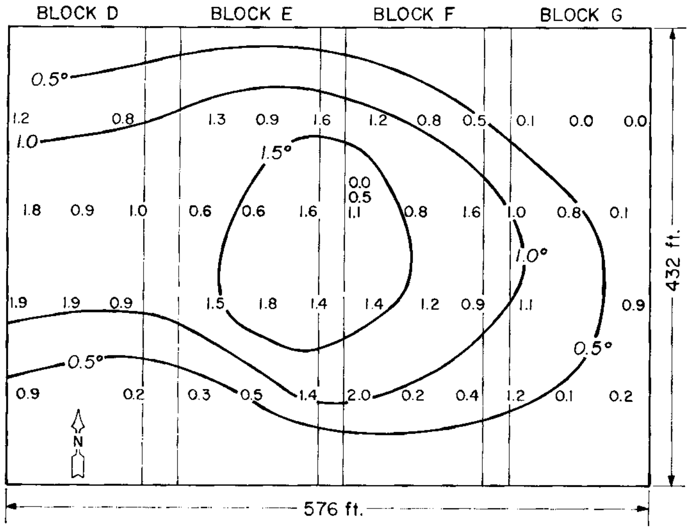
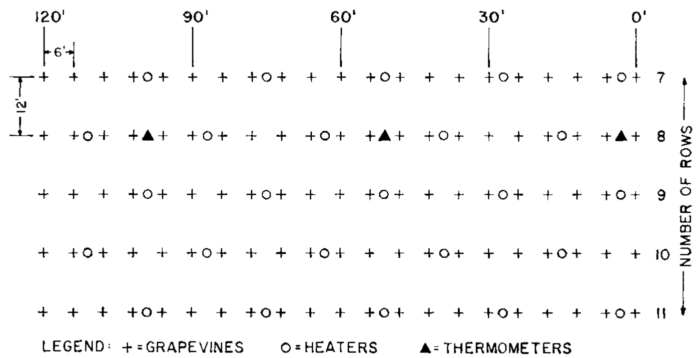
ORCHARD HEATING *with solid fuel heating*

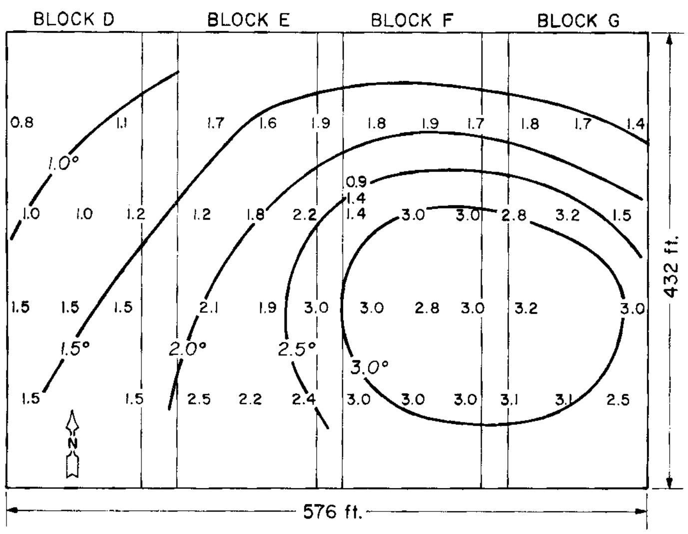
4-12-67, 2:40 A.M. WIND FROM EAST, NEARLY CALM



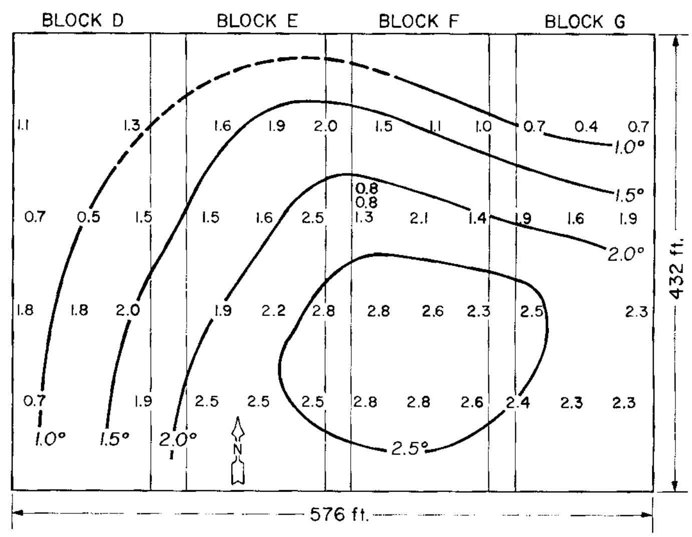
Plot diagram below shows location of grapevines, orchard heaters, and thermometers used in orchard heating test plot for this study at U.C., Davis. Response lines on graphs show temperature increases over the plot in timed sequence from 2:40 a.m. to 4:55 a.m. on the morning of April 12, 1967.



