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FREEZE SURVIVAL, TRUNK TEMPERATURE AND REGROWTH OF YOUNG 'HAMLIN' ORANGE TREES AS AFFECTED BY TREE WRAPS AND MICROSPRINKLER IRRIGATION

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Abstract. **Two-year old 'Hamlin' orange trees (*Citrus sinensis* (L.) Osb.) on trifoliate orange (*Poncirus trifoliata* (L.) Raf.) rootstock were used to study the effects of various microsprinkler irrigation treatments and tree wraps on trunk temperatures under freeze conditions. Irrigation treatments consisted of a factorial combination of 2 spray patterns (90° and 360°) × 4 application rates (0, 10, 15, 23 gal/hr/tree). All trunks were wrapped with fiberglass tree wraps. Data were obtained hourly during the advective freeze on 20 Jan. 1985 in Gainesville, Fla. Irrigated trunk temperatures were 2-4° F higher with the 90° than 360° spray pattern. The 15 and 23 gal/hr rates produced the highest trunk temperatures, although the 10 gal/hr rate maintained trunk temperatures above 27.0° F with air temperatures as low as 11° F, and was most efficient in temperature increase/gal/hr. All irrigated trees survived; regrowth was greater for trees irrigated with 90° than 360° emitters.**

Thousands of young, nonbearing citrus trees have been killed by severe freezes during the last 5 years. Young trees are particularly prone to freeze damage due to their small size and vigorous growth habit. Traditional, soil banks or tree wraps have been used for cold protection of young trees. Jackson *et al.* (2) compared several trunk wraps with conventional soil banks and found that wrapped trunks were 0-2.5° F warmer than unwrapped trunks, but 8-12° F colder than banked trunks. Although soil banks provide effective cold protection, they are labor intensive and often result in mechanical and/or disease damage to the tree trunk (1). In a subsequent study, wraps provided 0 to 5° F protection for young 'Hamlin' orange trees during several radiative freezes in Florida in 1982 (6).

Low volume, microsprinkler irrigation may provide an alternative to wraps and banks for young citrus cold protection. Davies *et al.* (1) successfully protected young 'Hamlin' trees during the advective freeze of Christmas 1983 using a combination of tree wraps and microsprinkler irrigation applied in a 90° pattern. They also showed that wraps used in conjunction with irrigation provide greater protection than either method alone. However, microsprinkler irrigation without trunk wraps may be less effective under advective than radiative freeze conditions because damage was observed on trees irrigated at 10 gal/hr during the 1983 Christmas freeze (3,4).

Because only one irrigation rate (23 gal/hr) and spray pattern (90°) was used in the study by Davies *et al.* (1), the objective of this research was to study the effects of different microsprinkler irrigation rates and spray patterns on trunk temperature of wrapped trees during a severe advective freeze. Treatment effectiveness was evaluated after the freeze by measuring tree survival and regrowth.

Materials and Methods

A 0.75 acre planting of 2-year old 'Hamlin' orange trees on trifoliate orange rootstock located in Gainesville, Florida was used in this study. Trees were spaced 15 × 20 ft, and were approximately 5 ft tall. The lower 16 inches of all trees were wrapped with a 4.0-inch thick foil-backed fiberglass insulation (R-11) secured by chicken wire. Microsprinkler irrigation treatments were applied in a factorial combination of 4 rates (0, 10, 15, 23 gal/hr/tree) × 2 spray patterns (90° and 360°). Emitters were located 3 ft from the tree on the northwest (upwind) side. A randomized complete block design with 3 replications was used with 3 trees / treatment / replication.

Trunk temperatures on 6 of the 9 trees in each treatment were measured under the wrap using T-type copper-constantan thermocouples placed 8 inches above the soil surface. The soil surface in the vicinity of the tree was kept weed-free. Air temperatures were measured at several locations throughout the planting by suspending ther-

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mocouples from the canopies of the trees approximately 3 ft above the soil surface. Data were taken hourly during an advective freeze beginning at 19:37 on 20 Jan. and ending at 08:00 22 Jan. 1985. Irrigation was started when air temperatures reached 32° F and discontinued when air temperatures returned to 32° F.

Fiberglass wraps were removed and survival and regrowth of the trees assessed on 27 Mar. and again on 22 Apr. 1985. Maximum height of live wood was measured on both dates, and new shoots were removed, counted and weighed on 22 Apr.

Results and Discussion

The advective freeze during 20-22 Jan. in our location was characterized by clear skies, minimum temperatures near 11° F with durations below 32° of 39 hr, windspeeds of 4-13 mph with gusts to 22 mph, and relative humidity of 30-50% (dewpoint was –15 to –5° F).

