Citrus Nutrition Box Program Update

Jamie D. Burrow, Extension Program Manager

Dr. Tripti Vashisth, Associate Professor

Dr. Davie Kadyampakeni, Assistant Professor

UF/IFAS Citrus Research and Education Center, Lake Alfred, Florida

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HAVE YOU FOUND ANYTHING?

KEY MESSAGES

- Nutrition box program was based on previous research
- Main objective was to help growers implement the research findings through a **collaborative project**
- From a statewide level, overall, **nutrition analysis looks good!**
- **Regional differences occur** with secondary macronutrients and micronutrients
- **Mn and Zn are a concern** for almost all areas
- **pH of 5.8-6.5 is ideal** for HLB-affected trees
- Grower update-visually looks good, but nutrient levels remained the same

SINCE THE DISCOVERY OF HLB

- Citrus tree health continually declined
- Decline in fruit production
- Visually see the decline
- Role of HLB tree nutrition management has been controversial
- Many nutrient research trials led to the foundation for the nutrition box program

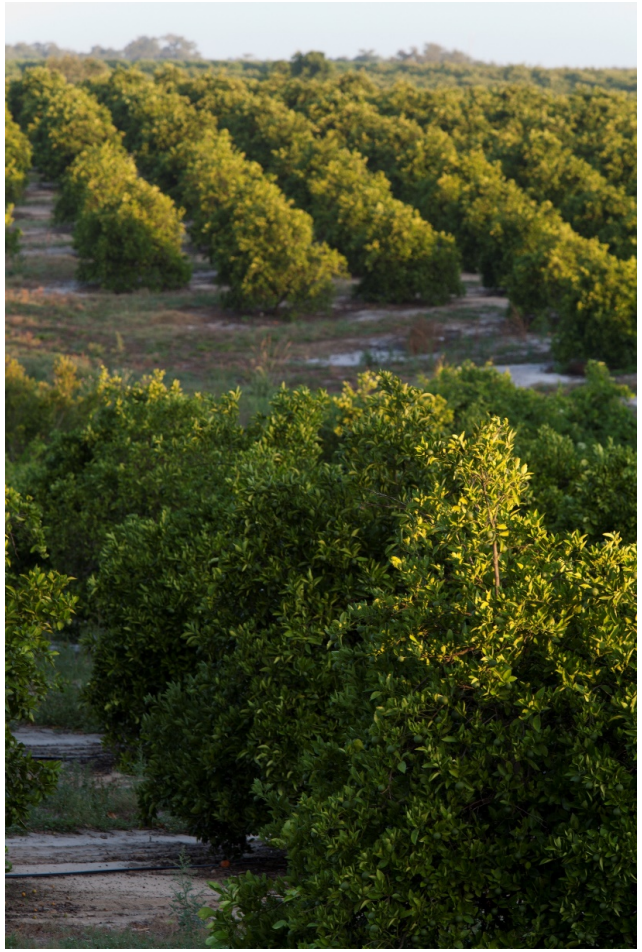
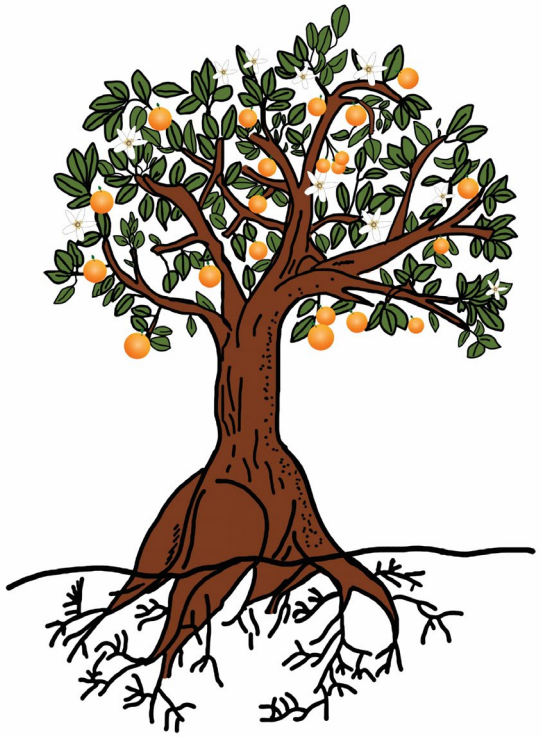
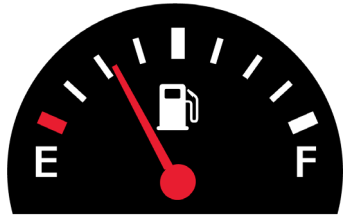


Photo Credit: T. Jones, UF/IFAS

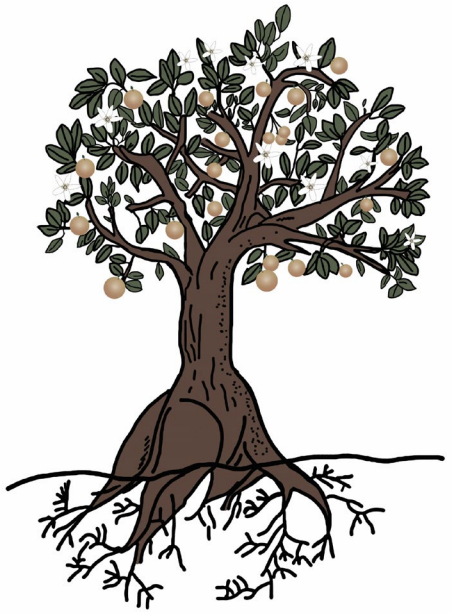
HEALTHY VS. HLB FERTILIZER APPLICATION



Healthy



Healthy trees go longer between fill ups.



HLB-affected

- Healthy trees can stand on their own longer between fertilizer applications
- HLB-affected trees used the nutrients quicker than healthy trees
- HLB-affected trees smaller root system need a constant supply to meet nutritional needs

Source: Shahzad, F., et al. (2020)
Graphics: N. Thapa, K.M. Snyder, T.R. Weeks, UF/IFAS;
http://clipart-library.com/clipart/700425.htm

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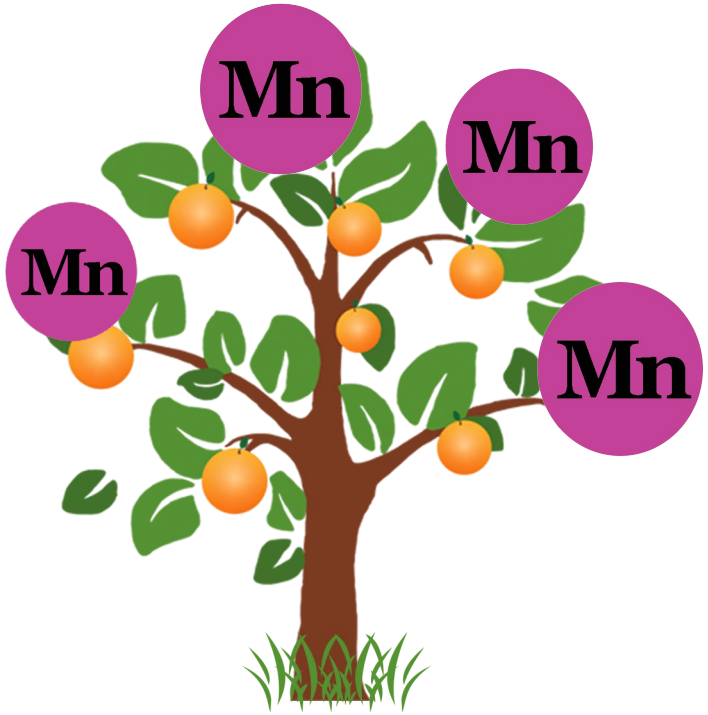
MANGANESE (Mn) APPLICATION

Goal

Mn

Optimum Range
25-100 ppm



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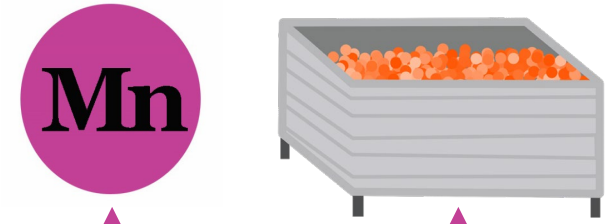

Closer to the high-end optimum

Yield improved

Need to apply higher rates of Mn than previously recommended for healthy trees

Source: Morgan, K.T., et al. (2016)
Graphics: T. R. Weeks, UF/IFAS

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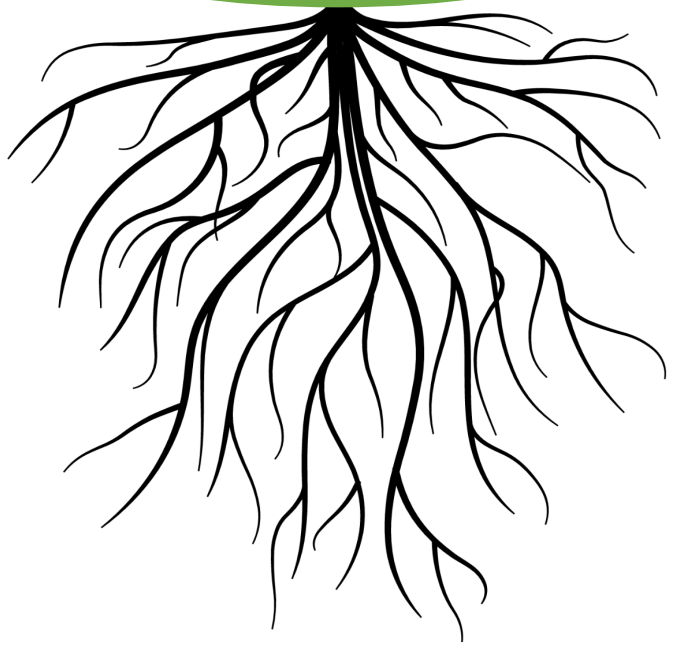
NUTRIENT APPLICATION

Strong root system



Healthy

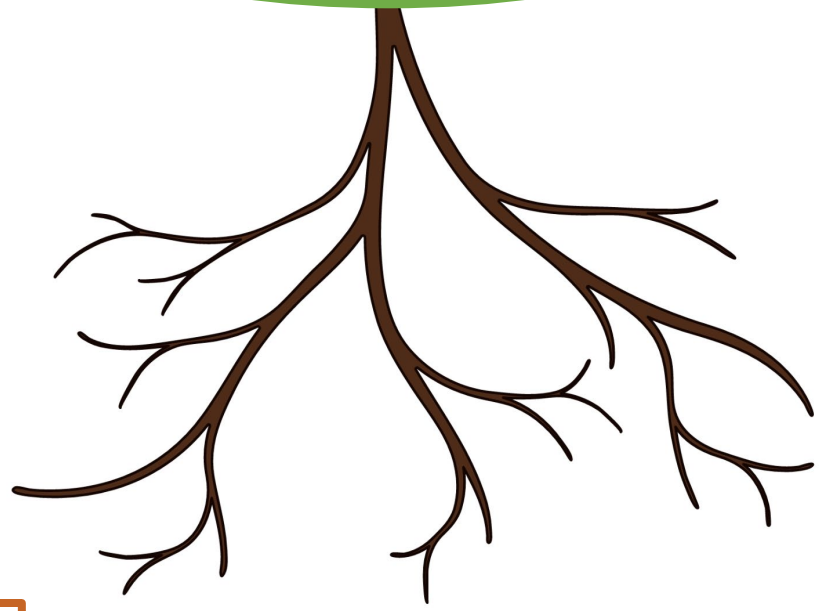
Both root systems are efficient in absorbing nutrients

But the problem is

- Limited to the amount it can absorb from less roots
- Work harder, get tired quicker

Tug of War

Small root system



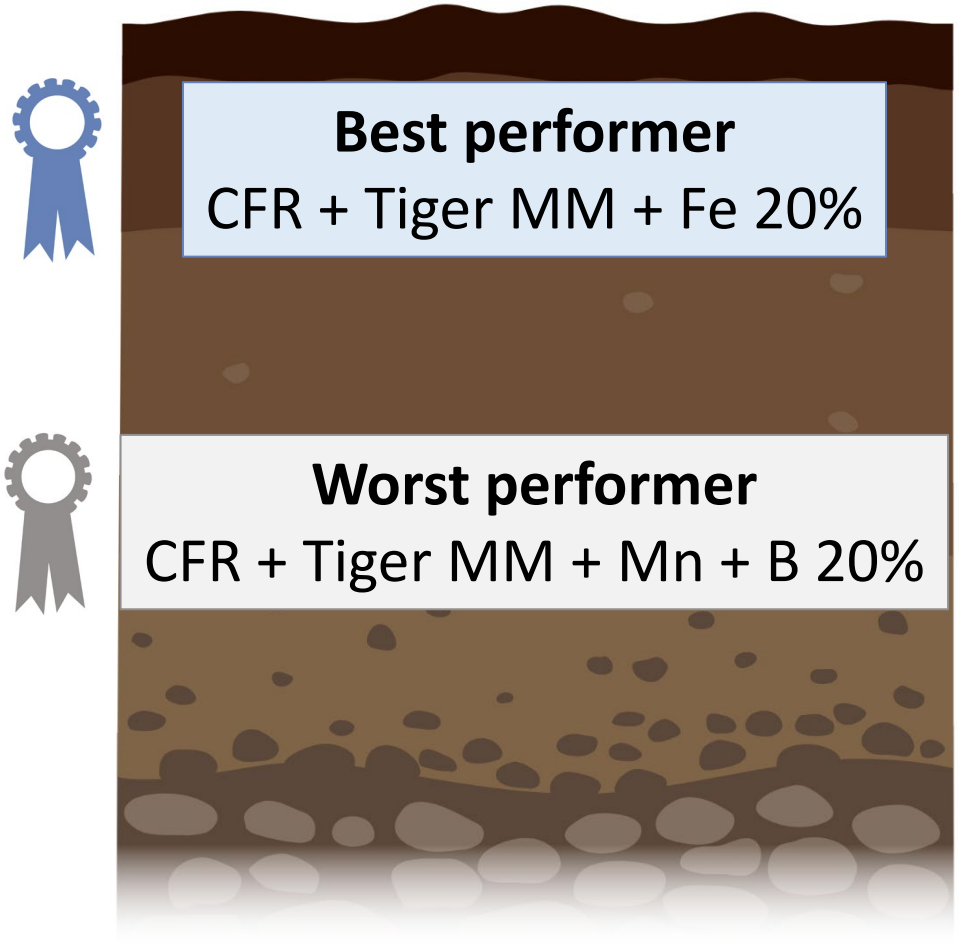
HLB-affected

Source: Shahzad, F., et al. (2020)

