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PERFORMANCE OF INDIVIDUAL TREE COVERS FOR COLD PROTECTION OF YOUNG CITRUS

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Abstract. **Various methods have been used to protect young trees from frost or freeze damage. Soil banks and trunk wraps of various insulating materials have been used, but they protect only the lower trunk and bud union. Recently, microsprinkler irrigation has been shown to effectively protect the lower part of trees. This paper reports work on various individual tree covers to protect young citrus trees to a greater height. Trees approximately 5 ft tall and 5 ft in diameter were covered with different types of covers. Eleven treatments were tested during the 1985-86 winter season. Various combinations of covers with and without microsprinkler irrigation were tested during radiation and advective freezes. The results show that some of the covers, in combination with water, could provide up to 14°F of protection and be effective during advective as well as radiation freezes. The covers by themselves offered no protection, but the addition of water greatly improved their effectiveness. This study shows that covers have the capability to protect the entire young citrus tree, not just the bud union.**

Young citrus trees, especially those in north and central Florida, have always been subject to cold damage either by frost or freeze. Methods used in the past to protect young trees have been directed toward saving the bud union and a small portion of the lower trunk (3, 10, 13). For many years, the only method used in Florida was the soil bank. Since the 1960's, tree wraps have been used with varying degrees of success (2, 3, 9). A concentrated effort has been underway since 1980 to develop techniques for using water applied through microsprinklers (with and without tree wraps) to protect young citrus trees (1, 5, 6, 7, 8).

The use of some type of cover to protect citrus trees is not new. In fact, as early as 1912, several acres of mature trees were protected with tobacco cloth stretched over wood frames in Riverside, California (10). Japan has long used straw and straw mats to protect citrus trees, and has been working with cheesecloth and woven materials in recent years (4). Covers have been used with a variety of vegetable and field ornamentals to protect them from frost (11). Covers have also been used on several fruit crops, such as peaches, to provide some cold protection (12). Observations after the 1985 freeze in Florida indicated that covers used in combination with water were effective in protecting citrus during an advective freeze (6). This study was undertaken to evaluate several different covers in combinations with and without water to determine their effectiveness in protecting young trees from cold weather.

Methods and Materials

The test was conducted during the winter of 1985-86 in a grove located east of Umatilla, FL. Navel (5611) oranges (*Citrus sinensis* (L.) Osb.) on sour orange (*Citrus aurantium* L.) rootstock were used in this test. The trees were planted in August 1984, on a spacing of 25 ft x 15 ft, and were approximately 5 ft tall by 5 ft in diameter. The grove was in excellent condition with extensive vegetative growth as a result of high fertilization and irrigation. Twenty-two trees were used for the test. Two thermocouples, located at a height of 20 inches and 40 inches were attached to a wooden stake that was located in the center of each tree. In addition, air temperature at 3, 5 and 10 ft, and wind speed at 10 ft above the ground were measured. Soil temperature was collected at 4 and 8 inch depths. Readings were made every half hour during freeze situations and every hour the rest of the winter. The datalogger was installed on December 13, 1985 and operated continuously until March 15, 1986.

The trial consisted of 11 treatments as shown in Table 1. A brief description of the materials and construction is provided. Two types of polyester shade cloth were used. This material was loosely woven with one type green (treatments 2 and 7) and the other brown (treatment 8). The polyvinyl alcohol product (treatment 9) from Japan was a clear woven product with cloth reinforcing string that

Table 1. Combinations of covers with or without microsprinkler irrigation.

Treatment no.		
1	no water	no cover
2	no water	woven polyester shade cloth; green color
3	no water	non woven spun polyester fabric; translucent
4	water (17 gph)[z]	no cover
5	water (17 gph)	corrugated plastic sleeve; no top; translucent
6	water (17 gph)	plastic base with polyethylene top; transparent
7	water (17 gph)	woven polyester shade cloth; green color
8	water (17 gph)	woven polyester shade cloth; brown color
9	water (17 gph)	woven polyvinyl alcohol; transparent
10	water (17 gph)	non woven spun polyester fabric; translucent
11	water (17 gph)	non woven spun nylon fabric; translucent

[z]gph—gallons per hour.

created a 1 x 1 inch square grid. A corrugated plastic box, and a polyethylene top attached to a plastic base were the only two commercially available covers in the test. The last two covers were made of non-woven porous materials: one was a spun polyester (treatment 10) and the other a spun nylon product (treatment 11). These last two covers were a translucent cloth-like material that covered the entire tree.

