Composition of Avocado Trees in Relation to Chlorosis and Tip-Burn
Author(s): A. R. C. Haas
Reviewed work(s):
Source: *Botanical Gazette*, Vol. 87, No. 3 (Apr., 1929), pp. 422-430
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/2471147
Accessed: 09/02/2013 21:33

COMPOSITION OF AVOCADO TREES IN RELATION TO CHLOROSIS AND TIP-BURN[1]

A. R. C. HAAS

The sensitivity of avocado trees to low temperatures has made it necessary that the trees be planted on slopes within short distances from the ocean, where suitable temperatures prevail. Such a restriction upon plantings, while eliminating the frost hazard, in many cases has not given suitable soil conditions for the growth of the trees. On the slopes extremely shallow soils are often encountered at the higher elevations, and frequently such hill sides show extensive outcroppings of limestone. In some coastal districts the water available for irrigation purposes contains considerable amounts of salts, such as chlorides and sulphates. The trees in such districts are subject to strong ocean winds, which although laden with moisture are an unknown factor in the desiccation of the leaves. HAAS and REED (2) have pointed out that dry winds may cause a temporary accumulation of salts within citrus leaves as a result of excessive transpiration, but the effect is not known as yet in regard to moist winds of high velocity. Chlorination of the irrigation water reservoirs in coastal districts is a common practice, and nothing is known in regard to the effect of such additions of chlorine upon the chlorine content of the irrigation water as it is delivered to the grower.

Heretofore the burning of avocado leaves has been ascribed to too long an interval between irrigations. This conclusion has been due to the fact that this tree is usually shallow rooted, and does not do well under extremely dry atmospheric conditions or under intense heat, but thrives best in the more humid coastal districts. Notwithstanding an adequate irrigation program, the leaves of avocado trees in many districts show tip-burn during late summer or early autumn, and progressive marginal burning[2] during the winter. Many if not all of these burned leaves fall the following spring as the new growth

[1] Paper no. 192, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

[2] The term tip-burn as commonly used by growers may indicate any stage of leaf burn that originates at the leaf tip.

appears, with the result that the sun's rays have full access to the branches and trunk. Young shoots may be killed as a result of sunburn, while the bark of older branches or the trunk may become dry and corky.

Very little is known in regard to the nutrition of avocado trees; in fact, some growers fertilize their trees very little, if at all, largely because of the difficulty of noting any relationship between fruiting and soil fertilization. The practices employed at present, in view of the lack of scientific data, are based largely on the results obtained in the culture of citrus. The present knowledge regarding cultural practices, and the frost resistance of the different varieties of avocado, has been well summarized by RYERSON, JAFFA, and GOSS (4). The present investigation is merely a beginning in the direction of an understanding of some of the difficulties encountered in avocado culture.

Many of the contoured slopes in the coastal districts show conspicuous outcroppings of limestone, so that the newly leveled soil above these outcroppings is frequently shallow and heavily charged with limestone. Newly planted trees in such locations may become chlorotic during the first season of growth or at any subsequent time. Applications of iron sulphate to the soil or injections of iron sulphate solution into the trees were found by THOMAS and HAAS (5) to be unsuccessful in overcoming the chlorosis, even temporarily, without injuring the trees. In such locations the generally accepted theory is that the trees are suffering from a faulty distribution of the iron supply within the tree. The function of iron is understood to be that of catalyzing the formation of chlorophyll, of which magnesium is a constituent. In chlorotic avocado leaves a reduced amount of chlorophyll is not necessarily accompanied by a reduction in the magnesium content of the leaves, as seen in table I. In such cases, however, the absorption of calcium by the leaves is excessive, so that the calcium present in relation to the magnesium is much greater than that occurring in normal leaves. The results obtained in table I for the calcium and magnesium content of chlorotic leaves do not necessarily mean that a definite ratio exists between calcium and magnesium in normal leaves, but rather that within a wide range of ratios the leaves may be expected to be normal.

