Nutrition and Fertilization

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UF/IFAS Citrus Research and Education Center
Citrus Health Forum, Quincy, Florida
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Credit: T. Jones, UF/IFAS

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Outline

- Methods
- Nutrients
- HLB and nutrient interactions
- UF and Grower Collaboration Program

Credit: T. Jones, UF/IFAS

Methods

- Soil applied
  - Granular
  - CRF
  - Fertigation
- Foliar applied

Credit: J.D. Burrow, UF/IFAS

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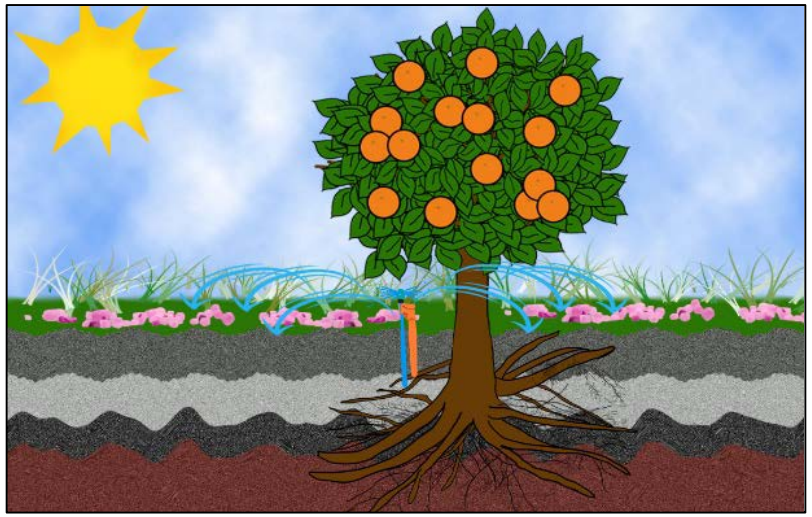
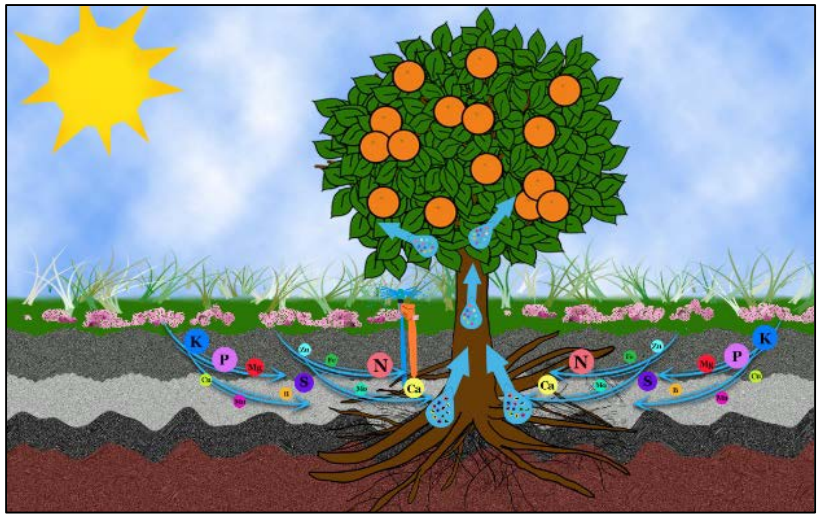
Soil-Applied Nutrition Program

- The plant uptakes nutrients via the roots when they are in a solution (water/irrigation)
- During the water uptake by the plant, the dissolved mineral nutrients get taken up by the plant and distributed throughout the tree canopy

