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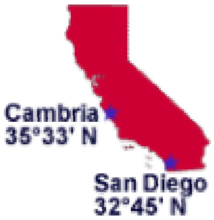
Avocado Irrigation in California



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Approximately 25,000 ha of California 'Hass' avocados are grown in a 600 km swath along the coast and inland about 60 km. The climate is mediated by the ocean and frost is rare. There are small plantings in the Great Central Valley, but these are limited to more cold tolerant varieties, such as 'Bacon' and 'Zutano.' Most of the trees are over 15 years of age, but there are a large number of orchards that are new, planted to root rot resistant rootstocks. Many of these new orchards have replaced less valuable orange and lemon acreage, but many are replanted older avocado orchards that have died of root rot. In replanting on flatter ground, growers will build 60 cm high berms to reduce water logging. Most groves that are replanted will also use a chipped yardwaste as a mulch to combat root rot.

With this great range in distance of these plantings, water requirements vary substantially. In the cooler north where there is more and extended rainfall, growers typically apply about 4,500 m^3ha^{-1}, while in the south growers will use between 10,000 and 15,000 m^3. This is for a typical rainfall year (250-500 mm), and in years with less rainfall, application amounts are higher.

Water quality is also highly variable. This is mainly due to the source. Many growers use well water, especially in the north. Salinity, chloride, sodium and boron can be at extremely high levels, depending on the local geology. It is not unusual to find 1,500 ppm salinity, 100 ppm chloride and sodium and 0.5 ppm boron. The dominant cation in these waters is calcium and to a lesser extent magnesium. In low rainfall years, it is common to see tip burn (salt damage) without the rain's leaching effects.

In the south, growers are more likely to use water that is from the Colorado River, and to a certain extent from the Feather River which is 1,500 km north of San Diego. The Colorado salinity runs at about 700 ppm and chloride and sodium are about 80 ppm. The Feather River water quality is better, but it is substantially more expensive.

As variable as the source of water is, so is the price. Some growers pumping out of rivers pay as little as US$0.008 m^3 and those growers using Feather River water are paying US$0.25. With the larger water requirements in the south and the higher prices, some growers are spending as much as US$5,000 ha^{-1} just to irrigate trees. This is not economically viable, and slowly the higher priced growers are going out of business.

This higher priced water is still subsidized to a certain extent by the water districts under the agreement that in low rainfall years, growers would be subject to delivery reductions.

Also depending on the source of water, delivery can vary. Growers with their own wells, decide when and how much water they will apply. However, most of the deliveries in the south are by water districts. These semi-public organizations contract for wholesale water, then retail it to growers. Water is delivered on demand for a specific period of time or volume. In many of the older districts, prior to the 1950's, water is on a rotation of some sort. For example, a grower will get water every two weeks for 24 hours. This complicates meeting the needs of the trees with an inflexible delivery schedule. It is often these older districts where root rot started and is still the worst. Because of the threat of root rot, avocado growers as a group are some of the best irrigators in California.

When a grower does have the opportunity to schedule irrigations, many will use one of several methods. The wetted root volume will determine the amount available to the tree. In most cases, young trees are started off with a dripper or a modified microsprinkler with a cap that can be removed in the future to wet a larger area. Most growers convert to microsprinkler or fan jet about year two or three to reduce dripper maintenance and to wet a larger area or the root system. Only a few older orchards still have high pressure, solid set systems. Scheduling is done on both a fixed volume basis, altering the interval between irrigations, as well as a fixed interval, altering the volume. A leaching fraction is included depending on water quality.

In scheduling, there are three basic techniques of assessment. These are based on either plant, soil or weather measurements. Devices such as porometers, stem flow gauges, pressure chamber or infrared are used only in research settings. They do no lend themselves to commercial agriculture because they have limitations such as cost, fragility, labor intensity or maintenance.

