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MINERAL COMPOSITION OF AVOCADO LEAVES IN FLORIDA

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Abstract

Avocado (Persea Americana Mill.) leaves of 'Tonnage' trees growing on sand, muck, and calcareous rock soils and 'Lula,' 'Taylor,' and 'Booth 8' trees on sand and rock were collected in 1974 and 1975 and analyzed for concns of N, P, K, Ca, Mg, Mn, Cu, Zn, and Fe. Differences, in levels of the 9 elements occurred with differences in soil types, cultivar, and fruiting status of the shoot. Variations generally were greater on sand than on muck or rock soils. Higher levels of Mn, Cu, and Zn were found on sand than on muck or rock, regardless of fertilizer or spray programs. There were differences among cultivars, but no consistent trend in nutrient absorption was found. The rank in level of the 9 elements was mixed and seemingly without bias among cultivars. N, P, and Mg were significantly lower both years, and K in 1975, in leaves on fruiting shoots than on nonfruiting shoots. There was no significant effect of fruit on leaf levels of the other elements examined. Branch girdling had no important effect on leaf level of minerals. The difference in level of minerals in leaves of the 1st flush, and the 2nd which matured about a month later was associated with leaf age. Methods for sampling avocado leaves are discussed.

Increased costs of fertilization have caused fruit growers to seek more efficient use of fertilizer materials. With fruit crops in general, one approach to this has been the use of leaf analysis as an aid in planning the fertilizer program. In California, the mineral concn of avocado (*Persea Americana* Mill.) leaves has been examined extensively (1, 2, 3, 4, 5, 9. 10, 11) and tentative levels of minerals to use in diagnosing the nutrient status of mature trees have been set (5). Relatively little work on avocado leaf analysis has been done in Florida. The relationship of boron to alternate bearing (6) and a leaf analysis survey in which 3 cultivars were sampled one time in 25 commercial groves, mostly on calcareous rock soil (1-1), have been reported. More information is needed before leal analysis can be of measurable help in planning an efficient fertilizer program for avocados in Florida. Recently, the effects of leaf age, leaf position on shoot, fruiting status of the shoot, cultivar, and soil on the levels of 9 minerals in Florida avocado leaves were examined (8, 18). This paper summarizes the range found in the mineral concn of leaves of several cultivars in Florida as affected by various factors. Some steps for collecting avocado leaf samples that will enhance the probability of getting reproducible analytical results are listed.

Materials and Methods

Leaf samples for examining the range in mineral concns were collected from mature trees of 'Tonnage,' Lula,' 'Taylor,' and 'Booth 8' on Astatula fine sand in the Ridge district of Highlands County; from 'Tonnage' on Torry muck near Canal Point in Palm Beach County; and from 'Tonnage,' Tula,' 'Taylor,' and 'Booth 8' on. Rockdale soil in the Redlands District of Dade County.

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 (1, 3, 8, 11, 16). To insure having leaves of uniform age in all sets of samples, the shoots from which leaves were to be taken were marked with plastic ribbon at the terminal when the leaves were fully expanded and hardened in May or June. Thirty non-fruiting shoots on each of 3 trees of each cultivar on each soil 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 lit of about 3 to 8 ft around the periphery of the tree.

Four-month-old leaves were sampled in 1974 and 1975. Each sample consisted of one leaf from approx the middle of each of the 30 marked flushes on each tree. A 2nd set of samples was taken at this time from the trees on sand and rock soils to examine the effects of fruiting on leaf level of minerals in these cultivars. These 30-leaf samples were from the midsection of fruiting shoots near the marked non-fruiting shoots on the same trees.

Leaves (blades and petioles) of each sample 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 65C and ground. The samples were analyzed for N, P, K, Ca, Mg, Mn, Cu, Zn, and Fe by methods described elsewhere (17).

Fertilizer and spray programs used on these trees at each location were obtained and a ranking of the yield of each tree made each season. Soil samples were taken at a depth of 0 to 6 inches at each 'Tonnage' tree on the 3 soils in February 1975 arid analyzed for pH and the 9 elements determined on leaves. These data on fertilization, sprays, and yield aided in interpretation of results of leaf analysis, but are not included in their entirety in this paper,

Results and Discussion

Mean and range. The mean and range in the concn of the 9 elements examined in the 4 cultivars on 3 soil types are summarized in Table 1. Variations with soil type Table 2) were primarily due to inherent differences in pH, soil N, K, Ca, and Mg levels, and Base

Exchange capacity (13). Astatula sand was acid with low K, Ca, and Mg levels, and low exchange capacity, as compared with a calcareous nature and high pH, K, Ca, and Mg levels, and exchange capacities for the muck and rock soils. The high Ca level in the soil favors Ca absorption through mass action, but tends to impede absorption of other bases which are "fixed" in alkaline soils, or may be at low soil levels. The effects of soil differences overshadowed all other variables. Crop sizes, fertilization, spray, and other cultural practices also affected mineral composition of the leaves to some extent.