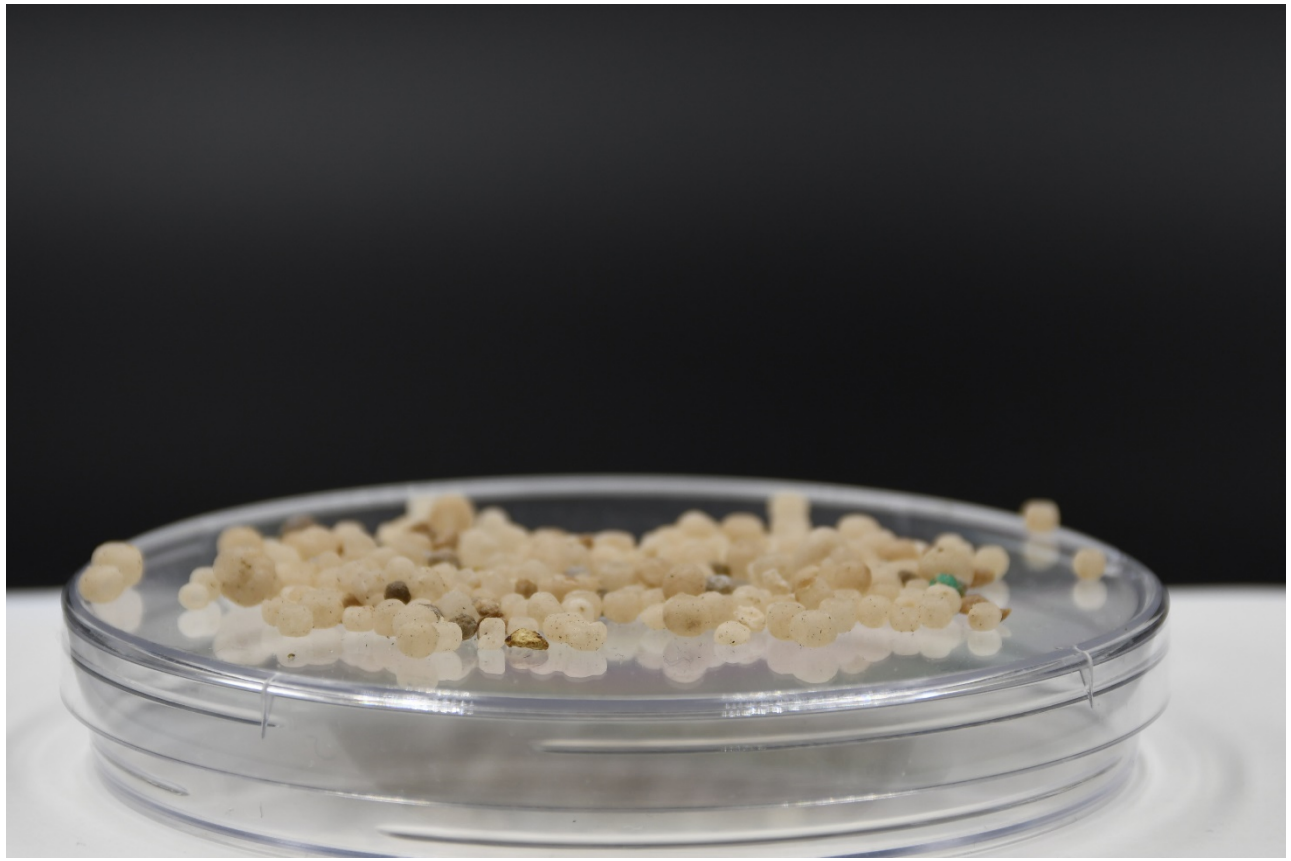




Credit: T.R. Weeks, UF/IFAS

Granular (Dry) Fertilizer

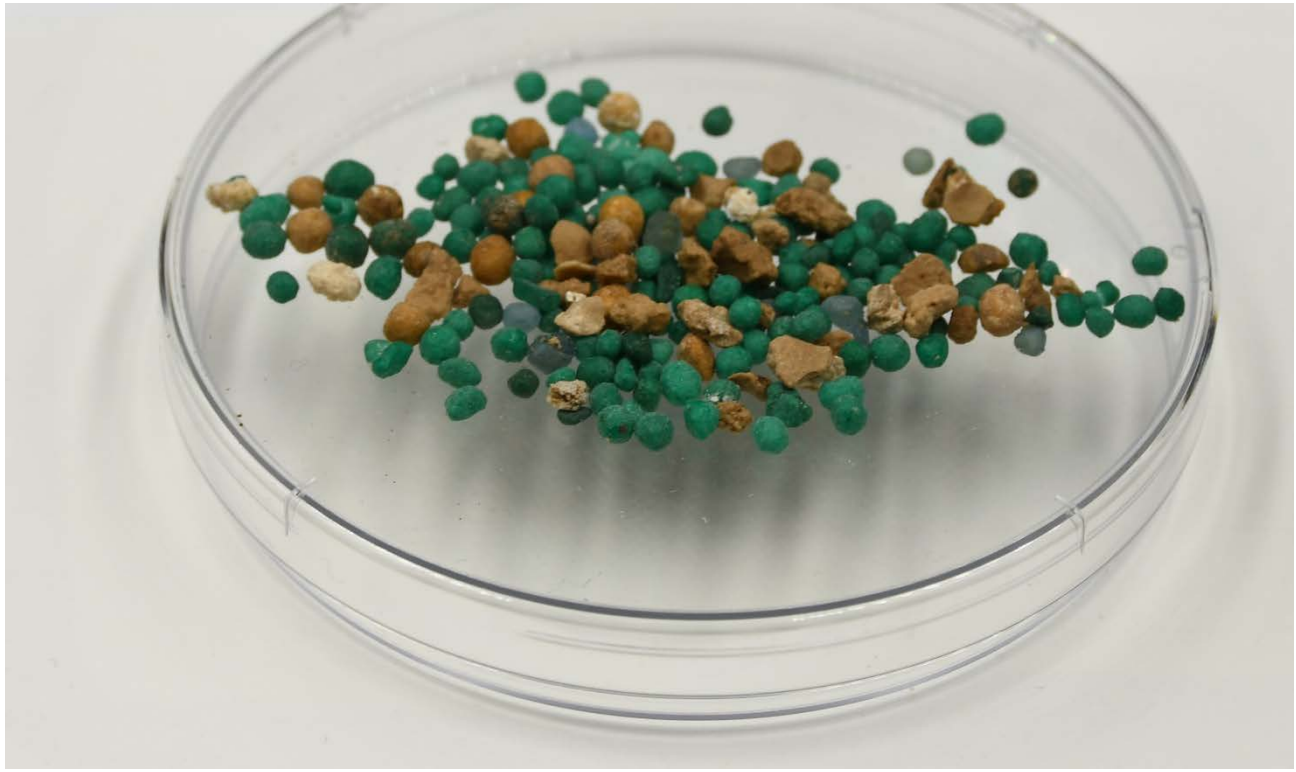
- Traditional soil applied fertilizer
- Advantages
  - Fertilizer is inexpensive
  - Readily available to plant
- Disadvantages
  - Subject to leaching
  - Multiple applications increase labor and costs



Credit: T.R. Weeks, UF/IFAS

Controlled Release Fertilizer (CRF)

- Granules release small amounts of fertilizer over time
- Advantages
  - Slowly released; therefore, a constant supply of nutrients
  - Fewer applications
- Disadvantages
  - Expensive



Credit: T.R. Weeks, UF/IFAS

Fertigation

- Liquid fertilizer applied through irrigation system
- Advantages
  - Relatively inexpensive
  - Flexibility in application
  - Small doses and constant supply
- Disadvantages
  - High maintenance (have a cleaning/flushing plan)
  - Not suitable for all nutrients

Credit: T. Jones, UF/IFAS

Foliar Nutrition Program

- Yield can increase 10%-25% with supplemental foliar feeding versus conventional soil fertilization only
- Best used as a supplemental and not a substitute for soil-applied nutrition
- Best time to apply is morning or evening
  - Right temperature (temperatures above 80°F can cause burn)
  - Minimal wind to ensure full coverage
  - Leaf stomates are open to increase uptake
- Best to apply when crop demand is high and tree needs additional help (vegetative growth, flowering, fruit set, and fruit growth)
- Quickest method to correct a deficiency, although, if a deficiency is observed, potential yield lost has already occurred

Foliar Nutrition Program

- Advantages
  - Quickest method
  - Assist trees during times of high demand or other hindering conditions (wet or dry conditions, cold weather, etc.)
- Disadvantages
  - Cannot use a foliar nutrition program alone, must be coupled with a soil nutrition program
  - Causes leaf burn when not applied at the correct time

Which fertilizer application method is best for fruit quality?

The method has no effect on fruit quality.

Fertilizer Application Method

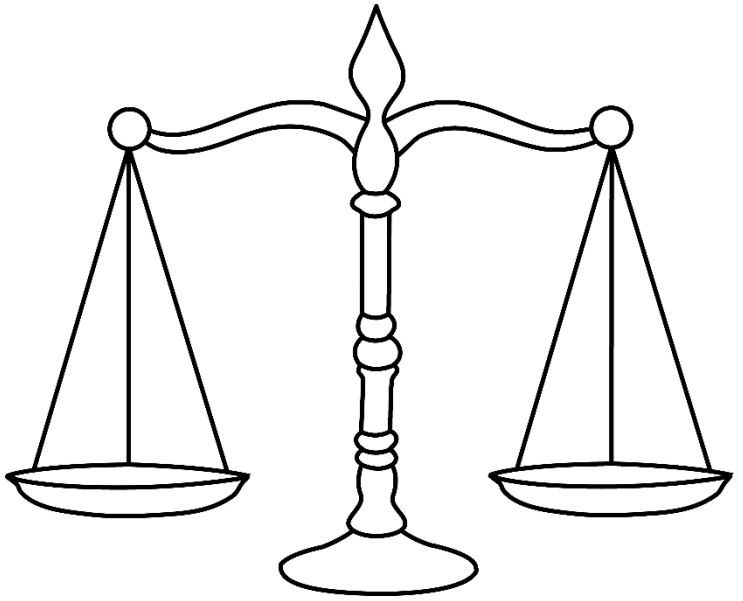
- It is not the method, but what you put into the tree
- Example:
  - Different brands of trucks have one purpose: get from point A to point B

- Application method gets the nutrients in the tree

Credit: https://www.ford.com; https://www.ramtrucks.com; https://www.ramtrucks.com

Fruit Quality and Application Methods

- Different nutrients are absorbed differently
  - Example: Micronutrients are absorbed best by foliar application for “quick fixes”; whereas, applying by soil **and** foliar along with regular leaf/soil testing keeps the micronutrients in balance
- Fruit quality will improve with the nutrients you provide the tree, not how you apply it
- Depending on what needs (juice, fruit size, etc.) to improve will determine what fertilizer you need to apply
- It’s all about balance between fruit **and** tree growth



Credit: http://cliparts.co/cliparts/ki8/ndx/ki8ndxaAT.png

Fruit quality

- Previous research provides guidelines for fruit quality
- Examples:
  - **Juice content:** increases when nitrogen and phosphorus are applied but other nutrients do not change the juice content
  - **Fruit size:** size decreases with excessive nitrogen but size increases with potassium (K) and magnesium (Mg)

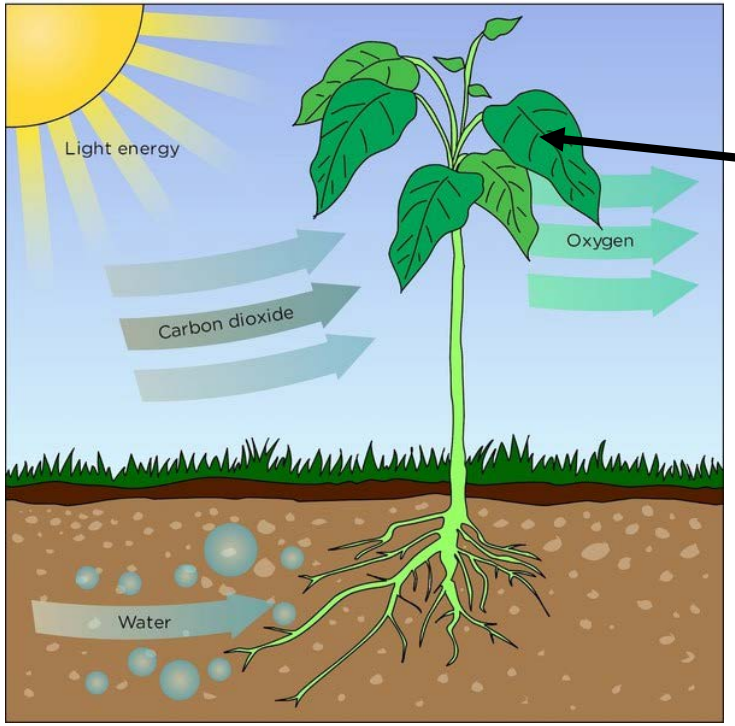
Table 3.4. Increasing levels of nutrients within recommended ranges result in the responses shown, whereas excess nutrition can reduce fruit yield and quality (Koo, 1988). Key to symbols: Increase (+), Decrease (–), No change (o), No information (?).

