

Understanding and Manipulating the Interaction of Rootstocks and Constant Nutrition to Enhance the Establishment, Longevity and Profitability of Citrus Plantings in HLB-Endemic Areas



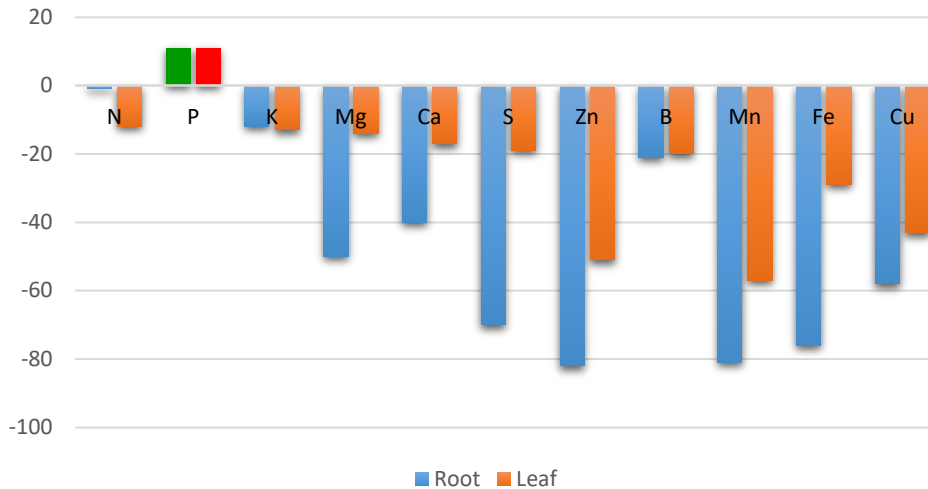
Jude Grosser, Manjul Dutt and Tripti Vashisth



CRDF 2019 – Report on Project 05-013

HLB Impacts Root Micro-nutrient Metabolism

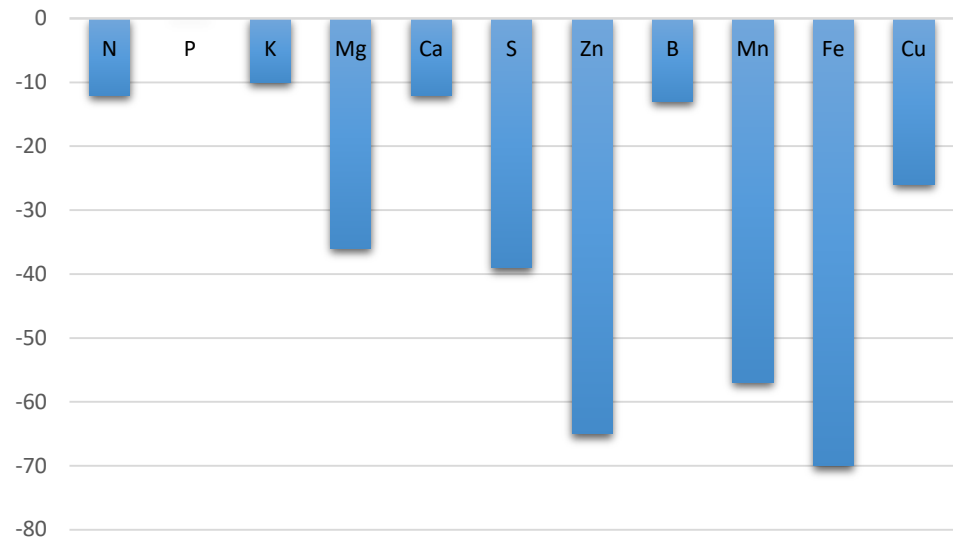
Val/CZO Greenhouse



- Comparison of Healthy/Symptomatic trees (average of 10 trees) - % change compared to healthy GH trees
- Root deficiencies are much higher than leaf deficiencies

- Comparison of Healthy/Symptomatic trees - % change compared to healthy field trees
- Same patterns as greenhouse trees
- Soil pH and micro-nutrient content not responsible!
- Foliar sprays do not address this!

Val/SW field Root



Supplemental Nutrients in Controlled Release Forms

Micronutrients – applied at 3x concentration

Tiger-Sul Micronutrients Zinc 18% (18% Zn, 65% S)

Tiger-Sul Micronutrients Iron 22% (22% Fe, 55% S)

Tiger-Sul Micronutrients Manganese 15% (15% Mn, 65% S)

Tiger-Sul 'Arnolds mix' (3.85% Fe, 7.50% Mn, 5.85% Zn, 63% S)

Florikote Polymer Coated Sodium Borate (8.82% B)

Florikote Polymer Coated Magnesium Sulfate (13.9%)

Florikote Polymer Coated Triple Super Phosphate (40% P_2O_5)

Florikote $FeSO_4$ Polymer Coated Ferrous Sulfate (28% Fe, 17% S)

BioChar from Southern Yellow Pine (97%)

Macronutrients—applied at 2x concentration

Florikote Polymer Coated Mini Ammonium Sulfate (19% N)

Florikote Polymer Coated Sulfate of Potash (47% K_2O)

Florikote Polymer Coated Urea (42% N)

Polycoated Florikote products kindly provided by Brian Patterson (Florikan Corp.)



Stick-graft method - Valencia budstick taken from heavily HLB-impacted field tree. Graft wrapped with budding tape, Budstick wrapped with parafilm. 10 trees per treatment.

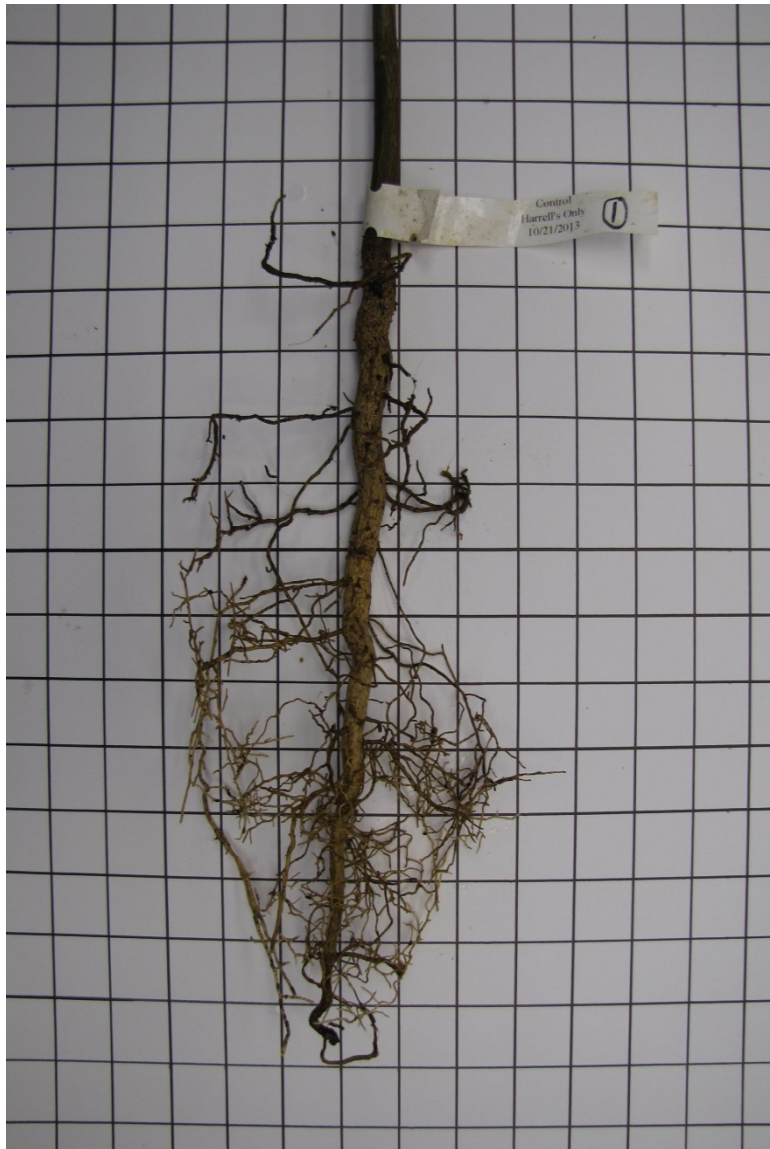
Greenhouse Study – Effects of nutrient overdoses on HLB-infected Valencia on UFR-3 (Orange #15) tetrazyg rootstock after 1 year. Total Root length (cm) , determined by winRhizo washed root image analysis.

Treatment	N	Mean*	Standard Deviations	Tukey Grouping
Harrell's + 3x TigerSul Mn	10	2361	848	A
Harrell's + 3x Tiger-Arnold's Mix (Mn, Fe, Zn)	9	2270	933	A
Harrell's + 3x TigerSul-Arnold's + Biochar	9	1955	1237	AB
Harrell's + 3x Tigersul Zinc Sulfur	10	1672	1039	AB
Harrell's - Control	8	1670	900	AB
Harrell's + 3x Florikan Sodium Borate	10	1554	1466	AB
Harrell's + 3x Tigersul Fe	7	1419	704	AB
Liquid Fertilizer Only - Control	6	1349	1273	AB
Harrell's + 3x Florikan Magnesium Sulfate	8	1315	1025	AB
Harrell's + 2x Florikan Ammonium Sulfate	8	1276	805	AB
Harrell's + 2x Florikan Urea	8	1173	766	AB
Harrell's + 3x Florikan Iron Sulfate	7	1032	544	AB
Harrell's + 3x Florikan Super triple Phosph	6	910	642	AB
Harrell's + 2x Florikan potash	4	902	226	AB
Harrell's + Biochar	9	559	403	B

* Means with the same letter are not significantly different at 95% confidence



Control liquid fertilizer Harrell's CRF+TigerSul Mn
HLB-infected greenhouse trees after one year;
Valencia/UFR-3.



Harrell's CRF Control #1



Harrell's+TigerSul Mn #10

Regarding micronutrient nutrition – there may be more to it than just figuring out what an infected tree needs; consider possible interactions with the pathogen!

Liberibacter has not been successfully cultured – WHY?
Maybe there is something it doesn't like!

Is it possible that trees could be fed one or more micronutrients at levels that are toxic to the Liberibacter that are below the toxicity thresholds for the trees? MAYBE!

qPCR ct averages from greenhouse treatments

Treatment	Midrib	Root
Harrell's + PC Boron	34.86	33.66
Harrell's + PC Super Triple Phosphate	33.95	33.95
Harrell's + PC Ammonium Sulfate	33.89	33.78
Harrell's + PC Magnesium Sulfate	33.07	31.59
Harrell's Plus TigerSul Zinc	33.05	33.11
Harrell's + PC Potash	33.01*	35.57*
Harrell's Plus PC-Urea	32.92	33.00
Harrell's + biochar	32.80	32.48
Harrell's + Arnolds's mix/biochar	32.35	30.87
Harrell's Plus TigerSul manganese	31.91	35.18
Harrell's + PC Iron Sulfate	31.17	33.30
Harrell's Plus Arnold's mix	30.64	29.88
Liquid control	30.57	34.57
Harrell's control	29.78	32.75
Harrell's Plus TigerSul iron	29.75	30.79

* Trees in very poor health

Topworked tree roots
now PCR-negative! WHY?