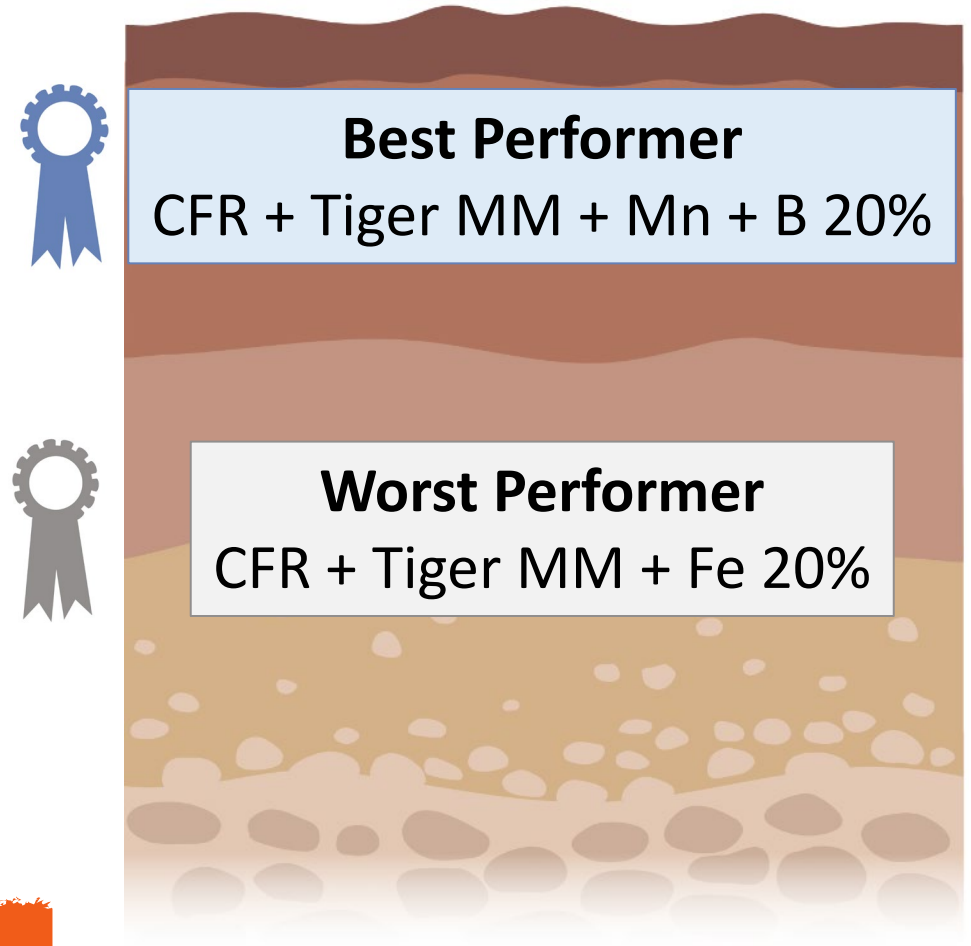
Graphics: BioRender.com; AdobeStock

LOCATION AND MICRONUTRIENT APPLICATION

South Florida (Arcadia)



Central Florida (Ft. Meade)



Source: Vashisth, T. (2020); Graphics: BioRender.com

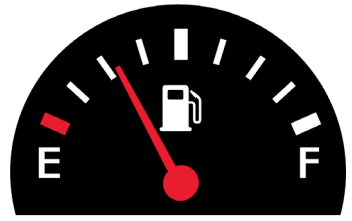
PROGRAM OBJECTIVE

Before HLB

- One leaf sample per year
- Three-four fertilizer applications

After HLB

- Frequent leaf sampling
- Fertilizing in real-time, precision management



Graphics: T. R. Weeks, UF/IFAS; AdobeStock; http://clipart-library.com/clipart/700425.htm

WHAT'S IN THE BOX?

- Instructional documents
- Calendar
- Sampling bags
- Pre-addressed envelopes/boxes

Photo Credit: T.R. Weeks, UF/IFAS

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HOW DOES THE PROGRAM WORK?

- Collaboration between growers and UF
- Quarterly leaf and annual soil sample collection
- Bags provided and labeled with a unique grower number

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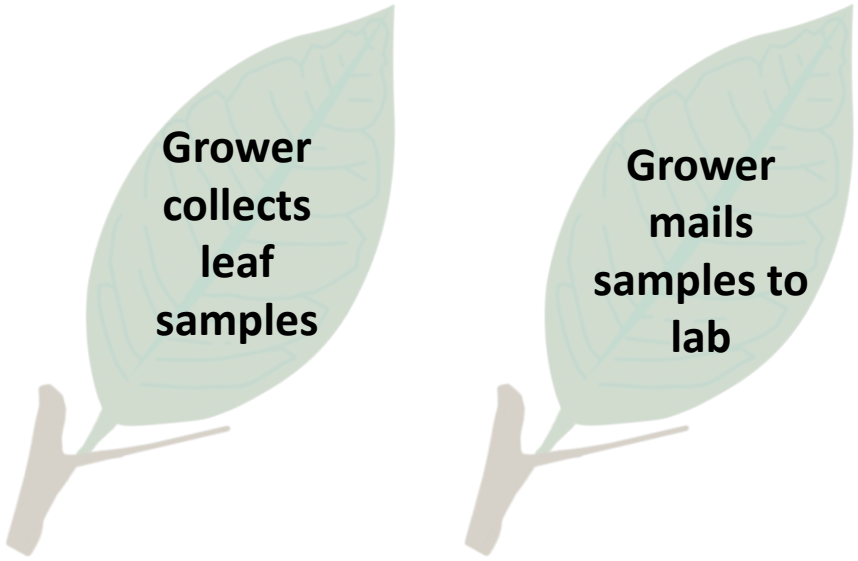
Graphic: T.R. Weeks, UF/IFAS

CITRUS NUTRITION BOX PROGRAM

- Only cost to grower
- Pre-addressed envelopes provided



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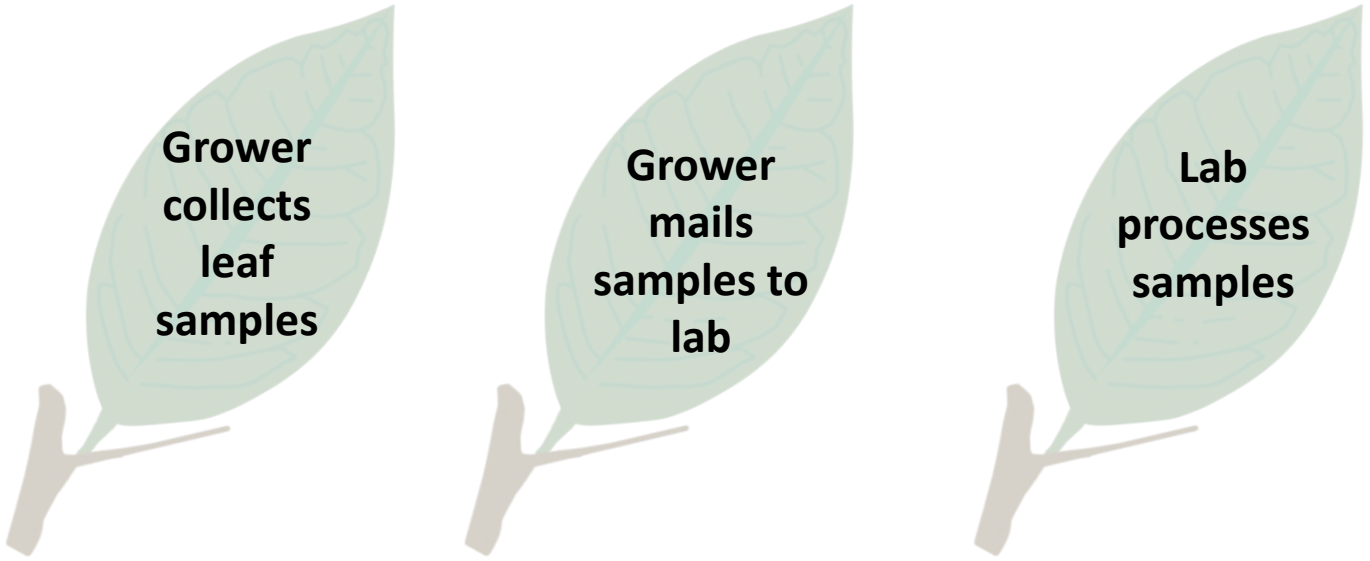
Graphics: T.R. Weeks, UF/IFAS

CITRUS NUTRITION BOX PROGRAM

- Lab processes samples
- Provides results to citrus nutrition team



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Graphics: T.R. Weeks, UF/IFAS

CITRUS NUTRITION BOX PROGRAM

- Nutrition team reviews individual results

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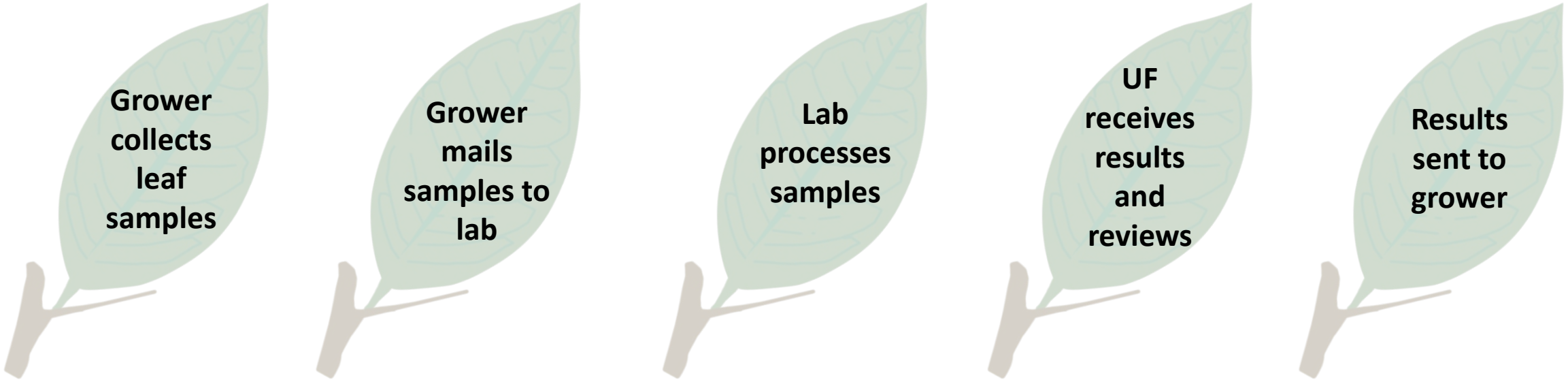
Graphics: T.R. Weeks, UF/IFAS

CITRUS NUTRITION BOX PROGRAM

- Results sent to grower via email
- Requested additional information to assist in future recommendations



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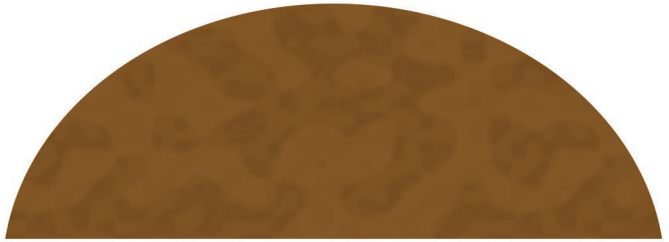
Graphics: T.R. Weeks, UF/IFAS

