Irrigation Management

The CCA Cherimoya Handbook

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Introduction

There are a large number of irrigation choices available to a grower. In the past growers were limited to flood, furrow, and high pressure sprinklers. In the 1970's drip irrigation became available and subsequently a great number of other low-flow systems were developed.

Low-flow systems include drip, microsprinklers, fan sprays, and a host of new technologies coming on the market, such as vortex emitters and fan jets.

Low-flow is distinctive in that emitter output is measured in a few gallons per hour rather than minutes. Using low-flow emitters versus high-flow impact sprinklers allows for lower operating pressures which, in turn, permits use of lighter weight, less expensive, and easier to build systems.

Relative to high-flow, full pattern sprinklers or surface methods like furrow, low-flow systems have the potential of improving irrigation and chemical application efficiencies, and reducing weed growth and energy requirements. These advantages come at a cost.

More maintenance is required on the low pressure systems, the root zone is restricted to the wetted pattern, and there is increased potential for salt accumulation in the root zone.

Most cherimoyas are grown on low-flow systems, so this chapter will discuss the components of this type of system. However, the principles of water management are generic for all systems. These principles strive to ensure a healthy, producing orchard.

The Irrigation System

Irrigation System Components

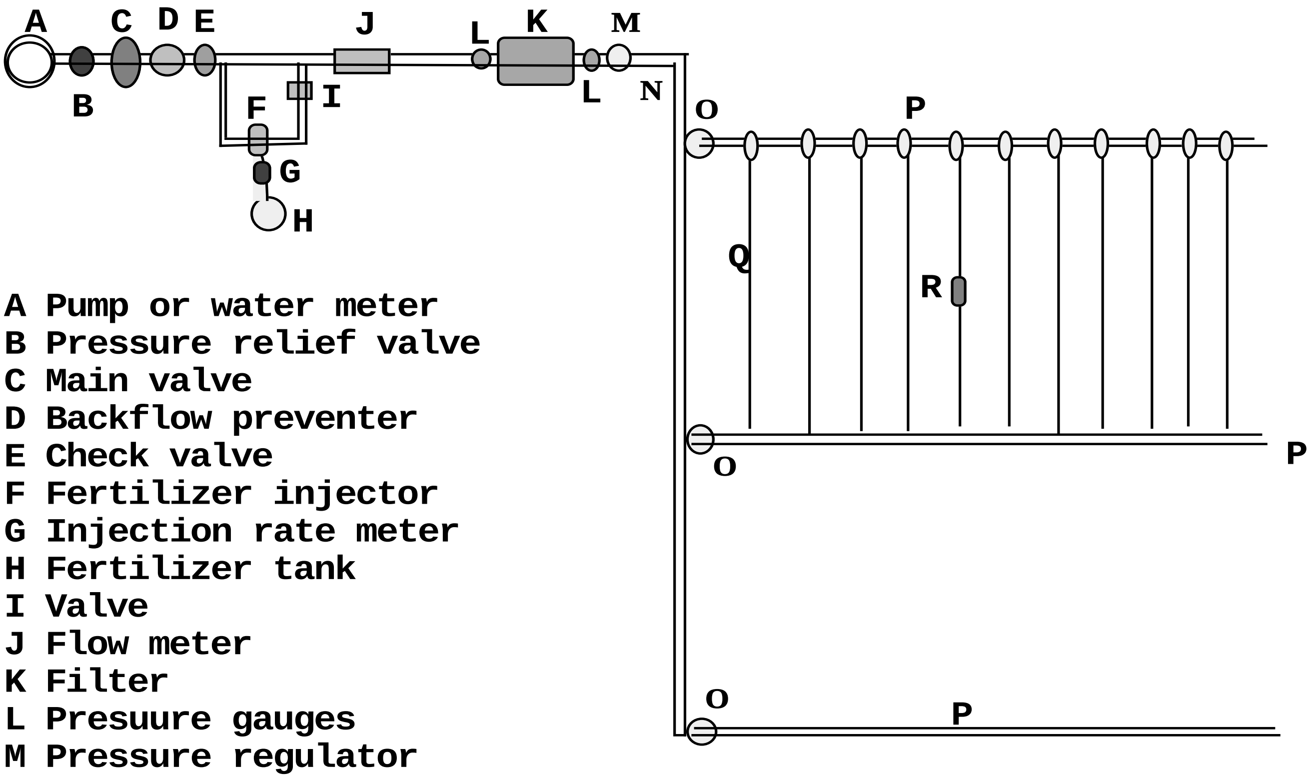
Before planting the cherimoya orchard the irrigation system needs to be in place, ready for the trees. The various parts of the system can be assembled and installed by the grower, but it is usually best to use a qualified low-flow irrigation system designer for the plans.

