GOOD NUTRITION MANAGEMENT CAN IMPROVE THE YIELD OF HLB AFFECTED SWEET ORANGES

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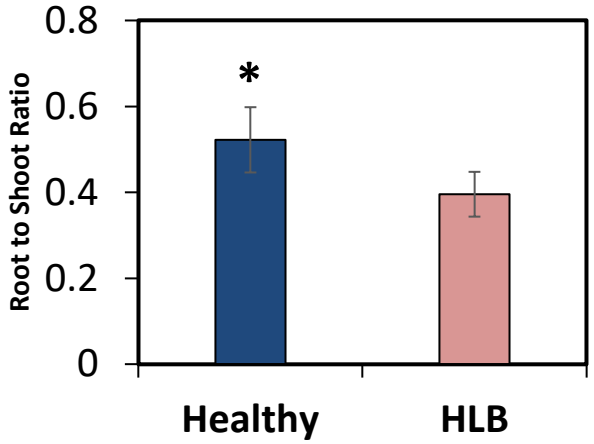
Objective

- Effect of controlled release form of mineral nutrients, elevated levels of soil-applied micronutrients, and soil pH amendments (to lower pH).
  - Constant supply of nutrients
  - Soil applied
  - Micronutrients at higher rate
  - Soil pH amendment

Constant supply of nutrients

HLB-affected plants are significantly low in root and shoot biomass



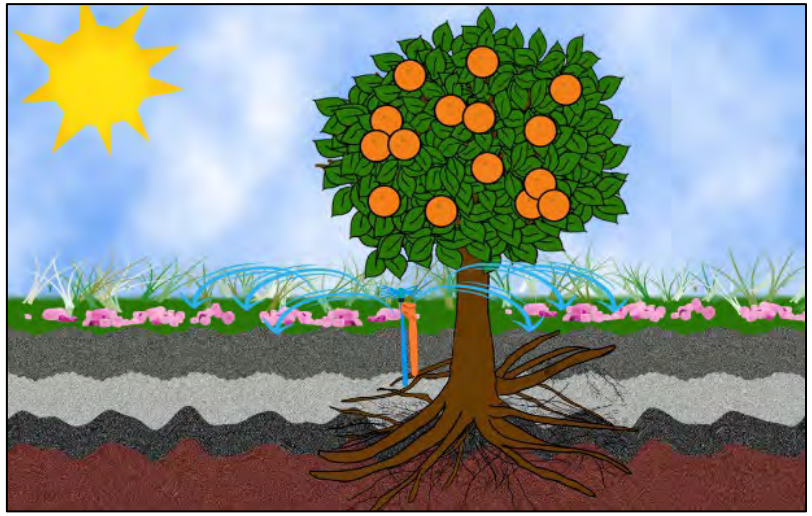
Use of CRF improves yield (Vashisth and Grosser, 2018)

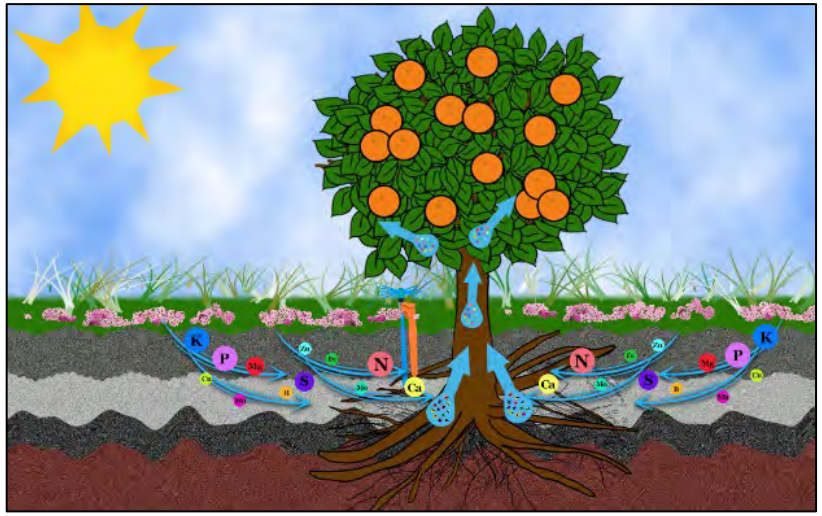
Table 1: Total number of fruit, fruit diameter (inch), and boxes per tree (calculated from yield) of harvested fruit from 4-year-old 'Valquarius'

	Boxes per tree[x] [mean ± SD]	Calculated boxes per acre (150 trees per acre)
A (Florikote; 14N–4P–10K)	1.42 ± 0.7	210
B (Citriblend; 17N–5P–12K)	1.80 ± 1.0	270
C (Harrell's; 13N–4P–9K)	1.46 ± 0.7	210
D (Citriblend; 18N–6P–11K)	1.25 ± 0.5	187
E (Harrell's; 16N–5P–10K).	1.35 ± 0.7	190

Soil-applied nutrition program

- The plant uptakes nutrients when they are in a solution
- During the water uptake by the plant, the dissolved mineral nutrients get taken up by the plant and distributed throughout the canopy
- Mobile and immobile nutrients have equal and uniform distribution to all parts of plant





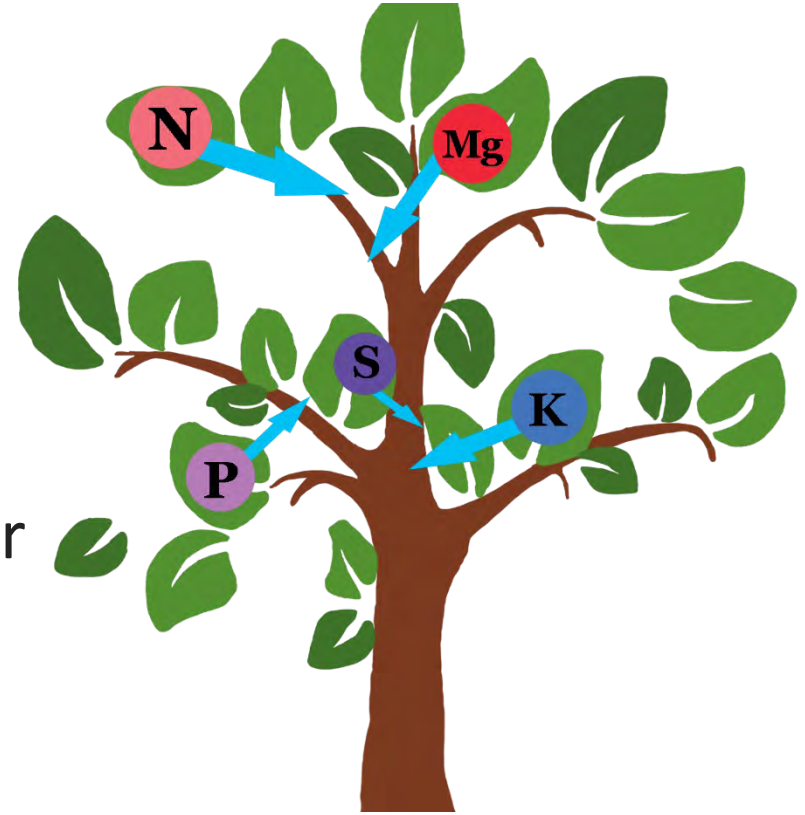
Foliar nutrition program

Background information

- Thick leaf cuticle limits the nutrient uptake
- Significant amount of foliar spray washes away in soil:
  - Pre HLB, trees had massive feeder root systems; therefore, could easily take up washed up nutrients
  - HLB-affected trees have few feeder roots therefore, may not be effective in nutrient uptake
- With foliar sprays immobile nutrients can get locked in leaves

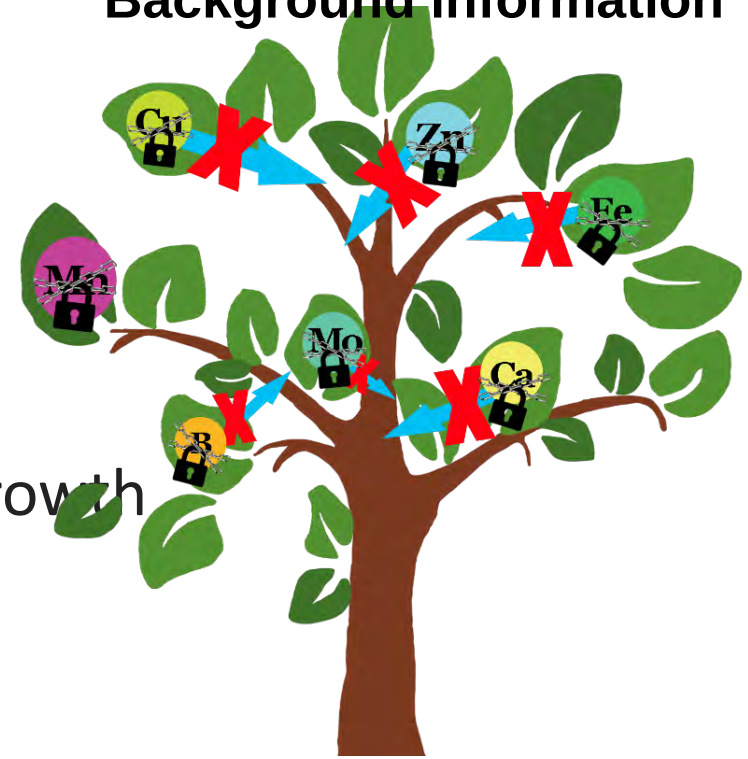
What are mobile nutrients?

