Citrus Fertilizer Recommendations

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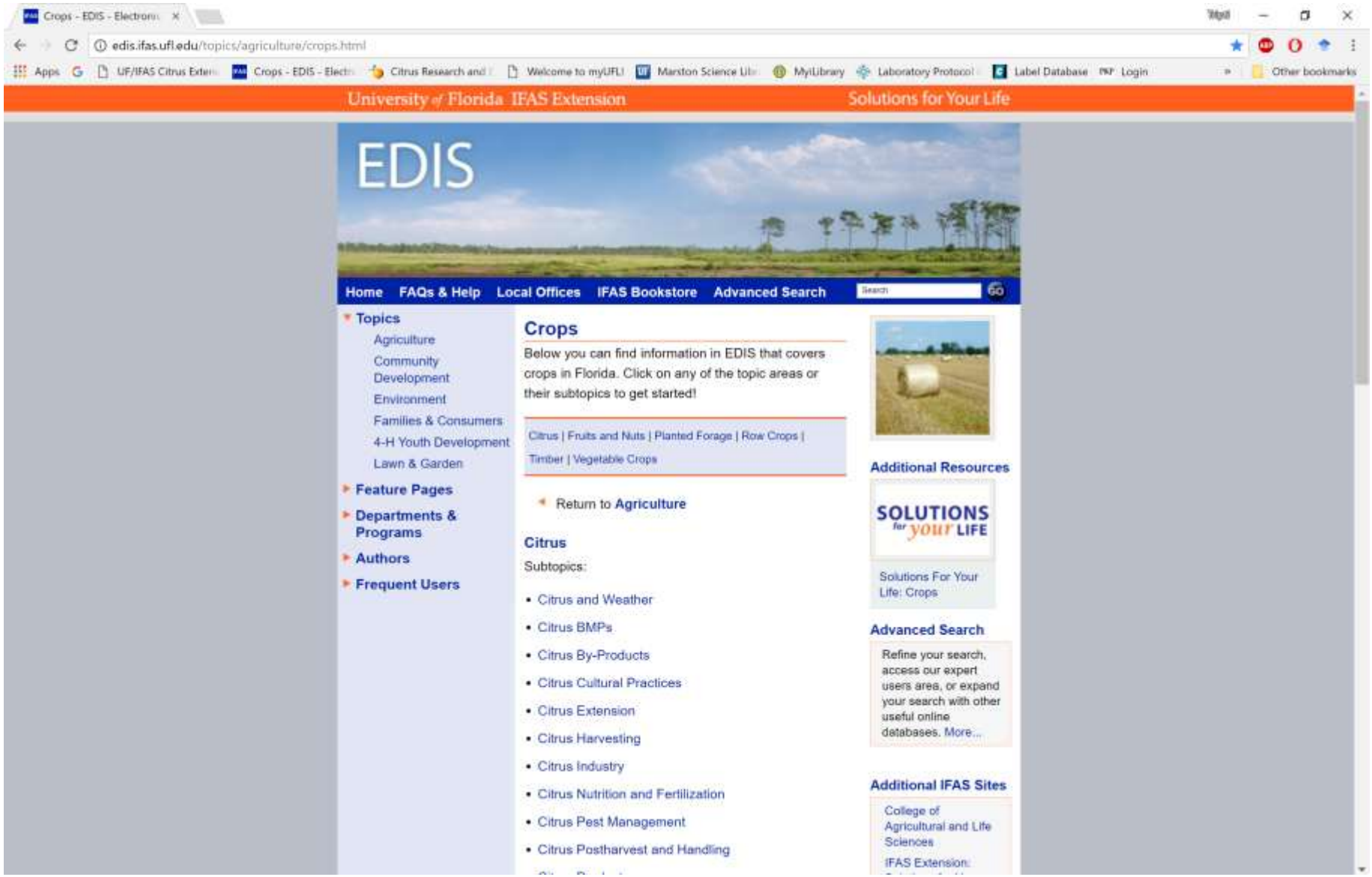
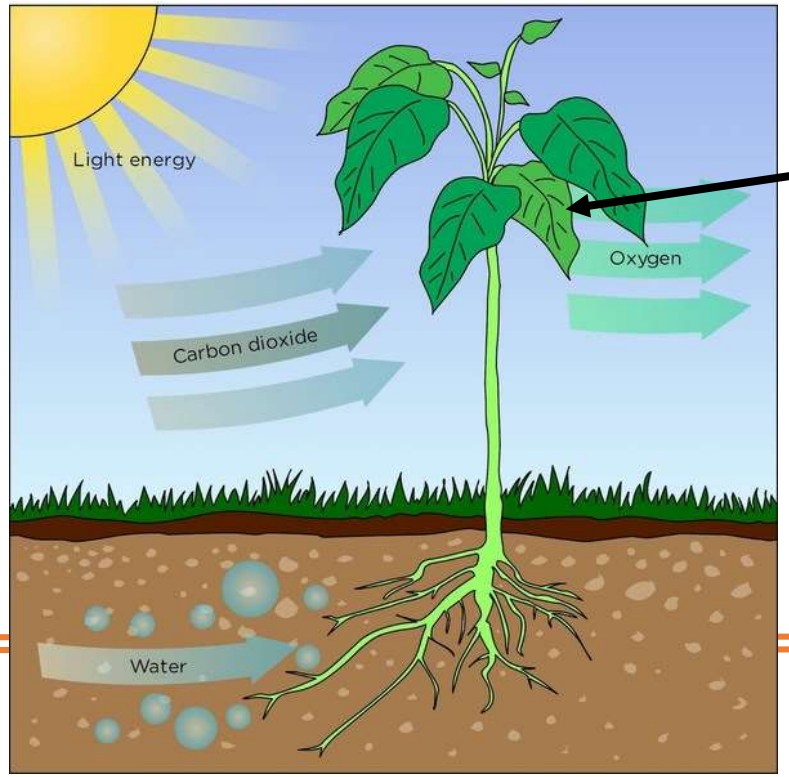
http://edis.ifas.ufl.edu/topics/agriculture/crops.html