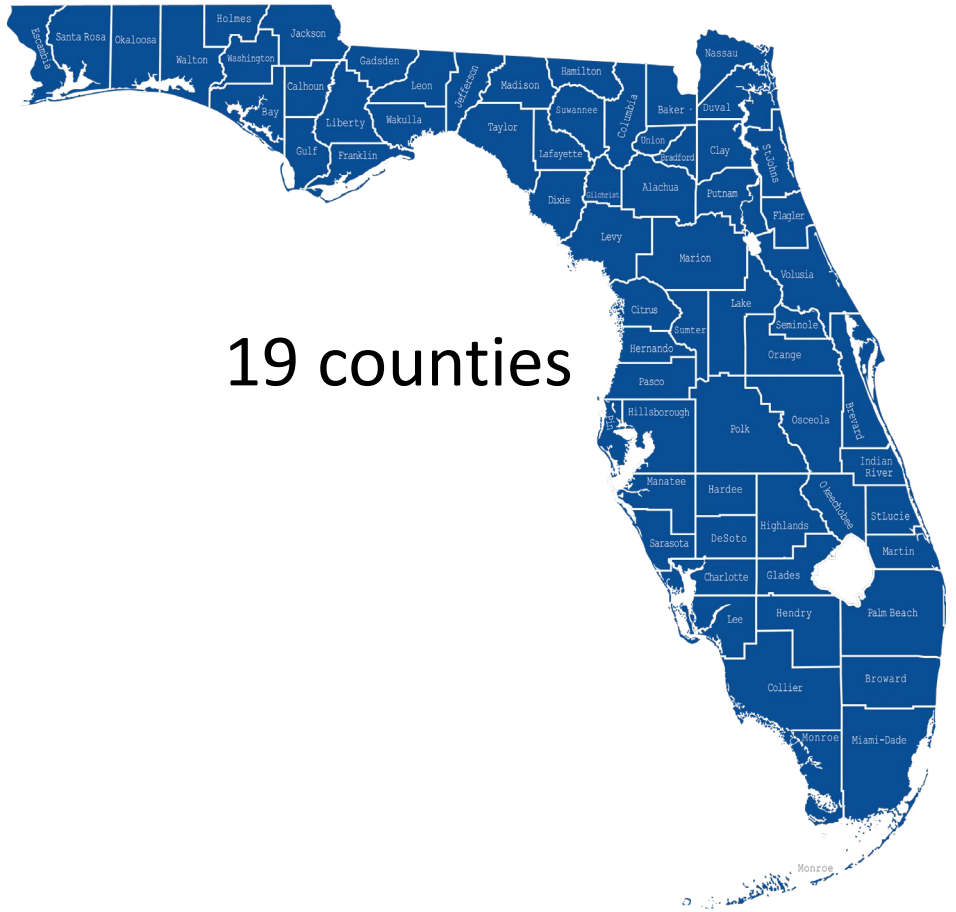
PROGRAM PARTICIPATION

October 2019-February 2021

258 leaf samples



81 soil samples



19 counties

Graphics: T.R. Weeks, UF/IFAS; AdobeStock

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BEFORE LOOKING AT THE RESULTS

- **Wide range of variables**
  - Varieties and rootstocks
  - Processed vs. Fresh
  - Location
    - Soil type
    - Rainfall
  - Tree age
    - 6 months to 30+ years
  - Tree health

Tree 1
Asymptomatic/ mild symptoms

Tree 2
Producing fruit, symptomatic

Tree 3
Symptomatic, declining

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Photo Credit: L. Tang, UF/IFAS

BEFORE LOOKING AT THE RESULTS

- **Three different views**
  - Statewide
  - Regional
  - Consistent participation

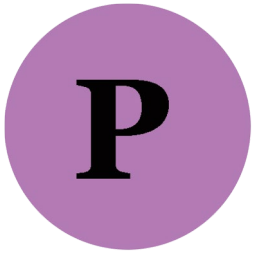
UF/IFAS RECOMMENDATIONS-OPTIMUM LEVELS

2.5-2.7

3.0-4.9

25-100

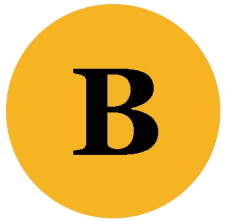
60-120



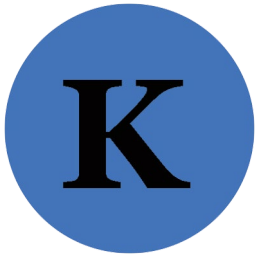
0.12-0.16

0.30-.049

25-100



36-100



1.2-1.7

5-16

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Source: Nutrition of Florida Citrus Trees, Third Edition, K.T. Morgan and D.M. Kadyampakeni; Graphics; T.R. Weeks, UF/IFAS

STATEWIDE LEAF AVERAGES

	Percentage (%)						ppm				
Quarter	**N**	**P**	**K**	**Ca**	**Mg**	**S**	**Mn**	**Zn**	**Cu**	**Fe**	**B**
Oct 19-Feb 20	2.66	0.16	1.45	3.42	0.37	0.32	50	38	19	63	89
Mar 20-June 20	2.74	0.16	1.47	3.28	0.33	0.31	44	31	12	70	82
Jul 20-Oct 20	2.72	0.15	1.55	3.22	0.36	0.36	51	36	18	72	96
Nov 20-Feb 21	2.53	0.16	1.52	2.90	0.34	0.34	44	33	15	68	99

- Remember, many variables!
- Averages have highs and lows
- **Overall, nutrition analysis looks good**

STATEWIDE LEAF AVERAGES

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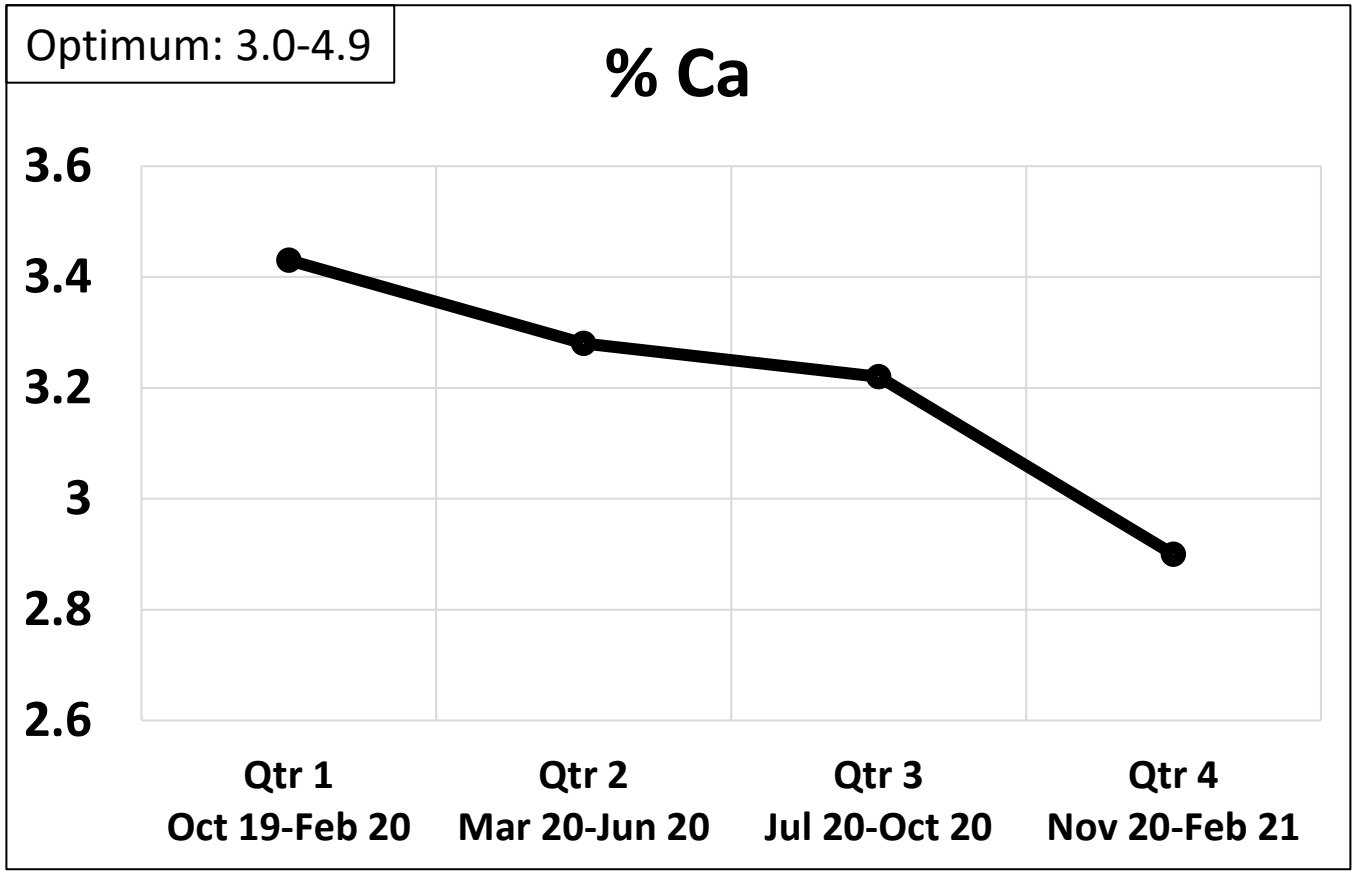
Areas of interest

Calcium
Magnesium

Manganese
Zinc

Boron

STATEWIDE LEAF AVERAGES



Ca

- Decreased over the year to below optimum
  - Ca typically increases throughout the year in healthy trees
- Constant struggle for many
  - 35% were low in Ca

Source: Nutrition of Florida Citrus Trees, Third Edition, K.T. Morgan and D.M. Kadyampakeni
Graphic: T.R. Weeks, UF/IFAS

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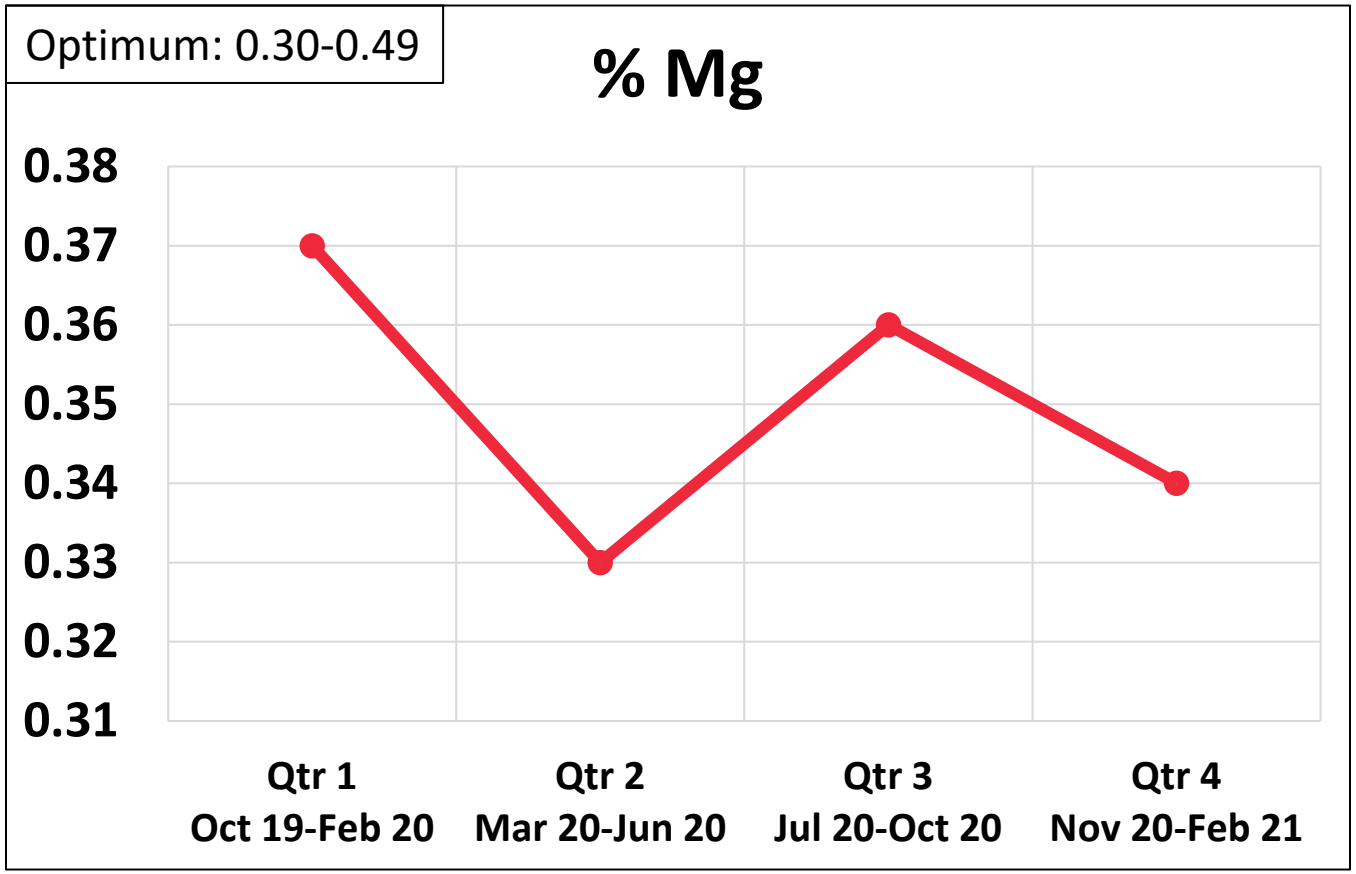
STATEWIDE LEAF AVERAGES