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



What are immobile nutrients?

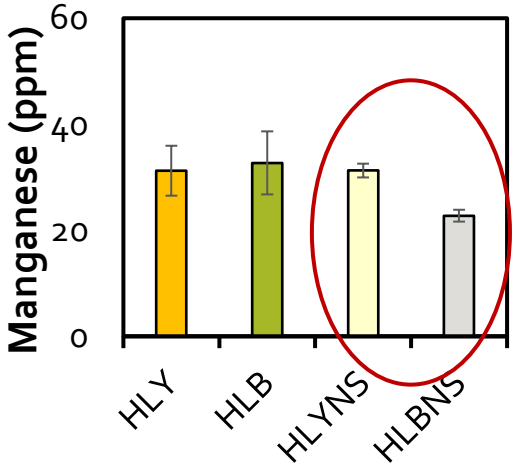
Background information



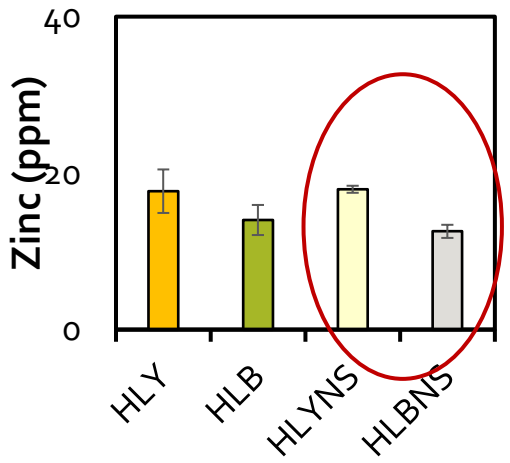
- Do not move in the plant
- Transported only via xylem
- Immobile nutrients will not move to new growth areas
- The deficiency symptoms will first show up in the new growth because they cannot take nutrients from the old leaves
- Nutrients: Calcium, Iron, Zinc, Copper, Manganese, Boron, Molybdenum
-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

HLB-affected trees often have deficiency of nutrients

- Due to significant reduction in root mass
- Compromised physiological processes
- Bacterial infection may result in higher metabolism (plant defense response)



Not Fertilized trees



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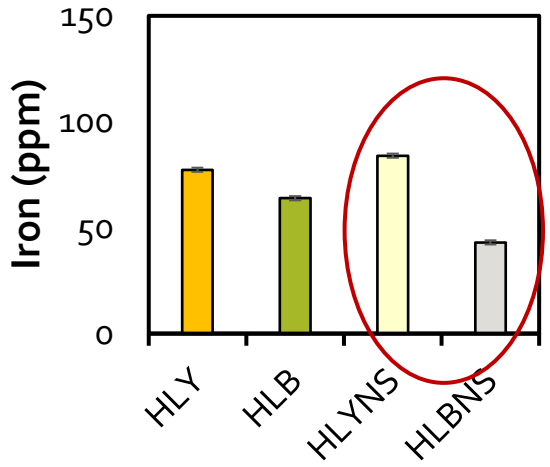

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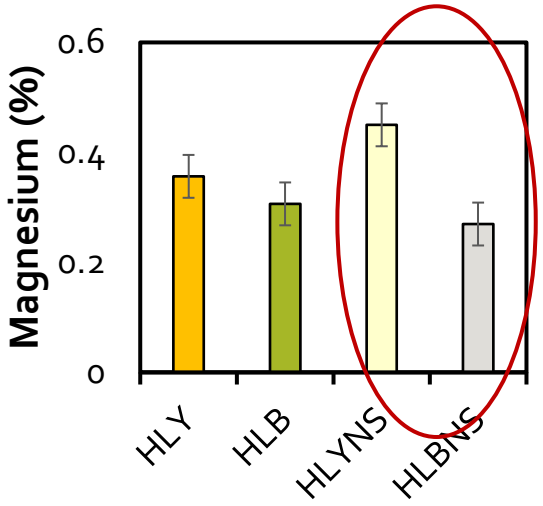
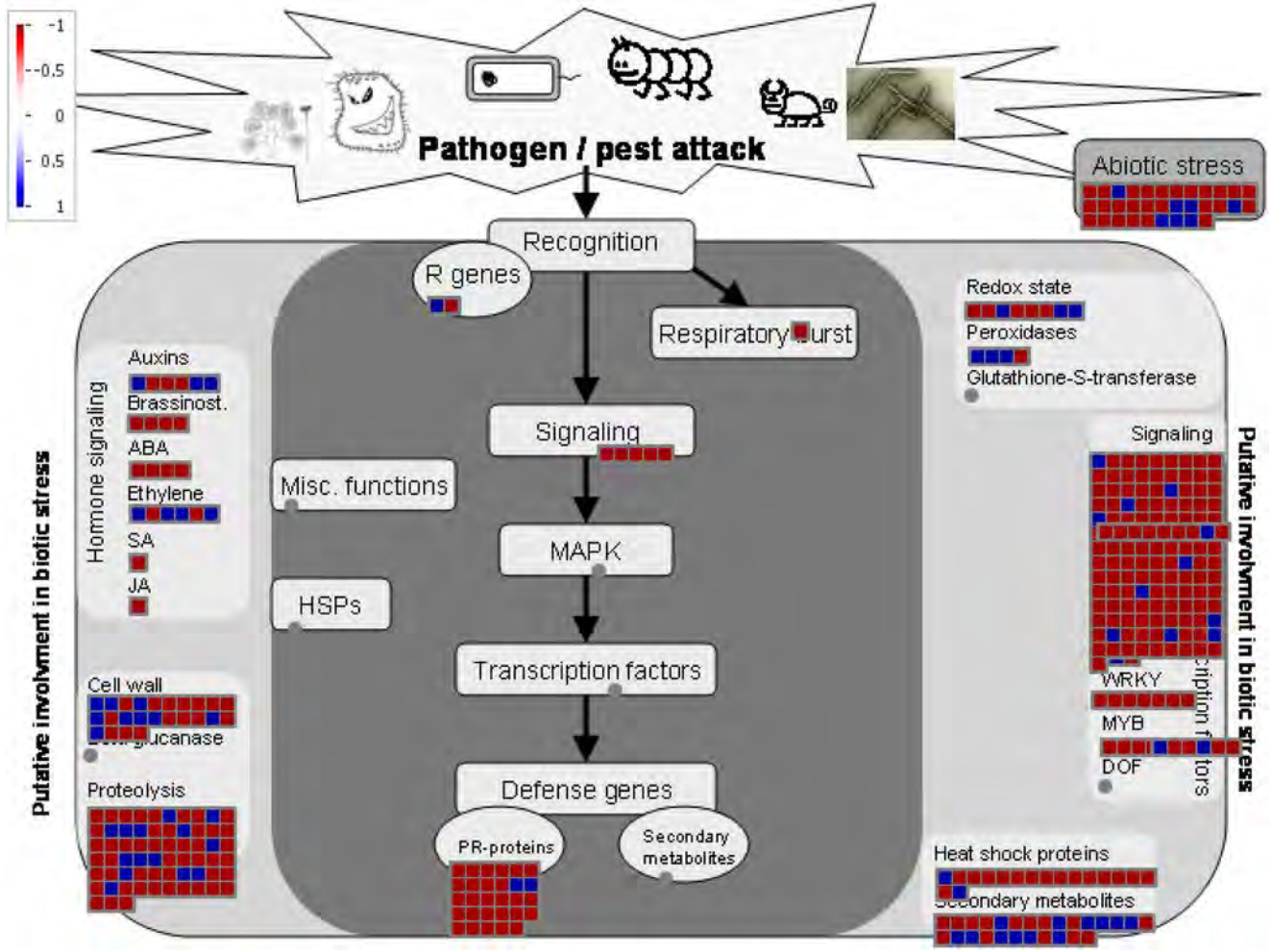


