MICROIRRIGATION SYSTEMS

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Irrigation systems for pistachios are frequently pressurized low volume microirrigation systems that provide the capability for the operator to carefully manage both quantity and timing of irrigation applications. High volume sprinkler irrigation systems have been shown to be associated with increased incidence of fungal diseases that attack the leaf canopy and the nut clusters such as Alternaria late blight and Botryosphaeria shoot and panicle blight.

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Microirrigation systems--surface drip, subsurface drip, and microsprinklers--are seeing increased use in orchards. These systems wet only a portion of the orchard floor. Generally, it is recommended that 40-60% of the orchard floor be wetted for good tree performance.

Advantages of microirrigation over other irrigation systems

1. They provide a high degree of water application uniformity, often the highest of all irrigation systems in use.
2. They allow excellent control of the amount and timing of irrigation. Small, frequent irrigations (often daily with drip irrigation) can be applied to match the tree's water needs. Runoff is minimized because of the low application rates, and deep percolation losses can also be minimized if the correct amount of water is applied. The frequent irrigation provides an excellent soil water condition for optimal tree performance.
3. They can easily irrigate irregular terrain.
4. Weed growth is minimized since only a portion of the orchard floor is wetted.

Disadvantages of microirrigation systems

1. High initial cost of the systems.
2. Excellent management is needed to maintain the system since clogging of the emitters by physical particles, organic materials, and/or chemical precipitates may occur.
3. The irrigation water must be pressurized, resulting in energy costs. The required pressures are generally less than those needed for sprinkler systems, but they are higher than those of flood irrigation systems.
4. Cover crops cannot be grown year-around due to the localized nature of the water applications.

Components and considerations

The various types of microirrigation systems--microsprinkler, surface drip, and subsurface drip systems--are all made up of the same basic components. Figure 6a shows the components of a typical microirrigation system. Generally, a microirrigation system consists of:

- a pump
- a flowmeter
- mainlines and submains
- drip or microsprinkler lateral lines
- valves
- filter(s)
- injection equipment

For the most part, microirrigation systems differ only in the emitter spacing, the type of emission device used, and the size of the components. The type of emitter used affects the size of the other components. Microsprinklers, for instance, generally require larger filters, mainlines, and submains as compared to drip systems.

In a microirrigation system for trees, the emitter spacing and discharge rate needed depend primarily on the tree spacing and water needs of the trees. The emission devices must be capable of supplying each tree with enough water during the peak water use periods to satisfy the evapotranspiration (ET) requirement.

