Removing leaf litter doesn't protect oranges from frost

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Left: Miniature net radiometer, used to measure radiation under t prevent condensation. Above: Orange Cove experimental site is

Removal of leaf litter from the soil surface has been reported to help protect some crops against frost damage. In at least one instance, leaf litter was implicated as a contributor to frost damage in oranges, but we know of no previous research on removing litter for frost protection. During the winter of 1980-81, therefore, we designed an experiment to test the effect of leaf litter removal in oranges.

Orange Cove experiment

The experimental site, near Orange Cove, California, is prone to frost damage. Cold air drainage from surrounding foothills is considered the major factor in the high frequency of cold temperatures.

Orange trees at the site were in north-south rows with approximately 15 feet between rows and 10 feet between trees. The trees averaged 10 feet tall and had a 10-foot canopy diameter. Leaf litter, averaging 1 inch deep, was raked by hand from underneath the trees in an area five rows wide by seven trees long. There was no litter between the rows. The center tree of the raked plot was instrumented to detect effects of raking on air temperature above and below the tree, soil temperature beneath the tree canopy, wind speed, and net radiation. Another tree in an unraked area was similarly instrumented.

Air temperatures were measured with thermistors at the top of the tree foliage and 1 foot above the soil surface beneath the foliage. The under-tree thermistor was approximately 2 feet south of the trunk. Soil temperature was also measured 2 feet south of the trunk at a 2-inch depth. Wind speed was measured with an anemometer 3 feet above the top of the tree. Net radiation (the balance between radiation gain and loss) was measured near the under-tree thermistor. All instruments were recorded with an electronic data logger, and results were transferred to cassette tape for analysis.

Results

Although the experimental site is known for frost damage, no severe frosts occurred during the 1980-81 winter. Leaf litter removal did allow better heat transfer into and out of the soil underneath the test tree, which affected the range in soil temperature, but had little or no effect on air temperatures above or below the tree. Clouds and fog had a great effect on air temperatures, and leaf litter removal was insignificant by comparison.

Figure 1 shows temperature trends for the night of January 8-9. Fog or clouds reduced sunlight reaching the soil surface during the day on January 8. Skies cleared in late afternoon, and all temperatures began to drop rapidly, except in littered soil, which was insulated from rapid heat loss. Soil temperatures near sundown (5:00 p.m.) on January 8

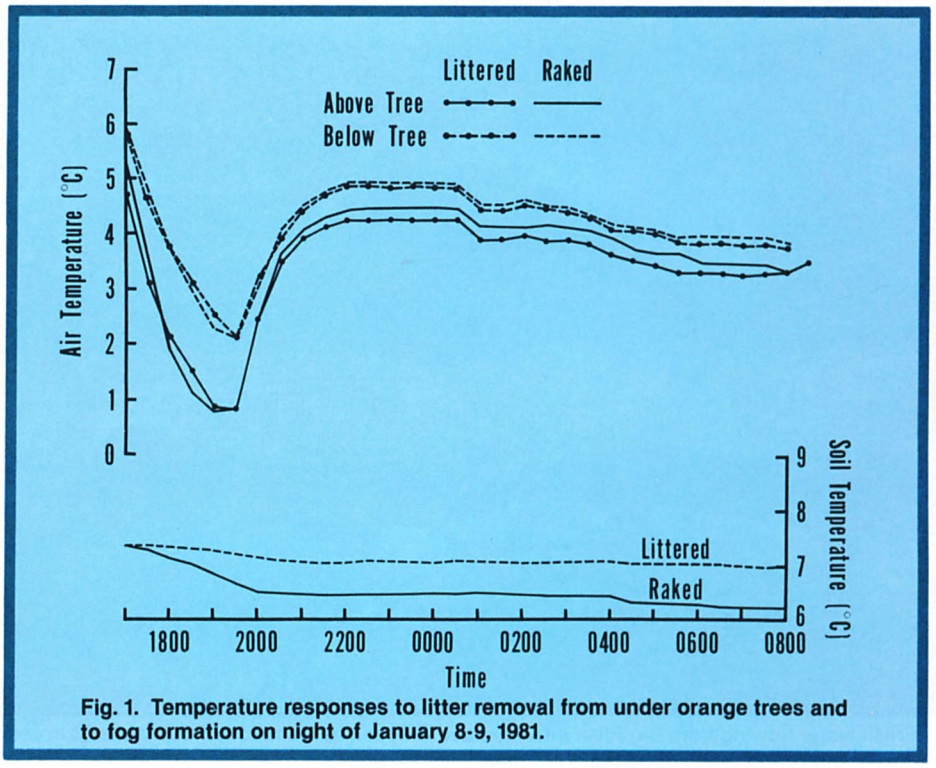
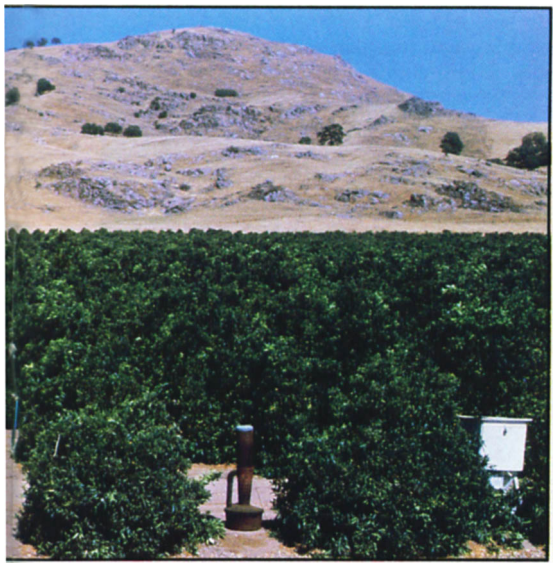


