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# IRRIGATION AND FERTILIZATION OF YOUNG INTERSET 'HAMLIN' ORANGE TREES IN FLORIDA

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*Abstract.* **Young 'Hamlin' orange (*Citrus sinensis* [L.] Osb.) trees on 'Swingle' citrumelo (*C. paradisi* Macf. × *Poncirus trifoliata* [L.] Raf.) rootstock were interset in a 10-year-old 'Hamlin' orange grove. The objective was to compare various irrigation schedules, emitter patterns and fertilizer types for optimizing interset growth while minimizing costs. Trees were irrigated using 90°, 180° or 360° 10 gph microsprinklers for either 2 (young tree) or 4 (mature tree) hours based on an available soil water content (SWC) of 70% for young trees or 70% Jan.-June and 50% July-Dec. for mature trees. One half of the trees in each group were either fertilized 5 times/year with dry, water soluble (8N-2$P_2O_5$-8$K_2O$) material or once/year with Sherritt® controlled-release fertilizer (44.5N-0$P_2O_5$-45$K_2O$). Trees on the young tree program were irrigated 27 and 17 times/year in 1993 and 1994, respectively, while those on the mature tree program were irrigated 15 and 11 times/year, respectively. SWC was generally lower for interset trees irrigated using 360° vs 180° or 90° emitters, although SWC was usually greater than 70% for all emitter patterns. Mean trunk diameter after years 1 and 2 in the field was similar for all emitter types, and both irrigation schedules. The dry fertilizer produced statistically but not noticeably larger trunk diameters than the controlled-release fertilizer. Therefore, interset trees may be watered on a mature tree schedule and fertilized once/year using controlled release materials without significantly decreasing growth during the first 2 years in the field.**

Pests and diseases, particularly blight and citrus tristeza virus, cause the death or economic decline of millions of citrus trees in Florida each year. Conservative estimates suggest that the average grove has 3.5% tree losses per year (Muraro and Holcomb, 1993) which translates to over 4,000,000 trees/year statewide. Removing damaged or dead trees and resetting with young trees cost growers an average of $31.58/acre/year (Muraro and Holcomb, 1993) to bring the trees into production during the next 3 years.

Interset trees are difficult to manage. Trees are often scattered throughout the grove and thus may become overlooked and neglected. Irrigation and fertilization rates and frequencies of application also differ for young interset, compared with mature trees. Young trees are fertilized (Ferguson et al., 1995) and irrigated (Davies et al., 1989) more frequently and at lower amounts than mature trees due to their smaller root and canopy volume. Therefore, the grower often has to compromise by either over-irrigating young trees when using higher rates for mature trees, or underirrigating mature trees when using a young tree rate. Similarly, broadcast fertilizer application for mature trees does not provide sufficient nutrition for young intersets. Conversely, if fertigation is used young trees may receive too much fertilizer, thus increasing the potential for nitrate groundwater pollution in some areas of the state. Growers have the option of changing microsprinkler emitter pattern when irrigating young interset trees, e.g., 360° to 90°, or in the use of controlled-release fertilizers to decrease the need for frequent, costly application of dry, water soluble fertilizers (Ferguson et al., 1988). However, there are no universally used practices in managing interset trees.

The objective of this study was to compare the effect of various microsprinkler irrigation schedules, emitter patterns and fertilizer types on growth of interset 'Hamlin' orange trees. The treatment combinations were arranged to give a wide range of management options and to determine the optimum irrigation-fertilization practices for young interset citrus trees.

## Materials and Methods

The study was conducted in a 0.8 acre planting of 'Hamlin' orange trees on sour orange (*C. aurantium* L.) rootstock planted in 1983 at Gainesville, FL. Soil type was an Arredondo fine sand (loamy, siliceous, hyperthermic, Grossarenic Paleudults). The soil had a volumetric field capacity of 10.2%, a permanent wilting point of 1.7%, and 1.66 $gcm^{-3}$ mean bulk density. Trees were planted at 20 feet between and 15 feet within rows. On 31 Mar. 1993 barerooted 'Hamlin' orange trees on 'Swingle' citrumelo rootstock (Southern Citrus Nursery, Dundee, Fla.) were interset halfway between the mature trees within the row.

