



FERTILIZATION OF AVOCADO TREES

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Introduction

For good growth and yield of avocado trees, fertilizer applications are usually required to supplement plant nutrients available from the soil. Some types of fertilizer are best applied before planting, and others are best applied afterward.

Preplant fertilizer and soil amendment applications may have a long-term effect on orchard productivity. These include applications of agricultural lime to reduce soil acidity and fertilizer phosphorus (P) to promote root growth. Such materials must be thoroughly mixed with the soil for maximum benefit. Their need is determined by soil tests.

Fertilizers are also applied to the soil surface at intervals during the establishment and bearing stages of the orchard. The timing and amount of these applications can influence tree vigor and yield. In mature stands, the plant nutrient requirement may be indicated by leaf analysis.

Specific nutrient requirements of avocado grown in Hawaii are not well known, and much of the information given here is based on avocado production elsewhere. This guide covers plant nutrients needed by avocado, fertilizer applications, and methods of diagnosing plant nutrient requirements.

Preplant Applications

For best results, have the soil tested before planting, and follow recommendations. Because soils of Hawaii are highly variable, samples for soil tests should be taken from each distinct area of an orchard. The soil type may be determined by using the soil survey of the island concerned.¹ Soil classification can provide useful information for soil management.²

Adjustment of soil pH and correction of soil P and calcium (Ca) deficiencies should be done before planting. The optimum soil pH for avocado is between 6.2 and 6.5. If soil is strongly acid, add lime (calcium carbonate) to raise pH to 6.5. If magnesium (Mg) is deficient, dolomite can be substituted for part of the lime requirement. To provide Ca when soil pH is adequate, calcium nitrate or calcium sulfate (gypsum) can be used without strongly affecting pH. Adequate Ca may be provided by P applications when superphosphate (20 percent Ca) or triple superphosphate (14 percent Ca) is used. Apply P based on soil test recommendations.

Lime, dolomite, and P fertilizers should be thoroughly mixed with the soil. If applied only to the soil surface, they do not readily move into the root zone. This results in the formation of roots at the soil surface, where they are susceptible to moisture stress, weed competition, and mechanical damage.

Postplant Applications

Many soils in Hawaii are low in nitrogen (N) and potassium (K). In soils of high rainfall areas, these nutrients are readily leached beyond the root zone and are best added in small, frequent applications. A complete fertilizer (containing N, P, and K) should be mixed with the soil in the planting hole when trees are transplanted to the field. Later, fertilizers are broadcast evenly over the root zone between about 1 foot from the trunk and 1 to 2 feet beyond the leaf drip line. Fertilizers may also be applied in solution by injection into drip irrigation waterlines, or in foliar sprays.

Avocado trees often have shallow root systems. Do not cultivate over the root zone to incorporate fertilizers, because mechanical damage to roots may promote *Phytophthora* infestation. Avocado is susceptible to *Phytophthora* root rot, a fungal disease associated with poor soil drainage. Certain soil conditions are believed to suppress *Phytophthora* activity.

¹Soil survey reports may be found at public libraries or obtained from county USDA Soil Conservation Service offices.

²See "Soil Classification in Hawaii," University of Hawaii Cooperative Extension Service Circular No. 476.

These are high Ca levels, which are sometimes indicated by soil pH between 6.2 and 7.0, and high levels of soil ammonium nitrogen (NH₄⁺). Practices that increase soil organic matter may also aid in combating *Phytophthora*. Ammonium nitrogen is released as soil organic matter decomposes, and application of organic matter to the soil surface allows development of new feeder roots to replace those damaged by *Phytophthora*.

Avocado is sensitive to soil salinity. Irrigation water should be monitored for salts. Excessive fertilizer applications may result in harmful buildup of salts. Trees infested with *Phytophthora* are susceptible to damage from chloride (Cl⁻) accumulation. Cl⁻ toxicity shows as burning of leaf tips and margins. To avoid Cl⁻ toxicity, the use of potassium sulfate is recommended instead of muriate of potash (potassium chloride), which is the most commonly used potassium fertilizer.

Nitrogen. N is usually the most limiting plant nutrient. The amount required by avocado depends on cultivar and growth stage, soil, amount of rainfall or irrigation, organic matter, cover crops, yield variations, and presence of *Phytophthora*.