Plant Mineral Nutrition

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



Photosynthesis

Carbohydrates

Minerals elements

Proteins | Organic compounds | Fatty acids

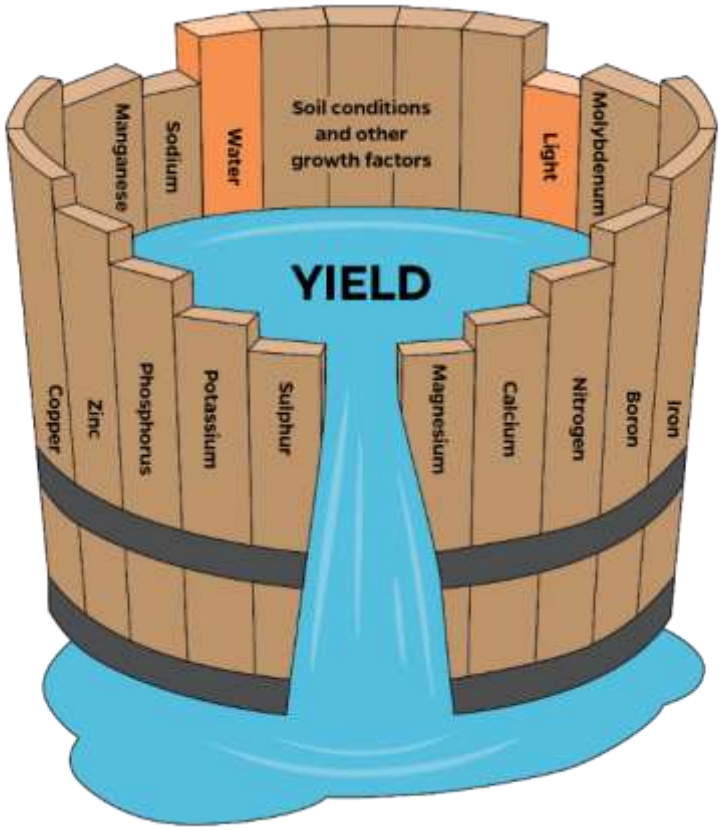
Mineral Nutrients

- There are 14 essential mineral nutrients for plants
- Only 13 have been proven essential for citrus
- These nutrients are not simply plant food necessary for optimum plant growth and yield; they also influence plant resistance or susceptibility to pathogens and pests

The 13 essential mineral nutrients required by all plants for normal growth and development.

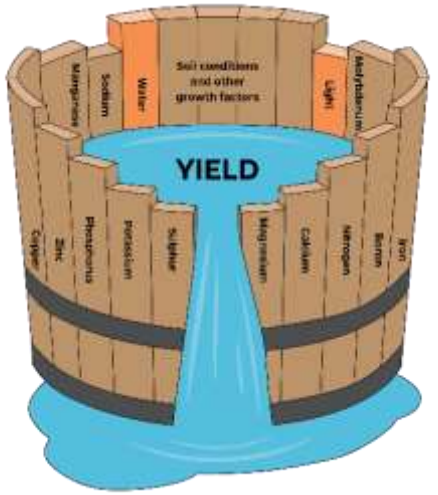
Nutrient	Chemical symbol	Relative abundance (%)	Function in plant
Nitrogen	N	100	Proteins, amino acids
Potassium	K	25	Catalyst, ion transport
Calcium	Ca	12.5	Cell wall component
Magnesium	Mg	8	Part of chlorophyll
Phosphorous	P	6	Nucleic acids, ATP
Sulfur	S	3	Amino acids
Chlorine	Cl	0.3	Photosynthesis reactions
Iron	Fe	0.2	Chlorophyll synthesis
Boron	B	0.2	Cell wall component
Manganese	Mn	0.1	Activates enzymes
Copper	Cu	0.01	Component of enzymes
Zinc	Zn	0.03	Activates enzymes
Molybdenum	Mo	0.0001	N metabolism

Liebig's law of the minimum



yield is proportional to the amount of the most limiting nutrient!