All of the homemade or non-commercial covers were constructed as follows. A 2 inch hem was sewn in the bottom and a 1/2 inch diameter poly tube threaded through to form a "hoop" on the bottom. The side and top were sewn closed, and the entire cover was dropped over and completely enclosed the tree. A metal stake was used to hold the cover on the ground.

The grove was irrigated with under-tree microspinklers that delivered 17 gal/hr. The emitters were on plastic stakes 6 inches above the ground. All of the emitters were placed on the NW side of the tree. Those treatments that included water receiv the full 17 gal/hr applied under the tree canopy. The water was turned-on regardless of the forecast, therefore data was collected during very windy and dry freeze situations.

Information was collected with a data-logger utilizing a cassette recorder to store the readings. Tapes were read and data sets generated by computer. Data were then transferred to floppy discs as well as a printed format. Temperature patterns were observed for each of the treatments so that conclusions could be reached relative to the performance of the covers during various freeze situations. At least two advective and two radiation situations were examined. Due to the large volume of data (over 100,000 readings) the results are presented as graphs rather than tables. Each treatment was replicated twice in the trial.

Results

The results will be examined in three categories. First will be an advective situation with wind speeds ranging from 10 to 40 mph. The second condition will be a radiation night with wind speeds in the 1 to 9 mph range. The third condition examined is the heat build up inside covers in the afternoon. For the freeze situations, two nights were examined for each freeze event. All four freeze nights had minimum temperatures of 21 to 27°F. The afternoon studied had a high temperature of 93°F, and was windy. All other afternoons with temperatures above 85°F were also windy. Therefore, the one very hot afternoon was used to demonstrate temperature build up. Air temperatures reported are from the 3 ft height and soil temperatures from the 8 inch depth.

For the advective freeze, the two nights studied were 25-26 December, 1985 and 27-28 January, 1986. Fig. 1 shows the results for the January night. The wind speed was 40 mph early in the evening and dropped to 13 mph by 6 a.m. The non-porous materials (treatments 5 and 6) provided 6 to 19°F protection, two of the semi-porous covers (treatments 10 and 11) provided 1 to 8°F protection, and the rest of the covers gave no protection at all. If water was not used, then no protection was provided regardless of the type of cover.

The two radiation nights studied were 26-27 December, 1985 and 28-29 January, 1986. The results from the January event are shown on Fig. 2. The non-porous materials (treatments 5 and 6) provided from 7 to 19°F protection and were able to keep the temperature well above freezing on both nights. Two of the *semi-porous* materials (treatments 10 and 11) gave 5 to 15°F protection, and were also able to keep the temperature above freezing both nights. Two other woven fabric covers with water (treatments 7 and 9) provided no protection *and in fact* at times were actually colder than the water and no cover treatment. Treatments 2 and 3, those that did not have water, provided no protection.

Temperatures in the low 90's may occur during the time covers are in place, and in fact did occur during the trial. The results are shown in Fig. 3. None of the covers produced any excessive or lethal temperatures even at air temperatures of 93°F. Treatments 5, 6, 10 and 11, had temperatures of 6 to 7°F higher than the uncovered trees, yet still less than 100°F. The rest of the materials were close to, or even a degree cooler, than the uncovered tree.

Discussion

During an advective freeze, those covers that stopped the wind and had water applied inside them provided substantial protection for the tree. Due to a mistake in December, one of these non-porous covers had the microsprinkler outside the cover. The result was no protection for the tree inside the cover. One semi-porous material (treatment 10) provided some protection during the windy freezes, however, while the rest of the treatments gave no protection.

During a radiaiton freeze the situation changed, especially for the semi-porous materials. The non-porous materials once again offered excellent protection as long as there was water applied. Some of the semi-porous materials also gave very good protection as long as they too had water. The rest of the materials did not perform much better in the calm situation than in the windy conditions, and these are obviously not satisfactory for cold protection.

