Proc. Fla. State Hort. Soc. 97: 28-30. 1984.

SPRINKLER IRRIGATION FOR COLD PROTECTION IN CITRUS GROVES AND NURSERIES DURING AN ADVECTIVE FREEZE

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Abstract. **Observations on the use of undertree sprinkler irrigation in groves were made during and after the severe advective freeze of December 25-26, 1983. Results from the use of high volume overhead irrigation in nurseries were also observed. Wind speeds during the 2 freeze nights ranged from 10 to 24 mph in Central Florida and dew point temperatures reached 5°F or lower. When undertree sprinklers applied only 0.12 inches/hr, evaporative cooling caused major damage to the lower wetted leaves and branches. In nurseries, overhead sprinklers that applied 0.37 inches/hr or more during both nights of the freeze protected up to 75% of the trees when air temperature went to 19°F. Damage occurred where wind distorted the sprinkler pattern or where sprinklers failed to operate properly. When no irrigation was applied on the first night of the freeze, 90 to 100% of the nursery trees exposed to 19°F were killed.**

Two cold protection sprinkler irrigation rate models are discussed. Observation from this freeze provide partial field validation of the application rates predicted by the SPAR 79 model.

In terms of total fruit loss, the December 25-26, 1983 freeze was the worst freeze in central Florida since 1894-95. However, central Florida experienced colder temperatures in the freezes of 1981 and 1982 (12). Damage was particularly severe because warmer temperatures before this 1983 freeze promoted little cold acclimation (12). Strong winds of 10 to 24 mph with gusts up to 31 mph were recorded. Dew point temperatures in central Florida were low and averaged around 5°F and were as low as 1°F in the Orlando area.

Water has been used for cold protection in past freezes with mixed success. Low dew point temperatures and high winds can promote evaporative cooling when insufficient amounts of water are used. Because of the risk of evaporative cooling, a major question asked immediately before this particular freeze was, "Should irrigation be used for cold protection during this advective freeze?" The objective of this paper is to review information and report on personal and growers' observations on the use of sprinkler irrigation during this freeze. By recording observations from this freeze, it is hoped that better guidelines can be developed for the proper use of water during future windy or advective freezes.

Methods and Materials

Observations were made in a grove near the Lake Alfred Citrus Research and Education Center where undertree sprinkler irrigation was operated during the freeze. Tree spacing was 25 X 25 ft, and the plastic impact sprinklers were spaced at 75 X 75 ft. Most of the nozzles had a 3/16 inch diameter orifice with a 23° angle of trajectory. The precipitation rate was estimated to be 0.12 inch/hr or less. Because of wind distortion and occasional insufficient overlap, some areas received no consistent application of water. The sprinklers wetted the trees to a height of 3 to 7 ft. Air temperature for Lake Alfred was obtained from a hygrothermograph trace and is shown in Fig. 1. Dew point temperature was obtained with a chilled mirror humidity analyzer (EG&G Model 911). Wet bulb temperature was determined by use of a psychrometric chart. Minimum temperatures reached 23 and 22°F the mornings of December 25 and 26, respectively. When temperatures were below 45°F, wind speeds were approximately 14 to 24 mph on December 24, and 10 to 20 mph on December 25. Observations were made periodically following the freeze.

Reports from several nurserymen who used high volume overhead irrigation were obtained. While these reports are only partially quantitative, they can be useful in verifying guidelines on the use of water in future advective freezes.

