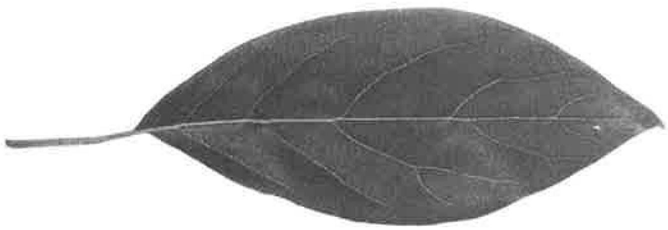
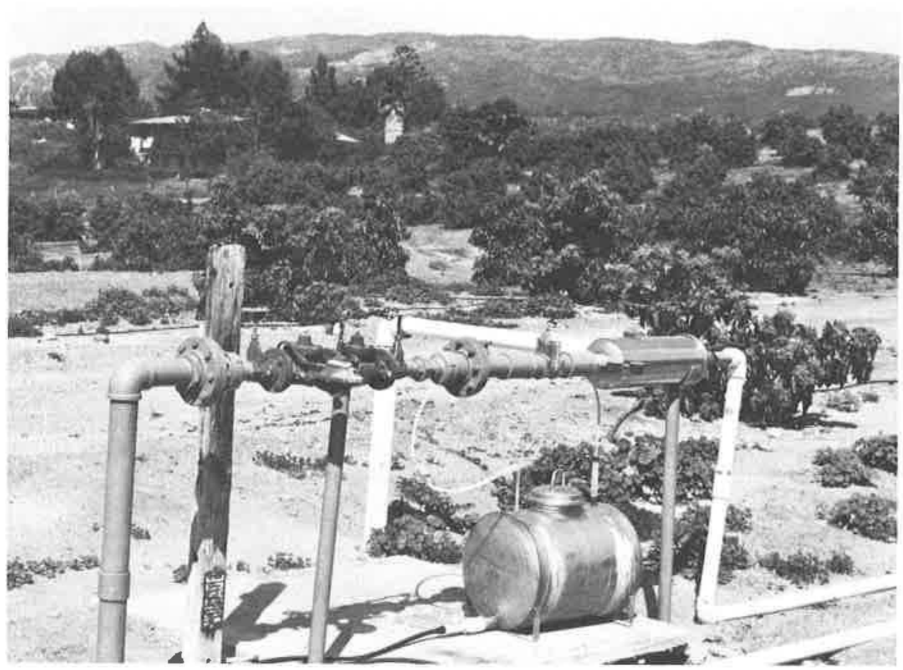
Avocado Fertilization





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Avocado Fertilization

Research has helped us to diagnose mineral deficiencies in avocado more accurately and to apply the appropriate amounts of fertilizers for best tree growth and fruit production. The recommendations in this leaflet are based on field experiments and on successful grove practices conducted in most of the avocado growing areas of southern California.

Avocado trees have comparatively few mineral deficiencies in commercial orchards in California. Only nitrogen and zinc need to be applied extensively; iron chlorosis occurs occasionally.

This leaflet is designed to aid growers in developing fertilization programs that will result in maximum yields of top-quality fruit.

TABLE 1. SUGGESTED NITROGEN LEVELS IN AVOCADO LEAVES

Variety	Nitrogen in leaf*
	percent
Fuerte	1.6 to 2.0†
Zutano	1.6 to 2.0
Hass	about 2.0
Bacon	about 2.0
MacArthur	2.0 (if attainable)

* Levels in 5- to 7-month-old spring-cycle leaves from mature trees.

† See fig. 1.

NITROGEN

Nitrogen is the most widely used fertilizer in California avocado production. To maintain normal yields, most orchards need annual nitrogen fertilization. Young trees need only a few ounces of nitrogen per tree annually.

Use fertilizers with caution. Excessive amounts on any size tree applied at any one time can cause root damage, leaf burn, and defoliation. In severe cases, trees may be killed.

Symptoms

Symptoms of nitrogen starvation include: lack of vegetative growth; pale green, small leaves; lower yields; premature defoliation; and, in severe cases, leaves with yellow veins.