Sweet orange OLL #7 topworked onto severely symptomatic HLB-infected Valencia on Swingle. Tree treated with Harrell's UF mix CRF + Mn and boron overdoses. Fruit set 2nd year.



Typical fruit from young HLB-infected (3 years) LB8-9 SugarBelle™ trees treated with controlled release fertilizer containing extra manganese and boron, and Tiger-Sul micros.



Typical fruit from young HLB-infected (3 years) LB8-9 SugarBelle™ trees with standard fertilization regime.

Ed English (w/ Kelly Morgan & Alton Green) Program:

Citra-Guard Nitrate Soil Ammendment 7-0-0; monthly treatment. Material is being applied through airblast sprayer, bottom two nozzle ports open on each side. It is applied at 50 GPA.

7% Nitrate nitrogen

0.75% copper

4.60% iron

3.80% manganese

3.80% zinc

all nitrate derived

Phosmax (Phosphorous Acid) @ 1 quart per acre. The goal is to get 60 lb of phosphorus per acre per year.

Dry and Foliar: 11-37-0



Revived 100% HLB-infected Valencia/Swingle trees in Alva, Ed English (Alton Green) monthly liquid nitrate program. Concept of 'tree momentum'



Inside fruit on Ed English Valencia/Swingle trees; 7.4 lbs. solids!

Evolution to the McKenna Liquid Program:

– they are applying the 5–0–7 ‘strawberry mix’ at 10gal/acre (calcium, potassium and magnesium nitrates) mixed with 1 quart/acre of the CitraGuard (micro–nitrates – see below). This is alternated weekly with a 9–4–9. They do not apply during weeks when they are spraying and during periods of heavy rain.

Citra–Guard Nitrate Soil Amendment 7–0–0; It is applied at 50 GPA.

7% Nitrate nitrogen

0.75% copper

4.60% iron

3.80% manganese

3.80% zinc

all nitrate derived

Results: increased yield and fruit quality, reduced fruit drop in first year across several groves, scion/rootstock combinations and trees of different ages! Take care of your roots!

Project Objective 1 – Greenhouse Study

Greenhouse study to determine if combined overdoses of TigerSul manganese and Florikan poly-coated sodium borate can improve HLB-infected tree health and reduce Liberibacter titers

Trees were grown in the air-conditioned 'Whitehouse', with temperatures favoring Clas replication year-round (no summer thermotherapy!)

Rootstocks evaluated in this study

1. Swingle citrumelo (commercial control)
2. X639 (commercial control)
3. UFR-3 (tetraploid of Nova+Hirado Buntan Pummelo x Cleopatra+Argentine trifoliate orange)
4. White grapefruit+trifoliate 50-7 (tetraploid somatic hybrid) and
5. UFR-15 (diploid of Hirado Buntan x Cleopatra).

Treatments

1. Harrell's nursery mix -1 tablespoon (Control)
2. Harrell's nursery mix -1 tablespoon + 25 pellets
Tiger-Sul Manganese
3. Harrell's nursery mix – 1 tablespoon + 0.176 g
Florikote polycoated boron
4. Harrell's nursery mix – 1 tablespoon + 25 pellets
Tiger Mn + 0.176 g FL boron
5. Harrell's St. Helena mix (12-3-9)
6. Florikote IFAS blend (12-3-9)



16-5-10

Batch #:

12 Month.

NPK+ Minors

GUARANTEED ANALYSIS

* Total Nitrogen (N).....	16.0000%
5.8630% Nitrate Nitrogen	
6.8760% Ammoniacal Nitrogen	
3.2620% Urea Nitrogen	
** Available Phosphate (P2O5).....	6.0000%
*** Soluble Potash (K2O).....	10.0000%
Magnesium (Mg)	1.0830%
1.0830% Soluble Magnesium (Mg)	
Copper (Cu)	0.0620%
0.0620% Soluble Copper (Cu)	
Iron (Fe)	0.2580%
0.2580% Iron (Chelated)	
Manganese (Mn)	0.1000%
0.1000% Soluble Manganese (Mn)	
Molybdenum (Mo)	0.0090%
Zinc (Zn)	0.0620%
0.0620% Soluble Zinc (Zn)	

0% Bo
0.1% Mn

Derived From: Polymer Coated Ammonium Nitrate, Polymer Coated Copper Sulfate, Polymer Coated EDTA Iron Chelate, Polymer Coated Magnesium Sulfate, Polymer Coated Manganese Sulfate, Polymer Coated Mono-Ammonium Phosphate, Polymer Coated Sodium Molybdate, Polymer Coated Sulfate of Potash, Polymer Coated Urea, Polymer Coated Zinc Sulfate, Polymer-Coated Potassium Nitrate

- * Has 14.05% slow release NITROGEN derived from Polymer Coated Ammonium Nitrate, Polymer Coated Mono-Ammonium Phosphate, Polymer Coated Urea, Polymer-Coated Potassium Nitrate
- ** Has 4.5% slow release PHOSPHATE derived from Polymer Coated Mono-Ammonium Phosphate
- *** Has 8.916% slow release POTASH derived from Polymer Coated Sulfate of Potash, Polymer-Coated Potassium Nitrate

Warning: — This fertilizer is to be used only on soils which respond to Molybdenum. Crops high in Molybdenum are toxic to ruminants.

Density - 81 lb./cu. ft.)

CAUTION MAY CAUSE STAINS ON CONCRETE

MANUFACTURED BY HARRELL'S INC. (F362) 720 KRAFT ROAD, LAKELAND, FL 33801 - (863) 687-2774 - (800) 282-8007
DISTRIBUTED BY HARRELL'S INC. (F362) 720 KRAFT ROAD, LAKELAND, FL 33801 - (863) 687-2774 - (800) 282-8007

NET WEIGHT 50 LBS

12-3-9



FERTILIZER

Batch #: 1601-0363

GUARANTEED ANALYSIS

Total Nitrogen (N).....	12.0000%
6.8280% Nitrate Nitrogen*	
4.3620% Ammoniacal Nitrogen*	
0.8100% Urea Nitrogen*	
Available Phosphate (P ₂ O ₅)*.....	3.0000%
Soluble Potash (K ₂ O)*.....	9.0000%
Calcium (Ca)	4.5270%
Magnesium (Mg)	0.7920%
0.7920% Water Soluble Magnesium (Mg)	
Boron (B)	0.0750%
Iron (Fe)	1.0880%
0.0880% Water Soluble Iron (Fe)	
0.3200% Chelated Iron (Fe)	
Manganese (Mn)	0.9200%
0.0650% Water Soluble Manganese (Mn)	
Molybdenum (Mo)	0.0060%
Zinc (Zn)	0.7130%
0.0380% Water Soluble Zinc (Zn)	

Derived From: Polymer Coated Ammonium Nitrate, Polymer Coated Calcium Nitrate, Polymer Coated Monoammonium Phosphate, Polymer Coated Muriate of Potash, Polymer Coated Sulfate of Potash, Polymer Coated Urea, Calcium Borate, Ferric Oxide, Ferrous Sulfate, Iron EDTA, Iron Humate, Iron Sucrate, Manganese Oxide, Polymer Coated Iron EDTA, Polymer Coated Magnesium Sulfate, Polymer Coated Manganese Sulfate, Polymer Coated Sodium Molybdate, Polymer Coated Zinc Sulfate, Sodium Borate, Sulfate of Potash-Magnesia, Zinc Oxide

* 12% coated slow release Nitrogen(N), 3% coated slow release available Phosphate(P₂O₅), and 8.712% coated slow release Soluble Potash (K₂O)

WARNING - The application of fertilizing materials containing Molybdenum(Mo) may result in forage crops containing levels of Molybdenum(Mo) which are toxic to ruminant animals. Product contains Boron(B). Do not apply to Boron sensitive crops.

Chlorine (Cl), Not more than..... 2.2490%

F352 Density - 45 lb./cu. ft.

Directions for Use

FOR USE ONLY BY PROFESSIONAL APPLICATORS AND COMMERCIAL GROWERS

Apply fertilizer in accordance with best management practices established by your State University or Cooperative Extension Service. Observe any State or Local fertilizer regulations pertaining to fertilizer content, application rates, or timing of application specific to your locale. Information about the components of this fertilizer may be obtained by writing to Harrell's, LLC at the address below. Include the Inventory # or Batch # found near the product name or guaranteed analysis.

0.075% Bo
0.92% Mn

Net Wt. 50 LBS. (22.7 KG)

1601-0363 211601



Warning

Dust may cause Serious Eye Damage

Skin, Eye and Respiratory Tract Irritant. Harmful if swallowed.



First Aid

If in Eyes: Flush with water for 15 minutes. Call a doctor for treatment advice if irritation persists.

If on Skin: Wash thoroughly with soap and water. Launder clothing before reuse.

If Inhaled: Remove affected person from source of exposure. Call 911 if breathing is difficult.

If Ingested: Do not induce vomiting. Get medical attention.

Have the product label with you when calling a doctor or going for treatment.

Precautionary Statements: Wear safety glasses with side shields or goggles when handling product. Avoid breathing dust. Wash face, hands and exposed skin thoroughly after handling. Do not eat, drink or use tobacco products when using this product.



