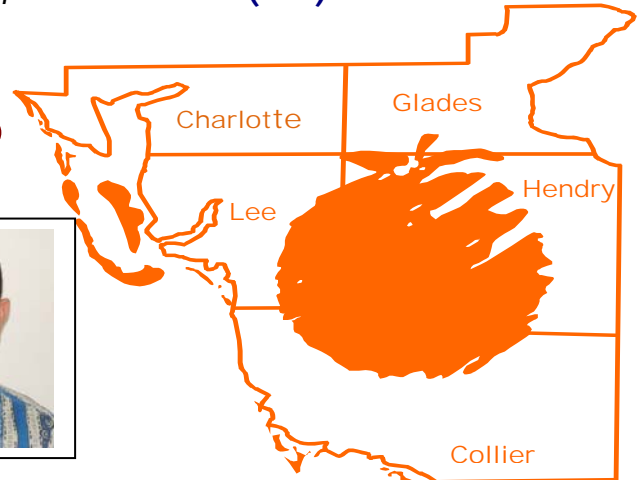


Hendry County Extension, P.O. Box 68, LaBelle, FL 33975 (863) 674 4092

# Flatwoods Citrus



**Vol. 17, No. 6**

**June 2014**

Dr. Mongi Zekri  
Multi-County Citrus Agent, SW Florida



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**Previous issues of the Flatwoods Citrus newsletter can be found at:**

<http://citrusagents.ifas.ufl.edu/agents/zekri/index.htm>

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# IMPORTANT   EVENTS

## Seminar –

### **Fruit drop control and psyllid and leafminer management**

Date & time: Wednesday, June 25, 2014, **10:00 AM** – 12:00 Noon

Location: UF-IFAS Southwest Florida Research and Education Center, Immokalee

Program Coordinators: Mongi Zekri and Sarah Markle

#### Agenda

10:00 AM – Introduction – Dr. Mongi Zekri

10:10 AM – Valent Products – Sarah Markle

10:20 AM

**Jeffrey Smith**, Valent FMD (Field and Market Development),

--New Section 18 on Belay 2.13 for use on bearing trees

--Proper use/review of Danitol for psyllid control

--ProGibb use for fruit drop

--Presidio use for non-bearing trees

#### **10:50 AM Break**

11:00 AM

**Dr. Michael Rogers**, UF-IFAS: "Psyllid and Leafminer Management on Young trees"

11:30 AM

**Dr. Gene Albrigo**, UF-IFAS: 'Some 2014 Fruit Drop Control Trials Using Plant Growth Regulators'

#### **12:00 Noon - Lunch**

**1.5 CEUs for Pesticide License Renewal**

**1.5 CEUs for Certified Crop Advisors (CCAs)**

**Pre-registration (RSVP) is required.** No registration fee and lunch is free Thanks to Sarah Markle **with Valent.** To reserve a seat, call 863 674 4092, or send an e-mail to Dr. Mongi Zekri at: [maz@ufl.edu](mailto:maz@ufl.edu)      **No RSVP = No lunch**



## **Can thermotherapy mitigate HLB in the field?**

Date & time: Thursday, July 10, 2014, **9:30 AM** – **12:00 Noon**

Location: UF-IFAS Southwest Florida Research and Education Center

Program Coordinator: Dr. Mongi Zekri, UF-IFAS

## Agenda

9:30 AM - **Introduction** – Dr. Mongi Zekri, UF-IFAS

9:40 AM - **Field demonstration of applying heat treatment to citrus trees** - Dr. Reza Ehsani, UF-IFAS

**10:40 AM – Break**

**10:50 AM - Thermotherapy: tent structure concepts** - Norman Parker Platts, UF-IFAS

**11:00 AM - Application of supplementary heat for rapid in-field heat treatment of citrus trees** - Dr. Reza Ehsani, UF-IFAS

**11:20 AM - Thermotherapy: a new way of coping with HLB** - Dr. Melissa Doud, USDA-ARS

**12:00 Noon - Lunch**

**2 CEUs for Certified Crop Advisors (CCAs)**

**2 CEUs for Pesticide License Renewal**

**Pre-registration is required.** No registration fee and lunch is free Thanks to the Citrus Research and Education Foundation (CRDF). To reserve a seat, call 863 674 4092, or send an e-mail to Dr. Mongi Zekri at: [maz@ufl.edu](mailto:maz@ufl.edu) **No RSVP = No lunch**



## CITRUS EXPO IN FORT MYERS

**Wednesday, August 13 & Thursday, August 14, 2014**

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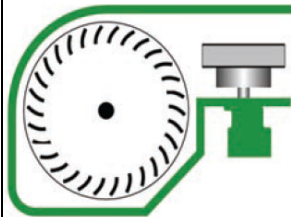
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# Summary from Causes and Prevention of Emitter Plugging In Microirrigation Systems

**Dr. Dorota Haman, UF-IFAS**

In the past two decades, the use of microirrigation to provide water to citrus trees has increased dramatically. Microirrigation, properly managed, offers several potential advantages over other methods of irrigation:

- greater water application uniformity.
- improved water use efficiency.
- minimized deep percolation and runoff.
- reduced bacteria, fungi, disease, and other pests that require a moist environment and a wet canopy.
- efficient delivery of fertilizer (fertigation) and other chemicals (chemigation) through the irrigation system.
- ability to irrigate land too steep for other means of irrigation.

The plugging of emitters is one of the most serious problems associated with microirrigation use. Emitter plugging can severely hamper water application uniformity.

## **I. Causes of Emitter Plugging**

Emitter plugging can result from physical (grit), biological (bacteria and algae), or chemical (scale) causes. Frequently, plugging is caused by a combination of more than one of these factors.

### Influence of the Water Source

The type of emitter plugging problems will vary with the source of the irrigation water. Water sources can be grouped into two categories: surface or ground water. Algal/bacterial growth is a major problem associated with the use of surface water. Whole algae cells and organic residues of algae are often small enough to pass through the filters of an irrigation system. These algal cells can then form aggregates that plug emitters. Chemical precipitation is normally not a major problem when using surface water. Groundwater, on the other hand, often contains high levels of minerals in solution that can precipitate and form scale. Water from shallow wells (less than 100 ft) often will produce plugging problems associated with bacteria. Chemical precipitation is more common with deep wells. Physical plugging problems are generally less severe with groundwater.

#### Physical

Sources of physical plugging problems include particles of sand and suspended debris that are too large to pass through the openings of emitters. Sand particles, which can plug emitters, are often pumped from wells. Water containing some suspended solids may be used with microirrigation systems if these suspended solids consist of clay-sized particles, and flocculation does not occur. Research has shown that using water with over 500 ppm suspended solids did not cause emitter plugging as long as the larger particles were filtered. Under some conditions, however, clay will flocculate and form aggregates causing plugging. Unflocculated clay and silt-sized particles are normally too small to plug emitters. Turbidity is an indicator of suspended solids, but turbidity alone is not an accurate predictor of the plugging potential of a water source. Turbidity should be combined with a laboratory filtration test to measure plugging potential.

