when the climate was particularly favorable for maximum plant susceptibility. It is also possible that additional compounds related to PAN and PPN may occasionally add to the toxicant complex. Controlled experiments with peroxybutyryl nitrate (PBN) have indicated it to be approximately twice as toxic as PPN. No analyses for additional compounds were made during this episode.

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Effects of spraying chemicals *on* YOUNG CITRUS TREES *for* FROST PROTECTION

R. M. BURNS

In attempts to increase the cold tolerance of young citrus trees, chemicals (including a growth retardant, three anti-transpirants and two plastics) were applied to grapefruit nursery trees that were then planted in the field. The results showed a slight but not commercially important increase in frost tolerance.

SINCE PROTECTING young trees against frost damage has always been a problem, the development of a chemical that would provide the necessary protection is desirable. Such a chemical should be easily applied, nontoxic, have no harmful residues, and have the ability to be effective for several months.

In 1955, it was reported that maleic hydrazide (MH) caused a depression in the cambial activity of grapefruit trees. Later experiments indicated that MH foliar sprays provided some frost protection by inhibiting new growth and inducing dormancy in young citrus trees, with the variability in response to MH sprays associated with relative humidity at time of application. Since the early 1960's, interest in MH for frost protection has decreased.

New chemicals tested included (1) Dimethyl Sulfoxide (DMSO), a solvent by-product of the paper industry which prevented freeze damage to living cells; (2) Decenylsuccinic acid (Decenyl), an unsaturated fatty acid which appears to protect peach, apple, and pear blossoms from freezing; (3) N^6 benzeladenine (N^6BA), a kinin which has protected antherium; and (4) a number of antitranspirants that gave ornamentals some cold protection.

Trials conducted in Florida during the winter of 1964–65 used MH, Decenyl, DMSO, N^6BA, and the antitranspirant Frost-X at various concentrations on both young Valencia and navel orange nursery trees and one-year-old Parson Brown orange trees in the field. There were slight differences in foliage damage due to freezing temperatures, but none of the treatments gave adequate protection.

Subsequently, in California during the winter of 1969–70, 14 compounds were sprayed on container-grown grapefruit nursery trees and one-year-old lemon trees in the field. Twelve of the compounds were antitranspirants and three were growth inhibitors. The three growth inhibitors were MH, the potassium salt of 6-hydroxy-3-(2H)-pyridacinone (KMH), and ethyl hydrogen 1-prophylphosphonate (NIA-10637).

Results of subjecting the grapefruit trees to temperatures as low as 20°F in a cold chamber showed no significant difference in cold protection. Temperatures in the field where the young lemon trial was located never reached freezing, but there were significant differences in growth response from the different sprays.

During the winter of 1971–72, seven treatments, with ten single tree replications, were sprayed on grapefruit nursery trees which were subsequently planted in

Photo 1. Polyurethane foam sprayed on young grapefruit tree (Treatment 4).

Photo 2. White polyester paint sprayed on young grapefruit tree (Treatment 5).

a lemon grove in Ventura County. Three of the treatments were antitranspirant-like, two were plastics, one was a growth inhibitor, and one a nonsprayed check (see table).

The growth inhibitor treatment Slo Gro (MH) was sprayed on the young grapefruit trees November 22, 1971. This was one week before planting and earlier than the other materials, since previous trials had shown it can take as long as three weeks before the growth inhibition effect of MH on citrus takes place.

The antitranspirant-like compounds (Chem Frost, Needle Fast, and Wilt Pruf) were sprayed November 24, 1971. The plastics, polyurethane foam (photo 1) and white polyester paint (photo 2), were applied November 27, 1971, by a commercial plastic fabrication company. The foam resulted in a rigid porous coating from 0.5 to 1.0 cm thick, primarily on the upper surface of most leaves and on portions of the branches. The polyester paint left a thin coat on the upper, and sometimes lower surface of most leaves, and on most of the branches.

Interplanted

All 70 treated trees, including the nonsprayed checks, were interplanted November 29, 1971, in a four-year-old lemon grove near Piru in Ventura County (photo 3). This grove had a history of yearly below-freezing winter temperatures.

