Proc. Fla. State Hort. Soc. 67:220-224. 1954.

SOME EFFECTS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE YIELD, TREE GROWTH, AND LEAF ANALYSIS OF AVOCADOS

S. John Lynch, Seymour Goldweber, and Clarence E. Rich
Experimental Farm Division of Research and Industry University of Miami Coral Gables

The avocado industry in the American tropics and subtropics has developed in the last three to four decades. Wilson Popenoe, in his classic "Manual of Tropical and Subtropical Fruits" in 1920, estimates that avocado orchards of California, Florida, Cuba, and Puerto Rico at that time had a total area approaching one thousand acres. Today the combined estimated acreage of commercial avocado plantings is upwards of 40,000 acres. In Florida alone there are between 10,000 and 11,000 acres (1) of avocado trees grafted to commercial varieties with 9,000 acres of these being on the soils of Dade County. There are approximately 25,000 acres of this tree crop growing in California and Florida, regions in which the addition of large quantities of mineral nutrient elements is required.

A survey of literature to date on the mineral nutrition of avocados (2) shows that the requirements of the minor mineral elements are known more definitely than the requirements of the major plant foods, i.e., nitrogen, phosphorus, and potassium. The need by the avocado for these major plant foods is well recognized but the quantity of the element and the ratios of the elements to each other for optimum tree growth, fruit yield, and fruit quality is yet to be established.

Pot culture work with avocados in California (3,4) indicates that avocado seedlings are gross feeders on nitrogen and that a greater potassium absorption occurred in the mature leaves of seedlings as the magnesium concentration in the culture solution increased and that of calcium decreased. Little or nothing is known about phosphorus absorption or utilization other than the assumption of its need in plant growth. Haas (5) described symptoms of phosphorus deficiency in avocado leaves from plants in solution cultures. Addition of phosphate to the phosphate deficient solution was followed by a prompt recovery by the new leaves.

In order to help translate some of the information gained by pot culture work to field conditions a long term experiment was set up at the University of Miami Experimental Farm, on Miami Oolite soil, using four prominent commercial varieties of avocados.

EXPERIMENTAL METHODS

The experimental block of trees consists of 2K acres each of Waldin, Booth 7, Booth 8, and Lula avocados grafted onto Waldin (W. I.) rootstock. The trees were set in the field in May, 1949 at 23 ft. spacing each way. The individual fertilizer plots consist of 3 trees completely buffered. There are 18 plots of each variety, each plot receiving a different variation of N, P, and K. Treatments were started December 28, 1950. The nitrogen levels are 2, 4, and 6%, with 30% derived from natural organic sources and the remainder from half nitrate and half ammonia salts. The phosphorus levels are 0, 3, 6, *9%* P_2O_5, derived from superphosphate. The potassium levels are 0, 3, 6, 9% K_2O, derived from potassium sulfate and muriate of potash. The Lula variety receives its source of potassium from potassium sulfate and the other three varieties receive theirs from muriate of potash.

The fertilizer treatments are applied at 60 day intervals in quantities similar to regular grove practices. At five years of age the application per tree is 7.2 pounds. These trees are all adequately irrigated and minor elements are supplied uniformly by maintenance sprays. Magnesium is applied at the rate of 2 units each fertilizer application.

Table 1 shows the variations selected for this experiment. Leaf samples were takerf in January and May, 1953, consisting of seven mature leaves taken at random from just behind the terminal growth on each tree in a plot. The leaves from the three trees in a plot were combined and considered as the representative sample of that treatment. The leaves were dried for 72 hours at 50° C. After being ground through a 40 mesh screen in a Wiley mill and thorough mixing, aliquots were taken for analysis. These aliquots were dried for one hour at 100° C. before being weighed for analysis. Total nitrogen was determined on 500 mgm. samples using the macro Kjeldahl procedure. Phosphorus and potassium were determined on 200 mgm.samples of leaves which had been wet-ashed by the nitric-perchloric acid method (6). Phosphorus and potassium, both expressed as p.p.m., were determined as previously described (7).

The trunk circumferences were taken in inches, using a flexible steel tape, at a level on the trunk permanently marked approximately 1 foot above the root crown. These^ measurements are taken once each year. However, for this paper the total increment of growth of the trunk from the beginning of the experiment to date is used. Tree condition is based on visual appearance of foliage-color and luxuriance of leaf growth on a scale of from 1 to 10. The highest figure on the scale is the deepest green color and heaviest leaf population for a variety. Tree size is based on tree volume for a variety on a scale of from 1 to 5 with the highest number being the largest trees of that variety. Average weight of fruit per tree represents the average of total crop per tree in a plot for the 1953-54 seasons, the first crop year for the experiment.

Table 1.

Effects of fertilizer treatments on tree growth, yield and foliar analyses of the Lula avocado.