#### Biological

A microirrigation system can provide a favorable environment for bacterial growth, resulting in slime buildup. This slime can combine with mineral particles in the water and form aggregates large enough to plug emitters. Certain bacteria can cause enough precipitation of manganese, sulfur, and iron compounds to cause emitter plugging. In addition, algae can be transported into the irrigation system from the water source and create conditions that may promote the formation of aggregates. Emitter plugging problems are common when using water that has high biological activity and high levels of iron and hydrogen sulfide. This is a frequent problem in Florida, because iron and sulfur are common constituents of many Florida waters.

Soluble ferrous iron is a primary energy source for certain iron-precipitating bacteria (Gilbert and Ford, 1986). These bacteria can attach to surfaces and oxidize ferrous iron to its insoluble ferric iron form. In this process, the bacteria create a slime that can form aggregates called ochre, which may combine with other materials in the microirrigation tubing and cause emitter plugging. Ochre

deposits and associated slimes are usually red, yellow, or tan. Sulfur slime is a yellow to white stringy deposit formed by the oxidation of hydrogen sulfide commonly present in shallow wells in Florida. Hydrogen sulfide (H<sub>2</sub>S) accumulation in groundwater is a process typically associated with reduced conditions in anaerobic environments. Sulfide production is common in lakes and marine sediments, flooded soils, and ditches; it can be recognized by the rotten egg odor. Sulfur slime is produced by certain filamentous bacteria that can oxidize hydrogen sulfide and produce insoluble elemental sulfur.

The sulfur bacteria problem can be minimized if there is not air-water contact until water is discharged from the system. Defective valves or pipe fittings on the suction side of the irrigation pump are common causes of sulfur bacteria problems (Ford and Tucker, 1975). If a pressure tank is used, the air-water contact in the pressure tank can lead to bacterial growth in the tank, clogging the emitter. The use of an air bladder or diaphragm to separate the air from the water should minimize this problem.

#### Chemical

Water is often referred to as the universal solvent since almost everything is soluble in it to some extent. The solubility of a given material in water is controlled by variations in temperature, pressure, pH, redox potential, and the relative concentrations of other substances in solution. Three gases (oxygen, carbon dioxide, and hydrogen sulfide) are important in determining the solubility characteristics of water. These gases are very reactive in water, and they determine to a significant extent the solubility of minerals within a given water source.

In order to predict what might cause chemical plugging of microirrigation system emitters, the process of mineral deposition must be understood. Carbon dioxide gas (CO<sub>2</sub>) is of particular importance in the dissolution and deposition of minerals. Water absorbs some CO<sub>2</sub> from the air, but larger quantities are absorbed from decaying organic matter as water passes through the soil. Under pressure, as is groundwater, the concentration of CO<sub>2</sub> increases to form carbonic acid. This weak acid can readily dissolve mineral compounds such as calcium carbonate to form calcium bicarbonate which is soluble in water. This process allows calcium carbonate to be dissolved, transported, and under certain conditions, again redeposited as calcium carbonate.

Calcium carbonate is the most common constituent of scale. Calcite, aragonite, and vaterite are mineral forms of calcium carbonate that have been found in carbonate scale. Calcite is formed at temperatures common within microirrigation systems, and is the most common and stable of the mineral forms.

Calcium minerals occur extensively in the form of limestone and dolomite (magnesium-calcium carbonate). Calcite is the principal constituent of limestone, and occurs in many calcareous metamorphic rocks such as marble. Therefore, it is not surprising to encounter calcium carbonate in solution in almost all surface and ground waters, especially in Florida where much of the groundwater is pumped from large underlying limestone formations. As groundwater passes through these limestone formations it dissolves the limestone and carries calcium carbonate with it.

Chemical plugging usually results from precipitation of one or more of the following minerals: calcium, magnesium, iron, or manganese. The minerals precipitate from solution and form encrustations (scale) that may partially or completely block the flow of water through the emitter. Water containing significant amounts of these minerals and having a pH greater than 7 has the potential to plug emitters. Particularly common is the precipitation of calcium carbonates, which is temperature and pH dependent. An increase in either pH or temperature reduces the solubility of calcium in water, and results in precipitation of the mineral.

When groundwater is pumped to the surface and discharged through a microirrigation system, the temperature, pressure, and pH of the water often changes. This can result in the precipitation of calcium carbonates or other minerals to form scale on the inside surfaces of the irrigation system components. A simple test for identifying calcium scale is to dissolve it with vinegar. Carbonate minerals dissolve and release carbon dioxide gas with a fizzing, hissing sound known as effervescence.

Iron is another potential source of mineral deposit that can plug emitters. Iron is encountered in practically all soils in the form of oxides, and it is often dissolved in groundwater as ferrous bicarbonate. When exposed to air, soluble ferrous bicarbonate oxidizes to the insoluble or colloidal

ferric hydroids and precipitates. The result is commonly referred to as 'red water,' which is sometimes encountered in farm irrigation wells. Manganese will sometimes accompany iron, but usually in lower concentrations.

Hydrogen sulfide is present in many wells in Florida. Precipitation problems will generally not occur when hard water, which contains large amounts of hydrogen sulfide, is used. Hydrogen sulfide will minimize the precipitation of calcium carbonate (CaCO<sub>3</sub>) because of its acidity.

### Fertigation

Fertigation is the application of plant nutrients through an irrigation system by injection into the irrigation water. Fertilizers injected into a microirrigation system may contribute to plugging. Field surveys have indicated considerable variation in fertilizer solubility for different water sources. To determine the potential for plugging problems from fertilizer injection, the following test can be performed:

Add drops of the liquid fertilizer to a sample of the irrigation water so that the concentration is equivalent to the diluted fertilizer that would be flowing in the lateral lines.

If no apparent precipitation has occurred, the fertilizer source will normally be safe to use in that specific water source.

## **II. Prevention of Emitter Plugging**

A properly designed microirrigation system should include preventive measures to avoid emitter plugging. Differences in operating conditions and water quality do not allow a standardized recommendation for all conditions. In general, however, the system should include the following:

- a method of filtering the irrigation water.
- a means of injecting chemicals into the water supply.
- in some cases a settling basin to allow aeration and the removal of solids.
- equipment for flushing the system.

Prevention of plugging can take two basic approaches: 1) removing the potential source of plugging from the water before it enters the irrigation system; or 2) treating the water to prevent or control chemical and biological processes from occurring. Both approaches will be discussed. In many cases, a combination of both approaches will be applicable.