Mineral Nutrition

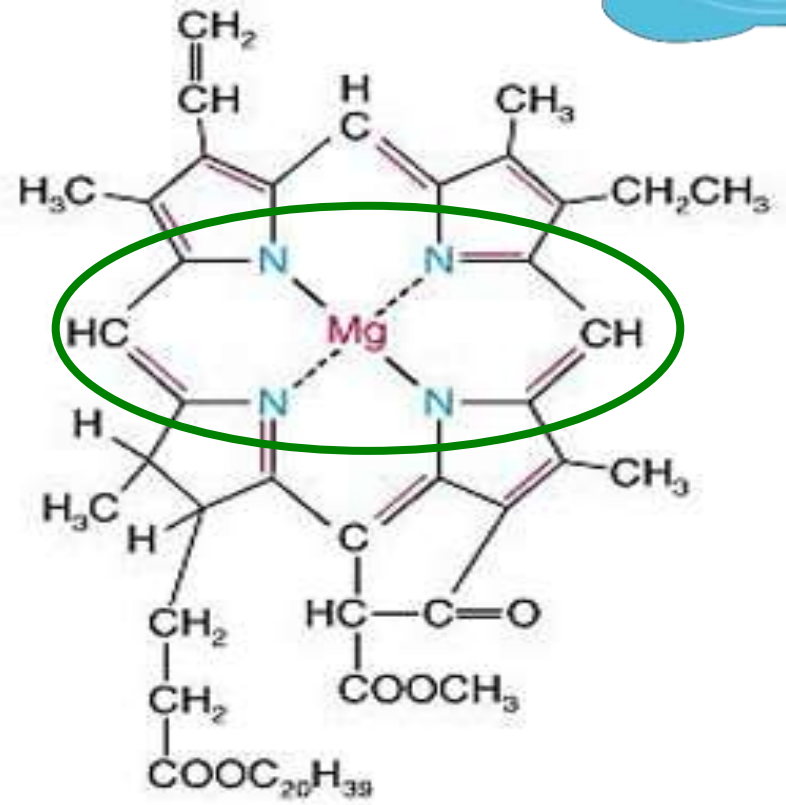


ABC of fertilization

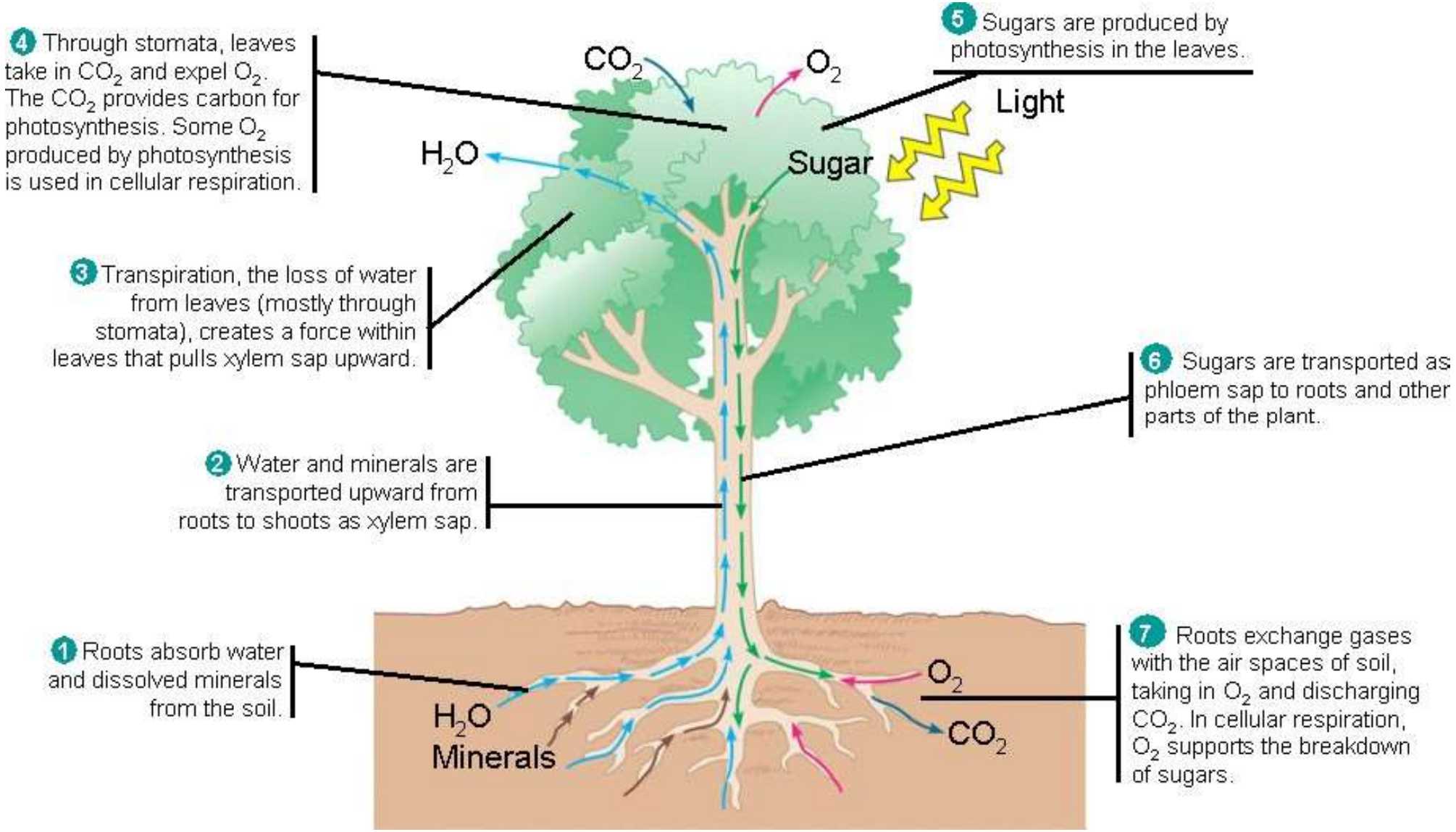
- ✓ All- 17 essential elements

  Example- Chlorophyll is critical for photosynthesis

  Magnesium
  Nitrogen



- ✓ Balance is critical
- ✓ Constant


4 Through stomata, leaves take in CO_2 and expel O_2. The CO_2 provides carbon for photosynthesis. Some O_2 produced by photosynthesis is used in cellular respiration.
CO_2
O_2
5 Sugars are produced by photosynthesis in the leaves.
Light
H_2O
Sugar
3 Transpiration, the loss of water from leaves (mostly through stomata), creates a force within leaves that pulls xylem sap upward.
6 Sugars are transported as phloem sap to roots and other parts of the plant.
2 Water and minerals are transported upward from roots to shoots as xylem sap.
1 Roots absorb water and dissolved minerals from the soil.
H_2O
Minerals
O_2
CO_2
7 Roots exchange gases with the air spaces of soil, taking in O_2 and discharging CO_2. In cellular respiration, O_2 supports the breakdown of sugars.

Fertilization Program

- Conventional broadcast application of dry fertilizer - inexpensive, readily available to plant, subject to leaching, multiple applications
- Controlled release fertilizer - slowly released, constant supply of nutrients, fewer applications
- Fertigation - Relatively inexpensive, flexibility in application, small doses and constant supply, high maintenance, not suitable for all nutrients, application during rainy season can be a concern

Mineral Nutrition

- Foliar application of mineral nutrients are quick solution for deficiency
- Young flush is more efficient is nutrient absorption
- Roots are most efficient in nutrients uptake and moving the nutrients to other parts of plant
- Soil applications is critical for long term solution
- Not every nutrient is mobile

Fertilization

- Young plants have smaller root systems
- Fertilizer should be applied in the wetted zone of the tree
- In wetted zone nutrients dissolve in water and gets taken up by the plant

Florida Fertilization Recommendations (Nitrogen)

Year in grove	lbs N/tree/year (range)	Lower limit of annual application frequency		
		Controlled-release fertilizer	Dry soluble fertilizer	Fertigation
1	0.15 – 0.30	1	6	10
2	0.30 – 0.60	1	5	10
3	0.45 – 0.90	1	4	10

Year in grove	Oranges	Grapefruit	Other varieties	Lower limit of annual application frequency		
	lbs N/acre/year (range)			Controlled-release fertilizer	Dry soluble fertilizer	Fertigation
4 through 7	120 – 200	120 – 160	120 – 200	1	3	10
8 and up	140 – 250 Yield-based[1]	120 – 160[2]	120 – 300[3]	1	3	10

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Fertilization Recommendations

- Phosphorus- Depends on leaf and soil nutrient analysis results
  - If leaf phosphorus is optimum low, apply about 50% of nitrogen
- Potassium-Should be 1:1 or 1:1.2 to nitrogen
- Magnesium- about 20% of nitrogen
- Calcium-Depends on leaf and soil nutrient analysis results
  - If low then apply, 50-75% of nitrogen
  - Application gypsum or dolomite can increase soil pH
  - $CaNO_3$

Fertilization Recommendations

- If trees are planted on previously non-cultivated land, apply Mn, Cu, and B at 5%, 2.5%, and 0.33% of the N rate, respectively

Table 8.4. Recommended methods, timing, and rates for micronutrient application to citrus groves.