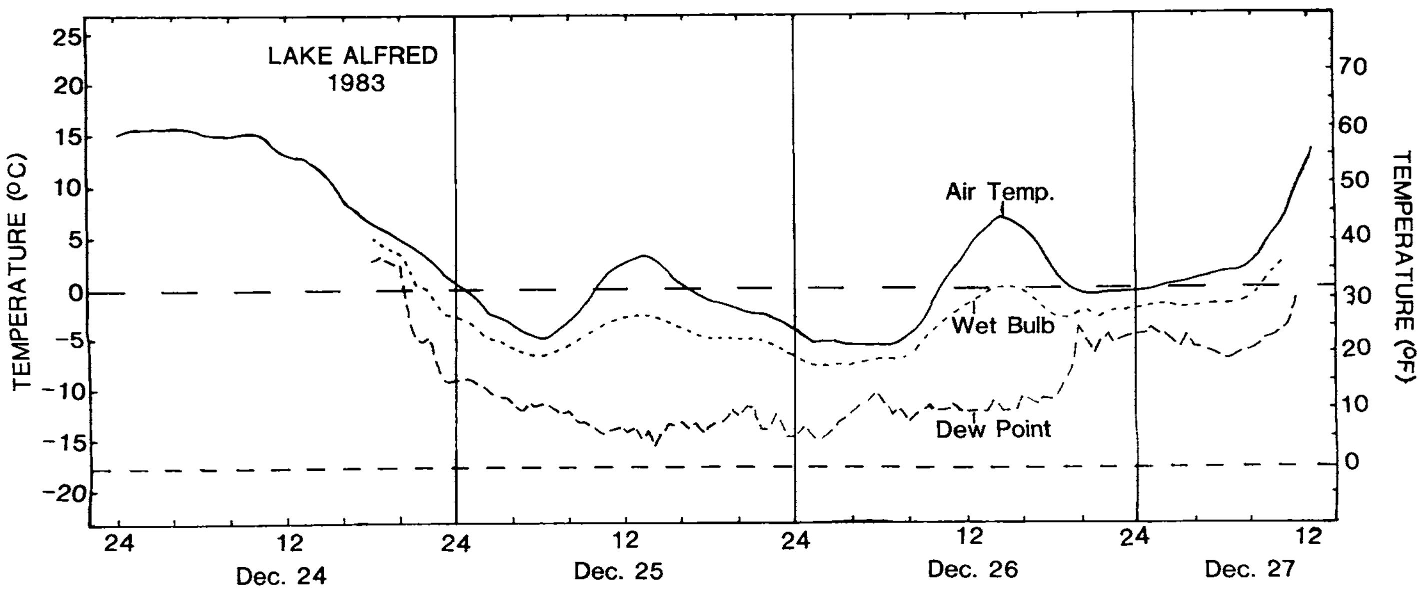

Fig. 1. Dry bulb, wet bulb, and dew point temperature at the Lake Alfred Citrus Research and Education Center during the December, 1983 freeze.

Data for irrigation sprinkler models including the Gerber and Harrison (5, 6) model and the SPAR 79 model (9, 10) were obtained by computer printout from Francis Ferguson, David Ayers, and John Jackson of the Lake County Cooperative Extension Service.

Results and Discussion

Groves. Major problems can result from using undertree sprinkler irrigation during an advective freeze. The precipitation rate of 0.12 inch/hr was insufficient to provide cold protection in this freeze. During the freeze, ice accumulated on the lower leaves and branches (Fig. 2). Some sprinkler heads froze up and stopped rotating. Immediately after the freeze, the wetted lower canopy of the tree looked green while the upper non-wetted leaves showed slight leaf curl (Fig. 3). One week after the freeze, however, the upper leaves had recovered but the wetted lower leaves and branches up to 1.5 inches in diameter were killed (Fig. 4). Hence, during an advective freeze with low dew point temperatures, undertree irrigation with a rate of 0.12 inch/hr should not be used. Similar results were found in the 1962 advective freeze when overhead sprinklers wetted the entire tree canopy and killed the trees (6).

Using a higher rate of 0.4 to 0.5 inch/hr, undertree systems have provided protection in previous radiation

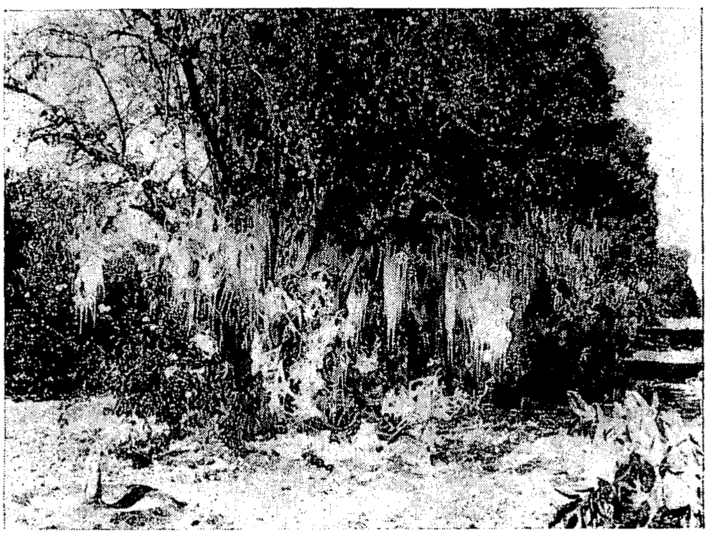

Fig. 2. Ice accumulation on lower part of the trees during the 1983 advective freeze.

Fig. 3. Appearance of trees the day after the freeze. Lower leaves were green and wet while upper leaves showed slight leaf curl.

Fig. 4. Appearance of trees one week after the freeze. Upper leaves had recovered, showed no leaf curl, and remained green. Lower leaves and small branches were brown and dead. Flag indicates height of wetted zone.

conditions (3, 4, 11). Such systems even provided some protection in an advective freeze with winds up to 15 mph (4). As was pointed out (4), cost and water availability make such high volume systems only practical for smaller acreages or nurseries. A recommendation from California suggests that sprinklers should not be operated on a freeze night when the dew point is predicted to be 5°F below the predicted minimum temperature (1). Since the dew point was 15°F or more lower than the minimum temperature in this Florida freeze, evaporative cooling killed the wetted lower leaves.

Brewer (2) found that solid set low head sprinklers provided more warming than furrow irrigation on calm radiation nights. On advective (5 to 7 mph winds) freeze nights when the dew point was 7°F below the minimum temperature, the same sprinklers cooled the area by 0.5°F. Brewer (2) recommended against using undertree sprinklers in a dry advective freeze, and the damage observed in this Florida freeze verified his findings.