Not Fertilized trees

Shahzad et al., 2020

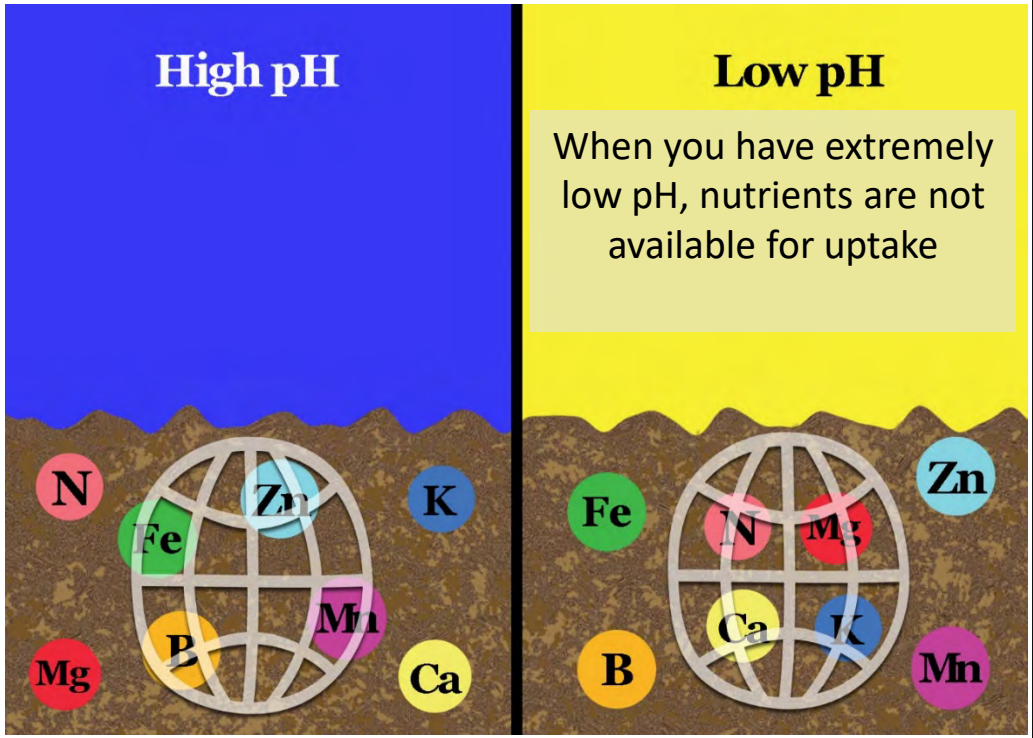
Upon nutrient availability several plant biotic and abiotic response pathways responded



Shahzad et al., 2020

Soil pH

- At high soil pH most of the micronutrients bind to the soil and becomes unavailable
- At extremely low soil pH most of the macro and secondary nutrients become unavailable
- The goal is to have right soil pH at the time when nutrient uptake is expected
- We recommend to keep soil pH between 5.5-6.5



HLB-affected trees decline rapidly at high pH

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

Ghimire et al., 2020

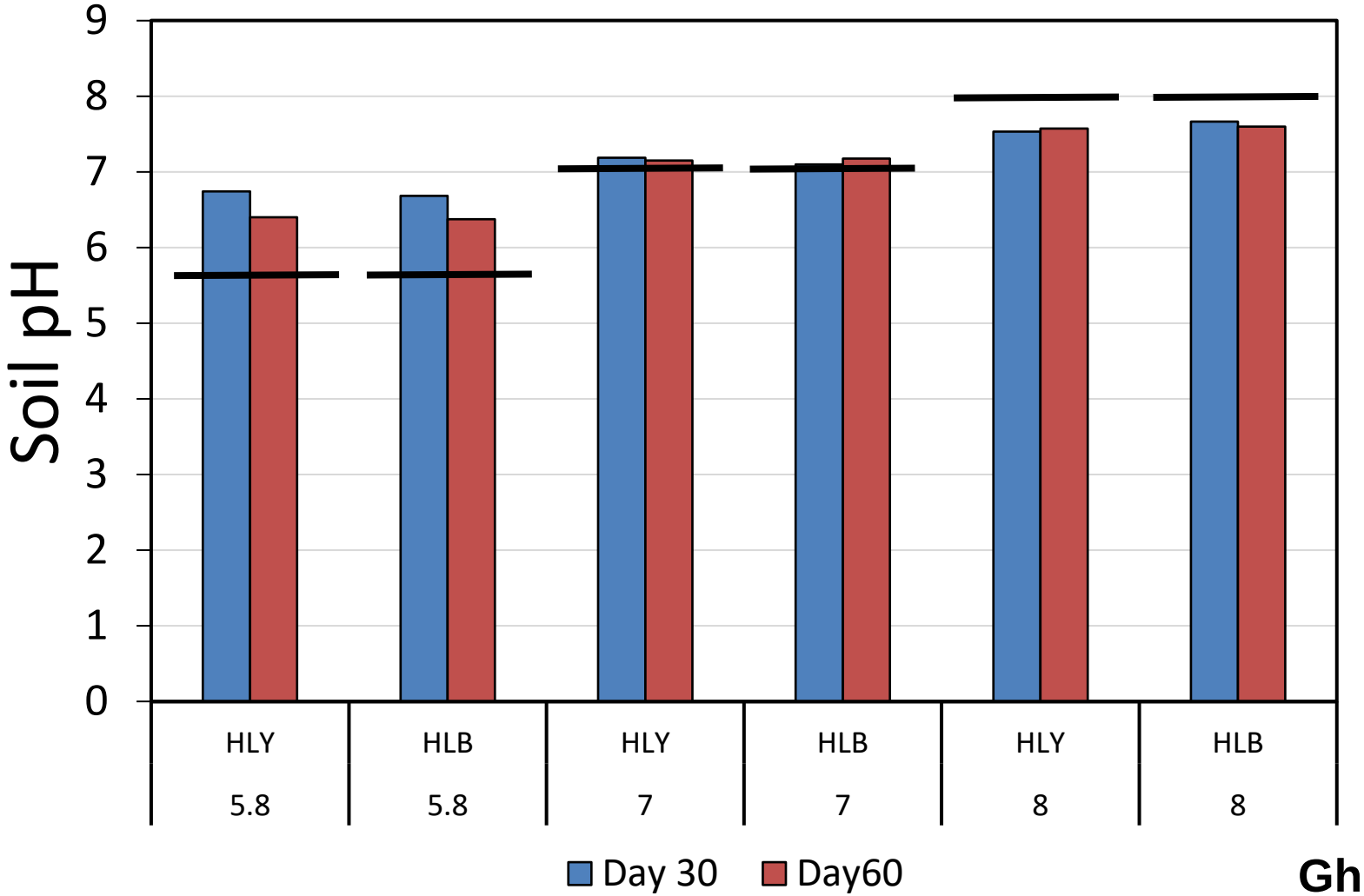
Day 60 –irrigation water pH 8.0 HLY vs HLB

HLY

HLB

Ghimire et al., 2020

Both HLB and HLY plants showed a tendency of bringing soil pH close to 7 in course of experiment-Soil pH adjustment should be an continuous effort



Ghimire et al., 2020

Micronutrient field trial

- Two locations: Fort Meade and Arcadia
- Valencia/Swingle; 10 to 15 year
- Completely Randomized Block Design
- Trial was initiated in February 2016 to end with 2019 harvest
  - Added 3 more years to have a total of five year yield data, will end with 2022 harvest
  - More treatments were added
- All the fertilizer treatments are applied 3 times a year by hand in the wetted zone

February, July, early October
Split as 45%, 35%, and 20%

About 75% of the fertilizer for year should be applied by Summer

Treatments (Original 10)

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

- Base applied fertilizer was 12-4-16 with 5% Ca and 3% Mg
  - Nitrogen: CNV: 180 lb/acre and CRF(Harrell's): 150 lb/acre
  - P, K, Ca, Mg were 15% less in CRF treatments
- Tiger Micronutrient mix (Mn-Zn-Fe-B:6-6-3-1); 225 lb/acre
  - Mn: 12 lb/acre
  - Zn: 12 lb/acre
  - Fe: 6 lb/acre
  - B: 2 lb/acre