Levels

Field research data show that each variety has its own particular response to nitrogen fertilization. High nitrogen rates reduce yields only in Fuerte. For varieties other than MacArthur, no advantage has been associated with leaf nitrogen levels above 2.0 percent.

Application of nitrogen at rates higher than necessary to maintain yield is not only more costly but can contribute unnecessarily to nitrate pollution problems. Consequently, the levels of nitrogen shown in table 1 are suggested for maximum yield and tree vigor.

For varieties not listed, a leaf nitrogen level of about, but not over, 2.0 percent is suggested.

The amount of nitrogen that should be applied to achieve the desired leaf level and yield varies from orchard to orchard, depending on past applications, soil type, irrigation and tillage practices, and materials used.

Where leaf analysis is not used, annual application of 100 to 200 pounds of elemental nitrogen per acre is suggested for mature orchards. Although this may not always be the correct amount for best yields, it has given acceptable production in many orchards. Some varieties, such as MacArthur, require more—perhaps 250 to 400 pounds of elemental nitrogen per acre.

A planted or volunteer cover crop under or near the tree will take nitrogen from the soil in competition with the trees. Therefore, additional nitrogen should be added to overcome this competition.

Where leaf analysis is used as a guide to nitrogen fertilization practice, determine the nitrogen level in the youngest fully expanded and mature leaves sampled in the August–October period. (These would normally be spring cycle leaves that are 5 to 7 months old.) Adjust the amount of nitrogen applied for the next year accordingly. If the nitrogen level in the leaves is greater than desired, apply less nitrogen than was applied the previous year; if lower than desired, apply more nitrogen than the year before. Leaf nitrogen at the desired level would suggest little or no change in the nitrogen program, provided no recent changes have been made in other cultural practices.

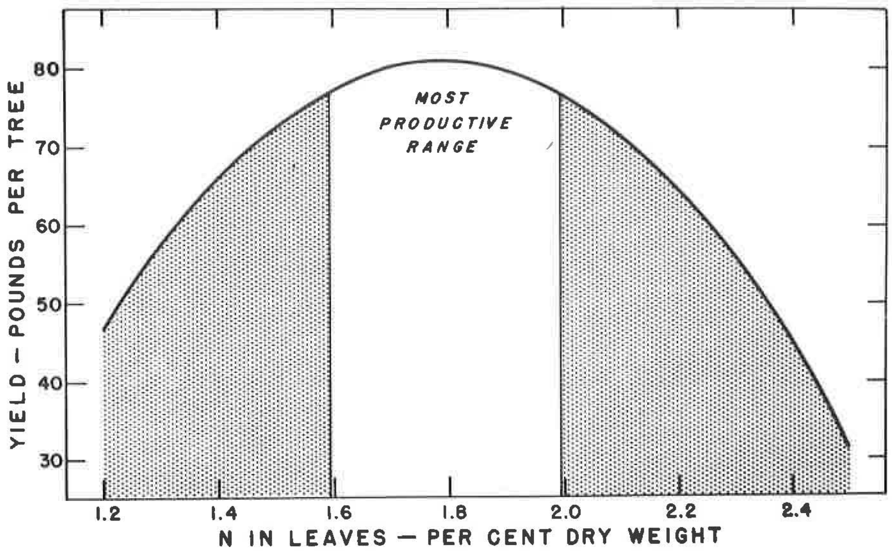

Fig. 1. The "most productive range" curve shows that Fuerte avocado yields reach a high level when nitrogen in leaves ranges from 1.6 to 2.0 percent.

In an experimental, nontilled orchard, application of about 125 pounds of elemental nitrogen per acre annually was optimum for Fuerte trees. Weeds under and near the trees were controlled so that no cover crop competed for nitrogen. Leaves of trees in the most productive range (fig. 1) were not as dark green as those with higher nitrogen levels. Below the most productive range, trees had light green to yellow leaves, shorter terminal growth, and less dense foliage. In other orchards, the amounts of nitrogen needed to attain the desired leaf nitrogen level have varied.

A number of agricultural laboratories throughout the avocado-growing districts perform leaf analysis. If leaf analysis is to be used as a guide for fertilization, let trained laboratory personnel collect and analyze the sample. The analysis is no better than the sample collected, and training is required to select the correct leaves for analysis. Your county University of California Cooperative Extension farm advisor can provide the names of laboratories in your area.