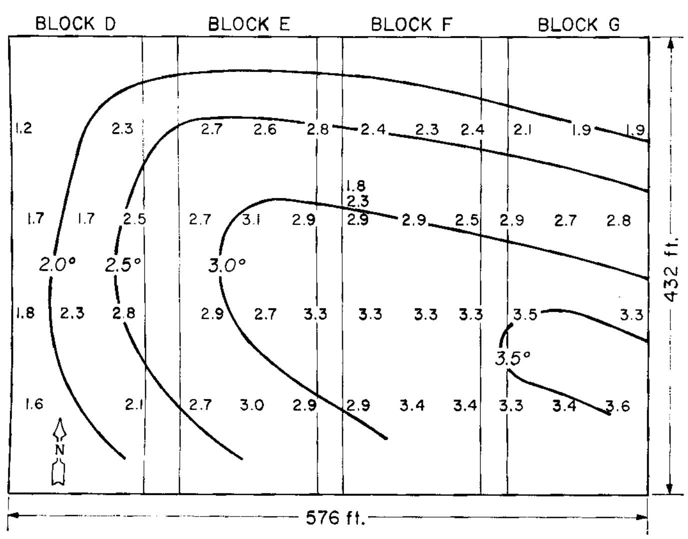
4-12-67, 3:05 A.M. CALM AFTER WEST DRIFT



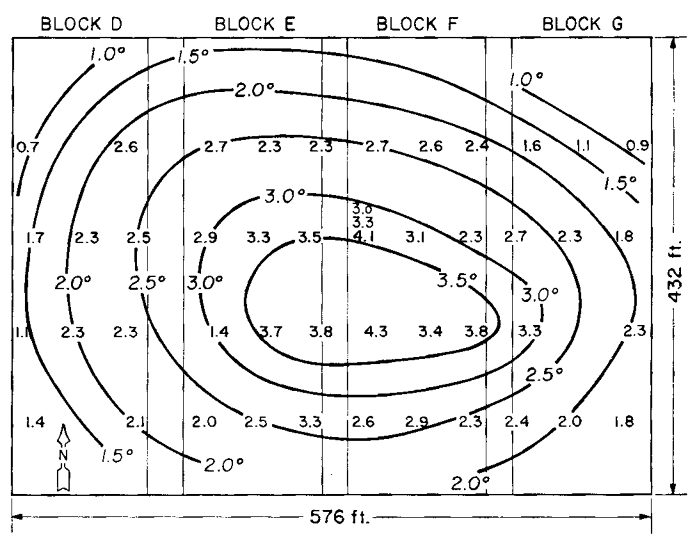
4-12-67, 3:50 A.M. WEST NORTHWEST - 3 M.P.H.



4-12-67, 4:40 A.M. WIND FROM WEST, 1 MILE P. H.



4-12-67, 4:55 A.M. CALM



bricks - - under minimum favorable conditions

H. B. SCHULTZ · L. A. LIDER · R. A. PARSONS

The performance of solid-fuel heaters (4-lb petroleum coke bricks) was unsatisfactory only after a long rainy spell just prior to burning, and then because of difficulties at starting time. However, the quality of the material had not suffered from exposure to prolonged hot, cold, or rainy weather. Although 10 bricks give the same heat output as one oil heater, only 150 bricks per acre were needed for a temperature rise normally produced by 25 oil heaters. In calm conditions a need for extra heaters at all borders became evident. However, a reduction in number of bricks toward the center of the plot appears possible since the temperature increased constantly toward the middle of the heated area in these tests.

FRUIT GROWERS often have difficulty applying information from frost protection research to their own orchards because of the difference between the conditions during the various tests and those of their orchards. The danger of misjudgment is comparatively small in reports on overhead sprinkling—where heat is provided by droplets freezing onto the plant —because this method has always been investigated on actual frost nights and, after nearly 40 years of testing at several experiment stations in the United States and other countries, a considerable body of information has been obtained.