Measurement	Macronutrient element					Micronutrient element					Irrigation
	N	P	K	Ca	Mg	Mn	Zn	Cu	Fe	B	
Juice quality											
Juice content	+	+	o	o	o	o	o	o	o	o	+
Soluble solids (SS)	+	o	–	o	+	o	o	o	+	o	–
Acid (A)	+	–	+	o	o	o	o	o	o	o	–
SS/A ratio	–	+	–	o	+	o	o	o	o	o	–
Juice color (red)	+	o	–	?	?	?	?	?	?	?	o
Juice color (yellow)	+	o	–	?	?	?	?	?	?	?	+
Solids/box	+	o	–	o	+	o	o	o	+	o	–
Solids/acre	+	+	+	o	+	o	o	o	o	o	+
External fruit quality											
Size	–	o	+	o	+	o	o	o	o	o	+
Weight	–	o	+	o	+	o	o	o	o	o	+
Green fruit	+	+	+	o	o	o	o	o		o	+
Peel thickness	+	–	+	o	–	o	o	o	o	o	–
Peel blemishes											
Wind scar	–	+	o	?	?	?	?	?	?	?	+
Russet	–	–	o	?	o	o	o	o	o	o	o
Creasing	+	+	–	?	?	?	?	?	?	?	o
Plugging	–	o	–	?	?	?	?	?	?	?	–
Scab	+	o	o	?	?	?	?	?	?	?	+
Storage decay											
Stem-end rot	–	o	–	?	?	?	?	?	?	?	–
Green mold	–	o	o	?	?	?	?	?	?	?	+
Sour rot	o	o	o	?	?	?	?	?	?	?	o

Credit: Nutrition of Florida Citrus Trees, T.A. Obreza and K.T. Morgan, 2011.

Plant Nutrition

- Seventeen elements are essential
- Carbon (C), Hydrogen (H), and Oxygen (O), make up 95% of tree biomass



Photosynthesis

↓

Carbohydrates

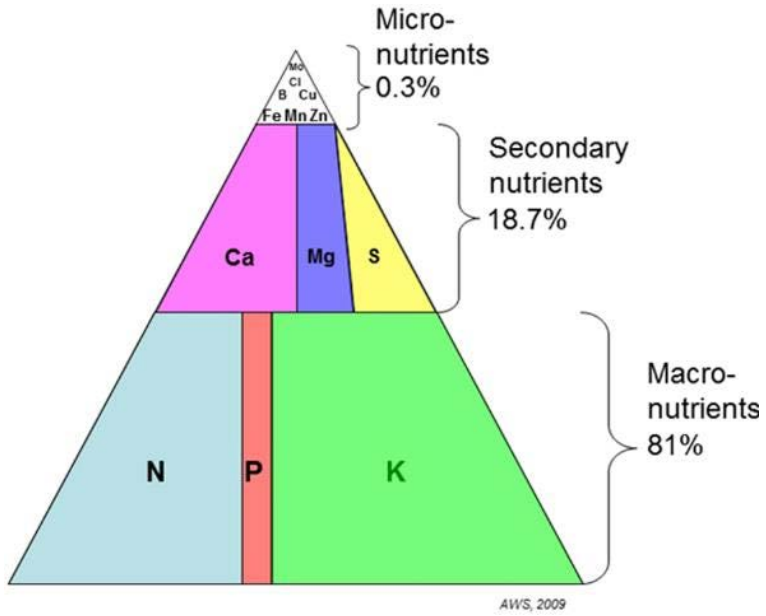
Minerals elements

↓

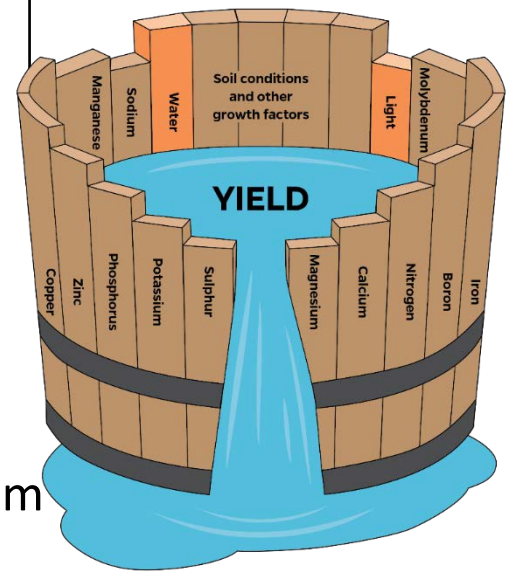
Proteins	Organic compounds	Fatty acids

Mineral Nutrients

- There are 14 essential mineral nutrients
- Each nutrient has a specific role in plant growth and function



Macro	Micro	Secondary
Nitrogen (N)	Manganese (Mn)	Calcium (Ca)
Potassium (P)	Zinc (Zn)	Magnesium (Mg)
Phosphorous (K)	Copper (Cu)	Sulphur (S)
	Iron (Fe)	
	Boron (B)	
	Molybdenum (Mo)	
	Chlorine (Cl)	
	Nickel (Ni)	



Liebig's law of the minimum

Credit: UF/IFAS Communications

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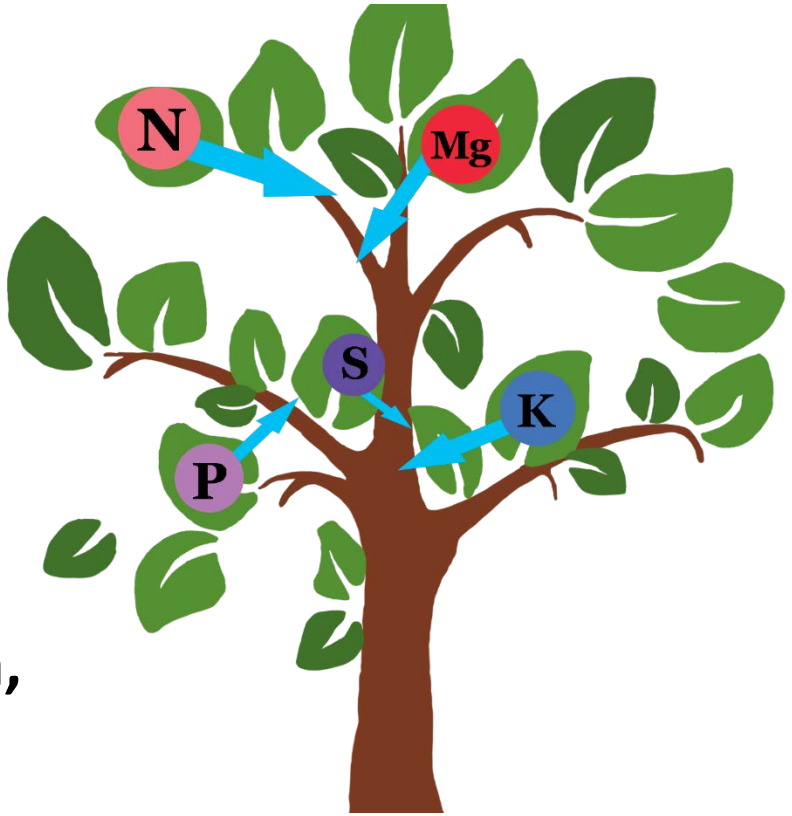
What are mobile nutrients?

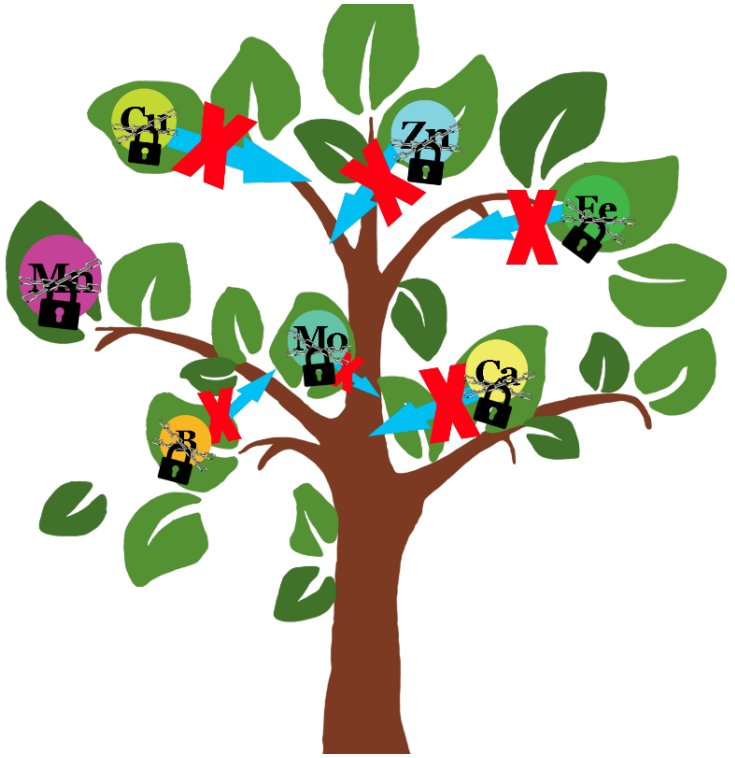
Mobile and immobile nutrients have equal and uniform distribution to all parts of the plant with movement of water



- Mobile Nutrients
  - Will move to new growth areas
  - Move in all direction
  - These nutrients can be transported via xylem and phloem
  - The deficiency symptoms will first show up in older leaves
  - Nutrients: **Nitrogen, Phosphorus, Potassium, Magnesium, Sulfur**
  - Soil-applied and foliar-applied both are adequate

What are immobile nutrients?