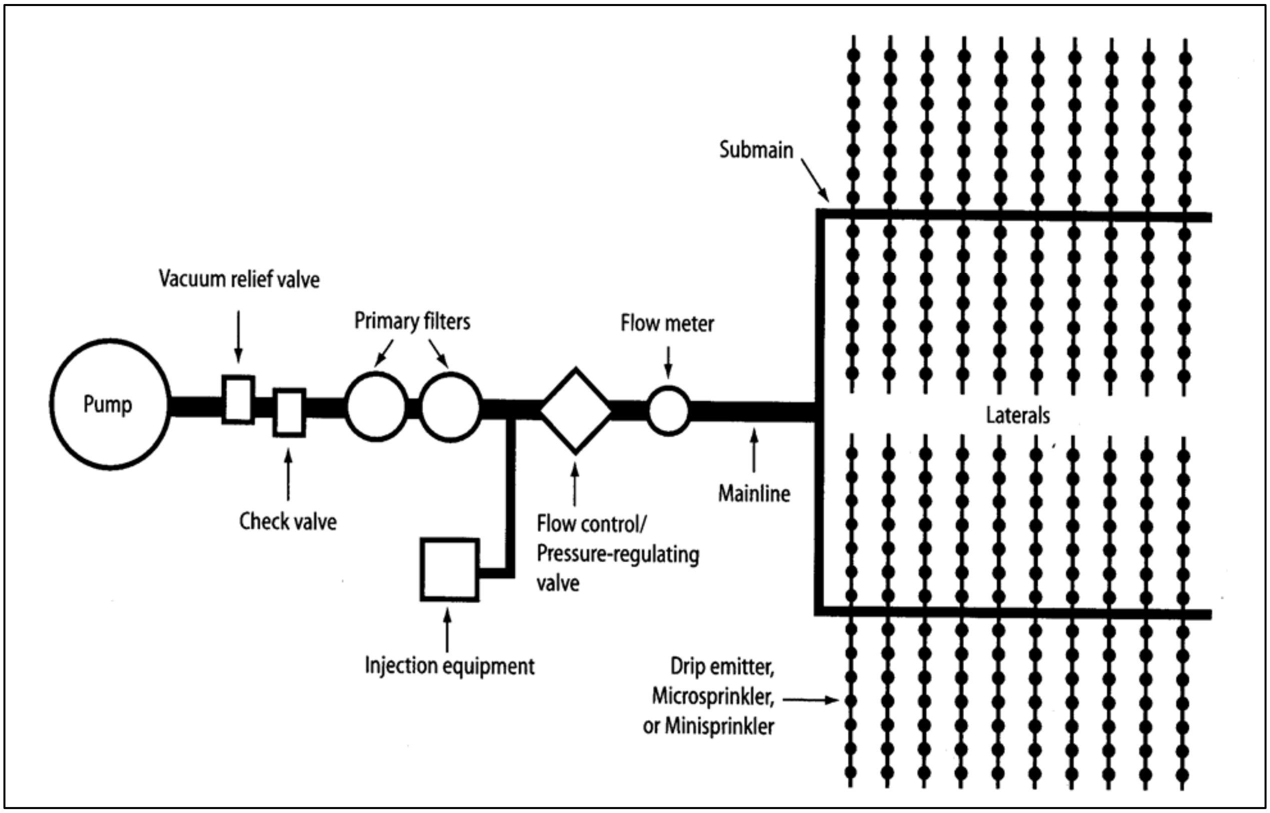

Figure 6a. Components of a microirrigation system.

Following is a brief overview of the components and operation of a microirrigation system for trees.

Pumping Plant: It is important to select a pump and motor (or engine) that will deliver the correct pressure and flow rate at the highest possible efficiency. The microirrigation system designer determines the flow rate and pressure to be delivered by the pump, and the pump supplier uses this information to select the most efficient pump for a given system.

Flowmeters: It is very important that a flowmeter be part of the irrigation system. Knowing the flow rate is necessary for determining the amount of water being applied, which, in turn, is critical to efficient irrigation and scheduling. A propeller meter, which displays either the flow rate and/or total water applied, gives an accurate measurement.

Injection Equipment: Microirrigation is well suited to injecting chemicals such as soluble fertilizer. Various types of injection equipment, differential pressure tanks ("batch tanks"), venturi devices, electrically driven or water-driven pumps, and solutionizer machines can be used, depending on the chemical applied, the accuracy level needed, and the injection rate required.

Valves: Valves are the control mechanisms of microirrigation systems. Several types are common: control valves, air/vacuum relief valves (which allow air to escape when the system is turned on and to enter when the system is shut down), and check valves (which prevent undesirable flow reversal). Pressure-regulating valves are important for maintaining a constant operating pressure in the system.

Filters: Selecting the appropriate filter requires consideration of water quality factors discussed earlier. Particulate matter (such as sand) in the water can be removed with vortex filters (frequently referred to as “sand separators”). Screen, disk, or sand media filters are also effective in removing particulate matter.

Organic matter such as algae or slime can be removed using screen, disk, or sand media filters. But, since organic matter can quickly clog a screen or disk filter and is difficult to flush from the screen or disk elements, sand media filters are the usual choice for filtering surface waters containing algae and slime.

Both screen and media filters must be periodically backwashed. The pressure drop across the filter indicates when backwashing is required. Backwashing can be accomplished either manually or automatically, with automatic backwashing taking place either on a defined schedule or when the filter senses a pre-determined pressure drop across the filter and begins the backwash cycle. The water used to backwash is frequently discharged out of the system.

Mainlines and Submains: Main and submain pipes, usually made of PVC, deliver water to the lateral lines and emitters. The mains and submains must be sized carefully, with the cost of the pipe balanced against pressure losses caused by elevational differences across the orchard and friction as water moves through the pipe. The system should be designed by a qualified microirrigation system designer.

Lateral Lines: Emitters are attached to tubing, or lateral lines, usually made of polyethylene. The length and diameter of the lateral lines to be used also depend on economics, balancing the tubing cost against pressure loss along the lateral. If the lateral lines are too long or the wrong diameter, the emitters may discharge water at different rates, resulting in non-uniform irrigation.

