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REVIEW OF AVOCADO FERTILIZER PRACTICES IN SAN DIEGO COUNTY

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Introduction

Avocado fertilization is probably the most controversial cultural practice the grower encounters as he attempts to grow avocados. There are two reasons for this. They are: 1) there are many different types of materials on the market, both organic and inorganic fertilizers, from which to choose; and, 2) every person in the industry seems to have his own special formula on how to fertilize avocados.

In San Diego County, most of the soils in which avocados are grown are decomposed granite. The soil series that avocados are most commonly planted in are: 1) Vista Sandy Loam, 2) Fallbrook Fine Sandy Loam, and 3) Cieneba coarse sandy loam.

The pH of these series is from 6.0 to 7.2. The nutrient level of nitrogen, phosphorus, potassium, and zinc is relatively low compared to other type soils in California. These soils are deficient in nitrogen, and this element must be applied to the soil and trees each year. Phosphorus, potassium, and zinc levels are becoming deficient; and these elements are being used more and more as orchards are planted on the steep hillsides in shallow soils.

Avocado trees, like other plants, require mineral nutrients for growth and production. These nutrients are obtained from the soil by the root system of the tree. After a tree has grown in the soil for some time, certain of these mineral nutrients may become depleted or, for other reasons, the roots may be unable to obtain enough to supply the trees. It is then necessary to apply fertilizers to overcome the deficiencies.

Avocado trees are shallow rooted with 80 to 90% of their root system in the first two feet of soil. Because of this shallow rooting, it is possible for the roots to obtain any nutrient element that is present in the upper portion of the soil profile. Also, avocado trees are good foragers and are able to pick up the required amounts of nutrients for good plant growth.

Long term experimentation and experience indicate the following nutrient elements must be applied to avocado trees in San Diego: 1) Nitrogen, 2) Zinc, 3) Phosphorus, and 4) Potassium.

NITROGEN

Nitrogen is the most widespread deficiency in San Diego County avocado orchards.

Nearly all orchards require some nitrogen fertilization each year in order to maintain normal yields.

The amount of nitrogen required by avocado trees will vary as to variety and age. For instance, Hass trees require up to twice the amount of nitrogen that other varieties, such as Fuerte, Bacon, and Zutano, need. The following table is a guide to a schedule of dosages of nitrogen materials per tree needed by avocado varieties other than Hass:

1st Year — 1 tablespoon of commercial fertilizer (ammonium nitrate, etc.) every third irrigation

2nd Year — 1/8 pound elemental nitrogen in split application each year

3rd Year — 1/4 pound elemental nitrogen in split application each year

4th Year — 1/2 pound elemental nitrogen in split application each year

5th Year — 3/4 pound elemental nitrogen in split application each year

10th Year — 1 pound elemental nitrogen in split application each year

11th - 20th Year — 1 ½ to 2 pounds elemental nitrogen in split application each year.

Nitrogen can be best applied in a chemical form. Materials such as calcium nitrate (15%N), ammonium nitrate (33%N), and urea (46%N) can be used in a good fertilizer program. A change, or rotation, of materials every year or so is suggested. Extensive use of acid forming residue materials like ammonium nitrate and urea will cause a lowering of the soil pH to what could be a harmful level. To avoid this situation it is recommended that these materials be alternated each year with calcium nitrate.

The shallow, infertile soils found on the hillsides of San Diego County, where most avocado orchards are planted, will benefit with the application of organic materials. There are bulky organic materials, such as straw and manures, and concentrated organics like blood meal, fish meal, etc. Bulky organics are less expensive, but their nutrient contents are much less than the concentrated organics. Following is a table giving examples of bulky organic, concentrated organics, and inorganic materials.

Kind	%N	%P_2O_5	%K_2O
Bulky Organic Materials			
Dairy Manure	.7	.30	.65
Steer Manure	2.0	.54	1.92
Horse Manure	.7	.34	.52
Poultry Manure	4.0	3.20	1.90
Kelp	.2	.10	.60
Concentrated Organics			
Blood	13.0	-	-
Fish Meal	10.4	5.90	-
Tankage	7.0	8.60	-
Urea	46.0	-	-
Inorganic Materials			
Calcium Nitrate	15	-	-
Ammonium Nitrate	33	-	-
Ammonium Phosphate	16	20	-

Organic materials can be applied at any time during the year, but fall is the best time. Caution should be used in applying organic matter to avocado trees. Do not apply the material too heavily to the soil. A heavy cover of organic material could cause the roots to become suffocated. Oxygen is very important to root activity and operation. If a heavy application of organic matter is made at one time, it could exclude air from the roots causing damage to the trees.