20% elevated levels on Mn= 14.4 lb/acre

20% elevated levels on Zn= 14.4 lb/acre

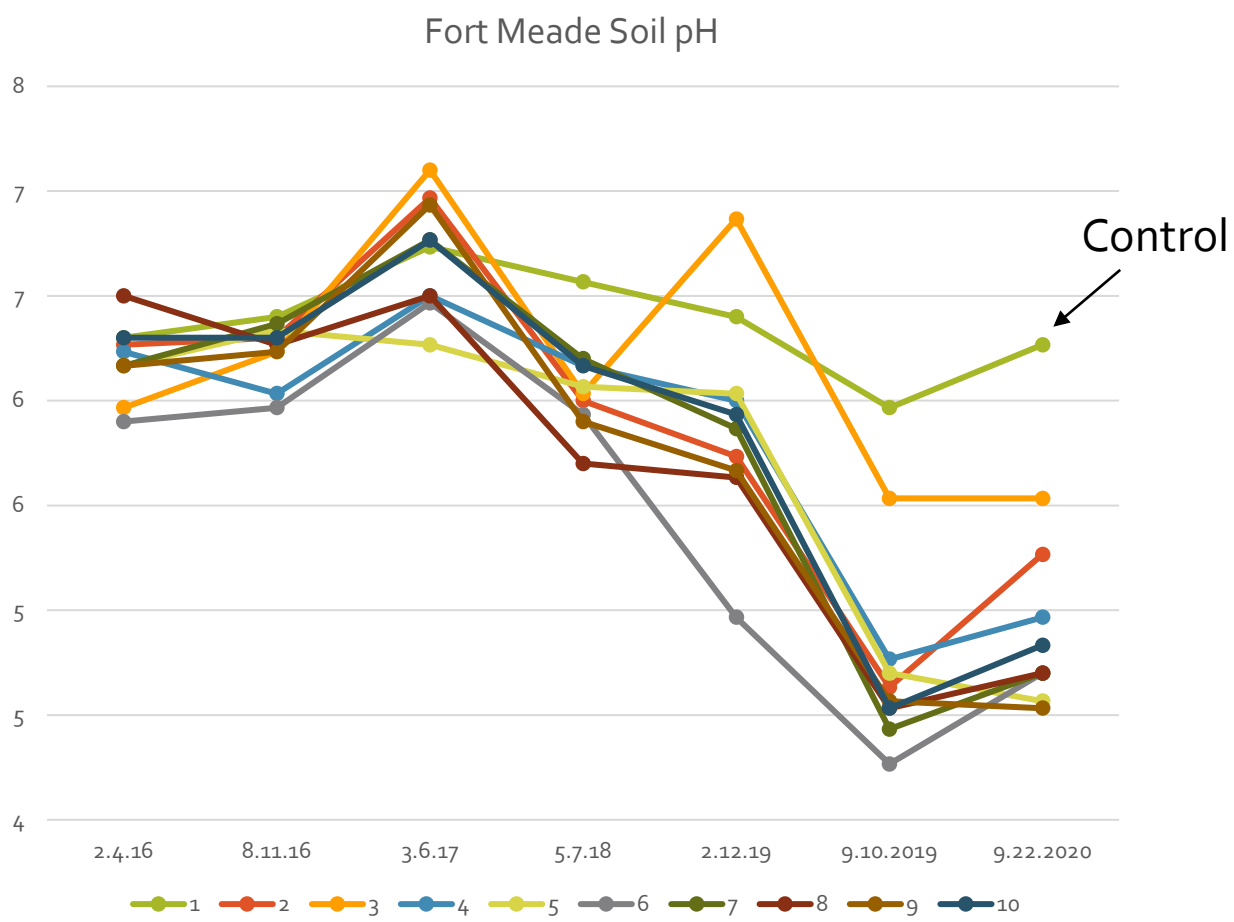
20% elevated levels on Fe= 7.2 lb/acre

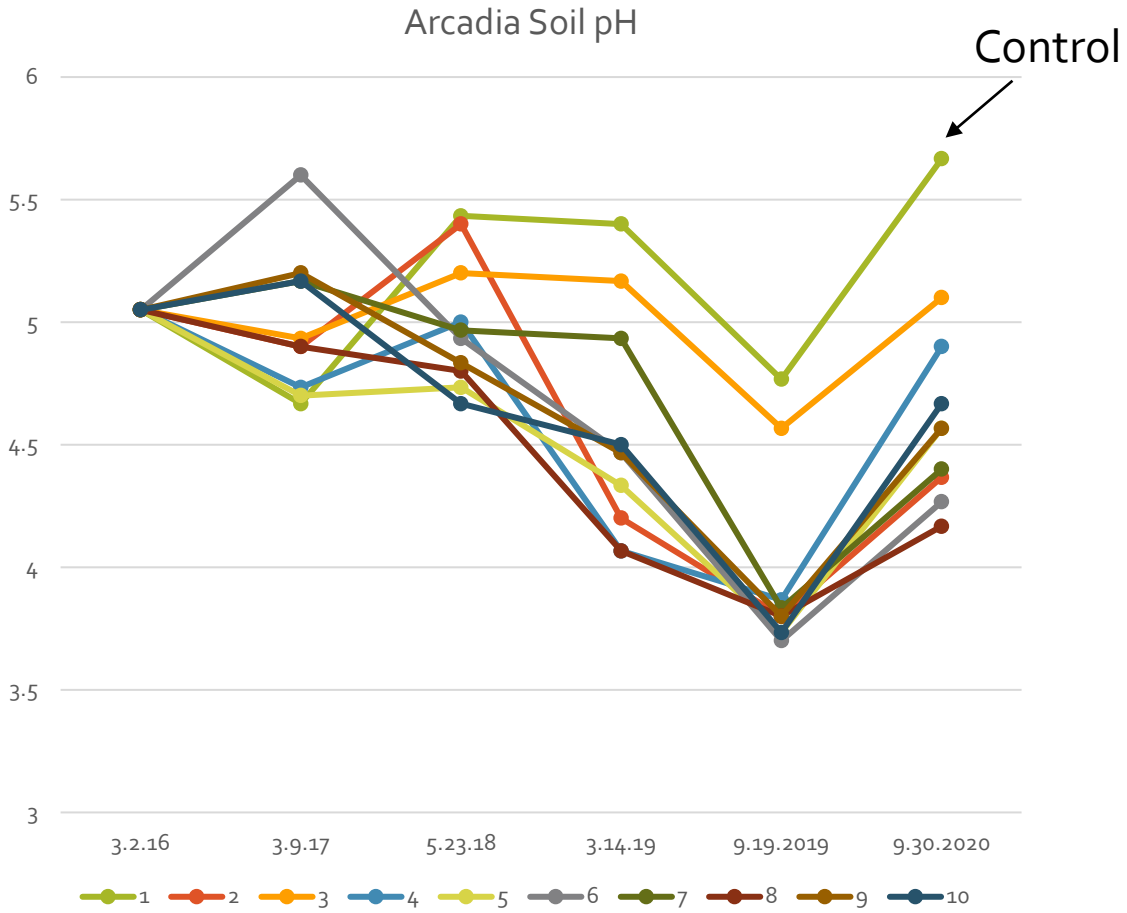
20% elevated levels on B= 2.4 lb/acre

Results

Soil pH dropped with use of Tiger mix

Stopped the use of Tiger mix since Fall 2019



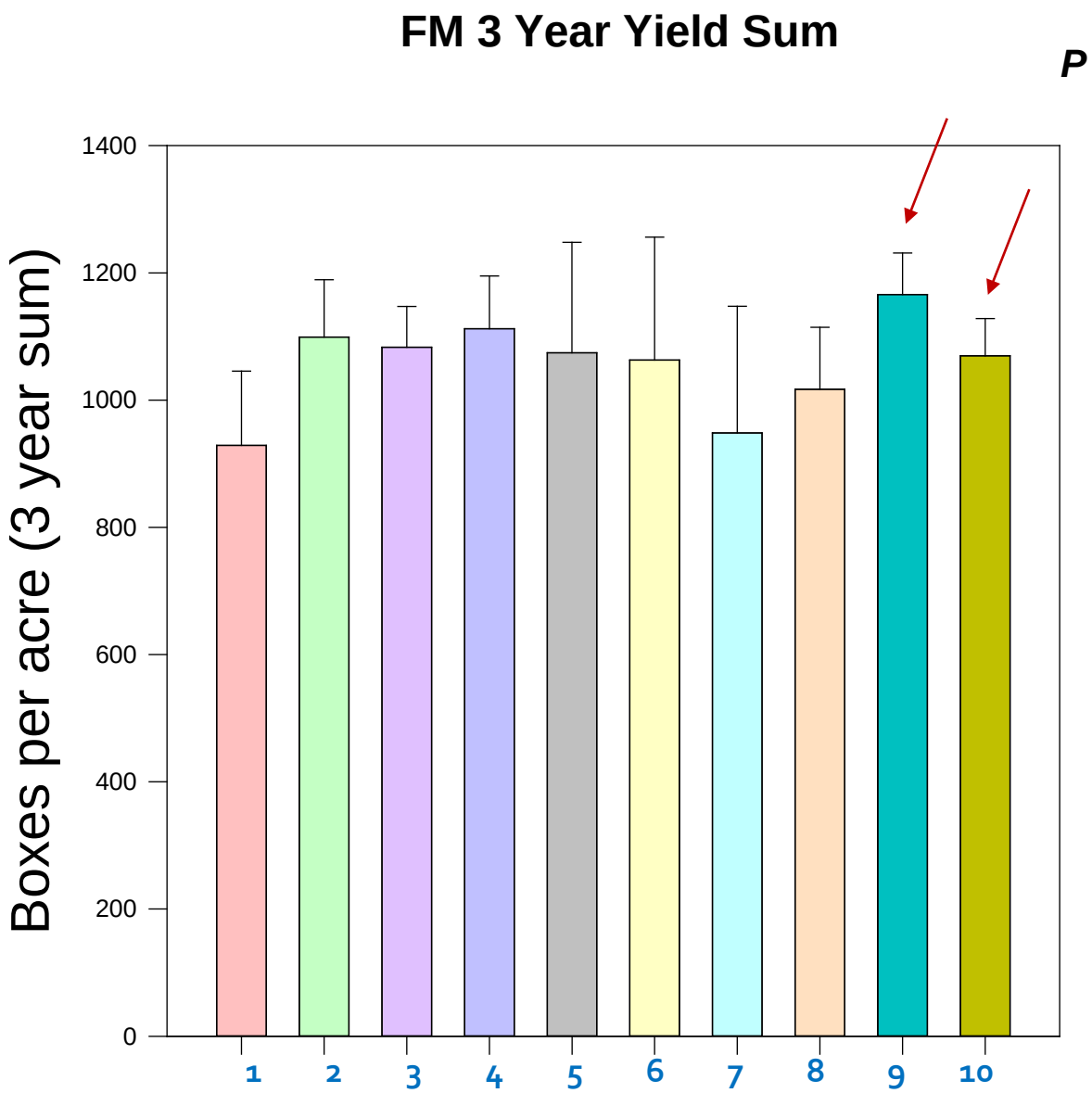


Results

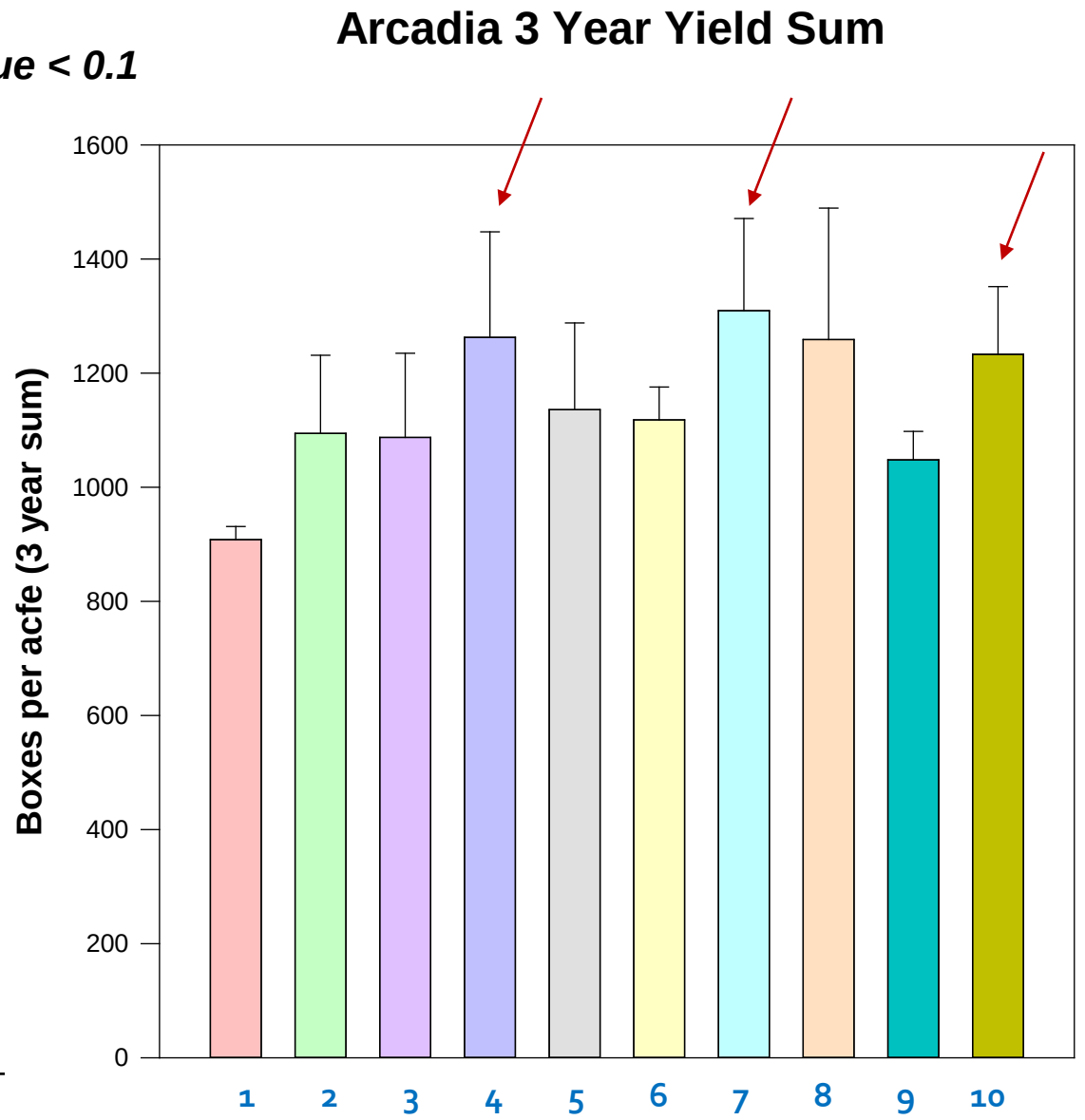
- No difference in yield for first two years
- Significant differences in 3rd year
- Canopy volume did not change significantly
- In Arcadia, yield per m^3 of tree was significantly higher for treatment 4, 5, 7, 10
- Overall, treatment (4) CRF+ soil applied micronutrients had consistently high yield at both sites

4. CRF + Tiger Micronutrient Mix
5. CRF + Tiger Micronutrient Mix + Tiger Mn elevated by 20%
7. CRF + Tiger Micronutrient Mix + Tiger Fe elevated by 20%