Treat-ment	* Average % Trunk Area Growth	Average Wt. Fruit (lbs) Per Tree	** Average Wt. Fruit (lbs)	*** Tree Cond. 1-10	Tree Size 1-5	FOLIAR ANALYSIS ****					
						% N Winter	% N Spring	% P Winter	% P Spring	% K Winter	% K Spring
N P K											
2 0 6	66.6	0	0	6	2	1.874	1.410	.162	.102	2.162	2.513
2 6 0	61.5	6.47	.66	5	3	1.558	1.456	.169	.117	1.345	.992
2 3 9	69.7	6.20	.80	6	2	2.028	1.680	.153	.117	2.050	1.990
2 6 6	45.8	6.26	.94	6	2	1.804	1.713	.159	.134	1.816	2.062
2 9 3	83.7	2.75	.69	7	1	1.700	1.336	.175	.150	1.768	1.418
2 9 9	74.1	1.67	1.00	5	3	1.854	1.375	.217	.127	1.729	2.150
4 0 9	84.0	15.52	1.02	8	4	1.985	1.667	.137	.115	1.555	2.095
4 9 0	143.4	15.29	1.00	8	3	1.962	1.800	.121	.136	.970	.736
4 3 9	85.9	5.92	.81	7	3	2.186	1.573	.153	.129	1.580	1.419
4 9 3	138.1	5.17	1.02	8	3	1.875	1.835	.131	.155	1.555	1.169
4 9 9	143.8	12.80	.94	8	4	2.149	1.944	.150	.149	1.692	1.628
6 0 3	116.3	13.08	1.07	9	4	2.142	2.031	.131	.124	1.280	1.119
6 0 6	125.3	17.58	.87	9	5	2.135	2.024	.113	.125	1.306	1.424
6 3 0	179.0	15.22	.81	9	5	2.214	1.903	.119	.142	.747	.585
6 6 0	115.2	7.83	.73	9	2	2.054	1.948	.131	.149	.847	.644
6 3 9	157.1	48.95	1.12	9	5	2.225	2.051	.137	.150	1.344	1.567
6 6 6	131.6	47.55	1.05	10	4	2.325	1.946	.147	.141	1.383	1.397
6 9 3	238.8	24.72	.95	9	5	2.079	1.860	.125	.134	1.093	.967

* Trunk area growth is inclusive to date.
** Fruit is for 1953 crop year.
*** Tree condition was taken in fall of 1954.
**** Leaf analyses samples are for 1953.

EXPERIMENTAL RESULTS

The data in Table 1 are but one year's results and represent too few samplings to analyze statistically but do indicate some general trends. Due to space limitations it is impractical to give the data for all four varieties. Only the data on the Lula variety are given in this paper, although the data for the other varieties were consulted in discussing trends or effects.

Tree Condition and Size

There is a direct correlation between tree condition and size with the levels of nitrogen applied. Where P & K levels were kept constant, increase in nitrogen resulted in increased depth of green leaf color, heavier foliage and larger trees. In plots of low nitrogen, with high phosphorus and variations in potassium, field observations seemed to indicate an increase in depth of green leaf color with the increased potassium in all varieties except Lula.

Increase of Trunk Area

The increase in the transverse area of the trunk is closely correlated with general tree condition and tree size. This means that the increment of trunk growth is directly affected by increased nitrogen levels. However, no apparent effect can be observed due to phosphorus or potassium levels in the fertilizer.

Fruit Yields and Size

The general trend, in fruit yield for all varieties, was for the high nitrogen level to give the greatest yield and the largest fruit. Phosphorus and potassium variations showed no consistent or distinguishable effect upon yield or fruit size in any of the varieties. However, it must be emphasized that this is but the first full crop under the conditions of the experiment. Alternate bearing tendencies and other natural effects on fruit bearing may change the accumulated yield figures.

Nitrogen in the Leaves

The nitrogen content of the leaf increases with added increments of nitrogen. This fact is substantiated by leaf color. Phosphorus and potassium variations appear to have no effect on the nitrogen concentration of the leaf. In general, leaves of the same age, under all nitrogen variations, gathered in the spring, tend to have less nitrogen than those of the same treatment and age gathered in the winter.

Phosphorus in the Leaves

When nitrogen levels are low, increasing the phosphorus levels in the fertilizer indicates a parallel increase of phosphorus in the leaves. At the highest nitrogen levels, increased phosphorus levels seem to have no influence on the amount of phosphorus found in the leaves. From these data apparently variations of potassium levels at the three nitrogen levels have no consistent effect on phosphorus in the leaves.

Potassium in the Leaves

As the nitrogen levels of the fertilizer are increased, there is a corresponding decrease in potassium in the leaves regardless of the potassium level in the fertilizer. However, at any one nitrogen level, when the potassium in the fertilizer is increased, it is directly reflected by increased potassium in the leaf. The two observations hold true consistently for all four varieties. There appeared to be no influence of the phosphorus levels in the fertilizer on the potassium content in the leaves.

