Frost Protection by Sprinklers

use of overhead sprinklers for frost protection on low growing plants tested on blueberries in Santa Cruz County

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Heat released by ice forming from water sprinkled on plants—that can carry the ice load—appears to be an efficient means of frost protection.

In comparison with heaters the sprinkling method often is preferred for protecting low plants—strawberries, tomatoes, potatoes, cranberries, flowers—which usually bend to the ground when coated by the heavy ice film, but do not break.

However, despite the success of the sprinkler method for frost protection—which does not even depend on favorable weather conditions such as inversions—there is some hesitation in putting the practice into more extensive use, because thorough information is lacking. There is a fear that the ice crust around the leaves, blossoms or flowers might cause physiological damage. The required supply of water—about 1⁄10″ per hour—makes all field operations impossible during the following days, and also root damage could result.

In orchards, the amount of breakage because of the ice load from sprinkler applied water has been disastrous in some cases. When overhead sprinkling of orchards is used—in certain countries—the reason might be shortage or high cost of fuel which prevents the use of heaters or wind machines. Economic feasibility also is doubtful in many places, as overhead sprinkling for frost protection requires complete coverage which is usually permanent installation.

In the spring of 1954, temperature measuring equipment was installed on a blueberry farm in Scott's Valley—in the Santa Cruz mountains—to investigate temperature conditions and verify the success of the sprinkler system. By comparison with surrounding stations, Scott's Valley with an elevation of 600′ proved to be a frost hole, because the surrounding hills—500′ higher—do not allow good cold air drainage. The opening of the valley is to the northwest, but the possible air drainage in this direction is strongly opposed by the overhead circulation pattern of prevailing northwest winds.

An additional cooling of sections of the blueberry plot was caused by a woodchip ground cover that acted as an insulator and mulch. The cover was beneficial primarily in reducing weed growth and conserving moisture in the root zone but it did not allow much solar heat absorption by the ground. At night, the woodchip mulch deprived the air above the surface of the ground heat supply and permitted about 5°F more cooling at 10″ height—shielded thermometer—than in the shelter at 5′ height.

To protect the blueberry bushes—3′-4′ high and planted in 8′ wide rows—pipes were installed every twelfth row at a distance of 96′. Elevated nozzles at 80′ intervals along the pipes provided overhead sprinkling with a little less than six sprinklers per acre. The sprinklers were of the slow revolving type operated under about 55 pounds pressure per square inch. By plugging the spreader nozzles of the conventional sprinkler-heads the watering was done by the 11⁄64″ diameter range nozzles only, thus cutting down the water supply to 6.3 gpm—gallons per minute—equal to an average rainfall of between 0.08″ and 0.09″ per hour.

Temperature Minima on Eleven Clear and Calm Nights at Scott's Valley, and Surrounding Stations for Comparison During the Spring Frost Season

	Davis	San Jose	Santa Cruz	Scott's Valley Shelter 5′	Scott's Valley at 10″	Scott's Valley 5′ unshielded
May						
1	46	42	37	(31)	(26)	(25)
2	43	43	37	33	28	27
16	49	50	43	38	35	33
23	51	52	44	38	33	31
26	46	47	40	36	31	30
27	51	46	43	32	27	26
June						
5	44	50	43	36	31	30
6	49	45	39	33	28	27
7	48	49	42	37	31	30
10	45	48	39	36	32	31
11	49	48	45	38	32	32
Ave.	47.4	47.4	41.1	35.3	30.4	29.3
Diff. vs. Sc. V. shelter	+12.1	+12.1	+5.8	0	–4.9	–6.0

The recording instruments were installed at the edge of the plot about 40′ from the last sprinkler and—because there was no overlap from other sprinklers at the instrument location—the equivalent of only 0.05″ of rainfall per hour was recorded during a four hour operation on May 1. The temperature records were plotted to show the comparison of two long distance thermographs with the two bulbs unshielded. The bulb located at the water measuring

