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Avocado Irrigation - How to Deal With High Water Costs

Gary S. Bender and Margarita M. Engle—
Gary Bender is a farm advisor with Cooperative Extension in San Diego County; Margarita M. Engle is the team leader for the Mobile Lab, Mission Resource Conservation District. Fallbrook. California.

The existence of the avocado industry in southern California depends on a steady supply of irrigation water, much of which is brought in by aqueduct from the Feather River in northern California and the Colorado River. As a crop, avocados use about the same amount of water a year (on an acre basis) as vegetables — about 2½ to 3 acre-feet/acre in San Diego County. Skimping on water has the habit of reducing yields, fruit size, and tree vigor. Unfortunately, not only is the water expensive (averaging $315 per acre-foot); but now growers are faced with possible cutbacks in supply due to the three-year-old drought in California.

How can a grower deal with high water costs and possible cutbacks in supply and still grow avocados? Obviously, the time has come for careful water management and conservation, in addition to serious consideration of alternative sources of water.

Irrigation Evaluation

The first step is to determine whether you are wasting water due to an inefficient system.

An irrigation evaluation performed by one of several Mobile Irrigation Labs operating out of local resource conservation districts and/or Soil Conservation Service offices is one of the most important services being conducted for growers at the present time. The service is usually free or at very low cost.

The purpose of the evaluation is to measure the efficiency of the irrigation system and suggest possible improvement. Irrigation efficiency is the ratio of water beneficially used to total water applied. If the efficiency of the system is 50 percent, then half of the water is being wasted.

For most groves irrigated with micro-irrigation systems, irrigation efficiencies average around 70 percent. This means that 70 percent of the water applied has been beneficial to the crop (for growth, leaching, frost protection, etc.). The remaining 30 percent is lost to deep percolation, runoff, spray drift, and evaporation. The Mobile Irrigation Laboratory in Fallbrook has found efficiencies ranging from 27 percent to nearly 100 percent.

In the case where efficiency is as low as 27 percent, scheduling changes are almost certainly needed. The two most common causes of low efficiency are scheduling problems and poor uniformity of distribution of water (i.e., some parts of the grove receive more water than others).

Very high efficiencies do not always correspond to optimum water management. In a case where efficiency is 90 percent or more, summer under-irrigation is probably reducing yields.

Efficiencies this high usually mean that nearly all of the applied water is put to beneficial use because the trees are so thirsty they must use every single drop within reach of the roots, with nothing left over. Under-irrigation can have serious consequences. For every 10 percent under-irrigation, if there is no rain, a 10 percent yield loss can be expected. In addition, severely under-irrigated trees are weak and much more susceptible to frost damage. This occurs because well-irrigated soil has less air space, and heat conduction to the surface is more efficient. Also, moist soil is darker and absorbs and holds daytime heat for release at night.

How efficient should an irrigation system be?

Drip irrigation systems can be expected to run around 85 percent efficiency. Mini-sprinkler systems are doing very well at 80 percent. Increasing efficiency to a reasonable level saves water and money.

Assume a 100-acre grove applying 2 acre-feet of water per year, at a typical northern San Diego County cost of $300 per acre foot. The irrigation efficiency can be increased by modifying schedules and improving distribution uniformity. If the irrigation efficiency is improved from 65 percent to 75 percent, this means a potential savings of 10 percent of the applied water. Translate this into dollars: 10 percent of 2 acre-feet is a savings of 2.4 inches per acre. Multiply this times 100 acres to get 240 acre-inches. Divide by 12 to get 20 acre-feet. Multiply by $300. The grower has saved $6000 in one year.

How can irrigation efficiency be determined?

A computer program developed by Cal Poly is used to assess irrigation efficiency. A detailed analysis of water usage via water bills and/or pumping records from wells is necessary to provide input for the program. Other input data include the type of crop (for salt tolerance and water usage), number of days between irrigations, depth of irrigation water applied during an irrigation interval, visual estimate of runoff, type of soil (for moisture holding capacity), and area wetted during an irrigation period.