The system should be designed to meet the water needs of the full grown orchard during the peak irrigation period. It should be designed so that daily operation does not exceed 16 to 18 hours. This added irrigation capacity allows for “catch-up” in case of system breakdown, such as a pump breakdown that requires repair.

Many growers have water delivered by an irrigation district, but in some instances it may be cheaper or the only alternative may be to drill a well.

If a well is the source of water, it is important to select a pump and motor that will deliver the correct pressure and flowrate at the highest possible efficiency. The system designer determines the flowrate and pressure to be delivered by the pump, and the pump dealer matches the motor to the pump for the greatest efficiency.

Figure 1. Parts of an irrigation system



A Pump or water meter
B Pressure relief valve
C Main valve
D Backflow preventer
E Check valve
F Fertilizer injector
G Injection rate meter
H Fertilizer tank
I Valve
J Flow meter
K Filter
L Presuure gauges
M Pressure regulator
N Mainline
O Valve
P Submain
Q Lateral
R In-line regulator

A flowmeter **and** pressure gauges **are essential parts of an irrigation system. The meter will tell how much water is being applied — knowledge that is critical for efficient irrigation and scheduling. For example, a flowrate that decreases during the season measured at the same pressure can indicate clogging of the system, while increasing flowrate might suggest a leak in the system.**

Valves **of various sorts help control the system. A main control valve is very important, particularly in the case of a well and pump. A backflow prevention device should be installed to prevent contamination of the water source.**

Air/vacuum relief valves allow air to escape the system when turned on and to enter the system when the system is shut down. Check valves will prevent undesirable flow reversal in hilly terrain. A pressure relief value protects the pump.

Injection equipment **may be critical to prevent clogging of the low-flow system, however, it is also a great convenience for the application of fertilizers. Differential pressure tanks or "batch tanks" are the simplest. Irrigation water flows in and out of the tank.**

Batch tanks have the disadvantage that as irrigation continues the chemical concentration

Figure 3. Various injectors.