### Water Quality Analysis

Knowing the quality of proposed irrigation water is necessary before designing a microirrigation system. Water quality analyses are performed at water testing laboratories. A water analysis specifically for microirrigation should be requested. The analysis should include the factors listed in Table 1. If the source is groundwater from a relatively deep well (over 100 ft), analysis for bacteria population may be omitted. Conversely, if the source is surface water, hydrogen sulfide will not be present and can be omitted. Table 1 provides concentration levels for evaluating the water quality analysis in terms of the potential for emitter plugging.

part per million (ppm) = mg/L = mg/kg

dS/m = mmho/cm

mmho/cm x 700 = dS/m x 700 = ppm (for salts typically found in Florida surface and ground water)

mmho/cm = 1000 μmhos/cm

μS/cm = μmho/cm

μmho/cm x 0.7 = μS/cm x 0.7 = ppm

A water quality analysis usually lists electrical conductivity in micromhos per centimeter (μmho/cm). To estimate parts per million (ppm) dissolved solids, multiply μmho/cm by 0.7. For example, if the electric conductivity meter reads 1000 μmho/cm, then dissolved solids can be estimated as 700 ppm.

Hardness is primarily a measure of the presence of calcium (Ca) and magnesium (Mg), and is another indicator of the plugging potential of a water source. If Ca and Mg are given in ppm rather than hardness, hardness can be estimated from the relationship shown in Equation 1: where calcium (Ca) and magnesium (Mg) are given in milligrams per liter (mg/L or ppm).

#### Equation 1:

$$\text{Hardness} = (2.5 \times \text{Ca}) + (4.1 \times \text{Mg})$$

Note that 1 mg/L equals 1 ppm. If the analysis lists the Ca and Mg concentrations in milliequivalents per liter (meq/l), they can be converted to ppm by the factors shown in Equation 2:

## Equation 2:

$$\begin{aligned}Ca \text{ (meq/L)} \times 20 &= Ca \text{ (ppm)} \\Mg \text{ (meq/L)} \times 12 &= Mg \text{ (ppm)}\end{aligned}$$

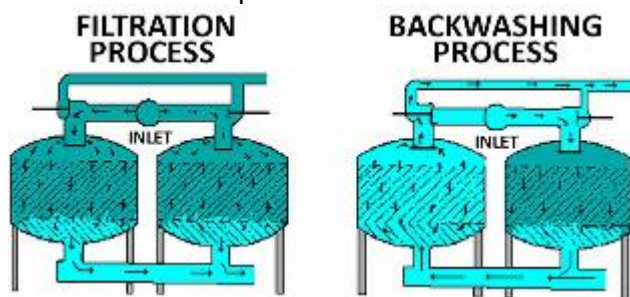
### Filters for Prevention of Physical Plugging

Many types of microirrigation filter systems that will perform adequately are available commercially. Important factors to consider in selecting a filtering method are emitter design and quality of the water source. Consider the emitter's minimum passageway diameter when selecting the filter mesh size. Filters should be sized according to the emitter manufacturer's recommendations. In the absence of manufacturer's recommendations, remove any particles larger than one-tenth the diameter of the smallest opening in the emitter flow path.

Screen filters come in a variety of shapes and sizes. Screen material may be slotted PVC, perforated stainless steel, or synthetic or stainless steel wire. Mesh size-- the number of openings per inch--determines the fineness of the material filtered.

Surface water sources should have a coarse screen filter installed on the pump inlet (suction) line to block trash and large debris. To avoid floating debris, the pump inlet should be located two feet below the water surface but suspended above the bottom.

Media (sand) filters are available with the capacity to efficiently remove most types of physical plugging sources. These filters will remove colloidal and organic material usually present in surface waters. The size and type of media used determines the degree of filtration. The finer the media, the smaller is the particle size that will be removed.



Size of the media filter required is determined by the flow rate of the system, and is measured by the top surface area of the filter. Media filters should be sized to provide a minimum of one square foot of top surface area for every 20 GPM of flow, or as the manufacturer recommends.

Filters are cleaned by reversing the direction of water flow through them; this procedure is called backwashing. Backwashing can be manual or automatic, on a set time interval or at a specific pressure drop. When using a media filter, install it with an additional screen filter (200-mesh or manufacturer's recommendation) downstream to prevent the transport of sand to the irrigation system during the backwash procedure.

### Settling Ponds

In addition to filtration, the quality of water with high levels of solids can be improved with settling ponds or basins to remove large inorganic particles. Settling ponds can also be used for aeration of groundwater containing high amounts of iron or manganese.

Experiments have shown that a ferrous iron content as low as 0.2 ppm can contribute to iron deposition. Iron is very common in shallow wells in many parts of Florida, but it can often be economically removed from irrigation water by aeration (or by some other means of oxidation), followed by sedimentation and/or filtration.

Existing ponds can sometimes be used as settling basins. They should be accessible for cleaning and large enough that the velocity of the flowing water is sufficiently slow for particles to settle out. Experience based on municipal sedimentation basins indicates that the maximum velocity should be limited to 1 foot per second.

A settling basin should be designed to remove particles having equivalent diameters exceeding 75 microns, which corresponds to the size of a particle removed by a 200-mesh screen filter. The basin works on the principle of sedimentation, which is the removal of suspended particles that are heavier than water by gravitational settling. Materials held in suspension due to the velocity of the water can be removed by lowering the velocity. In some cases, materials that are dissolved in



solution oxidize (through exposure to a free air surface), precipitate, and flocculate to form aggregates large enough to settle out of the water.

Settling ponds are also recommended when the irrigation water source is a fast-moving stream. Velocity of the water is slowed in the settling pond, thus allowing many particles to settle out.

### Flushing

To minimize sediment build up, regular flushing of microirrigation pipelines is recommended. Valves large enough to allow sufficient velocity of flow should be installed at the ends of mains, submains, and manifolds. Also, allowances for flushing should be made at the ends of lateral lines. Begin the flushing procedure with the mains, then proceed to submains, manifolds, and finally to the laterals. Flushing should continue until clean water runs from the flushed line for at least two minutes. A regular maintenance program of inspection and flushing will help significantly in preventing emitter plugging.

To avoid plugging problems when fertigating, it is best to flush all fertilizer from the lateral lines prior to shutting the irrigation system down.

### Chemical Treatment

Chemical treatment is often required to prevent emitter plugging due to microbial growth and/or mineral precipitation. The attachment of inorganic particles to microbial slime is a significant source of emitter plugging. Chlorination is an effective measure against microbial activity. Acid injection can remove scale deposits, reduce or eliminate mineral precipitation, and create an environment unsuitable for microbial growth.

#### Chlorine Injection

Chlorination is the most common method for treating bacterial slimes. If the microirrigation system water source is not chlorinated, it is a good practice to equip the system to inject chlorine to suppress microbial growth. Since bacteria can grow within filters, chlorine injection should occur prior to filtration.

Liquid sodium hypochlorite (NaOCl)--laundry bleach--is available at several chlorine concentrations. The higher concentration products are often more economical. Powdered calcium hypochlorite ( $\text{CaCOCl}_2$ ), also called High Test Hypochlorite (HTH) is not recommended for injection into microirrigation systems since it can produce precipitates that can plug emitters, especially at high pH levels.

The following are several possible chlorine injection schemes:

Inject continuously at a low level to obtain 1 to 2 ppm of free chlorine at the ends of the laterals.

Inject at intervals (once at the end of each irrigation cycle) at concentrations of 20 ppm and for a duration long enough to reach the last emitter in the system.

