DRIP IRRIGATION OF CITRUS–PANEL

DRIP IRRIGATION IN FLORIDA CITRUS

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Florida is considered by the population as a whole to have high annual rainfall and an abundant water supply. Those of us in Central and South Florida, however, no longer subscribe to this viewpoint. The annual rainfall (53 to 57 inches or 1,350 to 1,450 mm) has been below average over the past decade, and the deficit has reached disturbing proportions in some areas. The agricultural community, as much as any other group, is painfully aware of the situation. Stringent new laws governing well drilling and water consumption by many industries, including the giant agricultural complex, are now a reality. Irrigation practices are coming under close scrutiny and citrus growers are evaluating more critically the various types of irrigation in use.

Supplemental irrigation of citrus, during the dry spring months and to a lesser extent during the fall and winter, is necessary for maximum yield potential of most major citrus varieties grown in Florida. It is estimated that approximately 75% of Florida citrus could be irrigated by some method, and this proportion is expected to increase. It is clear, therefore, that the citrus industry is and will continue to be a major consumer of water resources.

Methods of irrigation available for consideration by the citrus grower include crown or flood, portable sprinkler pipe, permanent overhead sprinkler, self-propelled guns and more recently drip or low-volume systems. Growers should consider such factors as water consumption, initial investments (capital outlay) and operating costs (including labor and energy requirements) when evaluting these systems as they vary considerably with each type.

The first drip irrigation systems were installed in Florida citrus groves about 1970, and a conservative estimate of the total area now under this type of system is 12,000 acres (4,850 ha). Name brands include Sysag, Drip-eze, Spot, as well as others on smaller acreages. Micro-jet, a low-volume, low-profile spray system has also been installed on a significant acreage. Factors frequently given in favor of drip systems include low water consumption rates, low installation costs, low labor and energy requirements. The initial investment of permanent systems has increased, however, and so has the cost for drip systems. The low energy requirement still continues to be a very attractive aspect of drip systems in view of soaring energy costs. Labor and general maintenance costs have not turned out to be as low as predicted, due to problems which have arisen with water quality.

Let us consider drip irrigation in Florida citrus groves, first in relation to the tree moisture requirements and tree performance and second with respect to water quality. Water quality has, more than any other factor, affected the maintenance and operating cost picture. No reliable experimental data are available at this time, although records are available from commercial grove operations showing production figures. It is not known, for example, whether the per-acre yield of a 12-year-old 'Valencia' orange block irrigated with 2 emitters per tree will be equivalent to that under a permanent sprinkler system operating at the recommended capacity and frequency. Information is needed on the number of emitters required per tree of a certain age, at a specified spacing and on a particular soil type. Determinations of the wetting patterns below emitters on varying soil types on which citrus is grown in Florida indicate great differences in horizontal water movement. This movement is very limited in the infertile, fine sandy soils and deep, coarser sandy soils, and quite appreciable in the heavier marl soils and those soil types where a hardpan is near the surface.

Grower observations in the flatwoods areas of the

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south and east coast of Florida indicate that young bearing groves under properly functioning drip systems with 2 emitters per tree look well and are producing satisfactorily. Indeed, many blocks previously irrigated by travelling guns are in better condition and show increased production after 2 years under drip irrigation. A valid explanation here, however, lies in poor irrigation schedules and poor coverage obtained with volume gun units. Insufficient units to cover the acreage, wind conditions and inappropriate grove lay-out are among the contributing factors.

Soil variability is great in the flatwoods areas and much of the acreage is on poor sand-soaked areas. Trees with shallow root systems on such soils rapidly go into wilt in the dry spring months unless a high frequency irrigation schedule is followed. The installation of drip irrigation systems in these situations has resulted in improved grove conditions with less apparent tree wilt, probably due to the constant source of water in the root zone.

Water quality, especially in the south and east coast areas of Florida, has been the greatest single determining factor governing the success or failure of drip systems. Quality of water used is an important factor determining whether or not biological clogging problems will be encountered. Clogging of emitters, filters and lines has occurred quite frequently in drip irrigation installations in groves in the south and east coast of Florida. Such blockage is caused mostly by sulfur slimes and iron deposits.

Certain bacteria oxidize hydrogen sulfide to sulfur and the bodies of other bacteria are found in the slime complex. Iron deposits associated with iron bacteria have also been found in the form of filamentous gelatinous ochre. The sticky sludge adheres to the filters, emitter grooves and orifices. Iron sulfides have also been found to clog screens. Most of these problems are associated with both shallow and deep well water sources. More specifically hydrogen sulfide is usually associated with shallow and deep artesian wells and iron with shallow wells.