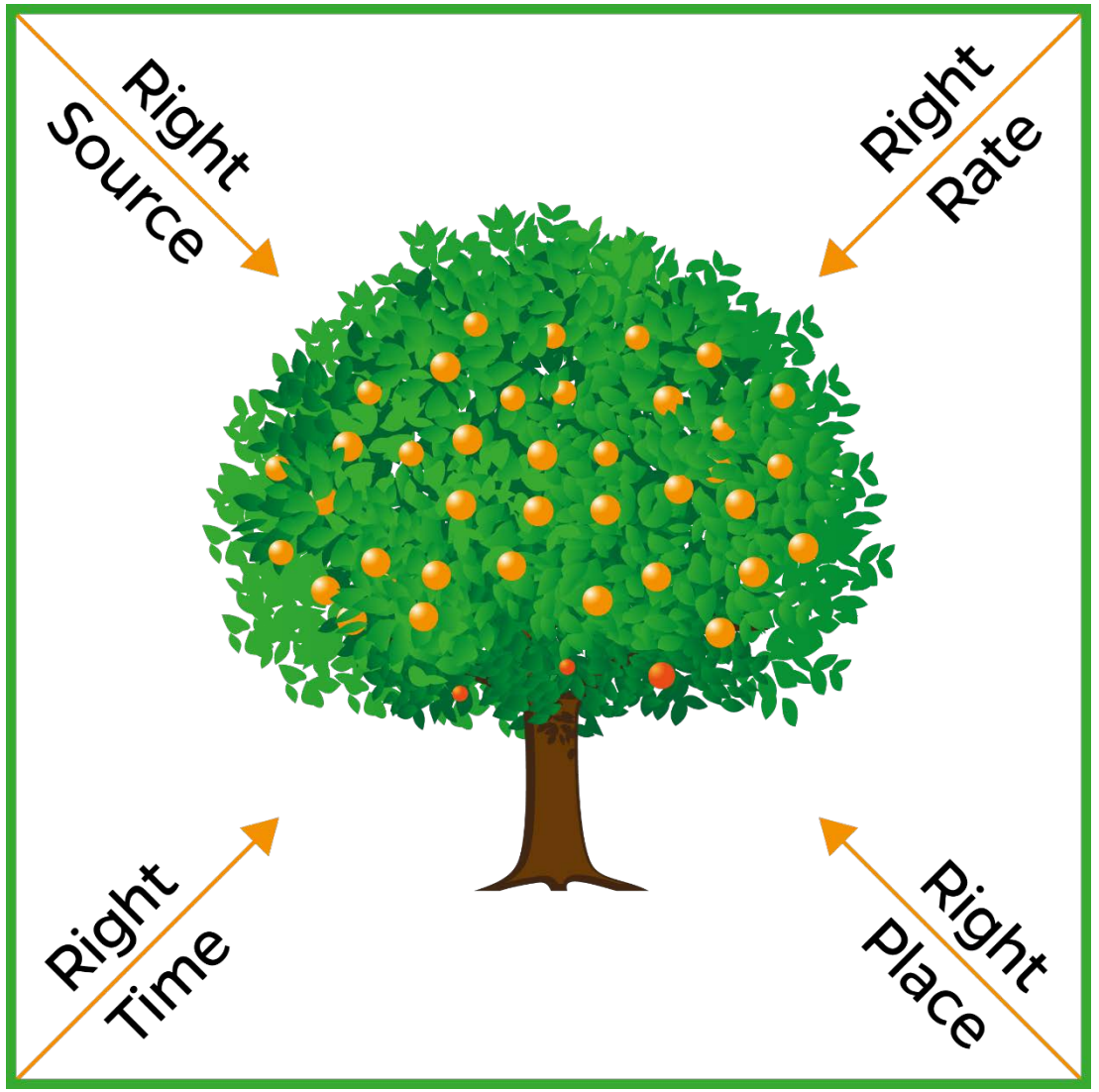
- Do not move in the plant
- Transported only via xylem
- Immobile nutrients will not move to new growth areas
- The deficiency symptoms will first show up in the new growth because they cannot take nutrients from the old leaves
- Nutrients: **Calcium, Iron, Zinc, Copper, Manganese, Boron, Molybdenum**
- Soil applied nutrients are adequate
- Should be supplied whenever there is growth



Credit: T.R. Weeks, UF/IFAS

4R's of Plant Nutrition

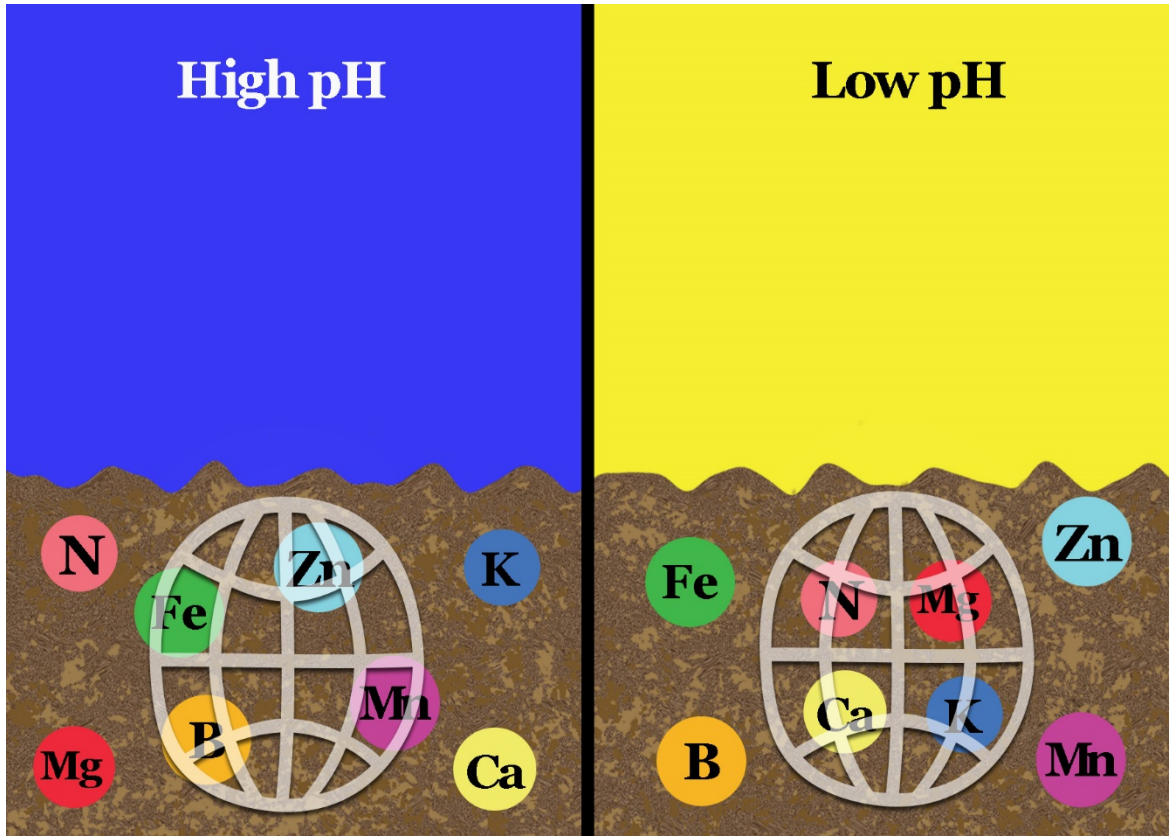
- Right Source
  - Nutrients
- Right Rate
  - Amount
- Right Time
  - High demand
  - Morning or evening
- Right Place
  - Soil or foliar



Credit: UF/IFAS Communications

Soil pH

- A critical factor for nutrient uptake
- At high soil pH, most of the micronutrients bind to the soil and becomes unavailable
- At extremely low soil pH, most of the macro and secondary nutrients become unavailable
- The goal is to have right soil pH at the time when nutrient uptake is expected
- Recommended to keep soil pH between 6.0-6.5



Credit: T.R. Weeks, UF/IFAS

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Does nutrition play a role in managing HLB?

