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AVOCADO NUTRITION - A REVIEW

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Summary

Avocado trees are known to have relatively low demand for nutrients. This assumption is based on:

(a) few mineral deficiencies that are found in commercial plantations (mainly N, Zn and Fe)
(b) very low nutrient removal (based on 10t/ha yield, 11 kg N; 2 kg P and 20 kg K).
(c) No significant yield increase from addition of N, P, or K in field experiments.

Added N benefits the avocado almost universally. Its affects mainly growth but much less the production. Increased amounts of nitrogen do not give any advantage to avocado production but on the other hand increase pollination of underground water with nitrates.

Leaf analysis is still the best way to assess nutritional needs of the avocado tree. Standardization of leaf sampling should be very accurate in order not to misinterpret the results received

Major problems still to be investigated are:

1. Calibration of critical levels in the leaves.
2. Establishing the relationship between nutritional level and alternate bearing.
3. The use of microelements in foliar sprays during critical growth periods.
4. The use of boron to increase fruit set.
5. Calibration of fertilizer applications in relation to the nutrient demand, in order to reduce damage to the environment.

Additional index words
Nutrient, removal, leaf analysis, Nitrogen

During the years, many research projects have been conducted in avocado nutrition in many growing areas in the world. The basic nutrition requirements of the avocado are quite known but it seems that our understanding of the subject have reached a plateau. Differences exist in the results of fertilizer experiments carried out in different parts of the world. In some places a marked increase in tree growth was found after fertilization, while in others no response was observed. In most places no relationship was found between the level of most nutrients in the leaves and yields. Moreover, it seems that the great variability among trees in the same plot and among trees in their "on" and "off" years, causes a deviation of the average, resulting in inaccurate interpretation of the results.

It is impossible to cover all aspects of the mineral nutrition of the avocado in this review. Only the subjects of nutrient removal, amount of nitrogen and leaf analysis will be discussed.

Nutrient removal

The avocado tree is well known for its low demand of nutrients (Lahav and Kadman, 1980). This is demonstrated by the low total content of nutrients in the crop as compared with other fruit trees and field crops (Table 1). On the basis of nutrient removal by avocado crop of 10t/ha all the nitrogen removed will be compensated by 55 kg/ha of $(NH_4)_2SO_4$ and the potassium by only 33 kg/ha of KCl (table 2).

Nitrogen

Nitrogen seems to be the most important element in avocado nutrition. Deficiencies of nitrogen in avocado result in small, pale leaves, early leaf drop, and smaller and fewer fruits (Lahav and Kadman, 1980). In addition, nitrogen deficient trees were found to be more susceptible to frost damage (Lahav et al., 1987). In many growing areas, avocado growers tend to apply large amounts of nitrogen to their plantations. Field experiments with high level of nitrogen in Israel showed that nitrogen (as NH_4N0_3) reduced soil pH (Table 3), increased iron chlorosis (Table 4) and somewhat tree size (Table 5), but had no affect on yields of cvs. Ardith and Ettinger (Table 6). However, a remarkable negative effect on yields of cv. Hass was found (Table 7). A similar experiment in California (Meyer et al., 1991) showed no effect of N on tree volume (Table 8), or yield (Table 9).

Too much N has been reported to reduce fruit set in Fuerte avocado in another experiment in California (Crowley, 1992). In all experiments N levels in the leaves were significantly affected by N application (Figs 1,2). These data suggest that mature avocado orchards may have sufficient N that cycles within the system to support normal growth and production. It also suggests that relatively small amounts of nitrogenous fertilizer should be applied to avocado plantations. This is indicated also by Avilan et al. (1978) in Venezuela assuming soil organic matter of 1% and a crop of 15 t/ha, that 25 crops of avocado could be produced from the soil N. Also, even a low application rate of 125 kg N/ha, results in 2/3 waste of N by volatilization or leaching.

Nitrogen is also related to improper use of fertilizers resulting in groundwater contamination which is becoming increasingly important issue. The chief pollutant at the present is nitrate which is applied routinely in quantities much greater than those actually required for the growth of the avocado. Presently, nitrate contamination of ground water is perceived as one of the most severe environmental problems. The best way to overcome this problem is probably to calibrate fertilizer applications to the nutrient demand and seasonal growth patterns in the avocado as suggested by Whiley et al. (1988). However, very little data and experimental results exists in this direction.

Leaf Analysis

The ability of the avocado tree to take up and utilize mineral nutrients is reflected in the concentration of each nutrient in the tissue. Chemical analysis of the leaves provides therefore valuable information on the nutritional status of the tree. Though the soil is almost always the source of mineral nutrients, soil analyses provides information on the total amount of a nutrient available and not on the amount taken up. Soil analysis also do not give consistent results and do not reflect the adequacy of nutrients for the avocado tree. Thus, despite the fact that in many cases also leaf analyses do not show direct relationship between the nutrient concentration in the tissue and the yield, it is still the best means of assessing the nutritional state of the tree.