Timing

The nitrogen requirement of the tree is greatest during the period of flowering and fruit setting, but too much nitrogen may reduce fruit set of the Fuerte variety. If an adequate supply of nitrogen is available for this period, there normally will be enough carry-over in the soil to take care of the tree until the following spring. Chemical forms of nitrogen, applied over the area occupied by the roots in January or February, will be moved into the root zone by the rains. If nitrogen is applied in the irrigation water, apply most of the nitrogen early in the irrigation season.

Materials

In selecting a nitrogen source material, consider economy, residual effects on soil reaction and tilth, and convenience. Table 2 shows some common nitrogenous chemicals and their percentages of nitrogen.

To find cost per pound use this formula:

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

Example: Urea, $250 per ton, 46 percent nitrogen—

$$\frac{\$250 \times 100}{46 \times 2{,}000} = 27.2¢ \text{ per pound of elemental nitrogen}$$

Continuous use of ammonium sulfate for many years may make the soil so acid that the penetration rate of irrigation water is reduced. Continuous use of ammonium nitrate, anhydrous ammonia, or urea will also acidify the soil, but less rapidly than will ammonium sulfate. Many alkaline irrigation waters tend to offset this effect.

If water penetration is a problem, you may consider supplying part of the nitrogen in the fall in the form of a bulky organic matter, such as manure. When manure is used on nontilled orchards, part of its nitrogen is lost to the air. If the manure is cultivated into the soil, most of the nitrogen will be available to the tree. Its use frequently results in more tipburn on the leaves because of the high chloride content of many manures in southern California.

Mixed orchards

In orchards with mixed varieties and production patterns, you may vary the amounts applied to individual trees based on the following rules of thumb. On trees with heavy fruit set, little new growth, and pale leaf color, use extra nitrogen—up to twice the grove average. (Be sure these symptoms are not resulting from some other cause, such as root rot disease.) On mature trees with few or no fruits, strong vegetative growth, and dark green leaf color, use less or no nitrogen.

Drip irrigation

Table 3 gives suggested amounts of nitrogen to inject into a drip irrigation system. These suggested amounts may require adjustment as determined by leaf analysis.

Young trees

Fertilize young trees sparingly so as not to harm them, yet sufficiently to ensure maximum growth. The following program is suggested per tree for average conditions, using ammonium nitrate as an example. (If fertilizers other than ammonium nitrate are used, the amounts applied will be slightly more or less, depending on their nitrogen content.)

First year: Apply no more than a total of 1/10 pound elemental nitrogen annually, divided into equal monthly increments during the irrigation season (normally 8 months). This equals an application of approximately 1 level tablespoon monthly for 8 months.

Second year: Apply no more than a total of 1/5 pound elemental nitrogen annually, divided into four equal increments during the irrigating season. This equals an application of approximately 1/4 cup every other month.

Third year: Broadcast 1/2 pound (approximately 1/6 pound elemental nitrogen each application) in February and again in July.

Fourth year: Broadcast 1 1/2 pounds (approximately 1/2 pound elemental nitrogen) in January or February. In all cases, the fertilizer should be broadcast evenly above the root system just before a rain is expected or irrigation is applied.

TABLE 2. COMMON NITROGENOUS CHEMICALS

Material	Nitrogen content	Amount needed to supply 100 lb elemental nitrogen
	percent	*pounds*
Calcium nitrate	15½	645
Ammonium nitrate	33½	300
Ammonium sulfate	20½	488
Anhydrous ammonia (gas)	82	122
Urea	45 – 46	217 – 222

TABLE 3. SUGGESTED AMOUNTS OF NITROGEN TO INJECT INTO A DRIP IRRIGATION SYSTEM

Orchard age	Amount per tree per month*		
	Urea	Ammonium nitrate	Calcium nitrate
	pounds	*pounds*	*pounds*
1st year	0.03	0.04	0.09
2nd year	.06	.08	.17
3rd year	.09	.13	.29
4th year	.14	.19	.43
5th year (and older)	.28	.38	.90

* Pounds of fertilizer material per tree per month during a typical 8-month irrigation season.

