Chloride Toxicity in Avocados

tests show chloride absorption and toxicity vary with the seedling variety and the form of nitrogen

A. R. C. Haas and J. N. Brusca

In many avocado orchards, the tips of the leaves—and in severe cases the leaf-margins also—become brown as the leaves reach full maturity. Tissue-yellowing usually precedes the leaf-burn, and the extent of leaf-burn depends on the nature of the seedling variety and concentration of chloride in the leaf tissue.

As the leaves develop, their accumulating of chloride may be very gradual, and often only upon their reaching full maturity will the leaf-burn at the tip—the terminus of the leaf-veinal system—become evident. When the irrigation water contains considerable chloride, the usual practice is to depend upon the rainfall to leach the chlorides to depths below the root zone, but unfortunately an adequate depth of soil, drainage, and rainfall is often lacking. When in addition to an excessive chloride concentration there is also present an excess of sulfate, sodium, and other elements, and an inadequate supply of calcium and magnesium, it is then that leaf injury becomes most severe.

A chloride-affected leaf of a Topa Topa—Mexican variety—avocado seedling grown in a sand culture with a nutrient solution which contained 422 parts per million—ppm—of chloride added as calcium chloride is shown in the picture on this page. Leaf injury from chloride accumulation often results in the premature abscission of the affected leaves.

A preliminary test was made to determine the effectiveness of various forms of ammonia nitrogen in reducing the injury brought about by chlorine. Earthenware containers of three-gallon capacity and provided with drainage were used for sand and soil cultures in the glasshouse. An avocado seedling was

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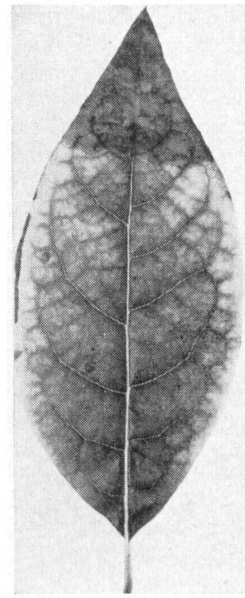

Leaf of a Topa Topa — Mexican — avocado seedling grown in a sand culture, the nutrient solution of which contained 422.3 ppm chlorine. Leaf-burn begins at the tip where the leaf veins terminate and if severe, may proceed along the leaf margin, a yellowing of the tissue often indicating the extension of the burn.

ROOTSTOCK-SCION

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Subsequent introductions of the swamp bay—*P. borbonia*—native to the Gulf Coast states; *P. lingue*, from Chile; the coyo or chinnini—*P. Schiedeana; P. nubigena*, of Guatemala; and *P. melanocarpa*, from Mexico, provided new materials for the study. The coyo, *P. nubigena*, and *P. melanocarpa* were readily propagated on avocado. However, complete failure resulted from all attempts to grow the swamp bay and *P. lingue* on avocado root or to obtain the reciprocal combinations.

Recent collections from Central America, Mexico, Peru, and Puerto Rico have provided additional materials for further study of this problem.

Introductions of new avocado materials from foreign countries frequently are made as scions. These are usually topworked into nurse trees for fruiting, which requires a variable time period.

In order to quickly multiply the material for testing purposes, it is frequently necessary to root cuttings from the nurse-limb introduction. A method for rooting these materials has been developed which utilizes etiolation of the stem section which causes the roots to form.

Attempts to graft some combinations have met with varying degrees of success. The following species have been grafted or budded easily and successfully on avocado: *P. floccosa; P. longipies, P. Schiedeana, P. gigantea, P. nubigena*, and *P. melanocarpa*. The introduced forms Parramos, Coscometepec, Tochimilco, Maltrata, Santa Engracias, Chimaltenango, Acultzingo, Chichoy, Comyagua, Prior, and Aguacate mico are easily grown on the common avocado.

Other combinations have failed regardless of efforts to combine them by budding or grafting and by utilizing the species either as rootstocks or scion in combination with the avocado. Among those which appear to be completely incompatible with the avocado by ordinary methods of propagation are the swamp bay—*P. borbonia*—*P. indica, P. skutchii, P. lingue*, the California bay, the Grecian laurel and the common camphor tree.