		Mn	Zn	Cu	B	Fe
Method	**Foliar**	Yes	Yes	Yes	Yes	No
	Soil	Yes[1]	No	Yes	Yes	Yes
Timing	**Foliar**	When spring flush leaves reach full expansion				
	Soil	Anytime as needed				
Rates		**lbs metallic equivalent/acre**				
	Foliar	3 to 5	5	3 to 5	¼	---
	Soil	7 to 10	---	5	1	See below[2]

[1]Soil applications of Mn are not recommended on calcareous soils.
[2]Acid soil: Fe-EDTA, ⅔ oz elemental Fe/tree; Calcareous soil: Fe-EDDHA, 1¾ oz elemental Fe/tree.

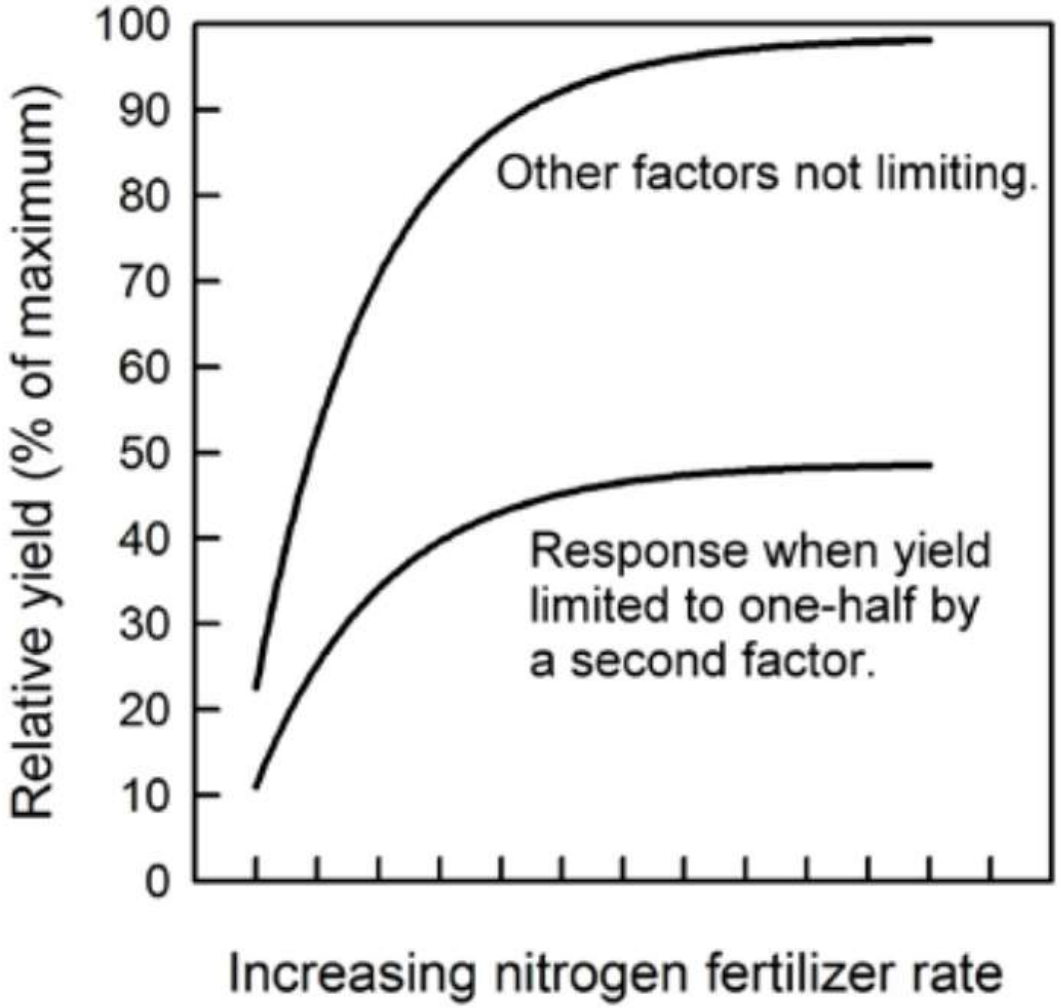

Fig. 3.1. Generic response of citrus yield to N fertilizer rate.

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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

Fertilization and Fruit quality

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Leaf and Soil Nutrient Analysis

- Nutrient deficiency or excess will cause citrus trees to grow poorly and produce sub-optimal yield and/or fruit quality
- Leaf tissue analysis is the quantitative determination of the total mineral nutrient concentrations in the leaf. Tissue testing includes analysis for N, P, K, Ca, Mg, S, Mn, Zn, Cu, Fe, and B
- Tissue analysis:
  - Determines if the tree has had a sufficient supply of essential nutrients
  - Evaluates the effectiveness of fertilizer programs

Leaf Nutrient Analysis

- The best time to collect 4 to 6-month-old spring flush leaves is July and August
- Collect leaf samples from trees and pool
- Take at least 2-3 samples (replicates)
- Wash the leaves with mild detergent
- Dry leaves in an oven at 140F and then send for analysis
  - University of Florida soils lab
  - Waters Lab Georgia

Leaf Nutrient Analysis

- Dc
  ap
- Dc
  sy
- Dc

Table 4.2. 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
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[1]
Na	%	---	---	---	0.15 – 0.25	> 0.25
Mn	mg/kg or ppm[2]	< 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

[1]Leaf burn and defoliation can occur at Cl concentration >1.0%.
[2]ppm = parts per million.

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Soil Nutrient Analysis

- 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
- 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

Soil Nutrient Analysis

- 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
- 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.

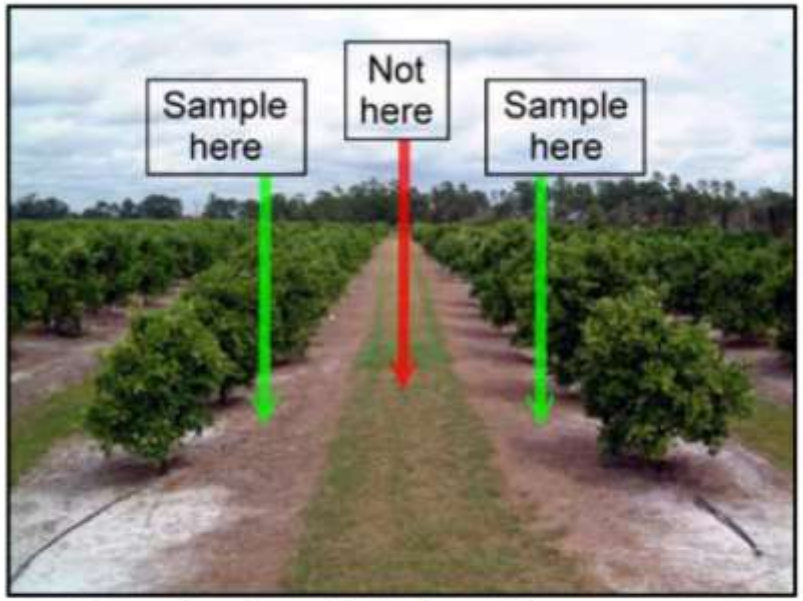

Fig. 4.6. Sample soil near the dripline of the trees, not in the row middle. (Thomas Obreza)

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Table 4.6. 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]	1. Lime to pH 6.0.	1. Do nothing. 2. Use acid-forming N fertilizer. 3. Apply elemental sulfur. 4. Change rootstocks.
Organic matter[2]	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 (see Chapter 8).	1. Do nothing.
K	1. Apply K fertilizer (see Chapter 8).	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.

