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Influence of Soil and Cultivar on Mineral Composition of Avocado Leaves in Florida[1]

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ABSTRACT. Leaves were collected in 1974 and 1975 from mature 'Tonnage', 'Lula', 'Taylor', and 'Booth 8' avocado trees *(Persea americana* Mill.) on sand, muck, and calcareous rock soils and analyzed for N, P, K, Ca, Mg, Mn, Cu, Zn, and Fe. Significant differences in levels of all 9 elements in 'Tonnage' leaves occurred among the 3 soil types. Crop size, fertilization, soil pH, soil Ca level, and exchange capacity of the soil appeared to be important factors in the variations. Differences in concentration of N and P were not significant among the 4 cultivars but were significant for the other elements.

The mineral composition of avocado leaves in California has been extensively examined (3, 4) and tentative levels of minerals to use in diagnosing the nutrient status of mature trees have been set (4). For fruit crops, this approach to fertilization is becoming increasingly common. Little work has been done on avocado leaf analysis in Florida, however. The relationship of boron to alternate bearing (5) and a leaf analysis survey, in which 3 cultivars were sampled one time in 25 commercial groves (9) have been reported. To obtain information on mineral composition of Florida avocado leaves, a leaf-sampling study using trees from commercial groves was conducted during the 1973-74 and 1974-75 seasons. The effects of cultivar, leaf age, position of leaf on shoot, whether from non-fruiting or fruiting shoots, and soil types were investigated. This report covers the effects of soil and cultivar. A companion paper (6) discusses the effects of leaf age, position of leaf on shoot, and fruiting status of the shoot.

Materials and Methods

Leaf samples were taken from 3 mature 'Tonnage' trees on each of 3 soil types; Astatula (Lakeland) find sand in Highlands County, Torry (Okeechobee) muck in Palm Beach County, and Rockdale soil in Dade County, Florida (1, 2). The 3 soils are referred to as sand, muck, and rock in this paper. 'Tonnage' was selected as the indicator plant for this phase of the work because trees of this cultivar were more extensively planted on all 3 soils. For the cultivar study, leaf samples were taken from 3

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mature trees each of 'Tonnage', 'Lulu', 'Taylor', and 'Booth 8' on sand and rock soils. Each tree was treated as a replicate.

Table 1. Effects of soils on mineral composition of 'Tonnage' avocado leaves.

Element	Year	Soil types Sand	Muck	Rock	Mean[z]	Interaction soil × year
N (%)	1974	2.31	2.03	1.85	2.06	
	1975	2.29	1.88	1.79	1.99	
	Mean[z]	2.30B	1.96A	1.82A		–
P (%)	1974	0.111	0.143	0.104	0.119b	
	1975	0.109	0.128	0.085	0.107a	
	Mean	0.110A	0.136B	0.095A		–
K (%)	1974	1.84	1.41	1.70	1.65b	
	1975	1.39	1.49	1.62	1.50a	
	Mean	1.62b	1.45a	1.66b		5%
Ca (%)	1974	0.70	2.41	2.52	1.88	
	1975	0.92	2.82	2.62	2.12	
	Mean	0.81A	2.62B	2.57B		–
Mg (%)	1974	0.413	0.460	0.230	0.368A	
	1975	0.753	0.689	0.371	0.604B	
	Mean	0.583B	0.575B	0.300A		5%
Mn (ppm)	1974	245	24	62	110	
	1975	244	37	87	123	
	Mean	245B	30A	74A		–
Cu (ppm)	1974	80	32	29	47B	
	1975	9	29	23	20A	
	Mean	44B	31A	26A		1%
Zn (ppm)	1974	114	91	97	100	
	1975	172	20	66	86	
	Mean	143B	55A	81A		1%
Fe (ppm)	1974	39	25	32	32A	
	1975	37	41	35	38B	
	Mean	38b	33a	33a		1%

[z]Means not followed by the same letters are different at 5% (small letters) or 1% (capital letters) level of significance. Means not followed by letter are not significantly different.

Avocados in Florida generally make 2 or more flushes of growth at intervals of several weeks during the year. After leaves of these different flushes have matured, they cannot readily be distinguished without marking for identification (3). It has been shown that levels of minerals in avocado leaves may vary with age (3, 7, 10). To insure having leaves of uniform age in all samples, the shoots from which leaves were to be taken were marked at the terminal with plastic ribbon when the leaves had just hardened in May or June. Thirty non-fruiting shoots on each tree were selected for sampling. In addition, 5 extra shoots were marked by color code on each tree to substitute for any loss in the original 30. These shoots were located at a height of about 1 to 2.5 m around the periphery of the tree. Each sample consisted of 1 leaf taken at about mid-shoot from each of the 30 marked shoots on a given tree. For the soils phase of the study, 2 to 3 month old leaves were sampled and for the cultivar phase 4 to 5 month old leaves were collected.

