FERTILIZATION METHODS

1 SOIL APPLIED

- 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

Granular

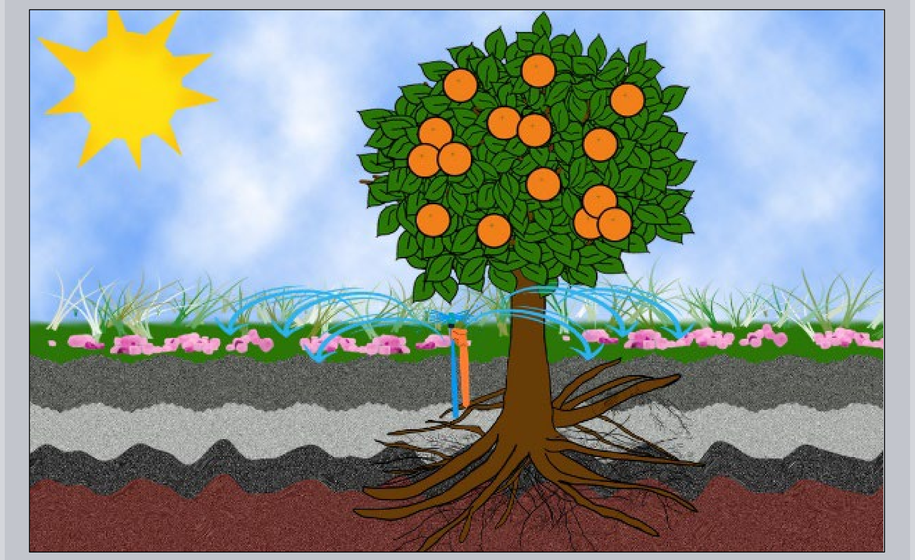
- Traditional soil applied fertilizer
- Advantages
  - Fertilizer is inexpensive
  - Readily available to plant
- Disadvantages
  - Subject to leaching
  - Multiple applications increase labor and costs

Controlled Release Fertilizer

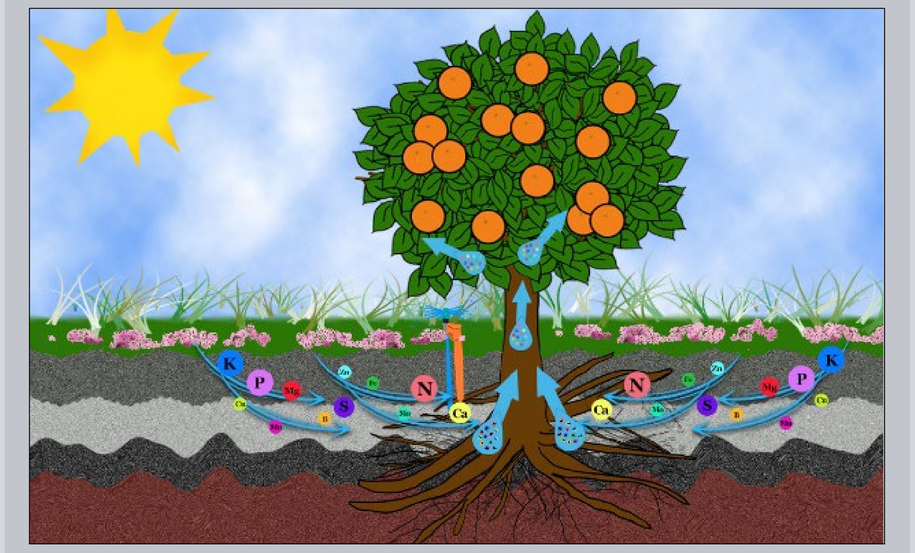
- Granules release small amounts of fertilizer over time
- Advantages
  - Slowly released; therefore, a constant supply of nutrients
  - Fewer applications, reduced rate
- Disadvantages
  - Expensive