10. CRF + Tiger Micronutrient Mix + Tiger Mn and B elevated by 50%

3 Year Cumulative Yield (Boxes per acre)



P value < 0.1



Ranking based on cumulative yield 2017+2018+2019

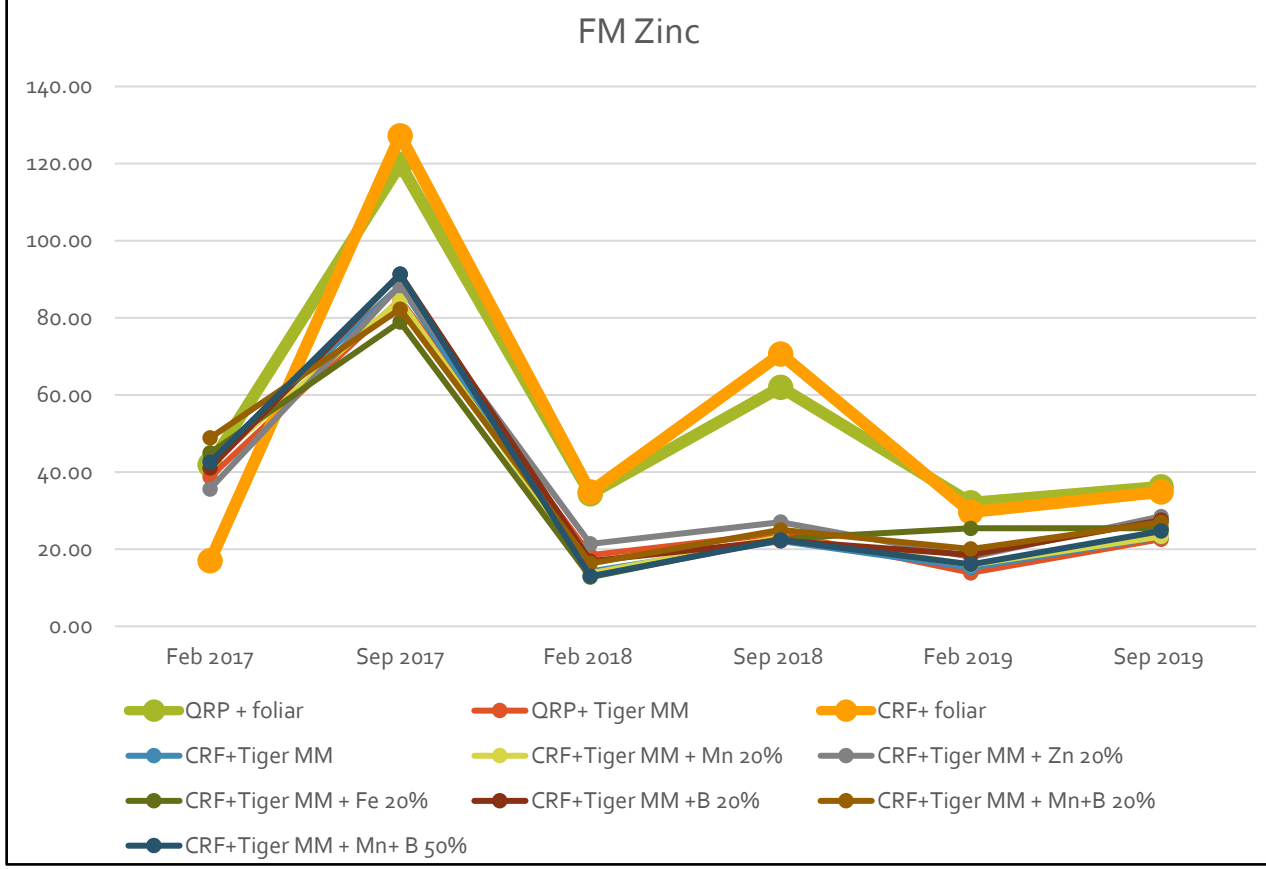
Arcadia Site				Fort Meade Site			
Treatment #	Treatment	T #	2020	Treatment #	Treatment	T #	2020
7	CRF+Tiger MM + Fe 20%	8	324	9	CRF+Tiger MM + Mn+B 20%	9	370
4	CRF+Tiger MM	7	315	4	CRF+Tiger MM	4	350
8	CRF+Tiger MM +B 20%	1	274	2	Conventional+ Tiger MM	5	348
10	CRF+Tiger MM + Mn+ B 50%	6	272	3	CRF+ foliar	7	346
5	CRF+Tiger MM + Mn 20%	10	269	5	CRF+Tiger MM + Mn 20%	6	338
6	CRF+Tiger MM + Zn 20%	5	261	10	CRF+Tiger MM + Mn+ B 50%	10	332
2	Conventional+ Tiger MM	3	260	6	CRF+Tiger MM + Zn 20%	2	331
3	CRF+ foliar	4	257	8	CRF+Tiger MM +B 20%	1	319
9	CRF+Tiger MM + Mn+B 20%	2	237	7	CRF+Tiger MM + Fe 20%	3	311
1	Control	9	171	1	Control	8	285

