DRIP IRRIGATION OF CITRUS—PANEL

DRIP IRRIGATION OF CITRUS IN CALIFORNIA

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Oranges and lemons were introduced into California with the founding of the first Spanish mission in San Diego in 1769. Soon, each mission along El Camino Real had orange trees in their gardens, but the only orchard of any size was at San Gabriel Mission near Los Angeles. The industry had its beginning in 1841 when William Wolfskill planted an orange grove in what is now downtown Los Angeles. He later added lemons. Navel oranges were introduced in 1873 and by 1900, the winter orange business was booming. Today, the citrus industry in California consists of approximately 336,700 acres (136,300 ha), divided by variety as follows:

	Acres	Ha.
Valencia oranges	110,000	44,500
Navel oranges	133,000	53,800
Lemons	62,000	25,100
Grapefruit	15,000	6,100
Mandarins - Tangerines	16,000	6,500
Limes	700	280
	336,700	136,280

The center of the citrus industry was located in Southern California until about 1957 when a great influx of people caused a great demand for land on which to put houses, commercial developments and industrial complexes. Growers sold ranches for high prices to developers and re-invested in citrus in the desert, Arizona and the great Central Valley of California, as new irrigation projects opened up thousands of acres.

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Citrus is grown from the Pacific coast to the desert. The climate of warm sunny days, mild breezes and cool nights make it possible to grow many colorful and flavor-rich varieties that are picked and shipped year-round. Citrus can be found growing on many kinds of soil, from almost pure sand to decomposed granite to loams to clay soils. Terrain ranges from flat desert to sloping or relatively steep hillsides.

California citrus must be irrigated as total rainfall is never adequate, but distribution is more important. Rain usually occurs from November to March or April, with most rain falling in December to February. Occasionally, good rainfall occurs between April and June, but in most years irrigation must be done from February—March to November.

DRIP IRRIGATION

Conventional irrigation consists mainly of sprinkler irrigation, with some desert areas using flood or basin irrigation where water is inexpensive. The high costs of water, upwards of $50 to $100 per acre-foot (12 ha-cm), in many citrus districts has forced growers into cost-cutting operations and improved cultural practices. Drip irrigation was introduced into California in 1969-70 on a commercial scale and it appeared at that time that this new method of irrigation could result in cost savings while still maintaining tree health and production.

New installations went in all over California as growers became acquainted with drip irrigation. Between 50,000 and 60,000 acres (20,200 and 24,300 ha) have been installed on all crops, including thousands of acres on citrus, a gigantic increase from only 100 acres (40 ha) in 1970. Growers quickly realized the potential of this new irrigation technology. The experience of the Isarelis, Australians and Mexicans showed that there were many advantages in the drip system, such as 1) water saving, 2) increased yields, 3) labor saving, 4) simultaneous fertilizer application, 5) less weeds and 6) better young plant vigor. There are also possible problems such as 1) orifice blocking, 2) filtration, 3) salinity, 4) disease factors and 5) engineering design.

Drip irrigation has created a wide interest in a short time in spite of a relatively small amount of experience, information and development. The main factor behind this interest is the potential of drip irrigation to reduce operating costs. Experience has shown that trees can be irrigated with 50% less water. Increased yields have been reported. Labor cost for irrigation is cut, since water applied by drip irrigation usually needs no tending, but is regulated by turning on valves. Growers are also faced with scarcity and high prices for labor and water.

Drip irrigation is the frequent, slow application of water to soil through mechanical devices called emitters located at selected points along water delivery lines. The application rate must be slow enough so that the flow of water across the soil surface is limited, and runoff in the usual sense does not occur. Most of the lateral movement of water to wet the soil between emitters occurs by capillarity beneath the soil surface. The volume of soil wetted in an orchard depends on soil characteristics and number of emitters but is usually much less than that wetted by other methods of irrigation, varying from 10% for newly planted orchards to as much as 50% for mature crops.