Lack of adequate N reduces growth and yield and increases disease incidence. N deficiency is indicated by slow growth, small leaves, and pale green leaf color or yellowing of the entire leaf (chlorosis). When N deficiency is caused by root damage, leaves may have yellow veins with pale green areas between them.

Overfertilizing with N may cause problems. In some avocado varieties, leaf N levels exceeding 2 percent are associated with production decline. N is needed most by the tree during flowering and fruit setting, but excessive N may cause flower drop and failure to set fruit.

Table 1. Application levels of elemental nitrogen for avocado

Year	Amount per tree ^a	
	(grams)	(ounces)
1	25-40	1.0-1.6
2	40-90	1.4-3.2
3	70-150	2.5-5.3
4	85-230	3.0-8.1

^aLow values are from South Africa (Koen and Langenegger). High values are from Goodall et al.

The total amount of N provided per year should be divided into two or more applications, one of which should be applied after harvest. Applications may be as often as monthly except during dry periods. Frequent applications are

necessary on 'a'ā lava soils, especially where rainfall is high, because N is easily leached below the root zone in these soils. N is applied as a topdressing or by injection into irrigation waterlines. Table 1 shows N application levels recommended for avocado.

Zinc. Zinc (Zn) deficiency appears frequently in avocado grown in California, and routine Zn applications are recommended there. Deficiency may result from low soil Zn levels, high soil pH (above 7.0), and excessively high soil P levels. It is first seen on new growth. Young leaves are smaller than normal and light green, progressing to pale yellow, between the leaf veins; the veins remain green, giving the leaves a mottled appearance. Fruit may be smaller and more rounded than usual for the variety.

Zn may be applied to the soil surface as a band along the leaf drip line or in holes 6 inches deep along the drip line. Care should be taken not to apply too much Zn. Appropriate rates depend on soil type and tree size. Apply test applications to a few trees before applying to large areas.

Rates of Zn as zinc sulfate (36 percent metallic Zn) for surface band applications in California begin at 0.7 pound per two-year-old tree, increasing to 6.5 pounds per tree for 20-year-old trees. When applied in holes, only half the amount of Zn per tree is required. A single application should be effective for several years.

Foliar spray application is an alternative to soil application and is usually done annually. Applications recommended in California are 1 pound zinc sulfate in 100 gallons water or 2 pounds zinc oxide in 100 gallons water, applied at 300 to 400 gallons per acre for young, bearing trees, and up to 600 to 800 gallons per acre for mature orchards. Zinc chelate may be used at 1 pound per 100 gallons water, applied at 100 to 200 gallons per acre. Soil application of Zn is considered more effective and more economical than foliar sprays.

Other elements. Other elements may be required as indicated by deficiency symptoms or leaf analysis. K is applied as a topdressing or via irrigation lines. P should be applied in holes beneath the leaf drip line, because surface applications will not readily move into the soil. Micronutrients may be applied by foliar spray.

Nutrient Budgets in Avocado

Avocados remove low levels of nutrients in the harvested crop. A yield of 9000 pounds of fruit per acre removes 10 pounds of N and 17 pounds of K. Before falling, leaves return to the tree about 60 percent of their N-P-K, 40 percent of their Ca, and 25 percent of their Mg content. Much of the remaining nutrients in fallen leaves and blossoms is cycled to the soil through litter

decomposition if the litter remains beneath the tree, although N and sulfur (S) may be lost to the atmosphere during decomposition.

It is difficult to estimate nutrient losses due to leaching, but they may be greater under trees with shallow root systems. On certain sites, nutrient losses due to soil erosion may be high. Trees infested by *Phytophthora* may have nutrient uptake confined to soil zones where roots are able to proliferate under relatively *Phytophthora*-free conditions.

Weeds compete with avocado for nutrients and soil moisture, and they should be controlled.¹ Cover crops also can be competitive if not properly managed. The extra nutrients that cover crops require should be supplied in fertilizer applications. The cover crops may be considered as nutrient "banks," because most of their nutrients will be returned to the soil as a leaf-litter layer forms beneath them, or as they are shaded out. Cover crops that include legumes may make a net N contribution to the orchard.

Leaf Nutrient Analysis

One method of assessing the tree's nutrient status is to monitor its internal nutrient concentrations. This is done by analyzing the amounts of nutrient elements stored in certain leaves of the tree.