*Irrigation.* The planting was randomly divided into 16 blocks of 6 mature and 6 interset trees each. Eight blocks were irrigated on a mature tree schedule based on $\frac{1}{3}$ soil water depletion (SWD) from Jan.-June and $\frac{2}{3}$ SWD the rest of the year (Koo, 1963). The other 8 blocks were irrigated based on a young tree schedule of 30% SWD for the entire year (Marler and Davies, 1990). Trees in the mature tree blocks were irrigated for 4 hours and those in the young tree blocks for 2 hours. Irrigation for 4 hours returned the soil water content to field capacity or above for mature trees. The 2-hour irrigation returned soil water content of young trees to field capacity. Within each of the 16 blocks, each of 2 interset trees was randomly assigned a different irrigation pattern using 90°, 180°, or 360° 10-gph Maxijet™ microsprinklers located about 3 feet northwest of the tree. Mature trees were irrigated using 10 gph 360° emitters located about 2 feet west of the trunk. Soil water depletion was determined using a Troxler model 1255 neutron probe (Research Triangle Park, NC) at a 1-foot depth. Readings to determine irrigation timing were made about every 3 days when no rainfall occurred on 4 mature (360°) and 4 young (360°) trees located throughout the planting. At the same time, SWD was measured for 6 trees in the 90° and 180° pattern treatments. Probe tubes were placed 1 foot from young trees and at the dripline of mature trees within the irrigation wetting pattern for each tree.

*Fertilization.* Three trees in each block received either a broadcast application of dry, water soluble fertilizer 5 times/year at 0.50 lb N/tree (year one) or 0.75 lb N/tree (year 2) as previously recommended (Koo et al., 1984), or controlled-release fertilizer once in April at 0.20 or 0.33 lb N/tree/year in years 1 and 2, respectively. These rates are higher than those currently recommended (Ferguson et al., 1995), but were appropriate at the time of the study. The dry fertilizer was an 8N-2$P_2O_5$-8$K_2O$ formulation (4% ammonium and 4% nitrate). The controlled-release material (Sherritt Fertilizer Co., Canada) was a 44.5N-0$P_2O_5$-45$K_2O$ formulation with urea as the N source. Ten leaves/tree were collected from fully expanded spring flush leaves in Aug. 1993 and Sept. 1994 and analyzed for

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N, P, K, Ca, Mg, Zn, B and Cu as described previously (Maurer and Davies, 1995).

Mature trees received 1.2 lbs N/tree/year in 3 applications (March 1, June 1, Sept. 1) based on projected yields of about 3 boxes/tree (90-lb equivalents) in both seasons. Fertilizer was broadcast around and within the dripline using the same analysis material as for young trees. Twenty fully expanded spring flush leaves from nonfruiting shoots were collected from 10 trees/main irrigation treatment in Aug. 1993 and Sept. 1994 and analyzed for leaf nutrient concentration as described for young trees.

*Experimental design.* The experiment consisted of a split-split-plot design with 2 main plots (mature and young irrigation schedules, 8 blocks each), 3 irrigation pattern subplots (90°, 180°, 360°) and 2 fertilizer type sub-subplots (dry and controlled release). Data were analyzed using ANOVA for split-split-plot designs as main, subplot and sub-subplot effects with appropriate interactions.

*Measurements.* Trunk diameter of intersets was measured monthly at 7 inches above ground level from 31 Mar. 1993 until 4 Dec. 1994. Trees were also subjectively evaluated for vigor and leaf color when trunk diameters were measured. Weeds were controlled using glyphosate and pests using citrus spray oil FC435-66 as needed. Mature trees were harvested in December of each year and yields were recorded.