Observations on Analysis of winter and Spring Leaf Growth

In general, leaves of the same age, under all nitrogen variations, gathered in the spring, tend to have less nitrogen than those of the same treatment and age gathered in the winter. This tendency is the same for phosphorus under the low and medium nitrogen levels, but little difference is noted at the highest nitrogen level. Under the conditions of this experiment to date, apparently season has no effect on potassium in the leaf.

DISCUSSION

General field observations, fortified by the first year's yield and analyses data on the avocado block under N, P, K, level variations, have indicated some general trends. Of the three major elements, nitrogen appears to have the most direct effect upon yield, tree growth and condition. It seems possible that adequate potassium applied on plots receiving low nitrogen, in itself has a visible beneficial influence on tree condition. This influence will probably be reflected in subsequent increased crop yields, larger trees and trees with more luxuriant growth than when low nitrogen levels are accompanied by corresponding low potassium levels.

From the small amount of data available it would be unfair to state that the effect of variations of phosphorus levels is negligible. However, no visible or analytical differentiations can be discussed to date from this experiment. The Miami Oolite soils on which these test plots are growing have a low available phosphorus content, and as the soil preparation methods of land scarifying tend to make phosphorus less available, the plots receiving either none or very low phosphorus levels should in time show the visual effects of the lack of phosphorus. The trees in these plots for the first year and a half of their juvenile life received a grower type fertilizer containing high levels of available phosphorus. It is possible that because some tree crops have an apparent low total phosphorus requirement, the carry-over from phosphorus applied during the juvenile stage is still adequate.

Even though only trends can be observed from this preliminary report, it is evident to the grower that the highest level of nitrogen, i.e. 6%, produces the most luxuriant tree with the best yields of good fruit. Some potassium must be included in the fertilizer as the leaf analyses show that at the highest nitrogen levels, if potassium is either withheld or applied at the lowest level, a very low potassium content of the leaf results. This condition on a continuous basis may drop the potassium content of the foliage so low as to be detrimental to tree growth. The indications are that phosphorus in the fertilizer can be kept at a rather low level but again if it is completely eliminated, eventual damage to the tree may result due to an actual deficiency of this element.

The data show that seasonal differences must be taken into consideration when comparing leaf analyses between years.

SUMMARY

Nitrogen level variations in applied fertilizers appear to have a direct effect on tree trunk growth, tree size, tree condition and yield of Booth 7, Booth 8, Waldin and Lula avocados.

Phosphorus and potassium level variations in the fertilizer have very little influence on the appearance of the tree or fruit yield in avocado as mentioned above under the conditions of this preliminary report. Increasing the nitrogen level in the fertilizer tends to increase the nitrogen in the leaf and decrease the potassium in the leaf. Increasing the potassium level of the fertilizer, at a constant level of nitrogen in the fertilizer, tends to increase the potassium level in the leaf without materially affecting the nitrogen content of the leaf in these four avocado varieties. Increasing the phosphorus levels, at the lowest nitrogen level in the fertilizer, tends to result in a slight increase of phosphorus in the leaf. However, at the two higher levels of nitrogen in the fertilizer, increased phosphorus level does not have this effect.

LITERATURE CITED

1. Ruehle, Geo. D. — Avocado Production on Florida Sands. Citrus Ind. 35: (8). 10-13: 19B4.
2. Childers, N. F., Editor—Mineral Nutrition of Fruit Crops. Hort. Publ., Rutgers Univ., New Brunswick, N. J. 905 pp.: 1954.
3. Haas, A. R. C.—Nitrogen Effects on Avocado Seedlings in Soil Culture. Calif. Avocado Soc. Yearbook. 51-54: 1947.
4. —. — (Growth and Composition of Avocado Seedlings in Soil Cultures as Effected by the Relation of Calcium to Magnesium in Applied Solution. Calif. Avocado Soc. Yearbook. 144-154: 1949.
5. —. —Avocado Leaf Symptoms Characteristic of Potassium, Phosphate, Manganese and Boron Deficiencies in Solution Cultures. Calif. Avocado Soc. Yearbook. 103-109: 1939.
6. Sterges, A. J., Hardin, L. J., & MacIntire, W. H. —A Modification of The Official Micro Method for Determination of Phosphorus Content of Plant Tissue. Jour, of Off. Agric. Chem. 33: 114-121: 1950.
7. Lynch, S. John, Seymour Goldweber, & Clarence E. Rich.—Some Effects of Nitrogen, Phosphorus & Potassium Fertilization on The Constituents of Persian Lime Fruits. Fla. State Hort. Soc. Proc. 224-227: 1953.