Fertigation

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



Water helps dissolve fertilizer into the ground
Graphic Design: K.M. Snyder and T.R. Weeks, UF/IFAS



Fertilizer is absorbed by the roots and moved throughout the tree
Graphic Design: K.M. Snyder and T.R. Weeks, UF/IFAS

2 FOLIAR APPLIED

- 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

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

Funding: UF IFAS UNIVERSITY of FLORIDA

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CITRUS BEST MANAGEMENT PRACTICES

1

Agricultural best management practices (BMPs) are practical measures that producers can take to reduce the amount of fertilizer, animal waste, and other pollutants entering our water resources. BMPs are designed to improve water quality while maintaining agricultural production.

2

NUTRIENT MANAGEMENT

- Choosing appropriate sources and formulations of fertilizer based on nutritional needs of the plants
- Using soil and tissue tests and UF/IFAS recommended fertilizer rates
- Calibrating and adjusting fertilizer application equipment
- Using split applications for soluble fertilizers
- Keeping records of nutrient application and location

3

IRRIGATION MANAGEMENT

- Using tools such as soil moisture sensors, water table observation wells, crop water use information, or weather data, to make good irrigation decisions
- Monitoring and maintaining irrigation systems and utilizing a Mobile Irrigation Lab if available
- Using the FAWN application irrigation and frost/freeze tools or other applicable weather monitoring tool when irrigating for frost/freeze protection

4

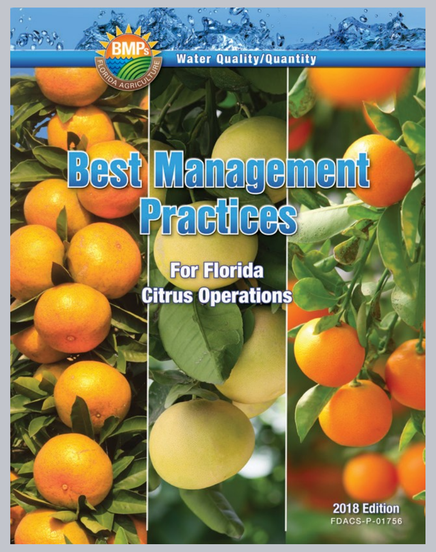
WATER RESOURCES PROTECTION

- Installing and maintaining appropriate vegetated buffers
- Using backflow-prevention devices at the wellhead
- Maintaining vegetative cover in row middles
- Managing water velocities near drainage structures to prevent sediment from entering the drainage system
- Restricting pesticides applications to within the citrus tree canopy drip line
- Stabilizing bare soil areas with grass or vegetation after soil bedding to minimize erosion

5

REASONS TO ENROLL IN THE FDACS BMP PROGRAM

- Some BMPs can help increase production efficiency and reduce costs while helping to protect the environment
- Enrollment provides producers access to technical assistance with BMP implementation
- Producers become eligible for cost-share, when available, for certain practices
- Implementing verified FDACS-adopted BMPs provides a presumption of compliance with state water quality standards for the pollutants addressed by the BMPs
- Producers who implement FDACS-adopted BMPs might satisfy some water management district permitting requirements. Check with your district
- In areas with adopted basin management action plans (BMAPs), and some other designated areas, producers who implement BMPs avoid having to conduct costly water quality monitoring
- BMP participation demonstrates agriculture's commitment to water resource protection and helps maintain support for this alternative approach



Information obtained from www.fdacs.gov

Funding:

FERTILIZER APPLICATION RATES

1 FERTILIZER APPLICATIONS

- Fertilizer applications should begin in February and end the first week of October
- Dry and foliar nutritionals should be divided into at least 4-5 applications, but do not need to be evenly divided
- For example, more nitrogen is needed in the spring than in early fall
- For HLB-affected trees, up to 20% yield increase has been observed with:
  - A combination of Ca (65 lbs/ac) and Mg (70 lbs/ac) increased yields
- Micronutrients applied 3x the IFAS recommendations increased the yield