Emitters: The many different types of microirrigation emitters available can be grouped generally into above or below-ground, drippers and microsprinklers. Choosing which microirrigation emitter to use is dependent on some physical issues such as soil type and water quality, but also on some personal preferences of the manager. The following is a brief discussion of the pros and cons of each type of microirrigation emitter.

Surface drip: Surface drip irrigation, along with microsprinkler irrigation, is one of the most commonly-used microirrigation systems in tree crops. The drip emitters can either be "punched-in" to the drip tubing or formed integrally in the drip hose ("in-line" emitters) at a specific spacing by the manufacturer. Both single and double drip lines per tree row systems are used. Double drip lines are usually chosen to achieve a greater wetted area in the orchard and/or to increase the application rate of the drip system. Increasing the wetted area is frequently an issue in orchards with sandy soils which don't wet laterally well. Increasing the application rate of a drip system requires fewer operating hours to satisfy tree water needs. This gives the manager more time when the drip system is not operating to accommodate other orchard cultural practices such as spraying or mowing. A higher application rate may also allow the manager to more easily irrigate using off-peak power rates. Double-line drip systems are initially more expensive than single-line drip systems.

Subsurface drip: Orchard subsurface drip systems are most often in-line drippers in hard drip tubing, due to their longevity. Drip tape products are seldom used in orchard applications. Both single-line and double-line subsurface drip systems have been used successfully. Subsurface drip systems' installation depth is usually 10" to 24". The deeper depths are chosen to minimize surface wetting but they make installation and repairs more difficult. Advantages of subsurface drip systems include reduced weed growth since the soil surface usually stays dry, reduced irrigation system damage during harvest or other cultural practices, and the ability to irrigate almost anytime, even right up to harvest. The major disadvantages of subsurface drip are the difficulty in detecting clogging problems and the hazard of root intrusion into the emitters. Root intrusion problems can be mitigated by using drip products with herbicide-impregnated emitters, but these products are more expensive.

Microsprinklers: Advantages of microsprinklers compared to drip systems include a larger wetted area, often a higher application rate, less susceptibility to particulate clogging since the orifices are larger, and easier visual inspection for clogging problems. While wetting a larger area may be a benefit for tree growth, it is a disadvantage due to increased weed growth. Another disadvantage of microsprinklers is a problem with insects entering or laying eggs in the microsprinkler orifice and causing them to clog.

Operation and Maintenance

Microirrigation systems can apply irrigation water quite efficiently, but only if they are operated and maintained properly. Irrigation scheduling, determining when to irrigate and how much water to apply, is critical to operating the system efficiently. Effective irrigation scheduling requires knowing how much water the tree is using or has used since the last irrigation (the evapotranspiration or ET of the tree) and how much water the irrigation system applies in a given period of time (the application rate; determining the application rate of a microirrigation system can be confusing at times, so a procedure is discussed at the end of this section). From that information can be calculated how long the microirrigation system should be run.

A virtue of a microirrigation system is its ability to deliver a uniform amount of water to each location it serves so that water is applied evenly over the field. But, because of pressure differences throughout the system and variability in emitter manufacture, even new systems may not apply water completely evenly. A carefully designed system can use pressure regulators in mains, submains, laterals or hoses or pressure-compensating emitters to overcome pressure differences and variation in emitter discharge rates.

While a well-designed system can deliver water with a high degree of uniformity, the system must be properly maintained to keep the application uniform. The principal cause of non-uniformity in microirrigation systems is emitter clogging by particulate or organic matter, lime precipitates, or iron precipitates. The following is a brief summary of the maintenance/clogging issue for microirrigation systems.

Particulate (silt and sand particles) clogging can be a problem with both groundwater and surface water sources, but it can often be prevented by good filtration. The microirrigation emitter manufacturers frequently specify a degree of filtration for their emitters.

Biological clogging is caused by bacterial slimes, algae, etc. which are either present in the irrigation water or may be growing in the irrigation system. Biological clogging is more frequently a problem with surface water supplies than when groundwater is used, but groundwater can have biological clogging problems associated with iron bacterial slimes. Maintenance practices to minimize biological clogging include injection of a biocide, such as chlorine, and good filtration. Serious biological clogging problems may require continuous chlorine injection at 2-5 ppm chlorine, measured at the end of the lateral line. Less severe problems may require only periodic chlorine treatments at 1-=20 ppm every few weeks.