[1]The sufficiency value for soil pH is 6.0.
[2]There is no established sufficiency value for soil organic matter.

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Nutrient Deficiency

Definition of Terms

- Interveinal: the areas between the leaf veins
- Chlorosis/Chlorotic: yellowing of leaves

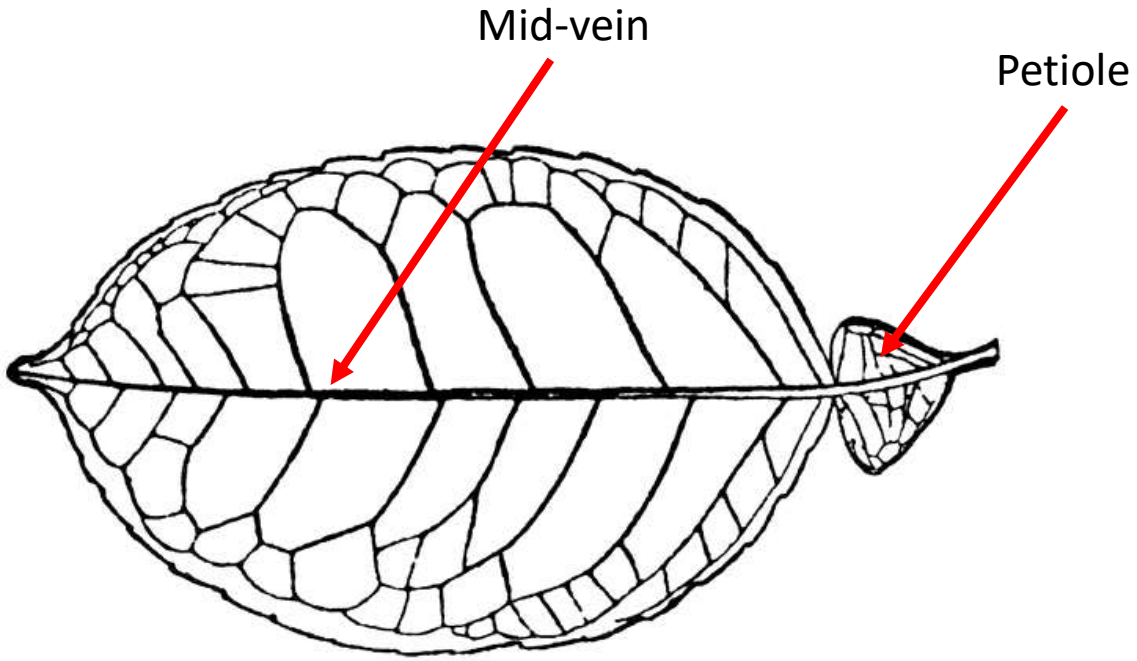

Photo Credit: http://etc.usf.edu/clipart/58500/58557/58557_grpfrt_leaf.htm

Nitrogen Deficiency

- Leaf Symptoms
  - Entire leaf yellowing of old leaves

Photo (above): Entire leaf yellowing
Photo (left): The photos showing nitrogen progression; left leaf is heathy

Photo Credit: Tripti Vashisth, UF/IFAS CREC; A Guide to Citrus Nutritional Deficiency and Toxicity Identification, S.H. Futch and David P.H. Tucker

Potassium Deficiency

- Leaf Symptoms
  - yellowing of the tips and margins which becomes broader

Photo (right): Tree with high number of fruit often show more potassium deficiency
Photo (left): The photos showing potassium progression

Photo Credit: Tripti Vashisth, UF/IFAS CREC

Magnesium Deficiency

- Leaf Symptoms
  - Inverted ‘V’ pattern at base of leaf
  - Leaves may become entirely yellow-bronze

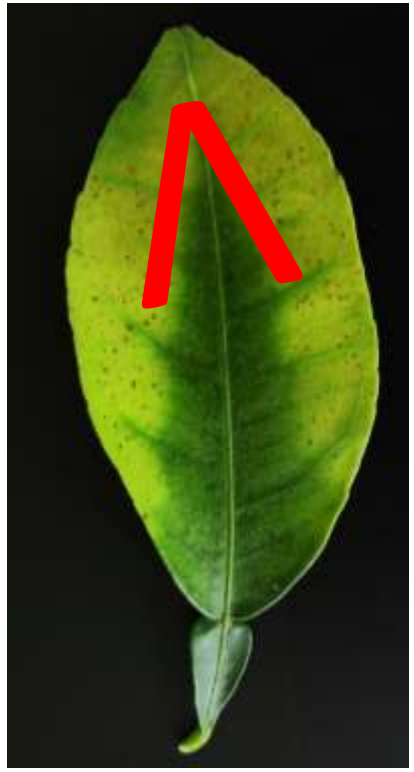

Photo Credit: Tom Obreza, UF/IFAS; Mongi Zekri, UF/IFAS; A Guide to Citrus Nutritional Deficiency and Toxicity Identification, S.H. Futch and David P.H. Tucker

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Boron Deficiency

- Leaf Symptoms
  - Corky veins

Photo Credit: Tripti Vashisth, UF/IFAS CREC

Manganese Deficiency

- Leaf Symptoms
  - Dark green bands along midrib and main veins surrounded by light green interveinal areas

Photo Credit: Tripti Vashisth, UF/IFAS CREC; A Guide to Citrus Nutritional Deficiency and Toxicity Identification, S.H. Futch and David P.H. Tucker

Zinc Deficiency

- Leaf Symptoms
  - Early symptoms have small blotches of yellow between green veins on leaf
  - Green islands
  - Leaf is yellow with green veins