Goal

- Effect of controlled release form of mineral nutrient, elevated levels of individual micronutrients, and soil pH amendments (to lower pH)
    - Soil pH amendment
    - Micronutrients at higher rate

Credit: T.R. Weeks, UF/IFAS

Soil pH of Healthy vs HLB Trees

- Evaluated different ranges of soil pH on healthy and HLB trees
- By day 60, significant leaf drop and tree death

pH 5.8

pH 7.0

pH 8.0

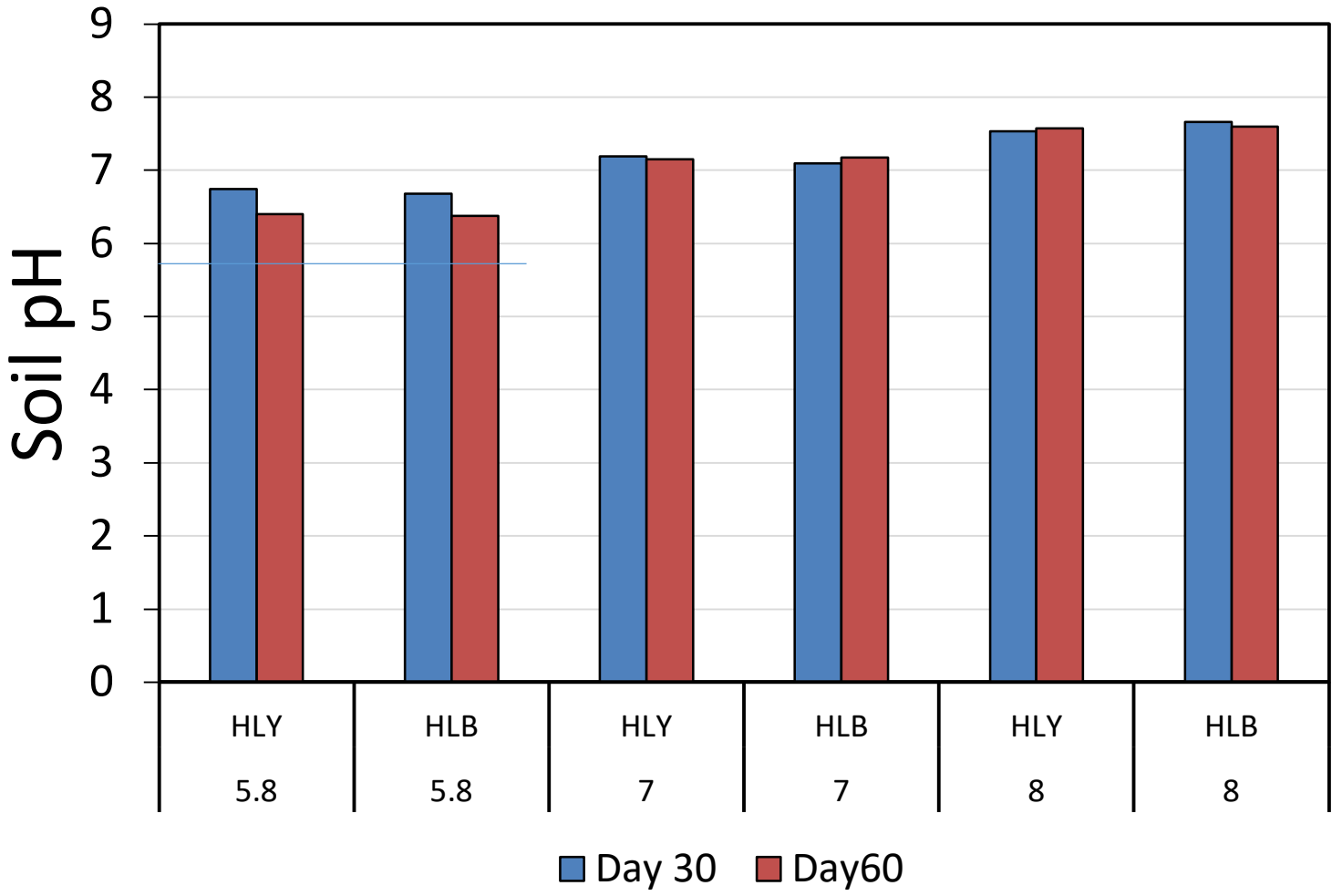
Soil pH of HLB vs Healthy Trees

- HLB-affected trees decline more rapidly than healthy trees at high pH

pH	Disease	Total no. of Plants	Dead	Leaf Drop (%)
5.8	Healthy	8	0	21
5.8	HLB	8	0	16
7	Healthy	8	0	50
7	HLB	8	1	57
8	Healthy	8	1	60
8	HLB	8	3	83

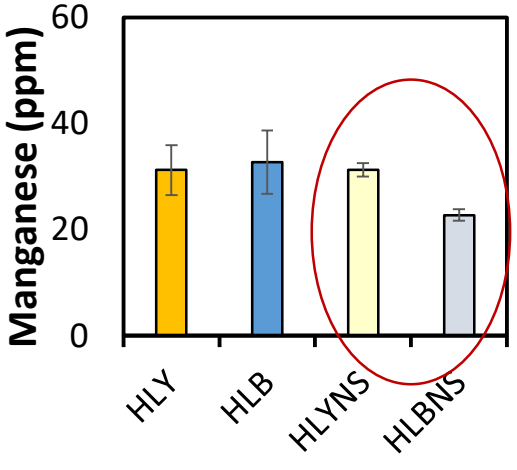
Soil pH of HLB vs Healthy Trees

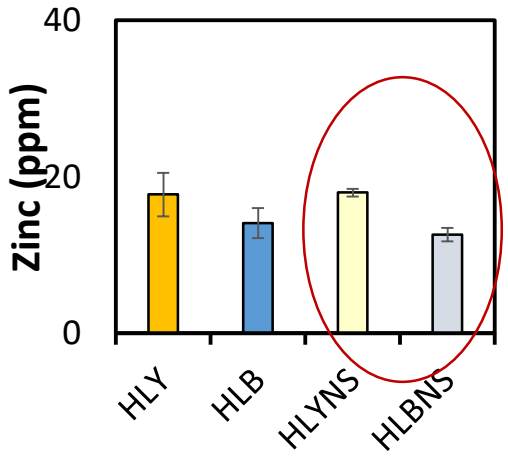
- Both HLB and healthy plants showed a tendency of bringing soil pH close to 7 in course of experiment
  - Soil has its own buffering capacity
- When pH is not in the optimum range, nutrients become bound and unavailable to plant
- Optimum ranges
  - HLB: 5.8-6.5
  - Healthy: 6.0-6.5

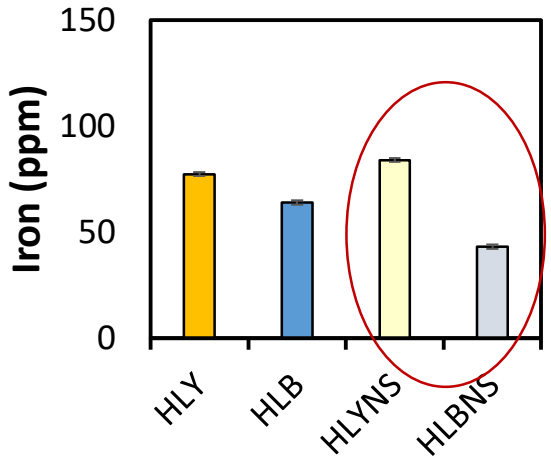


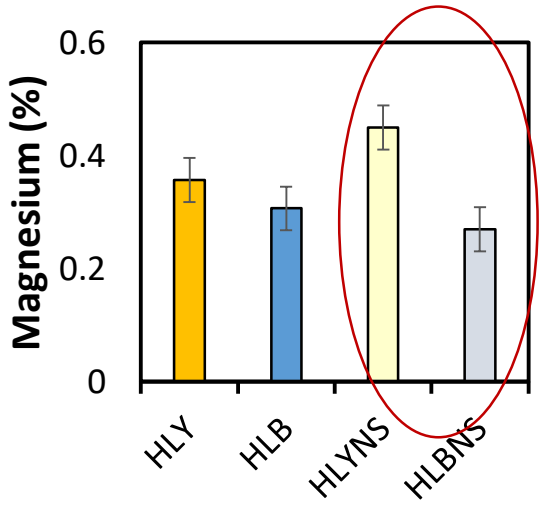
HLB-affected trees often have deficiency of nutrients

- Due to significant reduction in root mass/quantity
- Compromised physiological processes (photosynthesis, growth, etc.)
- Bacterial infection may result in higher metabolism (plant defense response)









- HLB-affected trees like a lower pH, higher micronutrients, and constant supply

Does nutrition play a role in managing HLB?

