Influence of Irrigation on Tree Growth, Nutrient Acquisition, and Water relation in High-Density Planting

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Water Use

- Due to the increasing water demand for drinking and industrial usages, the percentage of agriculture water is going to be lessened.

- The lack of water in any stage of the citrus trees growth decreases the yield and fruit quality.

- In contrast, higher irrigation amounts could result in substantial loss of nutrients and herbicides from citrus root zone through deep percolation and surface runoff.

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Water Use

- Consequence polluted the water resources in surrounding environment including lakes, rivers and groundwater which introduce a threat to living organisms (Hanson et al. 2006).

- Therefore, efficient use management is the only approach to save water for the increasing irrigated fields.

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The effect of irrigation treatment on selected trees parameters at selected sites in Florida (Hamido et al., 2017)

Treatment/ Site	Stem water potential (MPa)	Leaf area in^2/tree	Leaf area index	Sap flow (g ft^{-2} h^{-1})
Daily	-0.65a	1120a	4.77a	16a
Intermediate	-0.90b	871b	4.02b	12b
IFAS	-1.03c	712b	3.66b	9b
Avon Park	-0.79a	849b	4.21a	11a
Arcadia	-0.83ab	1119a	4.24a	12a
Immokalee	-0.85b	736b	4.04a	13a
Model	<0.0001	0.0001	<0.0001	0.0002
Treatment	<0.0001	0.0013	<0.0001	<0.0001
Site	0.1092	0.0022	0.1092	0.5278

Means in the same column with the same letter are not significantly different at $\alpha \leq 0.05$

Objective

- The aim of current study is to determine the amount of water required to grow trees at higher tree densities without reduction in trees productivity.

Site description and treatment

- The experiment was initiated in November 2017 on eight-month-old sweet orange ‘Valencia’ (Citrus sinensis) trees grafted on the ‘US-897’ citrus rootstock.
- The experimental area consists of five-540-foot-long beds with drainage swales on each side.
- Two irrigation treatments (62% and 100%) of daily ETo.

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Citrus planting densities

- The grove comprised 60 sub-plots divided into six trees densities as following:

1) 181 trees per acre (10 feet * 24 feet),
2) 207 trees per acre (14 feet * 15 feet),
3) 242 trees per acre (7.5 feet * 24 feet),
4) 290 trees per acre (10 feet * 15 feet),
5) 303 trees per acre (6 feet * 24 feet), and
6) 363 trees per acre (8 feet *15 feet).

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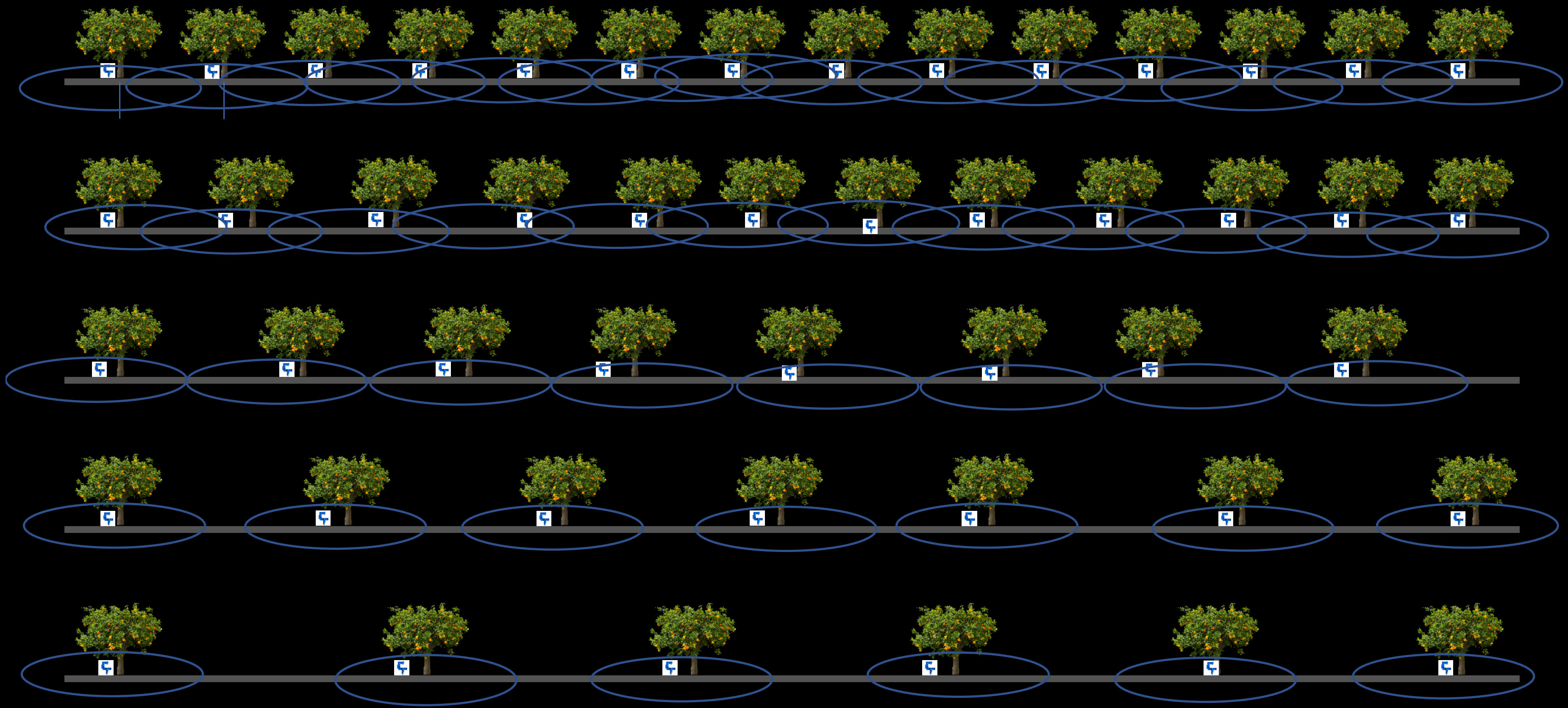
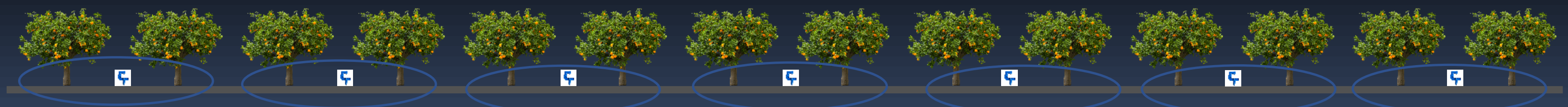