In order to ensure accurate interpretation of avocado leaf analyses - the most important tool for determining nutrient status of the tree - only leaves of the spring flush should be sampled (Lahav et al., 1990). These leaves are sampled during the period between September and November. Seasonal changes in the Ca, K, N, B, Fe and Mn levels have been shown to occur (Bingham, 1961). For this reason, leaf samples taken at other times of the year or from other flushes have little value for diagnosing deficiencies since the analyses data are not calibrated with yield and growth data of the tree. The leaves can be identified easily according to the rind of buds marking the end of the previous year's growth. After sampling, the leaves of the spring and summer flushes can be identified according to their Ca content (Figs 1 and 2). In autumn sampling, the Ca level in the summer flush leaves will never exceed 1.6% while that of the spring flush will always be above 1.8% (Lahav et al., 1990).

Conclusions

Over the past years, much progress has been made in avocado nutrition, especially in fertilization programs and leaf analysis as a tool to determine the nutritional demand of the tree. However, avocado nutrition is still far from being perfected and there are major problems still to be investigated as:

- Calibration of critical levels in the leaves,
- Establishing the relationship between nutritional level and alternate bearing or more specific a better understanding of the way in which carbon and N are allocated to different plant parts during the year,
- The use of microelements in foliar sprays during critical growth periods,
- The use of boron to increase fruit set
- Calibration of fertilizer application in relation to the nutrient demand in order to reduce damage to the environment. This probably can be done most efficiently by developing advanced fertigation programs.

References

Avilan, R.L., Chirinos, A., and Figueroa, M., 1979. Quantification of some minerals extracted from the soil by an avocado crop. Proc. of the Trop. Region Amer. Soc. Hort. Sci. 27: 108-113.

Bingham, F.T., 1961. Seasonal trends in nutrient composition of Hass avocado leaves. Amer. Soc. Hort. Sci. 78: 149-160.

Crowley, D.E., 1992. Soil fertility and the mineral nutrition of avocado. Circular No. CAS-92/1 Calif. Avocado Soc. Inc.

Lahav, E., Bar, Y., and Kalmar, D., 1990. Effect of nitrogenous fertilization on the annual variations in nutrients in avocado leaves. Commun. in Soil Sci. Pl. Anal. 21: 1353-1365.

Lahav, E., and Kadman, A., 1980. Avocado fertilization. Bull. Intern. Potash Inst. No. 6 Worblaufen-Bern, Switzerland.

Lahav, E., Kalmar, D., and Bar, Y., 1987. Nitrogen fertilization a guarantee for relative resistance of avocado trees to frost. J. Pl. Nutr. 10: 1859-1868.

Meyer, J.L., Arpaia, M.L., Yates, M.V., Takele, E., Bender, G., and Witney, G., 1991. Irrigation and fertilization management of avocados. Calif. Avocado Soc. Ann. Meeting. Sept. 27, 1991, Ventura Ca. p. 33-48.

Whiley, A.W., Saranah, J.B., Cull, B.W., and Pegg, K.G. 1988. Manage avocado tree growth cycles for productivity gains. Queensland Agric. J. 114: 29-36.

Table 1: Total content of nutrients (kg/ha) in various crops

Crop	Yield (t/ha)	N	P_2O_5	K_2O	MgO
Corn	6	120	50	120	40
Wheat	6	170	75	175	30
Potato	40	175	80	310	40
Tomato	50	140	65	190	25
Peanuts	2	170	30	110	20
Sunflower	3	120	60	240	55
Apple	25	100	45	180	40
Citrus	30	270	60	350	40
Banana	40	320	60	1000	140
Avocado	15	40	25	80	10

Table 2: Nutrients removed from an avocado plantation by 10t/ha crop

Nutrient	% of dry weight	kg/ha	Nutrient	ppm of dry weight	kg/ha
N	0.54	11.3	Na	400	0.8
P	0.08	1.7	B	19	0.04
K	0.93	19.5	Fe	42	0.09
Ca	0.10	2.1	Zn	18	0.04
Mg	0.24	5.0	Mn	9	0.02
Cl	0.07	1.5	Cu	5	0.01
S	0.30	8.0			

Table 3: Effect of nitrogen level on the pH in the soil profile.

Depth	N kg/ha			
(cm)	80	160	320	640
0-30	7.3	6.7	6.9	5.7
30-60	7.4	7.2	7.4	6.9
60-90	7.4	7.3	7.4	7.2

Table 4: Effect of nitrogen level on chlorosis (0 =green; 5=yellow) in autumn 1994.