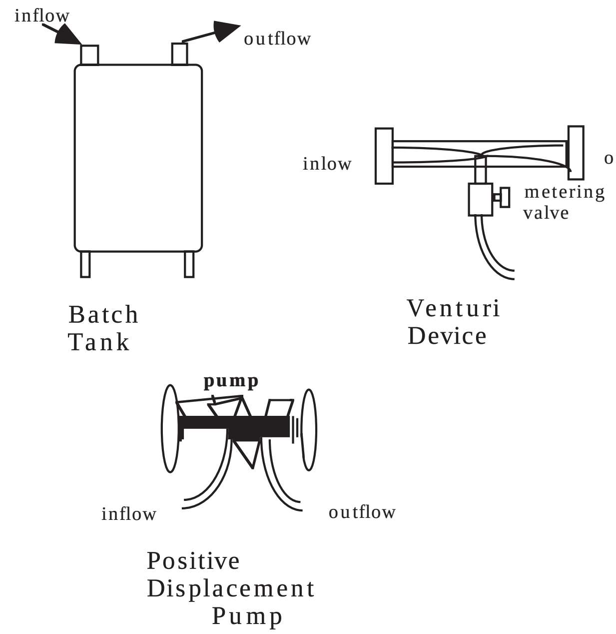
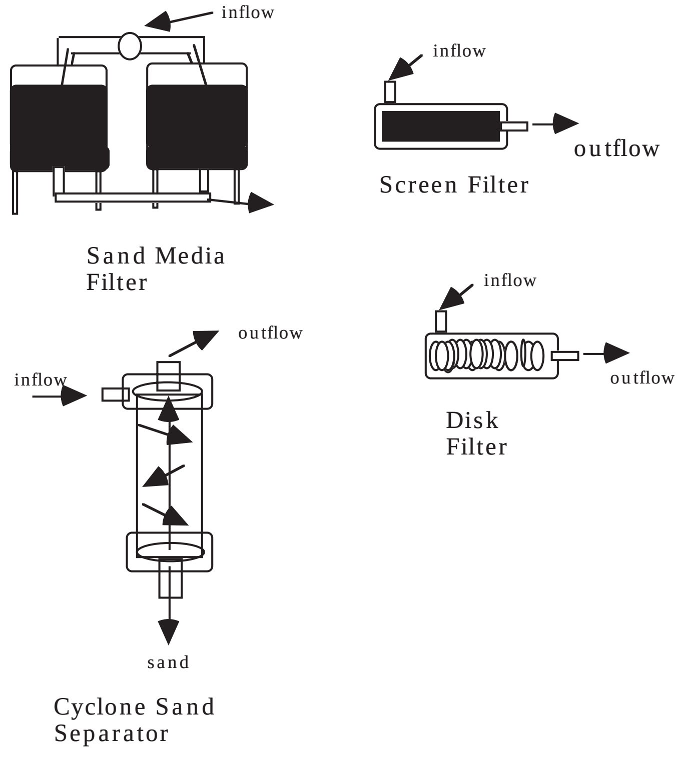


Figure 2. Various types of filters

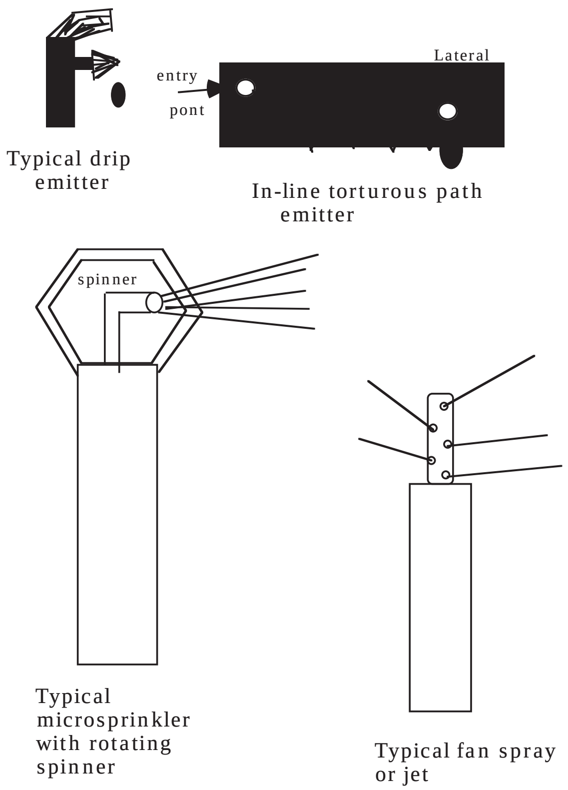


Installation of filters **is also important to low-flow systems because the emitter orifice has a greater tendency to clog than any other part of the system.** *Choices include media (sand), disk, and screen filters.*

Typically, media filters are used with surface waters that have a large organic sediment load that would tend to rapidly clog a screen filter. Screen filters tend to be less expensive and are used with well waters that need only sand filtration.

Disk filters with automatic backflushing are a happy medium between price and effectiveness for the removal of most sediments. Where the amount of sand sediments is high, a sand or cyclone separator should be installed upstream from to the filter.

Figure 4. Various emitter types.



of the irrigation water decreases. If the chemical concentration must be kept constant, a batch tank should not be used; however, in most fertilizer applications constant chemical concentration is not important.

A venturi injector is simple and inexpensive. It relies on a 10 to 30 percent pressure drop between the inlet and outlet of the injector. Venturis are better at maintaining a constant concentration of material than a batch tank, but neither is as good as a positive displacement pump.