The number of emitters used ranges from 1 or 2 emitters for newly planted trees to 8 or more for large trees. Each emitter provides the slow water-flow needed. Most emitters are manufactured to provide a fixed rate of output with a specified water pressure. A few have adjustable rates. Rates available usually range from 0.5 to 2 gallons per hour (gph), 1 gph being most common. Most emitters provide a point source of water, usually placed directly on the soil surface or buried at a shallow depth. Others provide a line source of water from a tube having perforated or porous walls, which is usually buried.

The emitters are connected to/or are part of a small diameter (3/8 to 3/4 inch or 9.5 to 19 mm) plastic lateral line. The laterals generally lie on the soil surface but may be buried at shallow depth for protection. They connect to a buried plastic main line that receives water from a head. The head is the control station for the system, where water is measured, filtered, treated with fertilizer in solution and regulated as to pressure and timing of application.

Some Advantages

Drip rates are low, hence main line and lateral line sizes can be smaller than those for sprinkler or surface irrigation. Much of the surface soil never becomes wet, thus orchard operations are not interrupted. Weed growth is reduced so control efforts are reduced. Frequent irrigations maintain a soil moisture condition that does not fluctuate between wet and dry extremes and keeps most of the soil well aerated. Avoidance of intermittent drying permits the use of more saline water than can be used with other irrigation methods.

Some Problems

The emitter outlets through which water must flow are very small, they can become plugged by particles of mineral or organic matter carried in the water. Dissolved salts can also crystallize around the external perimeter of the orifices, reducing the size of opening. These restrictions may reduce the emission rate, upset the uniformity of distribution of irrigation water, and cause plant damage before plugging is detected.

Most emitters operate at 3 to 20 psi. Nozzle pressure and discharge during the irrigation period may differ up to 50% from that intended if the field slopes steeply, and the lines drain through lower emitters after the water is shut off. Some plants would receive too much, others too little.

Some soils may not have sufficient infiltration capacity to absorb water at the usual discharge rate without runoff or undesirable ponding. The soil must have an infiltration capacity of 0.5 inch (1.25 cm) per hour to keep the pool of free water around the emitter from exceeding 2 feet (61 cm) in diameter when the discharge rate is 1 gph. Sandy soils are probably best adapted to drip irrigation, especially those with slight horizontal stratification. Such stratification is beneficial for drip irrigation because it promotes lateral water movement and wets a greater volume of soil. Experience has shown that the system usually performs well in medium-textured soils, but there may be problems with some fine-textured soils.

Salts tend to concentrate at the soil surface and also at the perimeter of the soil volume wetted by each emitter. Light rains will leach surface-accumulated salts into the root zone, thus irrigations should continue on schedule until substantial rain has fallen. Drying of the soil between irrigations may cause a reverse movement of soil water, resulting in the transfer of salt from the perimeter towards the emitter. Water movement must always be away from the emitter to avoid salt damage. The foraging ability of the roots for nutrients and water is limited to the small volume of soil wetted. Damage to the crop could occur rather quickly should uncontrolled events cause suspension of water and fertilizer supplies.

Operation of System

Clean water is essential. Most failures observed are caused by inadequate filtering. Multiple screens as fine as

200 mesh or sand filters should be used.

Irrigations must be frequent and light. The duration of each irrigation must not be too lengthy, helping avoid local excessive wetness in soils lacking rapid permeability and minimizing algae growth in laterals. The amount of water applied should be based on measured or carefully observed soil-water conditions.

Lateral lines must be designed with adequate capacity to carry the maximum expected flow rate with little or no loss of pressure, although water emission rates are low. Lateral lines are generally of uniformly small diameter but their length should not exceed 300 to 400 feet (91 to 122 m). Additional main lines are preferable to excessive lateral lengths.

Lateral lines must be designed to carry the larger initial flow rate needed for flushing if flushing-type emitters are used.

Pressure regulators are necessary on sloping land. Laterals should be laid as level as possible.