## Results and Discussion

### *Irrigation Effects in 1993*

Trees were irrigated based on SWD because this has been the traditional research method of scheduling irrigation in Florida. However, data are presented as changes in soil water content (SWC) over time because trends are easier to follow. A SWD of 30 and 50% is equivalent to 7.65 and 5.95% SWC, respectively. Soil water content was generally lower during spring and summer for interset trees irrigated using 360° vs 180° or 90° emitters (Fig. 1A). The pattern and magnitude of SWC changes were similar for all patterns during the fall. The soil reached 5.95% SWC (30% SWD) 27 times for interset trees on the young tree schedule (Table 1). Interset trees on the mature tree program had similar SWC patterns and magnitudes for all emitter patterns (Fig. 1 B). Trees in this treatment reached 5.95% SWC 10 times before 1 July and 7.65% SWC (50% SWD) 5 times after July 1 for a total of 15 irrigations/year. Mature trees on the young tree schedule had lower SWC than those on the mature tree schedule during May and June and higher SWC during Sept. and Oct. (Fig. 1C). However, often SWC was at or above field capacity.

### *Irrigation Effects in 1994*

Soil water content was similar for interset trees on the young tree schedule for all emitter patterns except in late spring and summer when SWC was lowest in the 360° pattern treatment (Fig. 2A). This is especially apparent from 21 Mar. (data not shown) to 20 May. Soil water content of interset trees on the mature tree schedule was generally lower for the 90° vs 180° or 360° treatments (Fig. 2B). Soil water content of mature trees on the young or mature schedules were similar throughout the year and showed less numerous fluctuations in SWC than in the interset trees (Fig. 3C). The neutron probe malfunctioned during July. Trees on the young tree schedule were irrigated 17 times and those on the mature tree schedule 11 times/year (Table 1). Trees on the young tree schedule were irrigated less frequently than those in 1993 because of higher rainfall from July-Sept. in 1994. In addition, irrigation was used for freeze protection in 1993 but was not needed in 1994.

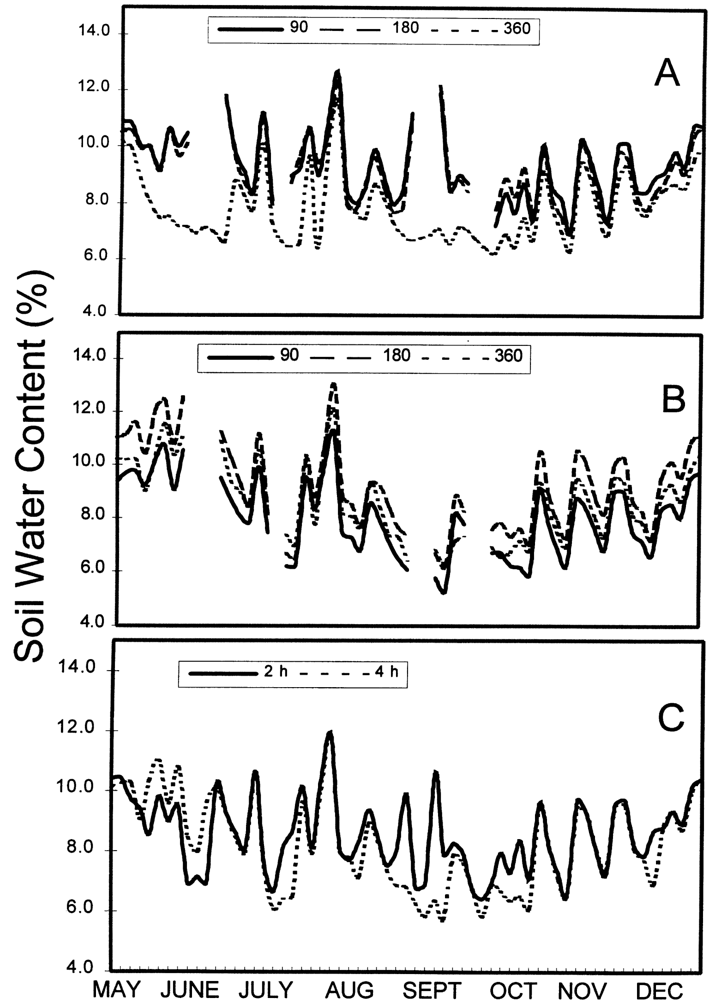


Figure 1. Effects of scheduling and irrigation emitter wetting pattern on soil water content under 'Hamlin' orange trees in Gainesville, Fla., 1993. A) Interset trees, young tree schedule (2h), n=6; B) Interset trees, mature tree schedule (4h), n=6; C) Mature trees, young (2h) and mature (4h) tree schedules, 360° pattern only, n=4. Measurements were made about every 3 days depending on rainfall.