Because of its apparent resistance or immunity to the causal organism of avocado root rot—*Phytophthora cinnamomi*, the swamp bay—*P. borbonia*—has been of especial interest as a potential rootstock for use in soils which have poor drainage or which are infected with the cinnamon fungus. Numerous attempts to graft or bud the avocado on *P. borbonia* have failed. Some buds of this combination have remained alive for more than a year but never developed beyond the length of ½″. The rather distant botanical relationship of this species of swamp bay to the avocado—*P. americana*—apparently precludes congeniality between the two. Other species, such as *P. gigantea, P. nubigena, P. floccosa, P. longipies, P. Schiedeana* and the form Aguacate mico, which are quite easily grafted on avocado, have also been found impossible to graft on *P. borbonia*, indicating a condition of incompatibility between these forms.

While *P. indica* and *P. lingue* have been shown to be incompatible with the avocado, these two species have been successfully grafted on swamp bay—*P. borbonia.*

One objective of these studies is to obtain an intermediate or sandwich stem piece which is compatible both with the avocado and disease-resistant or dwarfing rootstocks.

C. A. Schroeder is Associate Professor of Subtropical Horticulture, University of California, Los Angeles.

E. F. Frolich is Principal Laboratory Technician, University of California, Los Angeles.

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Growth of Topa Topa—Mexican—avocado seedlings in sand cultures provided with drainage when the culture solution contains a very high concentration of chloride as calcium chloride in addition to the major and minor nutrient elements. To this culture solution was added: Culture No. 1—*extreme right*—nothing; No. 2, ammonium nitrate; No. 3, ammonium sulfate; and No. 4—*extreme left*—ammonium di-hydrogen phosphate. The added ppm of nitrogen—111.3 ppm—in Cultures Nos. 2, 3, and 4 are the same.

planted in each culture: Spinks—Guatemalan; Dickinson—Guatemalan; Mexicola—Mexican; Harman—Mexican; and Topa Topa—Mexican. The nutrient solution consisted of distilled water containing in ppm: potassium, 174; calcium, 159; magnesium, 54; nitrate, 718; sulfate, 216; and phosphate, 79; with boron, .2; manganese, .2; zinc, .2; iron, .2; copper, .1; aluminum—as citrate—3; and molybdate, .05. The dry matter of avocado leaves contains approximately double the percentage of magnesium found in that of citrus leaves; hence magnesium chloride was used as the source of chlorine in the culture solutions in this experiment: 709 ppm chlorine and 243 ppm magnesium. To this culture solution for a given avocado variety was added: culture No. 1, nothing; No. 2, ammonium nitrate; No. 3, ammonium sulfate; and No. 4, ammonium di-hydrogen phosphate. The added ppm of nitrogen—16.7—in cultures Nos. 2, 3, and 4, are the same.

The Mexicola — Mexican — avocado seedlings showed the most severe leaf-burn regardless of the form of the additional nitrogen. Harman—Mexican—avocado seedlings, grown without additional nitrogen, were badly injured in sand cultures, whereas in sand cultures when ammonium phosphate was used, the seedlings showed the least injury. Analyses of the dry matter of the mature leaves and the rootlets of Topa Topa—Mexican—avocado seedlings grown in the soil cultures showed relatively narrow ranges of chloride content: leaves, 1.061% to 1.180%, and rootlets, .558% to .591%. Hence, any improvement brought about by the ammonium salts added to the culture solution was not the result of interference with the accumulation of chlorine in the tissues.

Increasing the concentration of ammonium salts added to the nutrient solution containing high chloride gave a clearer answer to the question as to the possibility of reducing the injury caused by excessive chlorine.

Four large galvanized iron pails provided with drainage served as sand cultures, in each of which a Topa Topa—Mexican—avocado seedling was planted and grown from May 3, 1951, to December 11, 1951. The nutrient solution consisted of distilled water containing in ppm: potassium, 194; magnesium, 54; calcium, 159; nitrate, 718; sulfate, 242; phosphate, 79; and the minor elements as previously used. A large concentration of chloride as calcium chloride—243.2 ppm calcium and 709.2 ppm chlorine—was added to the nutrient solution applied to each culture.

The effects of this solution are shown in the above picture—culture No. 1—and when to this solution was added: No. 2, ammonium nitrate; No. 3, ammonium sulfate; and No. 4, ammonium di-hydrogen phosphate. The added ppm of nitrogen—111.3—in cultures Nos. 2, 3, and 4, are the same; No. 3 having 388.4 ppm added sulfate, and No. 4, 756 ppm added phosphate. The most favorable growth was made in culture No. 4. In the four cultures, the leaves were severely burned as they became fully matured—lowermost leaves in the picture—because of their large accumulation of chlorine. Note the large leaves and vigorous growth in culture No. 4 which quite fully compensated with immature leaves for the damage to the mature leaves.

