Chemical Freeze Protection of Citrus 1988/1989

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Abstract

Five chemical frost protectants and a water treatment were applied to Lisbon lemons by dipping branches to insure complete coverage. A constant temperature bath was used to determine the effect of chemical frost protectants on the freezing temperature for leaf samples placed in test tubes with 10 ml of distilled water. Although the relative temperature at which the different treatments froze remained fairly constant, the differences were not significant.

Introduction

Research has shown that low temperatures are not the only factor involved in freeze damage. Ice formation starts around a nucleus of some other material, and in the absence of these nuclei, plant tissue can reach temperatures several degrees below the point at which freeze damage would normally occur. When ice crystals are formed in citrus fruit, frost injury appears as a result of mechanical disruption of the fruit tissue.

Certain bacteria which occur naturally on plants act as nucleating agents for ice formation. Two of the most commonly occurring ice-nucleation-active (INA) bacteria are Pseudomonas syringae and Erwinia herbicola. Laboratory research on over ten species of frost tender plants have shown that leaves with populations of INA bacteria were killed between -2°C and -3°C, while those lacking INA bacteria were not injured or killed until the temperature had reached -8°C to -9°C.

Commonly used materials to kill or prevent these INA bacteria from acting as a nucleus have included copper-based fungicides, trace mineral sprays, urea-based materials, a polymer product used to coat the plant, and commercially available material specifically formulated to protect against freeze damage.

Methods and Materials

The test was conducted with fourteen-year-old Lisbon lemons on rough lemon rootstock located at the Yuma Mesa Agricultural Center. The following six treatments were each applied to four trees using a completely randomized design: Frostgard, Kocide 101, Unocal Plus, ForEverGreen, Agri-mycin/Mycoshield combination, and water. In an effort to ensure complete coverage of leaf surfaces, 12 branches from each tree were dipped in five gallons of the appropriate material on December 21, 1988 and tagged accordingly. A list of the treatments and rates are provided in Table 1.

Eight samples of full-sized, young leaves were taken from treated branches on each tree on December 22-23 and December 27-30. The samples were placed in ziplock bags designated by treatment and replication.

Test tubes containing 10 ml of distilled water were prescreened to insure no nucleating agents were present by placing them in a cold bath at -8°C for thirty minutes. Any test tubes in which the water spontaneously froze were discarded. A leaf sample was placed in each of the test tubes which were randomized in the trays before being placed in the Neslab Exacol EX-410 constant temperature bath. It was outfitted with a digital controller accurate to $\pm$ 0.1°C and EN-850 flow through cooler. An ethanol solution was used in the bath to prevent freezing of the equipment.
Leaf samples were placed in the bath at -2.0°C, with the temperature being reduced by 0.5°C each half hour until the temperature reached -7.5°C. At each setting the bath was allowed to equilibrate for 25 minutes, after which test tubes in which the water had frozen were removed and the data recorded.

Table 1. Treatments, recommended rate, and rate applied as a dip to foliage of Lisbon lemon.

Material	Recommended Rate	Rate Applied
Agri-mycin/Mycoshield (Pfizer, Inc.)	200 ppm	22.5 gr/5 gallons
ForEverGreen (Safer, Inc.)	10 percent	1/2 gal/5 gallons
Frostgard (Custom Chemicides)	2 percent	378 ml/5 gallons
Kocide 101 (Griffin Ag Products)	2 lbs./acre	15 gr/5 gallons
Unocal Plus (Unocal)	5 L/20 gal	1.25 L/5 gallons
Water	---	---

Results and Discussion

As in previous field trials, when the results were analyzed statistically none of the freeze protectant materials provided protection that was significantly better than the control trees. In contrast to field trials conducted during the 1987/1988 season, the relative effectiveness of the treatments remained fairly constant throughout the study.

The procedure used in this study assumes that INA bacteria are the major factor involved in freeze damage. Other factors which may also be involved include hardening of the tree as a result of previous cold temperatures, degree of water stress, rootstock selection, and plant nutritional programs. A limiting factor of this procedure is that it evaluates the freezing temperature of leaves as an indicator of damage, whereas fruit integrity is the major concern of growers. Dipping branches to insure total coverage of leaf surface is a step away from normal cultural practices, but whether this could have an unexpected effect on the results is unknown.

Due to circumstances beyond our control, the corresponding field evaluation of these products on young trees had to be abandoned, even though temperatures reached into the lower twenties.

Table 2. Average temperature (C) at which distilled water with leaf samples froze in bath.

Treatment	Dec. 22	Dec. 23	Dec. 27	Dec. 28	Dec. 29	Dec. 30	6 Day Average	4 Day Average
Unocal Plus	-5.7 a*	-5.5 a	-5.2 a	-4.9 a	-5.1 a	-5.2 a	-5.3 a	-5.1 a
ForEverGreen	-5.4 ab	-5.0 a	-4.9 a	-4.6 a	-4.9 ab	-5.1 a	-5.0 b	-4.9 ab
Water	-5.3 ab	-5.0 a	-4.9 a	-4.5 a	-4.7 ab	-5.2 a	-4.9 b	-4.8 ab
Frostgard	-5.2 ab	-5.6 a	-4.9 a	-4.3 a	-4.4 ab	-5.0 a	-4.9 b	-4.7 b
Kocide 101	-5.0 b	-5.0 a	-4.7 a	-4.8 a	-4.5 ab	-4.7 a	-4.8 b	-4.7 b
Agri-mycin/ Mycoshield	-5.0 b	-3.2 b	-4.7 a	-4.4 a	-4.3 b	-4.8 a	-4.4 c	-4.6 b

* Treatments followed by the same letter are not statistically different from one another at the 5 percent level using the Student-Newman-Kuels Test for comparison of multiple means.