These pumps are powered by electricity, gasoline or water. The latter injectors are the most complicated and expensive and unnecessary for most cherimoya growers.

Mains and submains deliver water to the lateral lines and emitters. The size of the lines is balanced between the cost of larger PVC pipe versus the pressure losses occurring with water movement through smaller lines.

Lateral lines, usually of polyethylene or PVC, deliver water to the emitters. The length and diameter of the laterals must not be too long or of an incorrect diameter; if they are, the emitters may discharge water at different rates, resulting in non-uniform irrigation.

Pressure regulators can be installed after the filter at the head of the system as pressure regulating valves, as pre-set regulators at the head of laterals, as in-line pressure regulators, or as a part of the emitter itself (pressure-compensating emitters).

Pressure-compensating emitters are more expensive than standard emitters and may wear out sooner. Pressure regulation is critical for uniform application of water, since the output of standard emitters varies with pressure which can occur with varying elevation.

Emitters come in all sizes and shapes as drippers, microsprinklers and fan sprays. Characteristic of all of them is that they do not wet the entire orchard floor. Drip emitters, with outputs of 1/2 to 2 gph, wet a small spot at the surface thereby resulting in their being very effective at reducing weed growth.

The wetted pattern enlarges below the soil surface, and depending on the soil texture, this pattern can be a vary bulbous onion shape or more like a stove pipe.

Drippers are very good with young trees, and as the trees grow, more emitters and a second lateral should be added. Typically, 6 drip emitters should be able to meet the requirements of the mature cherimoya, depending on soil type, however.

Drippers are notorious for their maintenance requirements; the tortuous path emitters have fewer problems. These emitters rely on a long, relatively large channel to reduce water flow, rather than just a small opening.

Chlorine or acid injection will prevent clogging problems, but “walking the lines” must always be done.

Microsprinklers, most with a rotating orifice called a spinner, put out from 4 to 30 gph and wet a much larger surface area than drip emitters. Because the discharge flow is higher than that for drippers and their orifice is larger, there is less problem with clogging; however, the use of filters upstream is still important.

In sandier textured soils where lateral subsurface movement of water is small, a microsprinkler is often a preferred choice. One of the major drawbacks of some microsprinklers is that output varies with distance from the emitter.

The amount of water placed on the outside 2/3 of the wetted pattern may be as little as 1/3 of the amount placed on the inside of the wetted pattern.

This distribution means that salt can accumulate in the outer part of the wetted pattern, and near the emitter the water will often go below the root zone.

Fan sprays are often designed to overcome the poor output uniformity of microsprinklers by directing fingers of water in various directions. There are a number of patterns that can be obtained: butterfly, rectangular, etc. Both microsprinklers and fan sprays can be found in less than 360° patterns.

To prevent disease, it is important that the tree trunk is not wetted; so with all of these emitters, a pattern should be selected to keep the trunks dry.

There are many brands of emitters and many models within each brand. Although quality of low-flow emitters has markedly improved in the last 10 years, there can still be some problems in their manufacture.

Information about specific emitter performance can be obtained from both the Center for Irrigation Technology at Fresno State University and through the Cooperative Extension in the Department of Land, Air, Water Resources at U.C. Davis.

Supply and Quality Considerations

Water Supply

Most low-flow systems require relatively frequent applications of water during peak demand periods. With drip systems it may be as frequent as once a day. In some areas water is delivered by an irrigation district on a basis that may cause difficulty in following an "on demand" frequency.

In this case it is necessary to work out an agreement with the agency supplying water. If the infrastructure will not allow frequent deliveries, a pond or tank system should be installed to provide a reservoir. If not, a well should be considered.

Water Quality

Aside from the effects of water quality on plants, quality can affect the operations of a low-flow system. Emitter clogging with organic or mineral sediments is a major water quality concern.

These sediments can be filtered, but if major problems of backflushing occur, a continual injection of 2 parts per million (ppm) chlorine prior to filtration may be required to control organic sediments or a prefilter may need to be installed for sand sediments.

