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OBSERVATIONS ON THE USE OF WATER AND COVERINGS FOR COLD PROTECTION DURING AN ADVECTIVE FREEZE

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Abstract. **Observations were made on different cold protection methods used in central Florida after the severe 20-23 Jan. 1985 advective freeze when minimum temperatures reached 19° F on 2 nights. Because of strong winds, some microsprinkler irrigation systems were not operated during the first night of the freeze. In one block of young navel trees, microsprinklers with 180° caps were operated during the first two nights while microsprinklers in another section of the grove were used only on the second night. Young trees were protected when microsprinklers were used during both nights of the freeze and when jets were on the north or west side of the tree. Severe tree damage occurred when water was run only on the second night of the freeze. Results from this freeze suggest that microsprinklers with 180° caps can be successfully used for young tree protection during a severe advective freeze, but they must be run during all the cold nights, not just one night.**

Coverings were used in combination with microsprinklers at other locations. Coverings included tar paper, plastic bags, or 55 gallon drums. Observations suggest that the combination of coverings with water provided more protection than water alone.

Microsprinkler irrigation has been used successfully for frost protection of young and mature citrus trees (1,2,6,7). However, evaporative cooling has been a major problem when using water in windy, low dew point freezes (3,4,5,8,9). Because of improper water application rates, overhead irrigation damaged groves in the 1962 advective freeze by evaporative cooling and ice loading. Because use of water during advective freezes has caused damage in the past, growers are reluctant to use water under such conditions.

Experience has shown that use of overhead or undertree sprinklers that deliver less than 0.15 inch/hour is usually detrimental in an advective freeze (5,8,11). When installed on the downwind side or too far from a young tree, microsprinklers or spray jets can also cause damage in a windy freeze (9). However, other evidence suggests that microsprinklers can be successfully used on young citrus trees in an advective freeze if properly installed (2,9). Yet, when a two night windy freeze is predicted, growers often ask "Should I operate microsprinklers during both nights of the freeze, or only on the second night when the wind velocity is normally expected to be less?" Another common question is, "How effective are covers in a windy freeze?" The January 1985 freeze was an advective two night freeze, and observations after that freeze helped provide answers to these questions. The objective of this paper is to describe observations on the use of microsprinklers and tree covers during an advective freeze. It is hoped that these observations will help provide guidelines for future freeze protection.

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Methods and Materials

The advective part of the freeze with the lowest temperatures lasted from 20 to 22 Jan. 1985 and the third night was a relatively calm frost. Minimum temperatures at Lake Alfred were 19° F on the first 2 nights of the freeze and 29° F on the third night. Wind speed and temperature patterns are shown in Fig. 1.

Observations were made on a young tree grove in Lake Alfred. The grove consisted of navel oranges (*Citrus sinensis* L.) on Carrizo citrange (*Poncirus trifoliata* (L.) Raf. × *C. sinensis*) rootstock. Two red microsprinklers that delivered approximately 23 gallons/hour and had 180° caps were on either the east or west side of each tree. Each jet delivered an estimated application rate of 0.3 inches/hr, making the combined application rate equal to 0.6 inches/hr. This is a higher than normal application rate, and most groves have only one microsprinkler per tree. All trees had Reese wraps on them (Reese Citrus Insulators, Lakeland, Fla.). In one part of the grove, microsprinklers were operated on the first 2 nights of the freeze. In the other portion of the grove, irrigation was not started until the second night (21 Jan. 1985). Hence, this was an example of the same rootstock and scion combination side by side where one portion had microsprinklers operated during both nights and the other portion had microsprinklers operated only during the second night of the advective freeze. The main concern was whether evaporative cooling would be sufficient to cause damage when water was run on the first night. Trees were observed during the spring, and height measurements were made on 24 July 1985. A one-way analysis of variance was used to compare heights.

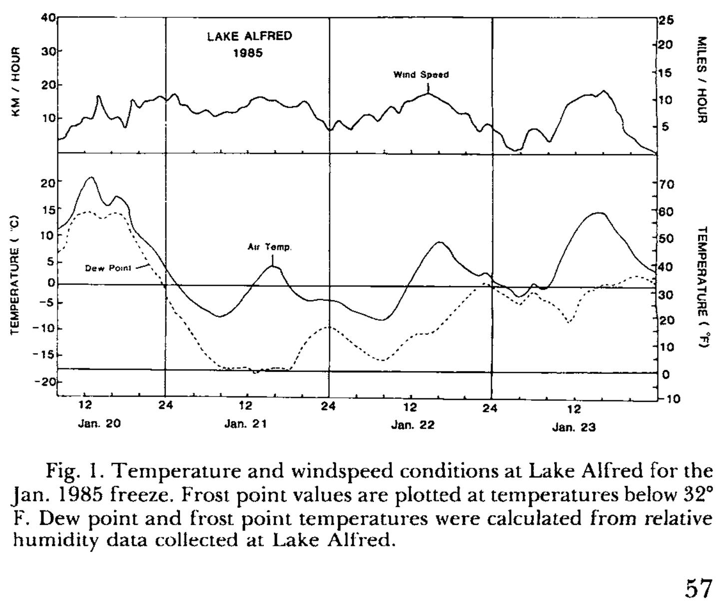

Fig. 1. Temperature and windspeed conditions at Lake Alfred for the Jan. 1985 freeze. Frost point values are plotted at temperatures below 32° F. Dew point and frost point temperatures were calculated from relative humidity data collected at Lake Alfred.