WITH NUTRICOTE[®] GAL-X[®] MC

12-3-9 Citrus Total

WITH NUTRICOTE[®]
CaNO₃

GUARANTEED ANALYSIS

Total Nitrogen (N)*	12%
6.80% Nitrate Nitrogen	
5.60% Ammoniacal Nitrogen	
Available Phosphate (P2O5)	3%
Soluble Potash (K2O)	9%
Calcium (Ca)	2.00%
Magnesium (Mg)	2.90%
1.95% Water Soluble Magnesium (Mg)	
Sulfur (S)	6.90%
6.90% Combined Sulfur (S)	
Boron (B)	0.11%
Chlorine (Cl) Not More Than	0.92%
Copper (Cu)	0.08%
0.02% Water Soluble Copper (Cu)	
Iron (Fe)	2.08%
0.59% Chelated Iron (Fe)	
0.49% Water Soluble Iron (Fe)	
Manganese (Mn)	0.57%
0.46% Water Soluble Manganese (Mn)	
Molybdenum (Mo)	0.001%
Zinc (Zn)	0.30%
0.24% Water Soluble Zinc (Zn)	

DERIVED FROM: Polymer Coated Ammonium Nitrate, Polymer Coated Calcium Nitrate, Polymer Coated Ammonium Phosphate, Polymer Coated Calcium Phosphate, Polymer Coated Ammonium Polyphosphate, Polymer Coated Potassium Sulfate, Polymer Coated Iron EDTA, Polymer Coated Sulfate of Potash Magnesia, Polymer Coated Magnesium Sulfate, Polymer Coated Iron Citrate, Polymer Coated Manganese Sulfate, Polymer Coated Copper Sulfate, Polymer Coated Zinc Sulfate, Polymer Coated Sodium Borate, Ferrous Sulfate, Iron Sulfate, Iron EDTA, Iron Citrate, Magnesium Sulfate, Magnesium Sulfate, Manganese Sulfate, Zinc Sulfate, Copper Sulfate, Sodium Borate, Sodium Molybdate, Manganese Sulfate, Zinc Sulfate. [*The (LIST NUTRIENTS) have been polymer coated to provide 13% Slow Release Nitrogen (N), 3% Slow Release Available Phosphate (P2O5), 9% Slow Release Soluble Potash (K2O)]

The below rates are provided as a guide only. Specific rates will vary by region, soil type, and performance requirements. Before deciding which formulation, release type, and rate to use, contact your Florikan Technical Representative. They will advise you in choosing the right product for your crop and conditions.

DIRECTIONS FOR USE: Florikan CRF[™] should be applied according to soil or growing media conditions and the specific nutrient requirements of the crop being grown. It is recommended that a soil analysis is done prior to incorporation of Florikan CRF[™]. If the soil or growing media is sandy and loose with good drainage (low Cation Exchange Capacity), a higher rate of the product should be used. For heavier, clay-type soils (high Cation Exchange Capacity) a lower rate of Florikan CRF[™] should be used.

NOTICE: Warranty of the product, either expressed or implied, is limited to a guarantee of the composition as shown on the label in as much as uses are beyond the seller's control. For the same reason, seller is not liable for any injury to living things, crops, soils or materials which may result from the use of this product.

NOTE: Low/high is crop specific information. HIGH refers to heavy feeding crop, LOW is for sensitive feeding crop.

Conversion 5 Grams = 1 Teaspoon | 15 Grams = 1 Tablespoon

PER TREE APPLICATION RATES

Type	UP TO 360 DAYS
Item #	12-3-9-360
YEARS IN GROVE	Lbs.
1 YEAR	.75-1
2 YEARS	.75-1.5
3 YEARS	1.0-2.0
4 YEARS	1.5-2.5
5 YEARS	2.0-3.0

UP TO:
360 DAYS

AVG MEDIAN TEMPS

60°	70°	80°
420 14	390 13	360 12
Days/Months	Days/Months	Days/Months

GUARANTEED BY: F1062

QUALITY CONTROL BATCH
NUMBER:

0.11% Bo
0.57% Mn

**WARNING TO PURCHASER, THIS IS A
DISCLAIMER.** The performance warranty and/or
release of this product, whether stated or
implied, is null and void if improperly stored.

Heavy Metal Statement: Information regarding the
contents and levels of metals in this product is available
on the internet at <http://www.apfco.org/metal.htm>

CAUTION: KEEP OUT OF THE REACH OF
CHILDREN. HARMFUL IF SWALLOWED. This product
must be stored under cool and dry conditions.

Environmental Caution: As a precaution,
fertilizer products should not be applied within
10 feet of any water body.

Caution: The application of fertilizer containing
Molybdenum (Mo) may result in forage crops
containing levels of Molybdenum which may be
toxic to ruminant animals.

WARNING: This product contains Boron (B) and
should be used according to directions only,
especially on crops sensitive to Boron (B) uptake.

NOTE: Fertilizer products can be hygroscopic and may
be affected by humidity and/or heat during improper
storage. Please keep this fertilizer product in a dry
condition and away from heat and moisture which may
start release in the bag.



This product was developed in
conjunction, and with assistance from
NASA using cutting edge research, quality
control and scientific methodology.

SKU: 12-3-9-360-CIT

**U.S. STANDARD
NET WEIGHT 50 LB. (22.68 KG.)**



Signal Word: **NON-REGULATED MATERIAL**

Hazard Statement: Harmful to aquatic life with long lasting effects

Precautionary Statement: Avoid release to the environment - dispose per US laws

Experimental Design

- 6-8-month-old seedlings were stick grafted with HLB infected budstick (at least 6-inch-long) in late spring 2017.
- Trees were fertilized with the combinations at a 6-monthly interval.
- qPCR data to monitor CLas levels were collected on the trees on a half-yearly interval.
- Leaf nutrition levels were evaluated on a yearly basis.



Mean cT values from the different treatments after the first PCR analysis

Treatment	Mean cT values			
	0 months	6 months	12 months	18 months
1 (control)	25.40 ^{a*}	25.62 ^b	26.74 ^{ab}	25.03 ^b
2	26.21 ^a	27.68 ^a	27 ^a	26.28 ^b
3	26.10 ^a	27.86 ^a	26.72 ^{ab}	28.17 ^a
4	26.22 ^a	26.58 ^{ab}	24.94 ^b	28.21 ^a
5	26.01 ^a	27.44 ^a	27.59 ^a	28.33 ^a
6	26.71 ^a	27 ^{ab}	26.33 ^{ab}	29.33 ^a

* Statistical analysis was carried using Proc GLM and ANOVA procedures of SAS. Means within a column represented by the same letter were not significantly different according to t-test ($\alpha = 0.05$)

Number of trees with cT values > 32 after 18 months,
 Indicating a non-active Clas infection.

Treatment	Number of trees with cT >32				
	Swingle	X639	WGFT+50-7	UFR3	UFR15
1 (control)	1	0	0	0	0
2	0	0	1	0	0
3	2	0	0	2	0
4	1	0	2	1	5
5	5	1	4	3	0
6	3	3	2	3	0

Average rating of trees after 1 year of inoculation

Treatment	Mean ratings (\pm Standard error)				
	Swingle	X639	WGFT+50-7	UFR3	UFR15
1 (control)	3.54 \pm 0.2 ^{a*}	3.75 \pm 0.1 ^a	3.75 \pm 0.2 ^a	2.50 \pm 0.7 ^b	2.55 \pm 0.7 ^b
2	3.66 \pm 0.2 ^a	2.5 \pm 0.6 ^c	2.36 \pm 0.5 ^c	2 \pm 0.7 ^d	2.81 \pm 0.4 ^b
3	3.66 \pm 0.3 ^a	2.33 \pm 0.5 ^{cd}	3.71 \pm 0.1 ^a	2.1 \pm 0.9 ^d	2.62 \pm 0.5 ^b
4	3.30 \pm 0.3 ^b	2.12 \pm 0.1 ^c	3.81 \pm 0.2 ^a	3.44 \pm 0.3 ^b	2.09 \pm 0.5 ^c
5	3.4 \pm 0.5 ^a	3.14 \pm 0.1 ^b	3.27 \pm 0.2 ^b	3.23 \pm 0.4 ^b	3.27 \pm 0.2 ^b
6	3.25 \pm 0.5 ^b	2.66 \pm 0.4 ^c	3.27 \pm 0.1 ^b	3.18 \pm 0.2 ^b	3.55 \pm 0.2 ^a

*Statistical analysis was carried among the rootstock lines using Proc GLM and ANOVA procedures of SAS.

Means within a column represented by the same letter were not significantly different according to t-test ($\alpha = 0.05$)

Tree rating was carried out on a scale of 0 to 4 as per chart below

- 0 Dead
- 1 Stunted, a lot of HLB symptoms
- 2 Not stunted but with a lot of symptoms
- 3 Healthy with mild HLB symptoms
- 4 Healthy, no HLB

Average rating of trees after 2 year of inoculation

Treatment	Mean ratings (\pm Standard error)				
	Swingle	X639	WGFT+50-7	UFR3	UFR15
1 (control)	2.09 \pm 0.5 ^{b*}	2.55 \pm 0.7 ^a	2.36 \pm 0.6 ^{ab}	1.5 \pm 0.7 ^c	2.75 \pm 0.7 ^a
2	2.60 \pm 0.6 ^b	1.27 \pm 0.4 ^c	3.15 \pm 0.4 ^a	2.91 \pm 0.9 ^c	1.5 \pm 1.0
3	2.66 \pm 0.1 ^b	1.81 \pm 0.8 ^c	3.41 \pm 0.5 ^a	2.66 \pm 0.7 ^b	2.33 \pm 0.5 ^b
4	2.25 \pm 0.7 ^b	2.62 \pm 0.5 ^a	2.81 \pm 0.8 ^a	1.18 \pm 0.3 ^c	1.12 \pm 0.6 ^c
5	3.30 \pm 0.1 ^a	3.09 \pm 0.3 ^a	3.27 \pm 0.5 ^a	2.44 \pm 0.7 ^b	1.14 \pm 0.3 ^c
6	2.40 \pm 0.9 ^b	2 \pm 0.8 ^b	3.64 \pm 0.1 ^a	2.23 \pm 0.4 ^b	2.66 \pm 0.7 ^b

*Statistical analysis was carried among the rootstock lines using Proc GLM and ANOVA procedures of SAS.

Means within a column represented by the same letter were not significantly different according to t-test ($\alpha = 0.05$)

Tree rating was carried out on a scale of 0 to 4 as per chart below

- 0 Dead
- 1 Stunted, a lot of HLB symptoms
- 2 Not stunted but with a lot of symptoms
- 3 Healthy with mild HLB symptoms
- 4 Healthy, no HLB

Mn and Zn status of leaves in the different treatments

Treatment	Mean concentration (ppm)			
	Year 1		Year 2	
	Manganese	Zinc	Manganese	Zinc
1 (control)	57.444	14.162	188.654	27.68
2	83.296	10.982	259.848	24.804
3	63.382	10.618	173.204	25.158
4	141.338	10.154	282.326	21.576
5	133.724	19.918	205.362	29.664
6	105.83	61.05	285.51	23.644

Due to size of the tree, only one leaf from each tree in the treatment was collected. Results obtained are the bulk aggregate for all trees in that particular treatment.

Mn and Zn status of leaves in the different rootstocks in year 2 of the experiment

Treatment	Mean concentration (ppm)									
	Swingle		X639		WGFT+50-7		UFR3		UFR15	
	Mn	Zn	Mn	Zn	Mn	Zn	Mn	Zn	Mn	Zn
1 (control)	24.73	14.52	172.99	32.29	230.81	29.47	311.72	33.57	203.02	28.55
2	201.55	24.84	384.43	34.2	247.09	24.12	225.99	21.5	240.18	19.36
3	37.31	13.55	174.3	33.51	251.62	24.96	260.59	30.97	142.2	22.8
4	365.22	22.04	318.19	27.58	230.71	19.05	235.4	20.53	262.11	18.68
5	187.88	32.6	200.01	30.36	273.44	29.07	243.54	32.42	121.94	23.87
6	387.94	29.52	307.95	24.2	229.62	20.33	235.7	21.16	266.34	23.01

Due to small size of the tree, only one leaf from each tree in the treatment was collected. Results obtained are the bulk aggregate for all trees in that particular treatment.