The first tree evaluation was December 9, 1971—after the previous cold night with a minimum temperature of 28°F. The only measurable cold symptom was leaf drop (see table). This was not great enough to be damaging, but there was significantly less leaf drop on treatments 3 (Chem Frost) and 7 (Wilt Pruf). Treatments 4 (polyurethane foam) and 5 (white polyester paint) had significantly more leaf drop than any of the other treatments.

The next evaluation was on February 29, 1972, three months after planting. Since the initial cold night of December 8, 1971, there had been cold weather, but no recorded temperatures below freezing. However, there were many treatment trees showing cold symptoms of leaf tip burn and necrotic spots. The only significant difference between treatments was growth inhibition (see table). Treatment 2 (Slo Gro) showed significantly less new growth inhibition (see table) .Treatment

A final evaluation on June 29, 1972, seven months after treatments and planting, showed no significant differences in tree evaluations between any treatments.

Residue

It was interesting to note that more than one year after the application of the two plastic treatments (polyurethane foam and white polyester paint) there was still some residue on the branches and leaves. The only detrimental effect was the somewhat increased leaf drop immediately after the one cold night at the start of the trial. When the plastic foam and paint finally came off the leaves, they were healthy and green underneath, showing that photosynthetic activity was apparently not curtailed.

In summary, after a relatively warm winter with only one night below 32°F the only significant differences between the chemical frost protection spray treatments were in leaf drop and growth inhibition. None of these differences were considered commercially important. However, the testing of chemicals for the prevention of freeze damage to citrus is continuing.

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FROST PROTECTION SPRAY TREATMENTS AND EVALUATIONS OF GRAPEFRUIT NURSERY TREES PLANTED IN THE FIELD NOVEMBER 29, 1971, NEAR PIRU, IN VENTURA COUNTY

Treatment†	Date applied	Rate	Evaluations* 12–9–71	2–29–72
			Leaf drop	New Growth
1. Check (no spray)			2.2b	2.6bc
2. Slo Gro (maleic hydrazide)	11–22–71	2 oz/gal H_2O	1.8ab	1.0a
3. Chem Frost (antitranspirant-like)	11–24–71	1:100 parts H_2O	1.4a	2.2ab
4. Polyurethane foam (Polyisocyanate)	11–27–71	coverage	3.2c	2.6bc
5. White polyester paint (Titanium Dioxide)	11–27–71	coverage	3.4c	2.6bc
6. Needle Fast (antitranspirant)	11–24–71	1:4 parts H_2O	2.6b	3.6c
7. Wilt Pruf (antitranspirant)	11–24–71	1:4 parts H_2O	1.4a	2.6bc

* Evaluation Index (1 = least and 5 = most leaf drop or new growth. All ranking is at the 5% level, means are significantly different if they do not have a subscript letter in common. Duncan's multiple range was used for testing the significance of difference.

† Five single tree replicates per treatment.

SPACING

FOR MAXIMUM

F. J. HILLS

G. F. WORKER

Tests indicate that maximum sugar production requires spacing beets no closer than 5 inches, in rows spaced 30 inches apart, or no closer than 7 inches in rows 14–26 inches apart (14 inches between rows on the bed and 26 inches between rows of adjacent beds), and that rows spaced 10–20 inches produced no more sugar than the 14–26-inch rows.

POOR SEEDLING EMERGENCE has in years past forced growers to plant sugar beet seeds close together. The resulting thick, irregular stand of seedlings was hand-thinned to leave about 12 inches between plants. Field emergence has been greatly improved in recent years, however, by the development of seed protectants, precision planters, improved methods and equipment for seedbed preparation, better irrigation, herbicides for weed control, and fast-emerging monogerm seeds. It is now possible for growers to plant to a preselected stand, or to plant at a greatly reduced rate and use synchronous electronic thinners to establish the final stand. Planting at a reduced seeding rate still has risks however, and the grower who plants to a stand usually plants seeds as close together as is consistent with his plan to establish a stand that will not require thinning. It is common to find stands with plants averaging 4 inches and closer. Crops in such stands may be commercially acceptable but are often lower in yield than they could be.

Davis experiment

The effects of close in-row spacings for the two most commonly used row spacings in California were tested in Davis in 1971. Seeds of the sugar beet variety US H9B were planted one inch apart on raised planting beds of two types: single-row beds spaced 30 inches apart, and double-row beds with 14 inches between rows on the bed and 26 inches between rows of adjacent beds (see diagram). Nine in-row spacings were established by