Small, frequent doses of <u>all nutrients</u> are beneficial for both the environment and tree health. It reduces leaching and allows trees a constant supply

2 HOW TO CALCULATE NITROGEN (N)

To determine the rate of N, you need the following information:

- Base N rate (yearly amount of N)
- Average yield (number of boxes/acre from grove)

Formula: Base N rate + {[(Average yield – 200 boxes/acre)/100] x 15 lb/acre}

Grower provides

Predetermined values based on healthy tree standards

<u>Example:</u>

Grower provided: Base N rate = 180

Grower provided: Average yield = 250

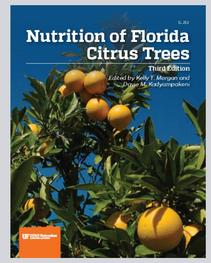
Step 1: Fill in the formula. 180 + {[(250-200)/100] x 15}

Step 2: Calculate parenthesis and brackets. 250-200=50; 50/100=0.5

Step 3. Calculate remaining brackets. 0.5 x 15 = 7.5

Step 4. Add the last two numbers. 180 + 7.5 = 187.5

187.5 = total pounds N per acre per year



For more information on fertilizer calculations, see Nutrition of Florida Citrus Trees, 3rd Edition

3 DETERMINING PHOSPHORUS (P) NEEDS

Scenario #1		
‘Hamlin’ grove, Bearing age, Ridge soil		
P Leaf Analysis	0.11 (low)	<u>Recommendation</u> P is sufficient and no P application is needed at this time. Monitor for any nutrient deficiency symptoms. Continue nutrient analysis and monitor for any continual declines in P.
P Soil Analysis	205 (very high/sufficient)	
pH	6.8 (high)	

Scenario #2		
‘Valencia’ grove, Bearing age, Ridge soil		
P Leaf Analysis	0.12 (optimum)	<u>Recommendation</u> P is sufficient and no P application is needed at this time. Continue to monitor for any changes.
P Soil Analysis	245 (very high/sufficient)	
pH	7.0 (high)	

Scenario #3		
‘Valencia’ grove, Bearing age, Flatwoods soil		
P Leaf Analysis	0.17 (high)	<u>Recommendation</u> Low pH decreases the ability of P used by the plant. Recommended; not apply P and raise pH levels. Once pH levels are optimum, tree can absorb P instead of storing it. Monitoring both pH and P levels on a regular basis.
P Soil Analysis	28.5 (less than sufficient)	
pH	5.05 (low)	