Studies of orchard heaters as well as wind machines, however, are often accelerated and tests are frequently conducted while temperatures are above freezing. For reasonable interpretation, it is necessary to state the amount of the inversion (temperature at 50-ft height minus that at 5 ft) and the wind drift. The inversions on "warm" test nights can often be misleading because the differences are likely to be greater—thus leading to better results with heaters or wind machines than would be obtained on nights with frost conditions. Inversions on various test nights have been found to range between 6° and 16°F in citrus orchards in winter, and between 3° and 8°F in deciduous plantings in spring. However, on real frost nights, most inversions are nearer the lower figures.

Tests at Davis in the 1967 spring season were therefore conducted under difficult conditions. Measurements on the night of April 11–12 showed an inversion of only 3° to 3½°F, and several periods of complete calm. Furthermore, the orchard-heating material (a new solid-type, 4-lb petroleum coke-based brick) was kept under very unfavorable conditions. Since further information was needed about their performance after prolonged storage, the unused bricks of the previous season's testing (reported in CALIFORNIA AGRICULTURE, January 1967) were exposed outdoors during the hot cloudless summer at Davis.

These bricks were then placed in the Davis vineyard in late winter, and subsequently subjected to one of the wettest springs on record. About 6 inches of rain fell during the 19 days prior to burning and rain also fell on the day before the test. The evaporating wet ground caused heavy dew deposits on the plastic wrapping of the bricks on the clear test night of April 11.

Placement of the glass thermometers (horizontally mounted and unshielded as in the previous year's tests) was arranged to show the smallest possible heating response. This was considered desirable since the previous tests were carried out on a 2-acre plot permitting only a limited number of thermometers—and some of these had been installed rather close to the heaters allowing the possibility of overemphasis on such data during the construction of temperature-response lines.

The new test area was increased from the 2-acre plot used the previous year to 5½ acres, while the same ratio of heaters (150 units per acre) was used. With 600 vines planted per acre, four vines were "heated" by one brick. These were distributed in a square pattern, as shown in the sketch, with the thermometers in the center of each square. About 50 thermometers were installed at 4-ft height in four of the 36 heated rows, as can be seen in the diagrams. Five control stations were located north, east, and south of the test site.

By 12:30 a.m. the 5-man crew had ignited all heaters, using standard lighting torches. However, many bricks which had failed to "burn off" the dew deposit had to be relighted, and one-third of the bricks still burned poorly and needed to be lighted a third time because they were covered by 10-inch-high dew-laden weeds. This third lighting was finished at 1:15 a.m. The first response diagram, representing the temperature rise by 2:40 a.m., reflects the early period of only partial burning of the blocks which in last year's tests lasted about one hour. The second diagram shows that the temperature had risen over 3°F by 3:05 a.m. and stayed high, thus confirming the previous year's few results regarding small inversions.

The weaker response, shown in the third diagram, was obviously caused by increased wind velocity (which is no disadvantage because windiness generally raises the field temperature, requiring less protection). The last two diagrams, obtained at 4:40 a.m. and 4:55 a.m., show a temperature rise even higher than that of the previous year—which must be ascribed to the increase in heated area (mass heating), as well as to the near calm conditions. In a complete calm all four borders were found to be considerably colder than the center area (see fifth diagram), thus demonstrating the need for extra heating at all sides. In mild frost conditions, however, the number of heaters can gradually be reduced toward the center.

All heaters burned red hot from 1¾ hours after the lighting—indicating that the year's summer storage exposure was not detrimental. The need for extra lighting was due to slow ignition under the heavy dew and tall wet weeds. The manufacturing firm supplying the bricks has now incorporated an improved ignition layer into its newer product (a type not included in this test). Since the purpose of the ignition layer is to provide more and quicker heat during the first hour until the bricks reach maximum temperature, this improvement should overcome the difficulty of obtaining adequate temperature response during early stages and in extremely wet nights.

Temperature responses were determined at three levels (20 ft, 10 ft, and 4 ft) in block F, row 15, by a recorder using liquid-in-steel thermometers. The diagrams show that warming took place at all three levels, although to a somewhat lesser degree at the higher levels. The records indicate the upward escape of convectional heat, as in previous tests with orchard heaters—but to a much lesser degree than in the case of conventional stack heaters, because of the smaller heating units.