Diagram illustrates the different irrigation patterns under different planting density with one emitter per tree



Current modified irrigation rate for higher density planting with one emitter per two trees.

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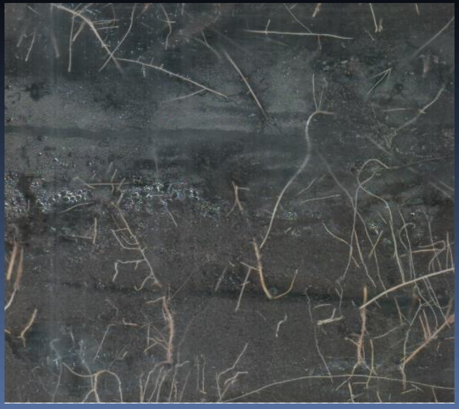
Measurements

- Soil moisture and soil pH
- Stem water potential
- Tissue P, K, Ca, Mg, Mn, Zn, Cu, Fe, B, and Na concentrations.
- Trunk diameter, tree height, and canopy volume
- Leaf area and root length



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Chemical analysis of irrigation water

- Initial results indicate higher water quality with 0.18±0.00 dSm^{-1}, TDS (total dissolved solids) = 121±0.4 ppm, and pH = 5.6±0.06.

- Irrigation water does not have a detectable trace of B, Cu, Mn, or Zn. Besides, it has Ca, Na, Mg, Fe, and P with small amounts as 17.7±0.01, 8.9±0.2, 3.3±0.04, 1.6±0.02, and 1.1±0.01 ppm, respectively.

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Soil acidity and salinity

Impact of irrigation rate and planting density on soil acidity (pH) and salinity (ppm).

Irrigation	Soil pH	Soil salinity
Lower rate (62%)	5.24	31.5
Higher rate (100%)	5.38	27.6
Planting density		
181	5.26	32.0
207	5.65	24.1
242	5.17	28.4
290	5.50	27.7
303	4.82	40.5
363	5.24	28.7

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Citrus trees leaf nutrition

Irrigation rate and planting density on citrus leaf nutrient acquisition

Irrigation	N	P	K	Na	Ca	Fe	Mn	B
62%	3.54	0.18	1.3	0.30	3.81	79	128	84
100%	3.56	0.20	1.4	0.27	3.83	83	95	108
Planting density								
181	4.03	0.19	1.6	0.33	3.93	89	99	101
207	3.22	0.18	1.4	0.26	3.56	74	96	90
242	3.84	0.22	1.4	0.31	4.18	89	156	110
290	3.50	0.18	1.3	0.27	3.87	75	94	96
303	3.77	0.20	1.4	0.31	3.86	88	131	120
363	3.28	0.17	1.2	0.26	3.69	76	108	73
Recomm. level	2.5-2.7	0.12 0.16	0.7 1.1	-----	3.0-4.9	60-120	25-100	36-100

Soil moisture and stem water potential

Impact of irrigation rate and planting density on soil moisture contents and citrus stem water potentials

Irrigation	**Soil moisture contents**	**Stem water potentials**
Lower rate (62%)	0.105	0.80
Higher rate (100%)	0.107	0.79
Planting density		
181	0.098	0.74
207	0.099	0.79
242	0.105	0.74
290	0.104	0.72
303	0.137	0.68
363	0.092	0.75

Citrus tree growth

Impact of irrigation rate and planting density of trees on development and growth

Irrigation	Height (in)	Trunk diam(in)	Canopy vol. (ft^3)	Leaf area (ft^2)
Lower rate-62%	45.7	0.77	8.48	21.1
Higher rate-100%	45.3	0.79	7.77	20.3
Planting density				
181	45.3	0.75	8.48	15.5
207	41.7	0.80	7.06	19.7
242	46.5	0.76	8.48	18.7
290	47.2	0.78	8.12	21.4
303	48.8	0.78	8.83	19.2
363	44.9	0.80	8.48	26.9

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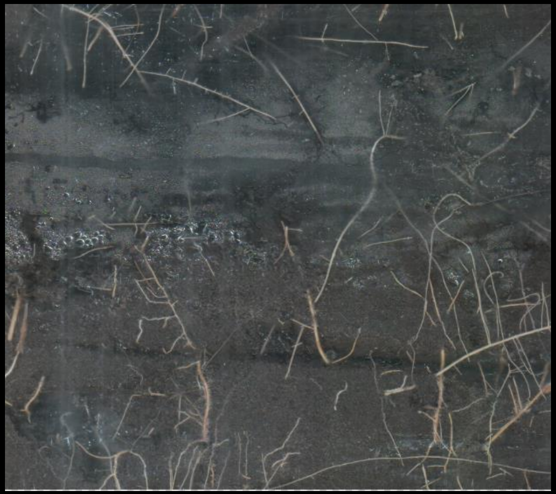
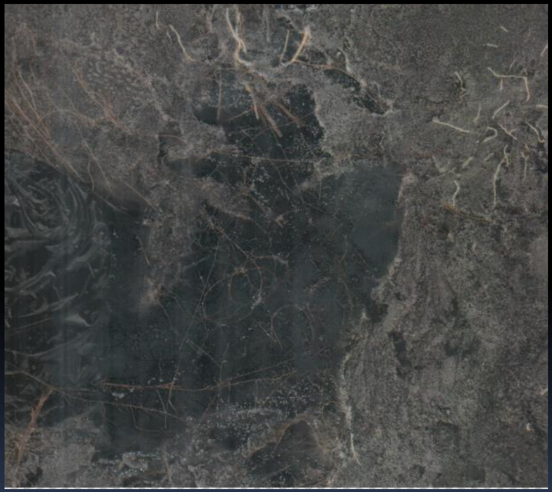
Root images

