Storage of Citrus Fruits

studies indicate use of 2,4-D and 2,4,5-T sprays on trees prolong storage life of citrus fruits

By Wm. S. Stewart

The marked increase in the storage life of lemons from trees sprayed with 2,4,5-T—compared with those sprayed with 2,4-D—indicates that 2,4,5-T may be more effective for treatment of citrus fruits after harvest.

A study was initiated in January, 1947 to determine the effects of 2,4-D and 2,4,5-T—2,4,5-trichlorophenoxyacetic acid—preharvest-drop sprays on citrus fruit storage.

The storage tests were made on citrus fruit from groves in southern California, and were of two general classes: *1*, storage of fruit from trees sprayed for control of preharvest drop; and *2*, storage of fruit treated with 2,4-D after harvest.

Lemons

Lemons are the only citrus fruits held in prolonged storage. Commercially, the duration of holding depends on the fruit color at the beginning of storage—such as yellow, silver and green—and the greener the fruit, the longer the time before decay and breakdown.

During storage lemons and other citrus fruit may develop black button. At harvest the button—calyx—is usually green, but during storage it may turn black. This condition indicates that internal Alternaria decay will soon occur, if it is not already present.

In one experiment drenching water sprays containing eight ppm—parts per million—2,4-D or 2,4,5-T were applied to lemon trees on April 8, 1948. The 2,4-D was applied as the triethanolamine salt and as the isopropyl ester. The fruit was stored up to 166 days at 58° F to 60° F and 88% relative humidity.

After storage fewer black buttons and less internal Alternaria decay were found in the treated fruit of all color grades. The growth regulator, 2,4,5-T, however, was four to five times as effective as 2,4-D in reducing black buttons on green lemons. It was not quite that effective on yellow and silver lemons, although it was more effective than 2,4-D. In general, with both 2,4-D and 2,4,5-T, there was a reduction in external or surface decay.

Similar results have been obtained using 2,4-D tree sprays in 50 out of 61 comparisons between fruit from treated and nontreated trees. Extensive data have not yet been obtained with 2,4,5-T.

Oranges

An experimental test plot was established in a Washington navel orange grove near Highgrove. A drenching water spray containing 25 ppm 2,4-D was applied to some of the trees. Others were left nonsprayed. Samples of sound fruit were selected at random from the sprayed and nonsprayed trees on April 21st for a commercial storage test.

After eight weeks of storage the fruit treated with 2,4-D had strikingly fewer black buttons and rind defects, but more surface decay than the nontreated samples. This decay would probably have been reduced if the usual fungicidal treatment had been given. Since each individual sample contained only 338 fruit, the results of this single test are not considered conclusive. The juice quality of both samples was good at the end of storage.

A commercial storage test was conducted with Valencia oranges. The trees in a grove near Spadra were sprayed with eight ppm 2,4-D on June 19th. Sound fruit samples, free of blemishes, were selected on October 7th for storage. Storage consisted of two weeks at 35° F—precooler temperature—then two weeks at between 40° F to 45° F—car temperature—and one week at 70° F to 80° F—room temperature.

After storage, the 2,4-D-sprayed fruit showed no appreciable differences in decay, rind pitting, aging, or black buttons, compared to the nonsprayed. In the fruit from both the sprayed and nonsprayed trees the amount of these defects was low. The nonsprayed fruit had 14.5% with severe granulation compared to 4.8% for the 2,4-D-sprayed. These figures are indicative of the need for further data on this possible effect of 2,4-D on granulation of Valencia oranges.

