LEAF AND SOIL SAMPLING, TESTING AND INTERPRETATION

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Leaf analysis is a useful tool to detect problems and adjust fertilizer programs for citrus trees because leaf nutrient concentrations are the most accurate indicator of citrus nutritional status. Sampling guidelines should be followed precisely to ensure that analytical results are meaningful.

BENEFITS OF LEAF ANALYSIS

- Determines if the tree has had a sufficient supply of essential nutrients.
- Confirms nutritional deficiencies, toxicities or imbalances.
- Identifies hidden toxicities and deficiencies when visible symptoms do not appear.
- Evaluates the effectiveness of fertilizer programs.
- Provides a way to compare several fertilizer treatments.
- Determines the availability of elements not tested for by other methods.

Procedures for proper sampling, preparation and analysis of leaves have been standardized to achieve meaningful comparisons and interpretations. If done correctly, the reliability of the chemical analysis, data interpretation, fertilization recommendations, and adjustment of fertilizer programs will be sound. Therefore, considerable care should be taken from the time leaves are selected for sampling to the time they are received at the laboratory for analysis.

Co-author Mongi Zekri with leaf and soil samples.

LEAF SAMPLE TIMING

- The best time to collect 4- to 6-month-old spring flush leaves is from July to September. If leaves are sampled later in the season, summer leaf growth can easily be confused with spring growth.

LEAF SAMPLING TECHNIQUE

- A sampled citrus grove block or management unit should be no larger than 20 acres. The sampler should make sure that the selected leaves represent the block being sampled.
- Each leaf sample should consist of about 100 leaves taken from non-fruiting twigs of 15 to 20 uniform trees of the same variety and rootstock that have received the same fertilizer program.
- Use clean paper bags to store the sample. Label the bags with an identification number that can be referenced when the analytical results are received.
- Avoid immature leaves due to their rapidly changing composition.
- Do not sample abnormal-appearing trees, trees at the edge of the block, or trees at the end of rows because they may be coated with soil particles and dust.
- Do not include diseased, insect-damaged, or dead leaves in a sample. Especially avoid leaves from greening (Huanglongbing) infected trees because they have pronounced nutrient imbalances that don't necessarily reflect the nutrition program of the grove.
- Select only one leaf from a shoot and remove it with its petiole (leaf stem).

Table 1. Guidelines for intepretation of orange tree leaf analysis based on 4- to 6-month-old spring flush leaves from non-fruiting twigs.

Element	Unit of measure	Deficient	Low	Optimum	High	Excess
N	%	< 2.2	2.2 – 2.4	2.5 – 2.7	2.8 – 3.0	> 3.0
P	%	< 0.09	0.09 – 0.11	0.12 – 0.16	0.17 – 0.30	> 0.30
K	%	< 0.7	0.7 – 1.1	1.2 – 1.7	1.8 – 2.4	> 2.4
Ca	%	< 1.5	1.5 – 2.9	3.0 – 4.9	5.0 – 7.0	> 7.0
Mg	%	< 0.20	0.20 – 0.29	0.30 – 0.49	0.50 – 0.70	> 0.70
Cl	%	---	---	< 0.2	0.20 – 0.70	> 0.70
Na	%	---	---	---	0.15 – 0.25	> 0.25
Mn	mg/kg or ppm	< 18	18 – 24	25 – 100	101 – 300	> 300
Zn	mg/kg or ppm	< 18	18 – 24	25 – 100	101 – 300	> 300
Cu	mg/kg or ppm	< 3	3 – 4	5 – 16	17 – 20	> 20
Fe	mg/kg or ppm	< 35	35 – 59	60 – 120	121 – 200	>200
B	mg/kg or ppm	< 20	20 – 35	36 – 100	101 – 200	> 200
Mo	mg/kg or ppm	< 0.05	0.06 – 0.09	0.10 – 2.0	2.0 – 5.0	> 5.0

HANDLING OF LEAF SAMPLES

• Protect leaves from heat and keep them dry. Place them in a refrigerator for overnight storage if they cannot be washed and oven dried the day of collection.

• For macronutrient analysis, leaves do not need to be washed.

• If accurate micronutrient analysis is desired, the leaves will need to be washed.

INTERPRETATION

• To interpret laboratory results, compare the values with the leaf analysis standards in Table 1.

• The goal in nutrition management is to maintain leaf nutrient

Table 2. Adjusting a citrus fertilization program based on leaf tissue analysis

Nutrient	What if it is less than optimum in the leaf? Options:	What if it is greater than optimum in the leaf? Options:
N	1. Check yield. 2. Check tree health. 3. Review water management. 4. Review N fertilizer rate.	1. Check soil organic matter. 2. Review N fertilizer rate.
P	1. Apply P fertilizer.	1. Do nothing.
K	1. Increase K fertilizer rate. 2. Apply foliar K fertilizer.	1. Decrease K fertilizer rate.
Ca	1. Check soil pH. 2. Check soil test Ca status. 3. Consider applying lime or soluble Ca fertilizer depending on pH.	1. Do nothing.
Mg	1. Check soil test Mg status. 2. Check soil pH. 3. Consider applying dolomitic lime or soluble Mg fertilizer depending on pH.	1. Do nothing.
Micronutrients	1. Check soil pH and adjust if needed. 2. Apply foliar micronutrients. 3. Include micronutrients in soil-applied fertilizer.	1. Check for spray residue on tested leaves. 2. Do nothing.

concentrations within the optimum range every year. If the interpretation is not optimum, various strategies can be used to address the situation (Table 2).