The chemical precipitate clogging hazard can often be anticipated by an irrigation water analysis. For example, an irrigation water with a pH of 7.5 or higher and a bicarbonate level of 2 meq/l or greater has an increased hazard for calcium carbonate precipitate clogging. Waters with iron levels of 0.5–1.0 ppm or higher are at risk of iron precipitate clogging. Calcium carbonate precipitate clogging can be prevented or remediated by lowering the water pH to 7.0 or less by injecting acid. Iron precipitate clogging is usually handled by storing the water in a reservoir, in which the iron precipitate is allowed to settle, prior to withdrawing the irrigation water.

The initial cost of a microirrigation system is approximately $900 to $1300 per acre.

Irrigation application rate

When designing an irrigation system, it is often difficult to choose an application rate. A major objective is to minimize runoff from the orchard. Ideally, water should soak in where it lands. The infiltration rate of the soil is not easy to determine; it changes during an irrigation and may change across the season. During an irrigation, the infiltration rate begins at its highest rate and decreases during the irrigation until a relatively constant, final infiltration rate is reached (see Figure 6b). This final infiltration rate should be equal to or greater than the water application rate so that no runoff occurs. Often the best guidance for choosing a water application rate can be made by seeing what has

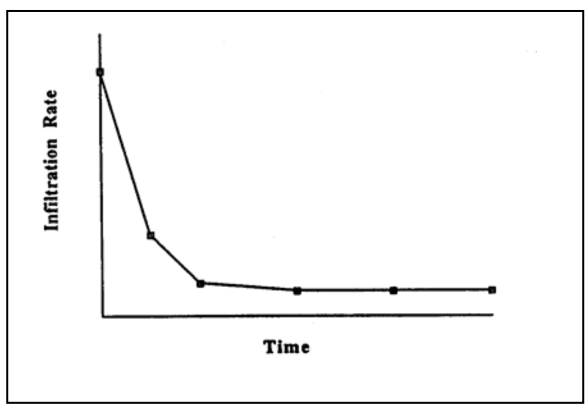

Figure 6b. Typical infiltration rate curve showing high infiltration rate at the beginning of the irrigation decreasing to a lower, constant final infiltration rate.

worked on other orchards with similar soil conditions, slope, etc.

When designing an irrigation system, it is preferable to choose the correct application rate at the design stage, but emitter sizes can be retrofitted. In the design stage, it is better to over-estimate the application rate and later decrease emitter flow rates because underground piping, pump sizing, etc. are all based on system flow rate If emitters with greater discharge rates (eg. microsprinklers replacing drip emitters) are later retrofitted to the system, it is likely that the piping and pump capacity will be too small resulting in inadequate pressure.

Irrigation uniformity

How uniformly or evenly water is applied is also important to good irrigation water management. An irrigation system with uniform water application means each tree will receive nearly the same amount of water during an irrigation.

Determining the application rate of a microirrigation system

Determining the application rate of microirrigation systems can be confusing because irrigation scheduling and tree water use information is usually presented in inches per day (in/day), while discharge from microirrigation emitters is measured in gallons per hour (gph). The following may be helpful in determining required operating times for microirrigation systems.

The water use of the tree and the application rate of the emission device(s) determines how long drip and microsprinklers should be operated.

Drip emitters and microsprinklers

Step 1 in determining the required operating time is to convert the tree water use (ET) information (usually available in inches per day) to gallons per day of tree water use. The following formula may be used (or see Table 1):

$$\text{Water use by the tree (gal/day)} = \text{Tree spacing } (ft^2) \times \text{Tree water use (in/day)} \times 0.623$$

Example: Tree spacing = 20 ft. x 20 ft. = 400 ft^2
Tree water use = 0.3 in./day

Water use by:
The tree = 400 ft^2 x 0.3 in/day x 0.623
(gal/day)= 75 gal/day

Table 1. Tree water use (gallons/day) for various plant spacings and tree water use (in/day).

