Citrus Section

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HIGH VOLUME UNDER-TREE SPRINKLING FOR CITRUS COLD PROTECTION[1]

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Abstract. **High volume under-tree sprinklers, 0.4-0.5 acre-inches/hr (0.41-0.51 cm-ha/hr), effectively protected 'Orlando' tangelo** (Citrus paradisi **Macf. x** Citrus reticulata **Blanco) leaves and fruit during 4 radiation-type freezes in 1979-80. Leaf temperatures for sprinkled trees averaged 2 to 4°F (1.1 to 2.2°C) higher than for non-sprinkled ones, while soil and trunk temperatures were generally lower. Furthermore, sprinklers provided a 1 to 2°F (0.5 to 1.1°C) increase in leaf temperatures even during a severe advective freeze on March 2 and 3, 1980. Leaf temperatures were generally greater than air temperatures even when sprinkling was discontinued before sunrise.**

High volume under-tree sprinkling has been used for frost protection in commercial citrus groves in California (1, 8) and Florida (7). Sutherland et al. (7) achieved a 1-2°F (0.5-1.1°C) increase in grove air temperature using a Senninger pop-up under-tree system. Similarly, high volume under-tree sprinkling increased air temperatures during a freeze in California by 4°F (2.2°C) (1). Unfortunately, irrigation can also decrease air and leaf temperatures via evaporation, particularly under low dew point conditions (2, 4, 6).

Much of the information on high volume under-tree sprinkling deals with air temperature changes only. However, air temperatures may differ from leaf temperatures by 3-4°F (1.6-2.2°C) under certain freeze conditions (4). Furthermore, little information is available on changes in soil and trunk temperatures with high volume under-tree sprinkling. Our objectives were to compare leaf, air, soil and trunk temperatures during radiation and advective freezes for under-tree sprinkled and non-sprinkled 'Orlando' tangelo trees.

Materials and Methods

Eighteen 14-year-old 'Orlando' tangelo trees on Carrizo citrange [*Citrus sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.], sour orange (*Citrus aurantium* L.) and sweet lime (*Citrus limettoides* Tan.) rootstocks were selected at the University Horticultural Research Unit located 8 km northwest of Gainesville, FL. This location is annually exposed to severe freeze conditions. A block of 9 trees was irrigated during 5 freezes in 1979-80 using Senninger pop-up under-tree sprinklers. Water was applied at 0.4 to 0.5 acre-inches (0.41-0.51 cm-ha) per hour beginning at approximately 12 midnight on each freeze night. Sprinklers were started when air temperatures reached 28°F (–2.2°C). Critical leaf temperatures were 20°F (–6.7°C) at this time of year as determined by the leaf freezing point technique (5). A second block of 9 trees was not irrigated during the freezes.

Temperatures were sensed during each freeze with copper-constantan (T-type) thermocouples attached to the underside of 4 leaves per tree for 2 trees in each block. Thermocouples were also inserted into the trunk cambium 15 cm above the soil surface and buried at 6 and 15 cm soil depths.

Radiation-type freezes (wind speeds < 3 mph) occurred on December 1, 1979, and February 2 and 4, and March 3-4, 1980. A severe advective freeze occurred on March 2-3, 1980. Air temperatures averaged below 25°F (–3.9°C) for at least 9 hours during each freeze with minima as low as 20.5°F (–6.3°C) on February 4. Only data from the December 1 radiation freeze and the March 2-3 advective freeze will be presented, since temperature patterns during the other 3 radiation-type freezes closely paralleled those of the December 1 freeze.