<u>Funding:</u> UF IFAS UNIVERSITY of FLORIDA

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IRRIGATION MANAGEMENT

1

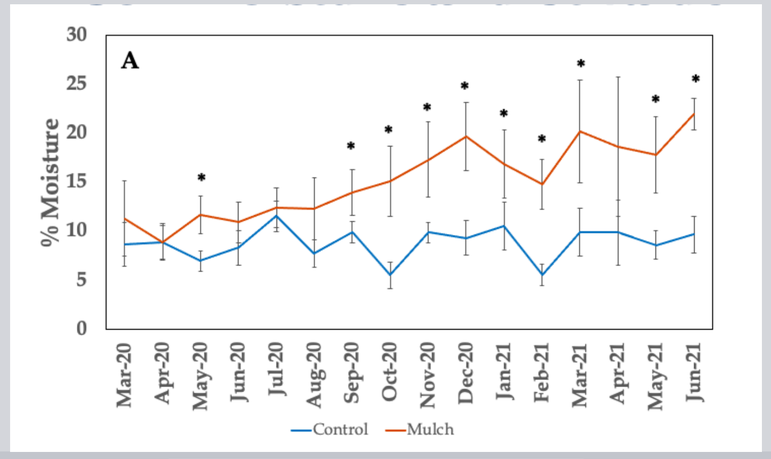
HLB and IRRIGATION

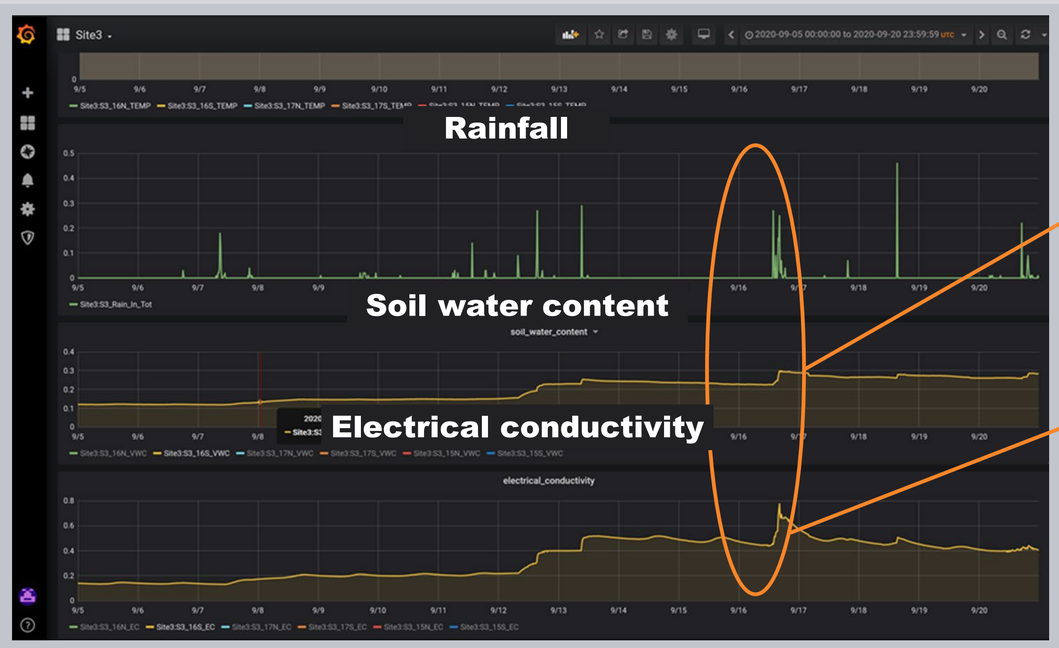
- HLB-affected trees have smaller and weaker root systems than healthy trees; therefore, water uptake is limited
- Schedule small, frequent irrigation applications for HLB-affected trees, but use the same total amount of water as a healthy tree
- Canopy size, root growth, and yield are improved with daily irrigation once or twice a day
- Drip irrigation/fertigation with reflective mulch appears to enhance canopy size and tree growth tissue nutrient content

2

OAK MULCH

- Results showed that plots treated with oak mulch had increased soil phosphorus and soil potassium compared to control plots at certain times of year
- No differences were observed in leaf phosphorus and potassium between oak mulched plots and control plots
- Soil moisture levels were consistently higher in mulched plots compared to control plot
- No significant differences were observed in leaf Ct value between treatments
- **These findings indicate that oak mulch increases soil nutrients and moisture but does not actively suppress HLB**





3

AFTER AN IRRIGATION EVENT

Soil moisture data tells you how much water is available for the trees

AFTER A FERTIGATION EVENT

Electrical conductivity (EC) data tells you where the nutrients are For sandy soils we can see spikes in EC after 1 hour

4

CONSIDERATIONS

- Some probes provide volumetric ion content (VIC) readings. These readings show more clearly the movement of fertilizers
- For controlled release fertilizers the spike in EC or VIC readings can be registered after two days or more
- To register good fertilizer management practices, it is necessary to compare the values from the upper to the lower sensor. If the upper sensor shows a spike and the lower sensor is flat, this means good fertilizer management

Funding: SARE Southern Sustainable Agriculture Research and Education

Funding: UF IFAS University of Florida; USDA National Institute of Food and Agriculture, U.S. Department of Agriculture

