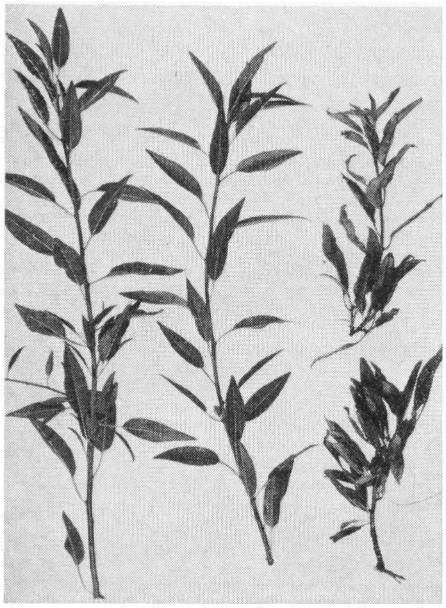
Copper Deficiency of Almonds

applications of copper compounds to trees near Paso Robles produced response in leaf growth, corrected kernel shrivel

D. E. Kester, J. G. Brown, and Tom Aldrich



Copper deficiency in almond. The two shoots on the left are typical of those on a tree sprayed with copper chelate. The upper and lower two shoots on the right are typical of those on an adjacent untreated tree.

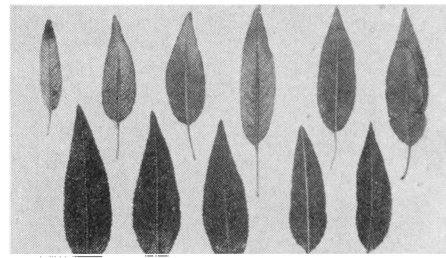
Poor growth and a rough bark condition in a group of almond trees in the Paso Robles area attracted attention in 1952. Some trees showed considerable gumming of the trunks and lower parts of the main branches.

Soil and leaf applications of copper compounds produced marked response, and diagnosis by leaf analyses indicated that the difficulty was the result of copper deficiency. Copper deficiency in almonds had not previously been reported in California, although copper deficiency occasionally has been found in the apple, plum, pear, and walnut.

Tree Location

Among the Paso Robles trees, the Ne Plus Ultra and the Nonpareil varieties showed considerable gumming of the trunk in the winter and early spring, but on the Texas—Mission—variety, there was little gumming. The trees were located on a low ridge extending into the rest of the orchard where the trees were making generally satisfactory growth. The degree of dwarfism varied with the depth of soil which decreased toward the top of the ridge.

In August 1955, characteristic leaf symptoms of copper deficiency appeared throughout the ridge area except on certain trees given copper treatments. Other than moderate tip burn, the characteristic leaf symptoms had not appeared in the two prior years. In 1955, it was noted that the soil was less dry and hard than in previous summers. Leaf analysis showed a lower level of copper in the untreated trees than in the treated trees or in trees outside the area.



Copper deficiency in almond leaf. *Lower row:* Leaves from tree which was treated with a soil application of copper sulfate. *Upper row:* Leaves from an adjacent untreated tree. The dark brown bands appearing on the two top leaves on the right are characteristic of copper deficiency symptoms in other species.

Kernel shriveling also was noted in the untreated trees. A correlation existed between the degree of shriveling and the copper content of the hull that was not evident in the copper content of the kernels. Trees sprayed with one pound of

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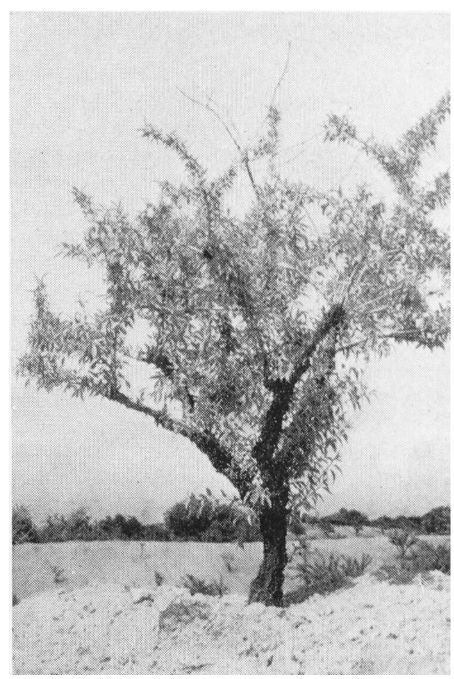
Dwarfism and rough bark condition of a Nonpareil almond tree near Paso Robles.



Relation Between Treatments, Tree Condition, and the Copper Content of the Leaf in the Test Plots and Surrounding Areas

Tree	Treatment	Appearance August 5, 1955	Copper content of leaves (ppm)
Mature almond	20# copper sulfate soil application 2/11/54	Leaves—normal. Vigorous growth.	3.6
Mature almond	None	Leaves—characteristic copper deficiency pattern. Little shoot growth.	1.4
Young almond	1# copper sulfate at planting time February 1955.	Leaves—pale but normal. Good shoot growth.	1.9
Young almond	None	Leaves—pale but normal. Good shoot growth.	2.1
Mature Texas almond	Sprayed April 9, 1955, with copper chelate.	Leaves—normal. Moderately vigorous growth.	2.3
Mature Texas almond	Sprayed April 9, 1955, with copper chelate.	Leaves—normal. Vigorous growth.	3.4
Mature Texas almond	None	Leaves—severe copper deficiency pattern. Little new growth.	1.4
Almond on same ridge about 400 yd. above deficiency area.	None	Leaves—normal.	5.0
Almond about one mile from deficiency area.	None	Leaves—normal.	8.8
Marianna plum graft in deficiency area.	Sprayed April 9, 1955, with copper chelate.	Leaves—normal.	6.8
Marianna plum graft in deficiency area.	None	Leaves—characteristic copper deficiency symptoms for plums.	1.2

GLADIOLUS

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covered corms were grown again in 1955 and produced an excellent flower crop.