Results and Discussion

Leaf and air temperatures were consistently higher in the irrigated versus the non-irrigated block on December 1, 1979 (Fig. 1). Temperatures for irrigated leaves were as much as 4°F (2.2°C) higher than those of non-irrigated leaves. Air temperatures in the irrigated block were also generally higher than leaf and air temperatures in the non-irrigated one. The irrigation water, which had an average temperature of 65-70°F (18-21°C), provided heat to the trees at the expense of soil temperature (Fig. 2). Irrigated soil temperatures were as much as 5°F (2.7°C) lower than non-irrigated temperatures. Some ice formation occurred on lower leaves but under-tree sprinkling provided protection to the grove mainly from heat stored in the water. This type of protection is similar to flood protection rather

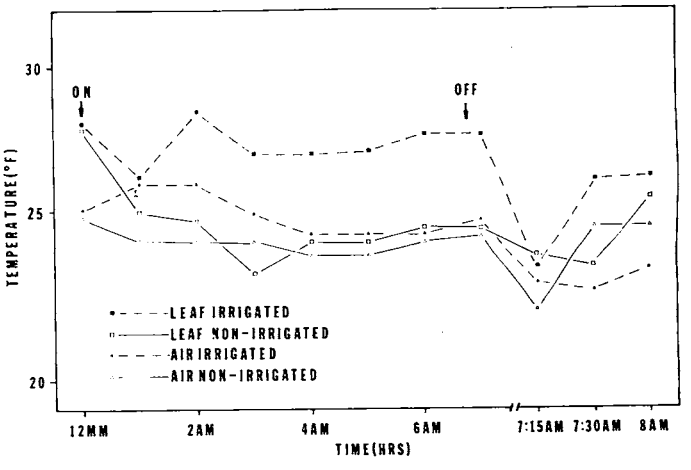

Fig. 1. Leaf and air temperatures for irrigated and non-irrigated 'Orlando' tangelo trees on December 1, 1979.

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than to protection via continual freezing found in overhead sprinkling. Leaf temperatures in the irrigated block dropped at a faster rate than in the non-irrigated one when the system was shut-off just before dawn. Nevertheless, leaf temperatures were generally higher than air temperatures even when sprinkling was discontinued at dawn. Furthermore, leaf and air temperatures actually increased again by 9 am indicating that extensive evaporative cooling was not occurring. Water was not applied directly to leaves as with overhead systems, hence, high volume under-tree sprinkling offered less opportunity for extensive tree damage via evaporative cooling or limb breakage.

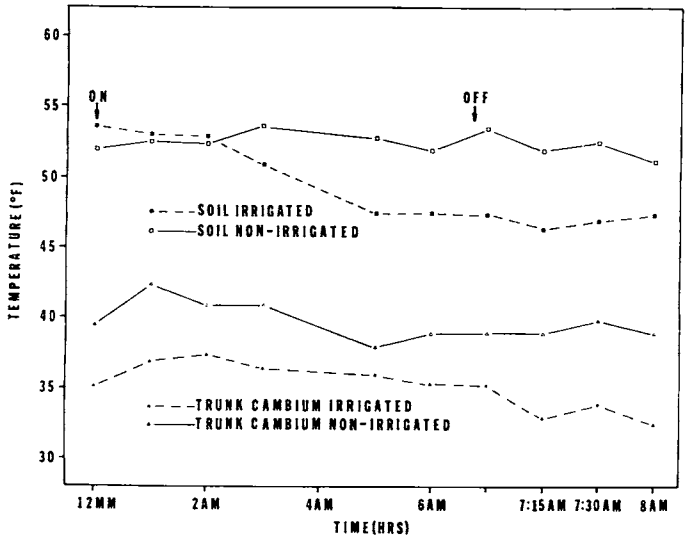

Fig. 2. Soil and trunk cambial temperatures for irrigated and non-irrigated 'Orlando' tangelo trees on December 1, 1979. (Soil temperatures were taken at 6 cm depths; trunk cambial temperatures were measured 15 cm above the soil surface.)

Irrigated blocks also had higher leaf temperatures than non-irrigated ones during a severe advective freeze on March 2-3, 1980, although the magnitude of leaf protection was much less (Fig. 3). Under-tree sprinkling provided protection even though the soil was at field capacity and wind speeds were as high as 15 mph. Brewer (1) found under-tree sprinkling was not very effective during advective freezes in California due to extensive evaporative cooling. However, he measured air, not leaf temperatures. Soil temperatures were also lower in irrigated vs non-irrigated blocks during the advective freeze; but, again the differential in temperatures between the treatments was less than that occurring in radiation-type freezes (Fig. 4).

