

Importance of nutrients for citrus trees

Let's talk about calcium (Ca) and sulfur (S).

By Mongi Zekri
and Tom Obreza

To maintain an economically viable citrus industry, Florida growers must consistently produce large, high-quality fruit, season after season. Efficiently producing commercially viable yields of high-quality fruit is difficult without an understanding of soils and nutrient requirements of bearing citrus trees. Most Florida citrus is grown on soils inherently low in fertility with low cation exchange capacity and low water-holding capacity. As a result, these soils are generally unable to retain sufficient quantities of available plant nutrients to protect against leaching by rainfall or excessive irrigation. The importance and deficiency of N, P, K, and Mg in relation to citrus trees were discussed in previous issues of *Citrus Industry*. In this article, we will focus on the importance of calcium (Ca) and sulfur (S) nutrition.

Ca and S are sometimes called secondary nutrients. This term does not mean that these nutrients play a

secondary role in citrus plant growth and development. Ca and S are as essential as N, P, K, Mg and other nutrients for healthy plant growth. Inadequate supply of Ca and/or S can be a major constraint to crop production and quality.

FUNCTIONS AND IMPORTANCE OF Ca AND S

Calcium

Ca is the most abundant mineral element by weight in citrus trees, accounting for approximately 1 percent of tree dry weight. Most Ca resides in the leaves, but fruit also contains Ca at a level of about 4.4 lbs. per 100 boxes of oranges. Ca is involved in cell division and cell elongation, is an important constituent of cell walls and plays a major role in cell membrane integrity.

Ca is also an important element for root development and functioning. Root growth is severely restricted in Ca-deficient plants, and the roots become more prone to infection by bacteria and fungi.

Ca is required for chromosome stability and cell division. Ca activates several enzyme systems and neutralizes organic acids in plants. Plant growth and fruit yield can be reduced by inadequate Ca supply long before deficiency symptoms become evident. Soil Ca content is rarely low since occasional applications of lime (calcium carbonate, CaCO₃) are used to control soil acidity, and because Ca is present in irrigation water. Florida's alkaline soils have an abundance of Ca because they contain free calcium carbonate (limestone).

Despite the abundance of soil Ca, citrus trees can suffer from a range of Ca-deficiency

disorders that affect plant tissue function. For example, the "creasing" disorder in navel and Valencia oranges may be caused by Ca deficiency in the albedo of the rind.

Sulfur

The S concentration in a citrus tree is approximately 10 times less than the Ca concentration, and it is about equal to the P concentration. The uptake and assimilation of S and N by plants are strongly interrelated and dependent upon each other due to their mutual occurrence in amino acids and proteins. Sulfur is an essential constituent of many proteins, vitamins and some plant hormones. As a result, protein synthesis, amino acid and chlorophyll production is retarded in S-deficient plants. S is also known to enhance the development of nodules and N fixation by legumes, indicating its importance in root growth and development as well as promoting root vigor and hardiness. S also affects carbohydrate metabolism. S is a major component of soil organic matter and becomes available to plants as organic matter decomposes. S is also present in some irrigation water sources.

S is often forgotten as a needed element and as a critical nutrient. The problem of S deficiency may be widespread, but not known because of

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| Interpretation of soil analysis data for Ca (ppm)* using the Mehlich 1 (double-acid) extractant | | | |
|--|-----|--------|------|
| | Low | Medium | High |
| Ca | | 250 | >250 |
| *parts per million (ppm) x 2 = lbs./acre | | | |

| Guidelines for interpretation of orange tree leaf Ca and S (%) analysis based on 4- to 6-month-old spring flush leaves from non-fruiting twigs | | | | | |
|---|-----------|-------------|-------------|-------------|--------|
| | Deficient | Low | Optimum | High | Excess |
| Ca | <1.5 | 1.5 – 2.9 | 3.0 – 4.9 | 5.0 – 7.0 | >7.0 |
| S | <0.14 | 0.14 – 0.19 | 0.20 – 0.40 | 0.41 – 0.60 | >0.60 |

Adjusting fertilization based on soil analysis

| | When below sufficiency | When above sufficiency |
|---------|--|--|
| Soil pH | Lime to pH 6.0 | <ol style="list-style-type: none"> 1. Do nothing 2. Use acid-forming N fertilizer 3. Apply elemental sulfur 4. Change rootstocks |
| Ca | <ol style="list-style-type: none"> 1. Check soil pH and adjust if needed 2. Check leaf Ca status | <ol style="list-style-type: none"> 1. Do nothing 2. Check leaf K and Mg status |

Calcium

If soil Ca level is less than sufficient, soil application of gypsum or soluble Ca fertilizer should be considered. If leaf Ca is less than the optimum level, calcium nitrate may be applied as a foliar spray.

the lack of lab analysis targeting this nutrient element. In general, plant tissue analyses are important to diagnose nutritional deficiency or sufficiency of all nutrients. Unfortunately, tissue analysis has not been used routinely to check the S status of citrus trees. Yield and quality effects as related to the S nutritional status for numerous crops are well documented, but not for citrus. S controls certain diseases and insect pests in many crops and improves plant tolerance to heavy metal toxicity.

Currently, sufficiency for Ca and S is defined as the optimum values in leaf tissue analysis and medium range for soil analysis.

NUTRIENT BEHAVIOR IN FLORIDA SOILS

Calcium

- Ca exists as solid compounds in the soil (mostly in combination with carbonate or phosphate) and in ionic forms held by the cation exchange complex.