- Short answer, yes!
- How?
  - Optimum pH range for healthy trees, 6.0-6.5
  - HLB-affected trees prefer a more acidic (lower) pH than healthy trees, 5.8-6.5
- Healthy trees can withstand stress better, but HLB-affected trees decline faster with any stress
- HLB-affected trees benefit from spoon-feeding
- The fertilizer plan should be customized for each grove-No one size fits all

How are these new findings being used in the groves?

Citrus Nutrition Box Program

- Good fertilizer program can be effective in managing HLB-affected trees
- Provide a resource to commercial citrus growers
- Assist in developing a customized nutrition management program

Credit: T. Jones, UF/IFAS

How does the program work?

- Collaboration between growers and UF
- Program operates from October 2019-November 2020
- Lab services are provided at no charge to the grower
- Only cost for the grower is the shipping cost

Credit: T. Weeks, UF/IFAS

How does the program work?

- Growers
  - Growers receive a nutrition box kit with a unique identifying number
  - Growers will collect samples and mail to lab
- UF
  - Will receive results from lab
  - Twice a month UF faculty and Extension agents will meet to make recommendations
  - Will send results and recommendation to grower for the next quarter
  - Will send collection sample reminders every 3 months

Credit: T. Weeks, UF/IFAS

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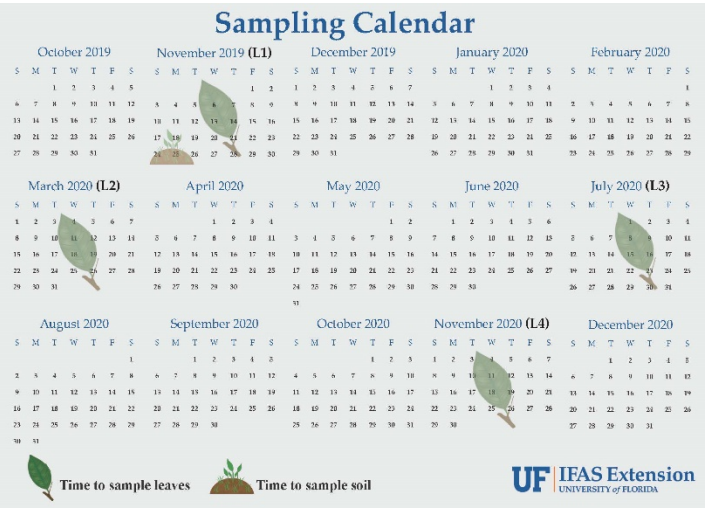
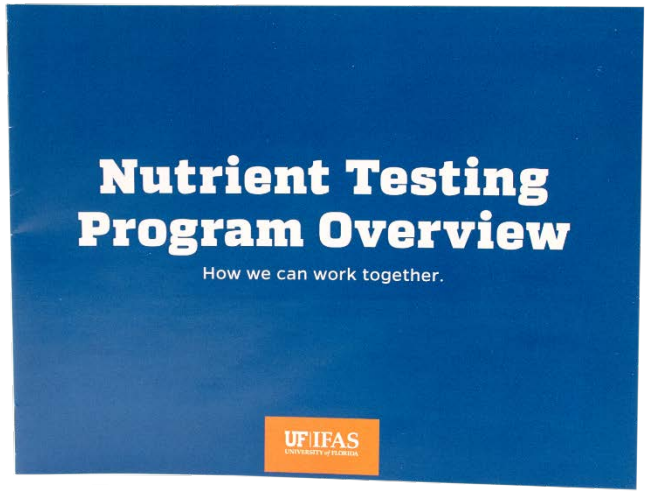
What's in the box?

- Nutrient Testing Program Overview
- Sampling Calendar
- Resources





Credit: T. Weeks, UF/IFAS CREC

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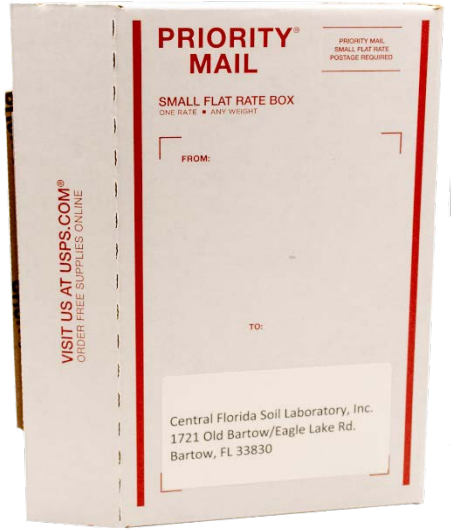
What's in the box?

- Four brown paper bags for leaf sample (L1, L2, L3, L4)
- Four shipping envelopes for leaf samples
- Zip top bag for soil collection (S)
- Shipping box for soil sample



Credit: T. Weeks, UF/IFAS

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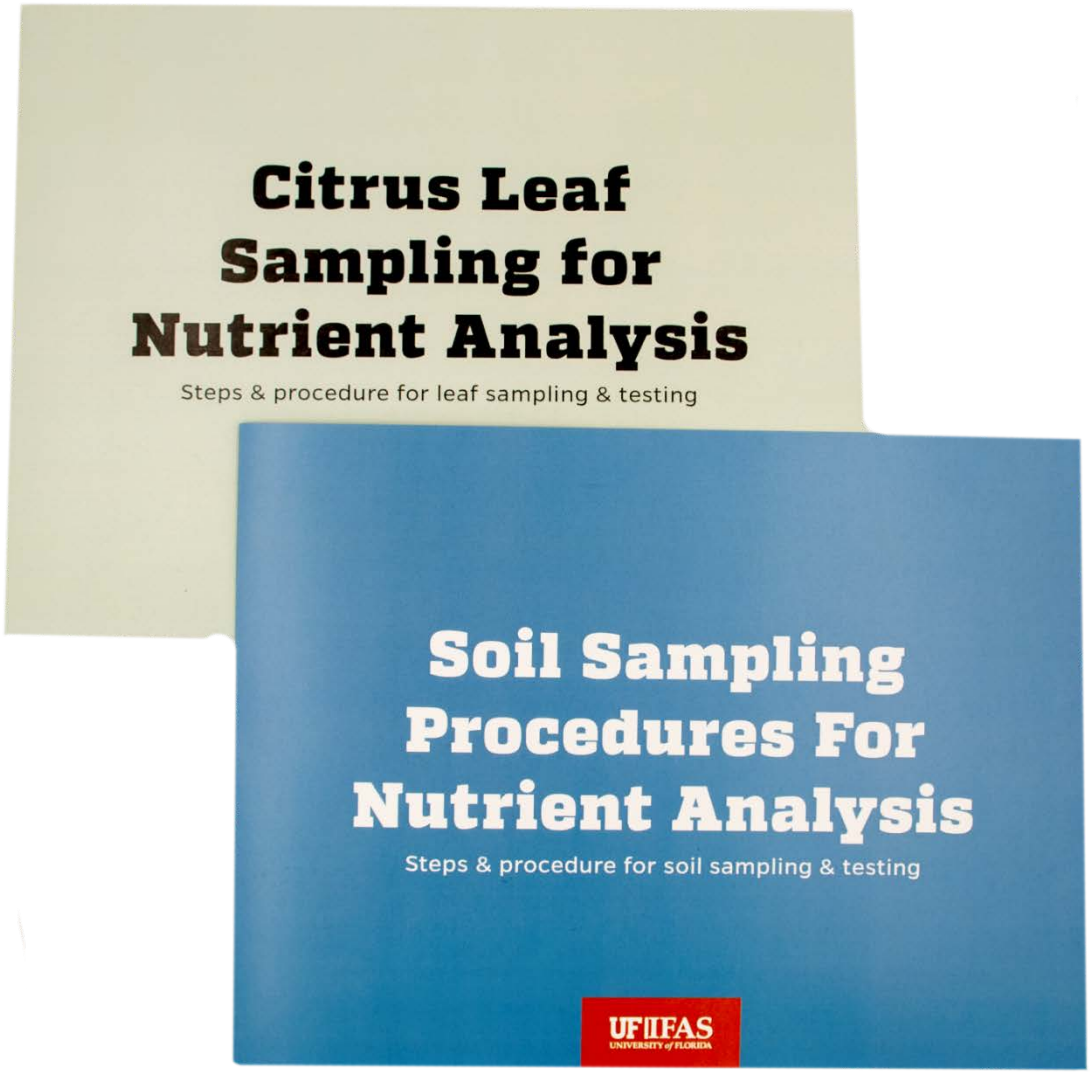
What's in the box?