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Inorganic Composition

Inorganic composition—average of duplicate determinations—of the dry matter of mature avocado leaves obtained December 3, 1952, from Tree 1, R 20—Carr Fuerte on Topa Topa—at the Citrus Experiment Station.

	Tip half of leaves no midrib	Basal half of leaves no midrib	Midrib and petiole or leaf-stalk
	% in dry matter		
Ca	1.586	1.547	2.079
Mg	0.666	0.643	0.494
K	0.947	1.020	1.799
Na	0.043	0.042	0.066

Chloride Content

Chloride content—average of duplicate determinations—in the dry matter of the leaves, trunks, and roots of the Topa Topa—Mex.—avocado cultures.

Culture No.	Added to nutrient of major and minor elements					Total chloride "Cl" as per cent in dry matter			
	Mg ppm	Cl ppm	Total N = NH_4–N+NO_3–N ppm	SO_4	PO_4	Upper leaves not fully mature and not burned	Lower, mature, burned leaves	Trunk	Roots
1	243.2	709.2	0	0	0	.573	2.793	.210	.642
2	243.2	709.2	111.3	0	0	.558	2.471	.339	.549
3	243.2	709.2	111.3	388.4	0	.359	1.896	.180	.353
4	243.2	709.2	111.3	0	756	.397	2.316	.232	.531

Chloride Absorption

Chloride absorption by mature leaves and the rootlets of avocado seedlings of a number of varieties of the Mexican and Guatemalan races grown in three-gallon capacity soil containers—provided with drainage—under glasshouse conditions. Several concentrations of chloride were added in the form of calcium chloride—$CaCl_2.2H_2O$—to the nutrient solution.

	Per cent Chloride—Cl in dry matter of leaves				Per cent Chloride—Cl in dry matter of rootlets			
Cl—ppm—in nutrient	50	100	150	200	50	100	150	200
Seedling variety								
(Guat.)								
Anaheim	.050	.057	.157	.207	.318	.434		.444
Dickinson	.050	.076		.096	.319	.422		.324
Itzamna	.034	.131		.263	.220	.264		.424
Nabal	.043	.035	.072	.155	.271	.352	.353	.593
Average	.044	.075	.115	.180	.282	.368	.353	.446
(Mex.)								
Blake		.101		.187		.502		.556
Ganter	.037	.075		.309	.678	.546		.452
Mexicola	.092	.134		.388	.393	.374		.535
Topa Topa	.046	.168		.386	.444	.588		.550
Zutano	.067	.106		.396	.598	.475		.923
Average	.061	.117		.333	.528	.497		.603

TOXICITY

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The smaller two column table on page 13 shows the chlorine content in the leaves, trunk, and roots. The upper—not fully mature—leaves from cultures No. 3 and No. 4 contain the least chloride, and these two cultures have made the best growth.

Preliminary tests were made as to whether there is a relation between the nature of the rootstock variety and its ability to absorb chloride. Three-gallon capacity soil cultures provided with drainage were used in the glasshouse with a nutrient solution consisting of distilled water containing in ppm: potassium, 276; magnesium, 81; calcium, 239; nitrate, 1078; phosphate, 158; together with the previously used minor elements. To this solution was added calcium chloride solution as to give 50, 100, 150, and 200 ppm chloride.

Avocado seedlings of several varieties of the Mexican and Guatemalan races were used, one seedling being planted in each culture. The seedlings all were planted on October 15, 1952—except Zutano—Mexican—planted January 27, 1953. The seedlings were grown until August 10, 1953. The largest table on page 13 gives the average percentages—closely agreeing duplicates—of chlorine in the dry matter of the leaves and rootlets, and the results indicate that when grown under similar conditions of chloride concentration, the dry matter of the leaves and rootlets of the Mexican avocado varieties of seedlings contain higher percentages of chlorine than is the case for the Guatemalan varieties.

A. R. C. Haas is Plant Physiologist, University of California, Riverside.

Joseph N. Brusca is Principal Laboratory Technician, University of California, Riverside.