Observations were made at several different locations where different types of covers were used on young trees. In nearly all observed cases, covers were used in combination with microsprinkler irrigation. In a few cases, there were examples of covers without irrigation. Microsprinklers were operated either inside or outside the cover. Covers were made of various materials including tar paper, fertilizer bags, inverted 55 gallon drums, and polyethylene tunnels. Quantitative measurements were not made because there were relatively few control or replicated treatments of the same scion, rootstock, or tree age. The idea of reporting on covers is to show the diversity of covers used and to present preliminary observations for future reference in testing of covers for freeze protection.

Results and Discussion

Trees where microsprinklers were run during both nights of the freeze survived noticeably better than where microsprinklers were run on only the second night (Figs. 2,3). Where jets were on the west side of the tree, mean heights in July were 4.2 feet and 3.1 feet for the both night and second night treatments, respectively. Heights were significantly different at the 0.05 level of confidence. When jets were on the east side of the tree and irrigated both nights, evaporative cooling damaged about 50% of the trees. This damage was also observed after the windy 1983 freeze when jets were on the east side of the tree (9). A nearby row of trees was covered with blankets or sheets but was not irrigated during the freeze. Mean height of these trees was 3.4 feet, but that was not significantly different from the trees irrigated on the second night only. While not significant, this does suggest that certain covers can help somewhat, but proper use of water can be more effective than a cover with no water or heat source under it.

The 19° F temperature severely damaged or killed many of the trees that were not irrigated during the first night. Trees that were irrigated both nights were protected and recovered with little damage to the wood. Hence, in spite of the wind and low dew point, the application rate of the microsprinkler was sufficient to protect the trees and overcome evaporative cooling.

Fig. 2. Appearance of a navel orange tree where microsprinklers on the west side of the tree were operated during both nights of 19° F during the Jan. 1985 freeze. The meter stick indicates tree heights. Photo was taken on 12 June 1985.

Work from California suggests that sprinklers should not be operated when the predicted dew point is 5° F or more below the predicted minimum air temperature (10). This would apply to overhead or undertree sprinkler irrigation that provides less than 0.15 inches/hour. On the other hand, observations from the 1983 and this 1985 advective freeze show that young trees can be protected with microsprinklers when the difference between the minimum air temperature and dew point temperature is as much as 15° F (2,6,9). With young trees, most of the protection is due to the release of heat of fusion when water turns to ice on the lower part of the tree.

Observations were made on tree covers to see how effective they were in this advective freeze. One of the more effective covers appeared to be the inverted 55-gal drum used in combination with a 10 gal/hr microsprinkler (Fig. 4). The microsprinkler was elevated on a riser to a height of about 2 feet and run inside the drum. In some instances, the tree canopy was bound with twine to allow the drum to fit over the top. For taller trees, some drums were set as much as 18 inches off the ground with wooden stakes. These covers protected trees to a height of approximately 4.5 feet. Water draining down from the canopy protected the lower part of the tree. Relatively little leaf damage oc-

Fig. 3. Appearance of a navel orange tree where microsprinklers were run the second night only during the January freeze. Photo was taken on 12 June, 1985.

curred except where outer leaves touched the drum. Unprotected trees in a neighboring grove showed greater damage than the covered trees.

Other covers that were effective included tarpaper sleeves that were stapled around young trees (Fig. 5). The tarpaper was sprayed from the outside with a 180° green jet that delivered approximately 15 gal/hr (approx. 0.25 inches/hr). Trees that were covered generally survived to a greater height than noncovered trees with the same type of irrigation. Fertilizer bags with microsprinklers spraying on them also appeared to provide good freeze protection to young trees.

A 6.5-foot tunnel or quonset hut structure over a microsprinkler system was also used to protect budwood trees in a citrus nursery. Microsprinklers that delivered approximately 10 gallons/hr were spaced every 15 feet. This irrigation and cover combination resulted in minimal damage to a 6-foot height as shown in Fig. 6. By acting as a greenhouse, this tunnel cover also provided greater vegetative growth during the winter.

Fig. 4. Appearance of trees that were covered with 55-gal drums during the January freeze. A 10 gph microsprinkler was run under the drum. Note greater damage to non-protected trees in the background. Photo was taken on 21 June 1985.

Fig. 5. Use of tarpaper wraps with microsprinkler during freeze. Photo taken on 22 Jan. 1985.