Conclusions from this study

- Nutritional treatments 1 & 2 had weak micronutrient packages, and the poorest performances.
- The four treatments that contained enhanced micronutrient packages clearly performed the best, producing trees among all rootstocks with lower bacterial titers and higher health ratings.
- Treatments 1 (control) and 2 did not contain boron, and both produced trees with statistically significant higher CLas titers across all rootstocks after 18 months.
- These data imply that boron can aid to suppress CLas infections in recovering/tolerant trees.
- The data also show that a high dose of manganese is not effective in improving tree health and reducing CLas titers without at least some baseline level of boron.

Conclusions from this study

- When Mn was combined with boron (treatments 3 & 4), tree health was improved with CLas titers reduced, even without enhanced levels of the other micronutrients. Treatments 5 & 6 that contained complete enhanced micronutrient packages also performed well.
- High levels of manganese and zinc were found in leaf samples from all treatments.
- Based on tree health observations, the unreleased somatic hybrid WGFT+50-7 (tetraploid citrumelo) was the most HLB tolerant followed by Swingle, X639, UFR-3 and UFR-15.
- The data also suggest that different rootstocks may have different micronutrient requirements, and bacterial titers were not always correlated with tree health indexes.

Shortcomings and unfinished business

At the end of the greenhouse experiment, 181 CLas infected but fairly healthy trees remained, and we are planning to include them in a field trial nearby with Gapway Groves, under permit from DPI (to plant infected stock). We plan to determine if HLB+ trees on these rootstocks can be established and brought into productivity using the latest optimized CRF formulation.



Project Objective 2

Micronutrient Field Trial Study



Goal: To evaluate the effect of complete, balanced and constant nutrition in HLB-infected mature trees

- Study the effects of controlled release forms of mineral nutrients, with elevated levels of individual micronutrients and soil pH amendments (to lower pH)
- Two locations: Fort Meade and Arcadia
- Valencia/Swingle; 10 to 15 year
- Completely Randomized Block Design
- Trial was initiated in February 2016 and ended with 2019 harvest (3 years)
- 45 trees per treatment
- All the fertilizer treatments were applied 3 times a year by hand in the microjet zone

Treatments

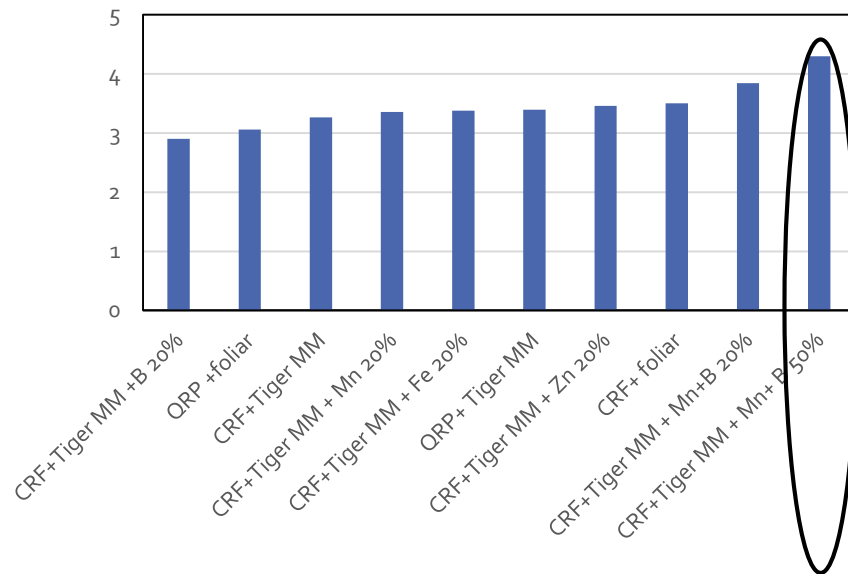
1. Conventional granular fertilizer + foliar
2. Conventional granular fertilizer + Tiger Micronutrient Mix
3. CRF + foliar
4. CRF + Tiger Micronutrient Mix
5. CRF + Tiger Micronutrient Mix + Tiger Mn elevated by 20%
6. CRF + Tiger Micronutrient Mix + Tiger Zn elevated by 20%
7. CRF + Tiger Micronutrient Mix + Tiger Fe elevated by 20%
8. CRF + Tiger Micronutrient Mix + Tiger B elevated by 20%
9. CRF + Tiger Micronutrient Mix + Tiger Mn and B elevated by 20%
10. CRF + Tiger Micronutrient Mix + Tiger Mn and B elevated by 50%

Rate of nutrients

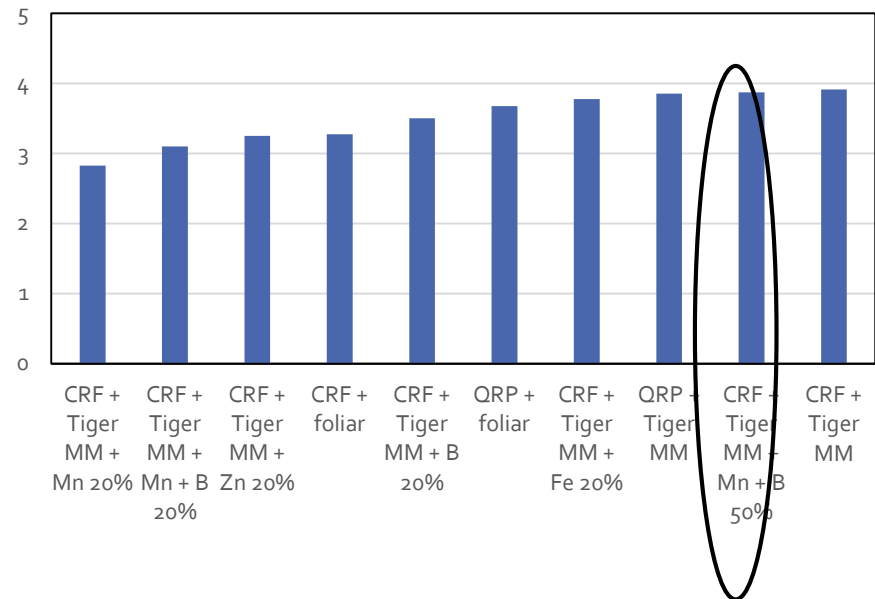
- All the treatments received same amount of P, K, Ca, Mg
- Nitrogen: CNV: 180 lb/acre and CRF(Harrell's): 150 lb/acre
- Tiger Micronutrient mix (Mn-Zn-Fe-B:6-6-3-1); 1.5 pound per tree
 - Mn: 12 lb/acre
20% elevated levels on Mn= 14.4 lb/acre
 - Zn: 12 lb/acre
20% elevated levels on Zn= 14.4 lb/acre
 - Fe: 6 lb/acre
20% elevated levels on Fe= 7.2 lb/acre
 - B: 2 lb/acre
20% elevated levels on B= 2.4 lb/acre

Higher rates of Mn and B improved the leaf density of trees-suggesting improvement in tree health

Ft. Meade



Arcadia



Yield

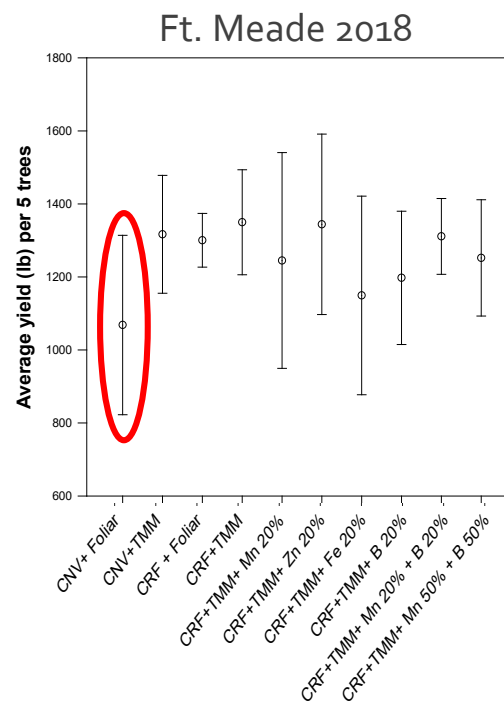
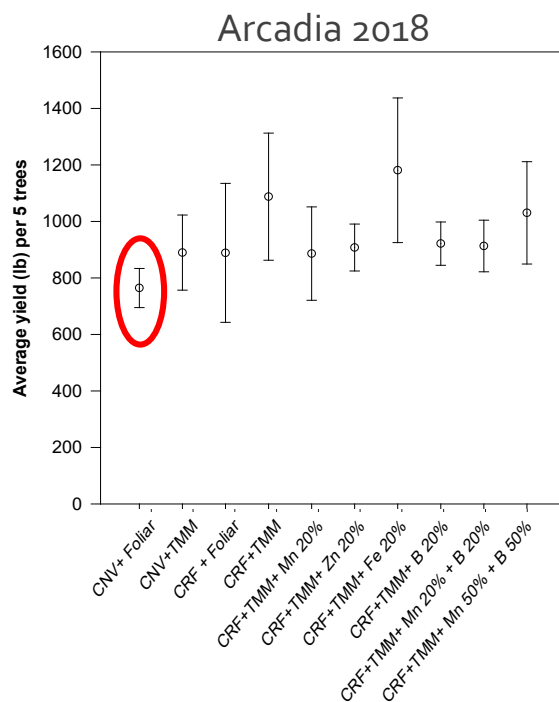
- As expected, no significant effect on yield was observed in first harvest (2017)
- Ground applied nutrition takes a long time to show any differences

Treatments	2017 Yield (lb)/5 trees	
	Ft. Meade	Arcadia
CNV+ Foliar	278	891
CNV+TMM	406	1113
CRF+ Foliar	313	939
CRF+TMM	428	1103
CRF+TMM + Mn 20%	381	1051
CRF+ TMM + Zn 20%	359	978
CRF+ TMM + Fe 20%	266	1208
CRF+TMM+ B 20%	336	1434
CRF+TMM + Mn 20%+B 20%	428	968
CRF+TMM+ Mn 50%+ B 50%	379	1114