DISTRIBUTION UNIFORMITY:

Uniformity is a single concept. If uniformity is high, most of the trees in a grove are receiving the same amount of water. If uniformity is low, some trees receive much more water than others. In this case, the irrigator tends to run the entire system longer in an effort to get enough water on dry portions of the grove. The result: water is wasted, and wet portions remain below their yield potential due to over-irrigation.

Checking emitter discharge

An important component of the evaluation is the measurement of water output from a random sample of emitters. Bob Miller and Nile Peterson, former team leader and technician, respectively, for the Mission Mobile Lab, invented a device to measure discharge from mini-sprinklers.

Dubbed the "Mad Bee," it is constructed from a two liter soft drink bottle (Figure 1). The bottle parts are held together using a silicone gasket paste that can be found in most hardware stores. Using a watch, measuring cup, and the Mad Bee, water discharge per minute can be translated into gallons per hour, the first step to evaluation and scheduling.

To gain a rough idea of distribution uniformity, 16 flow samples per irrigation block should be collected using the Mad Bee. The four lowest discharge rates should be averaged, then divided by the average discharge rate from all 16 samples. For instance, an average discharge of 20 gallons per hour from the "low quarter" emitters divided by the discharge average of 25 gallons/hour from all 16 emitters would give a 0.80 distribution uniformity. A professional evaluator will usually measure the flow of at least 50 emitters per block.

Can uniformity reach 100 percent?

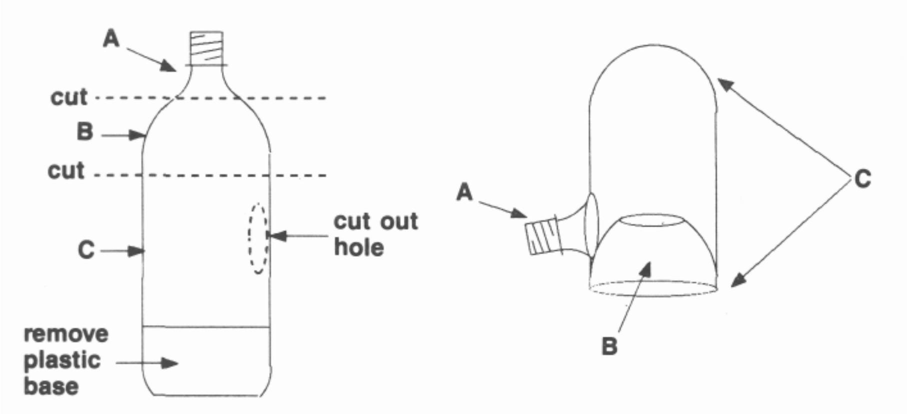
No! An irrigation system is performing very well at 80 percent uniformity. This means that 80 percent of the trees in the grove receive essentially equal amounts of water. Combined with scientific scheduling, high uniformity contributes to water conservation and optimum crop production.

How can uniformity be improved?

The uniformity of distribution of water in a grove results from two sources:

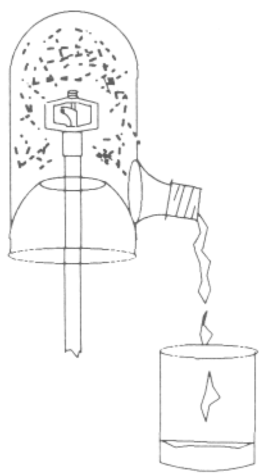
1. **Pressure variation**

If pressures are not properly regulated, trees at the top of a hill receive much less water than those at the bottom. Pressure variation is easily reduced by using manual valves and a hand-held pressure gauge to regulate all lateral inlets to 20 psi, by installing pressure regulators at each lateral, or even by adjusting the number of blocks irrigated at any given time.



A two liter soft drink bottle can be cut, as shown above, to create a device (dubbed the "Mad Bee" by its inventors, Nile Peterson and Bob Miller) to allow accurate measurement of mini-sprinkler discharge. The bottle parts are held together using a silicone gasket paste that can be found in most hardware or auto parts stores.

Using a watch, measuring cup, and the Mad Bee, water discharges from most mini-sprinklers can be measured and flow rates can be calculated.