Lime (calcium carbonate) or iron/manganese precipitates are the most common sources of clogging. These can be noted by the either white or reddish to blackish deposits associated with these two types of precipitates.

With private and municipal well waters, chemical precipitation leading to clogging is the major problem.

pH Requirements

If water contains more than 100 ppm (or 2 milliequivalents per liter, meq/l) bicarbonates and a pH greater than 7.5, lime precipitation can become a problem.

Example: **Martha measures 12 emitters and finds 8.5, 8, 7, 8, 7.5, 6.5, 7, 7.5, 8, 8, 8.5, 7.5 ounces in her graduated cylinder after 20 seconds of capture.**

Step 1. The values are arranged from low to high, summed, and averaged:

6.5
7
7
7.5
7.5
7.5
8
8
8
8
8.5
8.5
92.0 92/12 = 7.66

Step 2. The "low quarter" amounts are summed and averaged:

6.5
7
7
7.5
28.0 28/4 = 7

Step 3. The "low quarter" average is divided by the average of all the emitters:

7/7.66 X 100 = 91% DU.

Martha has a system with a DU of 91%. That is pretty good and hopefully she can keep it high through proper maintenance.

When these are deposited on the orifice of an emitter, it will eventually be clogged. Keeping water pH below 7 will help considerably.

This pH correction can be achieved most easily by injecting urea-sulfuric acid products in the system, or with the injection of the more dangerous sulfuric or phosphoric acids.

Acid injection rates vary with water quality, but typically run one to two gallons of acid per 5,000 gallons of water.

Fertilizer supply houses will often provide a recommendation based on a water sample used for irrigating the trees.

Iron and manganese precipitates can be much more difficult to control. Allowing the water to settle out in a pond prior to running the water through the system can be helpful.

Injecting chlorine and filtering is another method. Running acid water through the system for an hour may dissolve the iron precipitates clogging the emitters; or it may be necessary to inject acid and let it sit in the lines over night before flushing.

Some pressure-compensating emitters are damaged by water having a pH of 4 or below. Check with the manufacturer before lowering the pH. It may be necessary to run chlorine or calcium hypochlorite through the system at the end of the irrigation when bacteria that form slimes due to the presence of these precipitates of iron and manganese persist.

Water quality is also an important consideration for plant growth.

The individual salts of boron, chloride and sodium and the general salinity (Total Dissolved Solids or TDS) need to be considered. When boron exceeds 1 part per million (ppm) and chloride and sodium exceed 100 ppm, there should be an alerted concern for ensuring adequate leaching of the root zone to prevent accumulation of these salts.

When TDS exceeds 1200 ppm, leaching again should be carefully followed.

The sodium adsorption ratio (SAR) is another water quality measure that can be helpful in alerting a grower of potential water problems. SAR is the ratio of the amount of sodium to the sum of magnesium and calcium in the water.

When this ratio exceeds 6, there is a strong tendency for sodium to accumulate in the soil. Leaching and the application of gypsum (calcium sulfate) soil amendments should be considered when the SAR is high.

System Maintenance Considerations

What is DU?

The measure of the efficiency of an irrigation system is its distribution uniformity (DU). A DU of 100% means that every emitter is putting out exactly the same amount of water. If some emitters put out more or less than the average of the whole system, the DU is less than 100%.

A high level of DU is important since the system must run longer for those trees receiving a lesser amount of water to get an adequate amount. In addition, some trees may be getting more water than they need, resulting in a condition that may not be good for the overall health of the trees and the waste of water.

Because of pressure losses in lines and uneven terrain it is impossible to achieve 100% DU, but 80% is attainable and 95% is not unheard-of. Even in a new, well-designed system, clogging and leaks can rapidly reduce distribution uniformity.

The way to ensure a high DU is through maintenance.

DU need only be measured once a year to evaluate the performance of the system.

How to measure DU

Distribution uniformity is measured by selecting a specified number of emitters and measuring their output. If you have 100 emitters, lay out an evenly spaced grid across the orchard so that all parts of the orchard can be sampled.

Identify a minimum of 12 emitters that will be sampled; however, the more emitters sampled, the more accurate the measure of DU.

