IRRIGATION AND FERTIGATION OF YOUNG CITRUS TREES

F. S. DAVIES
Horticulturist
University of Florida, IFAS, Gainesville, FL 32611

INTRODUCTION

The freezes of 1983, 1985 and 1989 have damaged or killed over 200,000 acres of citrus, prompting the replanting of some areas or the movement to more southerly locales in the state. In 1987-88 alone over 126,000 acres of citrus trees were planted in Florida. Most of this new acreage has some type of microirrigation and in many plantings fertigation is used to fertilize the newly set trees. Many different irrigation and fertigation programs currently exist. Studies in the early 1960s by Rasmussen and Smith suggest that granular fertilizers need to be applied only 2 to 3 times/year to obtain optimum tree growth. Recently, however, with the movement of the industry to southern Florida, more frequent applications may be required due to the longer growing season. Similarly, several irrigation studies have been conducted using young citrus trees in other parts of the world, but the results are not directly applicable to Florida's growing conditions. The objectives of this paper are to discuss some of the principles involved with proper irrigation and fertigation management and to relate these to currently available recommendations.

IRRIGATION

Traditionally, newly set citrus trees were irrigated using a water wagon. Water rings were built out of soil around the trees and from 5-10 gallons of water were placed in the ring. This process was not very efficient, was wasteful because of rapid percolation of the water through the soil, and in many instances could not provide sufficient water for adequate tree growth. With the widespread use of microirrigation in newly set groves, tree survival and growth have increased substantially. However, a recent IFAS survey indicates that many microsystems are being operated much longer than necessary for optimum tree growth (Taylor et al., 1989).

Therefore, before irrigating it becomes important to understand some basic principles of irrigation for young citrus trees. Young trees, particularly during the first growing season, have very limited root systems. Marler and Davies (1990) found that 76% of the total root dry weight was located within 16 inches of the trunk for 8-month-old 'Hamlin' orange trees (Table 1). Although these data include the weight of large structural roots, the same trend was true for small fibrous roots. Moreover, most roots were within 12 inches of the soil surface with few roots in the top four inches of soil (Table 2). Marler and Davies (1990) also found that it was not necessary to irrigate newly planted trees for more than 1.5 hours when using 10 gallon-per-hour (gph) 90° microsprinklers in order to replenish water in the root zone. Obviously, the root system increases laterally and vertically as the tree grows and proportionally more of the soil surface must be covered using higher irrigation rates.

Table 1. Lateral root distribution for an 8-month-old 'Hamlin'/sour orange trees based on 3 years of cumulative data.

	Distance from trunk (inches)		
	0-16	16-30	>30
Total dry wt (%)	76.2	16.2	7.6

Source: Marler, T. E. and F. S. Davies. 1990. J. Amer. Soc. Hort. Sci. 115:45-51

Table 2. Feeder root distribution by depth for 8-month-old 'Hamlin'/sour orange trees based on 3 years of cumulative data.

Depth (inches)	(% of total root dry wt)
0-4	2.0
4-8	56.0
8-12	26.0
>12	16.0

Source Marler, T. E. and F. S. Davies 1990. J. Amer. Soc. Hort. Sci. 115:45-51

Young trees, unlike large, bearing trees, do not have the capacity to store much water and new leaves have less structural rigidity and poorer control over water loss than mature leaves. Therefore, young trees are very sensitive to water deficits. Thus, the grower must provide adequate but not excessive levels of water to the root zone for adequate tree growth.

IRRIGATION SCHEDULING

Methods. Most growers irrigate young trees either by the calendar method or by judging tree characteristics like leaf wilting. The calendar method does not take into account environmental conditions and will likely result in over- or underirrigation. However, it is easy to use and widely practiced. Using tree characteristics, such as the incidence of wilting, is also not the best method of scheduling irrigation. In some cases, young leaves may be wilted due to high evaporative demand conditions, yet soil moisture may be at high levels. In contrast, growth may be adversely affected long before wilting occurs.

Most irrigation research is based on the use of differing levels of soil moisture to determine when to irrigate. Soil moisture depletion (SMD), the amount of water which is removed from a given soil volume, can be monitored using a neutron probe which measures percent soil moisture. High speed neutrons, which are emitted from a radioactive source, are sent into the soil around an aluminum access tube. As the neutrons collide with water in the soil, their speed is reduced. A sensor then compares the ratio of fast to slow neutrons which then can be related to soil moisture content. Soil moisture tension is measured in centibars (cb) using tensiometers and indicates how tightly water is held to the soil. The neutron probe is more reliable than tensiometers in very sandy soils, but has a radioactive source and is expensive. Tensiometers only measure a small portion of the soil volume and may be inaccurate in very sandy soils, but are easy to use and inexpensive.