It is evident that the covers alone were not effective, and a heat source is necessary. The use of water as this heat source seems the most practical. This test used a uniform rate of application that was thought to be adequate for protection. Rates of application will be examined in another test, therefore, the only conclusion that can be drawn at this time is that water, or another heat source, is necessary. In this test, 17 gal/hr provided adequate protection with the covers made of non-porous materials.

Heat build up during warm days was a concern since the test was designed to leave the covers on for the entire winter (ca. 3 months). Afternoon highs in the 90's were experienced and yet no excessive temperatures were reached inside the covers. It should be noted that both of the non-porous covers had no top and technically could be called "sleeves". This lack of a completely confined area prevented excessive heat build-up. Others have observed burn, which resulted form high temperatures in completely enclosed non-porous covers.

When the covers were taken off in mid-March, some observations were made concerning tree condition. All trees appeared to have suffered no ill effects from three months under cover. However, mites and aphids were abundant in all trees. Generally speaking, those covers that performed the best in protecting the tree from cold also

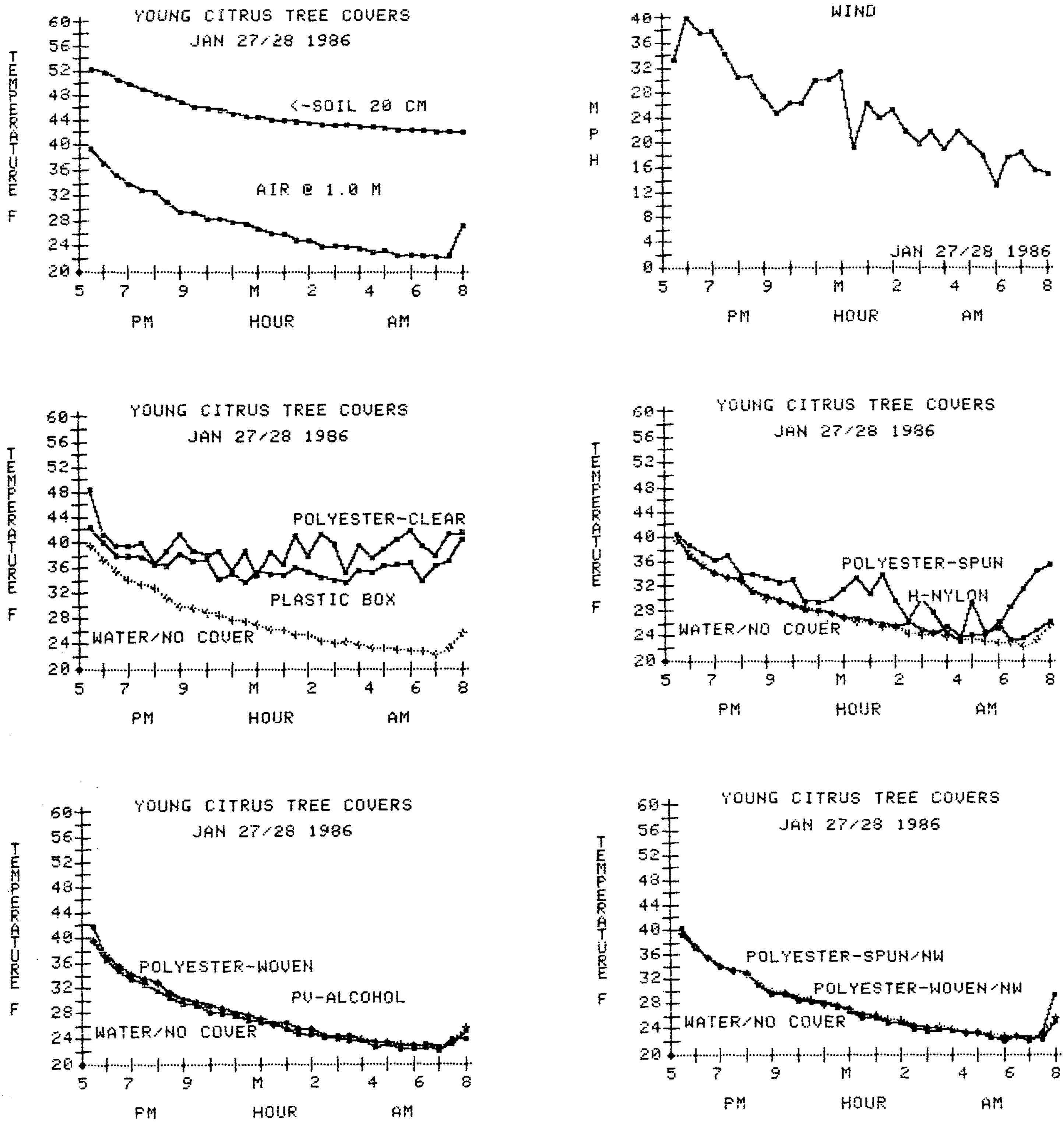

Fig. 1. Performance of covers during an advective freeze.