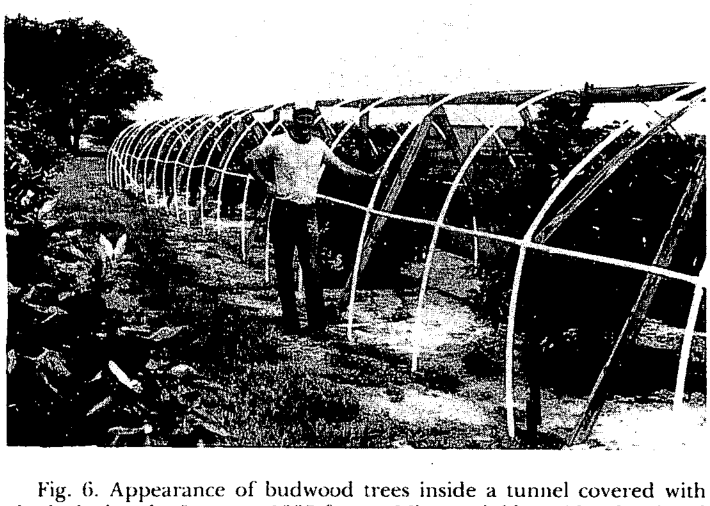

Fig. 6. Appearance of budwood trees inside a tunnel covered with plastic during the January, 1985 freeze. Microsprinklers (10 gph) placed every 15 feet were operated during all nights of the freeze. Photo was taken on 21 June 1985.

Row covers up to 3 feet tall have been used over vegetable crops to extend the growing season in cooler climates. Vegetable covers can be either supported with hoops or unsupported and "floating" on the foliage. With no microsprinkler irrigation, spunbonded, floating vegetable row covers provided frost protection of about 2 to 3° F for polyester and 3 to 5° F for polypropylene (12).

Tree size, value, and cover cost will determine the practicability of using covers for cold protection. At present, commercially made covers are available at a cost of $2.00 to $5.00, and when used with microsprinklers, are suitable for protecting young trees or the lower part of trees greater than 4 feet tall. A parachute and PVC framework combination costing around $25.00 has been used to cover peach trees to a height of 11 feet (13). When provided with a heater, these covers have given air temperature warming of 5 to 9° F. Several nurseries with high value budwood trees have found it economically practical to provide covers for trees up to an 11 foot height. Covers must be well anchored because winds can blow them away.

At present, covers appear to be most practical for young trees. When used with microsprinklers, covers should protect trees to a greater height than microsprinklers with no covers. Preliminary tests (Parsons, unpublished observations) in a cold room showed that an open top cover combined with a microsprinkler could provide up to 15° F of temperature warming at a 3 foot height when the outside temperature was 20° F. Trees protected to a height of 3 feet or more will recover faster after a freeze than those protected only to the bud union. Covers in combination with microsprinklers appear promising for protecting young trees and merit additional investigation.

Literature Cited

1. Buchanan, D. W., F. S. Davies, and D. S. Harrison. 1982. High and low volume undertree irrigation for citrus cold protection. Proc. Fla. State Hort Soc. 95:23-26.
2. Davies, F. S., L. K. Jackson, and L. W. Rippetoe. 1984. Low volume irrigation and tree wraps for cold protection of young Hamlin orange trees. Proc. Fla. State Hort. Soc. 97:25-27.
3. Gerber, J. F., and D. S. Harrison. 1964. Sprinkler irrigation for cold protection of citrus. Trans. Amer. Soc. Agr. Eng. 7(4):464-468.
4. Gerber, J. F., and J. D. Martsolf. 1979. Sprinkling for frost and cold protection. In "Modification of the Aerial Environment of Crops."

B. J. Barfield, and J. F. Gerber, Eds. Amer. Soc. Agr. Eng. Monograph No. 2, pp. 327-323.
5. Harrison, D. S., J. F. Gerber, and R. E. Choate. 1974. Sprinkler irrigation for cold protection. Univ. Fla. Circ. 348.
6. Parsons, L. R., T. A. Wheaton, and J. D. Whitney. 1981. Low volume microsprinkler undertree irrigation for frost protection of young citrus trees. Proc. Fla. State Hort. Soc. 94:55-59.
7. Parsons, L. R., T. A. Wheaton, D. P. H. Tucker, and J. D. Whitney. 1982. Low volume microsprinkler irrigation for citrus cold protection. Proc. Fla. State Hort. Soc. 95:20-23.
8. Parsons, L. R. and D. P. H. Tucker. 1984. Sprinkler irrigation for cold protection in citrus groves and nurseries during an advective freeze. Proc. Fla. State Hort. Soc. 97:28-30.
9. Parsons, L. R., B. S. Combs, and D. P. H. Tucker. 1985. Citrus freeze protection with microsprinkler irrigation during an advective freeze. HortScience 20(6):1078-1080.
10. Pehrson, J. 1985. Frost protection guidelines for 1985-86. Citrograph 70(11):237.
11. Turrell, F. M. 1973. The science and technology of frost protection. In "The Citrus Industry" Vol. III. W. Reuther, ed. Univ. Calif. pp. 338-520.
12. Wells, O. S. and J. B. Loy. 1985. Intensive vegetable production with row covers. HortScience 20(5):822-826.
13. Werner, D. J. and D. W. Cain. 1985. Cages for protection of tree fruit hybridizations. HortScience 20(3):450-451.

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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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