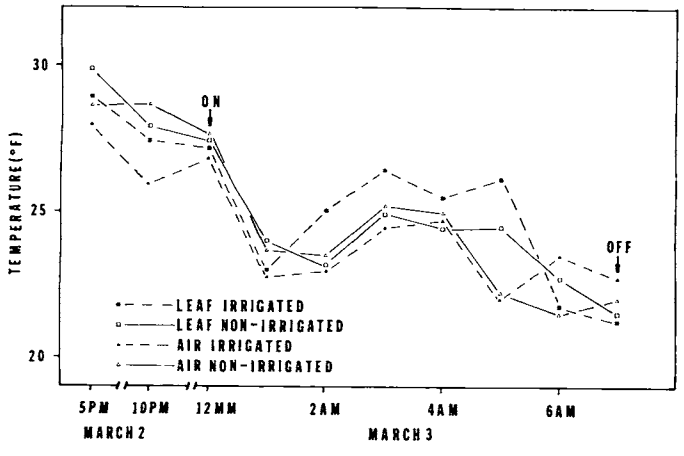

Fig. 3. Leaf and air temperatures for irrigated and non-irrigated 'Orlando' tangelo trees on March 2 and 3, 1980.

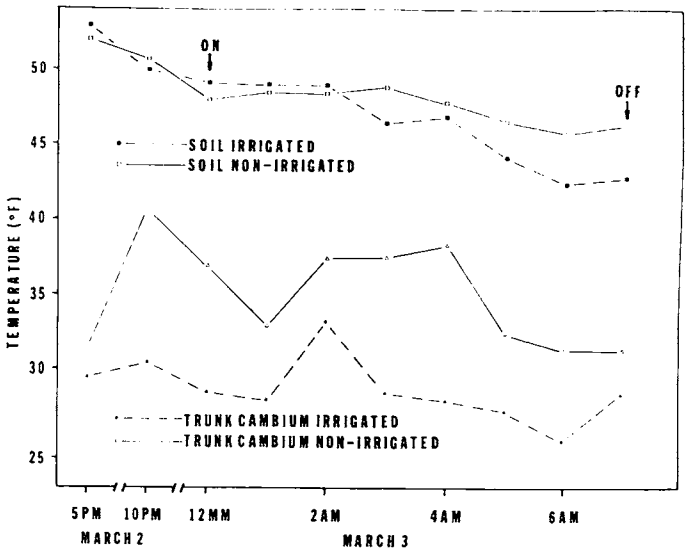

Fig. 4. Soil and trunk cambial temperatures for irrigated and non-irrigated 'Orlando' tangelo trees on March 2 and 3, 1980. (Soil temperatures were taken at 6 cm depths; trunk cambial temperatures were measured 15 cm above the soil surface.)

Temperatures of the trunk cambium appeared to be lower in irrigated vs non-irrigated trees during both radiation- and advective-type freezes (Figs. 2 and 4). This situation was directly opposite of that observed for leaves. However, closer examination of the data indicates similar temperatures occurred with 3 of 4 trees; those of one irrigated tree being consistently lower. The canopy of this tree was higher above the ground than in the other trees, consequently the trunk was more exposed to the air. Evaporative cooling from the trunk could have been greater under these conditions and caused the consistently lower temperatures.

High volume under-tree sprinkling can be an effective means of citrus cold protection (1, 3). Some protection may be achieved even under severe advective freeze conditions when soils are at field capacity; however, the differential between leaf and air temperatures is much less than under radiation-type freezes. Because water is being applied directly to the trunk, under-tree systems could be potentially harmful to cambial tissues if the sprinkling is discontinued before temperatures rise to 34°F (1.1°C) (4). Ice formation on lower limbs may cause some limb breakage and evaporative cooling may occur, so caution should be taken not to discontinue sprinkling too early in the morning.

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