The leaves were washed not later than the second day after collecting, and when there was a delay of more than a few hours between collecting and washing, they were refrigerated to maintain freshness. They were washed individually on both sides with soap solution, rinsed in tap water followed by 5% HC1 solution and finally in 3 changes of distilled water. They were oven-dried at 65°C and ground. The samples were analyzed for N, P, K, Ca, Mg, Mn, Cu, Zn, and Fe (11).

The fertilizer and spray programs at each location were obtained and an estimate of the yield on each tree was made by a ranking method each season to aid in the interpretation of results. Soil samples were taken at a depth of 0 to 15 cm at each 'Tonnage' tree in Feb. 1976 for the soils phase of the study. Samples were air-dried, screened, and analyzed for the same elements as in leaves (11). pH was measured with glass electrode using a 1:2 soil water dilution by vol.

Analysis of variance was calculated on data where appropriate. Significance among means was determined by Duncan's multiple range test.

Results and Discussion

SOIL. Significant differences due to 3 soil types were found in leaves of 'Tonnage' trees for all 9 elements (Table 1). Trees on sand had higher leaf N, Mn, Cu, Zn, and Fe concentrations than trees on muck and rock. Trees grown on muck had higher leaf P but lower K than trees on sand and rock. Ca was higher from trees grown on muck and rock than trees grown on sand. Higher leaf Mg was found in trees grown on sand and muck than those grown on rock.

Similar trends were found in both 1974 and 1975 for most elements except Cu. Highest Cu contents were found in trees on sand in 1974, but the same trees in 1975 had the lowest Cu compared to trees on muck and rock. Different rates of Cu applied in foliar spray in 1974 and 1975 may partially explain the difference. Trees on sand received 0.14 kg of Cu per tree in 1974. In 1975, only 0.03 kg was applied. Foliar spray in relation to sampling time may also contribute some variations. It has been shown that not all spray residue can be removed by thorough washing (11).

Table 2. Soil analysis and crop size estimate of 'Tonnage' avocado.

Soil measurement	Astatula fine sand	Torry muck	Rock-dale
pH	5.85	7.61	7.87
Total N (%)	1.05	1.76	1.58
Extr. P (kg/ha)	268	100	48
K	195	810	236
Ca	655	13102	10107
Mg	123	1232	411
Mn	168	Tr.	91
Cu	6	Tr.	Tr.
Zn	36	Tr.	36
Fe	16	15	2
Crop size estimate[z]			
1974	1.3	3.3	2.0
1975	1.3	4.0	4.0

[z]Scale: 0 = no fruit, 1 = very light, 2 = light, 3 = medium, 4 = heavy, 5 = very heavy.

Inherent differences in the 3 soils under study can account for many but not all the differences found in the mineral composition of leaves. Astatula fine sand is a well-drained acid sand of low-exchange capacity while Torry muck and Rockdale are alkaline soils with higher exchange capacities (8). Differences in pH and Ca content of the 3 soils (Table 2) are reflected in leaf Ca content (Table 1). It is known that certain heavy metals and cations are frequently "fixed" in alkaline soils with high Ca content and the absorption of these elements by plant roots may be impeded. This may partially explain the higher leaf Mg, Mn, Cu, Zn and Fe concentrations found in trees grown on sand than on muck and rocks.

Crop size also appeared to influence leaf composition, especially in N and P. Both N and P contents of leaves varied inversely with estimated crop size within each soil (Table 2). Tonnage' trees grown on sand produced light crops in 1974 and 1975 and little difference in N and P was found between the 2 years. Trees on muck and rock soils produced a heavier crop in 1975 than 1974 and lower leaf N and P contents were found in 1975 than in 1974.

Fertilizer practices other than N were not consistently reflected in leaf analysis. Trees on sand were fertilized with higher rates of N than trees on muck and rock soils (data not shown). These trees had higher leaf N content. These trees also produced light crops both years. Other cultural practices including sprays, irrigation, etc. did not seem to directly influence the mineral composition of Tonnage' leaves, except that nutritional and fungicidal sprays were reflected in leaf concentration of Mn, Cu, and Zn.

CULTIVAR. Two years' data of mineral composition of 'Tonnage', 'Lulu', 'Taylor', and 'Booth 8' leaves from trees grown on sand and rock are presented in Fig. 1 and summarized in Table 3. The principal difference in the leaf mineral contents was due to soil types. In general, a larger difference was found between trees grown on sand and on rock than trees of different cultivars. P was the only element that did not show significant difference between the 2 soils. Other elements showed similar trends between the 2 soils found in the cultivar study as in the 'Tonnage' study.