Nurseries. Overhead sprinklers have been used successfully in Florida citrus nurseries in past radiation freezes. However, a number of nurserymen were reluctant to operate overhead systems in this freeze because of the evaporative cooling risk. In one location where the minimum temperature was 24°F, a nurseryman protected much of his nursery by applying 0.33 inch/hr during both nights of the freeze. At another location where the minimum was 19°F, another nurseryman protected up to 75% of his plant material by applying 0.37 to 0.44 inch/hr during both nights. In both cases, damage occurred where the wind distorted the irrigation pattern or where sprinklers failed to function. In other locations where the minimum temperature was 19°F, nurserymen who did not operate irrigation systems during the first night of the freeze had 90% to 100% tree death or severe damage. Hence, in this freeze, an application rate of at least 0.37 inch/hr appeared to provide some protection except where the wind distorted the precipitation pattern. Using such systems during both nights of this freeze was better than not using them.

Other observations after freezes have been made on sprinkler application rates, but only a few of these (4) have been made after advective freezes. Buchanan et al. (3) indicated that at least 0.20 inch/hr was needed for cold protection to 18°F if the wind speed was less than 2 mph. Harrison and Smajstrla (8) showed that nurseries were protected to 17°F and winds up to 8 mph with overhead applications of 0.25 inch/hr. Harrison et al. (7) discuss sprinkler rates required in other situations.

Several models for use of irrigation for cold protection have been developed. One of the more commonly cited models is that of Gerber and Harrison (5, 6). Another is called SPAR 79 (9, 10). The application rates for protection at certain temperatures and wind speeds for these 2 models are plotted in Fig. 5 and 6. The Gerber and Harrison (G & H) model indicates that higher application rates are required for protection than does SPAR 79. To obtain protection to 20°F and winds over 20 mph (conditions that were reached on the first night in the northern citrus area), the G & H and SPAR 79 models would predict that 0.85 inch/hr and 0.44 inch/hr, respectively, would be required for protection. Since observations from this advective freeze showed that 0.37 inch/hr provided fair protection to 19°F, SPAR 79 gave a closer approximation of application levels that worked in this freeze. The higher application rates indicated by the G & H model certainly would provide protection and give an extra margin of safety. However, the irrigation system needed to apply the rates suggested by the G&H model would cost noticeably more than one required to apply the SPAR 79 rates. These observations provide some field validation of the SPAR 79 model and suggest that this model could be used as a guide when planning irrigation application rates for nurseries.

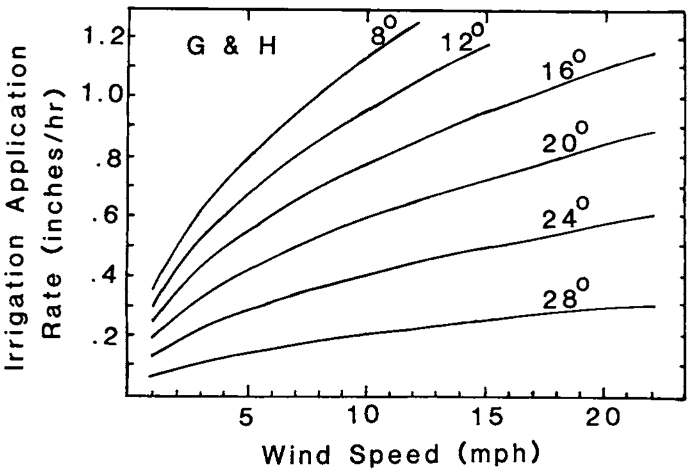

Fig. 5. Sprinkler application rates required for cold protection to different levels as determined by the Gerber and Harrison model.

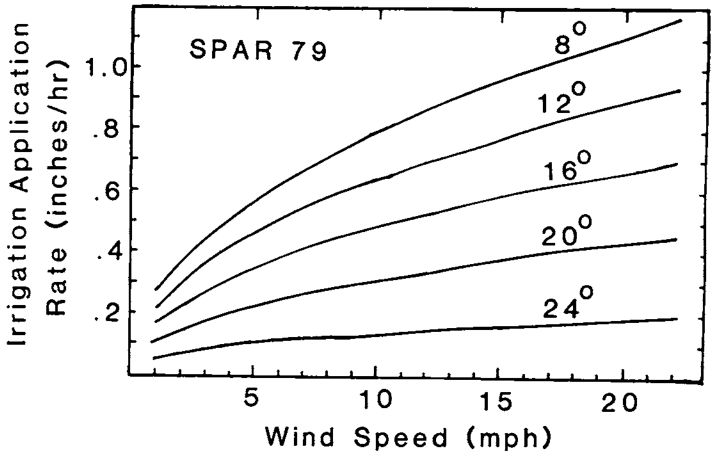

Fig. 6. Sprinkler application rates required for cold protection to different levels as determined by the SPAR 79 model.

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