100 % irrigation -181 trees

Irrigation	Root leng. (in)
62%	17
100%	9.6
Planting density	
181	20.7
207	11.1
242	13.5
290	14.0
303	9.7
363	10.8



62 % irrigation -181 trees



100 % irrigation - 303 trees

62 % irrigation - 303 trees

Impact of irrigation rate and planting density on citrus root development.

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Root images

100 % irrigation -207 trees

100 % irrigation -363 trees

Irrigation	Root leng. (in)
62%	17
100%	9.6
Planting density	
181	20.7
207	11.1
242	13.5
290	14.0
303	9.7
363	10.8

62 % irrigation -207 trees

62 % irrigation -363 trees

Impact of irrigation rate and planting density on citrus root development.

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Conclusions

- Lower irrigation rate exerted promising results during the watered period which would be favorably applied in commercial citrus trees groves.

- Lower irrigation rate in citrus is much more cost-effective than the full irrigation under the Southwest Florida conditions.

- Lower irrigation treatment promoted citrus trees root and shoot development and minimized nutrient losses.

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Thank You

Citrus Nutrient Management on Huanglongbing (Citrus Greening) affected Citrus trees on Florida Sandy Soils

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May 2019
Immokalee, FL

Problems associated with HLB affected citrus:

- Physiological and morphological disorder
- Develop nutrient deficiency
- Reduced yield and poor fruit quality

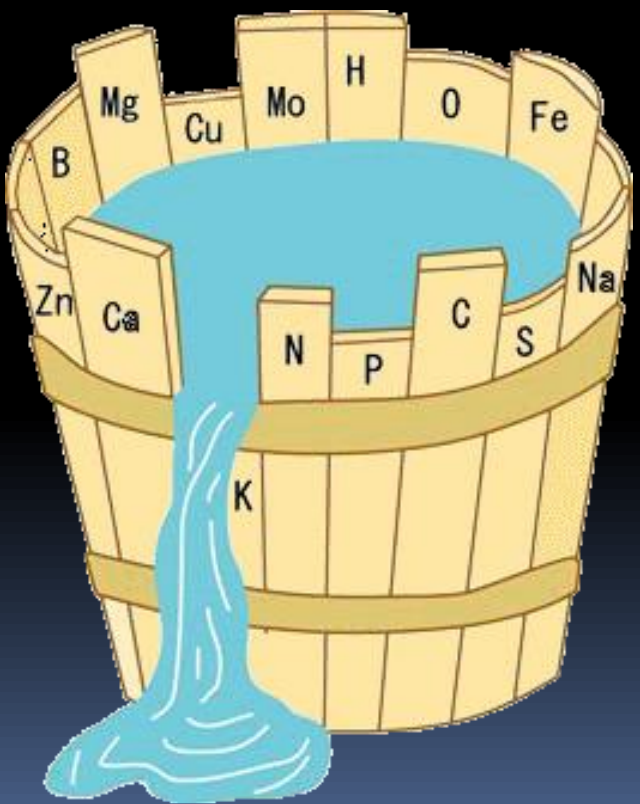
Among short-term solution:

❶ Plant nutrition

❷ Irrigation practices

❸ Rootstock type

❹ Grove design



Objectives of the study:

❑ Secondary macronutrients:

- ➢ Determine if soil applied Ca and/or Mg enhances leaf nutrient concentrations and tree growth of HLB affected 'Valencia' trees

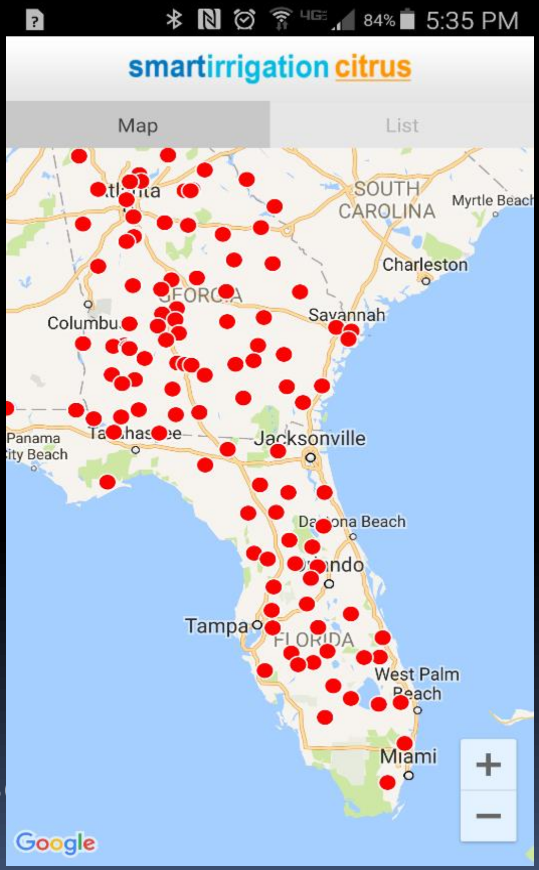
❑ Micronutrients:

- ➢ Soil and /or foliar applied Mn, Zn, and B improves tree leaf nutrient concentrations and growth of HLB affected citrus trees

Study ❶: Hamlin on Swingle / Cleopatra rootstocks.