2. Sprinkler/emitter performance

The most common causes and solutions to performance problems:

PROBLEM	SOLUTION
Use of more than one sprinkler or emitter model within a single irrigation block, resulting in higher application rates on some trees than on others.	Standardize by selecting one appropriate model
Plugging of sprinklers or emitters.	Install a tubular screen filter for mini-sprinklers, sand filter for drip. Check for plugging with every irrigation.
Wear of nozzles	This is only a problem on long lasting sprinklers such as brass twirlers and impact sprinklers; check for wear by inserting a drill bit into the nozzle to see whether the size has changed; replace worn nozzles.

How much water is saved by improving uniformity?

Let's look at the results of an actual field evaluation: At 48 percent uniformity, one grove manager needed 20 hour sets to provide mature avocado trees with enough water throughout the grove. By regulating pressures using existing manual valves, standardizing to a single sprinkler model, and filtering to reduce plugging, the uniformity increased to 82 percent. This reduced set times from 20 hours to 14 hours, saving 24 gallons per tree per day during the peak water use season. Significant annual water and dollar-savings are inevitable.

Uniformity is often overlooked.

Growers know that mature avocado trees in San Diego County, at a 20' x 20' spacing, generally require around 40 gallons of water per tree per day during the hottest part of summer. What is often omitted from scheduling calculations is the extra water needed when uniformity is low. At 48 percent uniformity, applying an average of 40 gallons per tree may result in some trees receiving 60 gallons, while other receive only 28. This is a common error when using a metering valve to determine a set time.

THE EVALUATION PROCEDURE

What happens when you call the Mobile Irrigation Laboratory?

1. Your name, phone number, and crop information are placed on a waiting list. You are asked to tabulate records of annual water use, using your water bills and/or pumping records.
2. As soon as possible, the irrigation evaluation is scheduled.
3. On the day of the evaluation, you will be asked to provide information concerning schedules, filtration, injection, leaching, etc.
4. Mobile Lab personnel spend several hours taking field measurements of pressure, discharge rates, soil characteristics, etc., during a typical irrigation.
5. Data from field trials are taken back to the office, and are analyzed using computer programs developed by Cal Poly San Luis Obispo and the Department of Water Resources.
6. Within two weeks, a detailed report is returned to the grower or manager who requested the evaluation. The report is strictly confidential.

The report includes:

a. An estimate of irrigation efficiency based on water use records, and an estimate of potential savings.

b. The determination of distribution uniformity, causes of non- uniformity, and recommendations for improving uniformity.

c. Scheduling guidelines based on average weather conditions, uniformity, soil characteristics, canopy size, spacing, etc. Scheduling guides recommend set times and frequencies needed to meet the water requirements of the "low ¼", or the 25 percent of trees in the grove receiving the least amount of water.

7. After at least a year has passed, Soil Conservation Service staff will call the grower/manager to ask follow-up questions about the effectiveness of the evaluation.
8. After one year has passed, or whenever major design modifications have been made, the evaluation can be repeated.

IMPROVEMENTS IN SCHEDULING

Use of daily CIMIS (California Irrigation Management Information System) data has given the grower the information needed to schedule irrigations to meet daily evapotranspiration (ET) demands. Daily ET can be obtained in the Rancho California area by calling (909) 676-4435, or in Ventura by calling (805) 388-8425. CIMIS weather stations in San Diego County include Escondido, Mission Valley, and Oceanside. Data from these stations may be obtained by using a computer modem, or by calling the

Farm Bureau at 1-800-336-3023 to get a weekly average ET. To hook up to your computer modem for ET information (via Sacramento), call Gloria Pacheco (Dept. of Water Resources) at (916) 445-8168.

A CIMIS worksheet using actual data from the Rancho California Station is presented below. The example presented is for mature avocados using a 0.5 crop coefficient and 0.75 emission uniformity. Emission uniformity values are supplied to the grower by the Mobile Labs; higher values = more efficient system = less water use.