In table II are given water-solubility data for the various inorganic constituents of dry avocado leaves. The ash of the soluble fraction represents relatively only a small part of the inorganic constituents of the dry matter. In the case of the chlorotic leaves the amount of ash of the water-insoluble portion is considerably larger than in the case of normal leaves. This is due to the large amount of insoluble calcium present. It is of interest to note the extremely low

TABLE I

EFFECT OF CHLOROSIS ON CALCIUM AND MAGNESIUM CONTENT OF AVOCADO LEAVES

Variety	Locality in California	Condition of leaves	Ash as percentage of dry matter	Percentage ash		Percentage dry matter		Ca/Mg
				Ca	Mg	Ca	Mg	
Fuerte.....	La Habra	Normal	9.60	16.64	11.52	1.597	1.106	1.444
Fuerte.....	Montebello	Leaf-burn	9.52	19.76	11.41	1.881	1.085	1.733
Puebla.....	La Habra	Normal	9.61	18.49	10.37	1.778	0.997	1.783
Fuerte.....	La Habra	Normal	10.33	15.84	10.32	1.638	1.067	1.535
Fuerte.....	Montebello	Leaf-burn	9.23	18.18	9.86	1.679	0.910	1.845
Puebla.....	La Habra	Normal	9.53	18.25	9.54	1.739	0.909	1.913
Fuerte.....	Brentwood	Normal	8.36	15.56	8.37	1.300	0.699	1.859
Fuerte.....	Culver City	Leaf-burn	9.64	19.24	8.03	1.855	0.775	2.394
Seedling....	Brentwood	Leaf-burn	9.48	17.43	7.70	1.653	0.730	2.264
Fuerte.....	La Habra	Chlorotic	9.04	16.78	5.90	1.517	0.534	2.841
Puebla.....	La Habra	Chlorotic	15.25	22.93	5.90	3.498	0.900	3.887
Fuerte.....	La Habra	Chlorotic	12.98	22.48	5.83	2.917	0.757	3.853
Lyon.......	La Habra	Chlorotic	8.36	19.20	5.36	1.606	0.449	3.577
Lyon.......	La Habra	Chlorotic	11.41	16.10	4.99	1.837	0.569	3.229
Fuerte.....	La Habra	Chlorotic	10.32	20.80	4.94	2.147	0.510	4.210
Puebla.....	La Habra	Chlorotic	18.63	25.97	4.77	4.840	0.889	5.444

water solubility in the case of the calcium of avocado leaves, as compared with the values given by HAAS (1) for citrus leaves. The calcium present in normal avocado leaves is considerably less than that present in citrus leaves. The magnesium content of avocado leaves, however, is from two to three times as great as that of citrus leaves. This large magnesium content may be of significance from the standpoint of the concentration of chlorophyll in avocado leaves and their capacity to manufacture carbohydrates, fats, and proteins. Practically all of the potassium is found in the water-soluble fraction. It is of interest to note the large concentration of potassium in the water-soluble fraction of the chlorotic leaves.

Table III shows the total phosphorus content of the dry matter

TABLE II

WATER-SOLUBILITY OF DRY MATTER OF MATURE AVOCADO LEAVES, EXPRESSED AS PERCENTAGE OF DRY MATTER

Variety	Locality in California	Condition of leaves	Ash of		Calcium			Magnesium			Potassium			Sodium		
			Soluble fraction	Insoluble fraction	Soluble	Insoluble	Soluble as percentage of total	Soluble	Insoluble	Soluble as percentage of total	Soluble	Insoluble	Soluble as percentage of total	Soluble	Insoluble	Soluble as percentage of total
Fuerte..........	La Habra	Normal	3.52	6.81	0.086	1.552	5.25	0.747	0.320	70.01	0.508	0.026	95.13	0.104	0.061	63.03
Puebla..........	La Habra	Normal	3.05	6.49	0.097	1.642	5.58	0.587	0.322	64.57	0.678	0.034	95.22	0.135	0.090	60.00
Puebla..........	La Habra	Chlorotic	4.24	14.45	0.099	4.755	2.04	0.605	0.375	61.73	1.544	0.112	93.24	0.312	0.077	80.21

of the leaves as determined by the magnesium nitrate method. The values for the most part are not very different from those found for citrus leaves.