Photo Credit: Tripti Vashisth, UF/IFAS CREC; Jamie D. Burrow, UF/IFAS CREC; UF/IFAS

Iron Deficiency

- Leaf Symptoms
  - Green veins on a light green leaf
    - In severe cases, the leaf will become yellow and eventually the entire leaf area will be an ivory color

Photo Credit: Tripti Vashisth, UF/IFAS CREC

Copper Deficiency

- Leaf Symptoms
  - Mild deficiency has large, dark green leaves on long angular shoots
- Stem/Twig Symptoms
  - ‘S’ curved branching
  - Inter-nodal stem gumming
  - Twig dieback

Photo (above): ‘S’ curved branching
Photo (left): Stem gumming

Photo Credit: Tripti Vashisth, UF/IFAS CREC; A Guide to Citrus Nutritional Deficiency and Toxicity Identification, S.H. Futch and David P.H. Tucker

Salt or Fertilizer Burn

- Leaf Symptoms
  - burned necrotic or dry appearing edges on leaves
  - overall leaf "bronzing" (right)

Photo Credit: Brian Boman and Ed Stover, IRREC

Herbicide (Contact Phytotoxity)

2,4-D foliar contact phytotoxicity (left)

Glyphosate foliar contact phytotoxicity (right)

Definition of Terms

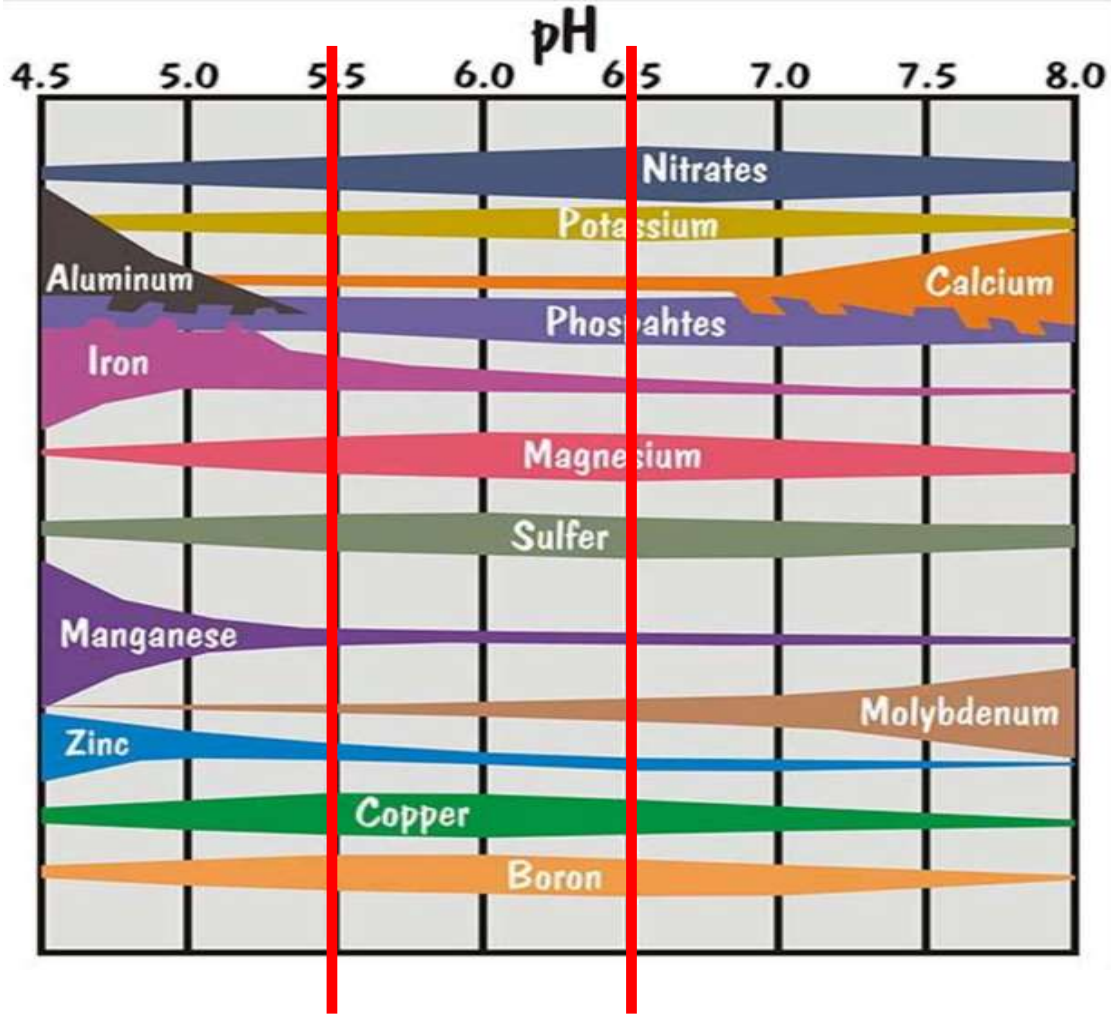
Indaziflam foliar contact phytotoxicity (left)

Paraquat contact phytotoxicity (right)

Photo Credit: Steve Futch

Soil pH

- Soil pH of the root zone is a very critical factor that affects nutrient uptake
- High soil pH reduces availability of metal ions such as Ca, Mg, Fe, Zn, Mn
- Rootstock sensitivity to high pH: Swingle > Carrizo > Sour orange > Cleopatra