Study ❷: Valencia on Swingle / Volkameriana rootstocks.

- Irrigation: micro-sprinkler (360°).
  - ❖ Daily
  - ❖ Schedule using Citrus SmartIrrigation.
- Fertigation:
  - ❖ Nitrogen: Biweekly (20x per year).
  - ❖ Secondary macro and micronutrients:
    - ✓ 3x per year (February, June, and S



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Study ❶ Secondary Macronutrients

N=168, 224 and 280 N and K=168 kg /ha/year

❶ Control

❷ Calcium (1 ×)

❸ Magnesium (1 ×)

❹ Calcium (0.5 ×) and Magnesium (0.5 ×) applications

Treatment	Relative to recommendation		Ca	Mg
	Foliar	Soil	(lb. ac^{-1})	
1	-	-	-	-
2	-	1.0×	40	-
3	-	1.0×	-	40
4	-	0.5×	20	20

Study ❷ Micronutrients

N=168, 224 and 280 N and K=168 kg /ha/year

❶ Control

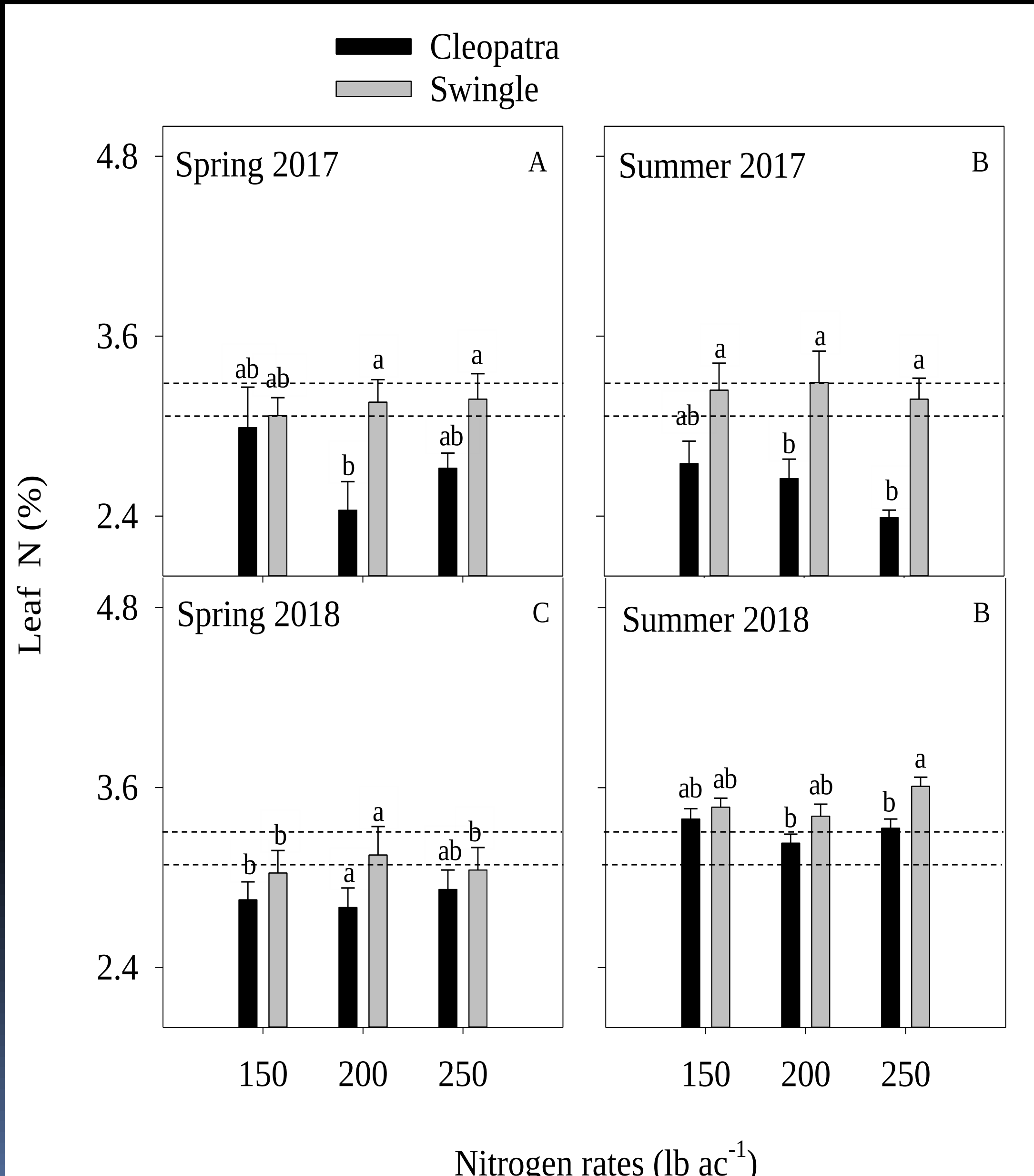
❷ Foliar application of micronutrient (1 ×)