Inject a high concentration (50 ppm) weekly at the end of an irrigation cycle and for a duration sufficient to distribute the chlorine through the entire piping system.

The method used will depend on the growth potential of microbial organisms, the injection method and equipment, and the scheduling of injection of other chemicals.

The amount of liquid sodium hypochlorite required for injection into the irrigation water to supply a desired dosage in parts per million can be calculated by the simplified method in Equation 3:

#### Equation 3:

$$I = (0.006 \times P \times Q) / m$$

where,

I = gallons of liquid sodium hypochlorite injected per hour,

P = parts per million desired,

Q = system flow rate in gpm,

m = percent chlorine in the source, usually 5.25% or 10%.

When chlorine is injected, a test kit should be used to be sure that the injection rate is sufficient. Color test kits (D.P.D.) that measure 'free residual' chlorine, should be used. The orthotolidine-type test kit, which is often used to measure total chlorine content in swimming pools, is not satisfactory for this purpose. D.P.D. test kits can be purchased from irrigation equipment dealers. Check the water at the outlet farthest from the injection pump. There should be a residual chlorine

concentration of 1 to 2 ppm at that point. Irrigation system flow rates should be closely monitored and action taken (chlorination) if flow rates decline.

Chlorination for bacterial control is relatively ineffective above pH 7.5, so acid additions is necessary to lower the pH to increase the biocidal action of chlorine for more alkaline waters. This may be required when the water source is the Floridian aquifer.

Since sodium hypochlorite can react with emulsifiers, fertilizers, herbicides, and insecticides, bulk chemicals should be stored in a secure place according to label directions.

#### Acid Treatment

Acid can be used to lower the pH of irrigation water to reduce the potential for chemical precipitation and to enhance the effectiveness of chlorine injection. Sulfuric, hydrochloric, and phosphoric acids are all used for this purpose. Acid can be injected in much the same way as fertilizer; however, extreme caution is required. The amount of acid to inject depends on how chemically base (the buffering capacity) the irrigation water is and the concentration of the acid to be injected.

If acid is injected on a continuous basis to prevent calcium and magnesium precipitates from forming, the injection rate should be adjusted until the pH of the irrigation water is just below 7.0. If the intent of the acid injection is to remove existing scale buildup within the microirrigation system, the pH will have to be lowered more. The release of water into the soil should be minimized during this process since plant root damage is possible. An acid slug should be injected into the irrigation system and allowed to remain in the system for several hours, after which the system should be flushed with irrigation water. Acid is most effective at preventing and dissolving alkaline scale. Avoid concentrations that may be harmful to emitters and other components of the irrigation system.

Phosphoric acid, which is also a fertilizer source, can be used for water treatment. Some microirrigation system operators use phosphoric acid in their fertilizer mixes. Caution is advised if phosphoric acid is used to suppress microbial growth. Care should be used with the injection of phosphoric acid into hard water since it may cause the precipitation of calcium carbonate at the interface between the injected chemical and the water source.

For safety, dilute the concentrated acid in a non-metal, acid-resistant mixing tank prior to injection into the irrigation system. When diluting acid, always add acid to water, never water to acid. The acid injection point should be beyond any metal connections or filters to avoid corrosion. Flushing the injection system with water after the acid application is a good practice to avoid deterioration of irrigation system components in direct contact with the acid.

Acids and chlorine compounds should be stored separately, preferably in epoxy-coated plastic or fiberglass storage tanks. Acid can react with hypochlorite to produce chlorine gas and heat; therefore, the injection of acid should be done at some distance (2 feet), prior to the injection of chlorine. This allows proper mixing of the acid with the irrigation water before the acid encounters the chlorine.

Hydrochloric, sulfuric, and phosphoric acids are all highly toxic. Always wear goggles and chemical-resistant clothing whenever handling these acids. Again, acid must be poured into water; never pour water into acid.

#### Pond Treatment

Algae problems which often occur with surface water sources such as a pond can be effectively treated with copper sulfate ( $\text{CuSO}_4$ ). Dosages of 1 to 2 ppm (1.4 to 2.7 pounds per acre foot) are sufficient and safe to treat algae growth. Copper sulfate should be applied when the pond water temperature is above 60°F. Treatments may be repeated at 2 to 4-week intervals, depending on the nutrient load in the pond. Copper sulfate should be mixed into the pond (i.e., sprinkled into the wake of a boat). The distribution of biocides into surface water must be in compliance with EPA regulations.

Copper sulfate can be harmful to fish if alkalinity, a measure of the water's capacity to neutralize acid, is low. Alkalinity is measured volumetrically by titration with  $\text{H}_2\text{SO}_4$  and is reported in terms of equivalent  $\text{CaCO}_3$ .

Backflow Prevention

To ensure that the water source does not become contaminated, Florida law, EPA regulations, and county and municipal codes require backflow prevention assemblies on all irrigation systems injecting chemicals into irrigation water. Appropriate backflow prevention should include the following setup:

- a check valve upstream from the injection device to prevent backward flow
- a low pressure drain to prevent seepage past the check valve
- a vacuum relief valve to ensure a siphon cannot develop
- a check valve on the injection line

If an externally-powered metering pump is used for injection, it should be electrically interlocked with the irrigation pump. This interlock should not allow the injection pump to operate unless the irrigation pump is operating. If irrigation water is being used from municipal or other public water supply systems, special backflow precautions must be taken.

**Summary**

Emitter plugging can occur from physical, biological and chemical causes. A water quality analysis is vital to the proper design and operation of the microirrigation system. Every microirrigation system needs some method of filtration. Regular flushing of the lateral and main lines will help to prevent plugging. Most microirrigation systems will require a method of chemical treatment of the water source, and a backflow prevention system will also be required.

Table 1. Criteria for plugging potential of microirrigation water sources.

Factor	Plugging Hazard Based on Concentration		
	Slight	Moderate	Severe
<u>Physical</u>			
Suspended solids(filterable)	< 50	7.0 to 7.5	> 7.5
<u>Chemical</u>			
pH	< 7.0	7.0 to 7.5	> 7.5
Dissolved solids (ppm)	< 500	500 to 2000	> 2000
Manganese (ppm)	< 0.1	0.1 to 1.5	> 1.5
Iron (ppm)	< 0.1	0.1 to 1.5	> 1.5
Hydrogen sulfide (ppm)	< 0.5	0.5 to 2.0	> 2.0
Hardness* (ppm)	< 150	150 to 300	> 300
<u>Biological</u>			
Bacteria (population)	< 10,000	10,000 to 50,000	> 50,000

\*Hardness as ppm CaCO<sub>3</sub>



# Water Quality: Alkalinity and Hardness

The terms alkalinity and hardness are often used interchangeably when discussing water quality. They share some similarities but are distinctly different.