ZINC

Zinc deficiency or "mottle leaf," as it is commonly called, occurs in many avocado orchards in southern California. The avocado tree may decline and even die without a small, but essential, amount of zinc.

Symptoms

The earliest symptoms are mottled leaves developing on a few of the terminals. The areas between the veins are light green to pale yellow. As the deficiency progresses, the yellow areas get larger and the new leaves produced are smaller. (See fig. 2.)

In advanced stages, a marginal burn develops on these stunted leaves, twig dieback occurs, and the distance between the leaves on the stem is shortened, giving a crowded "feather duster" appearance. Yield is reduced, and some of the fruits may be more round than is normal for the variety (fig. 3).

Control

Control can be achieved by applying zinc as a spray to the foliage or, in some soils, by application of zinc to the soil.

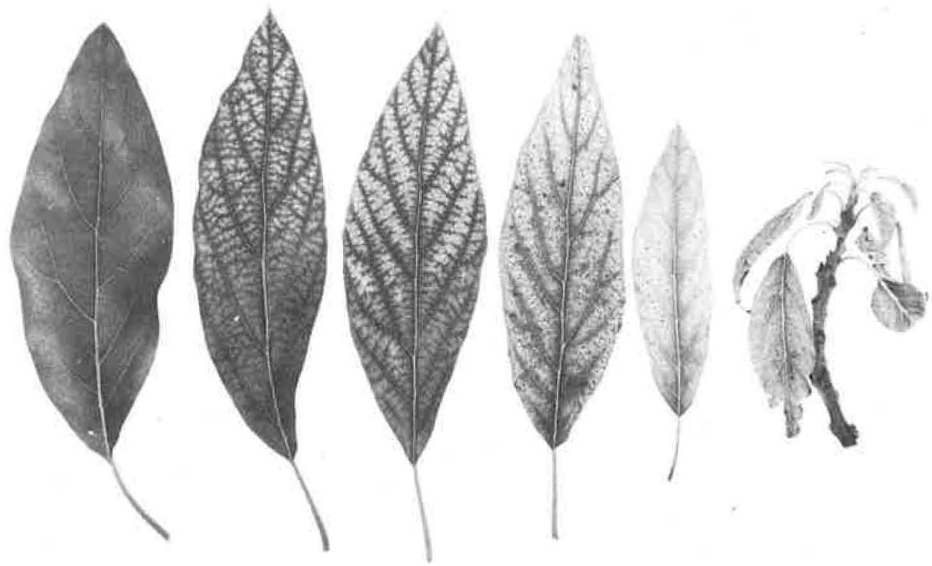

Fig. 2. Zinc deficiency shows in uniform mottling of the leaves. Leaf size is reduced with increasing deficiency, and in the most severe cases (leaves on the right) the distance between leaves on the stem is shortened. The leaf on the left is normal.