Optimum pH Range

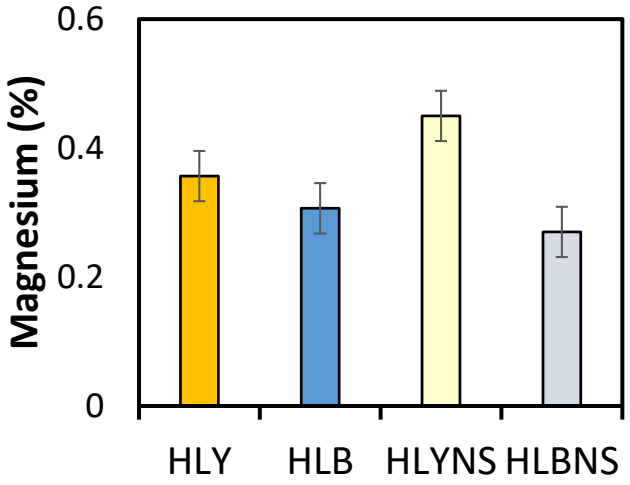
Soil pH, Water Quality and Bicarbonates

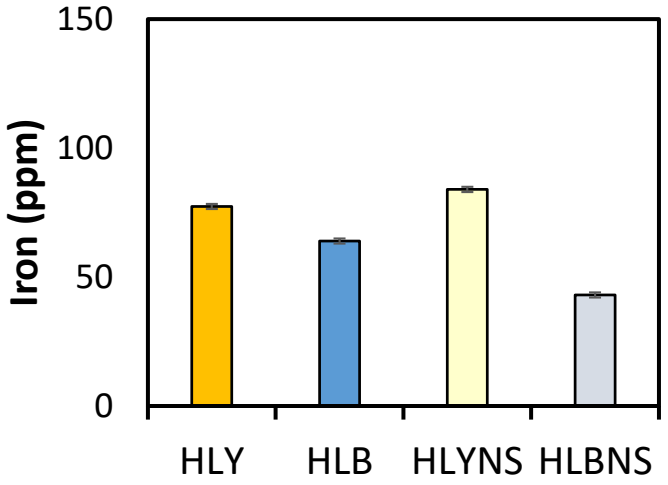
- Irrigation water in Florida is often high in bicarbonates
- Irrigating with such water over long periods of time can increase the soil pH
- Soil pH depends on irrigation water quality-the bicarbonate concentration in the water, irrigation timing and quantity, the buffering capacity of soil, and the rootstock variety

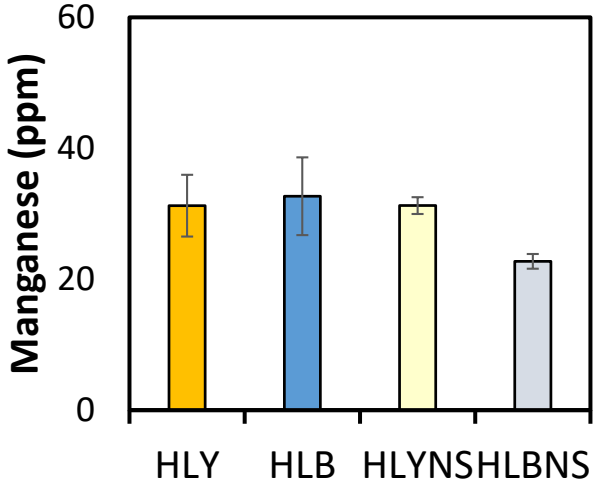
Maintaining Soil pH

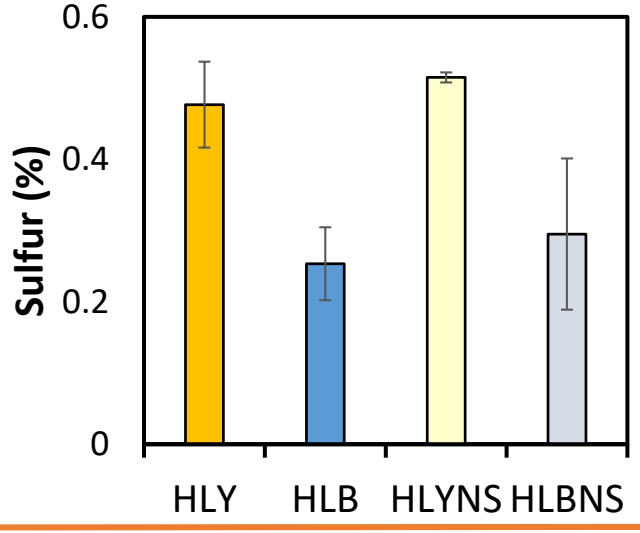
- Water conditioning: Inject N-phuric acid or sulfuric acid (40%) to reduce irrigation water to ≤ 100 ppm bicarbonate
  - Faster acting
  - Not working during rainy season
- Soil conditioning: broadcast sulfur in wetted zone to reduce soil pH
  - Slower acting
  - Works 24/7
- Soil pH can be increased by applying either calcitic or dolomitic lime. In addition to affecting soil pH, calcite is an effective source of Ca, whereas dolomite supplies both Ca and Mg

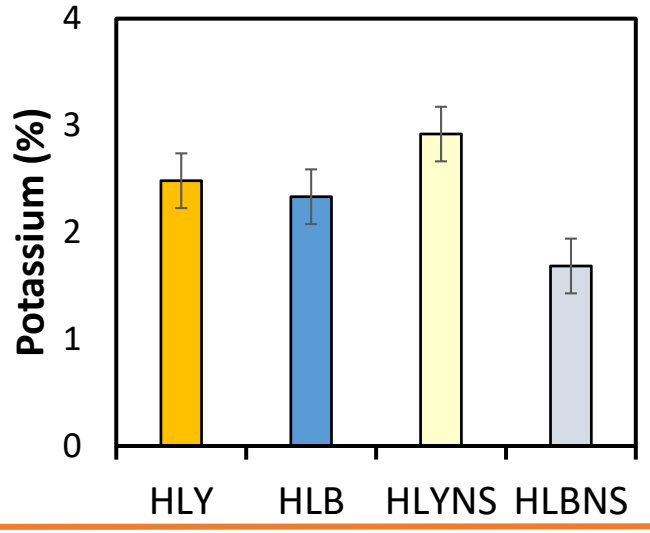
HLB and Nutrition

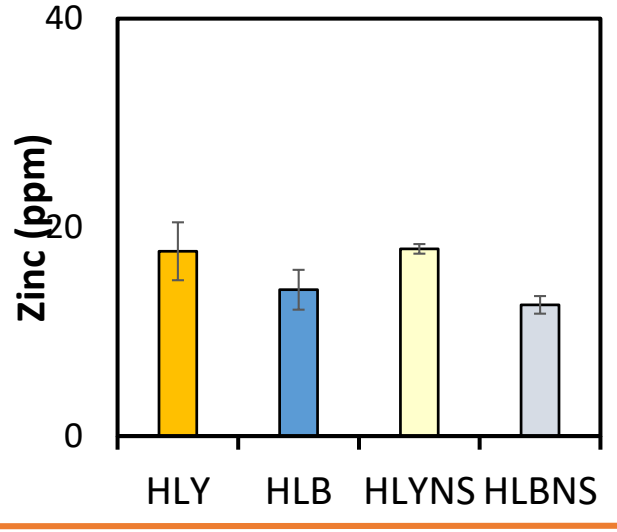












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HLB and Nutrition Survey

- Eight growers, spread throughout the state has been surveyed

Every grower agreed that their grove management programs are more intensive and better now then pre-HLB especially nutrition management.

