Project Number: 86-O6
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ANNUAL REPORT

FROST PROTECTION WITH UNDER-TREE SPRINKLERS

Objectives:

1. To develop and test a computer model of the environment in an almond orchard during freezing conditions.
2. To quantify the effects of sprinkler operation.
3. To study the effects of under-tree sprinklers when operated in conjunction with the use of chemicals to control ice-nucleating bacteria.

Interpretive Summary:

A computer model to characterize the environment during freezing conditions has been developed and improved on several occasions. The model currently includes the effects of soil heat flux, sensible heat transfer to and from the crop and air, and net radiation. More data during freezing conditions are still needed to further confirm model accuracy.

Although there were no nights with serious freezing conditions after bloom, the sprinklers were operated (0.08 inches per hour) on one night prior to bloom. The air temperature was allowed to drop to 27.7 degrees Fahrenheit before turning on the sprinklers. Our objective was to determine if there is a sharp drop in temperature when the sprinklers are started. We also wanted to determine if the temperature could be increased by operating the sprinklers. Starting the sprinklers did not cause any drop in temperature and operating the sprinklers led to a 3.6 degree Fahrenheit temperature increase within a period of 45 minutes. Clearly, sprinklers can provide considerable protection

even when started at lower temperatures than have been recommended in the past.

A structure to shelter a tree and minimize wind drift is currently being designed and built. Liquid carbon dioxide will be released inside the structure to attempt artificial inducement of freezing conditions that are similar to a natural frost. If successful, the method can be used to study the effects of minimum temperature and duration of minimum temperature on almond variety yields. Tests on the effectiveness of controlling ice-nucleating materials may also be possible.

Experimental Procedure

An automatic weather station was used to monitor the weather in an almond orchard north of Chico. Solar radiation, net radiation, temperature, humidity, wind speed, wind direction, and soil temperature were measured every half hour.

Trees in both the sprinkler plots and in the control area were sprayed to control ice-nucleating bacteria.

Results

There were no freezing temperatures during or after bloom, so the effectiveness of sprinklers for frost protection or the interaction with control of ice-nucleating bacteria could not be evaluated. We did, however, run the sprinklers on one freezing night prior to bloom. On that night, we let the temperature fall to 27.7 ^{o}F before starting the sprinklers to see if late starting would be detrimental to protection. Surprizingly, the temperature immediately began to increase by 3.6^{o}F within 45 minutes. Thus, even starting the sprinkler later than what is normally advised was beneficial for frost protection.

Discussion:

Starting under-tree sprinklers when the air temperature was 27.7 ^{o}F was clearly beneficial for frost protection of almonds. Others have reported a sharp drop in air temperature when starting sprinklers, but we found that air temperature steadily increased by 3.6 ^{o}F to a safe level.

We have been unable to test the interaction effects between sprinkler operation and control of ice-nucleating bacterial because of no freezing temperatures. Consequently, we are attempting to develop a method to artificially freeze a tree using a chamber and liquid CO2.

Much of the computer model is working properly, but improvements need to be made on the soil heat flux and the sensible heat transfer models.