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SOIL pH

1 pH AND NUTRIENT INTERACTIONS

- Soil pH affects nutrient availability of plant nutrients
- At high soil pH micronutrients availability reduces, whereas at low pH calcium and magnesium can be lost from the soil.
- Tables show multiple examples of the soil pH and calcium and magnesium content of same grove over the period of two years.
- Most Florida soil are acidic in their native state. Years of irrigation with alkaline water has raised the soil pH to over 7.0 at many places.
- HLB-affected trees decline at faster rate under high soil pH condition (Figure 2 and 3).
- Soil pH for HLB-affected trees should be maintained at 5.8-6.5.
- High soil pH can reduce the availability of soil-applied micronutrients as well as cause abiotic stress.
- High soil pH increases oxidative stress in the roots and plant.
- Oxidative stress is linked with pre-harvest fruit drop. Groves with well-maintained soil-pH drops fewer fruit than groves at high soil-pH.

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

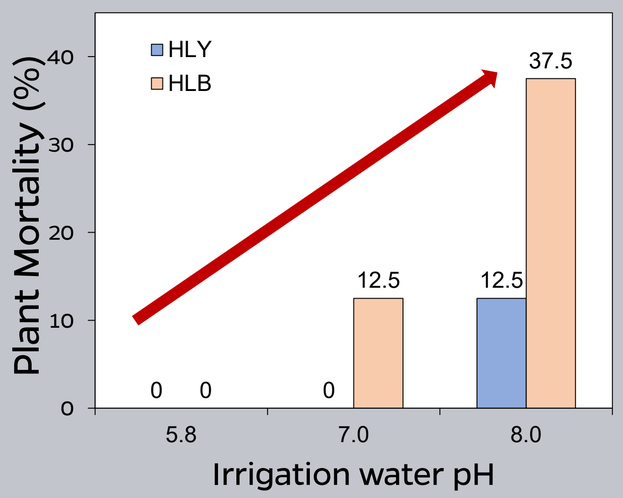
Grove 2			
Year	**pH**	**Ca**	**Mg**
2021	6.7	1786	351
2019	5.4	611	132

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

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

When adjusting pH, Ca and Mg are sensitive to pH changes than other nutrients. Red highlights extreme changes in pH resulting in extreme changes in Ca and Mg. A pH between 5.8 and 6.5 is ideal for all nutrients and allows a well-balanced nutrient uptake.

Funding: UF IFAS UNIVERSITY of FLORIDA · CITRUS INITIATIVE FUNDED BY THE FLORIDA LEGISLATURE · USDA National Institute of Food and Agriculture U.S. DEPARTMENT OF AGRICULTURE



At high pH, HLB plants have significantly higher mortality than healthy plants

At high pH, HLB undergo significant root loss, whereas at low pH, the feeder root growth is higher in HLB plants

2 ADJUSTING SOIL pH

- The pH should be maintained between 5.8-6.5.
- The soil pH adjustment is a continuous process
  - When making big changes, ideally monitor at least every 6 months
- How to measure soil pH: send soil to testing lab (most accurate method) or use soil pH meters
- If soil pH is low, use dolomite to bring it up
  - 1 ton per acre will raise one point of pH
  - It can take up to 6-8 months to see change
  - Since dolomite supplies calcium and magnesium, the fertilizer should be adjusted
- If soil pH is high, consider elemental Sulphur or thiosulfate or ammonium fertilizer for long term effect.
  - Irrigation water acidification for short term effect

For more information, please contact Tripti Vashisth, tvashisth@ufl.edu, Davie Kadyampakeni, dkadyampakeni@ufl.edu, Kelly Morgan, conserv@ufl.edu

PLANT GROWTH REGULATORS (PGR)