Two recent irrigation studies (Smajstrla et al., 1985; Marler and Davies, 1990) in Florida using newly planted citrus trees suggest that soil moisture tension should be maintained at around $^{-}$20 cb and SMD at between 30 and 45%. These levels allow the same growth levels as higher irrigation rates without overirrigating and causing leaching of nutrients. Irrigating at $^{-}$40 cb or >45% SMD (dry conditions) severely inhibited both canopy and new root growth. Moreover, there are strong indications that lack of water during the spring reduces shoot number and growth even during the following fall. In contrast, 'Valencia' trees receiving frequent irrigation at $^{-}$10 cb were chlorotic, suggesting nutrient leaching was occurring from the root zone.

Durations. Irrigation durations using 10 gph microsprinklers should range between 1 and 2 hours for newly set trees. Durations and amounts of water applied should be increased to 3 to 4 hours as the root system grows and spreads. A broad range of durations and frequencies of irrigation are given in Table 3. These will vary with environmental conditions and soil type and are intended to be general guidelines.

Table 3. Suggested irrigation durations and frequencies for 1- to 4-year-old citrus trees in Florida using 10-15 gph microsprinklers. These numbers should only be used as general guidelines. Conditions will vary from grove to grove.

Years in the grove	Duration of irrigation (hr)	Time between irrigations[z] (days)
1	1-2	2-3
2	2-3	2-3
3	3-4	3-5
4	3-4	3-7

[z]Period of time with less than $^1/_8$ inch of rain. This period will vary with time of year and evaporative demand.
Source: L. Parsons, Lake Alfred CREC.

FERTIGATION

Fertigation, the application of soluble fertilizers through irrigation lines, is rapidly becoming a widely used method of fertilizing young citrus trees in Florida. Fertigation has the advantages of being easy to use, efficient and also provides nutrients in a soluble form. Fertigation systems are also easily automated. Disadvantages include the initial cost for tanks and injectors, formation of precipitates when some nutrients are applied together, (e.g., phosphorus and magnesium), and lack of uniform coverage due to problems with irrigation system design. Fertigation should not be used with highly saline irrigation water. Because the system can be automated, there is a tendency to overfertilize with some growers applying as much as a pound of elemental nitrogen per year for newly set trees. Nevertheless, growers using fertigation systems have seen tremendous increases in young tree growth compared to standard fertilization and irrigation practices.

Frequency. There are many differing opinions as to how much and how often to fertigate. Recent studies by Willis and Davies (1989) suggest that growth of newly planted citrus trees is the same whether granular or liquid materials are applied provided that trees receive water at optimum levels. In addition, fertigating weekly, or every 3 or 6 weeks did not affect tree growth provided that trees received the same amount and analysis of fertilizer and water over the entire growing season. Rootstock selection and local growing and soil conditions, however, may affect these results. 'Hamlin' orange trees on 'Carrizo' citrange growing in a sandy soil typical of the Ridge appeared to grow better with 30 vs. 10 or 5 applications/year, although more research is needed to confirm this observation. Therefore, from a standpoint of growth, growers have the option of a wide range of fertigation frequencies. However, infrequent, heavy fertilizations may increase soil nutrient levels with the potential of causing ground water pollution.

Rates. Fertilization rates should be within those outlined for young citrus trees in IFAS Bulletin 536-D. For newly set trees, nitrogen rates of 0.3-0.6 pounds/tree/year are adequate whether using liquid or granular material. Use of liquid materials does not necessarily improve fertilizer efficiency provided that granular materials are irrigated in after application. Fertilizer rates, like irrigation durations, should be increased as trees increase in size.

SUMMARY

Proper irrigation and fertigation management of young citrus trees is an effective means of greatly increasing tree growth. Microsprinkler irrigation should be scheduled to apply water when SMD reaches 30-45% or soil moisture tension is $^-$20 cb. Durations should range between 1 to 2 hours for newly set trees to 3 to 4 hours for 3- to 4-year-old trees when using 10 gph microsprinklers. Durations should be adjusted if different types of emitters or gallonages are to be used. Excessive irrigation wastes water and energy, is costly, and may cause leaching of soil nutrients and herbicides.

Fertigation is a convenient and effective method of providing nutrients to young trees, particularly when used in conjunction with a well-managed irrigation program. Fertilizer rates should be within those

recommended for granular programs (IFAS Bulletin 536-D). Fertigation frequencies may vary from weekly to once every 6 weeks and should be determined based on water quality and management practices in a particular grove situation. More frequent application may reduce the amount of nutrient leaching below the root zone compared with less frequent fertigation. Excessive fertigation is also costly and inefficient and may lead to excessive nutrient leaching. A well-monitored and -managed irrigation/fertigation program makes cost-effective use of resources without compromising tree growth or the environment.

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