Table 1. Mean and range in mineral concn in avocado leaves on 3 soil types.[z]

Element		Astatula sand	Torry muck	Rockdale rock
N (%)	Mean	1.99	1.90	1.68
	Range	1.53-2.29	1.75-2.01	1.45-2.08
P (%)	Mean	0.11	0.13	0.10
	Range	0.07-0.12	0.12-0.14	0.08-0.15
K (%)	Mean	1.42	1.44	1.57
	Range	1.18-1.87	1.28-1.61	1.10-1.90
Ca (%)	Mean	1.76	2.85	2.78
	Range	0.72-2.58	2.43-3.45	1.79-3.62
Mg (%)	Mean	0.51	0.65	0.40
	Range	0.30-0.80	0.45-0.80	0.31-0.57
Mn (ppm)	Mean	204	40	90
	Range	65-396	28-47	34-161
Cu (ppm)	Mean	52	29	39
	Range	10-130	26-34	19-75
Zn (ppm)	Mean	137	56	73
	Range	61-320	18-92	14-160
Fe (ppm)	Mean	45	36	70
	Range	28-65	23-43	28-199

[z]Data based on 'Tonnage,' 'Lula,' 'Taylor,' and 'Booth 8' leaves from Astatula sand and Rockdale rock and 'Tonnage' leaves from Torry muck.

Table 2. Soil analysis of 3 soil types (0-6 inches).

Soil	pH	Total N	Extractable elements							
			P	K	Ca	Mg	Mn	Cu	Zn	Fe
		%	lb. per acre							
Sand	5.85	1.05	239	174	584	110	150	5	32	14
Muck	7.61	1.76	90	723	11,689	1,099	Tr	Tr	Tr	13
Rock	7.87	1.58	43	211	9,553	367	81	3	32	2

Leaves from sand and muck averaged higher in N than those from rock. Heavy N fertilization accounted for the high level on sand while on muck it was due entirely to the inherent high N content of the soil. No N fertilizer was applied on the muck soil. The mean levels of leaf P were comparable in the 3 soils, mostly as a result of recent or / and residual phosphate fertilizer. The somewhat higher mean level of K in leaves from rock than in those from sand and muck soils probably was partly clue to retention against leaching because of the high exchange capacity of the soil, as compared with sand, and partly because of higher K fertilization on rock than on muck. Antagonism of Ca and Mg for absorption of other bases may help to explain the higher leaf level of K on rock than on muck. Muck soil was higher in Ca and Mg than rock. Comparable amounts of K fertilizer were applied on sand and rock, but leaching losses likely would be greater on sand. No K fertilizer had been applied on the muck since late 1972, but because of the high exchange capacity this had been retained in adequate amounts. The higher mean Ca level in leaves from muck and rock soil than in those from sand is a reflection of the inherent high Ca level in the muck and rock soils, as compared with a low level in sand. Leaves from muck had the highest mean level of Mg. As with K, no Mg had been applied on this soil since 1972, but because of high exchange capacity, Mg had been retained in adequate amounts. The intermediate level of Mg in leaves from sand was clue to relatively heavy Mg fertilization, while the low level on rock likely was due to a combination of relatively low Mg fertilization arid interference with Mg absorption by the high soil Ca level. Mean levels of Mn, Cu, and Zn were rather consistently higher in leaves from sand than in those from muck or rock. This was due mostly to difference in soil types. These elements are "fixed" in soils of high pH and Ca levels. The mean levels of Fe probably would have been arranged in the same order as Mn, Cu, and Zn, with respect to soil types, had it not been for heavy Fe fertilization and sprays on rock, as compared with moderate Fe fertilization on muck and none in fertilizer or spray on sand. Furthermore, the highest level of Fe in leaves from rock was due partly, no doubt, to fungicidal sprays containing Fe. It is virtually impossible to remove all spray residues of Mn, Cu, Zn, and Fe from leaf surfaces before analyzing (17).

Cultivar apparently had no consistent strong effect on the mineral concn in avocado leaves (18). In the present study, there were differences among cultivars, but no definite trend or pattern to indicate that absorption was greater or more efficient with one cultivar than with another. The rank in levels of the various elements in leaves was mixed and seemingly without bias among the cultivars, probably because of interactions. Therefore, in Table 1, the means of the *4* cultivars were used.

The range in levels of the 9 elements on the 3 soils (Table 1) was, for the most part, reasonably close to the range tentatively set as adequate for 5 to 7-month-old leaves of mature avocado trees in California (5). Only a few were at deficiency or excess levels. The low level of N in leaves from sand was slightly deficient and the high levels on all, 3 soils slightly in excess. Cu was in excess on the 3 soils. Zn was in excess on sand and Fe deficient on muck.

Fruiting status of shoot. In the study or, the effect of fruiting, similar trends were found for all 4 cultivars on both sand and rock soil. Therefore, in summarizing these differences, the means are given (Table 3). N, P, and Mg were significantly lower both years, K in 1975 and Mn in 1974 on fruiting shoots than on nonfruiting shoots. There was no significant effect of fruit on the concns of the other elements examined. In general, trees with heavy crops had lower mineral concns in leaves than those with light crops (8). On the other hand, differences in concn of minerals in leaves between non fruiting and fruiting shoots did not appear to be related to crop size.