1 PGR DEFINED

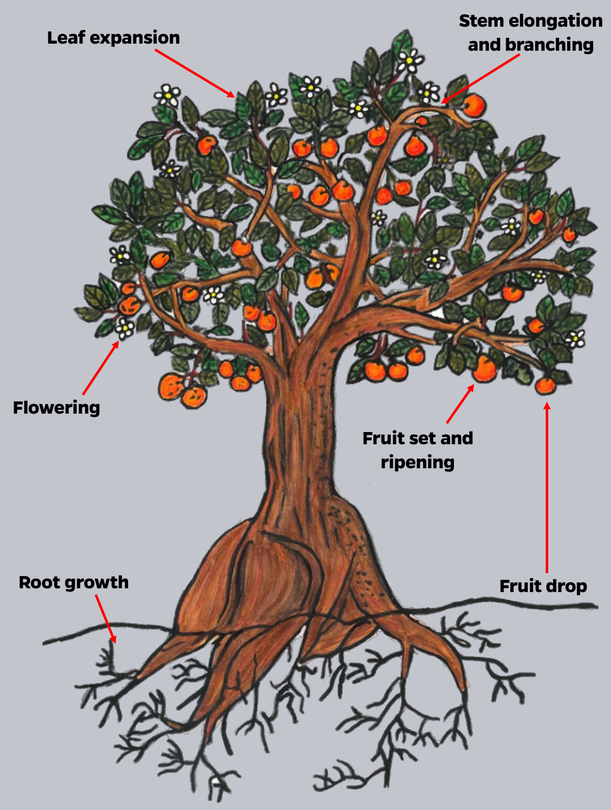
- Defined by Florida Department of Agriculture Consumer Services (FDACS)
- Any substance or mixture of substances intended, through physiological action, for accelerating or retarding the rate of growth or maturation or for otherwise altering the behavior of ornamental or crop plants or the produce thereof, but not including substances intended as plant nutrients, trace elements, nutritional chemicals, plant inoculants, or soil amendments
- Regulated as a pesticide
- Must follow pesticide laws when applying PGRs

3 PGR APPLICATION

- Must be absorbed by the plant tissue
- Uniform spray coverage must be ensured
- Absorption is often affected by weather conditions; warm and humid is favorable for absorption
- A surfactant helps in absorption of PGRs

4 COMMONLY USED PGRs

- In citrus, 2,4-dichlorophenoxyacetic acid (2,4-D) and gibberlellins (gibberellic acid; GA) can reduce premature and preharvest fruit drop in healthy trees
- Naphthalenacetic acid (NAA) can be used for fruit thinning in mandarin varieties



Plant growth regulators impact multiple components of citrus tree growth.

PGRs can have multiple effects on plant depending on the developmental stage and time of application.
For example, auxins can cause chemical thinning of fruit, reduce preharvest fruit drop, and promote next season bloom; therefore, careful consideration is needed when applying PGRs.

Funding: UF IFAS UNIVERSITY of FLORIDA

2 PGR FACTS

- Known as growth regulators or plant hormones
- Chemicals used to alter the growth of a plant or plant part
- Can be growth inhibitors, promoters, or retardants
- Play major role in abscission, dormancy, fruit ripening, fruit set, leaf expansion, stem elongation, root growth, germination, etc.
- Efficacy and effect of PGRs depends on rate, spray volume, and the developmental stage of plant or fruit
- Can work at very low concentration
- If applying two or more PGRs at a time, ratio of PGRs is very critical for efficacy

5 PGR RESEARCH

- Current research suggests that 2,4-D and GA are not effective in reducing HLB induced preharvest fruit drop. Further research is needed
- A new class of plant hormones, Brassinosteroids (HBr), has shown improvement of HLB-affected tree health in greenhouse studies
- Field trials on HBr are underway to evaluate their efficacy under Florida field conditions
- GA has been shown to be effective in reducing off season flowering and synchronizing spring bloom in HLB-affected trees when applied in late fall. This can be an effective tool to manipulate flowering if PFD is a concern