GRAPE LEAF FOLDER

Continued from page 4

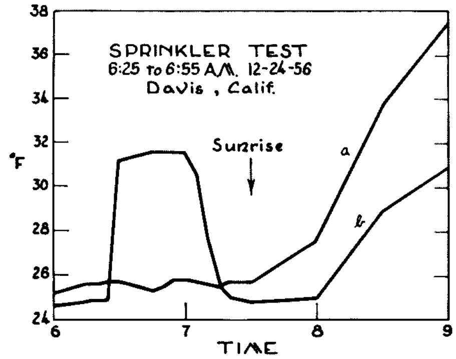
cides in 1955 showed parathion and endrin dusts to be much more effective than cryolite in control of second brood larvae. Various dusts applied in early September showed the following decreases in numbers of larvae as compared to the check: 4% Diazinon dust—94%; 4% methyl parathion dust—85%; 2% parathion dust— 78%; 5% Niagara Bio 1137 dust—71%; and 5% Trithion dust—42%.

In 1956 cryolite and parathion dusts and standard lead arsenate sprays were applied in both Fresno and Tulare counties for control of larvae in the first brood. Numerous untreated check plots were established to obtain some estimate of how the population of leaf folders varied in different parts of the treated vineyards. Counts of leaf rolls were made at the end of the first brood and again at the end of the second brood. In Tulare County the plots which were untreated in the first brood were dusted with 2% parathion dust at 20–25 pounds per acre in the second brood. This treatment was applied too late in the second brood to obtain the best results. Plots treated in the first brood were not retreated. Counts at the end of the second brood were made to observe the carryover effect. The results are briefly summarized in the table on page 4. The average number of rolls per vine in untreated plots estimates the over-all leaf folder infestation in the vineyards. Per cent reduction in leaf rolls is a measure of the initial control and degree of carryover effect of the treatments. The table is a simplification of the results since it does not show the variation in infestation in the check plots or variations in degree of control between plots receiving the same treatment within the vineyards.

Continued on page 10

station recorded a temperature rise of about 3°F above the outside control-bulb soon after the sprinklers were started. At the sheltered thermograph station—an hour later—a slow temperature rise began as some fusion heat went into the air. This effect, apparently, was experienced also at the outside control bulb, installed only 15′ from the last bush row.

The grower kept the sprinklers running till about one and one half hours after sunrise. A temperature drop was recorded when the sprinklers were started—probably due to evaporation cooling of the first droplets falling on the bulb—but the drop lasted a few minutes until there was a sharp temperature rise provided by the water changing into ice. There was no frost damage that particular night and the grower was satisfied, but a temperature rise to only 29°F seemed insufficient. Later tests, conducted at Davis during some winter frost nights—no more frosts occurred in Scott's Valley, possibly because the wood-chip mulch was removed—revealed that a water supply of 0.05″ per hour rain at the measuring location must have been too small. A sprinkler response—up to almost 32°F—when a rain of 0.4″ was applied, is too much, but in this test the sprinklers were turned off before sunrise. As a result the protected body cooled rapidly to the starting temperatures and would have been further cooled by evaporation if the relative humidity had not been close to saturation. For the same reason, no evaporation cooling was observed at the start of the sprinklers on that night.