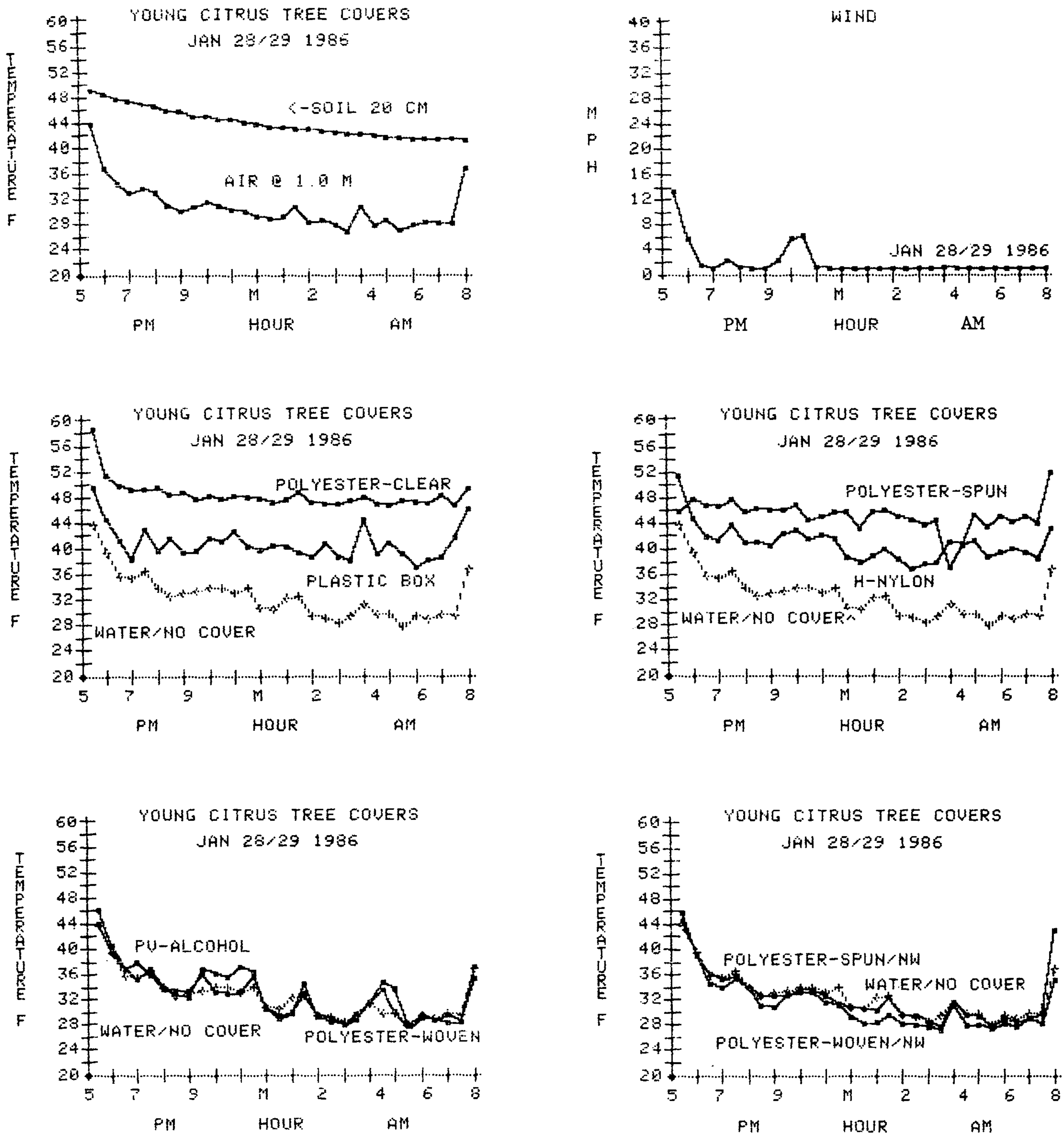

Fig. 2. Performance of covers during a radiation freeze.