❸ Foliar (1 ×) and soil (1 ×) applications

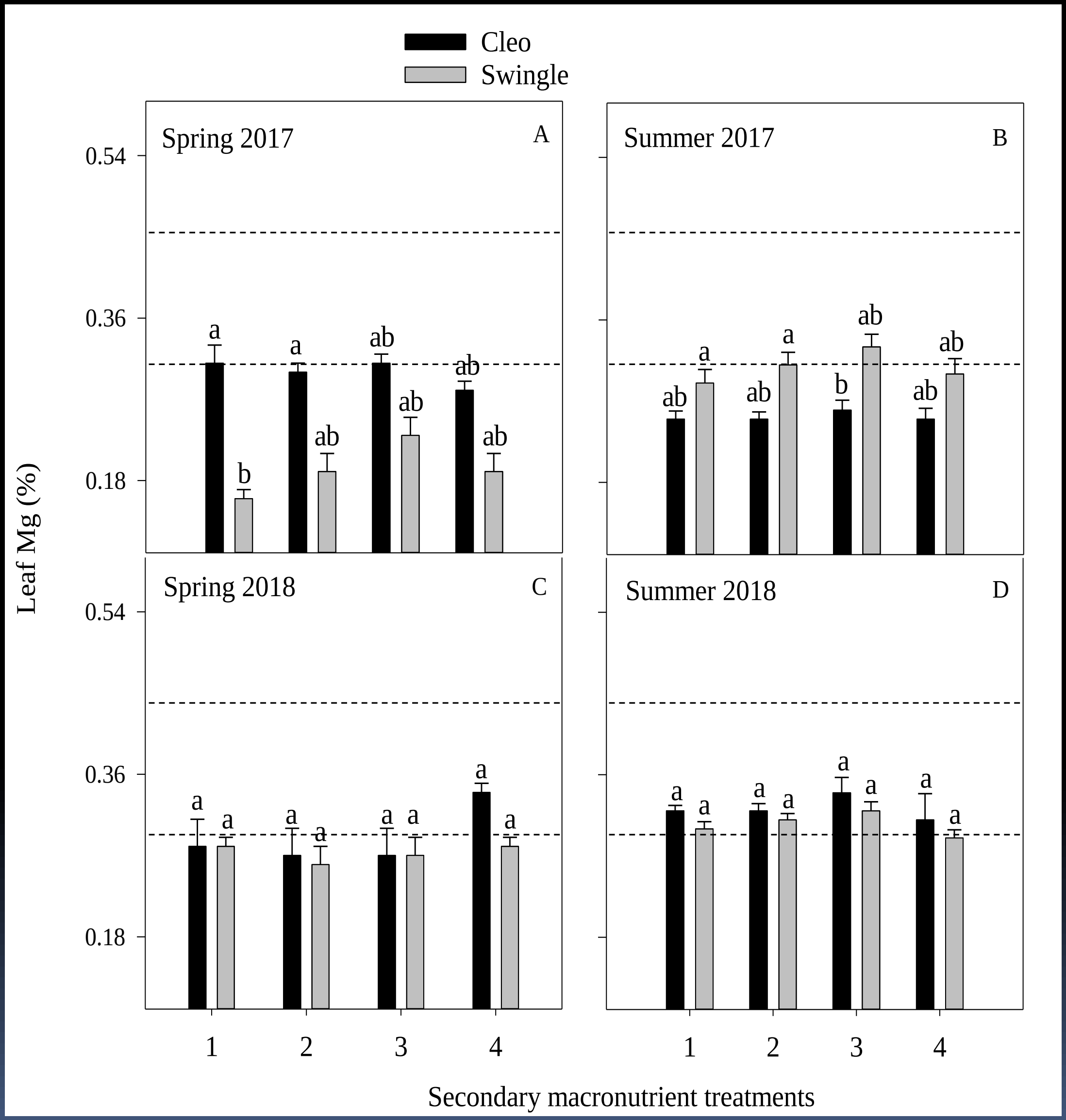
❹ Foliar (1 ×) and with soil (2 ×) applications

Treatment	Relative to recommendation		Mn & Zn	Boron
	Foliar	Soil	(lb. ac^{-1})	
1	-	-	-	-
2	1.0× /spray	-	10	2
3	1.0× /spray	1.0×	10	2
4	1.0× /spray	2.0×	10	2