**Alkalinity** is a measure of the sum of all titratable bases in the sample. Alkalinity in most natural waters is due to the presence of carbonate ( $\text{CO}_3^{2-}$ ), bicarbonate ( $\text{HCO}_3^-$ ), and hydroxyl ( $\text{OH}^-$ ) anions. However, borates, phosphates, silicates, and other bases also contribute to alkalinity if present. This property is important when determining the suitability of water for irrigation and/or mixing some pesticides and when interpreting and controlling wastewater treatment processes. Alkalinity is usually reported as equivalents of calcium carbonate ( $\text{CaCO}_3$ ).

**Hardness** is most commonly associated with the ability of water to precipitate soap. As hardness increases, more soap is needed to achieve the same level of cleaning due to the interactions of the hardness ions with the soap. Chemically, hardness is often defined as the sum of polyvalent cation concentrations dissolved in the water. The most common polyvalent cations in fresh water are calcium ( $\text{Ca}^{++}$ ) and magnesium ( $\text{Mg}^{++}$ ).

Hardness is usually divided into two categories: *carbonate hardness* and *noncarbonate hardness*. Carbonate hardness is usually due to the presence of bicarbonate [ $\text{Ca}(\text{HCO}_3)_2$  and  $\text{Mg}(\text{HCO}_3)_2$ ] and carbonate ( $\text{CaCO}_3$  and  $\text{MgCO}_3$ ) salts. Noncarbonate hardness is contributed by salts such as calcium chloride ( $\text{CaCl}_2$ ), magnesium sulfate ( $\text{MgSO}_4$ ), and magnesium chloride ( $\text{MgCl}_2$ ). Total hardness equals the sum of carbonate and noncarbonate hardness. In addition to  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ , iron ( $\text{Fe}^{++}$ ), and manganese ( $\text{Mn}^{++}$ ) may also contribute to hardness. However, the contribution of these ions is usually negligible.

Hardness is usually reported as equivalents of calcium carbonate ( $\text{CaCO}_3$ ) and is generally classified as soft, moderately hard, hard, and very hard. It is best to report results as the actual equivalents of  $\text{CaCO}_3$  since the inclusive limits for each category may differ between users of the information. The classification scheme used by the U.S. Environmental Protection Agency (EPA) is shown in **Table 1**. Water hardness classifications (reported as  $\text{CaCO}_3$  equivalents).

Classification	$\text{CaCO}_3$ equivalent, mg/L (ppm)
Soft	<75
Moderately hard	75–150
Hard	150–300
Very hard	>300

## **Sources of Alkalinity and Hardness**

Water alkalinity and hardness are primarily a function of 1) the geology of the area where the surface water is located and 2) the dissolution of carbon dioxide ( $\text{CO}_2$ ) from the atmosphere. The ions responsible for alkalinity and hardness originate from the dissolution of geological minerals into rain and ground water. Rainwater is naturally acidic, which tends to solubilize some minerals more easily. Surface and ground water sources in areas with limestone formations are likely to have high hardness and alkalinity due to the dissolution of bicarbonates and carbonates.

At pH 10.3, the bicarbonate ion concentration equals the carbonate ion concentration.  $\text{CO}_3^{2-}$  is dominant at pH > 10.3, and  $\text{HCO}_3^-$  dominates between pH 6.3 and 10.3. The pH of most natural waters falls in the 7 to 8 range because of the bicarbonate buffering.

## **Alkalinity and Hardness Relationship**

Alkalinity and hardness are related through common ions formed in aquatic systems. Specifically, the counter-ions associated with the bicarbonate and carbonate fraction of alkalinity are the principal ions responsible for hardness (usually  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ ). As a result, the carbonate fraction of hardness (expressed as  $\text{CaCO}_3$  equivalents) is chemically equivalent to the bicarbonates of alkalinity present in water in areas where the water interacts with limestone. Any hardness greater than the alkalinity represents noncarbonate hardness.

## **Hardness by Calculation**

Hardness can be measured by titration or by quantification of individual ion concentrations ( $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ ) contributing to hardness. Using the calculation technique, separate determinations of calcium and magnesium are made using an appropriate analytical technique. Hardness is calculated using this equation. Hardness (as mg  $\text{CaCO}_3/\text{L}$ ) =  $2.497 \cdot [\text{Ca}, \text{mg/L}] + 4.118 \cdot [\text{Mg}, \text{mg/L}]$



# High Bicarbonates in Irrigation Waters

Bicarbonate (HCO <sub>3</sub> ) hazard of irrigation water (meq/L)			
	None	Slight to Moderate	Severe
(meq/L)	<1.5	1.5-7.5	>7.5

## Some practices to solve problem of carbonates and bicarbonates in irrigation water

- Injection of sulfuric acid to dissociate the bicarbonate ions (pH around 6.2) giving off carbon dioxide. It allows the calcium and magnesium to stay in solution in relation with the sodium content.
- Add gypsum when soils have low free calcium plus leaching
- Add sulfur to soils with high lime content plus leaching

## Potential Bicarbonate Hazard (ppm HCO<sub>3</sub>)

<a href="#">None/slight</a>	<a href="#">Moderate</a>	<a href="#">Severe</a>	<a href="#">Very Severe</a>
0-120	121-180	181-600	>600

## What can I do to minimize the adverse effects of high-bicarbonate water?

Apply acids or acid-forming materials to the soil to counteract the bases applied in the water.

Neutralize the liming effect of the water by adding acid to the water before it is applied to the crop.

## What are the dangers of using acids for water neutralization?

Hydrochloric, sulfuric and phosphoric acids are highly toxic materials irritating to the skin, eyes, nose, throat, lungs, and digestive tract. Always wear goggles and chemical resistant (rubber, neoprene, vinyl, etc.) gloves, apron and boots whenever handling these acids. Acid must be poured into water, never vice versa, and should be done in a well-ventilated area.

--Determine the proper amount of acid to apply.

--Monitor the irrigation system to ensure that the correct amount is applied.

## How can I assure that I'm adding the correct amount of acid to my water?

Monitoring the pH of the acid-treated water is one way of checking on a daily operational basis. You can do this with a pH meter or with pH papers (both methods require some experience to give reliable results). Add acid to bring the water pH to 5.0. Because the neutralization reaction continues slowly over a period of a day or two, the measured pH of the water immediately after acid addition will usually be lower than that measured once the reaction is complete.

# Citrus Fertilizer Management on Calcareous Soils

Thomas Obreza, Mongi Zekri, and David Calvert

Soils in the south Florida Flatwoods are underlain by calcium carbonate ( $\text{CaCO}_3$ ) that has accumulated through marine deposition over thousands of years. In most flatwoods, the  $\text{CaCO}_3$  lies below the profile and the overlying surface soil is usually acidic. However,  $\text{CaCO}_3$  also can occur at the surface, either naturally or as a result of earth-moving operations that have mixed the soil. The resultant soil is called calcareous. Soils also can become calcareous through long-term irrigation with water from the Floridian aquifer. This water contains small amounts of dissolved  $\text{CaCO}_3$  that can accumulate with time. Florida calcareous soils are alkaline (have pH values greater than 7) because of the presence of calcium carbonate ( $\text{CaCO}_3$ ), which dominates their chemistries. These soils can contain from about 3% to more than 25%  $\text{CaCO}_3$  by weight, with pH values in the range of 7.6 to 8.3. Usually, the pH is not in excess of 8.3 regardless of  $\text{CaCO}_3$  concentration, unless a significant quantity of sodium (Na) is present.