Approximately,
310 boxes per
acre

No significant results at $\alpha=0.05$

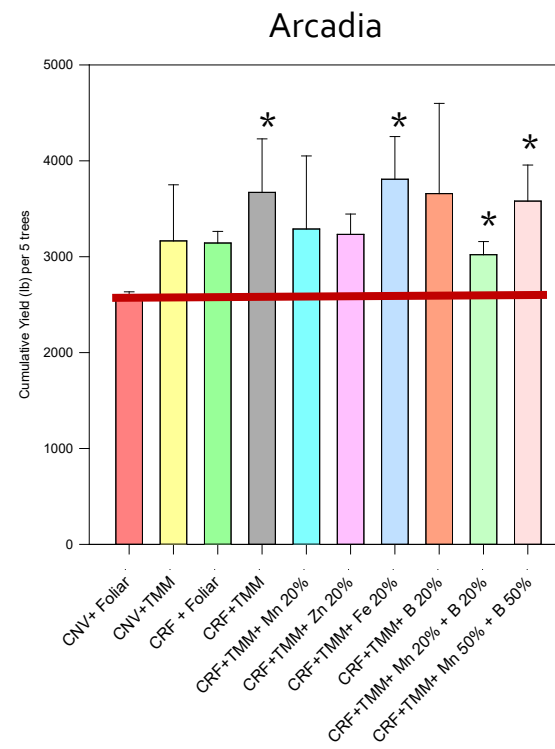
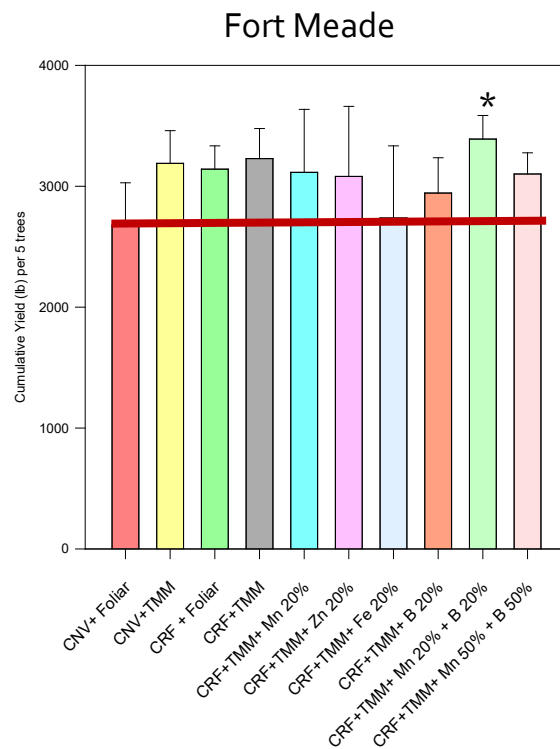
Large tree to tree variability!



Yield in 2018 and 2019 ($\alpha = 0.1$)

Treatments	2018 Yield (lb)/5 trees		2019 Yield (lb)/5 trees	
	Ft. Meade	Arcadia	Ft. Meade	Arcadia
CNV+ Foliar	1068	764	1333	963
CNV+TMM	1317	890	1467	1174
CRF+ Foliar	1301	889	1528*	1327
CRF+TMM	1350	1088*	1451	1491*
CRF+TMM + Mn 20%	1245	886	1489*	1364*
CRF+ TMM + Zn 20%	1344	908*	1378	1362*
CRF+ TMM + Fe 20%	1149	1181*	1322	1433*
CRF+TMM+ B 20%	1198	922*	1410	1314
CRF+TMM + Mn 20%+B 20%	1311	913*	1652*	1156
CRF+TMM+ Mn 50%+ B 50%	1252	1030*	1470	1448*

- Significant PFD incidence at Fort Meade site in 2017
- Hurricane Irma in 2018 resulted in considerable fruit drop at Arcadia site
- **Therefore, cumulative yield for 2017, 2018, and 2019 was analyzed ($\alpha = 0.1$)**



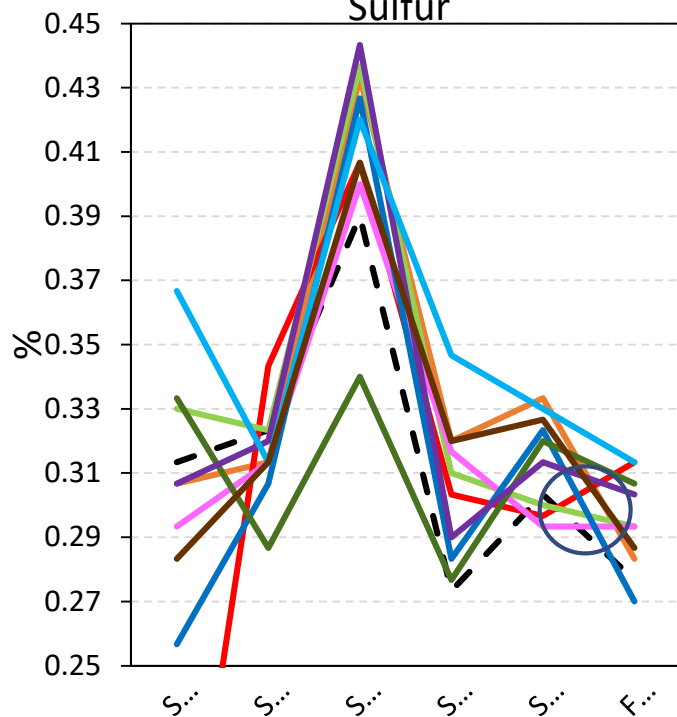
Yield ranking

Treatments	Ft. Meade				Arcadia			
	2017	2018	2019	Cumulative	2017	2018	2019	Cumulative
CNV+ Foliar	9	10	9	10	10	10	10	10
CNV+TMM	3	3	5	3	3	7	8	7
CRF+ Foliar	8	5	2	4	9	7	6	8
CRF+TMM	1	1	6	2	5	2	1	2
CRF+TMM + Mn 20%	4	7	3	5	6	9	4	5
CRF+ TMM + Zn 20%	6	2	8	7	7	6	5	6
CRF+ TMM + Fe 20%	10	9	10	9	2	1	3	1
CRF+TMM+ B 20%	7	8	7	8	1	4	7	3
CRF+TMM + Mn 20%+B 20%	1	4	1	1	8	5	9	9
CRF+TMM+ Mn 50%+ B 50%	4	6	4	6	3	3	2	4