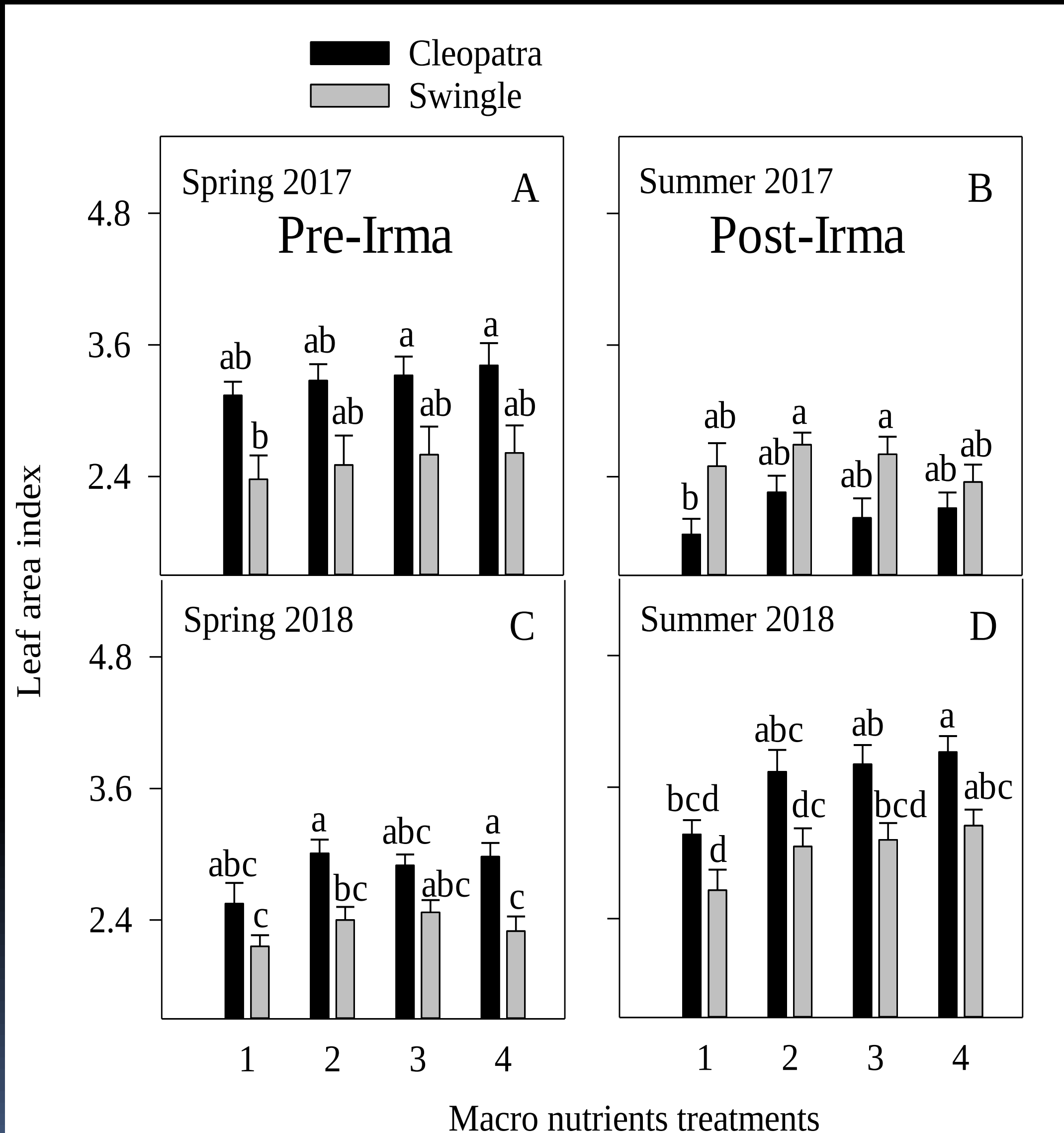
Study ➊ Result



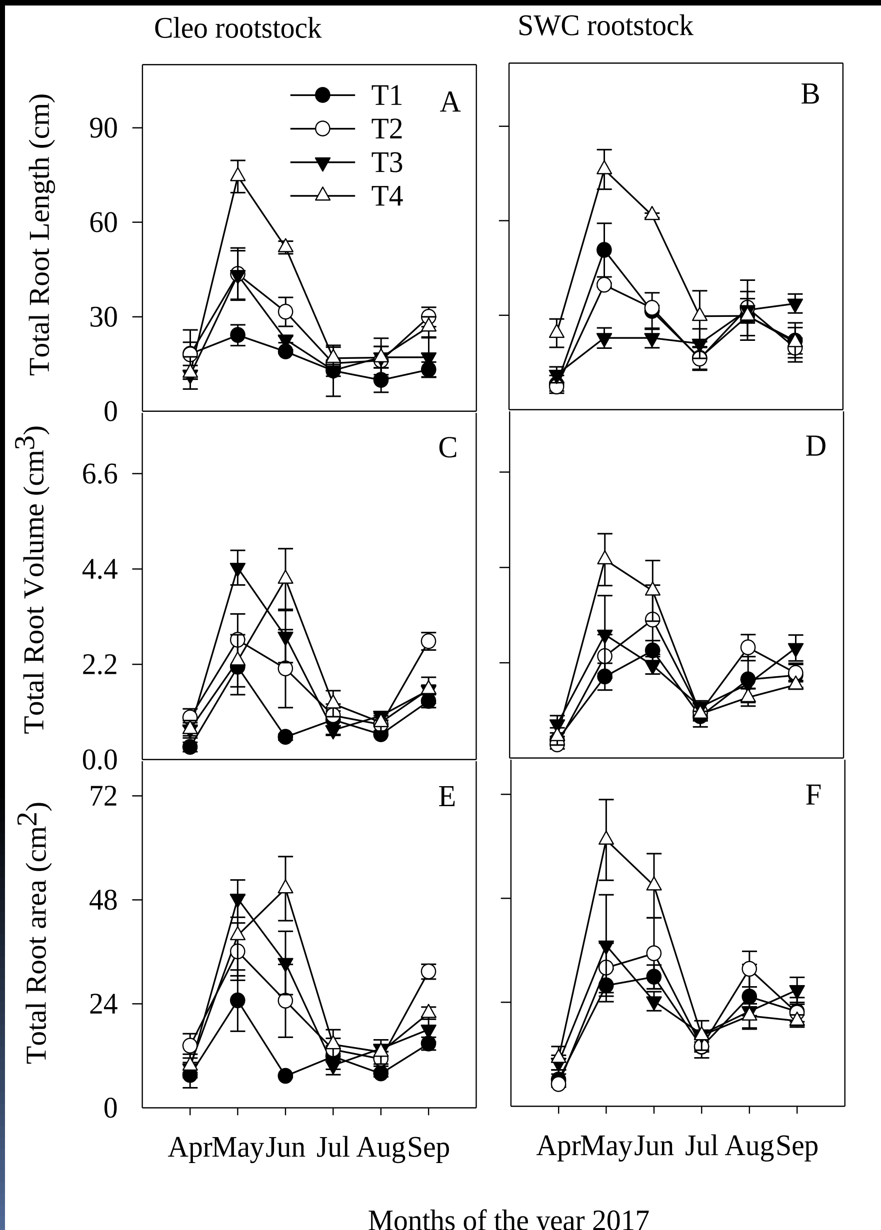
- Trees on Cleopatra rootstocks had leaf N below optimum for the Critical Nutrient Concentrations for Florida Citrus (CNCFC).
- After a year and half split nitrogen application fulfilled the optimum nutrient range.