Turn the system on, and upon going to the first emitter, invert the emitter over a graduated cylinder or measuring cup and capture the water for a specified time, such as 15 seconds. The length of time used to capture water is limited only by the capacity of the cylinder and the length of time you want to be standing there.

After sampling the emitters. arrange the amounts from low to high. Add the values up and find the average. Then look at the amounts that come from the 1/4 of the emitters putting out the least. Take their average, and divide this by the average of all the emitters.

Multiply by 100 to get the percentage of DU. If DU is less than 80%, something must be done. If it is greater than this, it might still be possible to improve the efficacy of the system.

A convenient method of measuring drip systems is to use a 35 mm film can. When the film can fills in 30 seconds, that emitter output is 1 gallon per hour. If it fills in half the time, it is a 2 gallon per hour emitter.

To determine DU when the can does not completely fill, take the proportion of the filled can as the emitter output. For example, if the 1 gallon per hour emitter only fills a percentage of the can in 30 seconds, use the percentage in the summation of values.

What to do about a low DU

Presumably the system was designed right. If low DU is caused by pressure differences in the system it may be necessary to install pressure regulators or pressure compensation emitters. If there is not enough pressure to run the system, it may be necessary to break it into two or more irrigation blocks with separate valves.

The major culprit of low DU, though, is poor maintenance.

Routine maintenance includes checking for leaks, backwashing filters, periodically flushing lines, chlorinating, acidifying, and cleaning or replacing clogged emitters.

Coyotes are very prone to biting and puncturing polyethylene tubing to get water. Thus, in coyote country walking the lines to inspect for leaks is critical. Pup season in spring and when surrounding hills have dried out in fall are times when most coyote damage is encountered.

Often putting a pan of water out for them can decrease the amount of damage. Sometimes it may be necessary to repair the lines before every irrigation. Also, during and after harvest when emitters and lines may have been kicked or tramped on by pickers is another time when leaks or bent emitters may be found.

Clogged emitters can often be identified visually by reduced flows. Sometimes the sound is changed. Sound can be helpful also in identifying spinners on minisprinklers that are jammed.

Backflushing filters should be done whenever there is a 5 pounds per square inch (psi) reduction in outflow pressure.

Clogged filters reduce the system pressure and lower application rates.

Depending on the model of emitter, distribution uniformity may be decreased. The frequency of backflushing depends on water quality. Automatic backwashing filters are available and are relatively inexpensive. They will initiate backwashing as soon as a large enough pressure differential exists.

Flush, flush, flush. Flushing should be a mantra.

Periodically flushing lateral lines — opening the lines and allowing them to run clear — is essential. Filters trap only the larger sediments. The laterals will gradually accumulate the smaller fraction which can eventually clog the emitters.

Emitters may need to be cleaned or replaced due to clogging. It is important to identify the cause of clogging. Acid and chlorine injection should be a regular program if organic slimes or chemical precipitates are a problem.

In particular, emitters at or near the end of the lateral should be watched very closely. Particles that escape the filter will most often collect at or near the end of the lateral.

If earwigs or other insects getting into the emitters are the problem, it may be necessary to replace the emitters with bug proof models. Although some brands of emitters are designed to be disassembled and cleaned, nearly all the drip emitters are sealed.

Most micro-sprinkler models clog at the orifice in the head and can be cleaned and reinstalled.

Irrigation Quantity and Frequency

Irrigation Scheduling

Irrigation efficiency requires not only uniform irrigation, but the proper timing and amount of applied water. It is important that the irrigator know the rate of water application of the system, either in inches per day, inches per hour, or gallons per hour.

Irrigation scheduling which determines the time and amount of water to be applied can be accomplished through a variety of methods, including measuring the soil moisture and determining evapotranspiration.

Evapotranspiration values measure the actual amount of water well watered plants would use. This information is available in many areas of the State from newspapers, irrigation districts, over the Department of Water Resources CIMIS network (California Irrigation Management Information System, 818-543-4621), and soon over the World Wide Web.