Table IV gives the percentage of total nitrogen in the dry matter of the leaves of four varieties of avocado. In some cases the nitrogen content is equal to that found in citrus leaves. When an avocado leaf burns, it is not known what becomes of the nitrogen in the burned area, whether it remains in the burned portion, or passes back into the unburned portion and remains there, or passes back into the shoots for new distribution. However, any water-soluble nitrogen remaining in the burned portion is likely to be leached out,

TABLE III

PHOSPHORUS CONTENT OF AVOCADO LEAVES

Variety	Locality in California	Condition of leaves	Total phosphorus as percentage dry matter
Fuerte........	La Habra	Normal	0.08
Fuerte........	La Habra	Normal	0.24
Fuerte........	Montebello	Leaf-burn	0.15
Puebla........	La Habra	Normal	0.15
Puebla........	La Habra	Normal	0.29
Puebla........	La Habra	Normal	0.24
Puebla........	La Habra	Chlorotic	0.19

especially with overhead irrigation, so that no comparison can be made between the nitrogen content of burned and that of normal leaves. Flowers of Puebla trees at Riverside, California, were collected and were separated from the flower stalks. The total nitrogen of the flowers was found to be 1.71 per cent of the dry matter. At present it is not known whether failure of avocado trees to set fruit may be in any way related to the nitrogen content of the flowers.

A high nitrogen content of a soil may become of very great importance when the soil solution contains considerable amounts of chlorides and sulphates. HAAS and THOMAS (3) have shown the toxic effect of sulphates on lemon trees to be much greater when the nitrate supply was inadequate. As was previously mentioned, many of the coastal and other avocado districts are irrigated with water containing considerable chloride or sulphate. The occurrence of tip-burn has not always been exclusively associated with the use of such irrigation water; in fact, it has been found to occur where the irrigation water was of good quality. The burning of a small portion of the leaf tip alone may occur as a consequence of an inadequate water supply, as was shown in sand cultures which received a culture solution containing no chlorine. In this case the sand cultures were covered but were not kept sufficiently moist, and although provided with a drainage system, they showed no drainage water except at the time of the addition of large amounts of new nutrient every three to

TABLE IV

NITROGEN CONTENT OF AVOCADO LEAVES

Variety	Locality in California	Condition of leaves	Total N as percentage dry matter
Fuerte........	La Habra	Normal	2.52
Fuerte........	Box Springs	Normal	1.87
Fuerte........	Riverside	Normal	1.84
Fuerte........	Riverside	Leaf-burn	1.80
Fuerte........	Riverside	Leaf-burn	1.77
Fuerte........	Culver City	Leaf-burn	1.76
Fuerte........	Lemona	Leaf-burn	1.30
Taft..........	Riverside	Normal	1.98
Taft..........	Riverside	Leaf-burn	2.25
Taft..........	Lemona	Leaf-burn	2.20
Puebla........	Riverside	Leaf-burn	2.07
Lyon.........	La Habra	Normal	2.53

four weeks. Such leaf-burn is not serious and is not the condition usually designated as tip-burn. In this latter condition one-fourth or more of the apical portion of the leaf may be brown and extremely desiccated, often with marginal burning proceeding farther toward the basal portion of the leaf. It may be mentioned that control cultures which were kept sufficiently moist were free from such tip-burn.

The causal factors producing this burned-leaf condition of the avocado tree, popularly called tip-burn, are best understood by comparing the analyses of normal avocado leaves (table V) with those of leaves affected with tip-burn (table VI). It is at once obvious that the leaves affected with tip-burn contain excessive amounts of total chlorine. In at least two of the cases examined, total sulphur may also be a contributing factor in bringing about the burning of the leaves. It is of interest that in some cases very little sulphate was found in the leaves, even though the irrigation water contained a considerable amount.

TABLE V

TOTAL CHLORINE AND SULPHUR CONTENT OF MATURE, NORMAL AVOCADO LEAVES

Variety	Collected	Locality in California	Percentage in dry matter	
			Total Cl	Total S
Fuerte	3/16/26	Brentwood	0.33	....
Fuerte	3/16/26	La Habra	0.32	....
Fuerte	3/10/28	Riverside	0.09	0.25
Puebla	3/10/28	La Habra	0.21	....
Taft	3/10/28	Riverside	0.17	0.29

