil moisture data redundant. A learning curve and good approach to effectively adopt soil moisture sensing in avocados could be to track the data for good quality over a period with several irrigations and/or rain events, accurately interpret the data for the period, implement changes needed in the irrigation practice accordingly, and track the impact for a following short period. Ensure good quality data, learn to interpret the data, and take action(s) for improving irrigation practices if needed!