- Leaf Mg concentration remained below the critical nutrient ranges during most of the study indicating Mg nutrition is necessary.
- The result indicated a follow up Mg nutrient management during the entire year.

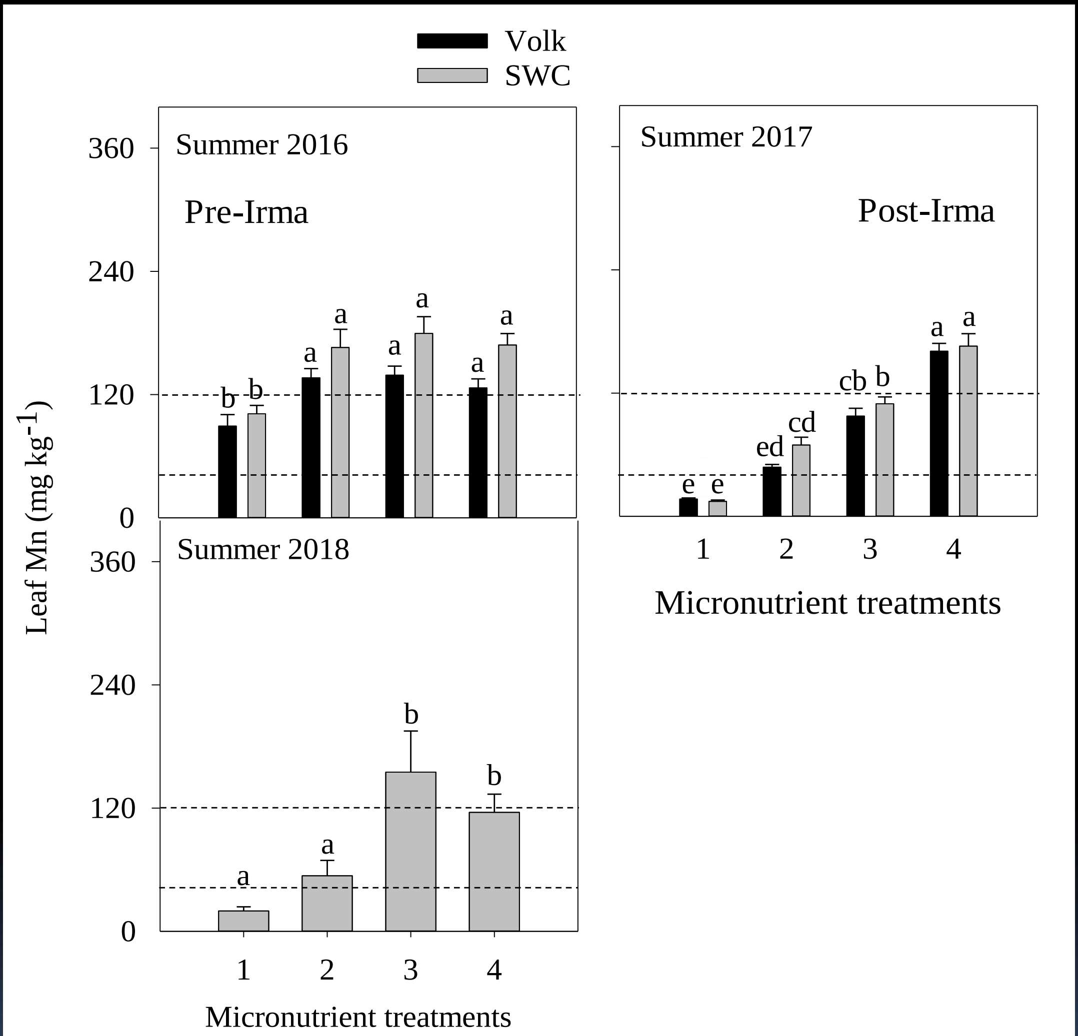


- Trees that treated with calcium and magnesium nutrition significantly increased leaf area index relative to the untreated control trees.
- Trees budded on Volkameriana rootstock responded faster and higher than trees on Swingle rootstocks.