Nitrogen can be applied twice a year, usually in February and July. Fertilizing is not recommended during the blossom and fruit setting period of March to June.

These recommendations are for hand application to orchards under fixed or rotating sprinklers. Following is a table showing the suggested amounts of nitrogen to inject into a drip irrigation system.

Age of Trees	Amount [pounds] / Tree / Month		
	Urea	Ammonium Nitrate	Calcium Nitrate
1	0.03	0.04	0.09
2	.06	.08	.17
3	.09	.13	.29
4	.14	.19	.43
5	.28	.38	.90

Nitrogen deficient trees will show leaves a light green in color, yellow veins, lack of vegetative growth, small leaves, reduced yields, and premature leaf drop.

PHOSPHORUS AND POTASSIUM

During the last few years; there have been decreasing levels of phosphorus and potassium observed in many leaf analyses from San Diego County avocado orchards. The granitic soils are inherently deficient of these two elements, plus the withdrawal of these nutrients by the avocado plant, results in lower leaf levels.

Various forms of phosphorus and potassium are available. They can be applied singly, together, or in combination with nitrogen. Some of these materials are: ammonium phosphate (16-20), treble superphosphate, triple 15 (15-15-15), potassium sulfate, etc.

Nitrogen and potassium materials are soluble in water, so these materials can be applied through an irrigation system. Phosphorus materials that have not been acidified cannot be used in an irrigation system where the high calcium Colorado River water is used. If the phosphorus material is not acidified, a precipitate will form causing a clogging of the irrigation system.

Mixed fertilizer of nitrogen - phosphorus - potassium can be applied in the same manner as with nitrogen alone. The amount of material will be governed by the nitrogen dosage required. If an N-P-K solution is used in an irrigation system, either sprinkler or drip, the solution should be acidified sufficiently to counteract the high calcium content in the Colorado River water. If nitrogen fertilization is accomplished by injecting into a drip irrigation system throughout the year, then the phosphorus and potassium can be applied to the soil in the fall. The winter rainfall will take these materials into the root zone.

There have been no leaf or tree growth symptoms determined relating to a phosphorus or potassium deficiency. Leaf analysis is the only known way to determine if there is a

phosphorus or potassium deficiency.

ZINC

Zinc deficiency, usually referred to as Mottle Leaf, occurs commonly on avocado trees. It is the one micronutrient element most often recognized as being deficient.

A nutritional problem, this deficiency causes reduced tree vigor and lower yields. If not corrected, the tree may die from lack of zinc. Symptoms of Mottle Leaf are: 1) light yellow (chlorotic) areas between the veins, starting at the margin of the leaf and extending to the mid-rib and base; 2) small and narrow leaves; 3) pear-shaped fruit becomes oval to round, and smaller than normal as deficiency becomes more pronounced; 4) terminal growth is of "feather duster" type; 5) twig dieback and defoliation occurs; and 6) on older trees the bark on the trunk becomes cracked and splits open.

Zinc deficiency is easily corrected, either by a foliage spray or soil application. The foliage spray is usually applied in the spring after the new spring flush of leaves has fully expanded. This normally occurs in June. The recommended spray is one pound of zinc sulfate (36% metallic zinc) in 100 gallons of water. Aerial application of zinc using a helicopter or fixed wing aircraft has had variable results. In some orchards the zinc level in leaves did not increase after an aerial application. The reason for this is not known. A leaf analysis is recommended yearly to maintain a check on the efficiency of the zinc treatment.

Soil application with zinc sulfate (36% metallic zinc) may be used with good results on acid-type soils. The soil application is suggested for orchards where spray rigs do not have access, such as crowded orchards and/or steepness of land. The soil treatment gives a slower response than a foliage spray, but has a longer lasting effect. Soil application will be effective from 3 to 6 years, while spraying must be done annually.