### *Irrigation Effects on Trunk Diameter*

Despite differences in irrigation frequency and SWC among treatments at some times, trunk diameters at the end of each season were statistically similar for all treatments. Mean trunk diameters were 0.73 and 0.72 in. in 1993 and 1.05 and 1.07 in. in 1994 for the interset trees on the young and mature tree schedules, respectively. There were also no differences in trunk diameter among irrigation patterns and there was no interaction between duration and pattern. Therefore, irrigating young interset trees on the same schedule as mature trees appeared to have no adverse effects on tree growth. This result was unexpected. Moreover, emitter spray pattern did not affect growth provided that SWC was maintained greater than 5.95% (30% SWD). Marler and Davies (1990) also found that growth of young citrus trees was similar over a wide range of SWC. Moreover, the number of irrigations used in this study for the young tree schedule was similar to those used in the above study. Marler and Davies (1989) also found that emitter pattern, 90° vs 180°, had no effect on growth of 2 year-old 'Hamlin' orange trees. Nevertheless, use of a 90° pattern may improve cold protec-

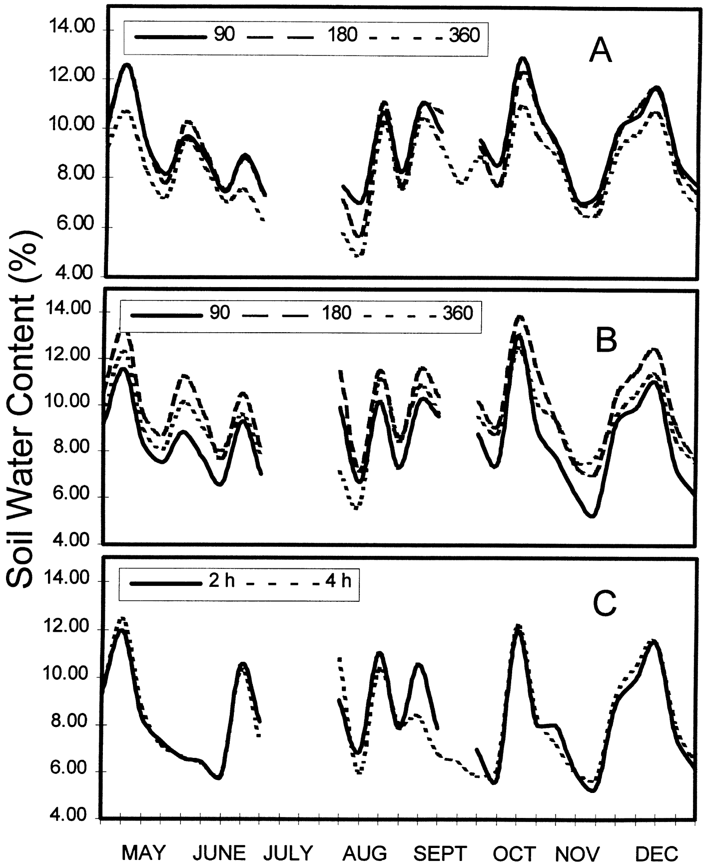


Figure 2. Effects of irrigation scheduling and emitter wetting pattern on soil water content under 'Hamlin' orange trees in Gainesville, Fla., 1994. A) Interset trees, young tree schedule (2h), n=6; B) Interset trees, mature tree schedule (4h), n=6; C) Mature trees, young (2h) and mature (4h) tree schedules, 360° pattern only, n=4. Measurements were made about every 3 days depending on rainfall.

tion over the other patterns (Davies et al., 1984) or reduce weed distribution in the wetted area.

