Ground Sprinkling Limitations for Frost Protection in Deciduous Orchards

H. B. SCHULTZ

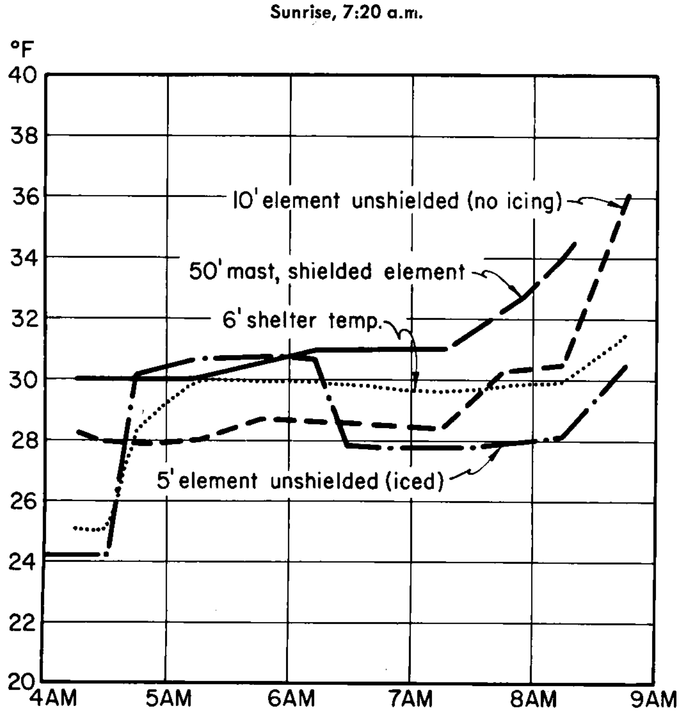
Under-tree sprinkling for frost protection in deciduous orchards involves a great amount of risk with only partial protection possible—as compared with no risk involved in the overhead sprinkling method, under practically all California spring frost weather conditions.

FROST PROTECTION using water has been proven successful when applied correctly by either (1) overhead sprinkling; or (2) flooding the surface with warm irrigation water. These methods are especially suitable for strawberries, vegetables, flowers, cranberries, grapevines, and other low-growing plants. However, such use of water in orchards is difficult to manage. With overhead sprinkling, the sprinkler heads must be mounted on tall risers to guarantee complete wetting of the trees, since the heating effect is provided by continuous freezing of the water droplets to an ice film around blossoms, branches, and leaves. With flooding, a large amount of water must be supplied from wells in a comparatively short time to cover the below-freezing ground surface with a layer of several inches of warm water. This method is especially successful in low vegetables when complete submersion of the plants can be achieved.

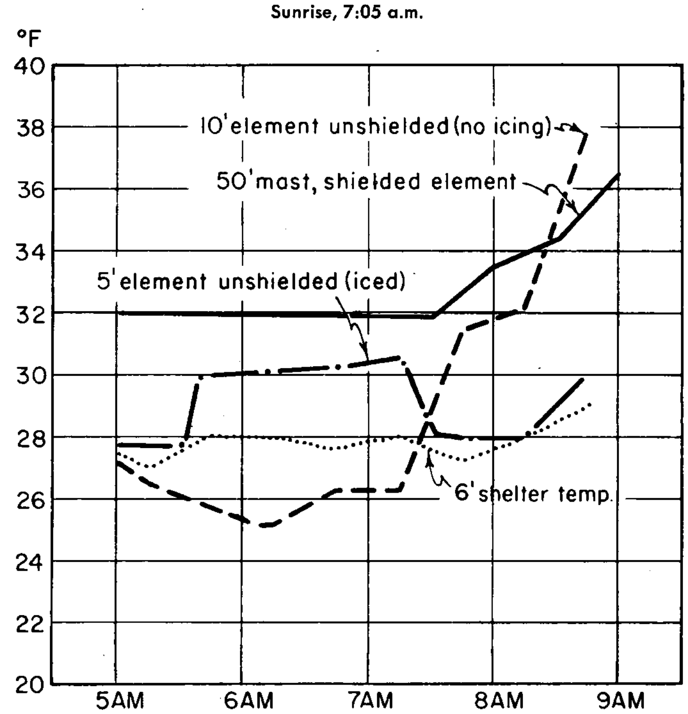
Some fruit growers have decided upon under-tree sprinkling as a compromise. This alternative is particularly attractive to growers with orchards that already have sprinkler installations for summer irrigation. However, it must be realized that there can be many shortcomings in this third method as compared with the first two. Sprinklers are not likely to provide quantities of water equal to the flooding method. There is little effect on air temperature or the temperature of the tree blossoms at the higher parts of the trees. Furthermore, the "heat of freezing" (heat of fusion) is mainly absorbed by the parts that are covered by droplets and that would receive protection similar to that from overhead sprinkling. A rise of air temperature could be nullified or even reversed by the cooling from evaporating droplets. The temperature decreases were slight in January 1957 tests because the potential evaporation has a low value on winter nights.