Growers who had better nutrition management program pre-HLB and early on adopted good psyllid control did not see as much decline as some other growers.

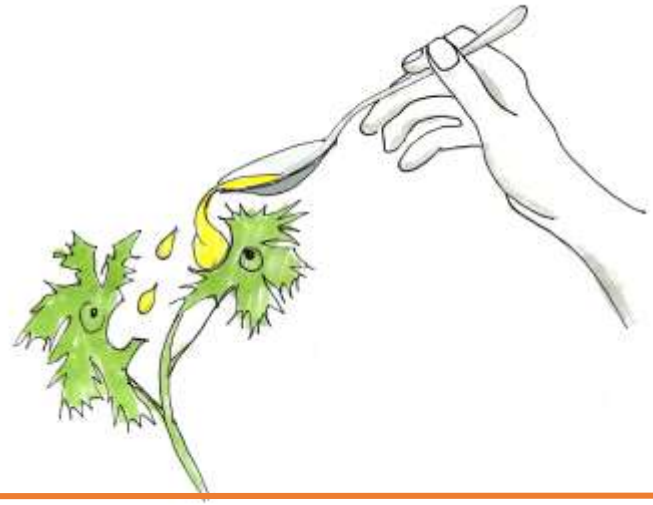
There is no fixed recipe for a management, programs are often site specific, requires good observation and analyses and then responding to tree needs.

Irrigation Management

- Majority of the groves are on microjet sprinklers with very few on seepage irrigation
- Increased irrigation frequency with smaller dosage
  - Season dependent
  - Everyday an hour or every second day for two hours or every 3 days for 4 hours

Nutrition Management

- Paying attention to leaf nutrient analysis, frequent sampling throughout the year
- Ensuring a constant supply of nutrients to the compromised root system
- Spoon feeding
- Rate of N range from 120 - 220 lb/acre
- Ratio N:K is around 1:1.3



Nutrition Management

- Majority of growers are using fertigation and dry fertilizer in combination
- Dry fertilizer applications are usually split in 2-3 application majority applied in early spring and early summer
- Fertigation is frequent, ranging from every week to every month, generally from February to October
- Some are using controlled release fertilizer in hybrid form about 3 applications a year

Nutrition Management

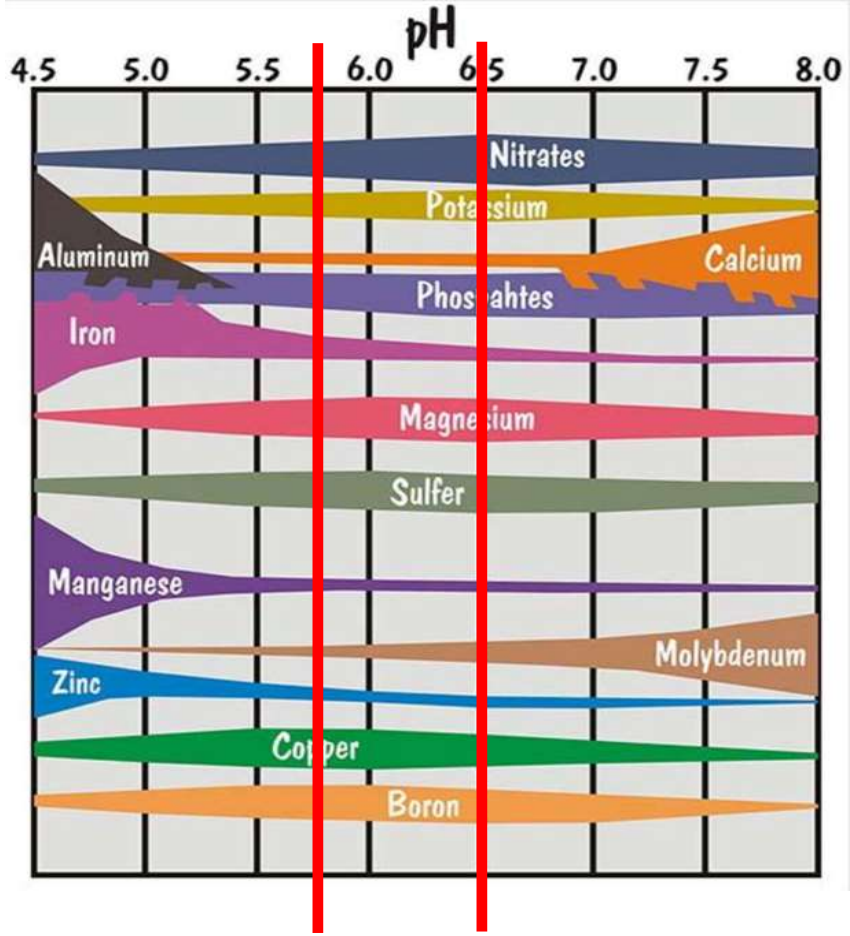
- Emphasis is paid on including all nutrients irrespective of method of delivery
- No focus on a specific nutrient
- Muriate of potash is generally avoided
- Generally applied rates of nutrients is slightly higher than IFAS recommendation but not extremely higher

Nutrition Management

- Micronutrients are present in every form of application
- Nitrate form of micronutrients in fertigation seems to be popular but sulfate and glucoheptonate are also applied
- Every grower is applying about 4-5 foliar sprays which include KNO_3 and micronutrients, starting from prebloom

Soil amendments and pH

- Majority of the growers are applying humic and fulvic acid
- Target soil pH range: 5.7-6.5
- No amendments unless 5.5
- To decrease pH – N-phuric, sulfuric, and nitric acid or broadcast application of elemental sulfur
- Fertilizer chemistry is often altered according to pH



Optimum pH Range

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Leaf Nutrient Analysis

	N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
1	3.0	0.11	1.3	0.3	3.6	0.3	84.3	27.0	34.3	113.5	97.8
2	2.5	0.10	1.2	0.4	4.0	0.4	62.1	114.4	73.0	71.1	213.8
3	2.9	0.15	1.4	0.4	3.3	0.3	95.2	32.4	35.2	70.0	45.6
4	2.9	0.10	1.2	0.3	4.2	0.3	95.7	21.7	25.2	59.8	9.5

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Survey Summary

- No one prescription for all!
- Growers are paying careful attention to trees and grove management especially nutrition and pH management is pretty dynamic
- Soil organic matter and CEC seems to have improved
- Leaf nutrient analysis shows optimum range for most nutrients
- Root density and canopy density seems to have improved
- A good nutrition program with balanced soil pH is helping trees in growing and increasing longevity

Questions?