Trunk temperatures were generally higher with the 90° than 360° spray patterns and remained at or above 27.0° F for all irrigation treatments even at air temperatures of 11° F (Fig. 1). In contrast, trunk temperatures of unirrigated wrapped trees were 17° F when air temperatures were 11° F. During both nights of the freeze, the rate of temperature decrease was highest for unirrigated trunks, intermediate with the 360° pattern and lowest with the 90° pattern, regardless of irrigation rate. Thus, differences in the rate of temperature decrease were responsible for the differences in minimum temperatures among the unirrigated, 360° and 90° treatments during the first night because all trunks initially had similar temperatures.

The fiberglass trunk wraps alone maintained trunk temperatures 5-7° F higher than air temperature (Fig. 1). However, previous studies indicate that fiberglass wraps provide only 3-5° F increase in trunk temperature (1,6). The larger trunk diameter of the trees used in this study compared to previous studies may account for such differences. Larger trunks provide greater thermal mass than smaller ones, and thus remain at higher temperatures than small trunks during freeze conditions.

Trunk wraps provide a larger surface to intercept water and thus allow large ice masses to accumulate around the trunk. This is particularly important with 360° emitters which produce several discrete streams of water that could miss a slender tree trunk if not precisely oriented or if used under windy conditions. Previous studies have shown that large ice masses can insulate trunks from cold for prolonged periods when irrigation is discontinued (1).

Trunk heating efficiency (°F increase in trunk temperature/gal of water applied/hr) decreased as irrigation rate increased (Fig. 2). Efficiency was calculated by subtracting the temperature of the unirrigated wrapped trunk from the irrigated wrapped trunk at 07:37 on 21 Jan. (lowest recorded temperatures occurred at this time), then dividing by the number of gal/hr. The highest efficiency possible in this experiment was (72 – 17)/10 = 5.5, where the

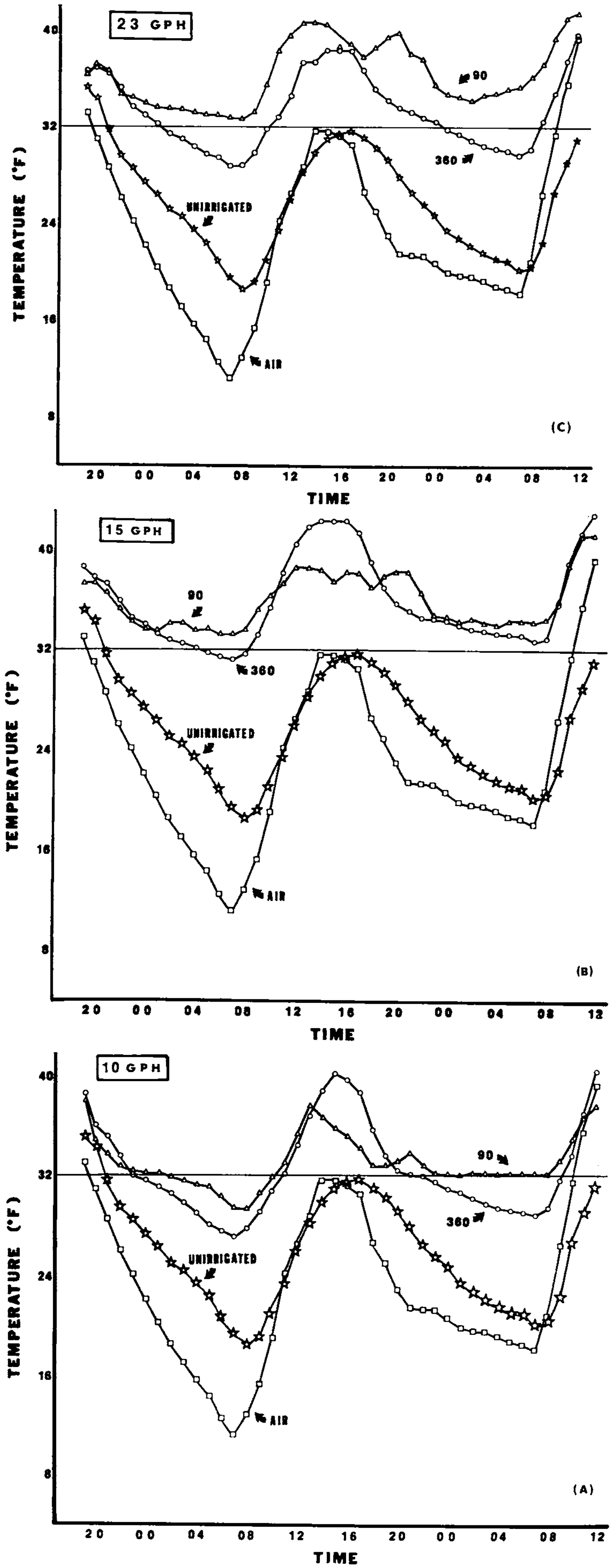

Fig. 1. Effects of microsprinkler irrigation rate and spray pattern on trunk and air temperatures of 2-yr old 'Hamlin' orange trees during the advective freeze of 20-22 Jan. 1985. All trunks were wrapped with fiberglass insulation. Irrigation rate was 23, 15, and 10 gal/hr; spray pattern is denoted by 90 or 360; and unirrigated trunk and air temperatures are provided for comparison. Each point is the mean of 6 measurements.