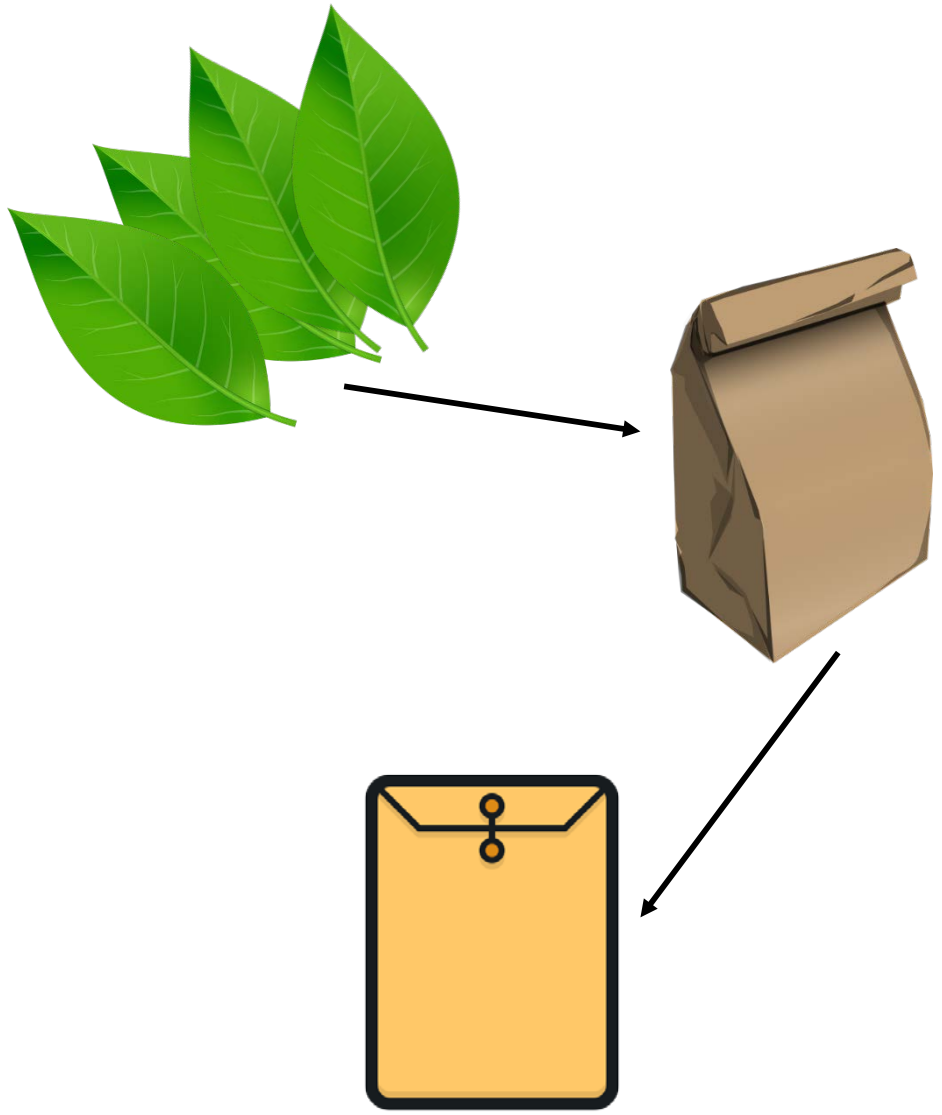
- Citrus Leaf Sampling for Nutrient Analysis
- Soil Sampling Procedures for Nutrient Analysis



Credit: T. Weeks, UF/IFAS

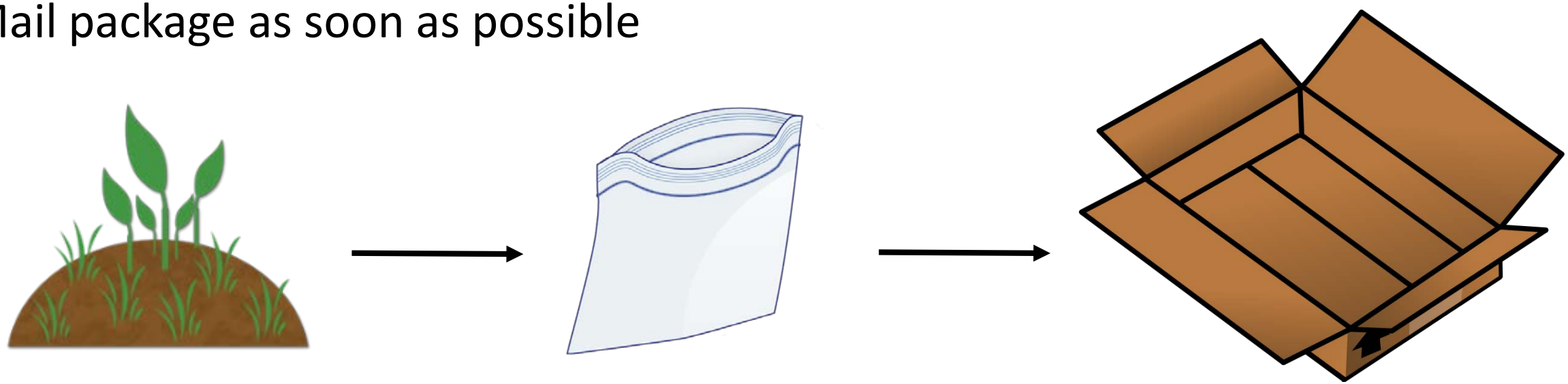
Leaf Sampling Instructions

- Place leaves into brown paper bag
  - L1: November 2019
  - L2: March 2020
  - L3: July 2020
  - L4: November 2020
- Insert brown paper bag into pre-addressed padded envelope
- Mail package as soon as possible



Soil Sampling Instructions

- Place soil into clear zip top bag
  - S: November 2019
- Insert zip top bag into pre-addressed box
- Mail package as soon as possible



Credit: T. Weeks, UF/IFAS (soil)

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Results

- Results will be sent via email
  - citrusnutrition@ifas.ufl.edu

LEAF ANALYSIS										
	N	P	K	Mg	Ca	B	Zn	Mn	Fe	Cu
	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
Lab Results	1.93	0.13	1.35	0.23	2.92	51.52	50.54	54.14	49.92	10.41

SOIL ANALYSIS												
	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu	CEC	pH
	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	meq/100g	
Lab Results	83	72	423	1910	72	0.48	19.82	7	17	10.59	7.42	7

Recommendation for next quarter per acre	N	P	K	Mg	Ca	B	Zn	Mn	Fe	Cu
	Add 50lb/acre	no change	Add 50lb/acre	Add 10lb/acre	Add 20lb/acre	Add 1/3lb per acre	Add 3 lb/acre	Add 3 lb/acre	Add 1.5 lb/acre	no change