For more information, please contact Tripti Vashisth, tvashisth@ufl.edu

SELECTING A PGR AND READING THE LABEL

CLASS	ASSOCIATED FUNCTION(S)	PRACTICAL USES
Auxins	Shoot elongation	Fruitlet thinning, increased rooting and flower formation; sprout inhibitor
Gibberellins	Stimulate cell division and elongation	Increase shoot length, fruit size, and fruit set
Cytokinins	Stimulate cell division	Prolong storage life of flowers and vegetables and stimulate bud initiation and root growth
Ethylene	Ripening, abscission, and senescence	Induce ripening and loosens fruit
Abscisic acid	Seed maturation, dormancy	Regulate plant stress
Jasmonates	Plant defense	Wound response
Salicylic acid	Systemic Acquired Response (SAR)	Defense against pathogenic invaders
Brassinosteroids	Developmental processes	Regulate germination and other developmental processes
Strigolactones	Suppresses branching and promotes rhizosphere interaction	Suppress branching, promote secondary growth, and promotes root hair growth

ACTIVE INGREDIENTS ON CHEMICAL LABEL

Auxins
1-naphthalenacetic acid (NAA)
2,4-Dichlorophenoxyacetic acid (2,4-D)
3-indoleacetaldehyde acid (IAld)
3-indoleacetic (IAA)
3-indolepyruvic (IPA)
indolebutanoic acid (IBA)

Gibberellins
GA_4GA_7
GA_3

Cytokinins
CPPU
Kinetin

Ethylene
Ethephon
Ethylene

Jasmonates
Methyl jasmonate (MeJA)
Linolenic acid (LA)

Salicylic acid
Methyl salicylate

SAMPLE PGR LABELS SHOWING ACTIVE INGREDIENT

ACTIVE INGREDIENT:
1-Naphthaleneacetic Acid, Potassium Salt* 6.25%
INERT INGREDIENTS: 93.75%
Total 100.00%

ACTIVE INGREDIENTS: By Wt
3-Indolebutyric acid (IBA) 0.85%
Cytokinin, as Kinetin 0.15%
OTHER INGREDIENTS: 99.00%
TOTAL 100.00%

Active Ingredient: Gibberellic Acid (A_3) 20%
Other Ingredients: 80%
Total: 100%

ACTIVE INGREDIENTS
*Cytokinin, as Kinetin 0.090%
*Gibberellic Acid 0.030%
*Indole Butyric Acid 0.045%
OTHER INGREDIENTS 99.835%
TOTAL 100.000%

FOLLOW ALL LABEL PRECAUTIONS

ACTIVE INGREDIENT:
Isopropyl Ester of 2,4-Dichlorophenoxyacetic Acid* 45.0%
INERT INGREDIENTS: 55.0%
TOTAL: 100.0%
*2,4-Dichlorophenoxyacetic Acid Equivalent 38% 3.36 lbs. 2,4-D acid equivalent per gallon
Contains petroleum distillates

USE PRECAUTIONS
- ALCO CITRUS FIX is a plant growth regulator for use on citrus only. Do not use as a herbicide!
- Do not use on citrus trees less than 6 years old.
- Do not apply during a flush of leaf growth.
- Do not apply within 7 days of harvest.
- Do not allow drift to susceptible plants, which include but are not limited to: cotton, grapes, roses, beans, peas, alfalfa, lettuce, ornamentals and broadleaf plants. This product may injure cotton, beans, peas, grapes, ornamentals, etc. (coarse sprays are less likely to drift).
- Do not use equipment that has been used to spray ALCO CITRUS FIX to spray 2,4-D sensitive plants. Always use caution in disposing of spray solutions as they can cause extreme injury or kill sensitive plants. (See Storage and Disposal section.)
- Before using spray equipment for any other purpose, thoroughly clean same with hot soap suds followed by soaking and washing with ammonia or baking soda.