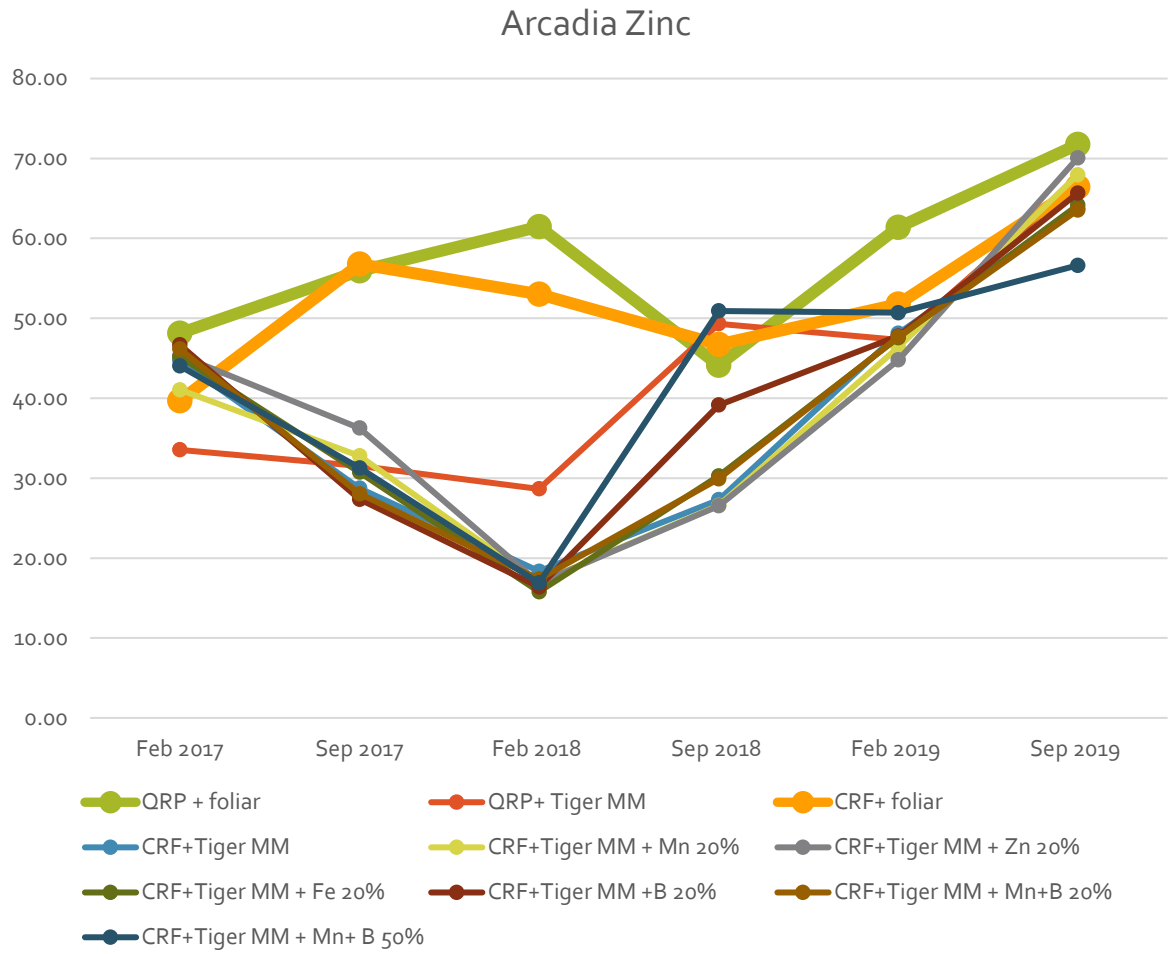
Soil differences should be taken in account

Soil Nutrient Analysis in 2016 (start of experiment)												
	pH	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu	CEC
Fort Meade	6.27	936.3	59.75	101.02	2456.8	54.2	0.34	65.27	16.58	61.63	76.12	8.13
Arcadia	5.05	28.5	74.00	81.50	618.5	76.0	0.58	6.52	9.50	28.00	4.01	4.18
State average	6.15	241.22	96.90	181.79	1450.81			40.77	60.79	238.64		

Iron has been found to be low in soil and leaves of southwest growing region- Citrus Nutrition Box

Change from foliar to soil micronutrient may show a drop in number





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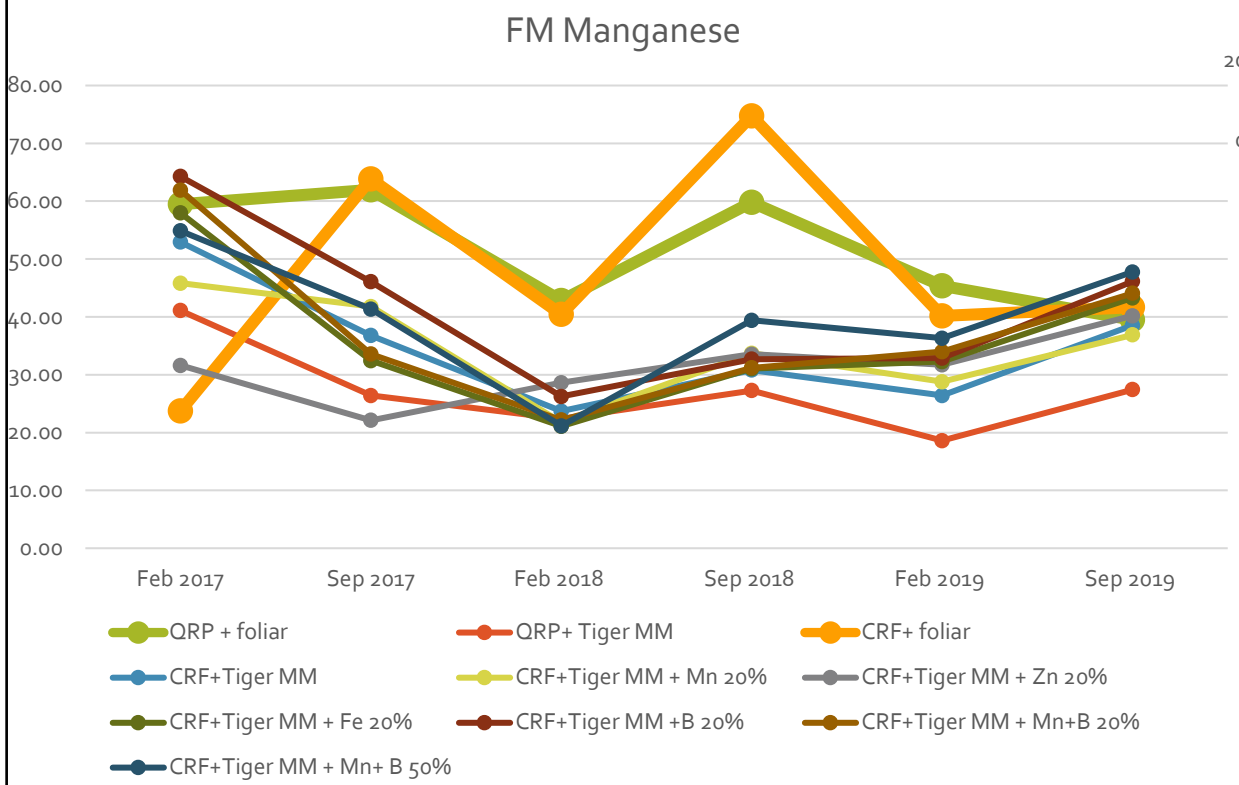