Current recommendations are to irrigate young citrus trees more frequently than mature trees due to their smaller root zone and canopy volume (Davies et al., 1989). This study suggests that irrigation frequency is probably less important than maintaining SWD greater than 30% in this soil type. A possible explanation is that irrigation number was similar in this study for the young and mature tree schedules from Mar.-May in both years. The major increase in irrigation frequency occurred in June and Aug. in 1993 and from June-Sept. in 1994. Apparently, increasing irrigation frequency during these times has less an effect on trunk diameter than maintaining favorable SWC in the spring. Marler and Davies (1990) also suggested that adequate SWC is more critical in spring than the rest of the year and that SWC in spring may affect tree growth in the fall. In contrast, Boman (1992) found no yield difference when irrigating bearing navel orange trees at differing SWD (30 or 50%) or in adjusting rates based on tree developmental stage. He recommended irrigating trees at 50% SWD all year inthe east coast flatwoods of Florida. also observed that young tree growth was similar over a range (20-45%) of SWD when individual trees are considered. However, maintaining trees at 45% SWD may reduce tree growth of some trees within a population due to differences in soil water-holding capacity. Differences in soil type (water holding capacity) and tree age are possible causes of differing results between these studies.

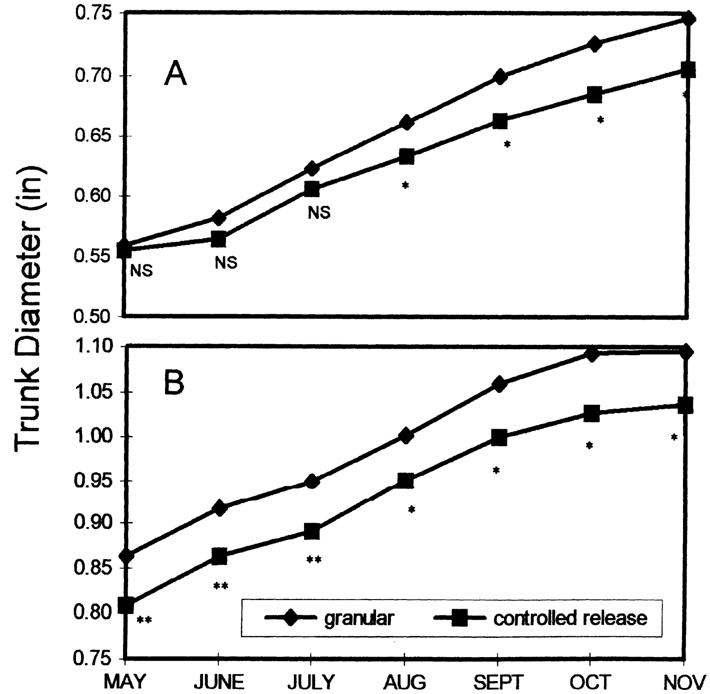


Figure 3. Effects of fertilizer type on trunk diameter of interset 'Hamlin' orange trees at Gainesville, Fla., 1993-94. Data points are means of 16 replications for each fertilizer type with 6 tree samples/replicate because there were no significant irrigation effects. NS = nonsignificant, * = significant at P=5%, ** = significant at P=1% based on a *t* test at each time.

Table 1. Effect of irrigation scheduling on number and frequency of irrigations for 'Hamlin' orange trees at Gainesville, Fla.

| | 1993 | | 1994 | |
|---|---|---|---|---|
| | Irrigation schedule | | | |
| Month | 2-hour | 4-hour | 2-hour | 4-hour |
| | Irrigation no. | | | |
| January | —[z] | —[z] | 1[y] | 1[y] |
| February | —[z] | —[z] | 2[y] | 2[y] |
| March | —[z] | —[z] | 1 | 1 |
| April | 2 | 2 | 1 | 1 |
| May | 7 | 7 | 4 | 3 |
| June | 5 | 1 | 1 | 0 |
| July | 1 | 0 | 2 | 1 |
| August | 8 | 1 | 2 | 1 |
| September | 0 | 0 | 2 | 1 |
| October | 0 | 0 | 1 | 0 |
| November | 2[y] | 2[y] | 0 | 0 |
| December | 2[y] | 2[y] | 0 | 0 |
| Total | 27 | 15 | 17 | 11 |

[z]Experiment was begun 31 March 1993 and ended 4 Dec. 1994. Therefore there are no values for the first 3 months of 1993.
[y]Trees were irrigated for freeze protection, not due to differences in SWC.