Step 1. Record ET for past seven days:

August 30	0.22	
August 31	0.22	
September 1	0.19	
September 2	0.21	
September 3	0.35	Santa Ana winds and
September 4	0.40	100 degree temperatures
September 5	0.31	
Average ET/Day =	0.27	

Step 2. Multiply by 0.5 to get ET crop (ETc) = 0.27x0.5 = 0.14 (ETc)
Step 3. Divide by 0.75 (emission uniformity) = 0.19
Step 4. Multiply by 27,154 to give gallons/acre inch = 5159
Step 5. Divide by 100 trees per acre = 51.6 gallons/tree/day

Scheduling is done by knowing your emitter and soil type. If your mini-sprinklers put out 20 gallons per hour, you would have had to run your system two-and-a-half hours a day, or seven-and-a-half hours every third day, to resupply the average soil with water that has been extracted by the tree during this week. Note that, in this case, you are scheduling based on an early September ET: if the weather changes, adjustments must be made.

It should be noted that crop coefficients are currently being developed for avocados at the University of California's irrigation plot in Corona. Coefficients currently range from .35 in January to .55 in August.

Fine Tuning the System

Scheduling irrigations on a weekly basis is important, but monitoring soil moisture **in your own grove** is critical.

Each irrigation block should have a pair of tensiometers measuring soil moisture at the 12-inch and 24-inch depth levels in the wetted rootzone. Tensiometers should be pumped once a month to remove air bubbles. If the tensiometer is reliable, we usually suggest avocado irrigation (mini-sprinkler) at a reading of 25 centibars (cb) and citrus at a reading of 40 cb (sandy loam soil).

Walking the lines? This is the least appealing, yet probably the most important part of system maintenance. Emitters break off, spiders lay eggs in drippers, coyotes chew holes in drip lines, branches grow into and block sprinkler patterns. Proper irrigation consists of more than just turning the water on and off.

Irrigation Reduction

Data from the University of California irrigation experiment being conducted in Corona have indicated that, in the first year's harvest, a 20 percent cutback in water (from 100 percent ETc) did not reduce yield. The yield data are preliminary and could change next year, but are worth noting. Cutbacks should not be done unless your system has a high degree of emission uniformity.

Top Working and Pruning

If worse comes to worst, and cutbacks in irrigation become mandatory, it might be a good time to prune trees back for canopy height reduction. If the grower desires to topwork to a different variety, this would be the time to do it. Stumping is a rapid way to reduce water use, yet keep trees alive.

Water savings could also be achieved by capping sprinklers to root-rot-affected trees and black streak or freeze-damaged trees.

Alternative Sources of Water

Figures from the San Diego County Water Authority indicate that 167 gallons of water are used per capita per day in southern California, yet only '/2 gallon of that amount is used for actual drinking. Is it necessary to require water for all uses to be treated to potable drinking standards?

Sewage effluent is a partial solution to our long range water crisis. Even if the Metropolitan Water District cuts back on "surplus" water for agriculture, agriculture will always get first priority for reclaimed sewage water. Other advantages include high nitrates (it may be possible to cease fertilization), less ocean pollution, and lower water costs.

Sewage water can be cleaned of debris and chlorinated, but delivery to the grove has always been a major obstacle. Other problems with reclaimed water which need to be worked out are elevated salinity levels (a problem both for the plant and to underground storage), insuring that grove workers will not drink the water, and possible heavy metal contamination from industrial sources.

With the future availability of some 35,000 acre feet/year from a sewage treatment plant being built in Murrieta, Rancho California is planning to use the existing water system to transport effluent to the groves in their water district. A new, much smaller system, will be installed to carry drinking water to residents in the area. Fallbrook and the Rainbow Water District are considering doing the same thing. Currently under way is a marketing study to determine how many growers would be in agriculture in the future if they could receive effluent water at the same or lower cost. Plans are being drawn to re-plumb

Fallbrook, using small reservoirs currently not in use.

By supplementing our water supply with the large source of (heretofore) untapped reclaimed sewage water, and by improving irrigation efficiency within the grove, we are hopeful that avocados and other agricultural crops will be profitably grown in southern California for many years to come.