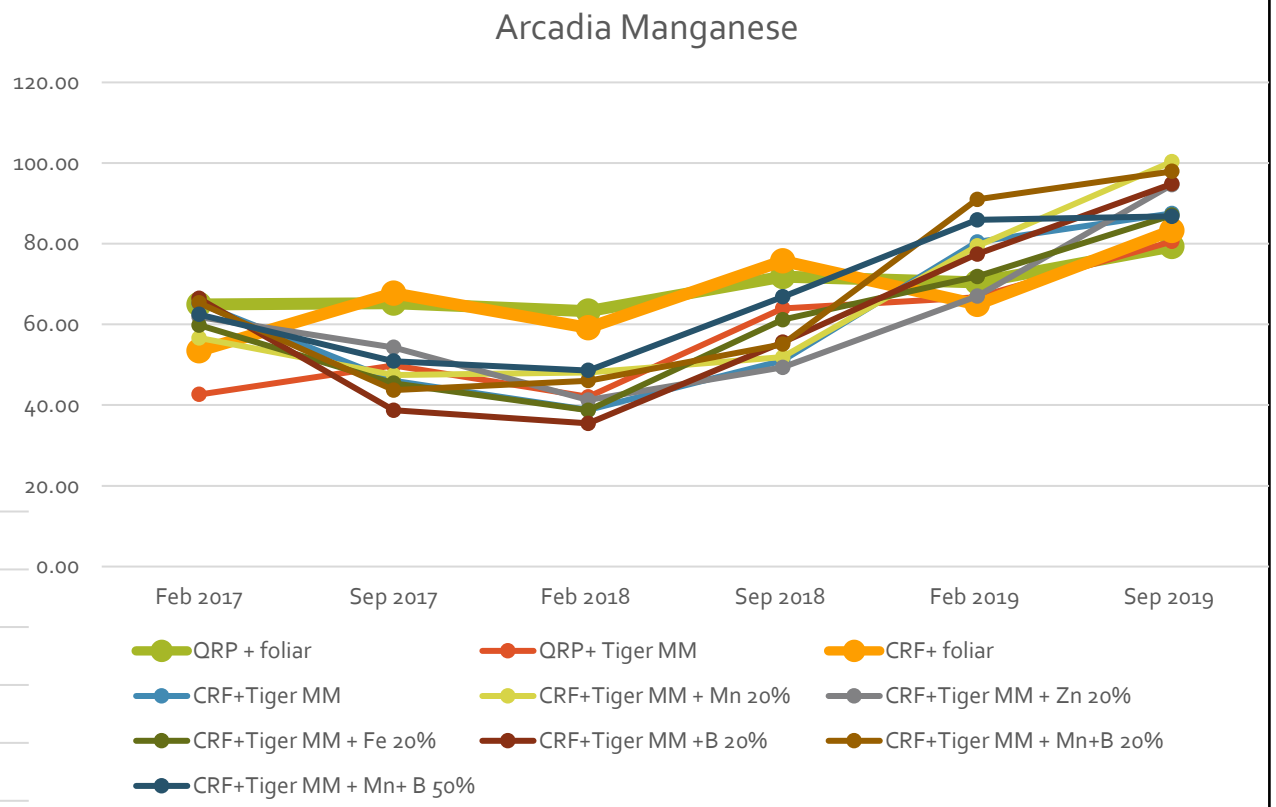

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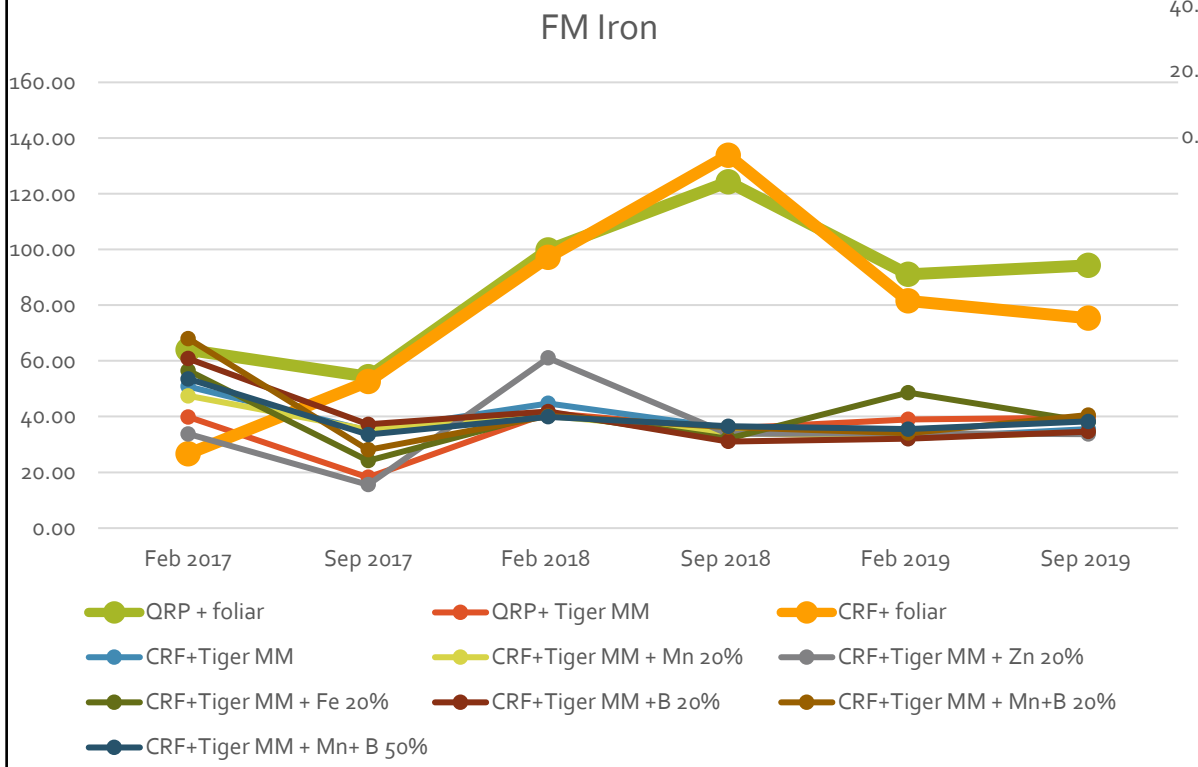
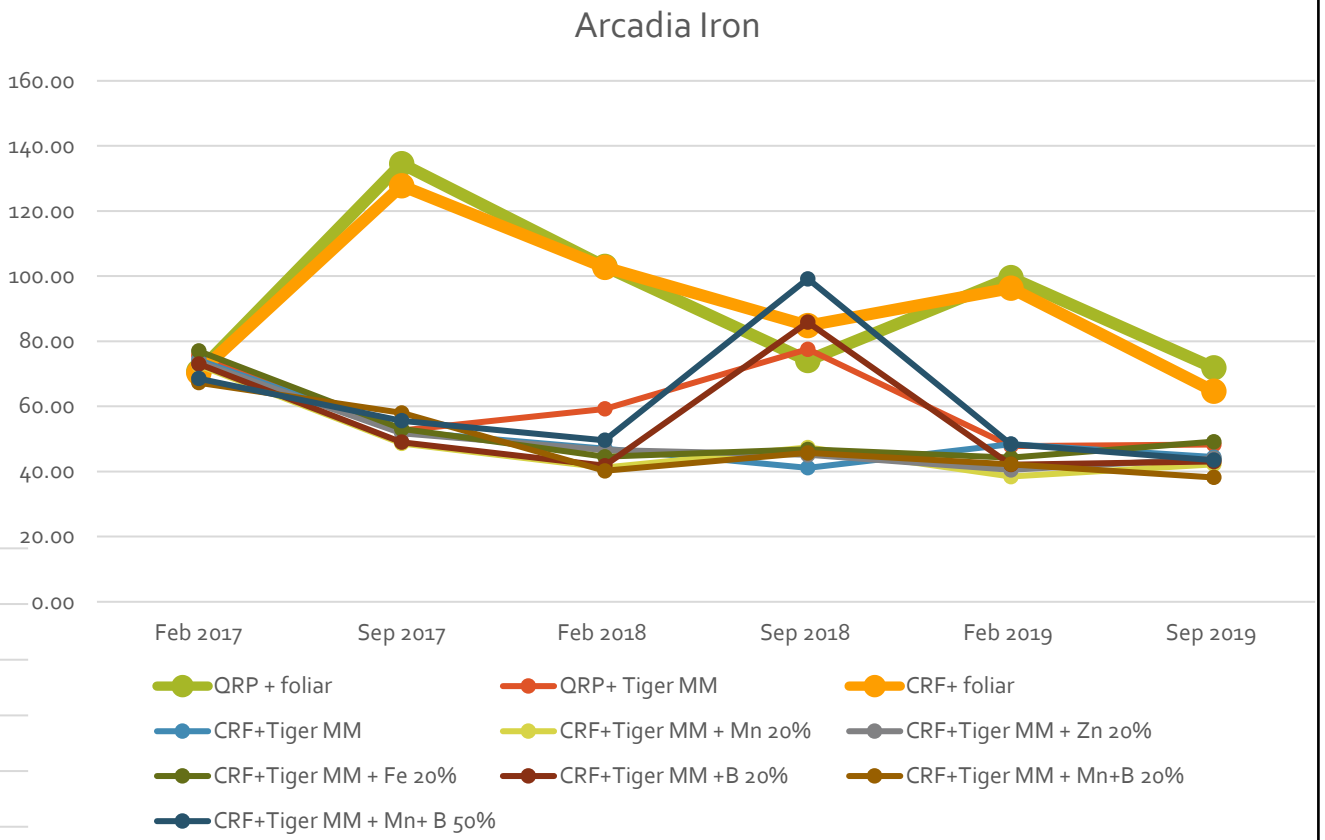