Fig. 1. Temperature responses to litter removal from under orange trees and to fog formation on night of January 8-9, 1981.



under the tree, is treated by researcher Jim Hatakeda to site is prone to frost damage.

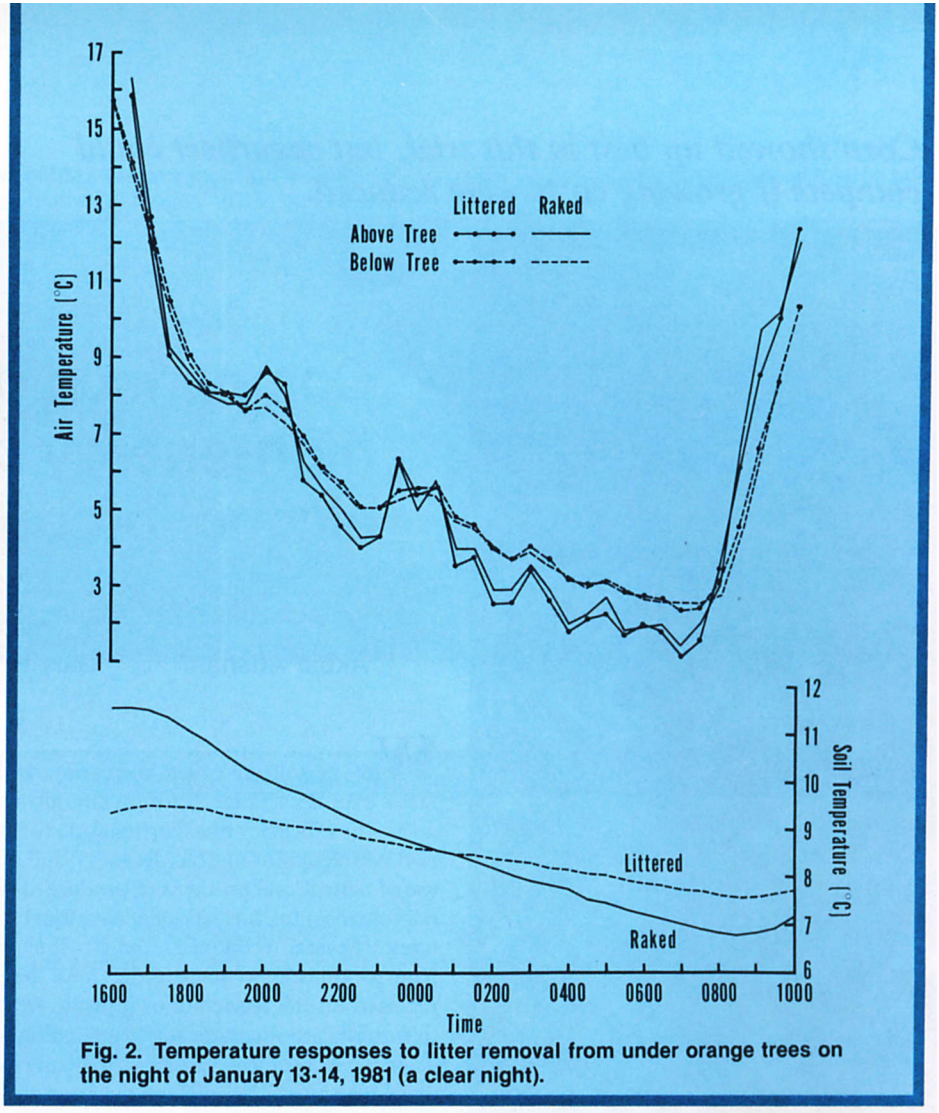


Fig. 2. Temperature responses to litter removal from under orange trees on the night of January 13-14, 1981 (a clear night).

were already lower than minimum soil temperatures on other days (fig. 2) because of the low net radiation during daylight.

Air and raked-soil temperatures dropped rapidly until 7:30 p.m. on January 8, after which the soil temperature stabilized and air temperatures rose 3° C (5.4° F). This rapid rise in air temperatures is most likely due to fog formation, which inhibited radiational heat loss from trees and soil. A similar air-temperature and heat-loss response to man-made fog was reported by Brewer, Burns, and Opitz (*California Agriculture,* May 1974).

Fog formation abruptly inhibited the rate of heat loss by radiation (also observed by Brewer and co-workers in 1974), but the soil and trees continued to supply heat to the air at the same rate as before fog formation. Heat was, therefore, being supplied to the air faster than it was being removed by radiation, and air temperature rose until a new equilibrium was established. Air temperature again declined after 10:00 p.m., but at a slower rate because of the fog.

If fog had not formed on the night of January 8-9, a serious frost might have occurred. Above-tree air temperatures had fallen to 1° C (33.8° F) by 7:00 p.m. and would have been very low by sunrise if the dew-point temperature had been low. Raking leaf litter affected the soil temperature but was not beneficial for frost protection, since no warming of air above or below the tree resulted.

Figure 2 shows the temperature responses on January 13-14 (a night with no fog or clouds). During the day on January 13, net radiation was quite high, so considerable heat was stored within the trees and soil, and sundown soil and air temperatures were higher than on January 8-9.

