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9. NUTRITION

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a. Survey of Leaf Composition

With the aim of obtaining the first sets of information on the composition of leaves of avocado trees in Israel, a survey was conducted from 1958 to 1961 with the aid of two grants from the Ford Foundation. The survey included orchards throughout the coastal plain and also in the Jordan Valley. Leaves were taken in the different seasons of the year and from the most important varieties — Ettinger, Fuerte, Benik and Nabal. The leaves were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, sodium, chlorine, iron, copper, manganese and boron. The more important results of these surveys are given below:

- The leaves should be taken from the northwest side of the trees, at a height of 150-200 cm, during the fall season.
- With the aging of the leaf, nitrogen, phosphorus and potassium contents decline and calcium and magnesium contents rise.
- On the lighter soils of the southern part of the coastal plain, potassium content of the leaves is relatively high and calcium and magnesium contents are relatively low. On the heavier soils, and especially in the northern part of the coastal plain, the opposite relationship is found. Even in one and the same orchard, potassium content of the leaves tends to be lower in that part of the orchard with heavier soil.
- The normal leaf content of Guatemalan varieties tends to be higher than that of Mexican/Guatemalan hybrids, such as Fuerte or Ettinger.
- Chlorine content of the leaves is directly influenced by that of the irrigation water; there is no such close relationship with sodium.
- From most leaf components, the values found in Israel were very close to those common in California. The one consistent difference was a very much lower boron content (see below).
- The usual methods of analysis for iron give values which have no relationship to the physiological condition of the leaf, as represented by its green or chlorotic appearance.

Analysis for nitrogen should be carried out twice yearly; for potassium, magnesium and zinc, once yearly; and for phosphorus and calcium, it may be done only once in several years.

During the years of the survey, the division did not have at its disposal an orchard where a fertilizer trial could be carried out. Therefore, we could not relate the content of the leaf— e.g. of nitrogen — to the actual yield performance of the tree. We had to assume that the condition was sufficiently similar to that known in California, where trees of the Fuerte variety produce best with a leaf content of 1.6-2% nitrogen. Since many well-producing trees had values within this range, this assumption seemed all the more valid. Nevertheless, there was never a doubt that fertilizer trials would have to be carried out, and for this purpose orchards were planted in 1958 at Bet Dagan and in 1963 at 'Akko.

b. Nitrogen Fertilizer Trial at Bet Dagan

The orchard which was planted in 1958 at Bet Dagan, comprises 45 plots of ten trees each (2 Ettinger, 1 Fuerte, 1 Anaheim, 2 Benik, 2 Nabal and 2 Hass), with a total of 450 trees on 16.2 du. For further particulars on this orchard, see section A. 3.

Plans for the trial were started in 1966, while taking counsel with colleagues at the University of California at Riverside, with members of the Division of Statistics and Experiment Design of the Volcani Institute, and with avocado growers in Israel. Early in 1967, we decided to carry out the trial according to the following scheme:

Five levels of nitrogen are used, with nine replications each. This relatively large number of replications was chosen due to the very high variability of avocado trees in one and the same orchard.

Blocks were not delineated on a purely topographical basis, but according to the success or failure of the different plots as represented by their mean yield during the five years before the beginning of the trial (1962/63 to 1966/67). The ten best and the ten worst plots were used as two blocks each, while the 25 medium plots were arranged in blocks on a more or less topographical basis.

Calcium ammonium nitrate was used as nitrogen source. The five levels are 0, 1.25, 2.50, 3.75 and 5.00 kg fertilizer per tree. The guard rows were given half the quantity of the two bordering treatments.

Manure was given for the last time before the start of the trial in 1966, and no manure will be given, unless the orchard suffers too heavy damage, during the period of the trial. In spring 1967, a uniform treatment of dolomite and zinc sulfate was given. The first differential fertilization was given in June 1967. In 1968 and 1969, the fertilizer was given in two applications, in April and June.

Since 1965, leaf analyses have been carried out every year in October. In 1965, we found that the leaves of the mature orchard contained, as compared to the young orchard in 1960/61, less nitrogen and potassium and more calcium and magnesium. In 1966 and 1967, analyses were carried out only for nitrogen and potassium, which showed some rise as over 1965. In 1968, calcium and magnesium values were found to be rather similar to those in 1965.

Yields of the trees before the start of the trial were not correlated with nitrogen content of the leaves in Ettinger; for the Fuerte variety, there was a negative correlation with

yields tending to become lower with higher nitrogen values (or nitrogen values tending to become higher with lower yields); for the Guatemalan varieties the correlation tended to be positive, with yields rising with the rise of nitrogen content.

Preliminary results

It is obvious that two years after its start, this trial cannot be presumed to have given results. For reliable yield responses we shall have to wait at least four years, due to alternate bearing of the trees, and better yet five years, disregarding the first. With this reserve we give herewith the yields (in kg) for the first two seasons after the start of the trial for all varieties and replications together:

Year	*Treatment* (kg N fertilizer/tree)				
	0	1.25	2.50	3.75	5.00
1967/68	6436	6768	6373	6720	6624
1968/69	6249	6227	6361	6193	5719

It is seen that in the first season after the start of the trial the uniformity, which was the basis for the choice of the plots, remained in effect. In the second year, the yield of the highest nitrogen level was somewhat lower, but this may have been due to some alternation of bearing. It is interesting that the 0 level does not, so far, show any distinctive lowering of yield. The influence of the nitrogen level on the quality, and especially the keeping quality, of the fruit, will be investigated later. With the idea that the reduction in yield at the highest level might be due to salt damage, a survey of leaf burn was carried out in spring 1969, but no differences in mean leaf burn were found between the treatments.

