Wind Machines in Orchards

best adapted to combatting short, light radiation frosts

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Wind machines afford economical frost protection where short, light radiation frosts are frequent and it is impractical to call out crews to light orchard heaters.

The most specific effect of the wind machine is the pumping of overhead warm air down into the colder trees. They are able to lift the orchard temperatures a degree or two but are not able to stop the natural cooling process.

Intensive field trials to determine the limitations of these machines were undertaken in three selected locations.

The first was in grapefruit between Riverside and Beaumont. The machines here failed to give adequate frost protection although some decrease in frost damage seemed to be related to their use.

Another location was in the Sacramento Valley for spring frosts in almonds, three miles east of Winters, where heavy frost damage occurred March 6. A short survey showed evidence of some machine protection in the trees whose blossoms were at the least susceptible stage.

A third location was in lemons on the reclaimed tideland flats four miles southeast of Oxnard where wind machines have an excellent record combatting short, light frosts, occurring about 30 nights per season.

Tests at Oxnard

The Oxnard data were interpreted first because conditions there were most favorable for learning how the wind machines produced the desired effects.

To determine the distribution of effectiveness, 50 thermocouple stations were laid out in a 1,500-foot **X** pattern, centered on a double engine machine putting 68 horsepower into each 12-foot propeller.

The recorded net temperature gains under typical radiation frost conditions were plotted as shown in the accompanying illustration. These observations showed there was negligible effect on the recording station located 750 feet up-wind from the machine. Another station placed upwind 250 feet distant showed a substantial 3° F gain at the five-foot level, and the observations 750 feet downdrift showed a surprising response of nearly 2° F. A cooler zone was found around the base of the machine as was expected from other reports of frost damage close in.

The air drift velocity for these observations was very low, averaging about one mile per hour at 40 feet above ground—tree tops were about 12 feet high—so the conditions were favorable for wind machine action.

Response of Exposed Lemon

To learn what happens to temperatures in a fruit exposed to the cold sky and subjected to repeated blasts from the wind machine, two fine-wire thermocouples were threaded under the skin of an exposed lemon. The couples were positioned to observe temperature difference from tree-side of fruit to air, and from tree-side to exposed-side of fruit while the lemon was losing heat by radiation to the cold sky.

In this special case even with the recurring boosts of warmer air blasts from the wind machine the temperature of the exposed side of the fruit averaged 3½° F colder than the average air temperature. The tree-side averaged only 1½° F colder.

Radiation Chilling of Orchard

For the usual atmospheric conditions during radiation frosts the net rate of heat loss to the clear, cold sky—as measured at Riverside—is about 20 to 25 Btu per hour for every square foot of ordinary surface—exposed ground, foliage or roofs except aluminum.

For orchards by the square mile where the inflow of cold air does not affect the main area, the air has so little heat capacity that the layer of the first 40 feet above the ground would cool down about 25° F per hour if this air were the only source of the heat radiated. The actual cooling rate before sunrise is about 1° F per hour. Under stable air conditions therefore, it is not the air itself that provides the heat; it is mostly a carrier of heat that comes from somewhere else.

The solid substance of tree trunks, branches and foliage has considerable heat capacity and when cooling 1° F per hour would yield about four Btu per hour per square foot.

Outside an orchard—on a plowed field—the air cannot get colder than the ground. Similarly within an orchard, the ground heat exerts the main control of temperature. Even though the orchard foliage gets colder than the air there must be some heat transfer upward from the ground which limits the degree of chilling of the foliage. This is partly by convection