Tree spacing (ft^2)	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
100	3	6	9	12	16	19	22	25
200	6	12	19	25	31	37	44	50
400	12	25	37	50	62	75	87	100
600	19	37	56	75	93	112	131	150
800	25	50	75	100	125	150	174	199
1000	31	62	93	125	156	187	218	249
1200	37	75	112	150	187	224	262	299
1400	44	87	131	174	218	262	305	349
1600	50	100	150	199	249	299	349	399
1800	56	112	168	224	280	336	392	449
2000	62	125	187	249	311	374	436	498
2200	69	137	206	274	343	411	480	548
2400	75	150	224	299	374	449	523	598

Tree spacing (ft^2) = row spacing (ft) x tree spacing with the row (ft)

Step 2 is to determine the application rate of the irrigation system in gallons per hour (gal/hr). For both drip emitters and microsprinklers, this requires determining: (1) the number of emission devices per tree, and (2) the discharge rate per emission device (gal/hr/emitter):

$$\text{Application rate (gal/hr)} = \text{Number of emission devices} \times \text{Discharge rate per emission device (gal/hr/emitter)}$$

Example: Drip emitters: 4 drip emitters per tree
Discharge rate per emitter: 1 gal/hr

Application rate (gal/hr.): = 4 emitters/tree x 1 gal/hr per emitter
= 4 gal/hr.

Example: Microsprinklers: 1 microsprinkler per tree
Discharge rate per microsprinkler: 12 gal/hr.

Application rate (gal/hr): = 1 microsprinkler/tree x 12 gal/hr per microsprinkler
= 12 gal/hr.

Step 3 is to determine the irrigation system operation time in hours per day. This requires using the tree water use (determined in Step 1), and the application rate (determined in Step 2). The following formula may be used (or see Table 2):

$$\text{Hours of operation per day} = \frac{\text{Tree water use (gal/day)}}{\text{Application rate (gal/hr)}}$$

Example:

Drip emitters**:**	Tree water use (gal/day)	=	75 gal/day (Step 1)
	Application rate (gal/hr)	=	4 gal/hr (Step 2)
	Hours of operation per day	=	75 gal/day ÷ 4 gal/hr
		=	18.8 hrs/day
Microsprinklers**:**	Tree water use (gal/day)	=	75 gal/day
	Application rate (gal/hr)	=	12 gal/hr
	Hours of operation per day	=	75 gal/day ÷ 12 gal/hr
		=	6.3 hrs/day

Table 2 gives the same hours of operation for these examples.

An alternative method of determining the depth of applied water (inches) is to monitor the flow meter (if available) at the pump. The following formula can then be used:

$$\text{Applied depth of water (inches)} \quad \frac{\text{Pump discharge (gpm)} \times \text{Irrigation time per set (hrs)}}{449 \times \text{Acres irrigated per set}}$$

Table 4. Hours of operation per day for various application rates (hrs/day) and tree water use (gal/day).

Tree Water Use (gal/day)	1	2	4	6	8	10	12	14	16	18	20
5	5.0	2.5	1.3								
10	10.0	5.0	2.5	1.7	1.3	1.0					
15	15.0	7.5	3.8	2.5	1.9	1.5	1.3	1.1			
25		12.5	6.3	4.2	3.1	2.5	2.1	1.8	1.6	1.4	1.3
50			12.5	8.3	6.3	5.0	4.2	3.6	3.1	2.8	2.5
75			18.8	12.5	9.4	7.5	6.3	5.4	4.7	4.2	3.8
100				16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0
125				20.8	15.6	12.5	10.4	8.9	7.8	6.9	6.3
150					18.8	15.0	12.5	10.7	9.4	8.3	7.5
175					21.9	17.5	14.6	12.5	10.9	9.7	8.8
200						20.0	16.7	14.3	12.5	11.1	10.0
225						22.5	18.8	16.1	14.1	12.5	11.3
250							20.8	17.9	15.6	13.9	12.5
275							22.9	19.6	17.2	15.3	13.8
300								21.4	18.8	16.7	15.0
325								23.2	20.3	18.1	16.3
350									21.9	19.4	17.5
375									23.4	20.8	18.8
400										22.2	20.0
425											21.3
450											22.5
475											23.8

Frequency of Irrigation

Determining how often to irrigate is accomplished by considering a combination of microirrigation system capacity concerns and soil/tree parameters. During peak ET periods, most drip irrigation systems are designed to be operated daily to meet ET demands. Microsprinkler systems, which generally have a higher application rate than do drip systems, may be able to be operated with multiple days between irrigations. Frequently, 3 or 4 days between irrigations is common for microsprinkler systems during peak ET periods. Microsprinkler irrigation duration should be more than just a few hours. Short irrigation events with microsprinklers result in only the surface soil being wetted. Particularly in young orchards, this shallow water may be lost to evaporation and not be available for tree uptake. Deeper penetration of irrigation water is desirable and this is often achieved by longer irrigation events. Soil moisture monitoring is helpful both before and after an irrigation.