Phosphate fertilizers should not be applied through a drip irrigation system. Phosphates react with calcium in irrigation water, forming a precipitate that can clog emitters.

Equipment and Installation

Two types of irrigation systems are installed in orchards, the conventional spitter system that can be converted to sprinklers and the drip system. There are different ways the drip irrigation system can be installed. The conventional type is buried PVC rigid pipe with a riser to each tree, and a plastic hose with emitters attached to the riser. Another method is to lay the hose on the ground in one continuous line near the trunk of the tree with 3 or 4 emitters placed at each tree site.

Equipment used in drip irrigation systems is very important. There are many pieces of equipment required. They include plastic hose or pipe, spaghetti hose, emitters, pressure regulators, pressure gauges, valves, fertilizer tanks, filters (both sand and screen), time clocks, tensiometers, evaporative pans, meters and fertilizer injectors. The most important item in the hardware for drip irrigation systems is the filter. Filtration is a must and extra money put into good filtration will give the required performance from emitters.

Increasing numbers of installations are going in with complete automation. Automation is accomplished with the use of a timer that can be set for daily operation at a certain hour of the day, or with the more sophisticated unit that is controlled by electrified tensiometers under the trees and coupled with the timer for operation.

Pressure regulation is very important. The difference of discharge of water from one emitter to the other must be kept to a minimum. This becomes extremely important and critical on hillside plantings. Engineers must make allowances in designing systems for differences in elevation either by pipe size difference or the installation of numerous pressure regulating devices so the same amount of water comes out of the emitter at the bottom of the orchard as at the top. Also, the fill-up time of the system, as well as the drain-out time, should be fitted into the calculations so one set of trees does not get more water than another portion of the orchard.

There are many emitters on the market today. They fall into 3 main categories: the moving parts type, the adjustable type and the fixed discharge type.

SUMMARY

It may be interesting in summary to note the crops using drip irrigation, either commercially or in experimental units.

The fruit crops include: avocados, grapes (table and wine), strawberries, grapefruit, lemons, limes, navel oranges, 'Valencia' oranges, tangerines, tangelos, macadamia nuts, papaya, peaches, pears, persimmons, walnuts, apples, boysenberries, melons, avocado nurseries, citrus nurseries, apricots, pistachio, plums, cherries, almonds, pecans, pineapple, coffee, bananas, mangoes, olives, figs, passion fruit and others.

Ornamentals, vegetables, and agronomic crops known to be using drip irrigation include: tomatoes, cucumbers, celery, potatoes, peppers, corn, asparagus, egg plant, peas, lettuce, ornamental trees and shrubs, bedding plants, cactus and succulents, bulbs, carnations, gladioli, poinsettias, chrysanthemums, ground covers on highway road cuts, street medians, turf (both home yards and golf courses), Christmas trees, forestry trees, radishes, sugar cane, cotton, sorghum, alfalfa, pasture, wheat and many others.

A preliminary report on the 1975 Worldwide Drip Irrigation Survey shows the following data for acreage under drip irrigation for the countries responding to date:

	1974 Est. Acres (Ha)	1975 Est. Acres (Ha)	1979 Est Acres (Ha)	1980 Est Acres (Ha)
U.S.A.	72,000 (29,150)	74,000 (29,950)	217,000 (87,800)	362,000 (146,500)
Other	65,000 (26,300)	123,000 (49,800)	90,000 (36,400)	241,000 (97,550)

Australia, Brazil, Canada, Costa Rica, Honduras, India, Iran, Israel, Japan, Mexico, New Zealand, Panama, Puerto Rico, South Africa, United Kingdom and West Africa are the only countries responding to date.

The 1974 and 1979 acreage figures were submitted at the time the 1974 survey was conducted. The 1975 and 1980 figures were derived from the 1975 questionaire. There are many other countries where drip irrigation is being used, but for some reason, the questionaire has not been received from them. However, it is safe to state that drip irrigation continues to create interest throughout the United States and in many other countries.