Mg

- Stayed within optimum range throughout the year
- A dip in the winter-spring

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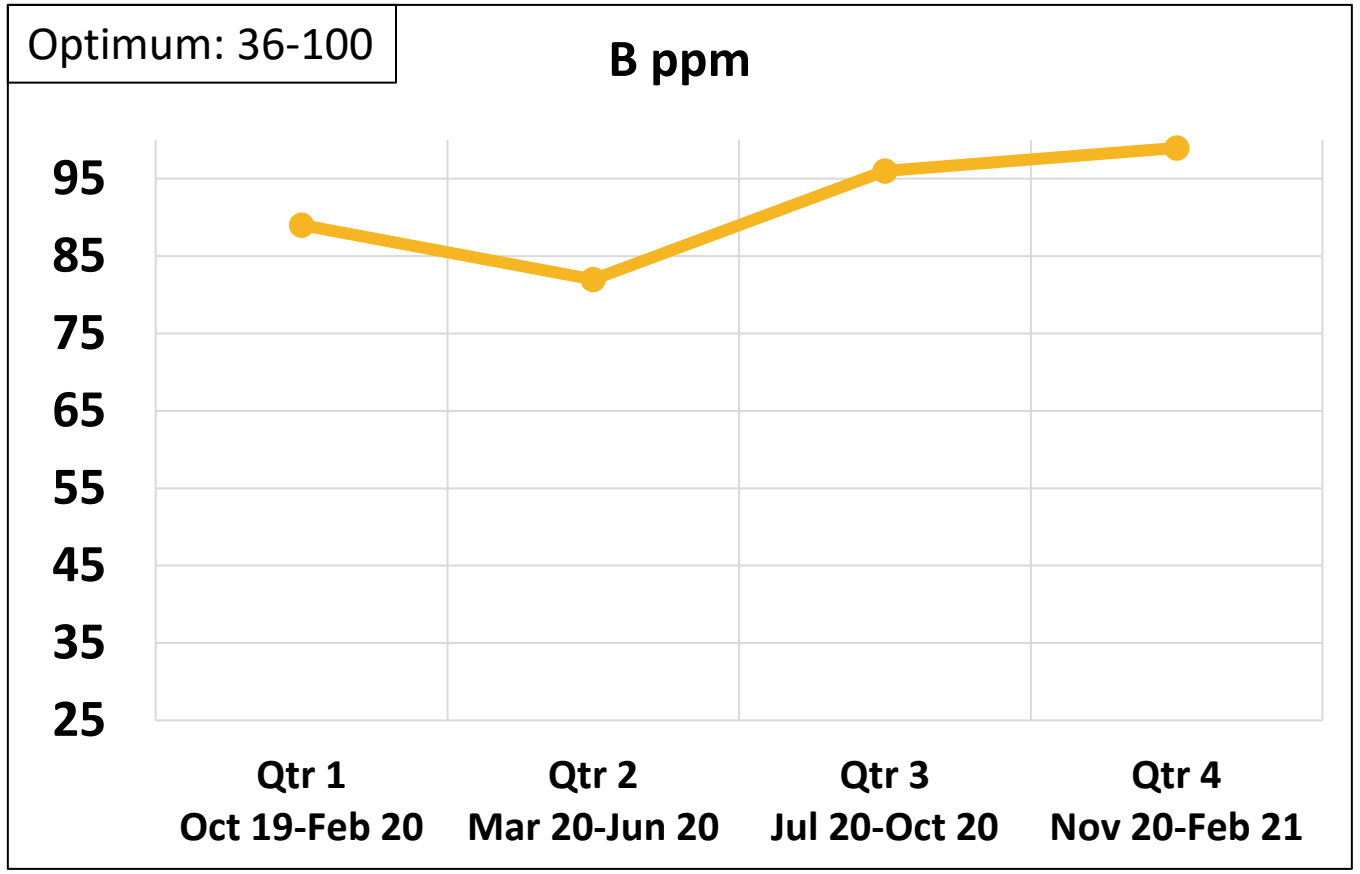
Graphic: T.R. Weeks, UF/IFAS

STATEWIDE LEAF AVERAGES



B

- Remained within optimum range throughout the year
- Saw an increase in B
- With high B levels from some areas, no toxicity has been reported
- Highest B: 307

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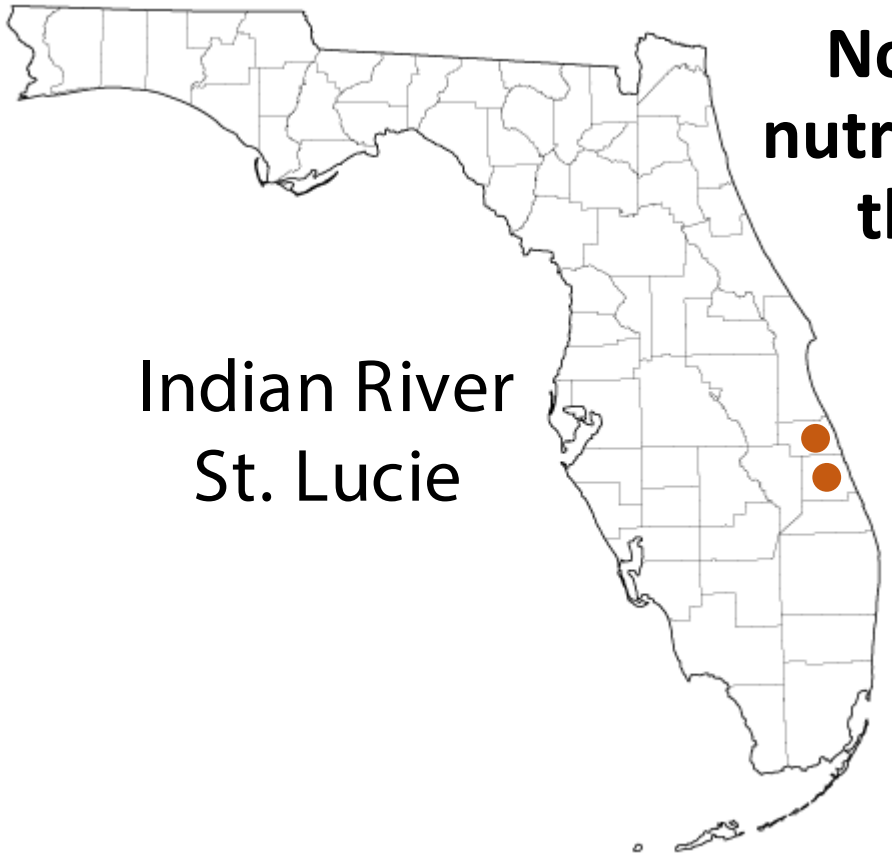
Graphic: T.R. Weeks, UF/IFAS

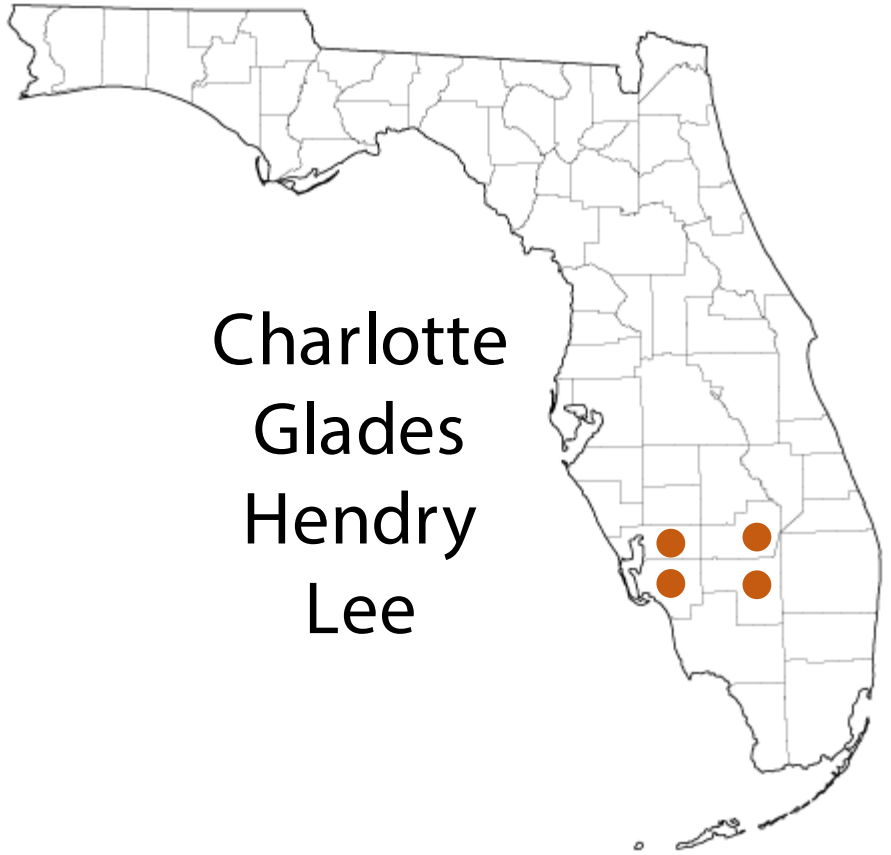
INDIAN RIVER REGION



Indian River
St. Lucie

No differences in nutrients throughout the year (time)

SOUTHERN REGION



Charlotte
Glades
Hendry
Lee

Graphics: NASS, USDA

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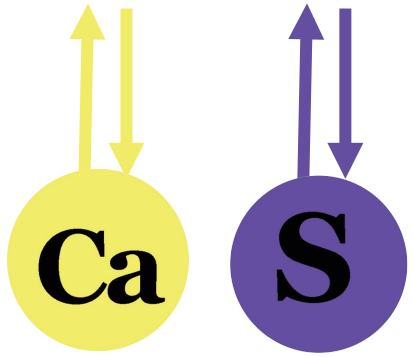
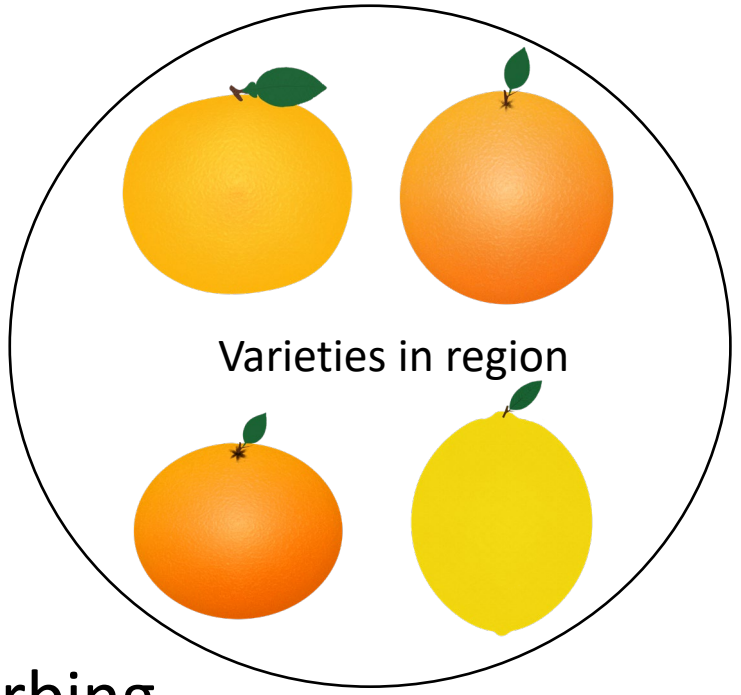
INDIAN RIVER AND SOUTHERN REGION

- Relationship: When Ca increased, S increased



- Why?
  - Ca can be a carrier for sulfate
  - Cu sulfate is often applied as a fertilizer or disease management
  - Is Cu being applied for canker and the plant is absorbing the S and Ca is moving it?