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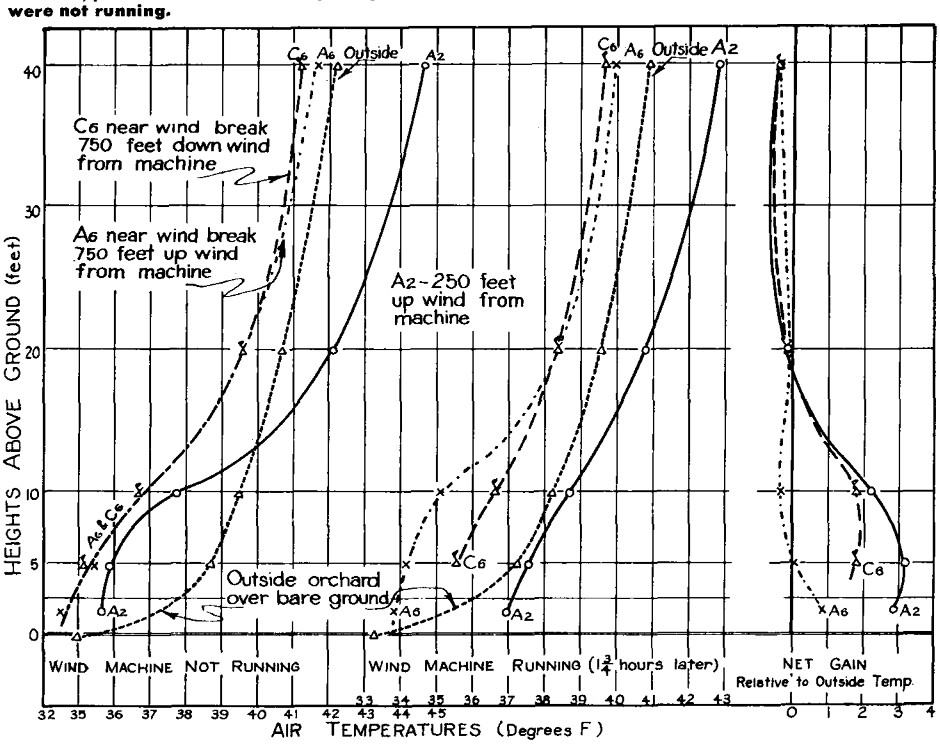
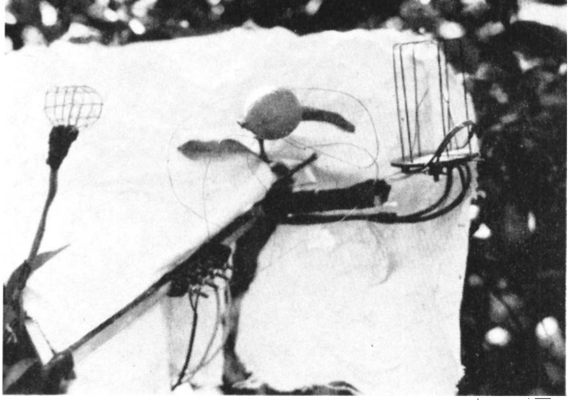
Plotted temperature profiles. Observations made while wind machines were running usually were made 1¾ hours later and consequently at a colder time of night than those made when machines were not running.





Thermocouples and hot-wire anemometer used to record transient temperatures during the passage of air blast in observation of heat radiation by lemon.

FROST

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but largely by thermal radiation of heat from earth to the slightly colder foliage; it is this heat transfer that keeps the air from being chilled excessively.

To reduce frost hazard under this complicated system of heat transfer it is desirable—and important—to promote heat flow into ground by day and heat out-flow by night. Hence it is advantageous to maintain the thermal conductivity of the soil at a maximum. This can be done by keeping the soil moisture up nearly to field capacity and not disturbing settled ground.

A cover crop usually increases frost hazard. A dry mulch on the surface is wrong for frost protection because in the sun it will have a hotter air surface than solid ground and thus more of the solar energy will go up in air convection and be lost than if good soil conditions had carried the heat into the ground. The dry mulch is also worse for frost than solid ground at night because with its greater thermal resistance the heat flow upward cannot match the radiation demand until the surface cools further to get a greater temperature difference from deep soil. Dry peat soil is a natural bad example. Over downtrodden grain near Davis a thermograph in July recorded a daylight temperature cycle of 98° F to 28° F.