## **FERTILIZER MANAGEMENT ON CALCAREOUS SOILS**

**Nitrogen.** Regardless of the initial form applied, essentially all N fertilizer ultimately exists as  $\text{NO}_3$  because nitrification proceeds uninhibited in calcareous soils. Rather than attempt to slow this process, citrus grove management practices should emphasize irrigation and fertilizer application scheduling strategies that decrease N leaching. These include irrigating based on tensiometer readings or evapotranspiration measurements and using split applications of N fertilizer. Applying a portion of the required N fertilizer with irrigation water (i.e., through fertigation) and scheduling irrigations to maintain the N in the root zone is a sound method to prevent large N leaching losses. Using controlled-release N also can increase N fertilizer efficiency.

Management of N fertilizer also should involve practices that minimize its loss through ammonia volatilization. Following an application of ammoniacal-N to the surface of a calcareous soil, the fertilizer should be moved into the soil profile with irrigation water if rainfall is not likely. Urea applied to the surface of any soil, regardless of its pH value, should be moved into the soil via rainfall or irrigation. Fertigation using either of these N sources is a suitable application method, provided that there is ample time to flush the fertilizer out of the lines and into the soil.

**Phosphorus.** To maintain P availability to citrus on calcareous soils, water-soluble P fertilizer should be applied on a regular, but not necessarily frequent, basis. Since P accumulates in the soil, it is at least partially available as it converts to less soluble compounds with time. Phosphorus deficiency has never been found in citrus grown on Florida calcareous soils where P fertilizer has been applied regularly.

**Potassium.** For citrus on noncalcareous soils, nitrogen and potassium fertilizer applications with a 1:1 ratio of N to  $\text{K}_2\text{O}$  are recommended. If leaf testing on calcareous soils reveals that high levels of soil Ca may be limiting K uptake, the  $\text{K}_2\text{O}$  rate should be increased by about 25%. This approach may not work in all situations, however. Another way to increase leaf K concentration is through foliar application of  $\text{KNO}_3$ . A solution of 20 lbs  $\text{KNO}_3$  per 100 gallons of water, sprayed to the point of foliar runoff, has been shown to raise leaf K, especially if applied several times during the year. Concentrations greater than 20 lbs  $\text{KNO}_3$  per 100 gallons of water should be avoided, since high salt levels promote leaf burn. The availability of N applied through foliar spray equals that of N applied in regular ground fertilizer programs. Therefore, the amount of N applied as  $\text{KNO}_3$  should be considered when determining annual N fertilization plans for citrus groves.

**Zinc and manganese.** The most common inorganic Zn and Mn fertilizers are the sulfates ( $\text{ZnSO}_4$ ,  $\text{MnSO}_4$ ) and the oxides ( $\text{ZnO}$ ,  $\text{MnO}$ ). Broadcast application of these compounds

to correct Zn or Mn deficiencies in calcareous soils is not recommended, since the alkaline pH renders the Zn and Mn unavailable almost immediately. Zinc is also available in chelated forms, including Zn-EDTA and Zn-HEDTA. A chelate is a large organic molecule that "wraps around" a micronutrient ion such as  $Zn^{2+}$ , sequestering it from soil reactions that make it unavailable. Chelated Zn is sometimes, but not always, superior to inorganic Zn sources. Soil applications of chelated Zn are rarely economical, however. Manganese chelates have limited effectiveness in calcareous soils and are not normally used. The least expensive way to apply Zn and Mn to citrus is through foliar sprays. In addition to the forms listed above, a number of other Zn and Mn formulations are available for foliar spraying, including nitrates and organically chelated forms using lignin sulfonate, glucoheptonate, or alpha-keto acids. Research data indicate little difference in magnitude of foliar uptake, regardless of the form of carrier or chelate applied. Similarly, foliar applications of low rates of Mn or Zn (e.g., 0.5 to 1.0 lb elemental per acre) are not adequate to correct moderate to severe deficiencies often found in soils with high pH values.

**Iron.** It is not easy to remedy iron chlorosis of citrus trees on susceptible rootstocks planted on calcareous soils. Iron fertilizer formulations are available that can correct chlorosis; however, the required application rate and frequency make the treatment expensive. Inorganic sources of Fe such as ferrous sulfate ( $FeSO_4$ ) or ferric sulfate [ $Fe_2(SO_4)_3$ ] are not effective unless applied at extremely high rates; these sources should not be used on calcareous soils. Iron chlorosis should be addressed through soil application of Fe chelates. Chelates are superior sources of Fe for plants because they supply sufficient Fe at lower rates than are required with inorganic Fe sources. The most popular synthetic organically chelated forms of Fe include Fe-EDTA, Fe-HEDTA, Fe-DTPA, and Fe-EDDHA. The effectiveness of these fertilizers varies greatly, depending on soil pH (see Table 1 ). Fe-DTPA may be used on mildly alkaline soils (with pH values of 7.5 or less), whereas Fe-EDDHA is the chelate of choice for use on highly calcareous soils (with a pH value greater than 7.5).

Natural, organically complexed Fe exists in organic waste products such as sewage sludge, but at lower concentrations than in chelated Fe fertilizers. On calcareous soils in the western United States, sludge applied at 15 tons per treated acre was an effective Fe source for field crops severely deficient in Fe. The efficacy of sludge as an Fe fertilizer for citrus grown on Florida calcareous soils has not been investigated. Sludge is potentially useful since it contains readily soluble forms of Fe that may remain in soil solution through organic complexation.

Foliar application of  $FeSO_4$  or Fe chelates has not proven satisfactory on citrus trees because of poor translocation within the leaf. The use of foliar sprays also increases the possibility of fruit and/or leaf burn. For these reasons, foliar application of Fe is not recommended to correct Fe chlorosis of citrus.

### **SULFUR PRODUCTS USED AS SOIL AMENDMENTS**

Although little work has been done in Florida on the use of sulfur (S) products (soil acidulents) for citrus grown on calcareous soils, application of these products may be beneficial under certain circumstances (Table 2). This section, drawn from the results of research conducted in other regions of the United States, discusses the potential benefits of sulfur products.

Soil acidulents can improve nutrient availability in calcareous soils by decreasing soil pH. The rates of soil acidulents required to cause a plant response depend on the amount of  $CaCO_3$  in the soil.

The rate of S should be limited to 1.1 lbs per 100 square ft in any single application.

The soil within the wetted pattern of a microirrigation emitter often becomes alkaline when the water contains bicarbonate, while the surrounding soil may be neutral or acidic. To lower the soil pH in this situation, acid or acidifying fertilizer must be applied to the wetted pattern only. Applying acid or thiosulfate fertilizer through the irrigation system can be effective in treating this problem.