Grapefruit

A storage test was made on grapefruit from Arlington Heights. On April 28th, certain trees in the plot were given drenching water sprays of eight or 16 ppm 2,4-D. All of the fruits from these plots were used in the storage test. Prior

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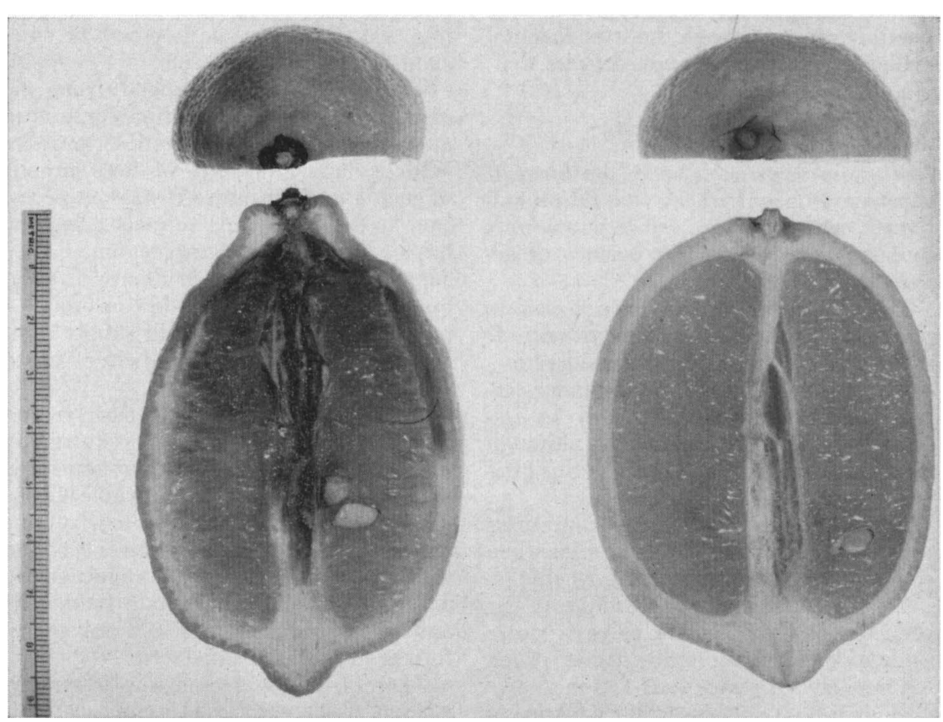
Left. **Storage lemon with black button and internal Alternaria decay.**
Right. **Storage lemon with green button and no decay.**



STORAGE

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to storage the grapefruit were washed with ½% soap solution, then treated with 1¼% of Exchange Wax No. 22.

Compared to nonsprayed fruit, those sprayed with either eight or 16 ppm 2,4-D had a reduced amount of surface decay, aging and black buttons throughout the storage. There was also a decrease in internal Alternaria decay as shown by cutting the black button fruit after storage.

After 15 weeks of storage, the fruit from trees sprayed with 16 ppm 2,4-D was rated the best with regard to firmness, color and general appearance. The eight ppm 2,4-D fruit rated next best, and the nonsprayed fruit was the poorest of the three lots.

2,4-D Treatment After Harvest

On May 17, 1948, after washing and waxing, both light green and green lemons from non-2,4-D-sprayed trees were dipped for two minutes in a lanolin emulsion containing either 500 or 1,000 ppm acid equivalent of the butyl ester of 2,4-D.

Another sample of green lemons was exposed for 69 hours to the vapor of the isopropyl ester of 2,4-D. After exposure, the treated lemons were placed in the storage chamber with the nontreated fruit.

Inspection showed that after 115 days of storage at 58° F to 60° F and 88% relative humidity, the nondipped light green lemons had 1.88% surface decay and 51.3% black buttons.

In contrast, after 162 days of storage, the light green 2,4-D-dipped lemons had only 3% with black buttons and none with Alternaria decay. At this time no surface decay had developed on the dipped fruit compared to 3.85% on the nondipped.

The green lemons dipped in either 500 or 1,000 ppm 2,4-D solutions had failed to develop a single fruit with a black button or Alternaria decay after 162 days of storage. Surface decay was 0.60% for the dipped fruit compared to 12.25% for the nondipped.