High amount of sulfur concentration was observed with Tiger Sul application

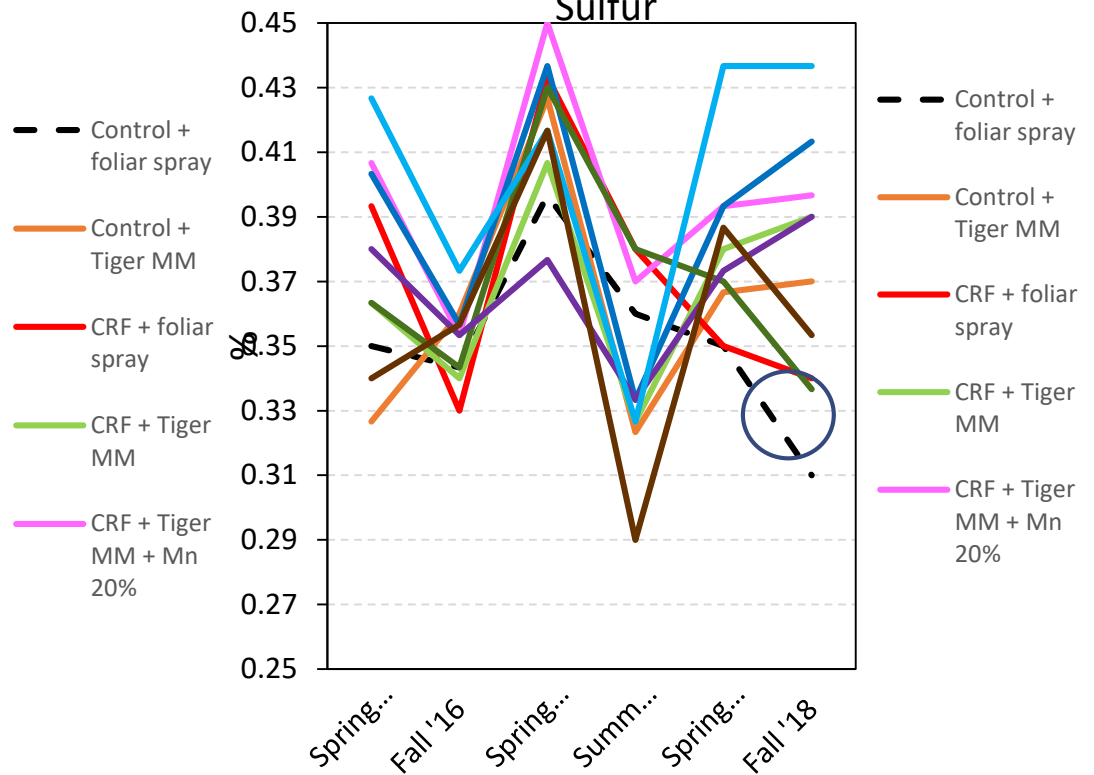
Fort Meade

Sulfur



Arcadia

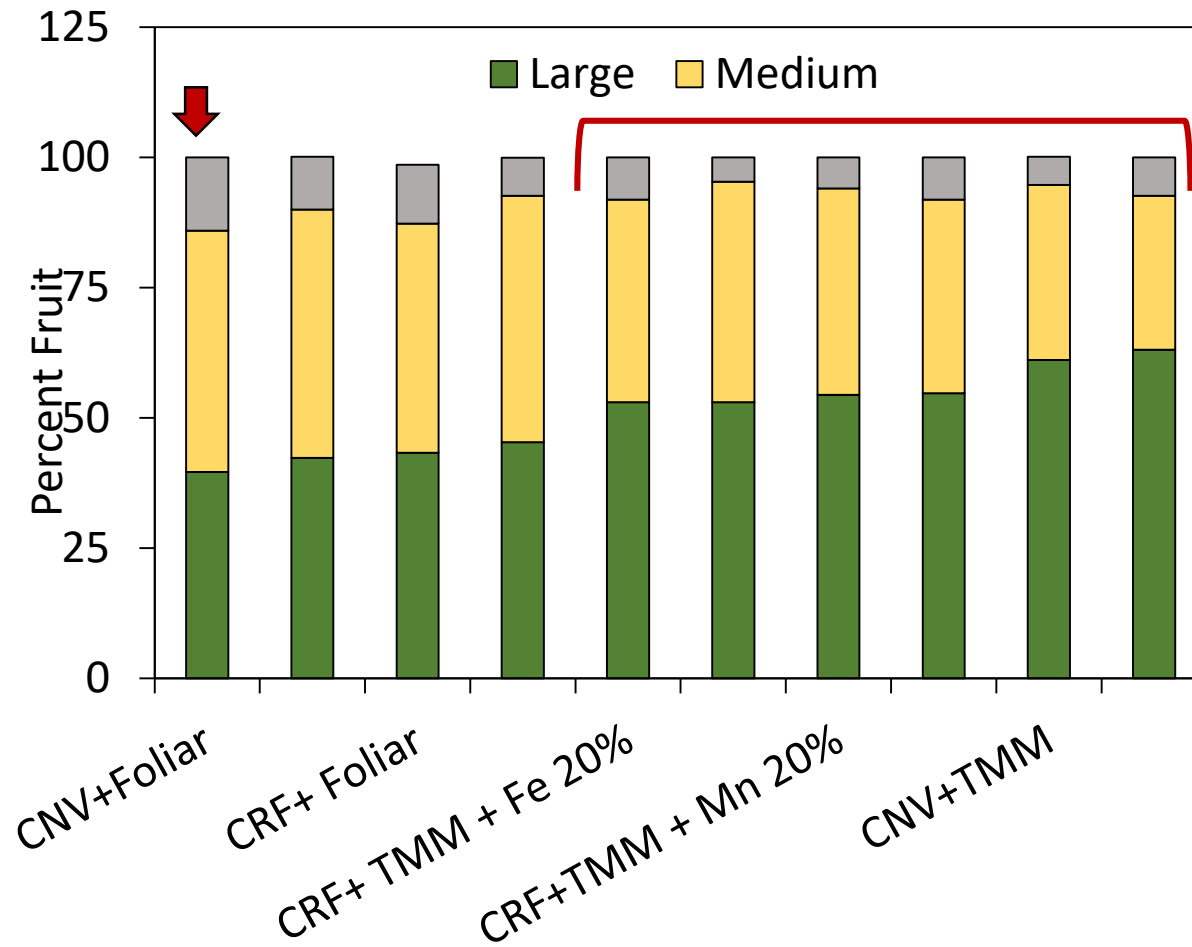
Sulfur



Soil pH- Tiger Sul application steadily lowered the soil pH

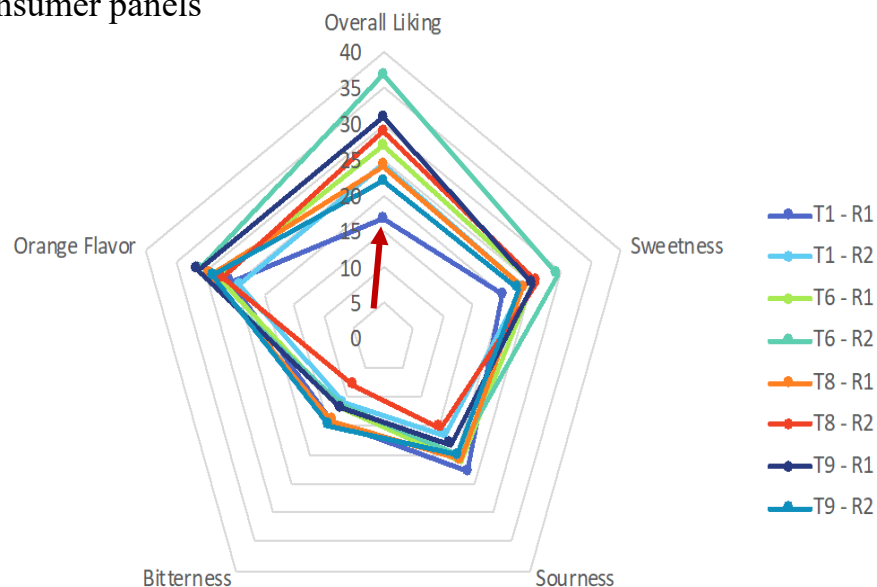
	Fort Meade			Arcadia		
	2016	2018		2017	2018	
QRP + foliar	6.3	6.6	0.3	4.7	5.4	0.8
QRP+ Tiger MM	6.3	6.0	-0.3	4.9	5.4	0.5
CRF+ foliar	6.0	6.0	0	4.9	5.2	0.3
CRF+Tiger MM	6.2	6.2	0	4.7	5.0	0.3
CRF+Tiger MM + Mn 20%	6.2	6.1	-0.1	4.7	4.7	0.0
CRF+Tiger MM + Zn 20%	5.9	5.9	0	5.6	4.9	-0.7
CRF+Tiger MM + Fe 20%	6.2	6.2	0	5.2	5.0	-0.2
CRF+Tiger MM +B 20%	6.5	5.7	-0.8	4.9	4.8	-0.1
CRF+Tiger MM + Mn+B 20%	6.2	5.9	-0.3	5.2	4.8	-0.4
CRF+Tiger MM + Mn+ B 50%	6.3	6.2	-0.1	5.2	4.7	-0.5

Significant improvement in fruit size at Arcadia all 3 years



consumer panels

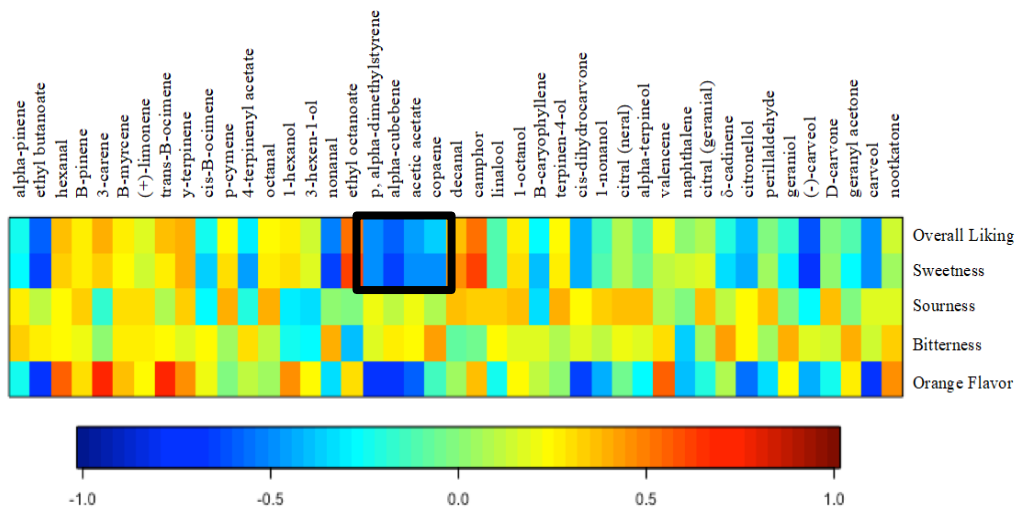
Fort Meade Sensory Attributes, Replicates 1 and 2



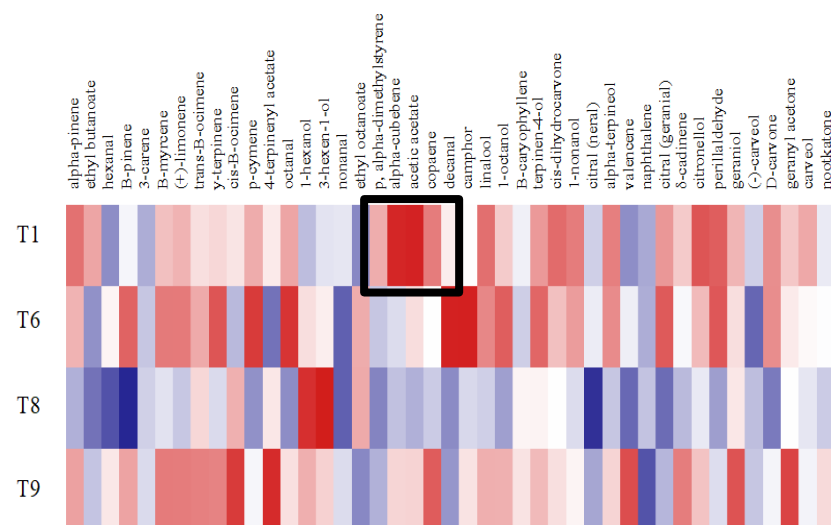
Consumer Preference Test

Consumer rated control treatment for lowest liking

Sample	Replicates	Comment	Brix	Acid	Ratio
T1	R1 & R2	CNV+Foliar	9.4	0.88	10.68
T6	R1 & R2	CRF+ TMM + Zn 20%	10.1	1.04	9.71
T8	R1 & R2	CRF+TMM+ B 20%	9.5	1.41	6.78
T9	R1 & R2	CRF+TMM + Mn 20%+B 20%	10.4	1.09	9.57
T1	R3	CNV+Foliar	9.6	0.77	12.51
T6	R3	CRF+ TMM + Zn 20%	8.7	1.11	7.84
T8	R3	CRF+TMM+ B 20%	10.2	1.22	8.42
T9	R3	CRF+TMM + Mn 20%+B 20%	10.3	0.86	11.97



Volatile compounds that are negatively related to OJ liking were absent in micronutrient treatments



Take home message...

- Soil-applied micronutrients can improve tree health, productivity and fruit quality of HLB-affected trees
- Soil acidification was beneficial for HLB-affected trees
- TigerSul products can slowly and steadily lower the soil pH: therefore, caution is needed (stay above 5.5)
- No one size fits all!
- The two sites responded differentially to same treatments
- Overall, Mn and B in combination consistently improved yield, canopy, and fruit quality – in agreement with the greenhouse study



14 year-old Valencia/rough lemon +CRF + extra Mn and boron
at Oriee Lee Alligator Grove, never any psyllid control

Alligator Matthew Block Nutrition Study – 2017 December PCR and yield results

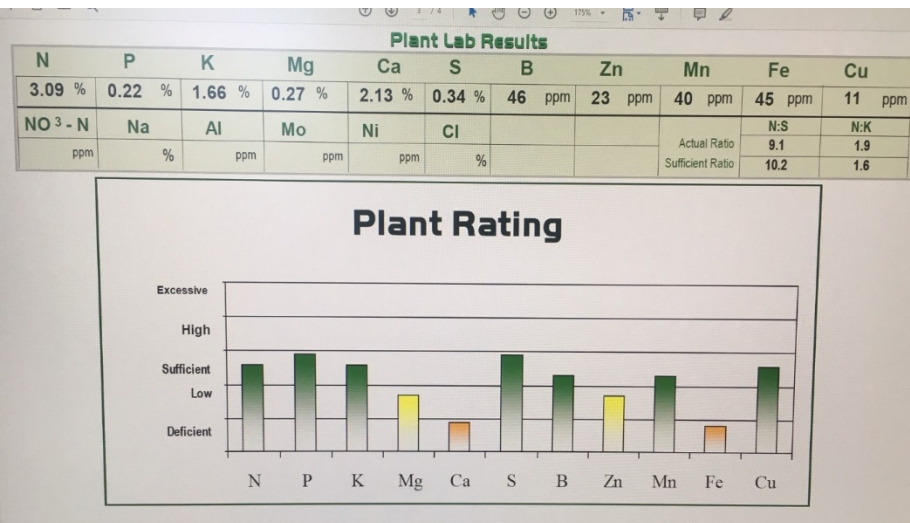
Vernia/rough lemon (10-years old; treatments started fall of 2015, 12 trees per treatment (2-six tree reps); 2017 harvest heavily impacted by PFD. Last column is boxes per treatment (12 trees) since trial began (2-years of production). Products: Harrells CRF St. Helena mix, TigerSul mn, Florikan polycoated boron. CT value 32 or above considered negative for *Liberibacter*. Trial trees and surrounding grove never under a psyllid control program.