Effectiveness of zinc placed on the soil depends upon the soil type, soil pH, and rate of application. The more coarse and open the soil, the quicker the response. On clay-type soils, the period before any correction is noticed will be about one year after application. Applying zinc to alkaline soils is seldom effective. Soil application of zinc can be done at any time during the year. Fall is usually best, however, because the winter rains take the zinc into the surface soil. Following is a table of dosages for various aged trees:

Age-Years	Dosage Per Tree [pounds]
2	1 Zinc sulfate (36% Zn)
5	2 Zinc sulfate (36% Zn)
7	3 Zinc sulfate (36% Zn)
10	4 Zinc sulfate (36% Zn)
15	6 Zinc sulfate (36% Zn)
20	7 Zinc sulfate (36% Zn)

Method of application is to place the material in a band about two feet wide at the drip-line of large trees. For smaller trees use a proportionately narrower size band.

Zinc chelate materials are effective as a soil treatment. Economics will determine whether zinc chelate or zinc sulfate will be used. Usually the sulfate is less expensive.

Avocado trees supplied with sufficient zinc remain in a healthy condition.

IRON

Iron deficiency does not occur in the soil series where avocados are usually grown in San Diego County. Deficiencies occur on soils that are highly calcareous. In San Diego County, the two soil series that would be detrimental to avocados are Altamont clay and Diablo clay. Knowledgeable growers will never plant avocados in these soils because of the high clay content and the large amount of calcium carbonate (limestone) present in the soil profile.

Symptoms of iron deficiency appear on the leaves, and in severe cases, defoliation and twig die-back take place. Leaf symptoms show a pale green to yellow color between the veins and veinlets. Veins remain green. As the deficiency increases the area between the veins becomes yellow to whitish in color and the veins lose their green color. Leaves will be smaller, completely chlorotic, and show marginal and tip burn in severe cases.

Control or correction of this deficiency is not always possible. High limestone in the soil limits the utilization of iron by the plant. West Indian type rootstocks are most tolerant to calcareous soil. Mexican and Guatemalan rootstocks are not too tolerant of high lime soils.

Iron chelate materials have given variable results. Treatment is expensive. An application of ¼ - ½ pound iron chelate per mature tree in May or June is suggested. This treatment should be done annually.

LIQUID FERTILIZERS

Liquid fertilizers are not new. They have been used on many crops, such as oranges, flowers, nurseries, strawberries, vegetables, etc., for many years. When it was convenient, avocado growers used liquids, but on a limited scale. Since many avocado orchards must use Colorado River water, irrigation systems would become clogged with a precipitate caused by the interaction of the high calcium in the water with the phosphorus containing fertilizer when it was injected into the irrigation system. Today, the suppliers of liquid fertilizers have formulated mixed fertilizer in such a way as to counteract the high calcium in the irrigation water which prevents the precipitate from forming.

Experience with fertilizing through an irrigation system has shown that less fertilizer is required, since the material is taken directly into the root zone and the tree is able to obtain the necessary nutrients easily. Fertilizing through an irrigation system reduces the loss of some types of fertilizer due to volatilization. "Fertigation" reduces labor costs in that orchard workers are no longer required to spend many hours spreading material by hand to thousands of trees.

There are a number of companies in San Diego County formulating numerous liquid fertilizer mixes. There are a few questions regarding the use of any type of fertilizer — wet or dry — that should be asked, and they are:

1. What does the avocado tree require in nutrient elements?

The avocado tree needs most nutrient elements. However, many of them are obtained from the soil and water. Some elements are deficient in both the soil and water. The nutrients that must be added to the soil for proper tree growth are nitrogen, phosphorus, potassium, and zinc. These must be applied annually. All other nutrients appear to be adequately supplied by the soil and water.

2. How does a grower know what the avocado trees require?

Leaf analysis is the best guide to fertilizing avocado trees. A leaf sample taken in the fall of the year will provide the information necessary to devise a good fertilization program. Refer to the following discussion on "Leaf Analysis."

3. Which fertilizer is best, liquid or dry?

Cost of the material, cost of application, ease of application, and the uptake of nutrients to provide adequate nutrition are factors to consider. A leaf analysis will give the answer to what elements, and how much, are taken up by the plant. Costs of each material or mix should be compared.