The yield of cormels and small corms —sizes No. 5 and No. 6—from the original two-thirds bushel was two bushels. These were hot-water treated and replanted the following year by the first grower. During the second year, the 10 bushels of cormels obtained by the second grower represented a ratio of 15:1 of the original two-thirds bushel stock. On this basis, multiplication of clean stocks from small lots of treated cormels would appear easy and rapid.

Advantages

There are numerous advantages of the hot-water treatment of gladiolus cormels. Bigger corms and a much higher yield of cormels are produced and most corms produced the first year are of blooming size.

Clean corms yield a higher flower cut and flowers are produced from smaller size corms when they are disease free. Furthermore, the same planting stock may be used for a number of seasons.

The hot-water treatment enables the growing of several varieties which demand a high price, but which have been unprofitable since planting stocks have become infested with disease. Also, treatment preserves rare varieties or new crosses and makes possible a more rapid increase.

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WALNUT KERNELS

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upon the length of time nuts have been so separated. If the moisture content of the kernels is above 25%, they will freeze at 28°F plus or minus 1°F. Mathematical curves showing the freezing point and degree of undercooling of hulled nuts of different moisture contents are shown in the graph in column 1, page 7. The graph in columns 2 and 3 on the same page shows a portion of a recorder chart of laboratory frozen walnuts. As the moisture content is reduced, the freezing point is lowered. Experimentally, no freezing could be produced at 10°F when the moisture content fell below 12%.

The undercooling curve reflects a phenomenon that may or may not occur to the same degree in nature. In this case, conditions favorable to radiation assume a role of consequence. A low dew point and dry ground may retard freezing and cause undercooling. Dew deposit or any other condition that promotes formation of ice crystals on the shell assists freezing without undercooling when the temperature of the kernel falls below its freezing point. The undercooling is of practical importance to the grower, for undercooling without freezing does not damage the kernel.

The degree to which a walnut may undercool is not predictable. As much as 10°F of undercooling was recorded in laboratory experiments. However, the majority of undercooling minima fell in the 0°F–4°F range. All data on walnuts frozen under field conditions fell in the latter range. The duration of undercooling is also unpredictable. Experimental values range from zero to 15 minutes, but conditions in an orchard might be somewhat different. The thermocouple is a foreign body in a kernel and, as such, it acts as a focal point where freezing may be initiated. The duration of undercooling may be greater under field conditions than under experimental conditions if no ice crystals form on the nut surface.

Influence of the Hull

When an early frost occurs, a substantial part of the crop may be on the trees with hulls intact to a varying extent. The moisture content of an intact hull or one just beginning to split is about 86%. This high moisture content favors freezing of the nut. Experimental freezing of intact hulls shows that the freezing point is the same as that for kernels of high moisture content, that is, 28°F plus or minus 1°F. The hull also may or may not pass through the undercooling stage before freezing, but whatever happens to the hull will affect the nut. If the temperature of the hull after undercooling rises above the freezing point, the nut will not freeze. But the kernel will freeze in the same instant if the hull freezes. Attempts to induce independent freezing of the hull and of the nut by creating a moisture-proof barrier between the hull and the shell failed.

The condition of the hull may serve as an indicator as to whether or not frost damage has occurred. A frozen hull breaks down quite rapidly. The hull of experimentally frozen walnuts became dark and mushy in 24 hours, staining the shell.

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ALMONDS

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copper chelate in 100 gallons of water produced an average kernel weight of 1.07 grams and no kernel shrivel. The copper content of the hull was 2.7 ppm—parts per million—and the copper content of the kernel was 7.3 ppm. The average kernel weight from trees not treated was 0.75 gram with 42% shrivel; the copper content of the hull was 1.4 ppm and 6.8 ppm in the kernel.

Experimental Treatments

Copper materials were applied both to the soil and to the leaves. Twenty pounds of copper sulfate applied in a trench around the base of a tree produced a marked response in the amount of new shoot growth and an improvement in leaf color. Applications of one pound of copper sulfate mixed with the soil at planting time, however, did not produce a response during the first year. Three pounds of copper sulfate applied to the soil around an extremely dwarfed older tree also produced a decided improvement in the condition of the tree.

During April 1955, spray applications of one pound of copper chelate per 100 gallons of water were made to a number of trees in the area. These sprays produced a marked response in the amount of shoot growth, an improvement in leaf color, and an increase in the copper content of the leaves. Marked response was also produced in the color and copper content of the leaves of Marianna plum grafts which had been placed on some of the trees.

The treatments were experimental applications designed to show whether or not copper deficiency was present. Experiments are underway to determine dosages which will serve to correct the deficiency and which will not be injurious to the trees in this orchard.

Varying Conditions

Response to any particular treatment does not always occur. Variations in soil type, growing conditions, species of tree, and perhaps rootstock are influential in the amount of response to various treatments.

At the present time it appears that, in California, the distribution of copper-deficient trees—of all species—is restricted to comparatively quite small areas in different districts.

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