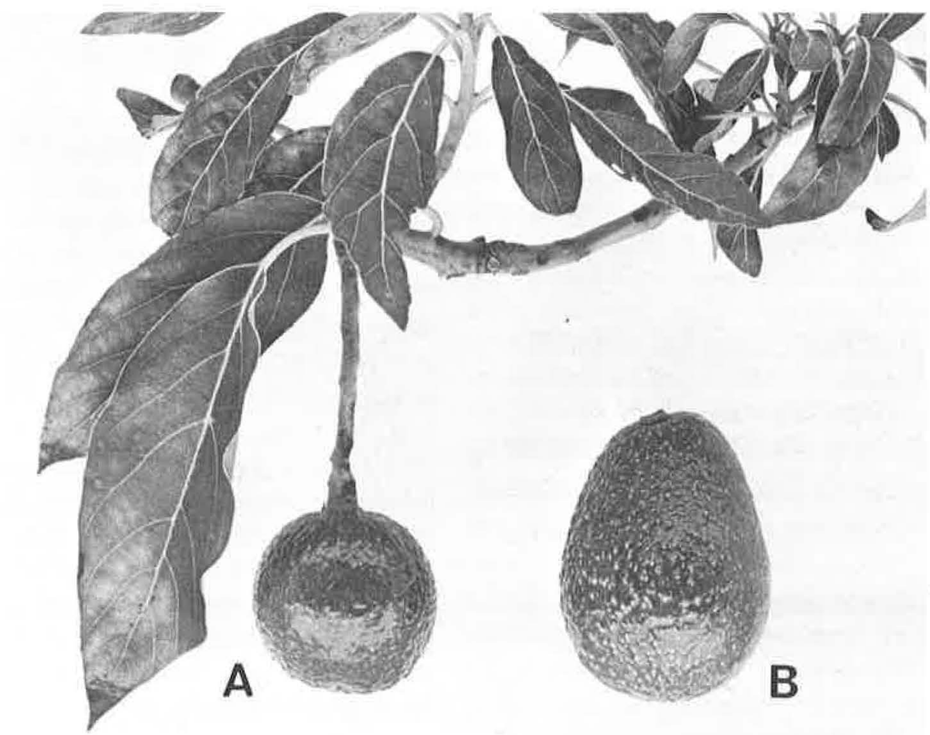

Fig. 3. Zinc deficiency makes avocado fruit small and roundish. (A) zinc-deficient Hass fruit; (B) normal Hass fruit.

Foliar applications. In most areas, best results are obtained by thoroughly wetting the foliage, using conventional pest control equipment. Amounts of spray required per acre depend on tree size; 300 to 400 gallons are suggested for young bearing orchards and up to 600 to 800 gallons for large mature orchards. Either of the following two formulas is satisfactory.

Formula No. 1:

1 pound zinc sulfate
(36 percent metallic zinc)
in
100 gallons of water.

Formula No. 2:

2 pounds zinc oxide
in
100 gallons of water.

Proprietary zinc compounds have also worked well. When using proprietary materials, follow the manufacturer's recommendations on dosage.

Zinc sprays have been successfully applied by airplanes and helicopters, particularly where groves are inaccessible to ground rigs. Air applications require about as much zinc per acre as do ground sprayers in mature orchards, but in 10 to 20 gallons of water per acre.

Timing normally is not critical, but applications are most effective in June and July, when spring-cycle leaves are expanded. Because zinc does not translocate readily from sprayed leaves to young growth occurring after spraying, severely affected trees may require respraying several months later.

Soil applications of zinc have been successful on acid soils in San Diego and Santa Barbara counties. This method of treatment is particularly useful where crowded trees or steep terrain limit spray rigs. Responses to soil applications have lasted up to 5 years, whereas foliage sprays must be repeated annually. Another use for soil treatment is on those trees that are so deficient in zinc that an annual foliage spray does not correct the deficiency.

The effectiveness of zinc application depends on the soil type, the amount used, and the method of application. Some trees have been injured, so it is wise to try an application on a few trees first. The dosage per tree has to be determined for each orchard. The methods of application are either to place the zinc on the soil surface in a band around the dripline or to pour a handful into 6-inch-deep holes made by a shovel at 15 to 20 places around the dripline of the tree.

TABLE 4. SUGGESTED AMOUNTS OF ZINC SULFATE (36 PERCENT ZINC) FOR SOIL APPLICATIONS

	Dosage per tree	
Tree age	Surface band	Inserted in holes
years	*pounds*	*pounds*
2	0.7	–
5	2.0	0.7
7	2.6	1.3
10	3.3	2.0
15	5.2	2.6
20	6.5	3.3

As a guideline, table 4 shows suggested amounts of zinc sulfate (36 percent metallic zinc). Chelated forms of zinc may correct the deficiency but appear to have no advantages over zinc sulfate.

IRON

Iron deficiency is difficult to correct. Fortunately, it is not generally found in California orchards.

Symptoms

In mild forms of iron deficiency, leaves show a network of green veins and veinlets against a lighter green background. As the deficiency increases, the interveinal area becomes yellowish white, and the veins lose their green color. In severe cases, leaves are smaller, completely chlorotic (yellow) and show tip and marginal burn. (See fig. 4.) This is accompanied by defoliation and twig dieback. Iron chlorosis may occur on individual limbs or affect the entire tree, and yield may be materially reduced.

Control

This deficiency usually occurs on soils containing lime (calcium carbonate), which limits the utilization of iron by the tree. The deficiency is accentuated by excess soil moisture and low oxygen content in the soil. The use of less water, by shifting to the alternate middle procedure of irrigation or replacing furrows with sprinklers, is sometimes helpful.