**SUMMARY**

1. Calcareous soils are alkaline because they contain CaCO<sub>3</sub>. They are commonly found in south Florida citrus groves, especially in the Indian River area.
2. The availability of N, P, K, Mg, Mn, Zn, and Fe to citrus decreases when soil CaCO<sub>3</sub> concentration increases to more than about 3% by weight. These soils generally have a pH value in the range of 7.6 to 8.3.
3. To avoid ammonia volatilization, fertilizers containing ammonium-N or urea should be moved into the root zone with rainfall or irrigation, or be incorporated into the soil.
4. Phosphorus fertilizer applied to calcareous soils becomes fixed in sparingly soluble compounds over time. To maintain continuous P availability, P fertilizer should be applied on a regular, but not necessarily frequent, basis.
5. Soil testing is useful in determining the magnitude of extractable P. Differences in P soil tests over time indicate accumulation or loss of soil P availability.
6. Leaf testing can gauge the effectiveness of soil P as a supply for citrus uptake and should be used to assess the need for P fertilizer application.
7. Citrus planted on calcareous soils may require above normal levels of Mg or K fertilizer for satisfactory nutrition. Foliar sprays of MgNO<sub>3</sub> or KNO<sub>3</sub> may be effective where soil applications are not.
8. The least expensive and more efficient way to correct Zn and Mn deficiencies of citrus in calcareous soils is through foliar application of inorganic or organically chelated forms.
9. The easiest way to avoid lime-induced Fe chlorosis on calcareous soils is to plant trees budded on tolerant rootstocks.
10. The most effective remedy for lime-induced Fe chlorosis on nontolerant rootstocks involves the use of organically chelated Fe.
11. Sulfur products that act as soil acidulents can potentially improve nutrient availability in calcareous soils.

**Table 1. Effective pH range of various Fe chelates.**

<b>Fe Chelate</b>	<b>Effective pH Range</b>
Fe-EDTA, Fe-HEDTA	4 to 6.5
Fe-DTPA	4 to 7.5
Fe-EDDHA	4 to 9

**Table 2. CaCO<sub>3</sub>-neutralizing power of several S sources.**

<b>Sulfur Source</b>	<b>Amount Needed to Neutralize 1,000 lbs CaCO<sub>3</sub></b>
Elemental S	320 lbs
Concentrated sulfuric acid (66° Baume)	68 gal
Ammonium thiosulfate 12-0-0-26S	1,600 lbs
Potassium thiosulfate 0-0-25-17S	3,800 lbs
Ammonium sulfate 21-0-0-24S	900 lbs



# Fertigation Practical example

## Use only complete soluble fertilizers for fertigation

### Enter your numbers:

- The percentage of nitrogen in your fertilizer (example 8% = 0.08)
- Weight in pounds of one gallon of your fertilizer (example 10 lb/gal)
- How many pounds of nitrogen you want to apply per acre (example 5 lb N/acre)
- The total acreage of your block (example 20 acres)
- Your irrigation flow rate of your irrigation system in gallons per minute (example 1,000 gal/min)
- The nitrogen concentration in parts per million you want to inject (example 200 ppm)

### Here is an example

We will use a fertilizer (8% N or 0.08 N, 10 pounds per gallon) to apply 5 lb N per acre to a 20-acre field. The irrigation flow rate is 1,000 gallons per minute and the target N concentration in the irrigation line is 200 ppm. To calculate the injection rate and time:

*Step 1: Total N:* 5 lb/acre N × 20 acres = 100 lb N

*Step 2: Pounds of Fert-8:* 100 lb N ÷ 0.08 = 1250 lb of the fertilizer

*Step 3: Gallons of Fert-8:* 1250 lb ÷ 10 lb/gal = 125 gal

*Step 4: Dilution factor:* 0.08 × 1,000,000 ppm ÷ 200 ppm = 400

*Step 5: Injection rate:* 1000 gal/min ÷ 400 = 2.5 gal/min

*Step 6: Injection time:* 125 gal ÷ 2.5 gal/min = 50 min

Therefore, in this particular case, we need 125 gallons of fertilizer to be injected in 50 minutes.

Assume it takes 10 minutes for the water to travel from the injection point to the farthest emitters and reach full system pressure. Then, we need 50 minutes to inject the fertilizer and 15 minutes to flush the remaining fertilizer through the system.

As a result, a total fertigation event should have:

- 10 minutes for water to travel from the injection point to the farthest emitter and reach full pressure +
- 50 minutes to inject the fertilizer solution +
- 10 minutes for the last bit of fertilizer solution to reach the farthest emitter +
- 5 minutes extra to be sure that the system is flushed=
- Total time of 75 minutes (1hour 15 minutes)**

When preparing to inject fertilizer, first allow time for the irrigation system to fully pressurize. In most small irrigation zones, the full system pressure is reached in 10 minutes or less, but you should check each zone to determine the actual time. Once the system reaches full pressure, you can begin fertigation. For most sandy soils, the total run time of a single irrigation event should not be more than 2 hours in duration to avoid fertilizer leaching. Calculations may be done by timing an actual injection, or by calculations. After fertigation, continue to run water to evenly distribute all of the fertilizer throughout the zone. The length of this run is generally a little longer than the time required initially to bring the system up to full pressure. After each fertigation application, flush the system and be sure that all the fertilizer is flushed from the lines. Determine the time required to inject the quantity of fertilizer needed.

In summary, the total time for an entire fertigation event includes the following:

- Time for water to travel from the injection point to the farthest emitter and bring the system up to full pressure
- Time to inject the fertilizer solution
- Time for the last bit of fertilizer solution to reach the farthest emitter
- Additional time to flush the system

Fertilizer must be completely flushed from the system after fertigation in order to keep microirrigation lines clean and prevent emitters from clogging.

## LEAF AND SOIL SAMPLING AND ANALYSES TO ADJUST FERTILIZER PROGRAMS

Optimum growth and yield of high quality fruit cannot be obtained without adequate nutrition. The most successful fertilizer program should be based on tissue analysis, knowledge of soil nutrient status through soil analysis combined with university recommendations. The deficiency or excess of an element will cause disturbance in plant metabolism and lead to poor performance.



### **Plant analysis**

Used in conjunction with other data and observations, tissue analysis aids in evaluating the nutrient elements of the soil-plant system. It has proven useful in confirming nutritional deficiencies, toxicities or imbalances, identifying “hidden” toxicities and deficiencies where visible symptoms are not manifested, and evaluating the effectiveness of fertilizer programs.

### **Leaf Sampling**

For reliable results and useful interpretation of lab analysis reports, citrus growers, production managers, and consultants must follow the proper procedures for leaf sampling and sample handling because improperly collected leaf samples will provide misleading information about the nutritional status of the trees and the fertilizer programs.

Considerable care is needed in taking samples. Chemical analysis values can only be useful if the samples obtained are representative of the blocks they were taken from. The proper sampling,

preparation and handling would affect the reliability of the chemical analysis, data interpretation, nutritional recommendations, and adjustment of fertilizer programs.