TABLE VI

TOTAL CHLORINE AND SULPHUR CONTENT OF MATURE AVOCADO LEAVES SHOWING TIP-BURN

Variety	Collected	Locality in California	Percentage in dry matter		Irrigation water*	
			Total Cl	Total S	Cl	SO_4
					p. p. m.	p. p. m.
Fuerte	1/25/28	Culver City	0.91	....	269–305	....
Fuerte	3/24/26	Culver City	0.88	....	269–305	....
Fuerte	3/10/28	Riverside	0.91	0.31	195–213	140–254
Fuerte	3/10/28	Riverside	0.93	0.37	195–213	140–254
Fuerte	4/16/28	Montebello	1.00	....	385	42
Fuerte	3/29/26	Montebello	1.21	0.88	....	....
Fuerte	3/29/26	Montebello	1.13	....	....	....
Fuerte	4/13/28	Lemona	1.01	....	52	....
Fuerte	5/17/26	Irvine	0.80	....	....	....
Seedling	3/16/26	Brentwood	1.34	1.13	....	....
Puebla	3/10/28	Riverside	1.01	0.22	195–213	140–254
Taft	3/10/28	Riverside	0.54	0.28	195–213	140–254
Taft	3/10/28	Lemona	0.72	0.28	52	28–32

* The writer is indebted to the Department of Chemistry of the Citrus Experiment Station for a portion of these analyses.

The chlorine content of the leaves of the trees at Lemona, California, is high in comparison with the low amount of chlorine in the irrigation water. In this case the water did not penetrate into the subsoil below the root zone. As root absorption and surface evaporation withdrew water from the soil, the chlorine that was added in the irrigation water could not escape into the subsoil, and consequently accumulated in the moisture about the tree roots. The trees were given very little if any nitrogen, and as a consequence chlorine was absorbed in sufficient amounts to burn the leaves. In another of the coastal districts, in connection with studies on the growth of citrus trees, as conducted by FAWCETT and the writer, it was found that, although the irrigation water and the first two feet of soil were relatively free from chloride and sulphate, the third and fourth feet of soil were rather heavily charged with sulphate. It was found that chlorination of the irrigation water at the irrigation-district dam did not increase the chlorine content of the water upon its arrival at the groves.

A source of chlorine that makes its way into avocado groves is found in certain barnyard manures. In some districts the more saline water that is unsuited for tree culture is used in growing alfalfa, etc., for dairy purposes, with the result that such manure frequently finds its way into the groves. In a specific case the manure applied contained 23 pounds of chlorine in one ton of dried material. When this supply supplements an already somewhat saline irrigation water, the application may hasten the appearance of injury. In certain avocado groves where the trees were losing most of their leaves as a result of tip-burn, concentrations of chlorine (as determined from a one to five water extract of the soil) constituted one-third of the total solids obtained from such water extracts.

In the selection of sites which have been valued largely according to the degree of frost protection they afford, due consideration should be given also to the nature, depth, and drainage of the soil and subsoil, to the amounts of chloride and sulphate in the irrigation water, and to the nature of the materials used in the fertilization program.

Summary

1. The effect of lime-induced chlorosis on avocado trees is to raise the calcium-magnesium ratio.

2. The total and the water-soluble calcium of the dry matter of normal mature avocado leaves are considerably less than that of citrus leaves. The magnesium content of the dry matter of normal mature avocado leaves is two to three times that of normal mature citrus leaves. Chlorotic avocado leaves have been found to con-

tain large amounts of water-insoluble calcium and water-soluble potassium.

3. The total nitrogen and phosphorus contents of avocado leaves are approximately the same as those found in the leaves of citrus.

4. Tip-burn of avocado leaves has been found to be associated with a high chloride or sulphate content of the leaves.

UNIVERSITY OF CALIFORNIA
CITRUS EXPERIMENT STATION
RIVERSIDE, CALIF.

[Accepted for publication July 2, 1928]

1. HAAS, A. R. C., Water-solubility of dry matter in relation to calcium nutrition of normal orange and lemon leaves. BOT. GAZ. **85**:334–340. 1928.
2. HAAS, A. R. C., and REED, H. S., Relation of desiccating winds to fluctuations in ash content of citrus leaves and phenomenon of mottle-leaf. BOT. GAZ. **83**:161–172. 1927.
3. HAAS, A. R. C., and THOMAS, E. E., Effect of sulphate on lemon leaves. BOT. GAZ. **86**: 345–354. 1928.
4. RYERSON, K., JAFFA, M. E., and GOSS, H., Avocado culture in California. Calif. Agric. Exp. Sta. Bull. **365**: 1–70. 1924.
5. THOMAS, E. E., and HAAS, A. R. C., Injection method as a means of improving chlorotic orange trees. BOT. GAZ. **86**: 355–362. 1928.