Scheduling, as opposed to a fixed amount applied at a fixed time, is especially important in Southern California coastal valleys. Although the average annual irrigation requirement is about 2 feet of applied water per year (2 acre-feet per acre or 651,702 gallons per acre), this value varies tremendously from year to year. The most important variable is how long the rainfall season is and the effectiveness of the rainfall.

Effective rainfall is defined as the amount of rainfall which is retained in the root zone of the tree. For example, if you have just irrigated, or if it rained 2 inches yesterday, and it rains 2 inches today, none of the rain is effective since the soil was already moist. It did leach salts out, however. Rain events of less than 0.25 inches are also not considered effective.

Soil-based Scheduling Methods

A method of determining when to irrigate should be learned by all growers A rule of thumb is that irrigation timing should occur when about 50% of the water available to the plant has been depleted from the soil.

The 50% figure is arbitrary, it allows a buffer of water in the soil in case the weather suddenly turns hot and windy.

Of course a sandy soil will hold less water than a clay soil, so irrigation will be more frequent. A common perception is that it takes more water to grow plants in sandy soil than clay soil.

The total amount required for the whole year by the cherimoya will not be changed by the soil type. This result is because it is the sun, wind, temperature and humidity which decide how much water the tree will need. The soil is only the reservoir.

To check the water content in the soil, take a trowel, shove, or soil tube and dig down 8 to 16 inches. A soil that has about 50% available water remaining will feel as follows:

coarse - appears almost dry, will form a ball that does not hold shape;

loamy - forms a ball, somewhat moldable, will form a weak ribbon when squeezed between fingers, dark color;

clayey - forms a good ball, makes a ribbon an inch or so long, dark color, slightly sticky.

Irrigation timing can be determined and also mechanized with the use of a tensiometer. These water filled tubes with a pressure gauge accurately reflect the amount of energy a plant needs to extract water from the soil. The pressure gauge measures “tension values” in centibar units (cbars). When the gauge reads 30 cbars, it is a good time to irrigate.

Placement of the tensiometers requires that they be within the root zone, between the emitter and the tree trunk. Having two tensiometers next to each can be helpful in deciding both when to turn the system on and when to turn it off.

A tensiometer at a one foot depth tells when the water should be turned on and a tensiometer at three feet tells when to turn the system off. Placing a plastic milk crate over the device will prevent pickers from kicking them over.

There are other devices on the market for measuring soil moisture. Gypsum blocks are

very effective. Although the part in the ground is inexpensive, the reading device costs in the $250 range. This cost means a large enough acreage is required to spread out the cost of the system.

There are portable meters on the market for measuring soil moisture. These meters rely on an electrical current carried by water in the soil. Even the cheap $10 ones can give a rough estimate of the soil water content. None are very effective in rocky ground because their sensitive tips break easily.

The amount of water to apply at an irrigation depends on the amount of water held within the root zone. A loamy soil where a microsprinkler with a 20 foot diameter throw has wetted a two foot depth will hold about 200 gallons of water at 50% water holding capacity.

Exceeding this amount of water will help leach salts; but if far in excess, additional water is only pushing existing water out of the root zone.

It is best to follow one or two irrigation cycles to find out how long to run the system to achieve a certain depth of infiltration. This can be done with a shovel or more easily with a pointed rod or tensiometers.

Water moves in a wetting front, and the wetted soil will allow the rod to be pushed in to the depth of dry soil. The irrigation system should be run to find out how long it takes water to infiltrate to a depth of two and three feet. That information will indicate how long to run the system when irrigating.

Applying water to achieve a two to three foot depth may take several hours. If run-off occurs, the system may be turned off for a few hours, then turned on again to get the total run time required for water to infiltrate to a given depth. If run-off is severe, use emitters with a smaller flow rate.

Calculating Tree Water Requirement

Determining the application rate of low-flow systems can be confusing because irrigation scheduling and water-use information is often presented in inches per day, while discharge from low-flow emitters is in gallons per hour.