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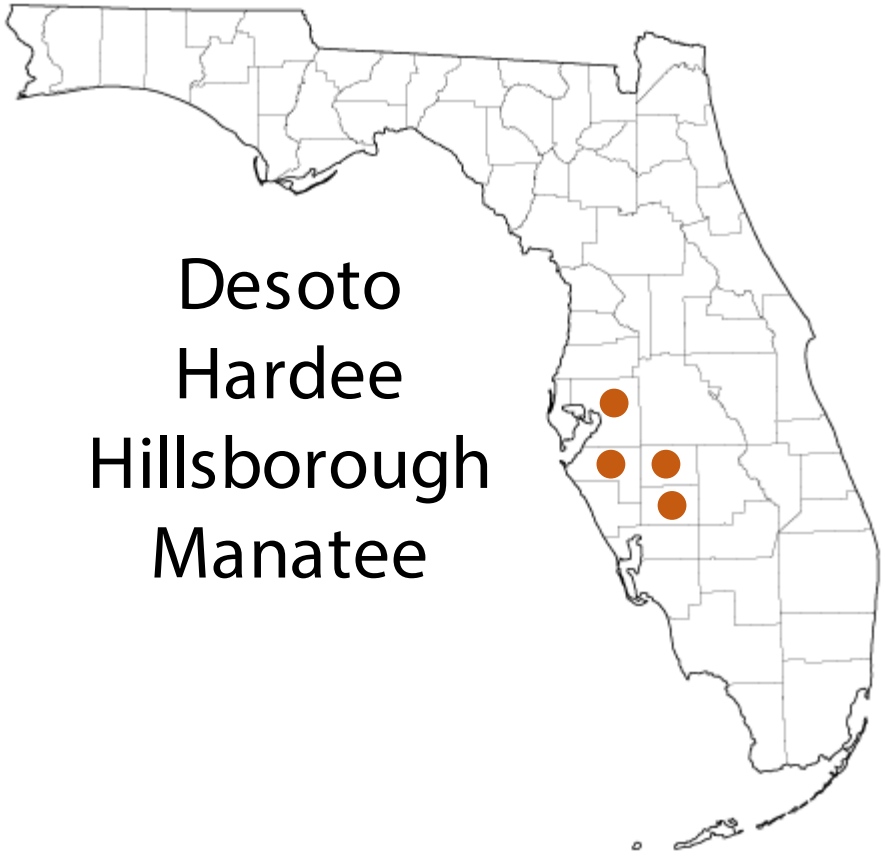
Source: Smith, Paul, Citrus Nutrition. *Nutrition of Fruit Crops*. p. 196, 1966.; Graphics: T.R. Weeks, UF/IFAS

WESTERN REGION

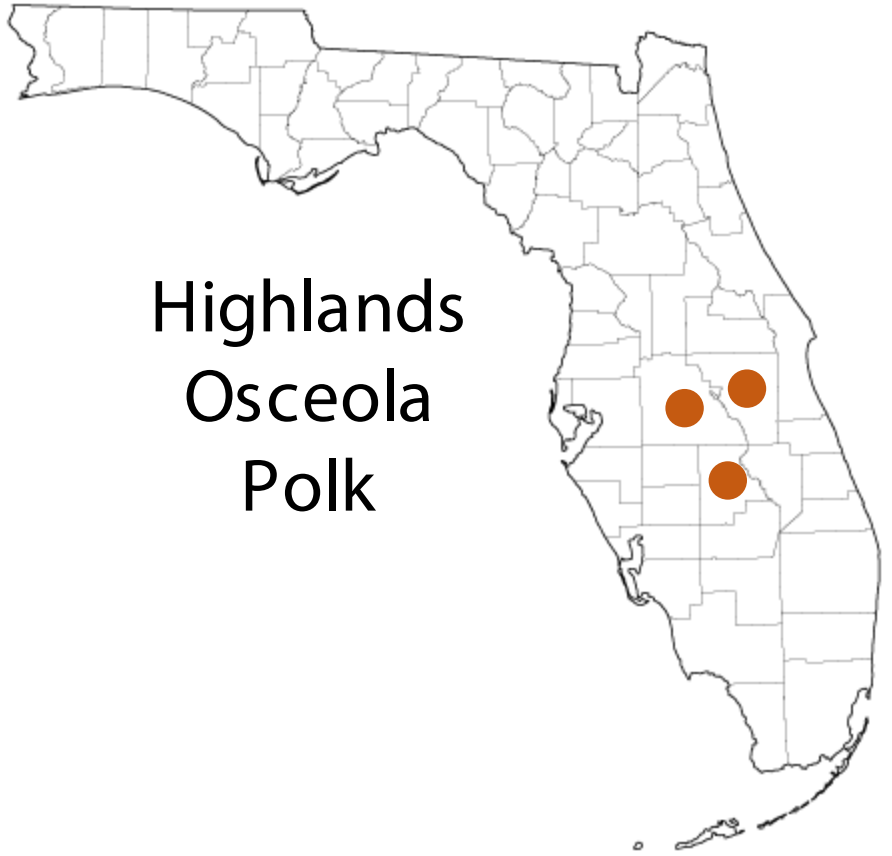


Desoto
Hardee
Hillsborough
Manatee

Ca

Mg

CENTRAL REGION



Highlands
Osceola
Polk

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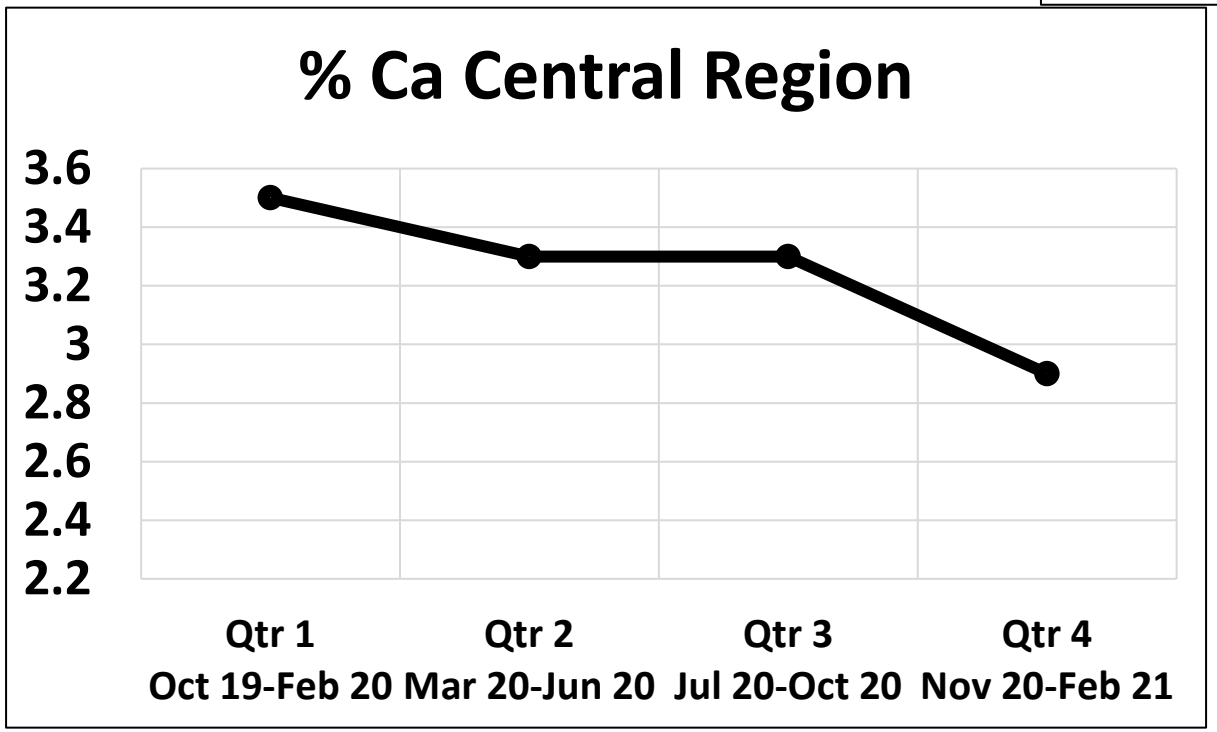
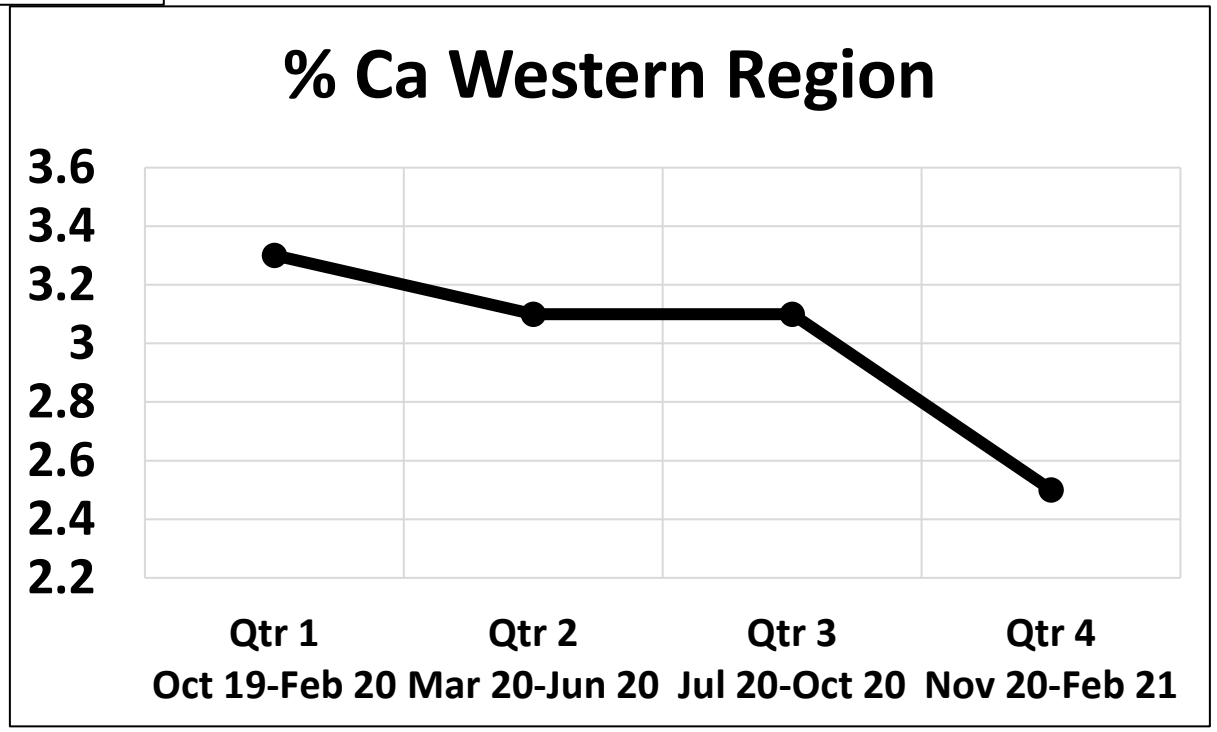
Graphics: NASS, USDA; T.R. Weeks, UF/IFAS

CENTRAL AND WESTERN REGION

Optimum: 3.0-4.9





Ca Both regions struggled with calcium in the last quarter (fall/harvest)

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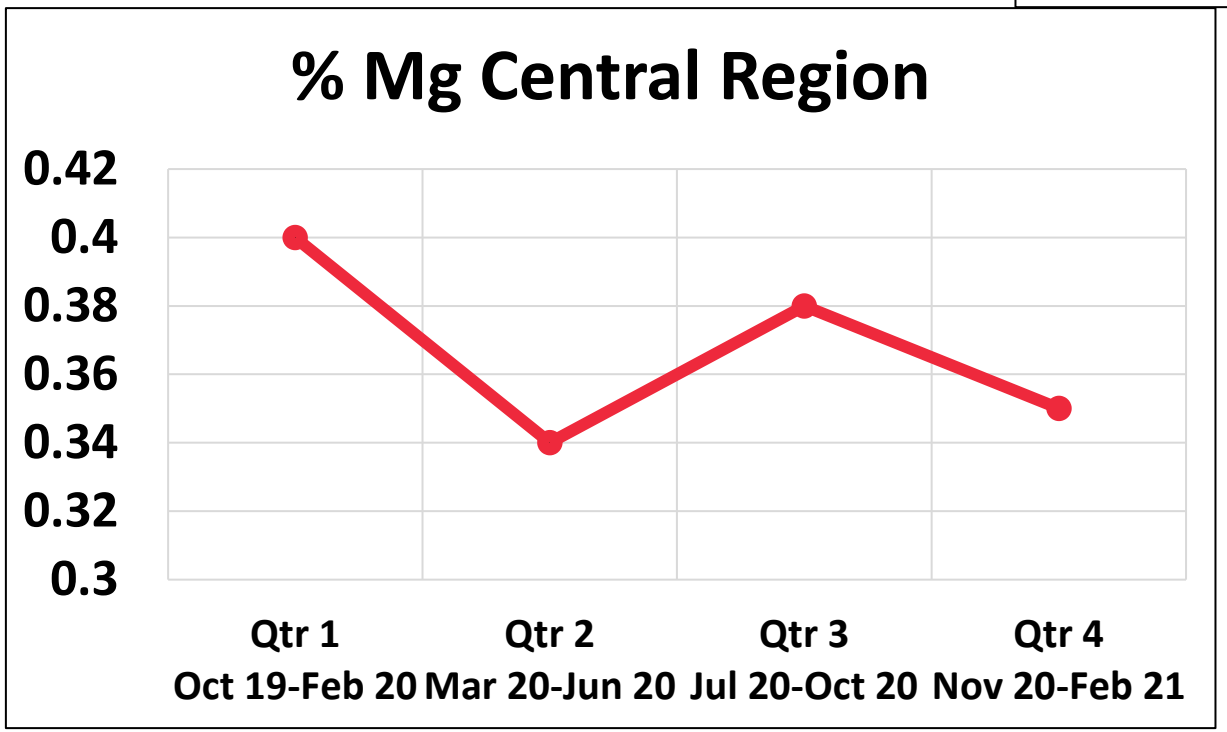
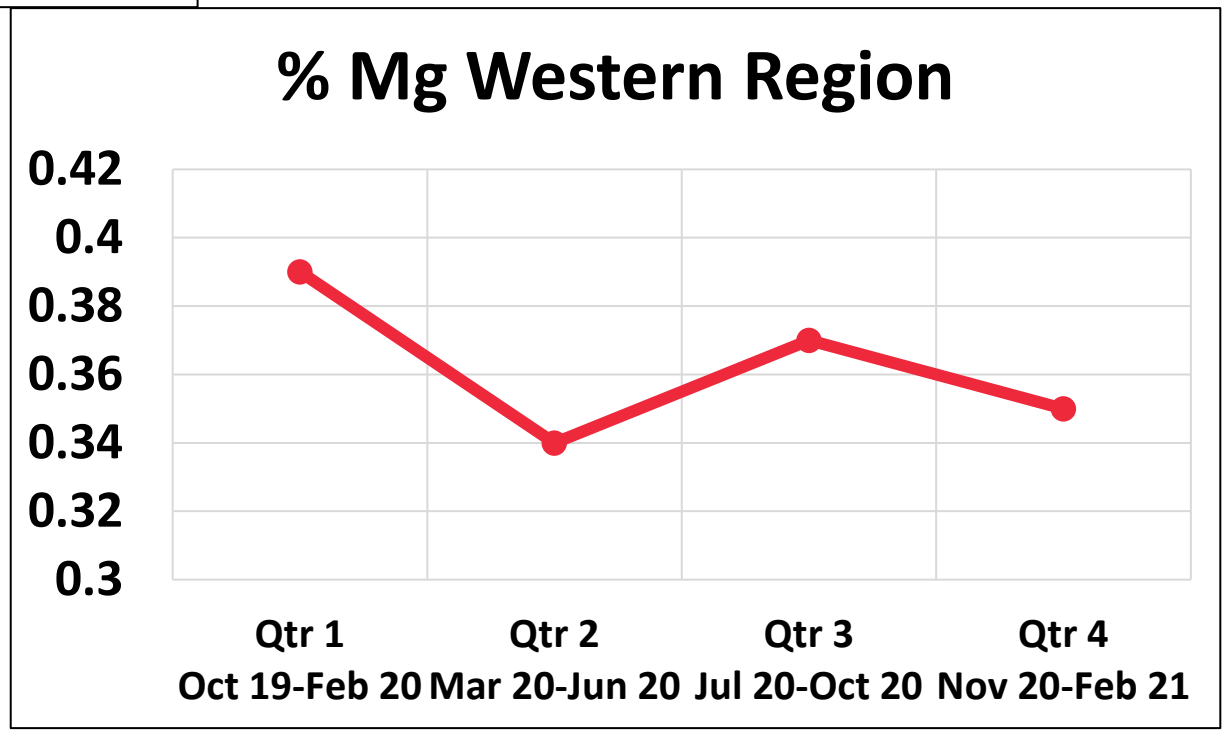
Graphic: T.R. Weeks, UF/IFAS