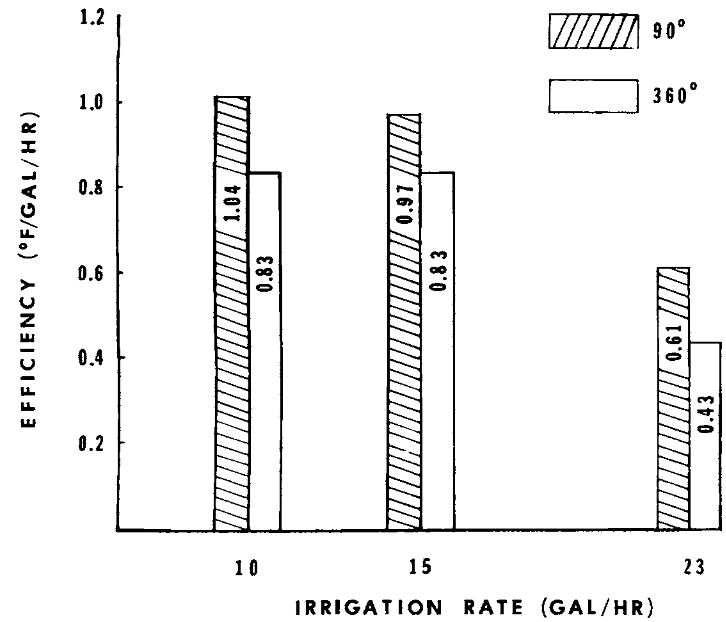

Fig. 2. Trunk heating efficiency of the 90 and 360 spray patterns at 10, 15, and 23 gal/hr irrigation rates. Values shown were calculated at 07:37 on 21 Jan. 1985; air temperature was 11° F. See text for calculation.

trunk temperatures of the 10 gal/hr treatment would be maintained at 72° F (temperature of the irrigation water) while the unirrigated trunks were at 17° F (lowest temp.). The lowest possible efficiency was taken as zero, although negative values could occur if the irrigated trunks were cooled by evaporation below the temperature of the unirrigated trunk. Trunk heating efficiency was higher for 90° than 360° patterns at all irrigation rates (Fig. 2). Therefore, the 90°-10 gal/hr treatment was the most efficient pattern-rate combination. Because pumping capacity is often a limiting factor when irrigating large acreages on a freeze night, further studies are needed to determine if rates less than 10 gal/hr might have equal or higher efficiency and maintain trunk temperatures above critical levels.

All irrigated and wrapped trees had live scion wood as of 27 March, and only one unirrigated, wrapped tree was killed to the bud union. The height of live wood increased as irrigation rate increased for the 90° spray pattern (Table 1). Additionally, the dry weight and number of new shoots increased with irrigation rate only for the 90° pattern.

Table 1. Effect of microsprinkler irrigation rate and spray pattern on height of live wood, shoot dry weight, and number of shoots per trunk on 22 Apr. 1985.

Rate (gal/hr)	Height (in)		Dry Wt. (oz)		New shoots (no.)	
	Spray pattern					
	90°	360°	90°	360°	90°	360°
0	9.21		0.19		6.9	
10	16.7	12.8	0.31	0.14	9.3	8.4
15	16.2	13.3	0.43	0.18	10.8	7.8
23	21.6	12.2	0.61	0.10	28.5	7.8
	**[z]	NS	*	NS	*	NS

[z]Regression coefficients significant at 1% (**), or 5% (*) level.

Conclusions

A microsprinkler irrigation rate of 10 gal/hr was most efficient for maintaining young trunks of 'Hamlin' above damaging temperatures under severe freeze conditions. Emitters producing a continuous spray (90°) are superior to those producing discrete streams of water (360°) with respect to maintenance of trunk temperature, trunk heating efficiency and regrowth of the tree. Use of a 90°, 10 gal/hr microsprinkler saves water, but compromises the regrowth of the tree when compared to 15 or 23 gal/hr emitters. However, slight differences in regrowth of the trees in the spring may not be apparent later in the season, suggesting that use of irrigation rates higher than 10 gal/hr for wrapped trees would be a waste of energy and water even under severe advective freeze conditions.

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