Solid fuel, candle-type heaters have been tested to determine their effectiveness when used, both under trees and in the open, to protect against freezing damage in a citrus orchard. Two heaters under each tree were found effective in increasing fruit temperatures under the tree by about $3^\circ F$, and heaters both under the tree and outside the tree more than doubled the temperature rise. Heaters placed outside the tree were less than half as effective as those under the tree in increasing fruit temperature—either for fruit inside the tree or for exposed fruit on the outside of the tree.
HEATERS

SOLID FUEL HEATERS with a low flame for use under a tree are on trial for orchard heating. Oil companies have designed and are experimenting with several types of these heaters. This report discusses tests using solid petroleum wax candles as a source of heat.

Heaters used in these tests were contained in cylindrical cardboard cartons about 8 inches in diameter and 10 inches high. The cartons were filled with a petroleum wax and had a fiberglass wick about 8 inches in diameter and 10 inches long handle, which acted as a candle snuffer.

The idea of supplying heat beneath the canopy of the tree is a new approach to orchard heating. In the past the efficiency of heaters in orchards has been low because much of the heat is dissipated into the atmosphere or radiated to the sky where it is lost and does not warm the trees. This new method is much more efficient since a higher percentage of the heat can be retained by the tree.

Grapefruit

To determine the effectiveness of these solid fuel heaters for frost protection, field trials were conducted to study temperature responses. A grapefruit orchard with both large and small trees, located about two miles northwest of Lake Elsinore, Riverside County, was used in the tests.

The heaters were tested on five different nights requiring limited frost protection: January 24-25, and 25-26; February 11-12, 12-13, and 16-17, 1965. The orchard was heavily instrumented with thermocouples to record air, leaf, wood and fruit temperatures both inside and outside the trees. Similar temperature measurements were made in the control area outside the influence of the heaters. Wind speed and direction were also recorded, as well as soil temperature, wet and dry bulb temperature, and three radiometer readings. Temperature recordings from test trees were compared with temperatures at similar locations on unheated control trees. Air and fruit temperatures were taken at a height of about 6 ft.

Two heaters

On the night of January 24-25 a test was made using two heaters under each large tree. There were 104 heaters lit. The test started at 4:00 a.m. and ended at 7:00 a.m. The heaters were difficult to light as they were wet from a rain the previous day. The average temperatures of the test trees and the control trees were compared for the two-hour period from 5:00 to 7:00 a.m.

As shown on the chart for January 24-25, the temperature of fruit outside the canopy of the tree in the test area remained about the same during the test while the control temperature went down. The average difference was 1.5°F. Temperature of fruit inside the canopy of the tree started to increase about one-half hour after lighting the candles, and increased steadily until 7:00 a.m. The average difference when compared with the control tree was 3.0°F, and the difference at 7:00 a.m. was 11.6°F.

Air temperature outside the tree for the same period averaged 3.1°F higher than the control, while the air inside the tree averaged 6.7°F higher than the corresponding control. Leaf temperatures were similar to air temperatures. Outside leaf temperatures were only 1.6°F warmer than the control, while inside leaf temperatures averaged 7.3°F higher than similar leaves on the control trees.

Heaters in rows

On the night of January 25-26, two heaters were lit under each tree and additional heaters were placed in the rows between the large and small trees. Lighting started at 3:00 a.m., and required one hour and forty minutes for the 230 heaters. Many went out and re-lighting, sometimes two or three times, was necessary. A count at 5:00 a.m. showed 21% were either out or not burning properly. Average temperature response was taken from 4:00 to 7:00 a.m.

The temperature response of the test tree showed fruit on the outside of the tree averaged 1.9°F warmer than the unheated control tree. Fruit inside the tree during the same period averaged 6.4°F warmer. Air temperature on the outside of the tree at 6-ft height averaged 3.1°F warmer, while air temperature at the same height inside the tree averaged 7.0°F warmer than the control tree. Leaf temperatures were similar to air temperatures. Outside the tree the leaf temperature was 3.0°F warmer than the control tree, and leaf temperature inside the tree averaged 7.2°F warmer.

Under trees

On February 12-13, heaters in the rows between the trees were lit before those located under the trees. About one hour was required for lighting. Outside heaters were started from 1:00 to 2:00 a.m., and the under-tree heaters were started from 3:00 to 4:00 a.m. Temperature responses from 2:00 to 3:00 a.m. were used to indicate the response to the first lighting, and from 4:00 to 7:00 a.m. for the response with heaters both under.
Cotton lint yields of Acala 4-42, Deltapine Smooth Leaf, and Strain A decreased as planting was delayed after March 22, but an earlier planting (March 8) did not increase yields in tests at the Imperial Valley Field Station in 1962 and 1963. Gin turnout (expressed as percentage of lint) of Acala 4-42 increased slightly as planting was delayed, but decreased in Strain A and DPL-SL. There seems to be no advantage in planting cotton before March 20 in the southern part of Imperial Valley. The advancement of pink bollworm infestations in Arizona and Bard Valley, California, puts further emphasis on planting dates for help in control of this pest.

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