More commonly used in commercial agriculture are soil-based ones. Soil-based methods monitor some aspect of soil moisture which, depending on the method, requires a 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 with 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 roles 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 and gypsum blocks can now be found with digital readouts and connections to data loggers which make data easier to manage. 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
Porous blocks	L	H	M	H	L	Yes
Tensiometer	L	M	H	M	L	Yes
Portable tensiometer	M	M	H	M	L	No
Time domain reflectometer	H	M	H	H	M	Both
Neutron probe	H	L	H	H	L	Yes
Feel (soil probe)	L	H	H	H	L	No
Gravimetric	L	M	H	H	L	No
Frequency domain reflectometer	M	H	M	H	M	Both
Time domain transmometer	M	H	H	H	M	Yes
Amplitude domain reflectometer	M	H	H	H	M	Yes
Phase domain transmometer	M	H	H	H	M	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 be both. The "Ease of Use" category in the table indicates not just the ease of reading the device, but also the maintenance.

All of the techniques require that someone pay attention to them. Many of the devices can be downloaded onto a computer either directly, through radio signal or infrared. Then the manager/grower can make the readings from the office. There are quite a number of growers who do go out and read their tensiometers on a regular basis and schedule irrigations based on those readings. There are also a lot of rusted tensiometers out in the field where growers gave up on using them.

Weather-based techniques, such as evaporation pans have been used for many years, but few growers have employed them because of their maintenance. In the mid 1980's a state wide program for estimating evapotranspiration with automatic weather stations was installed. ET based scheduling has been adopted by many large field and tree crop growers, managers and consultants.

In much of the avocado growing areas, trees are planted on hills with different slopes and aspects, so even if the grove is near a weather station, the ET values may be quite different. We measured ET on four sides of a hill, at the base, midway and at the top. We found that there could be as much as 120% difference in ETo between the top of the slope and the shaded side in the winter and there was still a 32% different in the summer.

To circumvent this problem of using the state weather system, some growers have installed atmometers in various positions of their hilly orchards. These can be used with a data logger and downloaded periodically or installed with a wireless communicator. Unlike evaporation from a pan which requires a pan coefficient, the atmometer value can be used directly for reference ET. The maintenance on an atmometer is also much lower than with a pan.

Using ET to schedule irrigations is dependent on several assumptions 1) that you know what the crop coefficient (kc) is, 2) that salts are being dealt with by leaching and 3) that there is a high distribution uniformity to the irrigation system. Complicating these assumptions is that microsprinklers have an uneven distribution pattern, emitting water in an uneven pattern around the riser. Some put out a lot in the immediate surrounding and gradually less and less with distance and some put out more in the midrange. The question then becomes one of how much or little that water the root system is exposed to. The soil salinity then is going to vary with depth and distance from the emitter. And when we get little winter rain, we do not get the leaching we expect.

A number of studies have been done in California to determine the kc for avocado. It is approximately 0.7 for mature trees. With most of our waters we have a 10% leaching fraction, but that varies with water quality. In many of our groves, irrigation districts provide a yearly measure of distribution uniformity. Some growers will measure this themselves. In our hilly terrain a uniformity of 90% is considered good, this even though there is pressure regulation in the irrigation lines and the emitters. Irrigation blocks are broken down to a size that gets the best distribution uniformity. So with our kc of 0.7, our 10% leaching fraction and our 90% uniformity, growers using ET to schedule will put on approximately reference ET. And when it does not rain in the winter, the kc is not altered. An irrigation calculator can be viewed at the California Avocado Commission website - http://www.avocado.org/growers/irrigcalc.php.

Application frequency has been studied on a limited scale in California. Arpaia did a study comparing once, twice and seven times a week irrigation schedules. Leaves showed higher levels of sodium and chloride with the more frequent schedule because of salt accumulation in the root zone. There are some growers experimenting with more frequent schedules, but are on a once a week to 10 days schedule during the summer.

One of the greatest concerns for not only avocado growers, but all growers in the State, is the enforcement of new water quality regulations. The Clean Water Act was passed in 1972 forbidding the degradation of surface waters. Initially it was just enforced against industry, but is now being enforced against growers. No water is allowed off a grower's property that could hold contaminants, sediments included. There are few cases of irrigation water running off property, but in winter rains it is common. Growers are being forced to monitor water quality and if a problem is found, it needs to be corrected or the grower can be fined. So this is just one more thing for growers to think about when it comes to water.