- Solid forms of Ca are sparingly soluble and can reside in the soil for many years if the pH is not too acidic. Dissolution is more rapid at low pH, which is the basis of the liming reaction.

- Because it is a divalent cation, Ca dominates on the cation exchange complex, limiting its mobility in soil.

Sulfur

- Ninety percent of the S that occurs naturally in soils is associated with organic matter. Soil humus contains about 0.5 percent S. Like N release, S release depends on organic matter quantity and decomposition rate. Organic S release combined with S from other sources like rain and irrigation water may provide this nutrient to plants at a sufficient rate.

- The plant-available form of S is sulfate, a negative ion, which makes it prone to leaching. Sulfate can be adsorbed by soils, but adsorption usually occurs much deeper in the soil profile than the majority of plant roots.

- Calcium sulfate (gypsum) is a sparingly-soluble compound that is applied as a long-term source of available Ca, but it also supplies S to plants.

CALCIUM DEFICIENCY

A deficiency of Ca in citrus is expressed as a fading of the chlorophyll along the leaf margins and between the main veins during the winter



Fig. 1. Calcium deficiency symptoms: fading of the chlorophyll along the leaf margins and between the main veins during the winter months

months (Fig. 1). Small necrotic (dead) spots can develop in the faded areas. Ca deficiency produces small, thickened leaves and causes loss of vigor, thinning of foliage and decreased fruit production. Severely deficient trees can develop twig dieback and multiple bud growth of new leaves. Trees with a Ca deficiency produce undersized and misshapen fruit with shriveled juice vesicles (Fig. 2, page 16). Fruits from Ca-deficient trees are slightly lower in juice content, but higher in soluble solids and acids.

Ca deficiency usually occurs on acidic soils where native Ca has



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Figure 2. Calcium deficiency symptoms: undersized and misshapen fruit with shriveled juice vesicles

leached. Continuous use of ammonium-containing fertilizer, particularly ammonium sulfate, accelerates Ca loss from soils. Use of muriate of potash and S causes similar losses of soil Ca. Soil testing is a widely used method of making liming recommendations. In the long term, liming is the most effective and economic practice to supply Ca to crops in Ca-deficient acid soils because liming the soil not only neutralizes soil acidity, but also supplies

available Ca. Ca deficiency can also occur in highly saline soils due to the excessive sodium (Na) concentration. Under such a situation, gypsum can correct the deficiency and reduce the deleterious effect of Na. Short-term calcium deficiency can be addressed by foliar spraying with a water-soluble Ca source like calcium nitrate. Calcium efficiency in crop production can also be improved by the use of farmland manures.

SULFUR DEFICIENCY

Since S is associated with the formation of proteins and chlorophyll, deficiency symptoms resemble those of N, but symptoms first appear on the new growth (Fig. 3). Such chlorosis in citrus is worse on new growth because S does not move readily from old to young leaves like N. Plants are stunted and pale green to yellow in color. Visual diagnosis of S deficiency is not easy to identify in citrus production. Accurate diagnosis should involve tissue analysis.

S deficiency occurs most commonly with high N fertilizer rates.

If the supply of N is not supplemented with adequate S, the N available for crop use may be excessive in relation to S. Under high N and low S conditions, plant growth processes are disrupted and plants develop symptoms of S deficiency. Sometimes, total growth is reduced by fertilization with N alone, whereas combined applications of N and S have provided normal growth and yield.

S deficiencies have become more common in the past few decades with the increased use of fertilizers lacking S, such as

ammonium nitrate, potassium nitrate, urea, concentrated superphosphate, monoammonium phosphate and diammonium phosphate. Decreased use of S-containing pesticides and fungicides may also contribute to the more common occurrence of S deficiency. S deficiency in citrus can easily be corrected by soil application of S-containing fertilizers like ammonium sulfate, potassium sulfate or magnesium sulfate. Applying gypsum is an inexpensive option that can also correct S deficiency and supply Ca. Use of manures may also be a good management strategy to increase S availability to citrus trees.

COMMON SOLID SOURCES FOR SOIL APPLICATION

Calcium

- Calcium carbonate (calcitic lime)
- Calcium sulfate (gypsum)
- Calcium nitrate

Sulfur

- Ammonium sulfate
- Potassium sulfate
- Potassium-magnesium sulfate
- Ordinary superphosphate
- Calcium sulfate (gypsum)
- Elemental sulfur

CONCLUSION

To produce optimum fruit yields of good quality, citrus trees must have a sufficient supply of all essential plant nutrients. If one or more is not supplied in adequate quantity, yield will be reduced. This effect is somewhat analogous to the fact that a wooden barrel will hold no more water than its shortest stave. Growth and crop yield are limited by the element that is in shortest supply. To achieve optimum plant nutrition, an appropriate balance of nutrients in the soil is necessary.

Balanced use of plant nutrients corrects nutrient deficiencies and toxicities, improves soil fertility, increases nutrient and water use efficiency, enhances crop yields and fruit quality, develops tree tolerance to pests, diseases and other stresses, and improves environmental quality. Unbalanced availability of nutrients can lead to mining of soil reserves for nutrients in short supply and to losses of plant nutrients supplied in excess. Over- or under-fertilization is economically wasteful. Therefore, use of proper rates, sources and methods of application are important strategies to maximize nutritional efficiency and crop productivity and quality.

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Figure 3. Sulfur deficiency symptoms: chlorosis (pale green to yellow in color) similar to N deficiency, but on new growth because S does not move readily from old to young leaves like N

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