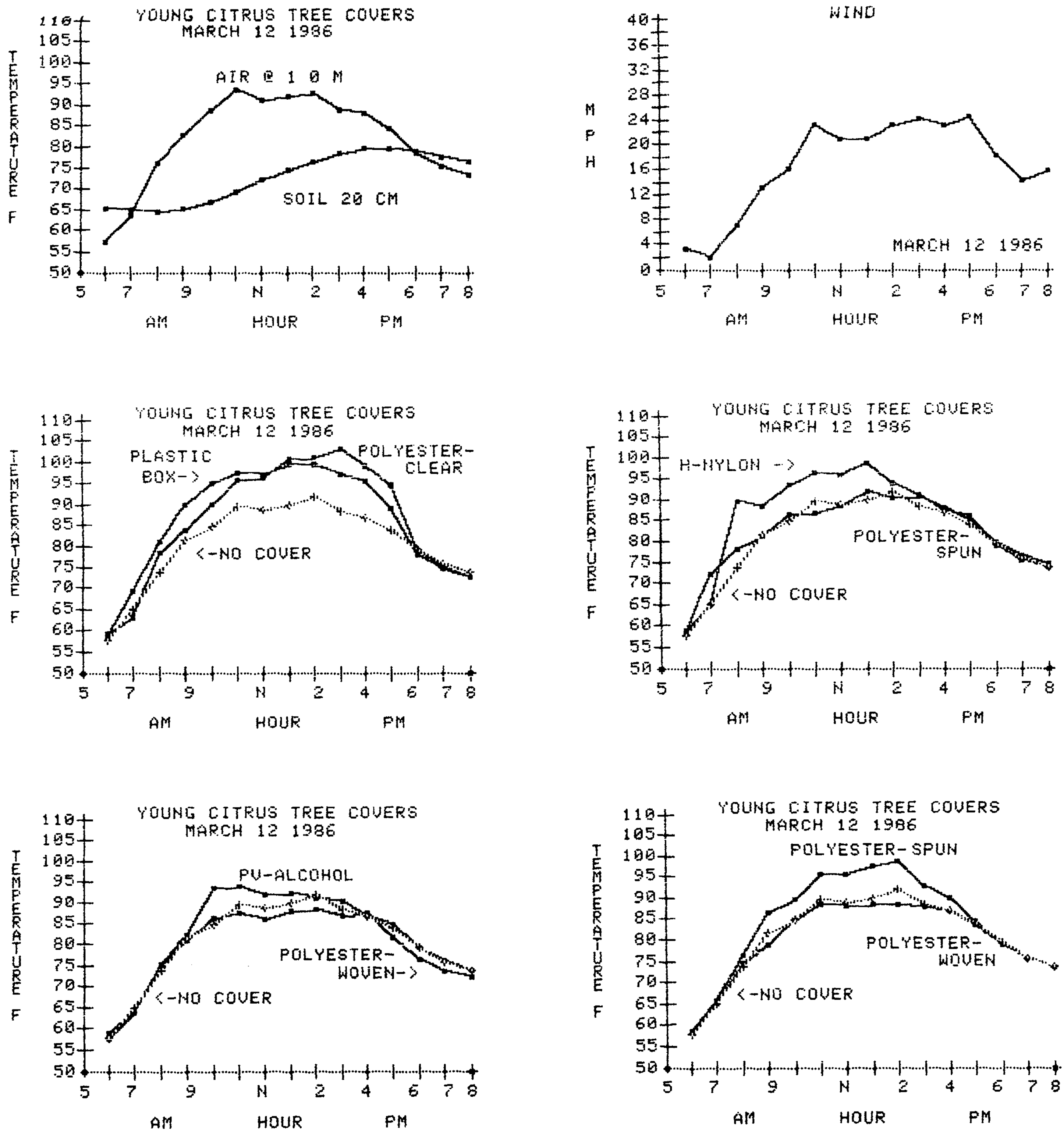

Fig. 3. Daytime temperature under the covers during a warm day.

produced the most severe mite and aphid problem. The populations were high enough to justify a spray.

The wind definitely influenced the effectiveness of the covers. It appeared that at the moderate speeds (8 to 16 mph), some of the semi-porous covers were able to provide protection. Therefore, slowing the wind some may be of value even during an advective freeze.

The authors observed that under certain conditions at least one of the covers produced unusual results; it was colder under the cover (with the water) than it was in the water and no cover treatment. This suggests that the cover was actually lowering the temperature. At this time, the authors do not have a complete explanation for this. Because of this potential for lowering the temperature, one should test covers before using them on a wide scale basis.

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CITRUS TRUNK AND SOIL TEMPERATURE VARIATIONS IN SOIL BANKS DURING FREEZE CONDITIONS

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Abstract. **Thermocouples were placed at various depths in each quadrant of 2 soil banks and on the trunks of 2-year old 'Hamlin' orange (*Citrus sinensis* (L.) Osb.) on sour orange (*C. aurantium* L.) trees to monitor temperature changes prior to and during freezes of 25-26 Dec., 1985 and 27-28 Jan., 1986. Daytime soil temperatures at 1- and 5-inch depths generally were highest in the SE and lowest in the NW quadrants but were comparable at the interior of the bank. Maximum daytime temperatures occurred between 1200 and 1500 hr at the exterior of the bank and between 1600 and 1800 hr in the interior, reflecting lag time necessary for heat transfer. Nighttime soil temperatures were comparable at 5- and 9-inch depths in the bank. Trunk temperatures were higher during the day and lower at night in the upper vs the lower 6 inches of the bank. Nighttime trunk temperature in the upper part of the bank paralleled those of the air, but