FROST PROTECTION SPRINKLER TESTS IN DECIDUOUS ORCHARDS

Live Oak, Jan. 10, 1957—Sprinklers 4:30 a.m. to 6:15 a.m.—
Sunrise, 7:20 a.m.



Live Oak, Jan. 30, 1957—Sprinklers 5:30 a.m. to 7:15 a.m.—
Sunrise, 7:05 a.m.



Although the frost danger for deciduous orchards comes in the spring months, an earlier testing time is advisable, because severe frost nights are needed for the study of frost protection by sprinkling. In the spring such nights may not occur or may be "hairline" border cases and not provide conclusive information. Even in winter, the opportunities for test operations using water are scarce, because growers are not in favor of adding water to the wet soils at that season.

An opportunity for tests occurred in the winter of 1956–57 when necessary rains failed to appear on a two-acre fertilizer test plot. C. Bergthold, owner of the orchard, cooperated by scheduling sprinkler applications during frost nights only. Valuable temperature data were obtained on the nights of January 10 and 30, 1957.

Temperature recording

A spot climate recorder was operated on the test plot during that season which registered air temperatures at 6 ft in the shelter. Two other temperature elements were fastened to tree branches at 5 and 10-ft heights. They were left unshielded to represent blossom and branch temperatures. Also, temperature records were made on a 50-ft tower which had been installed for several years in that orchard.

The sprinkler installation provided an average rainfall of 0.25 inch per hour. It was operated during the early morning hours when the temperatures had fallen to near 24° F (at 5 ft) on January 10, and to about 27° F on January 30.

The two graphs show the temperature traces at the various measuring points during these hours. The sprinklers wet the trees up to a height of 7 ft. The elements installed at 5 ft showed the benefit from the "heat of freezing" by a sharp rise to temperatures near 31° F, which lasted as long as the sprinklers were running. During the first night, the thermometer shelter happened to be open toward one of the nozzles so that the element iced up and also showed a rise to near 31° F. The instruments were then rearranged somewhat after the first test with respect to exposure to the nozzles, although they remained at the same locations. Thus, on the second test night, the water droplets did not enter the shelter, and no rise could be noticed in air temperature. The curves for the temperature element at 10 ft (which did not show temperature increases for either of the two cases) show decreases occurred immediately after the sprinkler start in both tests. The recordings of the 50-ft mast showed 5° to 6° F higher temperatures there than in the orchard, indicating radiation inversions of a little greater strength than normal for this location.

Temperature decreases at the 10-ft level, besides being small, were of short duration; and recovery took place after about one hour. This might indicate that the air gradually became saturated so that no further evaporation occurred. On damp nights, evaporation may never occur, in which case no heat would be removed from the air. Under such conditions, a certain amount of air warming could be expected from contact with the warmer droplets. Although this was not noticed in the temperature records of these two tests at the 10-ft height, it is possible that the lower parts of the trees might be affected by the warming trend. The 6-ft temperature curve for January 30 gave no such indication, however. Some protection from total loss has occasionally been reported from under-tree sprinkling in almond orchards. In such cases, the favorable conditions of high relative humidity, resulting in low evaporation, might have existed, but it must be suspected that most of the saved blossoms were low and within reach of the droplets so that they were protected by the heat of freezing (heat of fusion).

Partial protection

Partial protection may occasionally be possible with under-tree sprinkling, but this is not likely to happen often because California spring frosts occur mainly in rather dry polar air. The chances of partial protection would be greatly increased by using larger amounts of water. But this again compares unfavorably with overhead sprinkling which provides 100% protection with a rainfall rate of only 0.08 inch per hour in air temperatures as low as 25° F—under calm conditions. Somewhat higher "rainfall" rates would be needed for overhead sprinkling on windy nights, or when temperatures fall lower than 25° F, or when sprinkler heads are revolving slower than every two minutes (none of which are conditions likely to occur).

Under-tree sprinkling could provide a fair amount of protection during mild frost nights when only the lower parts of the trees are in danger but a greater risk is involved—as compared with no risk in the overhead sprinkling method, under practically all California spring frost weather conditions.

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