Systems using surface water sources such as open ditches and canals have also had difficulties. Here, the decomposition residues of filamentous algae have been responsible for the fouling of filters and emitters. Algae form soft gelatinous organic slimes which can in turn accumulate iron and support the growth of iron bacteria.

Considerable work has been done in an effort to determine the causes of clogging, to identify the causal organisms and to develop chemical treatments with practical applications. Modification of system design and manipulation of operational procedures have also been recommended for the alleviation of these problems. Water sampling and testing procedures have been developed which are specific to problems associated with drip irrigation. Permissible ranges for iron and sulfide levels have been determined. Recommendations can be made whether water from a particular well or surface source can be used satisfactorily with or without chemical treatment. The selection of an alternate source of water if iron levels are above 1 ppm is recommended instead of chemical treatment which may be impractical because of cost.

Chlorine gas, hydrochloric acid and various chlorine-based chemicals have been commonly used in most drip systems as maintenance treatments. Such treatments are not considered effective in situations where systems have already become inoperable due to blockage. A non-chemical treatment recommended in the case of sulfur water systems involves the continuous operation of systems with no air leaks. This procedure of oxygen exclusion retards the growth of the sulfur bacteria. Continuous operation is neither practical in terms of water consumption nor desirable for the citrus tree, hence it is recommended that the lines be kept full and air-free by bleeding water into the system between irrigation cycles through maintenance of a continuous low pressure.

Sophisticated filtration procedures frequently are not the complete answer to the biological clogging problems, as many of the reactions take place in the lines and at the emitters after the water has passed through the filters. Filtration and automatic flushing procedures for surface water sources are proving fairly satisfactory, however, for the elimination of algae and other forms of organic debris.

Fertilizing with nitrogen and potash sources through irrigation systems has been attempted on a limited acreage, but reliable research data have not yet been obtained to determine its feasibility. Growers using this procedure are advised to apply it to a limited acreage experimentally and to observe tree condition for signs of nutritional deficiencies. Leaf analyses after trees have had a period of 2 years to adjust to the new method of fertilization would be helpful in determining the nutritional status.

Fertilization with certain heavy elements may aggravate an already present blockage problem by forming insoluble precipitates with the sulfides in the water. It is also worth noting that fertilization is as stimulating to the growth of bacteria and algae as it is to the citrus trees, and therefore may encourage the proliferation of these organisms in the system.

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QUESTIONS FOR PANEL

Q: I didn't hear much about lateral movement and how much of the root system would receive water. Is there any reason for that?

Gustafson (California): We have done quite a bit of work on lateral movement. Fortunately, we have soil that will move the moisture very well. It's a combined sandy loam and fine sandy loam, so we have good transmission of the water laterally away from the point source. According to work in Australia, we could have 25% of our root system not wetted, and still not have a reduction in the production of that tree.

If you used an emitter of 1 gph for 4 hours on a sandy loam soil, the pattern of distribution will be different than the same system in a heavy clay soil for *X* number of hours. For instance, in the San Joaquin Valley, which has very heavy soil, a 0.5-gph emitter has to be sequenced—possibly 15 minutes on and 10 minutes off—in order to permit even half a gallon of water per hour to infiltrate the soil to any depth to take care of the root system. In sandy loam soils, we can put on water for 4 hours and it all goes in. However, our soil is such that the water-holding capacity is low, so we have to irrigate more frequently and for longer periods of time.

The longer we run it, the wider and the deeper distribution we get. We have potentiometers at 12 and 24 inches (30 and 61 cm), and we are always able to touch the 24-inch (61-cm) instrument. Those instruments are read Mondays, Wednesdays and Fridays and we keep the average at 20 cb. If it goes over 20 cb, we make adjustments in time, which is usually half an hour. Right now, we are running 2 hours a day. Sometimes we run 4 hours, in which case we will run 2 hours at 9:00 at night and 2 hours at 4:00 in the morning. But tensiometers under our sprinklers read 50 to 60 cb and we have a difficult time penetrating the soil with sprinklers, even with 2 to 3 hours or irrigation. With drip irrigation, we can keep between 8 and 15 and maybe 8 and 18 cb, which is what we like to do, and the trees seem to respond to it.

Q: What is the pattern of salt accumulation in the soil under drip irrigation?