averaged 4-9°F higher, possibly resulting in trunk dieback into the bank during severe freezes. In contrast, trunk temperatures near the base of the bank paralleled those of the soil surrounding the trunk, averaging 14-19°F above air temperatures. Heat accumulation in most of the soil bank was provided directly by solar radiation. In contrast, temperatures of the lower trunk were regulated by heat transfer from lower soil depths, solar radiation and the high insulating value of the soil at the base of the bank.**

Soil banks have been used since the 1890s for cold protection for young citrus trees (3). For many years soil banks were the major method of cold protection in central Florida and are still being used although many growers are now converting to tree wraps and microsprinkler irrigation systems (2). Although soil banks have been used for many years, little information is available on diurnal or nighttime temperature changes within soil banks during a freeze. Yelenosky (5) monitored changes in soil temperatures at 6, 12 and 18 inch depths into the bank and found they lagged behind those of air temperatures, particularly at the 18-inch depth. Minimum soil temperatures averaged 10, 19 and 28°F higher than air temperatures at the 6, 12 and 18 inch depths, respectively. Similarly, Jackson et al. (4) observed that trunk temperatures inside a soil bank averaged 10-12°F above air temperatures during a freeze. However, in some years growers have observed substantial dieback of the trunk into the bank, suggesting that temperatures in the upper portion of the bank may vary from those in the lower portion. Moreover, there has been considerable discussion concerning the major source of temperature modification in a soil bank, i.e., does the bank serve as a heat sink during the day and insulator at night or is heat transferred from the lower soil depths to the bank at night? Studies by Yelenosky (5) suggest that considerable energy is stored by the bank in the daytime and released at night.

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