Treatment	CT Value mean	SD	# trees 32+ ct	Yield (B/T): 2016	2017	2018	Cumm
1 standard	23.19	4.8	0	1.67	0.56	1.71	27.2
2 + Harrells	27.81	5.3	5	1.50	1.02	1.75	33.2
3 + Harr/2x mn	27.57	5.3	3	1.50	0.83	1.54	28.4
4 +Harr/2x bn	29.48	5.4	5	1.92	0.83	1.71	30.5
5 +Harr/2x mn&bn	30.32*	5.5	5	1.50	0.94	1.71	31.8
6 +4x mn	32.75*	5.7	7	1.75	0.92	2.21	37.6
7 + 4x bn	28.07	5.3	5	1.58	0.44	1.63	24.8
8 +4x mn & bn	23.81	4.8	0	1.50	0.90	1.79	32.3

*significantly different than standard at 95% CI

Evidence: Overdoses of manganese can be therapeutic against HLB!!!!!!

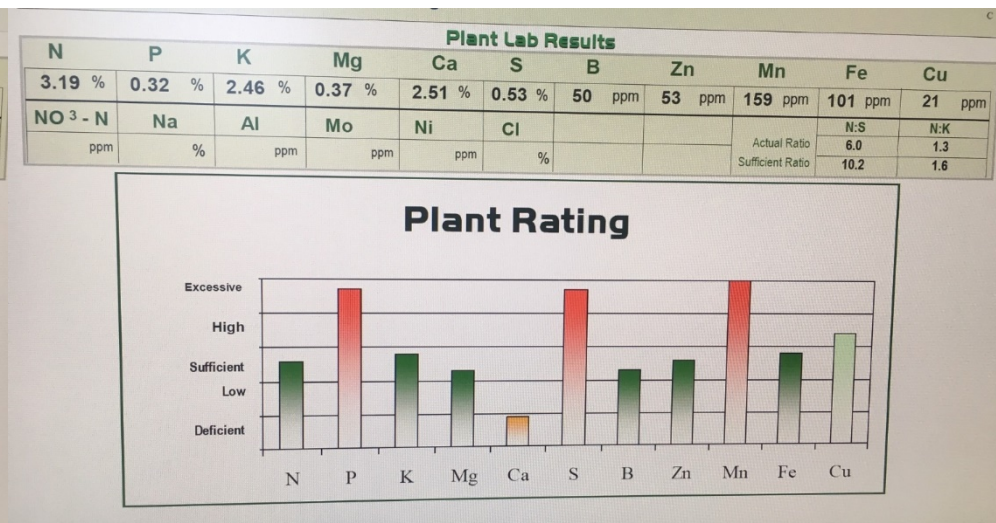
Zambon, F.T., D. M. Kadampakeni and J.W. Grosser. 2019. Ground Application Overdoses of Manganese Show a Therapeutic Effect in Sweet Orange Trees Infected With Candidatus *Liberibacter asiaticus*. HortScience (in press)



Red grapefruit /Sw on standard CREC soluble dry nutrition



qPCR
Ct
value
25.4

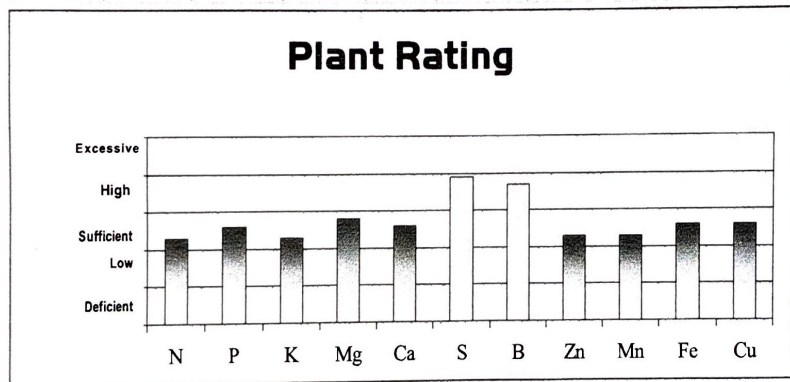


Recovering Cybrid Flame/Sw on CREC + Harrells 14-3-11 + Florikan Mn



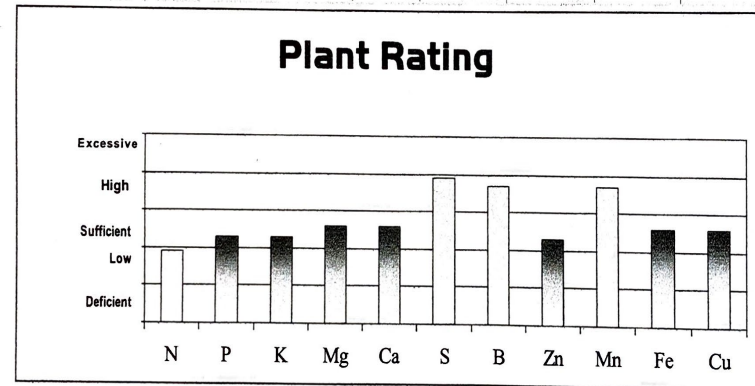
qPCR
Ct value
32.9

Plant Lab Results										
N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
2.7 %	0.2 %	1.41 %	0.51 %	3.76 %	0.43 %	118 ppm	27 ppm	45 ppm	95 ppm	10 ppm
NO ³ -N	Na	Al	Mo	Ni	Cl			Actual Ratio		
ppm	%	ppm	ppm	ppm	%			N:S	N:K	
								6.3	1.9	
								Sufficient Ratio		
								10.2	1.6	



Sweet Orange on standard Lee Groves soluble dry

Plant Lab Results										
N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
2.47 %	0.15 %	1.21 %	0.42 %	4.12 %	0.43 %	121 ppm	38 ppm	113 ppm	92 ppm	10 ppm
NO ³ -N	Na	Al	Mo	Ni	Cl			Actual Ratio		
ppm	%	ppm	ppm	ppm	%			N:S	N:K	
								5.7	2.0	
								Sufficient Ratio		
								10.2	1.6	



Karen's OLL trial block on standard + Harrells + FI-Mn



2019 Yield data (boxes/tree) from Lee Groves 'Karen's Block OLL somaclone/rootstock trial; planted June, 2013. Two-trees per plot, trees all produced from field budwood under DPI permit; trial grown with no psyllid control, past two years trees received supplemental Harrells 12-3-9 or 14-3-11 and Florikan Mn. Trial propagated from field budwood under DPI permit.

	1	3	7	2	4	5	6	8	
RS	OLL 7	OLL 4	OLL 20	OLL 8	OLL 5	OLL 10	OLL 6	OLL 9	X Box/8Tree
Swingle	1.0	1.0	0.5	1.0	0.5	0	0.5	0	4.5
x639	1.75	1.5	0.7	1.25	1.5	1.0	0.65	0.13	8.48
Carrizo	1.83	1.25	0.63	1.25	0.63	0.63	0.25	0.25	6.72
White 1	1.5	2.0	1.13	1.75	1.5	1.0	1.13	0.38	10.39
White 3	1.13	1.0	0.75	0.75	0.88	0.63	0.63	0.38	6.15
UFR 6	1.75	1.25	0.85	1.25	1.25	1.0	0.63	0.88	8.61
UFR 4	2.0	1.88	1.9	1.25	1.25	0.63	0.88	0.13	9.92
UFR 1	1.83	1.75	0.5	2.0	1.0	1.5	1.0	0.5	10.08
UFR 2	1.5	0.5	1.8	1.75	1.0	1.25	1.63	0.38	9.81
Orange 14	2.0	1.75	0.85	2.15	1.25	1.75	1.75	1.0	12.5
Orange 15	0.85	0.88	0.63	0.9	0.5	1.38	0.75	0.88	6.77
Orange 2	0.87	0.75	0.75	1.25	1.38	0.13	0.63	0.75	6.51
Orange 13	1.0	0.75	0.65	1.0	0.75	1.5	0.63	0.75	7.03
Orange 16	1.4	2.25	0.6	2.0	1.63	1.5	1.75	0.5	11.63
UFR 5	1.5	1.5	0.63	2.5	1.75	2.13	1.25	0.75	12.01
Green 7	1.5	1.25	0.38	0.5	1.13	1.5	0.63	0.5	7.39
AMB+CZO	0.85	1.0	0.35	0.5	1.5	1.0	0.5	0.38	6.08
Green 2	2.85	1.25	0.6	1.0	1.75	0.75	0.63	0.13	6.96
	25.11	23.51	14.20	24.05	21.15	19.28	15.82	8.67	
	1.4	1.31	0.78	1.34	1.18	1.07	0.88	0.48	