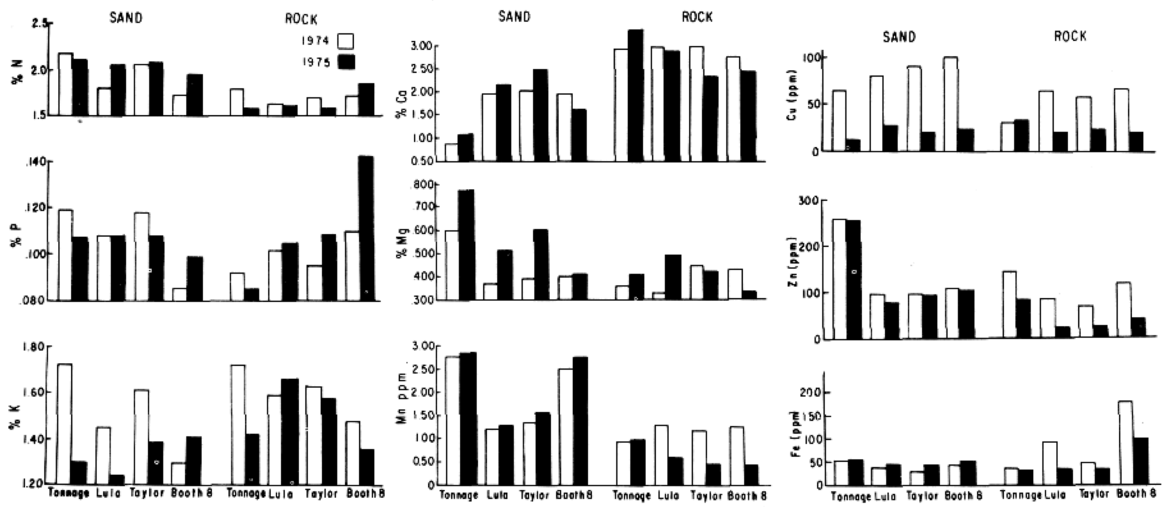

Fig. 1. Mineral composition of 4 avocado cultivars grown on 2 soils for 2 years.

No difference in N and P contents was found among the 4 cultivars. Significant differences were found for all other elements, but these differences did not follow any pattern from the standpoint of cultivars. Crop size, fertilizer, and other cultural practices can explain some of the trends but not all. Interactions found among the variables undoubtedly were involved in these differences. For leaf analysis guides, the same range in leaf levels of the various elements can be applied to the 4 cultivars.

Levels of the 9 elements examined in 'Tonnage' leaves on 3 soils and in 4 cultivars on 2 soils were generally within the satisfactory range of the tentative standards set for 5 to 7 month old leaves of mature avocado trees in California (4). N was higher from trees grown on sand than the suggested optimum. This was due in part to the high N fertilization program used on sand. N content was also affected by leaf age. N content decreased with age of leaves (6, 10). Leaves used in the present studies were 2 to 3 and 4 to 5 months old leaves while the tentative standards established were for 5 to 7 month old leaves. Cu was in the excess range in many of the samples in both the cultivar and soil studies and on all 3 soils. Cu was used as fungicidal sprays in Florida for many years. Fe was found to be in the deficient range both years and on all 3 soils.

Fe deficiency symptoms were observed in both studies especially early in the season. In general, Fe deficiency was more severe on muck and rock than on sand. Some of the trees on rock soil were sprayed with a fungicide containing Fe in the cultivar study (Table 3), which may partially explain the higher leaf Fe found on rock than on sand.

It is evident from these studies that soil types have significant effects on the mineral composition of avocado leaves. The absorption of mineral nutrients from soils of high exchange capacity with high levels of Ca, as in the muck and rock soils, is markedly different from that in the sandy soil of low exchange capacity and a low level of Ca. These differences were reflected in the N, Ca, Mn, and Zn concentration of leaves from trees grown on different soil types.

Table 3. Summary effects of soil and year on mineral compositions of 4 avocado cultivars.

Variables		Element								
		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Fe (ppm)
Cultivar	Tonnage	1.91[z]	0.100	1.54ab	2.05A	0.536B	190B	34A	186B	44A
	Lulu	1.77	0.106	1.49ab	2.50B	0.424A	109A	47B	71A	53A
	Taylor	1.86	0.107	1.57b	2.46B	0.466AB	114A	48B	71A	40A
	Booth 8	1.82	0.109	1.39a	2.08A	0.396A	175B	52B	93A	94B
Soil	Sand	1.99B	0.104	1.42A	1.76A	0.505B	204B	52B	137B	45A
	Rock	1.69A	0.108	1.57B	2.78B	0.404A	90A	39A	73A	70B
Year	1974	1.83	0.106	1.58B	2.31	0.414A	157	69B	122B	65B
	1975	1.85	0.105	1.42A	2.23	0.497B	137	22A	88A	50A
Interaction	cv. × yr	5%	1%	5%	1%	1%	–	5%	–	5%
	cv. × soil	1%	1%	–	1%	1%	1%	–	1%	1%
	yr × soil	5%	–	–	1%	1%	1%	1%	1%	1%
	cv. × yr × soil	–	–	–	1%	–	–	–	–	5%

[z]Means not followed by the same letters are different at 5% (small letters) or 1% (capital letters) level of significance. Means not followed by a letter are not significantly different.

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