The 2,4-D vapor treatment of green lemons for 69 hours at the beginning of storage also reduced black buttons and Alternaria decay as well as surface decay compared to nontreated fruit. The reduction was much less than for the dip treatment.

Wax Preparations

In addition to the dip and vapor 2,4-D treatments, 500 ppm 2,4-D as the butyl ester was added to the Exchange Water-Wax preparations. In comparison to nontreated lemons in all color groups there was a remarkable reduction in percentage of fruit with black buttons, internal Alternaria decay and surface decay.

In a single storage test of Valencia oranges dipped in 2,4-D solutions, it was found that, as with the lemons, they developed fewer black buttons than the nontreated fruit.

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The above progress report is based upon Research Project No. 1346.

The study initiated in January 1947 was a coöperative project between the Research Department of the California Fruit Growers Exchange, Ontario, and the Division of Plant Physiology of the University of California Citrus Experiment Station, Riverside.

POMEGRANATES

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being sharply delimited. The lower two fruits have the blemish occasionally found on pomegranates, but not associated with the mites. The checked and dark brown discolored areas coincide and are sharply defined. There is no tendency for the blemished area to be concentrated at the stem end of the fruit.

Control

In experiments made in 1948 it was shown that all the commonly used mite treatments will control the *Brevipalpus* mite, but since sulfur dust is highly effective as well as being inexpensive, it is recommended as a control measure. Experimental and commercial control treatments made in June and July 1948 with one half pound of sulfur dust per tree, resulted in excellent control, while untreated check trees were severely infested, with a high percentage of blemished fruit.

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The above progress report is based on Research Project No. 1339.

ALMOND

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There is a great variation in the type of hulls obtained in harvesting different varieties of almonds. Certain hulls, such as the IXL which were used in this test, are thick and meaty, while those from some other varieties are thin and papery. The nutritive value of the hulls undoubtedly varies accordingly. It is planned to do further work on almond hull feeding this fall.

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The above progress report is based on Research Project No. 700.

SULFUR

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yses of the lemon peel. Thus it was proved ground sulfur can enter citrus fruits as sulfur vapor or gas.

Sulfur vapor alone in a glass bottle heated to the melting point of sulfur will combine with hydrogen to produce hydrogen sulfide. Oxygen is needed for this reaction and sulfur dioxide is produced in the process.

Glass tubes having the same surface as the lemons used in the experiments were sulfur dusted and placed in a bottle which was kept at 105° F. At the end of two days time, no hydrogen sulfide nor sulfur dioxide gas had been formed. This, it is believed, shows that elemental sulfur must get into citrus fruit to make hydrogen sulfide and sulfur dioxide gases at atmospheric temperatures.

Plants need sulfur to build proteins. Sulfur, usually in the form of sulfate, is supplied to plants through the soil. The sulfate may be put on the soil as a neutral salt or as a weak solution of sulfuric acid. The roots absorb sulfate, but must be able to change the sulfate into other forms in order to build the sulfur into protein.

Enzymic Action Suggested

Another experiment was conducted to observe what would happen if citrus fruit were dipped in weak radioactive sulfuric acid and kept at about 115° F for several hours. The fruit yielded slightly radioactive sulfur dioxide and hydrogen sulfide gases, very radioactive sulfate and protein. The sap in the peel had become more acid.

It might be said in passing that the fruit resembled sulfur-burned fruit as did the fruit kept at 105° F in hydrogen sulfide or sulfur dioxide gas for a few hours.

This experiment suggests that enzymes are present in the fruit peel which can change sulfate to other forms of sulfur. But the rate of change of sulfur to sulfate is a more rapid process than the one changing sulfate back to other forms of sulfur.

Experiments are under way to determine the effect of temperature on the relative rates of changing sulfur to sulfate or vice versa.

Other experiments in which lemons are being treated with radioactive hydrogen sulfide and sulfur dioxide are being run. This and other work probably will bear out the evidence already found on how ordinary elemental sulfur is changed to sulfuric acid.

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The above progress report is based on Research Project No. 1200.