Stack heaters generally produce a temperature rise of 3° to 4°F when using at least 25 per acre at an approximate burning rate of ¾ gal/hour, or about 90,000 Btu/hour per heater. The heating equivalent would be ten coke bricks (8,000 to 10,000 Btu/hour, each) per each stack heater, or 250 bricks per acre. However, in this test, 150 bricks produced about the same response as 25 stack heaters. The previous year's data had indicated a similar result, despite the uncertainty of finding correct values for maximum field response because of the small plot size and winds which had greatly displaced the hot air plumes. This was also evident in the fourth test, run at 4:40 a.m. in this trial. At times, the hot plume moved out far enough to reach one of the control stations 200 ft away (which was then disregarded). This was no surprise since downwind frost protection has been experienced frequently in commercial orchard heating, and also in wind machine operations.

The results of these tests again confirm the advantage of many small heating units over a few large ones. In the trials reported here only 60% of the Btu's commonly required when using oil heaters produced similar rises in temperature. The possibility to further reduce this ratio of 150 bricks to 25 heaters is indicated in the last diagram where it appears that the number of bricks could be reduced toward the center, especially in light frosts. This suggestion is not feasible for oil heaters, because operating with less than 25 oil heaters per acre would leave large unprotected ("dark") spots.

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This study was conducted under project 400 U. The petroleum coke bricks, manufactured under the label "Tree-Heet," were supplied by the Mobil Oil Corporation.

SUMMARY

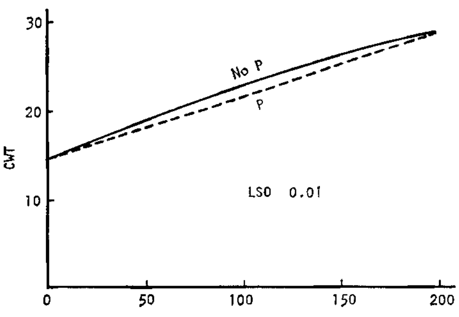
These tests, and other field observations, indicate that moisture is a key consideration in selecting a fertilizer program for safflower in the Valley. For dry-land soils or soils with low sub-surface moisture levels, 20 to 60 lbs per acre of N appear to be sufficient. Excess N may reduce yields.

Greater amounts of N may be utilized when safflower is grown under irrigation, or on soils with a high water table, or on deep soils filled with moisture. The effect of the previous crop is important here: when safflower follows rice or sorghum, up to 150 lbs per acre of N are generally adequate. However, when it follows a nitrogen-fixing crop such as alfalfa or vetch, smaller amounts may be sufficient. No reduction in safflower yield has been observed from excess N under high-moisture conditions.

Because safflower may not be irrigated, fertilizers should be placed in the moist root zone, at least 4 inches deep. If a nitrogen fertilizer is broadcast, at least 1 inch of rain or its equivalent in irrigation is needed to move it into the root zone.

Spring applications are preferable to fall applications. In a dry spring, aqua or anhydrous ammonia placed at a depth of from 4 to 8 inches can be expected to be more effective than broadcast dry materials. If dry materials are to be used, applications early in the spring are desirable to take advantage of spring rains.

THE EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON SAFFLOWER YIELD, SUTTER COUNTY, 1965



FERTILIZER IN

SAFFLOWER rapidly gained prominence as an oil crop in the Sacramento Valley during the 1950's. Because the fertilizer requirements of the crop were largely unknown, trials were conducted in several counties. The following data constitute a progress report, summarizing some of the more important findings.

Like most other crops in California, safflower has been found to respond favorably to nitrogen fertilization. Table 1 shows the results of some nitrogen-rate trials conducted in several counties since 1960. The 1960 trials in Glenn and Colusa counties were planted after rice, using aqua ammonia and ammonium sulfate as the nitrogen sources. In both cases, 60 lbs of N gave the greatest increase in yield per unit of N. Moisture was not a limiting factor, because rice preceded the safflower and rain fell after planting. The 1963 trial in Yolo County illustrates a different situation, where moisture was in short supply. Safflower was grown after barley and without irrigation. The highest yield was obtained with 25 lbs of N; higher rates reduced yield.

When sufficient moisture was available, yields continued to increase with high amounts of nitrogen. This was illustrated by the excellent response to 150 lbs of N, obtained in a 1964 trial in Yolo County (planted after sorghum on a Sacramento clay with a high water table). A positive response was evident even with 240 lbs of N applied in 1966 in Sutter County.

Time of application

The results of two tests illustrate the importance of the time of fertilizer application. In 1960, 100 lbs of N were applied in the spring and compared with applications made in the fall (table 2). The spring application of aqua was superior to the fall application. The reason for this is not clear, but it would appear that some nitrogen was lost by denitrification during the wet winter months. A total of 9.39 inches of rain fell from December to the planting date in March. On the other hand, the spring application of aqua was made 8 inches deep into moist soil and was almost immediately available to the