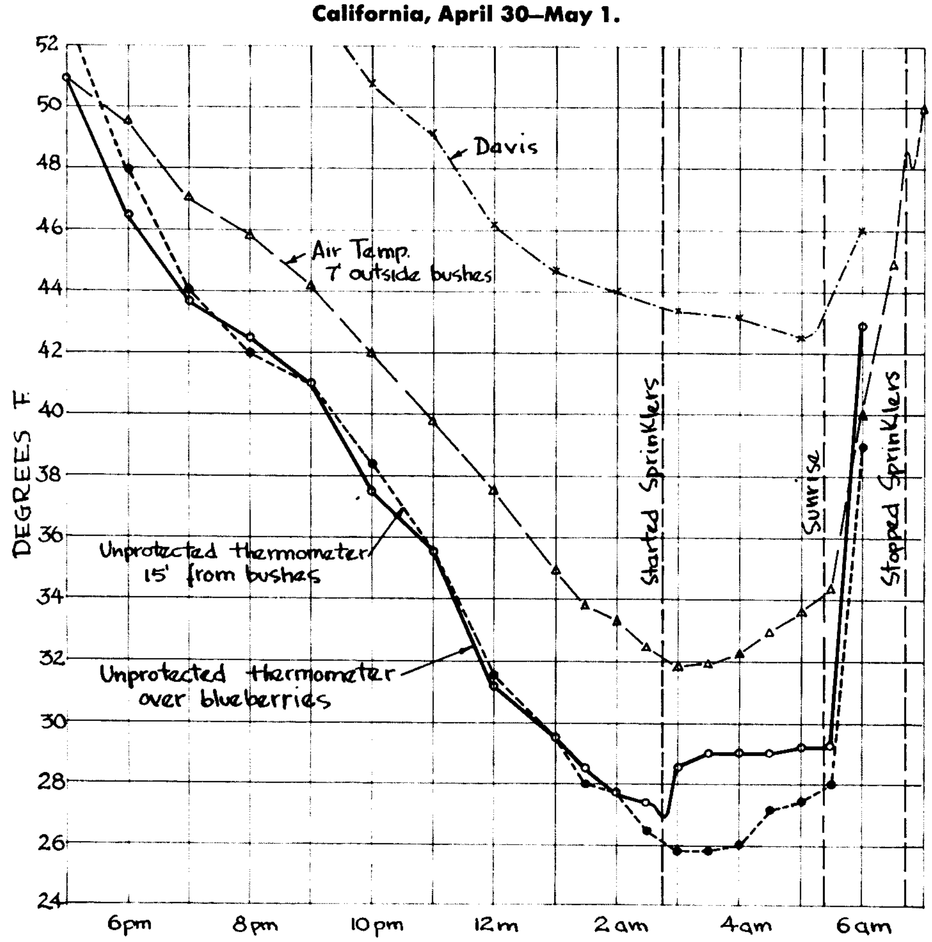


Temperature rise during sprinkling—curve *a*. As operation was stopped before sunrise the sprinkled bulb cooled to previous temperature and stayed colder than the outside control bulb—curve *b*—until the ice crust had melted and the water had evaporated.

In another test the relative humidity was 70% only, and together with a north wind of five miles per hour caused peculiar results but furnished useful information. There was an almost constant temperature at the outside station until and somewhat after sunrise which was at about 7:30. There were different responses at three different locations. At one location, the simulated rainfall from sprinkling was measured with 0.08″ per hour and provided very satisfactory frost protection. However, at the start and after the turn-off, evaporation cooling caused a considerable temperature drop. The recording from two other locations—wind trouble resulted in receiving less sprinkling—showed much smaller responses; in one location there was almost none. These conditions do not exist during spring frost nights which usually are calm. However, the tests did show that a successful operation of protection by icing requires an artificial rain of about 0.08″ per hour under average spring frost conditions.

From these tests it might be concluded that ice forming from overhead sprinklers will give protection from freezing to most any crop that can carry the ice load. However, it is necessary to continue the rate of sprinkling required to supply the heat when the liquid water changes to ice. Furthermore, drainage must be such that the extra amount of water can do no damage to the crop.

Sprinkler frost protection from 2:45 a.m. to 6:45 a.m. Scott's Valley, California, April 30–May 1.



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Wind trouble at stations *c* and *d* diminished water supply making frost protection insufficient. Only station *b* got full amount—0.08″ per hour rain. Curve *a* represents outside control bulb. After sprinkler was turned off at sunrise, strong evaporation cooling due to dry wind caused a temperature drop to 3°F lower than before operation started.