CENTRAL AND WESTERN REGION

Optimum: 0.30-0.49





Mg Identical pattern; dip in quarter 2; typical of healthy trees

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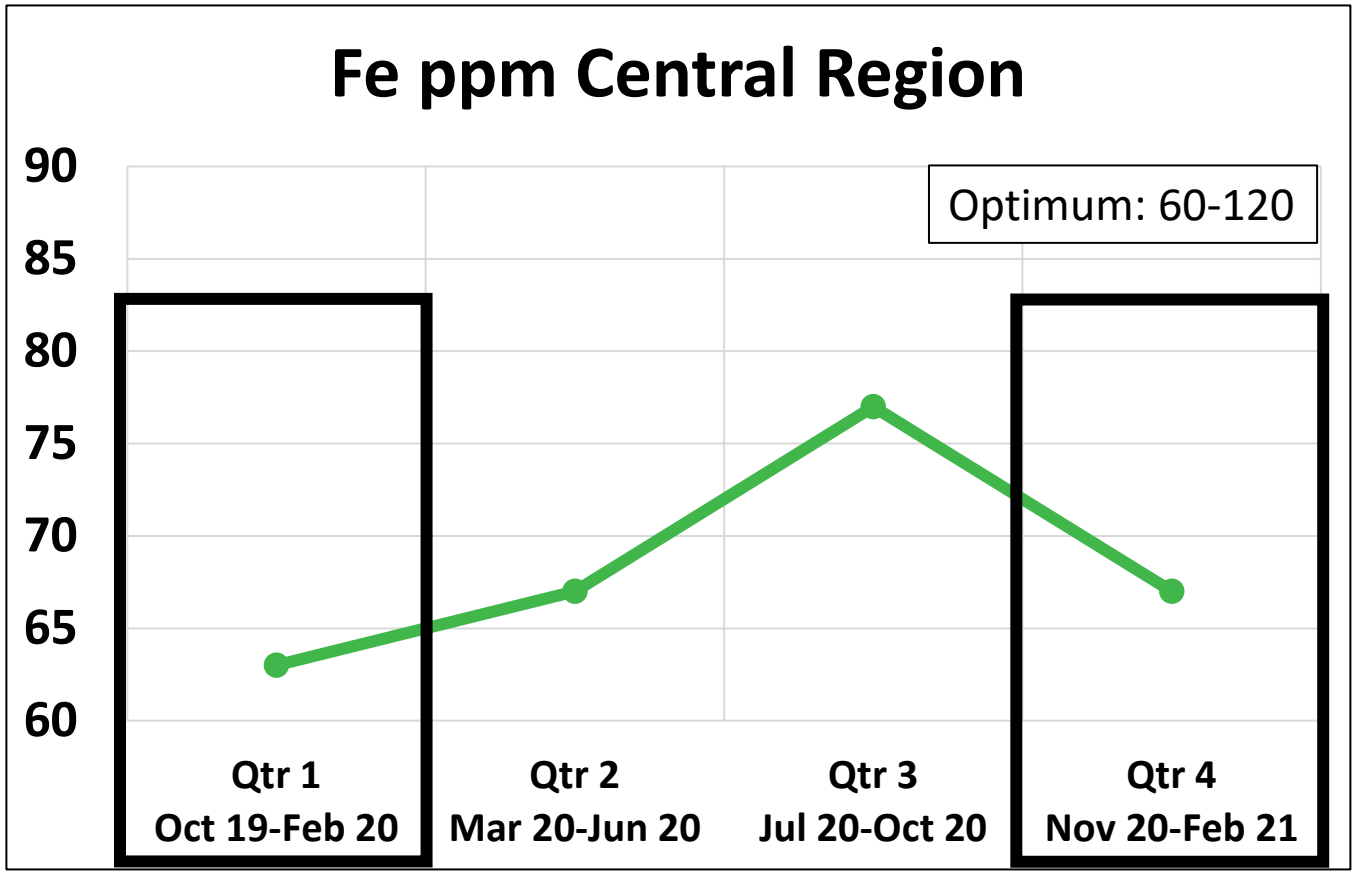
Graphic: T.R. Weeks, UF/IFAS

CENTRAL REGION



Fe

- Observed a sudden increase during late summer/early fall
- Drop in quarter 4, higher than a year ago in quarter 1
- **Improvement is being noticed!**

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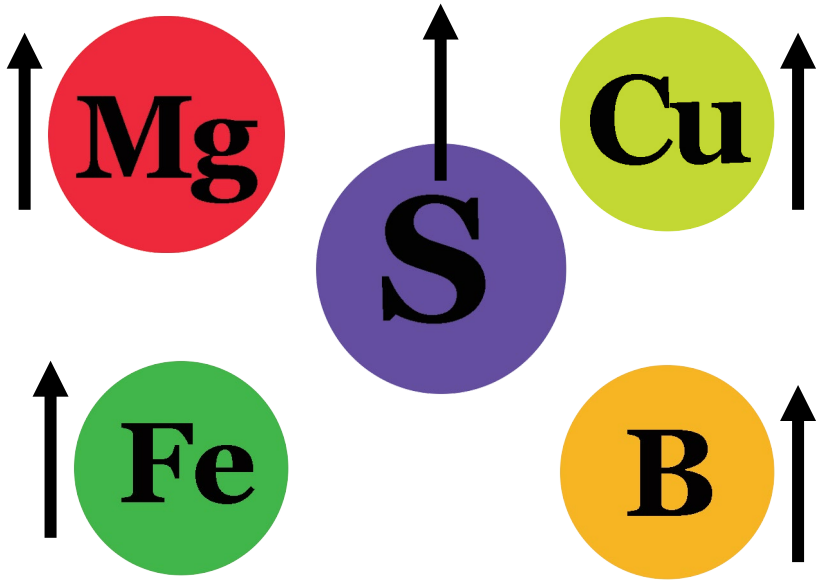
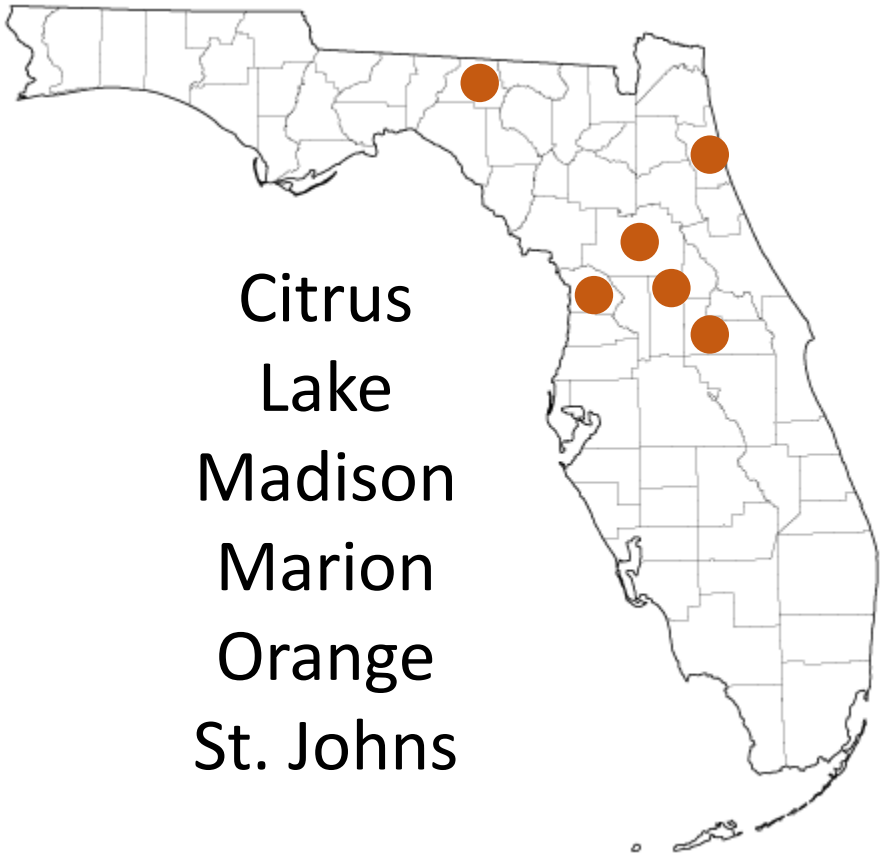
Graphic: T.R. Weeks, UF/IFAS

NORTHERN REGION



- Mg, Cu, and Fe often applied in sulfate form
- B possibly added to the tank mix



Citrus
Lake
Madison
Marion
Orange
St. Johns

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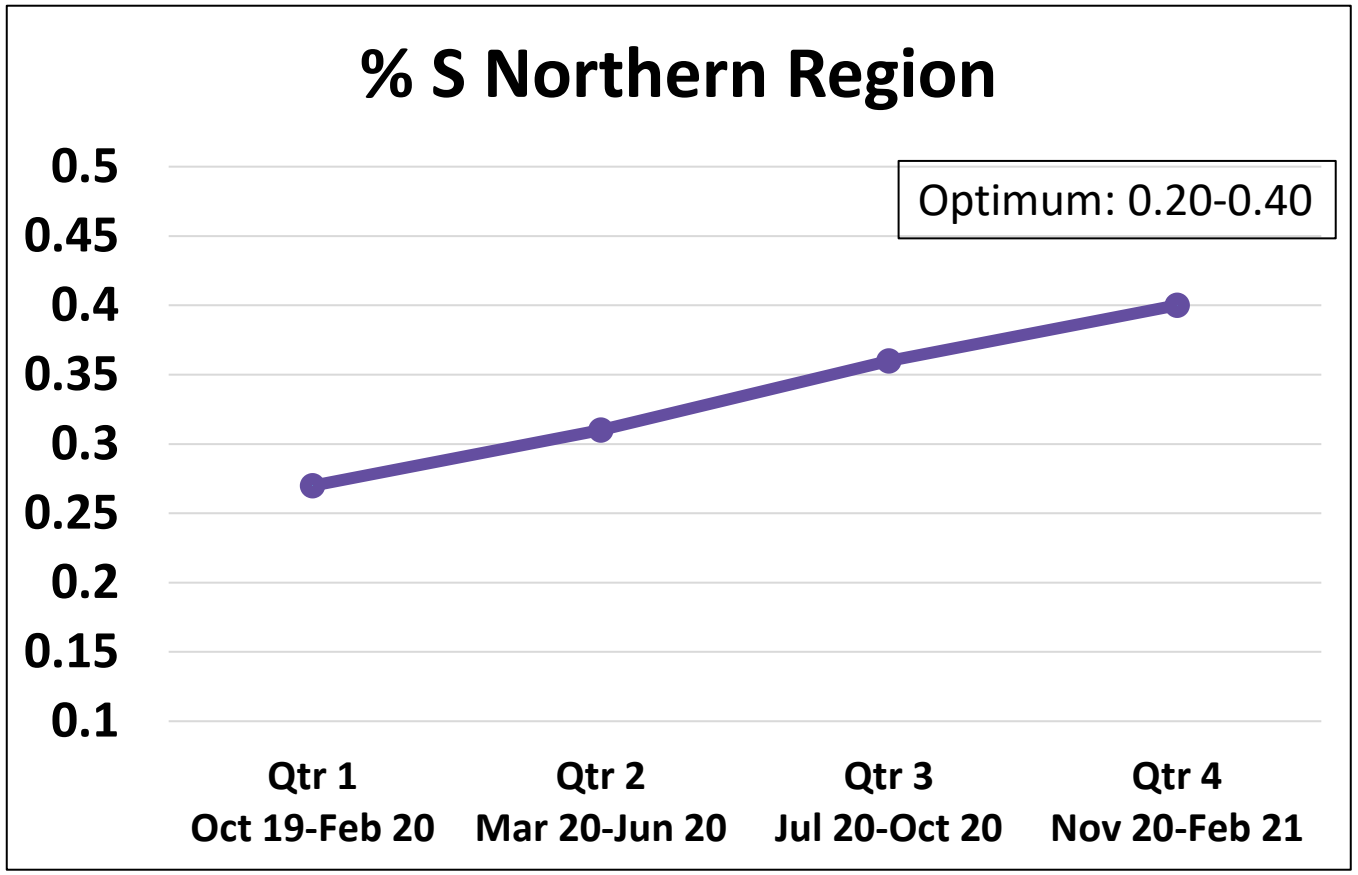
Graphics: T.R. Weeks, UF/IFAS; NASS, USDA

