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Chloride Toxicity in Avocados

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

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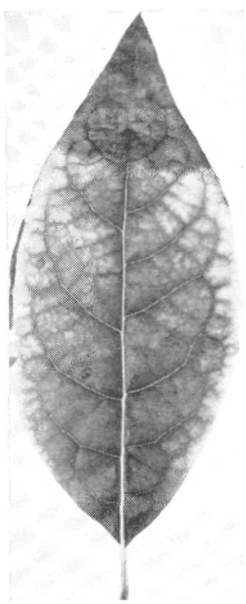
In many avocado orchards, the tips of the leaves—and in severe cases the leaf-margins also—become brown as the leaves reach full maturity. Tissue-yellowing usually precedes the leaf-burn, and the extent of leaf-burn depends on the nature of the seedling variety and concentration of chloride in the leaf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

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.



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 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.

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.

The Mexicola (Mexican) avocado seedlings showed the most severe leafburn 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, 0.558% to 0.591%. 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.

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

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.

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

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

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 dements. 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.

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