Leaf analysis: For leaf analysis, the influence of the different nitrogen levels might be expected as early as a few months after the start of the trial. In October 1967, leaves from all the 450 trees were analyzed for nitrogen and potassium, and compared with an analysis of mixtures of leaves from the 10 trees in each plot. As no significant differences were found between the value for the composite sample and the mean of the ten individual analyses, only analyses of the composite samples were used in 1968, but analyses were carried out for many elements. Nitrogen values in 1967 were 1.8% (level 0), 1.88% (1.25 kg), 2.00% (2.50 kg), 2.10% (3.75 kg) and 2.02% (5.00 kg). There seems to be a small difference between the values for the two lowest levels as compared to those for the other three levels. The mean values for the varieties were: Ettinger 1.80%, Fuerte 1.98%, Hass 1.97%, and Nabal 2.02%.

As for potassium, values for the 0 treatments were slightly higher than those for all others, among which there was no difference.

The values for a number of elements from the composite samples in 1968 are given in Table B. 9.1. Phosphorus values were uniform at 1.15%, boron values were uniform at 35 ppm — about three times higher than found in the earlier survey —, and copper values were uniform at 11 ppm. From this table the following can be concluded:

TABLE B. 9.1

LEAF ANALYSIS VALUES ACCORDING TO NITROGEN TREATMENT

(October 1968)

Nitrogen fertilizer level (kg / tree)	N (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Cl (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)
0	1.87	1.38	1.54	0.64	0.008	0.71	46	42	94
1.25	1.93	1.23	1.67	0.67	0.009	0.74	57	39	105
2.50	1.92	1.23	1.69	0.67	0.009	0.72	55	37	121
3.75	2.09	1.24	1.73	0.68	0.010	0.76	59	36	109
5.00	2.05	1.27	1.85	0.72	0.011	0.70	56	38	130

- Nitrogen values in the leaves rise with the level of nitrogen fertilization. Significance values represent three groups: 0, 1/2 and 3/4.
- Calcium values also rise with the level given in the fertilizer. Significance values also represent three groups: 0, 1/2/3, and 4.
- The differences in potassium (high value with 0), iron (lower value with 0), zinc (high value with 0) and manganese (low value with 0) were found to be non-significant.
- The chlorine values were very high in all treatments, and showed the influence of the rising salt content in the irrigation water used at Bet Dagan.

Additional fertilizer trials were carried out in the Western Galilee and the Central District.

Western Galilee

Potassium (with the cooperation of M. Bareket of "Haifa Chemicals"): Potassium nitrate was chosen for the trial; this is a fertilizer with a high potassium content, which is highly soluble and contains neither chlorine nor sulfur. The trial started in 1968 at the 'Akko Experiment Station. There are five treatments with six replications each of eight trees (two each of Ettinger, Fuerte, Hass and Nabal). The treatments consist of 0, 40, 80, and 120 kg potassium nitrate per dunam, and potassium sulfate equivalent to 80 kg of potassium nitrate. The additional nitrogen was given in the form of urea in the potassium nitrate treatments, and in the form of ammonium sulfate in the additional treatment.

In addition to the usual measurements we shall investigate the relationship of potassium level to the chlorosis which is common in trees of the Hass variety, especially after high yields.

Zinc: In the same orchard a trial with four treatments in six replications of eight trees, as above, was started in 1969. The treatments are: 0.25% zinc sulfate as spray; 2.5 and 5.0 kg zinc sulfate per tree, given as soil treatments; and a control without zinc. The trial will make it possible to compare soil treatments to sprays. The percentage of round fruit, which is a sign of zinc deficiency, will be recorded as one of the parameters.

Central District

Level of nitrogen: In cooperation with the Government Extension Service, observations on the behavior of trees supplied with two levels of nitrogen will be carried out in seven orchards. In one level, nitrogen will be given so as to keep leaf values as close to 2.00% as possible; in the other, no nitrogen will be given so long as the leaf analyses do not show values below 1.60%. The trials started in 1968 with pairs of trees of known and, as far as possible, similar yields in the previous years.

Time of nitrogen application: In a trial in one orchard, started in 1969, three treatments — nitrogen given in winter, nitrogen given in summer, and control — will be compared.

Zinc and iron: In a trial started in 1969, five treatments will be compared — 5 kg zinc sulfate, 300 g zinc chelate, 150 g iron chelate, 300 g iron chelate (all per tree), and control. There are no signs of iron or zinc deficiencies in the orchard and the aim of the trial is to determine whether hidden deficiencies can be treated, with subsequent advantages for the tree and fruit.

Fertilizer trial on light soil: The trial comprises treatments with nitrogen, potassium, magnesium and zinc. It was started in 1969, in cooperation with "Haifa Chemicals", and will compare potassium nitrate and ammonium nitrate. Each treatment consists of six replications of 20 trees each.