In diagnosing poorly growing trees, suspected nutrient deficiencies should be confirmed by leaf nutrient analysis, because diseases, insect damage, pesticide damage, and other causes may also be the reason(s) for the observed symptoms. Leaf nutrient analysis may also be used in the attempt to optimize fertilizer inputs and maximize yields. Soil analyses are often done in conjunction with leaf analyses.

Leaf nutrient analysis is sometimes difficult to interpret because of variation caused by inconsistencies in leaf sampling techniques and the lack of leaf analysis standards for local varieties and conditions. Getting accurate leaf nutrient analysis data depends on careful sampling and handling of the leaves. Subsequently, with good record keeping on fertilizer applications and tree yields, and follow-up leaf analyses, the value of the method may be realized.

Leaf analysis is most reliable in mature orchards with trees over seven years old; it may have limited use in monitoring younger trees. The effects of alternate-year bearing on leaf nutrient levels are not known.

Uniform sampling is critical to interpreting leaf analyses. Factors that should be rigorously standardized for each sample include cultivar,

age of tree, age of leaves sampled, season when sampled, side of tree sampled, crop load, and timing of sampling relative to fertilizer applications.

Samples should be healthy, full-sized, mature leaves produced by the most recent growth flush and taken from branches that are neither flushing nor fruiting. In California, such leaves may be five to seven months old when sampled. Six to eight leaves taken from each tree are combined to make one sample for each tree. The leaves may be taken from several branches if uniformity is maintained. Samples from uniform trees may be combined. Leaves should be gently wiped or rinsed (without soaking) in tap water to remove any soil or spray residues. To prevent rotting, refrigerate leaves in plastic bags; use paper bags if refrigeration is not available. Sample bags should be clearly labeled with an indelible pen, and the sample source information should be completely and explicitly recorded. Transport leaves to the laboratory as soon as possible after sampling.

Leaf analysis results may be compared to the values given in Table 2. When nutrient deficiencies are confirmed, applications of supplemental nutrients should be made to trees on a trial basis, maintaining untreated trees for comparison. After another growth cycle, sampling should be repeated to determine the response to the treatment.

Suggested Fertilizer Program

P is needed during early growth stages to develop a strong root system. After trees begin to bear, N and K are needed to produce large, high quality fruit. In general, use 10-30-10 fertilizer in the early years and 10-5-20 after trees begin bearing.

Use fertilizers carefully. Excessive amounts on any tree can cause root damage, leaf burn, and defoliation. In severe cases, trees may die.

This is an example of a fertilizer application program for avocado, assuming that soil pH and P deficiencies have been corrected during field preparation:

- 4 oz triple superphosphate (0-46-0), plus 4 oz 10-30-10 in hole at planting; mix thoroughly with soil before planting or transplanting.
- 4 oz 10-30-10, 4 months after planting.
- 4 oz 10-30-10, 8 months after planting.
- 4 oz 10-30-10, 12 months after planting.
- 1.5 to 2 lb 10-30-10 per tree per year split into 3 applications during year 2.
- 2 to 4 lb 10-30-10 per tree per year split into 3 applications during years 3 and 4.
- To bearing trees, for each inch of tree diameter measured at a height 4 to 5 feet from the ground, apply 1 pound of 10-5-20 per year, split into two or three applications.

¹See HITAHR Brief No. 59, "Chemical Weed Control in Avocado."

Table 2. Ranges of elements in avocado leaves^a

Element	Symbol	Unit	Deficient	Ranges for mature trees ^b	
				Adequate	Excess
Nitrogen	N	%	<1.6	1.6-2.0	>2.0
Phosphorus	P	%	<0.05-0.1	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	0.25-0.8	>1.0
Sulfur	S	%	<0.05	0.2-0.6	>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	>1000
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 ⁻	%	?	?	>0.25-0.5
Sodium	Na	%	-	-	>0.25-0.5

^aFrom Table 5 in Goodall et al. Based on analysis of the most recently expanded and matured healthy leaves from nonflushing terminals sampled during mid-August to mid-October (these are normally leaves from the spring growth cycle). Values are expressed on a dry-matter basis.

^bData are based on the 'Fuerte' variety. Values may differ for other varieties. For example, although raising leaf nitrogen levels above 2 percent will neither decrease nor increase yields in many varieties, reduction in yield may occur above that level with 'Fuerte'. Adequate P levels in the 'Hass' variety should be above 0.1 percent.

Selected References

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