The nutrients used should be based upon the data obtained in the leaf analysis. To find the cost per pound of nitrogen, use the following formula:

$$\frac{\text{Cost per ton x 100}}{\text{Percent nitrogen x 2,000 pounds}} = \text{Cost per pound of elemental nitrogen}$$

Example: Urea, $200 per ton, 46% nitrogen

$$\frac{\$200 \text{ x } 100}{46 \text{ x } 2{,}000 \text{ pounds}} = 21.7¢ \text{ per pound of elemental nitrogen}$$

LEAF ANALYSIS

Annual leaf analysis provides an excellent technique to monitor the level of nutrients in the plant. The usual analysis will include nitrogen, phosphorus, potassium, calcium, magnesium, and zinc. A more complete analysis, including such elements as iron, copper, manganese, boron, etc., is not usually necessary because these elements are not lacking in the avocado plant. A complete leaf analysis could be done every five years just to keep track of how the tree is picking up the nutrients.

Following is a table giving the ranges (deficient, adequate, and excess) of elements in avocado leaves.

Element		Unit	Ranges for mature trees*		
			Deficient: less than	Adequate	Excess: more than
Nitrogen	(N)	%	1.6	1.6-2.0	2.0†
Phosphorus	(P)	%	0.05	0.08-0.25	0.3
Potassium	(K)	%	0.35	0.75-2.0	3.0
Calcium	(Ca)	%	0.5	1.0-3.0	4.0
Magnesium	(Mg)	%	0.15	0.25-0.80	1.0
Sulfur	(S)	%	0.05	0.20-0.60	1.0
Boron	(B)	ppm‡	10-20	50-100	100-250
Iron	(Fe)	ppm	20-40	50-200	?
Manganese	(Mn)	ppm	10-15	30-500	1,000
Zinc	(Zn)	ppm	10-20	30-150	300
Copper	(Cu)	ppm	2-3	5-15	25
Molybdenum	(Mo)	ppm	0.01	0.05-1.0	?
Chloride	(Cl)	%	?	?	0.25-0.50
Sodium	(Na)	%	—	—	0.25-0.50
Lithium	(Li)	ppm	—	—	50-75

*Based on analysis of the most recently expanded and matured, healthy, terminal leaves from non-flushing and non-fruiting terminals sampled during mid-August to mid-October. (These are normally leaves from the spring growth cycle.) Values expressed on a dry-matter basis.

† Values above 2 percent N will not increase yield in most varieties; however, a reduction in yield of the Fuerte variety may occur above that level.

‡ ppm, parts per million

Spring cycle leaves taken from the trees in the fall months (August 15 to October 15) are subjected to a chemical test in the laboratory. The nitrogen percentage is the most reliable figure, and that of which most is known, in relationship to production. The 1.6-2.0% nitrogen level is satisfactory for Fuertes. Bacons, and Zutanos. Hass leaf nitrogen levels should read higher, 2.0-2.4%.

SUMMARY

Fertilization of avocados in San Diego County must be done on a regular basis. All age trees should be fertilized either with dry or liquid materials. Scheduling applications will vary depending upon age of trees, type of irrigation system (drip, sprinklers), and material used.

If drip irrigation is used to irrigate the orchard, fertilization must begin in February and continue until November 1. Fertilizers must be injected into the system on a weekly or twice a month basis. The amount of material to use is outlined in the table found in the nitrogen section of this paper. If a liquid mixed fertilizer containing nitrogen, phosphorus, and potassium is used, the solution should be acidified enough to counteract the high calcium in the irrigation water. This prevents a precipitate from forming and clogging the system. The liquid fertilizer likewise will be applied weekly.

Before purchasing any fertilizer it is good financial management to determine the cost of each product available. A comparison can be made, based upon the cost of the material and what is actually needed by the plant. There is no need to pay for elements that are already well supplied to the trees.

A leaf analysis made each fall will provide a good record of a fertilizer program. Laboratory results will vary each year. If an analysis is done faithfully each year, the value of leaf analysis is enhanced. It is really more important to establish trends in each of the elements over the years than to have just one reading within a span of years. Leaf analysis is an excellent tool and should be a part of every grower's fertilization program.

For many years, growers have used acid-residue type of nitrogen fertilizers such as urea and ammonium nitrate. If a soil pH reading has not been done within the last 2-5 years, it may be a good idea to have the soil pH tested. If the pH drops below pH 6, then some type of liming should be done. Switching to calcium nitrate as a nitrogen source is an effective way of correcting the acid condition. Limestone can be used if the pH is low and a relatively quick response is necessary.

Careful attention to the fertilizer program will pay dividends: 1) reduced use of fertilizer, 2) reduced costs, 3) good soil conditions, 4) improved tree health, and 5) good yields.