Goal

- Goal is to have all nutrient levels within the suggested range

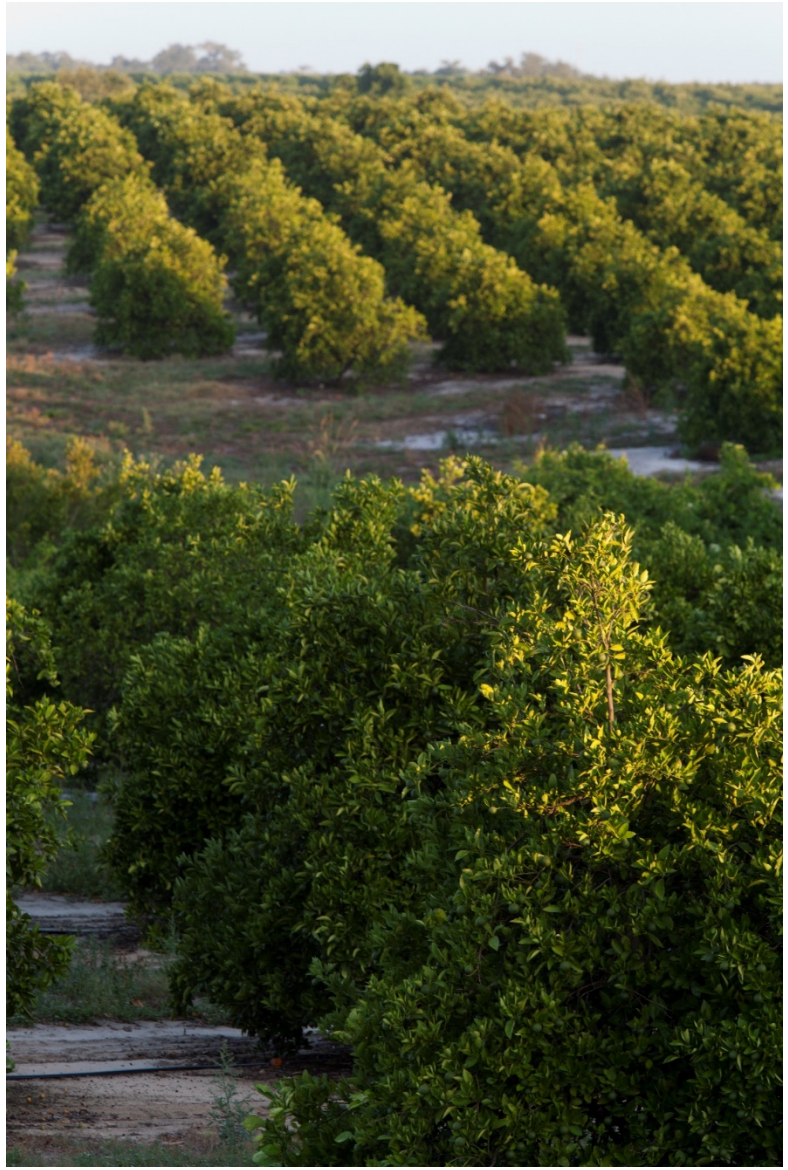
Guidelines for interpretation of orange tree leaf analysis based on 4 to 6-month-old spring flush leaves from non-fruiting twigs (Koo et al., 1984)							
Element	**Unit of Measure**	**Deficient**	**Low**	**Optimum**	**High**	**Excess**	**Suggested Range for HLB[3]**
N	%	<2.2	2.2 - 2.4	2.5 - 2.7	2.8 - 3.0	>3.0	2.6-2.9
P	%	<0.09	0.09 - 0.11	0.12 - 0.16	0.17 - 0.30	>0.30	0.14-0.23
K	%	<0.7	0.7 - 1.1	1.2 - 1.7	1.8 - 2.4	>2.4	1.45 - 2.10
Ca	%	<1.5	1.5 - 2.9	3.0 - 4.9	5.0 - 7.0	>7.0	3. 5 – 6.00
Mg	%	<0.20	0.20 - 0.29	0.30 - 0.49	0.50 - 0.70	>0.70	0.35 – 0.60
Mn	mg/kg or ppm	<18	18 - 24	25 - 100	101 - 300	>300	50– 150
Zn	mg/kg or ppm	<18	18 - 24	25 - 100	101 - 300	>300	50 – 150
Cu	mg/kg or ppm	<3	3 - 4	5 - 16	17 - 20	>20	10 – 18
Fe	mg/kg or ppm	<35	35 - 59	60 - 120	121 - 200	>200	90 – 160
B	mg/kg or ppm	<20	20 - 35	36 -100	101 - 200	>200	68 – 150

These are suggestions for HLB-affected trees based on the field observations, these ranges have not been scientifically proven yet.

Source: Nutrition of Florida Citrus Trees. Second Edition. Thomas A. Obreza and Kelly T. Morgan. https://edis.ifas.ufl.edu/pdffiles/SS/SS47800.pdf; Soil and Leaf Tissue Testing for Commercial Citrus Production, T.A. Obreza, M. Zekri, E. A. Hanlon, K. Morgan, A. Schumann, and R. Rouse. https://edis.ifas.ufl.edu/pdffiles/SS/SS53100.pdf

Value of the Program

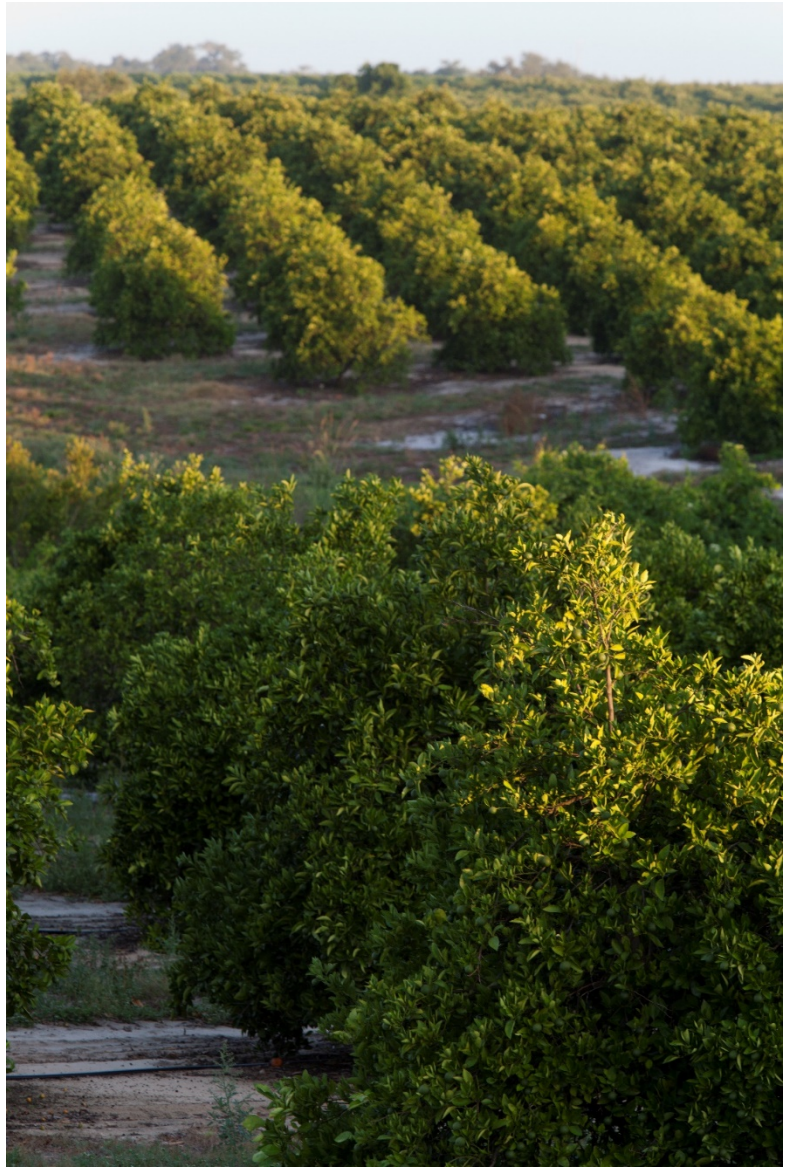
- Personalized nutrition management plan for one year
- Demonstration of the effectiveness of regular leaf sampling and developing customized fertilizer program
- Intensive nutrient management should improve productivity
- Monetary value = 4 leaf nutrient test and 1 soil nutrient test > $ 120



Credit: T. Jones, UF/IFAS

Future of the Program

- Currently considering if the program will continue next year
- Announcements will be made through the All In for Citrus newsletter
  - citrusresearch.ifas.ufl.edu to view newsletters and sign up



Credit: T. Jones, UF/IFAS

Take Home Message

- The method used to fertilize does not determine fruit quality
- Good nutrition practices are a must whether the trees are healthy or HLB-affected
- Every grove will have its own plan-No one size fits all!
- HLB-affected trees respond to intensive (spoon feeding) fertilizer management
- Regular nutrient sampling helps in assessing trees nutritional needs
- With regular sampling, the fertilizer program can be tweaked to ensure that trees demands are being met

Resources

- 2019-2020 Florida Citrus Production Guide: Fertilizer Application Methods. https://edis.ifas.ufl.edu/pdffiles/CG/CG09200.pdf

- Citrus Nutrition Management Practices. https://edis.ifas.ufl.edu/pdffiles/HS/HS129200.pdf

- Nutrition of Florida Citrus Trees, Second Edition. https://edis.ifas.ufl.edu/pdffiles/SS/SS47800.pdf

Any questions?