NORTHERN REGION

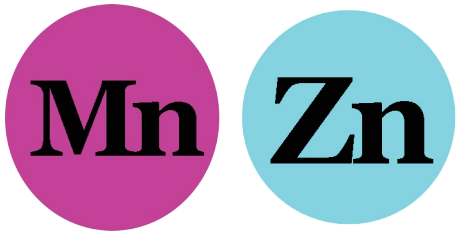


S

- Gradually increased over the year
- S is often in fertilizers or used as a pesticide
- Recommendations have been to apply more micronutrients which are commonly applied in sulfate forms

Source: Smith, Paul, Citrus Nutrition. *Nutrition of Fruit Crops*. p. 196, 1966.; Graphic: T.R. Weeks, UF/IFAS

Mn and Zn GO TOGETHER



Indian River, Western, Central, Northern

Statewide Averages		
	ppm	
Quarter	Mn	Zn
Oct 19-Feb 20	50	38
Mar 20-June 20	44	31
Jul 20-Oct 20	51	36
Nov 20-Feb 21	44	33

- Moderate/strong relationships in many regions
- Often applied together
- Nutrients rely on each other to function
  - Photosynthesis and chlorophyll production
- HLB has caused a behavior change, increased application of Mn and Zn based on previous research
- Still below 50 ppm, need to be closer to 100 ppm
- **Need improvement!**
- Trends in Hamlin and Swingle

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Graphic: T.R. Weeks, UF/IFAS

SOIL pH

COUNTY pH	
Lake	6.5
Polk	6.4
Highlands	6.2
St. Lucie	6.5
Indian River	5.9
Hardee	5.9
Desoto	5.2
Manatee	6.5
Hendry	6.2
Charlotte	5.3

- **Optimum: 6.0-6.5**
- **pH range, 4.4-7.8**
- **Possible cause**
  - Regional = soil type
  - Soil acidification
  - HLB trees perform better around a soil pH of 6.0

HIGH

LOW

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Graphic: NASS, USDA

SOIL pH

Grove 1			
Year	**pH**	**Ca**	**Mg**
2019	6.6	1140	186
2021	5.7	889	132

Decrease

When adjusting pH, Ca and Mg are **more sensitive** to pH changes than other nutrients.

A pH between 5.8 and 6.5 is ideal for all nutrients and allows a well-balanced nutrient uptake.

Grove 2			
Year	**pH**	**Ca**	**Mg**
2019	5.4	611	132
2021	6.7	1786	351

Increase

SOIL pH

Grove 3			
Year	**pH**	**Ca**	**Mg**
2019	7.7	3704	363
2021	6.9	1450	180

Decrease

Change pH
=
Change Ca and Mg

Extreme pH change
=
Extreme Ca and Mg change

Grove 4			
Year	**pH**	**Ca**	**Mg**
2019	4.8	364	51
2021	6.2	1025	241

Increase

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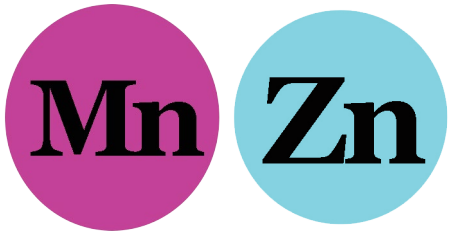
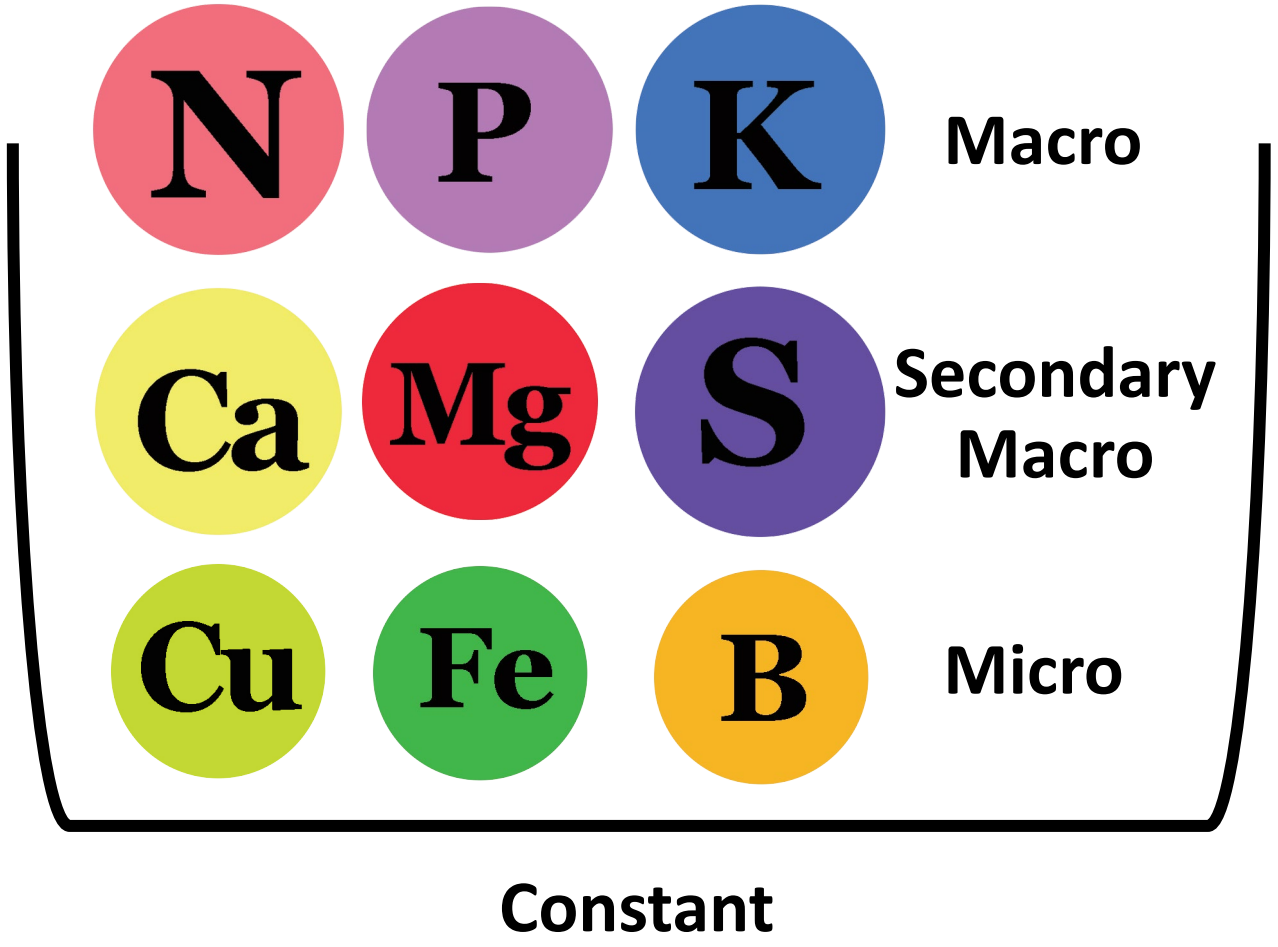
LEAF NUTRIENTS YEAR ROUND

- **Trends from 46 sites**
  - All four quarters
  - All five regions
  - Variety and rootstock
- **All nutrients were constant except two micronutrients**



Micro



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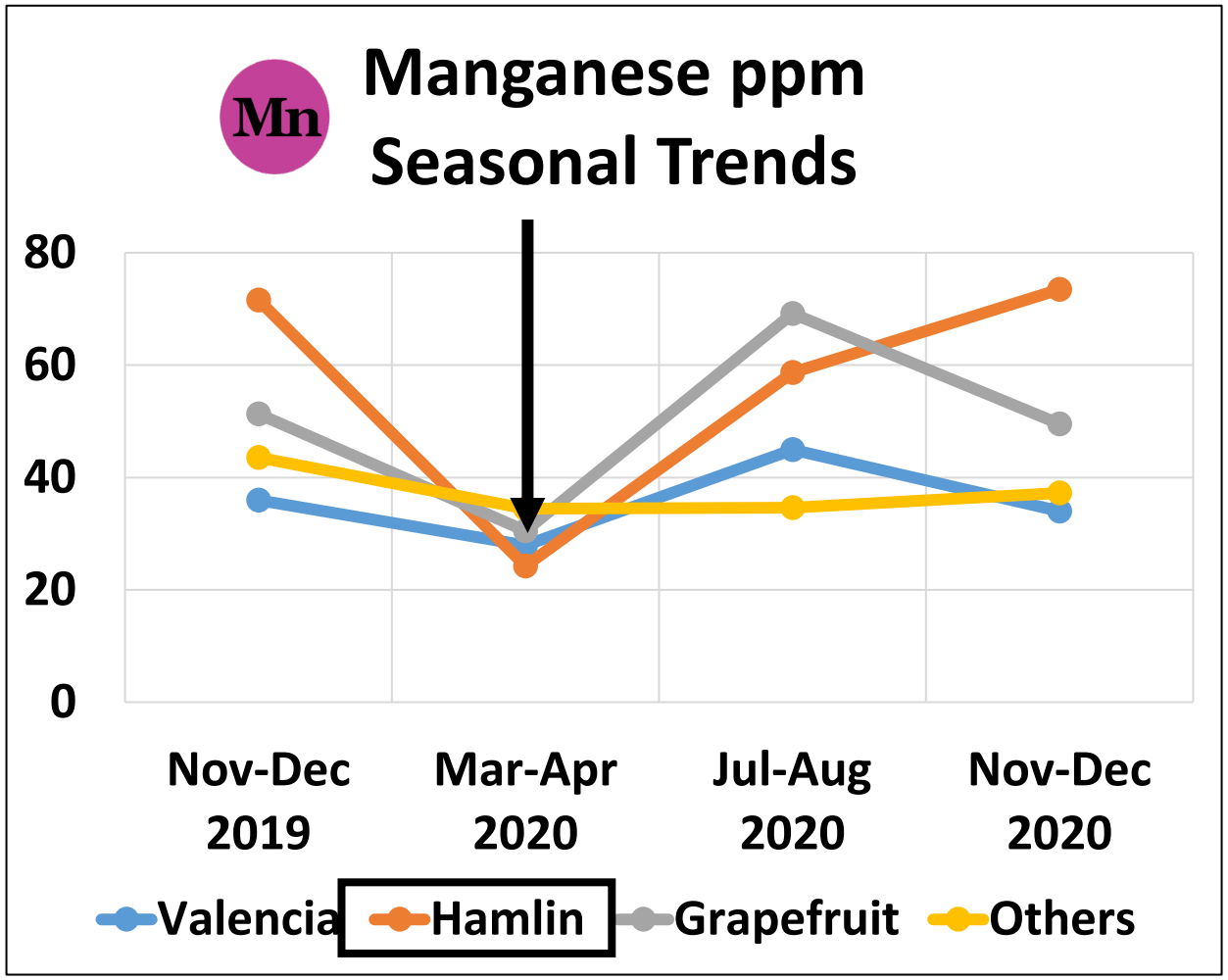
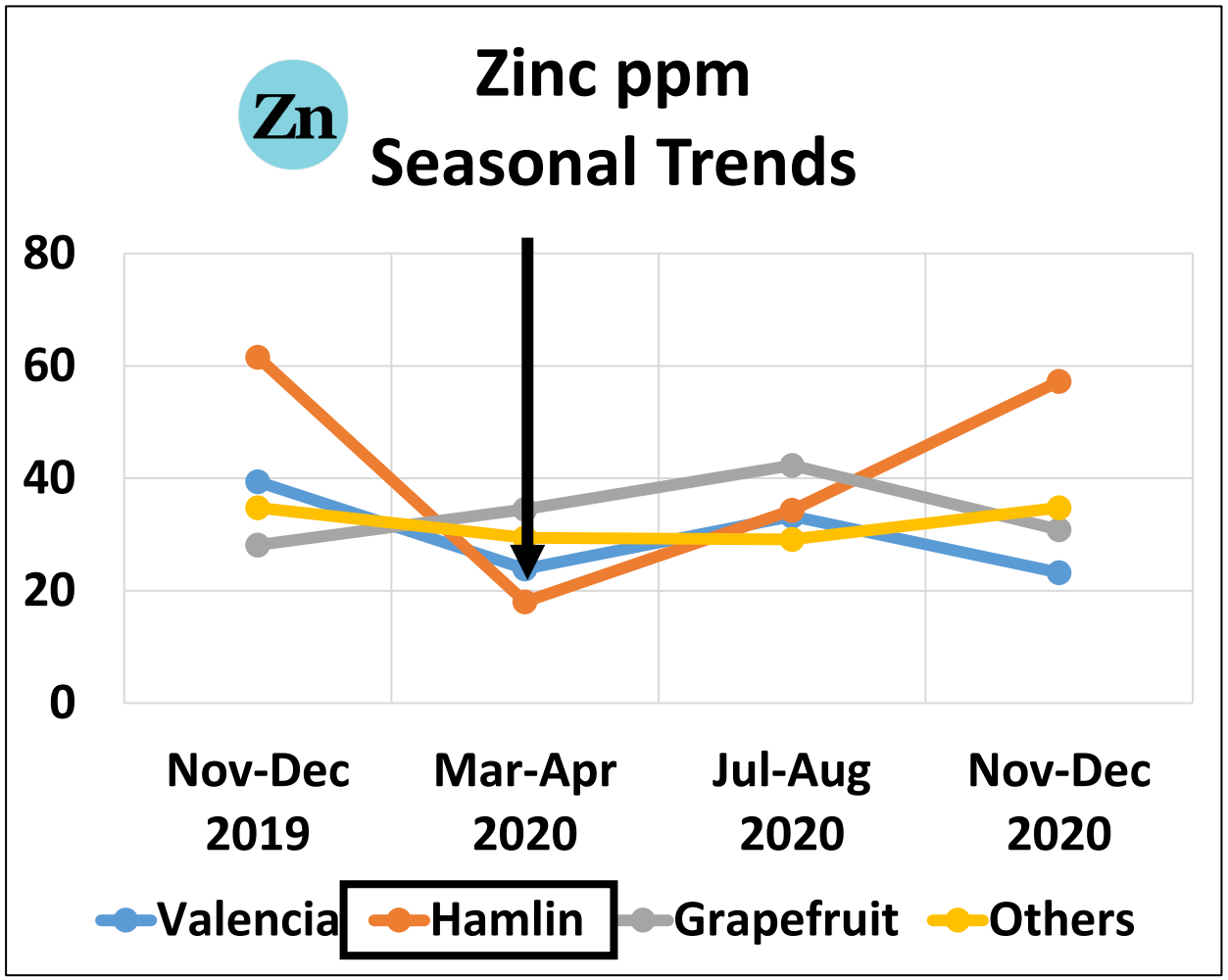
Graphics: T.R. Weeks, UF/IFAS