Leaf samples must also be taken at the proper time because nutrient levels within leaves are continually changing. However, leaf mineral concentrations of most nutrients are relatively stable within 4 to 6 months after emergence of the spring flush. Therefore, for mature tree blocks, the best time would be in **July and August** to collect four- to six-month-old spring flush leaves. If taken later in the season, the summer flush would probably be confused with the spring flush.

Each leaf sample should consist of about 100 leaves taken from non-fruiting twigs of 15- 20 uniform trees of the same variety and rootstock, and under the same fertilizer program. Clean brown paper bag should be used. Information sheets from the testing lab should be completed for each sample as this information helps when interpreting the results. The sample bag and the corresponding information sheet should each be carefully labeled with the same identity so that samples and sheets can be matched in the laboratory.

### **Sampling techniques for leaves**

- ◆ Immature leaves should be avoided because of their rapidly changing composition.
- ◆ Abnormal-appearing trees, trees at the edge of the block and trees at the end of rows should not be sampled because they may be coated with soil particles and dust or have other problems.
- ◆ Do not include diseased, insect damaged, or dead leaves in a sample. Use good judgment.
- ◆ Select only one leaf from a shoot and remove it with its petiole (leaf stem).

### **Diagnosing growth disorders**

- ◆ Collect samples from both affected trees as well as normal trees.
- ◆ Trees selected for sampling should be at similar stage of development and age.
- ◆ Whenever possible, confine the sampling area to trees in close proximity to each other.

### **Handling of leaf samples**

- ◆ Samples should be collected in clean paper bags and clearly identified.
- ◆ They should be protected from heat and kept dry and cool (stored in portable ice chests), and placed in a refrigerator for overnight storage if they cannot be washed and oven dried the same day of collection.
- ◆ For macronutrient analysis, leaves usually do not need to be washed.
- ◆ Leaves should be dried in a ventilated oven at 60-70°C.

### **Preparation for analysis**

- ◆ Leaves that have been recently sprayed with micronutrients for fungicidal (Cu) or nutritional (Mn, Zn) purposes should not be analyzed for those micronutrients because it is unlikely to remove all surface contamination from sprayed leaves.
- ◆ For accurate Fe and B or other micronutrient determination, samples would require hand washing, which is best done when leaves are still in a fresh condition.

### **Soil analysis**

Soil analysis is an important method for gaining basic information regarding the chemical status of the soil. Soil analysis is particularly useful when conducted over several years so that trends can be seen.

Unlike leaf analysis, there are various methods and analytical procedures of soil analysis used by laboratories. In Florida, soil tests for the relatively mobile and readily leached elements such as N and K are of no value. Soil tests are

mainly important for pH, P, Mg, Ca, and Cu. For Florida sandy soils, using the Mehlich-1 or double acid (hydrochloric acid + sulfuric acid) extraction procedure adopted by the University of Florida analytical lab, 40-60 lbs/acre (20-30 ppm) of P, 70-120 lbs/acre (35-60 ppm) of Mg, 500-800 lbs/acre (250-400 ppm) of Ca, and 5-10 lbs/acre (2.5-5 ppm) of Cu are considered adequate for citrus. A Ca:Mg ratio of 7:1 seems desirable and ratios of higher than 10 may induce Mg deficiency problems. Copper levels higher than 50 lbs/acre may be toxic to citrus trees if the soil pH is below 6.

### **Soil sampling**

The accuracy of a fertilizer recommendation depends on how well the soil sample on which the recommendation was based represents the area of the grove. In Florida, if soil samples were to be collected once a year, the best time would be at the end of the summer rainy season and prior to fall fertilization, usually during September and October. However, soil sampling may be conducted at the same time as leaf sampling to save time and reduce cost.

Standard procedures for proper sampling, preparation and analysis have to be followed for meaningful interpretations of the test results and accurate recommendations. Each soil sample should consist of 15-20 soil cores taken at the dripline of 15-20 trees within the area wetted by the irrigation system to a depth of 6 inches. The area sampled should be uniform in terms of soil and tree characteristics and correspond to the area from which the leaf sample was taken. Individual cores should be mixed thoroughly in a plastic bucket to form a composite sample. Subsample of appropriate size should be taken from the composite mixture and put into labeled paper bags supplied by the lab.

**Soil samples should be air-dried but not oven-dried before shipping to the testing laboratory for analysis.**

**Conclusion**

Tissue and soil analyses are a powerful tool for confirming nutrient deficiencies, toxicities and imbalances, identifying "hidden hunger," evaluating fertilizer programs, studying nutrient interactions. However, if initial plant and soil sampling, handling, and analysis of the sample were faulty, the results would be misleading.

If properly done, tissue and soil analyses can point the way toward more economical and efficient use of fertilizer materials, avoiding excessive or inadequate application rates.

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

## **Standard Table for Assessing Nutritional Status and Adjusting Fertilizer Programs for Citrus**

**Leaf analysis standard for assessing current nutrient status of citrus trees based on concentration of mineral elements in 4- to 6-month-old-spring-cycle leaves from non-fruiting terminals.**

<b>Element</b>	<b>Deficient less than</b>	<b>Low</b>	<b>Satisfactory</b>	<b>High</b>	<b>Excess more than</b>
Nitrogen (N) (%)	2.2	2.2-2.4	<b>2.5-2.8</b>	2.9-3.2	3.3
Phosphorus (P) (%)	0.09	0.09-0.11	<b>0.12-0.17</b>	0.18-0.29	0.30
Potassium (K) (%)	0.7	0.7-1.1	<b>1.2-1.7</b>	1.8-2.3	2.4
Calcium (Ca) (%)	1.5	1.5-2.9	<b>3.0-5.0</b>	5.1-6.9	7.0
Magnesium (Mg) (%)	0.20	0.20-0.29	<b>0.30-0.50</b>	0.51-0.70	0.80
Sulfur (S) (%)	0.14	0.14-0.19	<b>0.20-0.40</b>	0.41-0.60	0.60
Chlorine (Cl) (%)	-----	-----	<b>less than 0.5</b>	0.5-0.7	0.7
Sodium (Na) (%)	-----	-----	<b>less than 0.2</b>	0.2-0.5	0.5
Iron (Fe) (ppm)	35	35-59	<b>60-120</b>	121-200	250
Boron (B) (ppm)	20	20-35	<b>36-100</b>	101-200	250
Manganese (Mn) (ppm)	18	18-24	<b>25-100</b>	101-300	500
Zinc (Zn) (ppm)	18	18-24	<b>25-100</b>	101-300	300
Copper (Cu) (ppm)	4	4-5	<b>6-16</b>	17-20	20
Molybdenum (Mo) (ppm)	0.06	0.06-0.09	<b>0.1-1.0</b>	2-50	50



# Flatwoods Citrus

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Multi-County Citrus Agent  
Hendry County Extension Office  
P.O. Box 68  
LaBelle, FL 33975

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## **Racial-Ethnic Background**

\_\_ American Indian or native Alaskan

\_\_ Asian American

\_\_ Hispanic

\_\_ White, non-Hispanic

\_\_ Black, non-Hispanic

## **Gender**

\_\_ Female

\_\_ Male