Cultivar	N kg/ha			
	80	160	320	640
Hass	0.11	0.42	0.96	1.15
Ardith	0.29	0.96	1.53	2.09
Ettinger	0.41	0.99	1.45	2.53

Table 5: Effect of nitrogen level on tree size (1=very small 5=large)

Cultivar	N kg/ha			
	80	160	320	640
Ettinger	3.6	3.8	3.6	3.6
Ardith	3.1	3.5	3.8	3.7

Table 6: Effect of nitrogen level on yield (fruit/tree)

Cultivar	Year	N (kg/ha)			
		80	160	320	640
Ardith	1992/3	26	19	31	45
	1993/94	57	70	47	43
	1994/5	140	188	217	172
	Average	76	96	100	87
Ettinger	1993/4	83	106	45	57
	1994/5	136	141	139	230
	Average	109	123	92	140

Table 7: Effect of nitrogen level on yield (fruit/tree) of cv. Hass

Year	N (kg/ha)			
	80	160	320	640
1987/8	63	38	41	53
1990/1	98	96	115	83
1991/2	190	246	175	223
1992/3	197	215	184	244
Average	137	149	129	151
1993/4	184	75	48	51
1994/5	245	205	215	145
Average	215	140	131	98

Table 8: Effect of nitrogen on tree volume (m^3) Corona Experiment.

N (Kg/ha)	1988	1989	1990	1991
0	65	71	81	86
190	69	77	88	91
380	66	73	82	88
Sig	N.S.	N.S.	N.S.	N.S.

Table 9: Effect of nitrogen on yield (kg/ha) Corona Experiment.

N (kg/ha)	1988	1989	1990	1991	Total
0	10050	4790	9510	800	25160
190	9980	6500	8140	780	25410
380	9720	4670	8740	450	23580
Sig.	N.S.	N.S.	N.S.	N.S.	N.S.

Fig. 1. *The effect of leaf age, fertilization regime, and sampling date on nitrogen content of avocado leaves.*

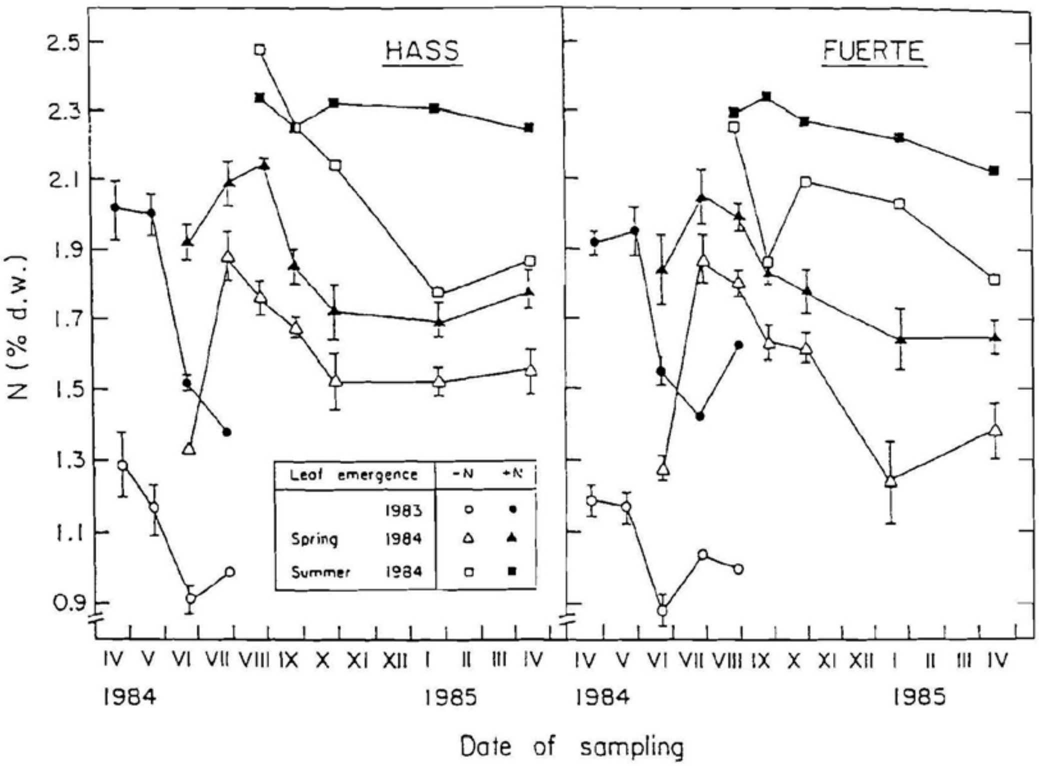

Fig. 2. *The effect of leaf age, fertilization regime, and sampling date on calcium content of avocado leaves.*