The use of Mexican race rootstocks such as Topa Topa, Duke, and Ganter rather than rootstocks of the Guatemalan race, has minimized the amount of iron chlorosis.

Chelate forms of iron have given variable results, treatment is expensive, and results are short-lived. The most effective application methods have been to inject the chelates in solution into the root zone or to rake back the leaves, broadcast the material, and work it into the surface soil, pushing the leaves back and irrigating immediately. The suggested amounts of Sequestrene® 138-Iron are 1/4 to 1/2 pound per mature tree applied in May or June. Annual applications appear necessary.

OTHER NUTRIENTS

Other nutrient deficiencies have not been recognized in California avocado orchards, even in areas where phosphorus, potassium, manganese, and magnesium deficiencies have been found on other subtropical fruit crops. Thus, additions of these nutrients are not recommended.

® Registered trade name.

Fig. 4. Symptoms of iron deficiency in leaves. Leaf A is normal. Increasing deficiency is shown on leaves from A to B. Tipburn develops when leaf is mostly yellowish-white.

Needless phosphorus applications may induce or aggravate zinc deficiency. Questions on possible further fertilizer needs and local conditions will be answered by your farm advisor.

EXCESS SALTS

Salt accumulations are often confused with a nutritional difficulty. The avocado is particularly sensitive to salts. It accumulates chlorides and sodium more readily than do most other tree crops. An accumulation of chloride manifests itself as a tip and marginal burn of the older leaves, premature defoliation, and sometimes a progressive mottled yellowing behind the burn (fig. 5). Excess sodium shows up as an interveinal leaf burn along with twig dieback. A rapid burn at the tip or at the base of the leaf, followed by defoliation, suggests either an excessive fertilizer application or inadequate irrigation. For assistance in reducing tipburn, see your farm advisor.

TENTATIVE LEAF ANALYSIS GUIDES

Through experience gained thus far in leaf analysis, the ranges of elements in avocado leaves have been tentatively established (see table 5). These are useful as guides to fertilization and orchard management but should not be taken as the absolute values for all varieties under all conditions. In most cases, deficiencies of the micronutrients (zinc, iron) may be determined by visual symptoms.

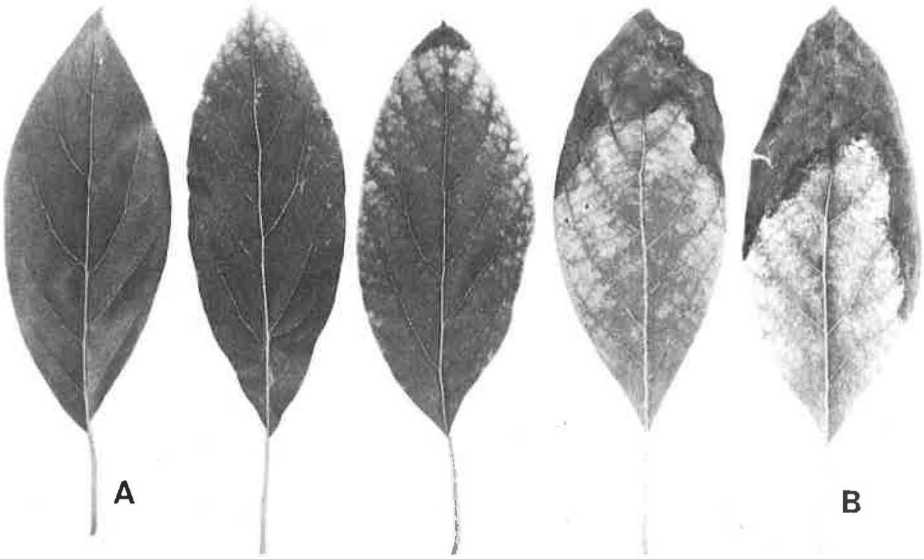

Fig. 5. Symptoms of chloride excess in leaves. Leaf A is normal. Increasing excess is shown on leaves from A to B. Note that mottling increases in intensity near the margin of the leaf.

TABLE 5. RANGES 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 nonfruiting 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.