Funding: UF IFAS UNIVERSITY of FLORIDA

For more information, please contact Tripti Vashisth, tvashisth@ufl.edu

GIBBERELLIC ACID (GA)

1 RECENT GA WORK ON HLB-AFFECTED TREES

- Current findings suggests that GA can improve productivity of HLB-affected trees by improving source to sink ratio. The effect of GA is 'holistic', in addition to reduction of fruit drop
- GA increases vegetative growth (Figure1).
- When applied in late fall, it delays and decreases flowering; GA causes 50% reduction flowering with suppression of early flowering wave
- Resulting flower are leafy blooms; leafy blooms have tendency of better fruit set and growth
- According to four-year average, GA treated trees produced 228 lbs of fruit per tree versus 175 lbs of fruit per tree. This can be extrapolated as 370 boxes per acre with GA treatment as compared to 292 boxes per acre in untreated control. (Figure 2)

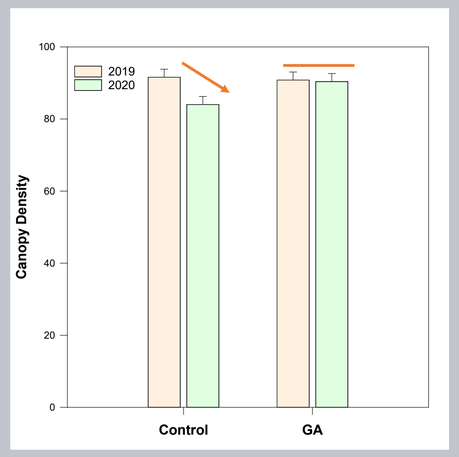


Figure 1. GA-treated trees maintained canopy density while untreated trees decreased in canopy

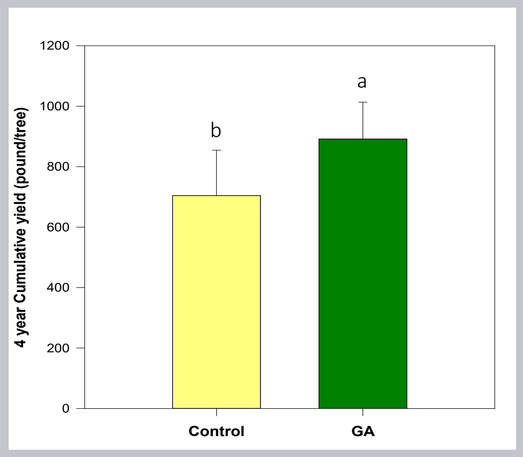


Figure 2. GA-treated trees produced 23% more pounds of fruit per a tree than the control

2 CURRENT RESEARCH AND PRELIMINARY

- In a current study, GA was applied from September-January, 10 fl oz per application in Valencia
- Attention should be paid as the fruit remained green in GA treatment, making it unsuitable if the goal of production is fresh market
- Preliminary work suggests that fewer GA application (two applications in November-December at 10 fl oz per application) might be sufficient
- More work on timing and rate is in progress

3 LABEL USE CHART

Variety	Response	Time of Application	Growth Regulator and Formulation	Product Rate or Volume per Acre
Grapefruit	Delay of rind aging process and peel color development at maturity	August–November. Late sprays can result in re-greening.	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	16–48 gram a.i.[3]
Tangerine-hybrids				20–40 gram a.i.
Navel oranges				16–48 gram a.i.
All round orange				20–60 gram a.i.
Navel oranges Ambersweet orange Sweet orange	Improvement of fruit set and yield; can result in small size and leaf drop.	December–late January	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	15–25 gram a.i.
Tangerines Mandarins Grapefruit		Full bloom		8–30 gram a.i.
Processing oranges (late varieties)	To increase juice extraction yield	Color break	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	20 gram a.i.

Funding:

UF IFAS UNIVERSITY of FLORIDA

CITRUS INITIATIVE
FUNDED BY THE FLORIDA LEGISLATURE

CRDF Citrus Research and Development Foundation, Inc.

For more information, please contact Tripti Vashisth, tvashisth@ufl.edu