SOIL SAMPLING, ANALYSIS AND INTERPRETATION

Soil analysis measures organic matter content, pH, and extractable nutrients, which are useful in formulating and improving a fertilization program. Soil analysis is particularly useful when conducted for several consecutive years so that trends can be observed. However, a citrus grower cannot rely on soil analysis alone to formulate a fertilizer program or diagnose a nutritional problem in a grove.

Soil nutrient extraction procedures vary from lab to lab. Several accepted chemical procedures exist that remove different amounts of nutrients from the soil because the extractants vary in strength. To draw useful information from soil tests, consistency in use of a single extraction procedure from year to year is important to avoid confusion when interpreting the amount of nutrients extracted.

The single most useful soil test in a citrus grove is for pH. Soil pH greatly influences nutrient availability. Some nutrient deficiencies can be avoided by maintaining soil pH between 6.0 and 6.5. In addition to pH, soil testing is important for P, Mg, Ca and Cu. The UF-IFAS Extension Soil Testing Laboratory uses the Mehlich 1 (double acid) extraction procedure, which was developed for acidic, low-fertility sandy soils. Most of the soils used to produce citrus in Florida meet these criteria. The exceptions are the calcareous soils of the Indian River production area that do not meet the pH requirement. The UF-IFAS soil test interpretations for P, K and Mg are shown in Table 3.

Some commercial agricultural laboratories use the Mehlich 1 extraction procedure, but others use procedures different from Mehlich 1 as their preferred soil test method.

SOIL SAMPLE TIMING

- In Florida, soil samples should be collected once per year at the end of the summer rainy season and before fall fertilization (August to October).
- It is convenient to take soil samples when collecting leaf samples to save time and reduce cost.
- The accuracy of soil test interpretations depends on how well the soil sample represents the grove block or management unit in question.

SOIL SAMPLING TECHNIQUE AND PREPARATION

- Each soil sample should consist of one soil core taken about 8 inches deep at the dripline of 15 to 20 trees within the area wetted by the irrigation system in the zone of maximum root activity.
- Sampled areas should correspond with grove blocks where leaf samples were collected. The area should contain similar soil types with trees of roughly uniform size and vigor.
- Thoroughly mix the cores in a non-metal bucket to form a composite sample. Take a subsample from this mixture and place it into a labeled paper bag.
- Soil samples should be air-dried before shipping to the lab for analysis.

TRADITIONAL VS. ALTERNATIVE SAMPLING STRATEGIES

A basic principle of traditional

Table 3. Interpretation of soil analysis data for citrus using the Mehlich 1 (double-acid) extractant

Element	Soil test interpretation				
	Very Low	Low	Medium	High	Very High
	---------- mg/kg (ppm)----------				
P	< 10	10 – 15	16 – 30	31 – 60	> 60
Mg	---	< 15	15 – 30	> 30	---
Ca			250	>250	
Cu			<25	25 – 50	>50

sampling is to return to roughly the same sampling locations from year to year. This technique assumes that the selected area is less variable, but also representative of the entire grove or major portion of the block. Representative sites are selected based on tree observation, past experience, crop yield, soil type, and/or remotely-sensed images. Traditional sampling minimizes sampling errors, the number of samples taken, cost, and time required, but it does not fully indicate field variability.

Nutrient management using grid sampling information is still in development and more research is needed before variable rate technology (VRT) becomes widely used to manage Florida citrus tree nutrition.

Between traditional and grid sampling strategies lies the "management zone" method. Knowledge of grove characteristics such as soil types, high and low yielding areas, soil water and nutrient holding capacities, and depth to the water table allows a grower to delineate management zones. The zone concept requires less sampling than the grid method, but it is more targeted than the traditional strategy. With this technique, different fertilizer rates can be applied to a smaller number of zones without VRT equipment.

Table 4. Adjusting a citrus fertilization program based on soil analysis

Property or nutrient	What if it is below the sufficiency value in the soil? Options:	What if it is above the sufficiency value in the soil? Options:
Soil pH	1. Lime to pH 6.0.	1. Do nothing. 2. Use acid-forming N fertilizer. 3. Apply elemental sulfur. 4. Change rootstocks.
Organic matter	1. Do nothing (live with it). 2. Apply organic material.	1. Do nothing.
P	1. Check leaf P status. 2. Apply P fertilizer if leaf P is below optimum.	1. Do nothing.
K	1. Apply K fertilizer.	1. Lower K fertilizer rate.
Ca	1. Check soil pH and adjust if needed. 2. Check leaf Ca status.	1. Do nothing. 2. Check leaf K and Mg status.
Mg	1. Check soil pH and adjust with dolomitic lime if needed. 2. Check leaf Mg status	1. Do nothing.
Cu	1. Do nothing.	1. Lime to pH 6.5.

ANALYSIS AND INTERPRETATION

• The basic soil analysis package run by most agricultural laboratories includes soil pH and extractable P, K, Ca, and Mg. Organic matter is sometimes part of the basic package or it may be a separate analysis. Extractable Cu is normally determined upon request.

• The lab interprets each soil test result as very low, low, medium, high, or very high, and may also provide fertilizer recommendations accordingly.

• The interpretations should be used to make management decisions regarding soil pH adjustment or fertilizer application (Table 4)

For more details, consult UF-IFAS publication SL 253, "Nutrition of Florida Citrus Trees," at http://edis.ifas.ufl.edu/pdffiles/SS/SS47800.pdf

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