Branch girdling. The yield of some avocado varieties is increased substantially by branch girdling prior to bloom (12). The 'Taylor' and ''Pollock' cultivars in Florida respond well to this practice. To examine the effects of branch girdling on the level of minerals in leaves of avocado, leaves from 3 branch-girdled 'Taylor' trees were sampled at the same time and by the same method as the non-girdled 'Taylor' trees on rock soil. The 2 sets of trees were in different groves, but on the same soil type and under similar growing conditions. Macro element fertilization was comparable in the 2 groves, but there was some difference in microelement applications in fertilizers and sprays. The girdled trees had heavy crops and the non-girdled trees light crops both years. The only significant difference in the levels of the 9 elements in leaf was in Ca, Cu, and Fe. Leaves from the non-girdled trees were higher in Ca both years but the difference was within limits of normal variation on rock soil. Cu was higher in leaves from non-girdled trees, but these trees received considerably more Cu in sprays than the girdled trees. The girdled trees, which received chelated Fe fertilizer and fungicidal sprays containing Fe, had a higher level of Fe in leaves than those from nongirdled trees, which received Fe as iron sulfate fertilizer only. In general, girdling had no apparent effect on the mineral composition of the leaves.

Other variables. Changes with age in level of mineral, elements have been reported in California (1, 3, 11) and in Texas (16). With 'Tonnage' in Florida, leaf N, P, and K generally decreased with age while the other 6 elements examined increased. Levels of all 9 elements tended to stabilize when leaves were around 5 to 7 months old (8).

Differences in levels of minerals in avocado leaves were found between the basal and terminal leaves of the same shoot (8). The levels followed somewhat the pattern associated with age. The basal leaves of a given growth flush on Florida avocados may be as much as 3 weeks older than the terminal leaves.

There usually was an inverse relationship between crop size and the leaf levels of the 9 elements examined (8)

It was pointed out earlier that avocados generally make more than one growth flush a season (3). A 2nd growth flush occurred both years on practically all the marked 'Tonnage' shoots on the 3 soils within 3 to 6 weeks after the 1st flush had hardened. The 2nd flush, which came after summer rains started, generally was larger and more vigorous than the 1st flush, which came during; relatively dry weather. The 2nd flush was color code marked to distinguish it from the first. By midfall, many of the 1st flush leaves were chlorotic, weak, or had shed, while most of those on the 2nd flush were in good condition. Leaf samples were taken from about midsection of each of the 2 flushes in late December both years. With a few minor exceptions, N and P were higher in the 2nd flush, K about the same in both, and all other elements lower in the 2nd. flush than the 1st. The differences could be accounted for rather consistently by the difference of about 4 or 5 weeks in age between the flushes. It is suggested that the 2nd flush would be more suitable for sampling than the 1st. flush where it was desired to sample late in the season Care should be taken not to mix the 2 flushes in sampling. A 3rd flush sometimes occurred, but was not of sufficient incidence to have a measurable effect on analytical results if mixed in approx proportion to occurrence with leaves of the 2nd flush. Differences in leaf position and condition should help distinguish between the 1st and 3rd flushes.

Methods for avocado leaf sampling. Methods for leaf sampling of fruit trees have been described (7, 15). For avocados, the following precautions will help in collecting samples:

1. Take leaves within range of normal size.
2. If deficiency symptoms are present, take only leaves showing average incidence of the symptoms.
3. Take leaves as free of insect and disease damage as possible.
4. Sample when growth flush is still young enough that age is known or mark flush in some manner so approx age will be known for later sampling.
5. Sample 5 to 7-month-old leaves (Sept.-Oct.) unless special purpose sampling dictates other time.
6. Take midshoot leaves from non-fruiting shoots.
7. Avoid sampling recently pruned, trees.
8. Confine individual samples to one cultivar.
9. Confine individual samples to one soil type.
10. Confine individual samples to trees under similar cultural practices.
11. Sample before rather than after spraying with any nutrient element for which analysis is to be made.

Table 3. Comparison of mineral composition of avocado leaves from nonfruiting and fruiting shoots.

Element	1974 Non-fruiting	1974 Fruiting	Sta. sig.[y]	1975 Non-fruiting	1975 Fruiting	Sta. sig.[y]
N (%)	1.82[z]	1.74	*	1.91[z]	1.74	**
P (%)	0.11	0.10	*	0.11	0.10	**
K (%)	1.59	1.60	NS	1.35	1.27	*
Ca (%)	2.30	2.17	NS	2.30	2.30	NS
Mg (%)	0.42	0.35	**	0.50	0.46	*
Mn (ppm)	152	122	*	131	127	NS
Cu (ppm)	66	63	NS	21	23	NS
Zn (ppm)	117	104	NS	81	77	NS
Fe (ppm)	67	70	NS	50	48	NS

[z]Each value is mean of the 4 cultivars on 2 soil types.
[y]Statistical symbols: NS—not significant, *—significant at 5%, **—significant at 1%.

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