Nevertheless, irrigation timing appears less critical for growth of 1-2 year-old citrus trees than previously thought for the soil type (Arredondo sand) tested. It also appears that emitter wetting pattern is not important from a growth standpoint provided that SWC is maintained above a critical level.

*Fertilizer Type Effects on Trunk Diameter and Leaf Nutrient Levels*

Trunk diameters of trees receiving dry, water soluble fertilizer 5 times/year were statistically greater than those for trees receiving a single application of controlled-release material (Fig. 3A, B). Mean diameter began to diverge slightly on 2 Aug. of 1993 and trunk diameter remained significantly different between treatments until the end of the study in Dec. 1994. However, final trunk diameter means differed by less than 0.11 in. (11%). Therefore, from a practical standpoint, differences in trunk diameter were unimportant. These small differences may have resulted from some biuret toxicity in the controlled-release fertilizer treatments. Most trees receiving controlled release fertilizer had biuret symptoms during 1993 which disappeared by the end of the study in 1994. Leaf nutrient concentrations of all elements tested were similar for both irrigation schedules, emitter patterns and fertilizer types in both years (data not shown). Some variation in leaf nutrient concentration did occur but was unrelated to treatment and probably occurred because of inherently high variability in young trees. Several studies comparing various controlled-release with dry materials also found no differences in growth related to fertilizer type (Marler et al., 1987; Ferguson et al., 1988; Zekri and Koo, 1991; Ferguson and Davies, 1995). Use of a single application of controlled-release fertilizer has the potential to reduce costs of fertilizing intersets depending on unit costs for materials (Ferguson et al., 1988).

Yields and leaf nutrient concentrations of the mature 'Hamlin' trees were also not affected by irrigation scheduling in either year (data not shown). Leaf nutrient concentrations were within the acceptable range for all elements tested (Koo et al., 1984). Thus, mature trees remained productive (average yields equivalent to 450 boxes/acre) even when irrigated on a young tree schedule. This finding is contrary to the idea that mature trees should be irrigated less frequently but for longer durations than young trees in order to maintain adequate soil water levels in the root zone. Results from the mature tree portion of the study should be viewed with caution since they represent only 2-years' data.

## Conclusions

Interset 'Hamlin' orange trees were irrigated using 90°, 180° or 360° Maxijet® microsprinklers on a young (2 hours) or mature (4 hours) tree schedule. Within each irrigation schedule and emitter type, trees were either fertilized 5 times/year using dry, water soluble material or once/year using a Sherritt® controlled-release material. There were no differences in main, subplot or sub-subplot effects on trunk diameter or tree appearance after 2 years in the field, even though SWC and irrigation frequency varied between main effects and among emitter patterns. Dry fertilizer application resulted in a significantly larger trunk diameter for the interset trees than use of controlled-release fertilizer. Nevertheless, trunk diameter differences, although significant, were so small that they have no practical significance from a grower's standpoint.

Therefore, it appears that interset trees can be grown using a mature tree irrigation schedule along with one application/year of controlled-release fertilizers provided that SWD is maintained greater than 30% particularly during the spring. These findings only apply to interset trees and not to solid-set young tree plantings which may have different irrigation requirements because of differences in microclimate. Interset trees were often shaded and protected from wind by mature trees. Using this irrigation scheduling system and controlled-release fertilizers would not disrupt cultural practices in a mature grove and should reduce costs associated with irrigation and fertilization of interset trees, without reducing growth. These conclusions only apply to trees growing in Arredondo sand with the water holding characteristics described in the Materials and Methods section and should not be applied to all situations. In addition, irrigation of mature trees on a young tree schedule (2 hours) did not affect yields or leaf nutrient concentrations as might be expected. However, in this instance there is an economic disadvantage to irrigating more, rather than less, frequently.

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