LEAF NUTRIENTS YEAR ROUND





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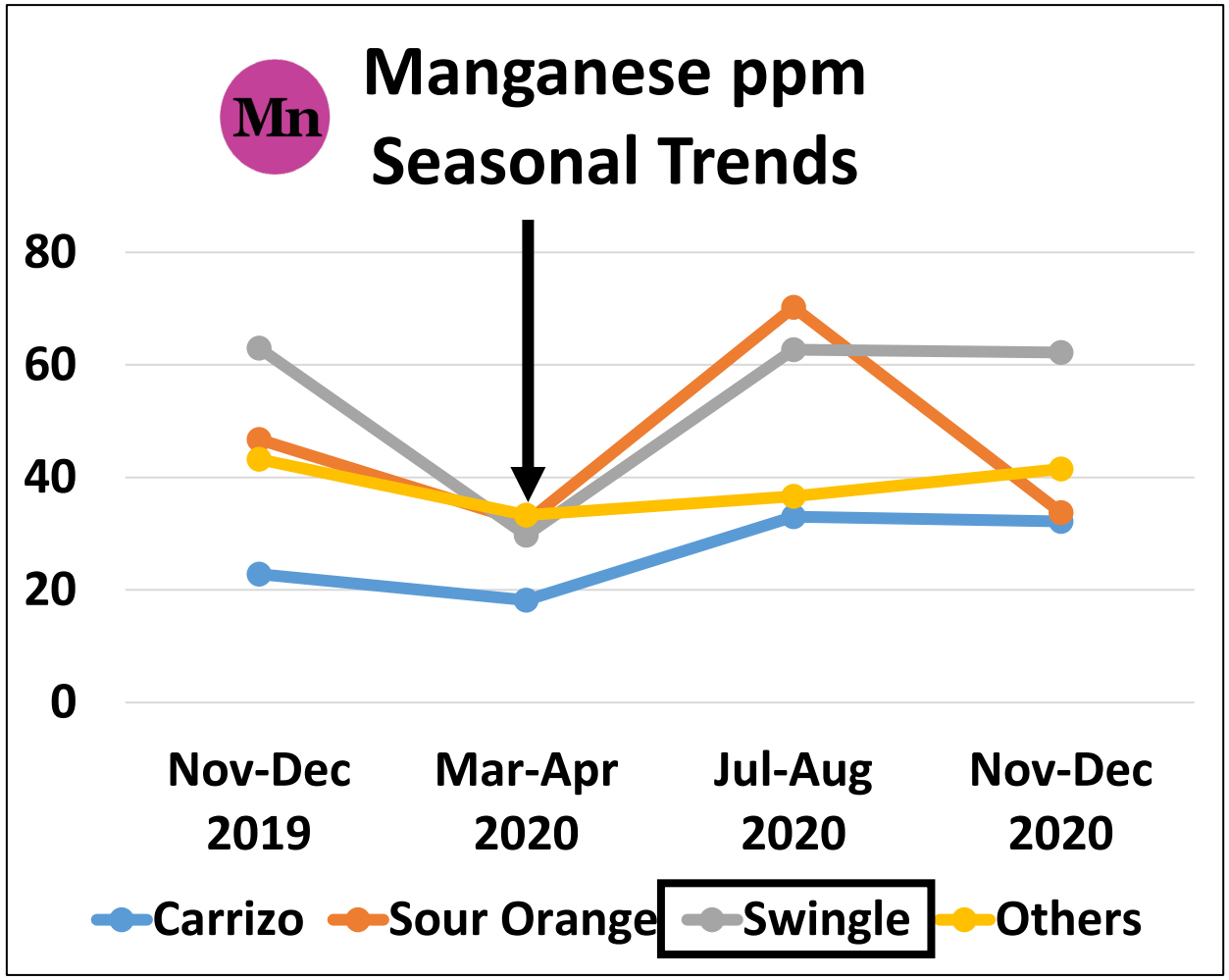
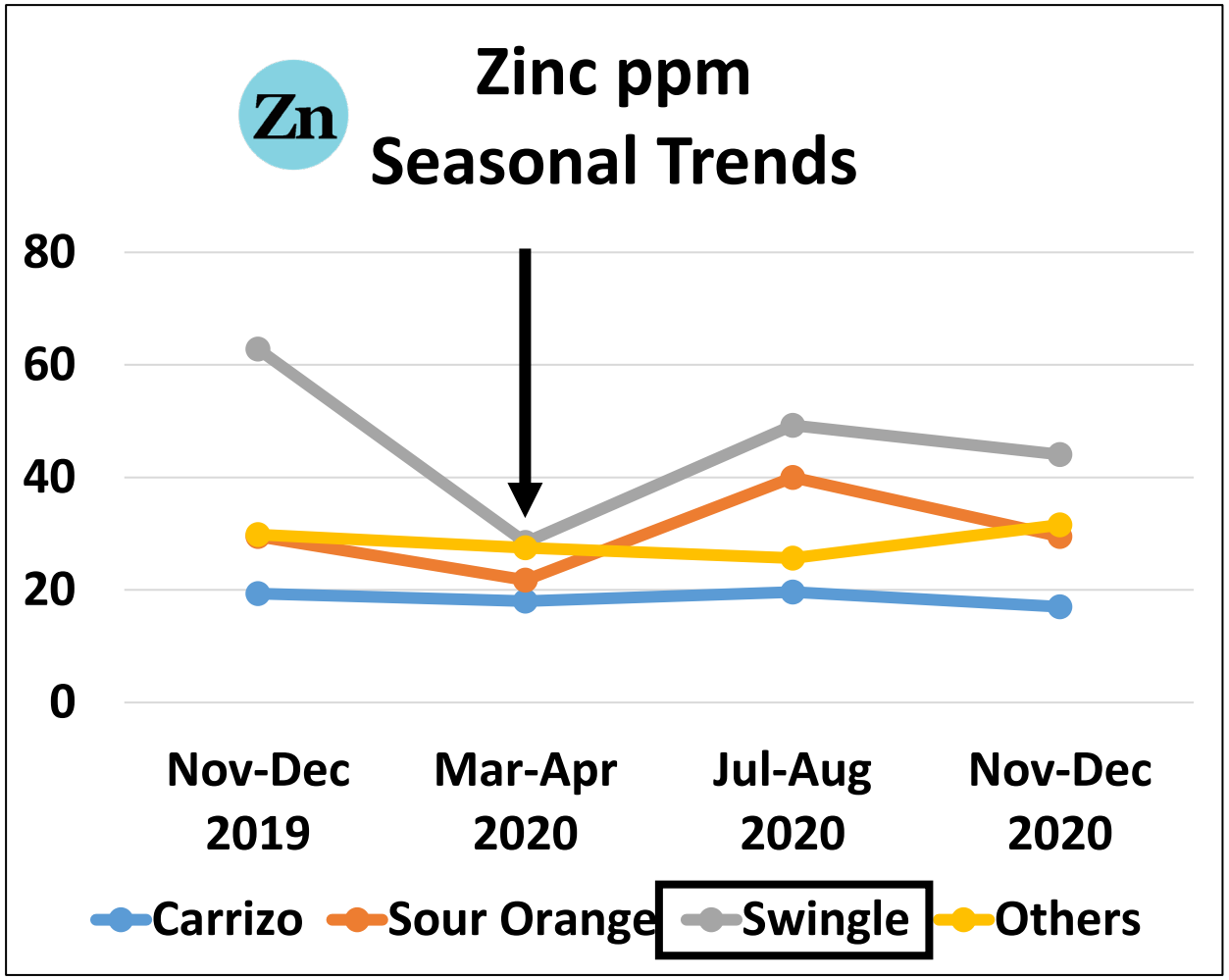
Graphics: T.R. Weeks, UF/IFAS

LEAF NUTRIENTS YEAR ROUND





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Graphics: T.R. Weeks, UF/IFAS

WHAT ARE WE RECOMMENDING?

- **Goal: high end of optimum to middle of high range for all the nutrients, year-round; soil pH 5.8-6.5**

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.

Source: Nutrition of Florida Citrus Trees, Third Edition, K.T. Morgan and D.M. Kadyampakeni

GROWER UPDATE

- Permission given to share results
- Grapefruit on Swingle, Central Region
- Severely HLB symptomatic and significant dieback
- Fully applied recommendations

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GROWER UPDATE

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Sampling Dates	N leaf	P leaf	K leaf	Ca leaf	Mg leaf	S leaf	Mn leaf	Zn leaf	Cu leaf	Fe leaf	B leaf
December 2019	3.2	0.16	1.4	4	0.46	0.23	14	20	10	26	113
April 2020	2.9	0.14	1.5	3.4	0.44	0.33	16	112	3	31	121
August 2020	3	0.15	1.9	2.8	0.37	0.23	13	47	5	47	98
December 2020	2.7	0.14	2	2.9	0.4	0.29	13	25	5	39	107

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March 2020

Summer 2020

November 2020

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GROWER UPDATE

← 2020

March

2021 →

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MOVING FORWARD

- **Continue nutrition box program for a second year**
  - Collecting yield data
- **Research project funded by CRDF (2021-2023)**
  - Determine number of leaf nutrient sampling needed to effectively capture nutritional status
  - Establish relationship between leaf concentration with yield, fruit drop, and canopy density
  - Determine how leaf nutrient levels change throughout year
  - Evaluate how leaf age affects leaf nutrient status

KEY MESSAGES

- Nutrition box program was based on previous research
- Main objective was to help growers implement the research findings through a **collaborative project**
- From a statewide level, overall, **nutrition analysis looks good!**
- **Regional differences occur** with secondary macronutrients and micronutrients
- **Mn and Zn are a concern** for almost all areas
- **pH of 5.8-6.5 is ideal** for HLB-affected trees
- Grower update-visually looks good, but nutrient levels remained the same

SPECIAL THANKS!

- **Program participants**
- **Extension agents and faculty**
  - C. Oswalt, M. Zekri, A. Paolillo, J. Popenoe, A. Rezazadeh, L. Hurner, M. Smith, D. Sprague
  - T. Vashisth, D. Kadyampakeni
- **Program setup**
  - M. Rogers, R. Borger, T. Weeks, A. Persaud, T. Siegel, Vashisth Lab
- **State Legislature Funding for Citrus Initiative**

Photo Credit: J.D. Burrow , T.R. Weeks, UF/IFAS

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CITRUS INITIATIVE

FUNDED BY THE FLORIDA STATE LEGISLATURE

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RESOURCES

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THANK YOU!

Any questions?

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