GRAPES

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a uniform schedule of wages—typical for plants that packed Emperor and summer grapes but about 20% lower than in the Tokay plants—was used throughout the calculations. The costs of direct packer labor, however, were computed from the packer wage plan used in the individual plant and at the average rate of output per packer when the plant was at its full-output rate. Packaging materials costs were made uniform.

Fixed costs for buildings and equipment were based on estimated replacement costs. Uniform methods of calculating fixed costs were used for all plants, although the costs were adjusted to reflect the basic types of building and equipment used in the individual plant. Unit fixed costs were based on the annual volume that would have resulted in each plant if the indicated rate of output were maintained for 250 hours per season. Physical data used in the analyses are based on accounting records for the 1951 season, but the costs of labor, materials, equipment, and other items were calculated at the 1953 price level.

There was a substantial variation between plants in the total cost per standard display lug. With Emperor grapes, total costs—based on the standardized conditions—ranged from 58¢ to 85¢ per lug and averaged 65¢; with Tokay grapes the range was 62¢ to 70¢ per lug and the average was 66¢; and with summer grapes the total costs ranged from 61¢ to 99¢ and averaged 75¢ per lug.

The major components of total cost are labor—which for all plants taken together averaged 31% of the total cost—and packaging materials, which averaged 56% of the total cost. Since packaging materials costs were taken as uniform for all plants, the principal source of variation in unit total costs between plants is in the costs of direct labor. The largest single labor item, and the principal source of variation between plants, is the direct packing labor. For Emperor grapes, packer labor costs ranged from 7¢ to 18¢ per lug and averaged 9¢; for Tokays, the range was 9¢ to 12¢ and the average was 10¢ per lug; and for summer grapes, the range was 7¢ to 23¢ and the average was 12¢ per lug.

The second largest item of labor cost was the category, handling incoming fruit and culls. For all plants, the range in costs for this item was 1.7¢ to 6.0¢ per packed display lug, and the average for all plants was 2.7¢ per lug. Regarding the remaining labor categories, costs per lug are relatively small, although the percentage variation between plants is high.

Fixed costs for buildings and equipment range from 2.9¢ to 17.2¢ per lug, and for all plants, averaged 6.0¢ per lug.

Season Average Unit Costs

With computation of costs on a standardized basis, relative costs with different methods of plant operation can be illustrated. For a particular plant, however, such a cost estimate may differ considerably from the actual season average cost, primarily because the costs represented in the graph are based on a full output rate of plant operation and a standardized wage schedule. If these costs were based on the season average rather than the full output rate, an increase ranging from 1% to 30% of the total unit cost would result in individual plants. Taking all plants together, adjustment to reflect a season average—rather than a full output rate—increases the level of labor costs about 15%. If total costs, including packaging materials are considered, the average increase for all plants is about 7%.

Similarly, adjustments which reflect the actual wage schedule used in the individual plant rather than the standardized schedule used in computations for the graph would vary with each plant. Both the direction and the amount of such adjustments would depend on the actual wage level in a given plant in relation to the standardized wage schedule.

Cost Reduction

Sizable cost reductions could be achieved in many grape packing plants. As a rule, such savings are effected through the introduction of numerous relatively small improvements in individual operations and by improved plant and industry organization. More sweeping changes—in the nature of innovations which would affect the level of costs in all plants—are desirable, especially if they could be easily adopted. The potential rewards for such developments are greatest in the major cost categories. In packing grapes for table use, these are direct packing labor and packing materials. Judging from recent changes in the packing of some other commodities—for example, citrus fruits and western head lettuce—the development of a more economical package seems a likely possibility.

Improvements in local packing and shipping operations which would yield significant savings in the annual marketing bill for California table grapes can apparently be achieved.

L. L. Sammet is Co-operative Agent of University of California Agricultural Experiment Station and of the Agricultural Marketing Service, U.S.D.A.

B. C. French was Co-operative Agent of University of California Agricultural Experiment Station and Agricultural Marketing Service, U.S.D.A., at the time the above study was made.

Improvements in fruit packing house operations will be reported in an article to be published in a future issue of California Agriculture.

VARIETIES

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Where large trees are topworked, as at Riverside, only a few years are required to determine the important characteristics of a variety. Fruit quality, yield, and hardiness are the main characteristics used to determine a variety's value for commercial planting.

M. M. Winslow is Senior Administrative Assistant, University of California, Riverside.

Julius Enderud is Senior Laboratory Technician, Department of Horticulture, University of California, Riverside.