Gustafson: Salt accumulation is probably in the first 3 inches (75 mm) of the top of the soil and then around the outer edge of the wetted pattern. This is why it is very important in our area, especially in October and November, that if we get 0.5 to 1 inch (12 to 25 mm) of rain, we have to continue to irrigate. Otherwise, the salt in the first 3 inches (75 mm) of soil, which is very highly concentrated, will be pushed into the root zone, causing very severe burning. This is a management practice and this is our educational program with growers. We have to have at least 2 inches (50 mm) of rain in a period of 1 to 3 days before we can stop the irrigation. Up until that point, we have to turn the irrigation system on to keep the salt out of the wetted root zone.

Q: How far do you put your emitters from the trunk of the average tree?

Gustafson: In our test grove and for most growers installing it, the row of emitters will be just inside the drip line. According to the work in Australia, they are pretty well convinced that if you wet a certain pattern, the root system of the tree will kill back to that pattern and you will be able to control that. You cannot permit that area to dry out, especially in soils of a high saline condition—drying for even a day will cause very serious tip-burn. If you have plants as susceptible to salts as avocado and in some areas, citrus, you'll note chloride burn where they have not done a good job of irrigating.

Q: Has Dr. Koo or anyone said anything about more roots, particularly feeder roots, in the wetted area?

Tucker (Florida): We are doing some work on that now, taking some borings next to the emitters. I think it obvious there are more, but there seems to be a lot of variation. If there are more, we don't know how much more. Of course, we have rainfall in Florida to keep the roots outside the wetted area going.

Q: Is there any need for different placement of the emitters in the case of sloping terrain in California as compared to flat terrain?

Gustafson: I haven't seen that the placement is much different. When we plant the tree, we have an emitter right at the trunk of the tree to wet the ball. As the tree grows and the roots get beyond the ball and into the orchard soil, we will move the emitter upslope slightly. This depends more upon soil type and the lateral spread and downward movement of moisture in the various soil types.

We haven't found that emitter placement on slopes makes any difference. We have emitters upslope from the tree, we have emitters looped around the tree, and there doesn't appear to be any difference. Right now the Drip-Eze Company is manufacturing loops of 4 emitters, 3 feet apart, to be put around 1-year-old trees. However, in this case they can simply cut the time of irrigation from 4 hours to 1 hour or less, as they are putting out 4 gph with each loop. As the tree grows, they can simply enlarge the loop to keep it at or near the drip line of the tree. However, we have not seen that that is necessary in California.

Q: Has anybody seen any water damage to trees as a result of mishandling of drip irrigation or excessive use of it?

Lyons (Texas): Yes, you can certainly get water damage from misuse of drip irrigation, particularly on heavier soils. A soil physicist in Texas was doing some work on root systems and irrigation, and when he irrigated the equivalent of 0.4 of class "A" pan, where we know the maximum required is 0.3 of pan, the roots were killed underneath the emitters, and there was a significant reduction in the total number of roots in the wetted zone. In addition, we seriously retarded the growth for 1 year of interplants under drip irrigation, where we were applying half as much water as we applied to mature trees.

Gustafson: I would like to add a note on that. In a 4-year-old avocado grove, which will take approximately 12 to 15 gallons of water per day per tree, a grower called us in because spotted through his grove were trees which had no new growth flush, a dull color, and all indications of having dryness and the start of avocado root rot. It didn't seem possible that this grove, which was high-producing and well taken care of, could have such problems. Upon closer examination and digging underneath some of the affected trees, we found the soil to be completely wet. We finally pinned the grower down and discovered that he had been applying 18 to 20 gallons per day, which is entirely too much water. We have found more damage from over-irrigation with drip irrigation than from under-irrigation. Psychologically, because of the minor dripping of the system, you think the trees are not getting enough water, but it is amazing how much a few drops of water constantly dripping for 2 or 3 hours will amount to. Again, it is management and knowledge of how much water the trees need and the type of soil involved.

Q: When will these papers be ready so that we will be able to determine what water quality we can use or whether we can use our water?

Tucker: Dr. Ford has these papers out now in the form of handouts that will give you some idea of what quality you can work with.

Q: Mention was made of the desire to wet 75% of the roots without much concern for the 25% of the root system outside of the wetted area. Considering the drip irrigation systems in the Ridge in Florida, what percent of the rooting area are we designing our drip irrigation systems to wet?

Koo (Florida): I have been suggesting that they try to wet 60% of the roots for drip irrigation. This goes back to sprinkler irrigation, where we keep the soil moisture in the root zone at about 60% of field capacity to attain maximum potential yields.

Q: Have you done or do you know of any research using under-tree sprinkling or microjets for possible freeze protection?

Panel: No.