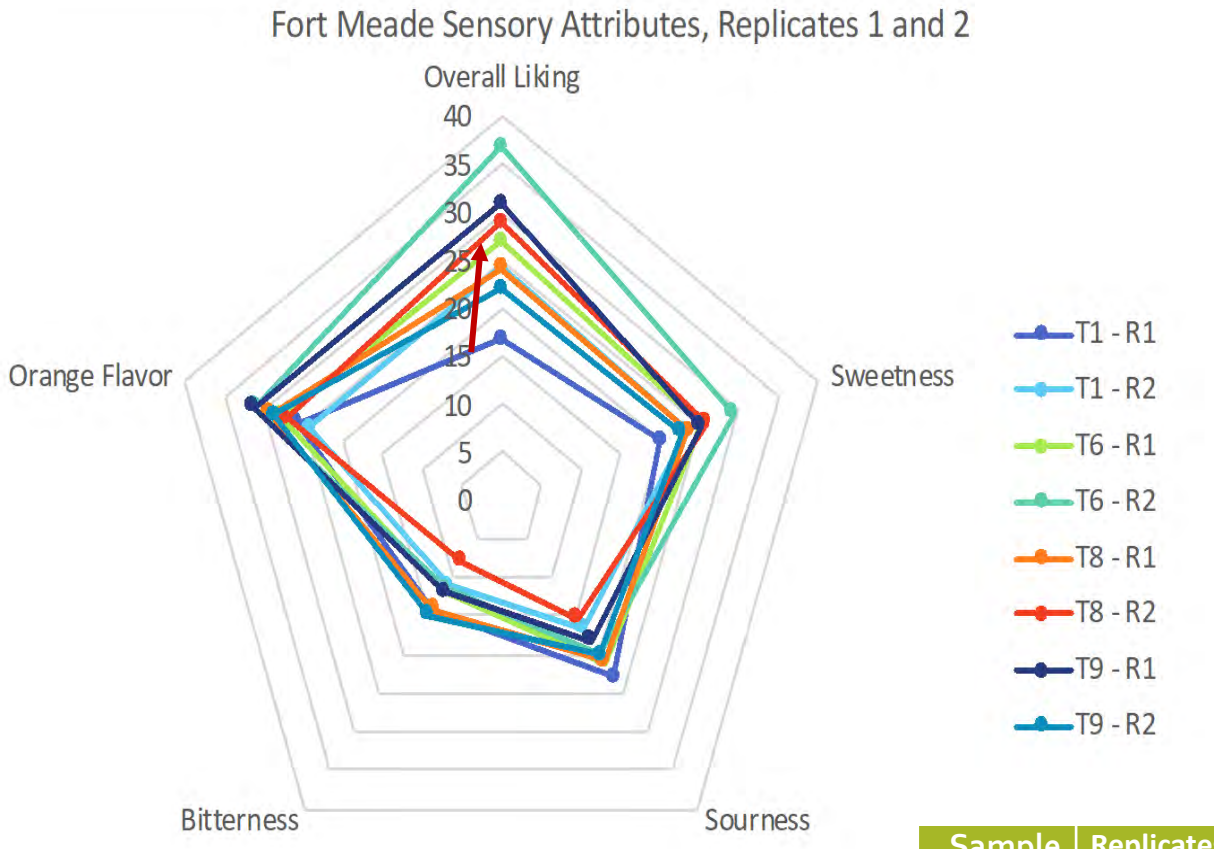
Correlation results

- To assess relationship between leaf nutrient and other parameters
- Fruit size increase with increase in leaf N, P, K, Mg, S, B, Mn
- Brix increase with increase in leaf N, Mg, S, B, Mn and increase in fruit size
- Acid decreased with increase in leaf N, P, Mg, S, B, Mn and increase in fruit size
- Yield increase with increase in leaf N, Mg and increase in fruit size
  - decrease in leaf Zn

Zn seems to be very important!!!

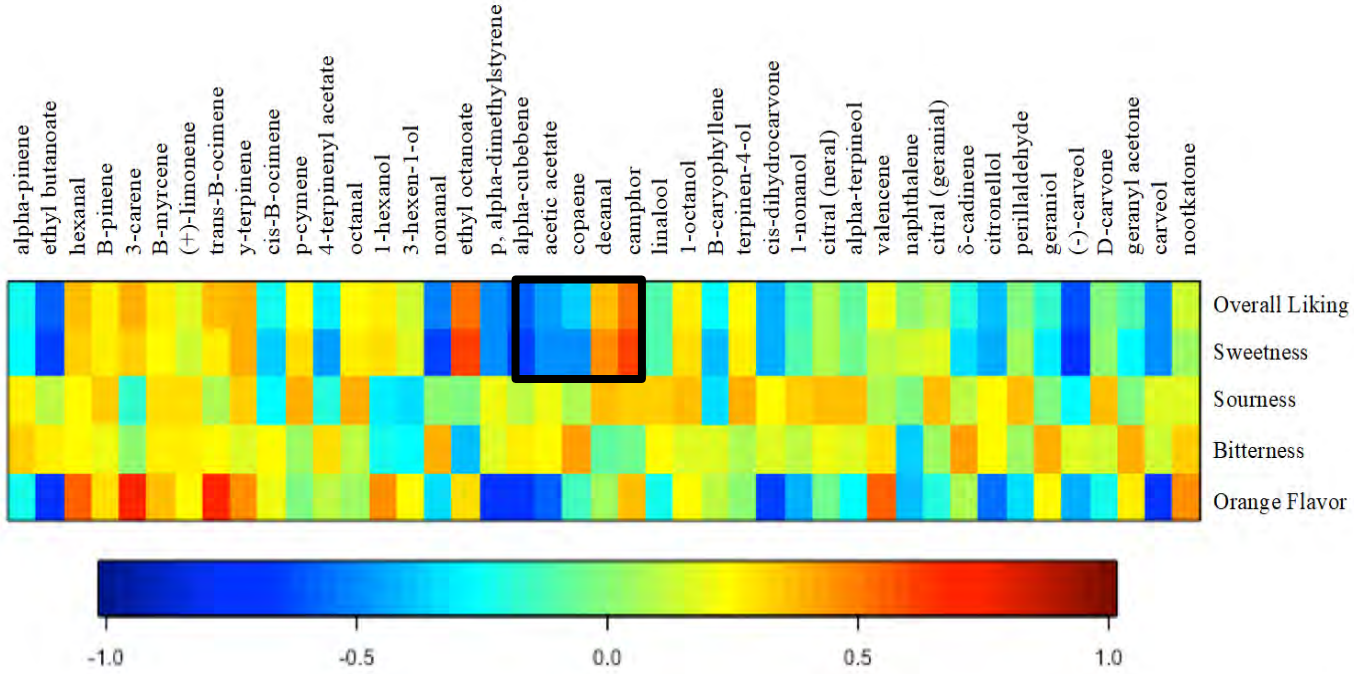
Multiple studies have been indicating towards role of Zn in managing HLB-trees. More zinc is metabolized are required in HLB trees.

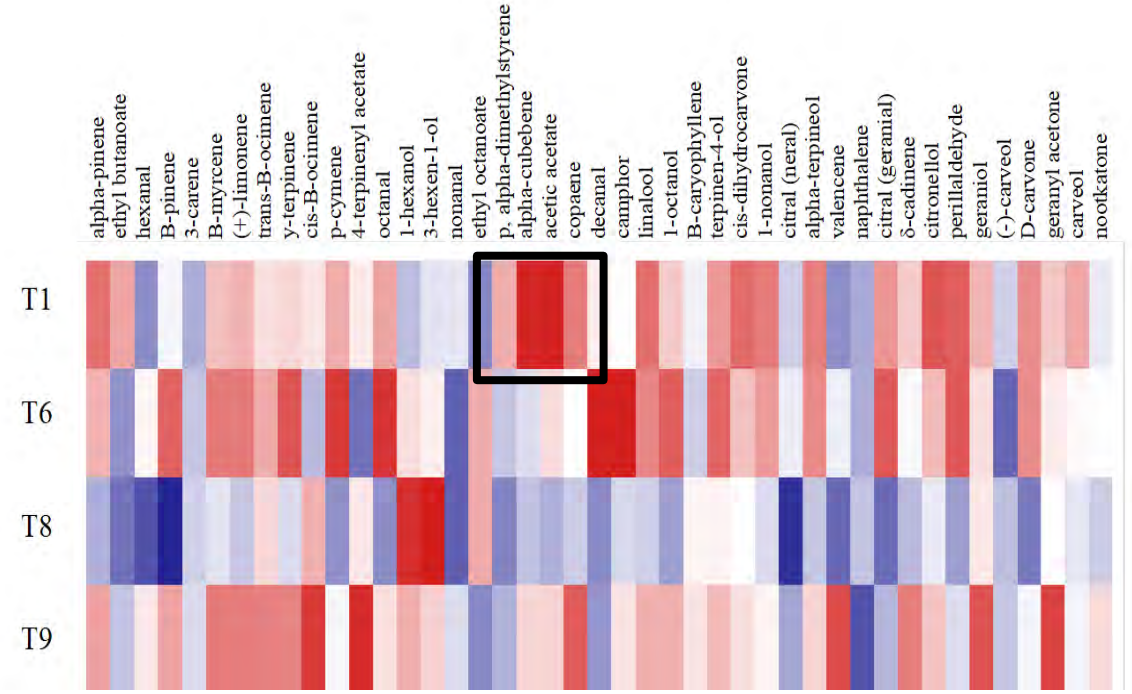
Consumer Sensory Analysis



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

Dr. Yu Wang's Lab





Dr. Yu Wang's Lab

Take home message

- HLB-affected trees do benefit from micronutrients at higher than recommended rate
- 20% higher than recommended rate of micronutrients can improve productivity of HLB-affected trees
  - Iron and Zinc treatments are performing better in Arcadia location
  - Manganese treatments are performing better in Fort Meade
- Soil applied nutrient are better than foliar micronutrients
- Mg, S, B, Mn, and N improves fruit quality
- With CRF, the rate of N applied was reduced to150 lb/acre as well as other nutrients
- Constant supply of nutrients and soil acidification is beneficial
  - Soil pH should be monitored regularly

Thank you

- Dr. Jude Grosser
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- Peace river packing
- Orange Co/Alico
- Matt Shook and Trey Whitehurst
- Jack Zorn

CRDF Citrus Research and Development Foundation, Inc.

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