2019 Juice quality data – Karen’s Block 13W – Lee Groves planted 2013, no psyllid control, enhanced nutrition.

	Sample ID		Wt. Sample	Wt. Juice	Lbs. Juice Per Box	Acid	Total Brix	Ratio	Lbs. Solids Per Box	Juice Color
1	Carrizo	OLL4	27.99	16.65	53.537	0.94	12.92	13.74	6.92	38.2
2	Carrizo	OLL8	27.32	16.21	53.400	0.98	13.93	14.21	7.44	37.5
3	White 1	OLL4	26.44	15.97	54.361	0.91	12.66	13.91	6.88	38.2
4	White 1	OLL8	27.00	16.68	55.600	0.90	11.89	13.21	6.61	38.6
5	White3	OLL4	25.13	15.27	54.688	0.96	12.34	12.85	6.75	38.4
6	White3	OLL8	24.92	15.35	55.437	0.89	12.31	13.83	6.82	38.5
7	UFR-6 (Chang+50-7)	OLL4	24.65	15.00	54.767	0.92	12.40	13.48	6.79	38.4
8	UFR-6 (Chang+50-7)	OLL8	24.73	15.57	56.664	0.96	13.51	14.07	7.66	38.7
9	UFR-4 (Orange 19)	OLL4	30.74	18.44	53.988	0.85	11.65	13.71	6.29	37.8
10	UFR-4 (Orange 19)	OLL8	23.46	14.37	55.128	0.86	12.46	14.49	6.87	38.3
11	UFR-1 (Orange 3)	OLL4	28.26	17.18	54.713	0.95	12.40	13.05	6.78	38.2
12	UFR-1 (Orange 3)	OLL8	24.00	14.90	55.875	0.92	11.85	12.88	6.62	38.2
13	UFR-2 (Orange 4)	OLL4	30.82	18.44	53.848	0.80	10.47	13.09	5.64	38.1
14	UFR-2 (Orange 4)	OLL8	23.22	14.24	55.194	0.81	11.85	14.63	6.54	39.1
15	Orange 14	OLL4	27.48	16.82	55.087	0.80	11.07	13.84	6.10	37.8
16	Orange 14	OLL8	24.17	14.52	54.067	0.94	11.23	11.95	6.07	37.8
17	UFR-3 (Orange 15)	OLL4	29.98	18.27	54.847	0.82	10.69	13.04	5.86	38.1
18	UFR-3 (Orange 15)	OLL8	24.26	15.36	56.983	0.80	11.44	14.30	6.52	38.4
19	Orange 2	OLL4	29.87	18.35	55.290	0.93	13.18	14.17	7.29	38.6
20	Orange 2	OLL8	25.36	15.46	54.866	0.79	12.33	15.61	6.76	37.8
21	Orange 13	OLL4	27.48	16.57	54.269	0.86	11.82	13.74	6.42	37.7
22	Orange 13	OLL8	26.46	16.02	54.490	0.85	12.21	14.36	6.65	38.5
23	Orange 16	OLL4	26.75	15.80	53.159	0.90	11.70	13.00	6.22	38.1
24	Orange 16	OLL8	25.54	15.89	55.995	0.88	11.91	13.53	6.67	38.0
25	UFR-5 (White 4)	OLL7	29.45	18.16	55.497	0.90	11.86	13.18	6.58	38.3
26	UFR-5 (White 4)	OLL4	29.34	17.66	54.172	1.02	13.03	12.77	7.06	37.8
27	UFR-5 (White 4)	OLL20	24.65	15.23	55.606	0.86	11.86	13.79	6.59	38.6
28	UFR-5 (White 4)	OLL8	24.24	14.84	55.099	0.96	12.43	12.95	6.85	38.6
29	UFR-5 (White 4)	OLL5	26.90	16.52	55.271	0.95	12.00	12.63	6.63	38.6
30	UFR-5 (White 4)	OLL10	26.29	16.40	56.143	0.93	12.47	13.41	7.00	38.1
31	UFR-5 (White 4)	OLL6	22.79	14.24	56.235	1.04	12.88	12.38	7.24	38.1
32	UFR-5 (White 4)	OLL9	28.25	16.90	53.841	1.08	12.49	11.56	6.72	36.0
33	Green 7	OLL4	29.11	17.29	53.456	0.98	12.40	12.65	6.63	37.8
34	Green 7	OLL8	23.06	13.12	51.206	0.94	13.55	14.41	6.94	37.6
35	AMB+Carrizo	OLL4	25.25	15.26	54.392	0.87	12.65	14.54	6.88	38.1
36	AMB+Carrizo	OLL8	24.15	14.45	53.851	0.88	11.96	13.59	6.44	38.6
37	Green 2	OLL4	28.51	17.23	54.391	0.97	11.61	11.97	6.32	38.2
38	Green 2	OLL8	26.71	16.39	55.227	0.93	11.71	12.59	6.47	38.2
41	639	OLL4	24.57	15.21	55.714	1.07	11.00	10.28	6.13	38.6
42	639	OLL8	23.28	14.06	54.356	0.89	12.81	14.39	6.96	38.0
43	Swingle	OLL4	24.31	14.90	55.162	1.06	12.82	12.09	7.07	38.5
44	Swingle	OLL8	24.90	15.24	55.084	0.99	12.56	12.69	6.92	38.2

Average ct values (+ s.d.) per rootstock in the Lee Groves Karen's Block 13W after 5 years with no psyllid control; OLL scions all grafted from field budwood under DPI permit.

<u>Rootstock</u>	<u>Scion</u>	<u>Average ct value</u>	<u>standard deviation</u>	<u>Trees 32 or above</u>
Swingle	OLL	38.4	3.14	7/8
X639	OLL	38.4	2.23	8/8
Amb+Czo	OLL	28.6	4.42	3/16
UFR-6	OLL	32.9	4.40	8/16
Carrizo	OLL	30.2	4.71	4/16
Green 2	OLL	27.8	3.33	2/16
Green 7	OLL	36.4	4.92	14/16
Orange 13	OLL	31.3	5.65	7/16
Orange 14	OLL	27.5	3.92	1/16
UFR-3	OLL	29.41	4.64	3/16
Orange 16	OLL	31.8	4.55	7/16
UFR-4	OLL	36.5	3.98	14/16
UFR-1	OLL	29.9	4.28	6/16
Orange 2	OLL	27.3	3.46	1/16
UFR-2	OLL	34.4	7.03	11/16
White 1	OLL	30.0	4.73	6/16
White 3	OLL	27.7	3.34	2/16
UFR-5	OLL	27.5	3.44	1/16

St. Helena Project – w/ increased Mg and Mn in the Harrell’s CRF, 60% increase in yield and 20% increase in lbs. solids across the entire trial for 2019 – Clas titers diminishing!

Scion/Rootstock Combination 10-year old trees	PS/Box [2019]	Boxes/Tree [2019]	PS/tree [2019]	Optimum Trees/Acre	Optimum Sq ft/tree [2019]	PS/Acre Projected [2019] (% increase 2019/2018)	Boxes/Acre Projected [2019] (% increase 2019/2018)	cum PS/acre [projected] 2011-19 (9 years of data)	HLB Diagnosis c/o Southern Gardens Diagnostic Lab	Ct
Vernia:Orange1804	6.5	3.0	19.1	207	210	3951 (150)	611 (114)	16509 (9)	HLB positive	26.05
Vernia:KCZ	6.9	2.6	17.7	212	205	3756 (119)	543 (87)	13466 (9)	Questionable	31.93
Valquarius:Orange1804	5.9	3.3	19.6	189	230	3713 (121)	629 (95)	13479 (8)	No HLB found	32.21
Vernia:Yel1800	6.5	2.4	15.4	235	185	3619 (136)	559 (122)	13516 (9)	HLB positive	27.22
Vernia:Blue1	6.5	2.5	16.0	223	195	3573 (NA)	546 (173)	18278 (9)	HLB positive	28.10
Vernia:MG-11	6.8	2.3	15.6	229	190	3571 (113)	527 (72)	16081 (9)	Questionable	30.25
Vernia:Orange21	6.6	1.9	12.5	281	155	3518 (129)	534 (83)	14550 (9)	Questionable	31.02
Vernia:Purple2	6.1	2.0	12.1	281	155	3411 (46)	556 (21)	17951 (8)	Questionable	30.36
Vernia:Volk	5.6	3.5	19.7	171	255	3362 (104)	604 (84)	14339 (9)	HLB positive	28.43
Valquarius:FG1793	6.1	3.0	18.1	185	235	3341 (150)	551 (139)	13651 (8)	No HLB found	33.02
Valquarius:Orange13	6.6	2.0	12.9	256	170	3312 (127)	502 (93)	16746 (9)	HLB positive	28.82
Vernia:Aqua1803	6.6	2.3	15.4	203	215	3131 (114)	473 (73)	16612 (9)	No HLB found	32.24
Vernia:Cleo+CZO	6.9	1.8	12.4	249	175	3097 (NA)	448 (39)	18089 (9)	HLB positive	29.47
Vernia:Chang+50-7 [UFR 6]	7.3	1.4	10.3	300	145	3079 (249)	420 (156)	13902 (9)	No HLB found	32.38
Valquarius:Amb+HBJL-2B	6.4	2.3	14.8	207	210	3067 (223)	482 (177)	15128 (8)	Questionable	30.32
Valquarius:681G26F4P6	6.2	2.5	15.1	198	220	2993 (70)	485 (53)	15716 (8)	HLB positive	29.63
Valquarius:Aqua1803	6.2	2.3	14.4	207	210	2971 (145)	482 (112)	14538 (8)	HLB positive	27.00
Valquarius:White1805	6.1	2.8	17.2	171	255	2942 (138)	484 (112)	15380 (8)	HLB positive	28.19
Vernia:Wgft+50-7	6.7	1.9	12.3	235	185	2891 (NA)	435 (104)	16168 (9)	HLB positive	29.73
Valquarius:Pink1802	6.4	1.7	10.5	272	160	2868 (73)	449 (53)	12977 (9)	not sampled	
Vernia:White1805	6.9	1.4	9.9	290	150	2866 (101)	415 (69)	13868 (9)	No HLB found	32.77
Valquarius:MG-11	6.0	2.1	12.4	229	190	2834 (109)	476 (69)	13885 (8)	HLB positive	28.72
Valquarius:FG1707	6.8	1.9	13.2	212	205	2790 (72)	409 (45)	14208 (8)	No HLB found	32.50
Vernia:Orange19 [UFR 4]	6.4	1.9	12.2	223	195	2730 (147)	426 (102)	14720 (9)	Questionable	30.03
Valquarius:FG1733	6.3	1.8	11.4	229	190	2609 (172)	412 (110)	15233 (8)	HLB positive	26.55
Vernia:Orange18	6.7	1.5	10.1	256	170	2573 (NA)	384 (49)	13824 (9)	Questionable	31.12
Vernia:Orange3 [UFR 1]	6.8	1.6	10.8	235	185	2542 (127)	376 (86)	12726 (9)	HLB positive	29.21
Vernia:SWC	6.7	1.8	12.1	207	210	2513 (114)	377 (88)	12500 (9)	HLB positive	29.98
Vernia:Purple4	7.5	1.1	7.9	311	140	2466 (NA)	330 (42)	15659 (9)	Questionable	30.12
Valquarius:Orange3 [UFR 1]	6.5	1.8	11.5	212	205	2445 (93)	377 (82)	16295 (8)	Questionable	30.06

CONCLUSIONS

- Enhanced ground nutrition featuring ‘hybrid’ programs that include CRF and/or liquid applications can help restore and sustain production from HLB-infected trees – but it takes time!

The Ticket For the Immediate Future

Improved Scion Genetics for HLB Tolerance

Plus

Improved Rootstock Genetics for HLB Tolerance

Plus

Improved Affordable Production Systems w/ Enhanced Root Nutrition

\$\$ Success \$\$



Combination of good scion genetics, good rootstocks genetics and evolving nutrition (McKenna nitrate program): OLL-8 sweet orange/UFR-4 rootstock, 4 year old trees – Working!



THANK YOU CRDF!