Limitations

There has been no major freeze in southern California in the past 10 years and it is probable that when one does occur a large number of the approximately 1,000 wind machines now in use will prove to be inadequate. The observed failures of wind machines seem mainly due to too fast an indrift of cold air. Furthermore there is no expectation that wind machines will afford protection when there is a freeze with cold daytime conditions, cold soil, and no relatively warm air overhead on a clear, cold night. Since the machines do not add appreciable heat it is a mistake to start them long before needing the gain due to air mixing or forced convection. Some improvement in machine protection can be gained by lighting border heaters on the upwind side of an orchard.

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OLIVE

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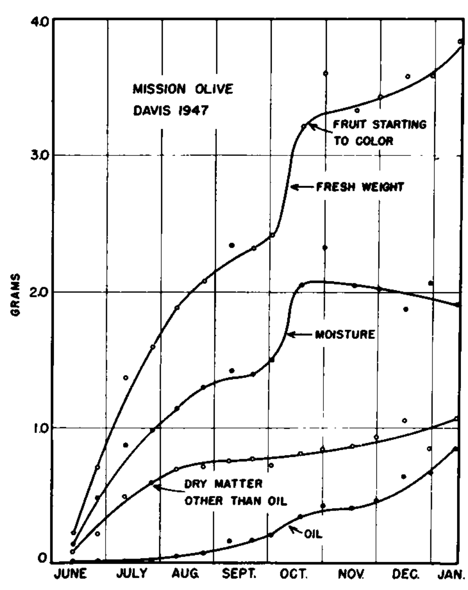
pleted in the Mission variety at Davis in 1947 by the third week in October. The Mission fruits at Davis in 1947 increased in size during the first two weeks in October as much as they had during the preceding two months.

The usual harvest period for pickling olives in California occurs generally from the first of October until mid-November depending upon the variety. Undoubtedly much of the fruit is harvested after this period of final swell. Growers who make a practice of early harvesting may not be obtaining the maximum size from their fruit which is possible.

There are other factors than fruit size, of course, which may determine the optimum time to harvest the crop. These are largely the processing characteristics of the variety which necessitates harvesting at certain stages of maturity in order to make a satisfactory product.

The sharp increase in the Mission fruit size just prior to fruit coloring in October is accounted for largely by increased moisture in the fruit. There is no particularly large increase in oil or dry weight other than oil at the time of the precoloring increase in fruit size.



Fresh weight, moisture, oil and dry matter other than oil of Mission olives during the 1947 growing season at Davis. Weight per fruit, based on average of 100 fruits.

For the grower to obtain the full benefit of this size increase it would appear necessary to keep the trees supplied with sufficient water during this period. In fact other research workers have found in the olive that when the soil moisture drops to the permanent wilting percentage it is reflected in a reduced rate of size increase, resulting in a smaller size fruit at maturation even though subsequent irrigations are given.

The Mission is the leading olive variety in California for the production of olive oil. The data obtained in the studies for oil content in this variety agree with the experience of olive growers, in that the oil content increases steadily into midwinter. As seen in the accompanying graph concerning Mission olives, in which the oil content is expressed in grams of oil per fruit, there is an actual pronounced increase in the oil content of the fruit during December and January. In addition, during this same time there is a decrease in the moisture content of the fruit. Very few olives are harvested for oil in California before the middle of December and probably the bulk of the oil olives are picked during January.

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COLOR

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to react with the breakdown products of the sugars, giving rise to dark-colored polymers of the type rather inadequately described as humins.

Control is Complex

The control of this type of deterioration is no simple matter as yet. If the product is kept at the lowest practicable temperature, this is still the most effective means of retarding the damage and the most effective supplementary treatment is the well-known long-established use of sulfur dioxide.

Research in these various fields is slowly bringing about a better understanding of the behavior of the compounds involved and will determine procedures to be used in controlling undesirable changes.

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