Inches per day can be converted to gallons per day by the following formula:

$$\boxed{\begin{array}{l}\textit{water use}\\ \textit{by the tree}\\ \textit{(gal/day)}\end{array}} = \boxed{\begin{array}{c}\textit{Tree spacing}\\ \textit{(ft}^{2}\textit{)}\end{array}} \times \boxed{\begin{array}{l}\textit{Crop water}\\ \textit{use (in./day)}\end{array}} \times \boxed{0.623} = \boxed{\begin{array}{l}\textit{water use}\\ \textit{(gal/day)}\end{array}}$$

for example: with full grown trees substitute the following:

tree crop spacing = 20 ft. X 20 ft. = 400 (ft^2)
crop water use = 0.1 in./day

water use
by the tree = ***400 (ft^2) X 0.1 in./day X 0.623 = 25 gal/day***

Adjust for smaller trees

With smaller trees, the area of the canopy should be used in lieu of the plant spacing.

Extra operating time must be factored in when distribution uniformity is low. With a DU of 80%, allow 25% more operating time to ensure that all trees receive the minimum amount of water required.

Weather-based Scheduling Methods

Another scheduling technique that has become popular is the use of weather data that has been converted to a crop water use value. This value is the estimated amount of water an orchard would use.

The value is often referred to as the evapotranspiration (ET) of the crop. ET is the amount of water that can be lost by a well watered crop either through the leaves (transpiration) or evaporation from the surface of the soil.

By applying the ET amount at an irrigation, the trees are kept at an optimum moisture content. The technique is often called the water budget method or checkbook scheduling.

The CIMIS network of over 50 weather stations calculates reference evapotranspiration (ETo). This value is an estimate of the amount of water lost from a well watered field of grass. Grass is the standard or reference for all other crops. ETo is modified for the specific crop with a crop coefficient (kc). The formula for converting ETo to crop ET is: ETo X kc = ETcrop.

For a full grown cherimoya orchard a kc of 0.8 should be adequate to account not only for the crop water as well as a distribution uniformity of 90%. With smaller trees, a smaller kc is used. When trees are young and intercept little energy to drive water loss, a kc of 0.1 works well.

As the trees increase in size to where their shade covers about 65% the soil surface, the kc is gradually increased each year. With rapidly growing trees, the kc increase is usually about 10 % each year.

The increase from planting in the first year would be something like this: 10%, 20%, 30%, 40%, 50%, 60%, 70%, and 80% at year 8.

Reference evapotranspiration values are available fro many irrigation districts, CIMIS, several weekly journals and magazines. In Ventura County the values are available through County Flood Control.

One of the drawbacks of the centralized weather stations is that in our hilly terrain with different sun exposures, the station values can be quite different from the water loss at a grove. When using evapotranspiration figures it is always important to back up the estimates with field checks in the grove.

An alternative to using the centralized weather stations is establish ones own. These electronic stations cost in the range of $5,000 and require regular maintenance, as well.

A simpler weather station can be developed with an evaporation pan or an atmometer (atmosphere meter). Both of these devices actually measure the loss of water due to evaporation and since the physics of evaporation and transpiration are very similar, the values can easily be used in a water budget.

The major drawback to the evaporation pan is the maintenance required to keep birds, coyotes, and bees from causing inaccurate readings. Algae also needs to be kept free of the pool.

An atmometer is a closed system with a ceramic head, much like a tensiometer. As water is drawn out of a reservoir, a sight tube shows how much water has been evaporated. The atmometer is more expensive (≥$300) than a pan, but it is much easier to maintain.

Regardless of what scheduling technique or combination of techniques is used, a thorough evaluation of the system needs to be performed so that a known amount of water is being applied. Until volume and distribution of water are known, it make little sense to schedule applications.

Suggested Readings

Irrigation Scheduling: A Guide for Efficient on-farm Water Management, U.C. Pub. 21454

Applying Nutrients and Other Chemicals to Trickle-irrigated Crops, U.C. Pub. 1893

Drip Irrigation Management, U.C. Pub. 21259

Irrigation on Steep Lands, U.C. Pub. 2825

Measuring Irrigation Water, U.C. Pub. 2956

Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc): Trees and Vines, U.C. Pub. 21428

Low-Volume Irrigation, LAWR, U.C. Davis Water Management Series 93-03