Subsurface Irrigation of Citrus

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Subsurface irrigation is utilized in areas having favorable soil characteristics and naturally, or artificially controlled high water tables. A second method of subsurface irrigation permits application of water below the soil surface by man-made devices. Apparent advantages and the development of new technology have prompted a recent increase in research on this type of irrigation.

To study subsurface irrigation of citrus, a system was designed and installed in 1966 in young grapefruit trees at the Citrus Experiment Station in Tempe.** Two 4-tree plots with subsurface irrigation and an adjacent 4-tree control plot with surface irrigation were established. The soil in the plots is a well-drained Laveen gravelly, sandy loam. A calcium carbonate concentration of 2 to 4 per cent occurs in the upper 30 inches with a porous caliche layer below this level.

The System

In 1966 and 1967, the subsurface system consisted of perforated plastic pipe, ½ inch in diameter, buried about 6 inches below the surface in a 40-inch diameter circle around each tree. The pipe perforations in the north plot were 1/32-inch diameter holes spaced 15 inches apart. In the south plot, 1/16-inch diameter holes on 30-inch centers were used. In 1968, an additional concentric ring of ½-inch plastic pipe, 70 inches in diameter, having 1/16-inch holes spaced 15 inches apart, was placed around each tree in both plots.

Method and Results

The water for irrigation was obtained from deliveries of the Salt River Project to the Citrus Experiment Station and applied to the subsurface plots with pressures from ½ to 2 pounds per square inch. Two strainers were used to remove solid particles. The dissolved salt content of the water varied from 320 to 1760 parts per million with an average value of about 750. Some plugging of the perforations occurred, probably from solid material left in the pipe during installation or from particles which passed through the strainers. Salt deposits or tree roots may have contributed to the problem.

During the first three years, irrigations were applied at approximately two-week intervals. In 1967, tensiometers placed 8 inches from the tree, indicated a lower moisture content occurred in the subsurface plots than in the surface plots. Tensiometers were also placed 25 inches from the tree in 1968 with the same indications as in 1967.

In 1969, the north plot was irrigated at one week intervals and the south and control plots at two week intervals. The same quantity of water was applied to both subsurface plots during the season, however, the tensiometers indicated soil in the south plot had a much lower moisture content just prior to irrigation than in the north plot. Tensiometer readings in the north subsurface plot and the surface irrigated control plot were similar.

The average depth of water applied per acre per year is shown in Table 1. These values are based on approximate water depths over an area 23 feet by 6 feet per

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** *This study was initiated by Dr. C. D. Busch.*

tree in the control plot. The water to the subsurface plots was measured with meters and the depth determined

Table 1. Water applied in acre-feet per acre of surface area irrigated.

Year	Acre-Feet/Acre Subsurface	Surface
1966	2.3	3.6
1967	3.7	4.2
1968	5.2	4.7
1969	4.5	4.5

for a circular area 14 inches in radius greater than the largest ring of perforated pipe installed. The 14-inch value was based on the lateral distance of water movement during a normal irrigation.

A considerable water savings can be achieved by irrigating only a small area around each tree. Table 2 shows the average amount of water applied per tree per year.

Table 2. Water applied to citrus by surface and subsurface irrigation.

	WATER APPLIED		
	Cubic feet/tree		Per cent:
Year	Subsurface	Surface	Subsurface / Surface x 100
1966	58	500	12
1967	93	580	16
1968	271	640	42
1969	234	620	38

In 1966 and 1967 subsurface delivery was 12 per cent and 16 per cent of the surface water applied for those years, respectively. The increase to 42 per cent in 1968 and 38 per cent in 1969 was caused by adding the second ring of pipe and consequently irrigating a larger area. The 60 per cent water reduction is still a significant amount, although this will decrease as the trees mature and a larger area is irrigated.

Table 3. Effect of surface and subsurface irrigation on average trunk area.

	Trunk Cross-Sectional Area, square inches		
Growth Period	Surface Irrigation	Subsurface Irrigation	
		South Plot	North Plot
1967	2.0	1.6	1.4
1968	4.4	3.4	3.0
1969	8.2	5.2	4.8

Yield data are not yet available, however, trunk cross-section measurements clearly show the surface irrigated trees are larger (Table 3). The difference probably reults from one or more of the following conditions on the subsurface plots: plugging of holes causing uneven water distribution, insufficient volume of wetted soil for the irrigation frequency used and limited lateral movement of water from the perforated pipe. The 40-inch ring was too large to provide water to the root ball without applying an excess amount which wasted water below the root zone. Because of these water distribution problems and lack of an economical mechanical means for installing the rings, this design is not recommended. However, it is believed that trees of comparable size can be obtained by subsurface irrigation using improved design and management.

Distribution of Salts

Studies have shown that the distribution of salts in the soil after irrigation is dependent upon the method of irrigation used. Subsurface systems tend to result in salt accumulations above the buried pipe. To study the salt accumulation in the plots, 60 soil samples were taken in November 1968 and saturation extracts analyzed for salt content.

The results of the soil analysis for salt content are shown in Table 4. Each value represents an average of several samples taken at the same depth and distance from a tree. The salt content increased in the subsurface irrigated plots, particularly near the trees. The greatest accumulation is found in the top 6 inches. The concentration of salts at a few locations has reached a level capable of affecting plant development (electrical conductivity greater than 2.5-3 millimhos/centimeter for grapefruit). An appreciable difference between the two treatments can be noted.

Table 4. Soil salinity as determined by the electrical conductivity of a saturation extract.

	Soil Salinity, millimhos per cm.				
Depth of	Subsurface Irrigation			Surface Irrigation	
Sample,	Distance from Tree, Inches			Distance from Tree, Inches	
Inches	55	80	132	48	132
0 - 6	6.47	3.13	2.02	0.83	0.85
6 - 12	2.19	1.48	1.89	0.84	0.55
12 - 18	1.20	1.55	1.37	1.07	0.47
18 - 24	1.40	1.25	1.86	1.65	0.63

The possibility of reducing water application with subsurface irrigation could be a great advantage to Arizona. However, more information is needed on design and management of subsurface systems under a variety of soil, water and plant situations. This study is therefore being continued and expanded as new ideas and products become available. For example, a subsurface system using microporous plastic pipe is planned for 1970. The microporous pipe is ½-inch in diameter and has pores approximately 3 to 10 microns in diameter which allow water to pass through the pipe wall.