Air above the trees was warmer during the day and cooler at night than below the trees, because the treetops are more exposed to daytime sunlight and more open to the cold nighttime sky. Because there was no fog or clouds on the night of January 13-14, temperatures continued to drop after sunset until sunrise the next morning. Temperatures did not fall below 0° C (32° F), because sufficient solar energy was stored during the day on January 13. If it had been cloudy or foggy during the day and clear at night, a severe frost might have occurred.

Removal of leaf litter definitely had an effect on soil temperatures. Raked soil was warmer during the day and cooler at night; litter insulated the unraked plots against rapid temperature changes. Evidently, the total heat from the soil directly under the trees is small in comparison to that supplied by the soil between rows and by the trees themselves. The greater range in soil temperature for the raked treatment indicates that soil beneath those trees was releasing more heat. This was not reflected in higher air temperatures, however, so the unshaded soil between the rows and the trees themselves were probably providing most of the heat to maintain air temperature.

Removal of leaf litter from beneath orange trees did not benefit the trees and is not recommended as a cost-effective method of frost protection in orange groves. Heat storage within the soil between the rows of trees and in the tissue of the trees themselves is probably much greater than in the soil under the trees. Hence, the enhanced heat supply from raking litter from beneath the trees was small by comparison.

Because wind speed was slow on each night of the experiment, its effect on the raking treatment could not be assessed. Clouds and fog, however, have tremendously beneficial effects on frost protection.

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