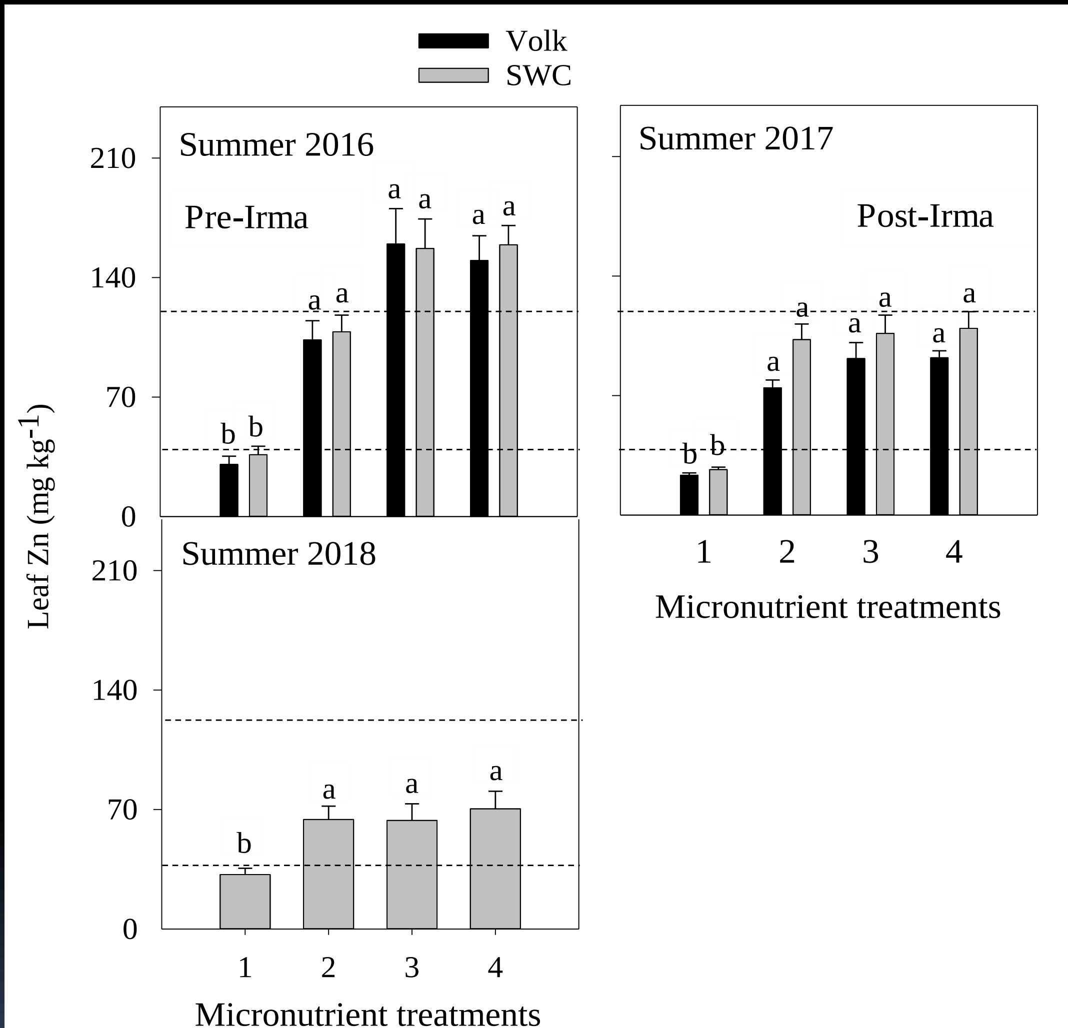


- Trees treated with calcium and/or magnesium responded significantly higher than the untreated control trees.
- Significantly higher root growth in May and June.

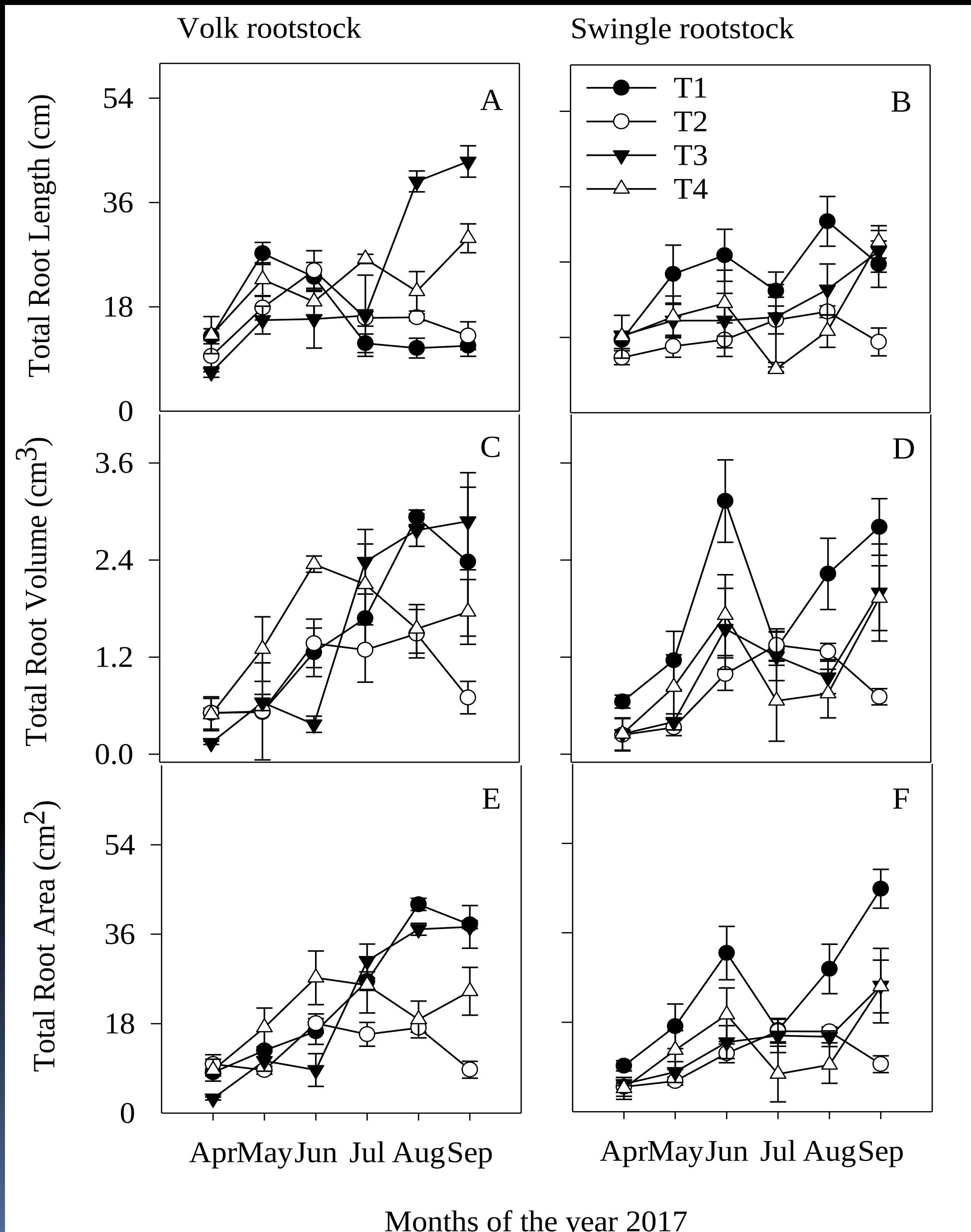
Study ❷ Result



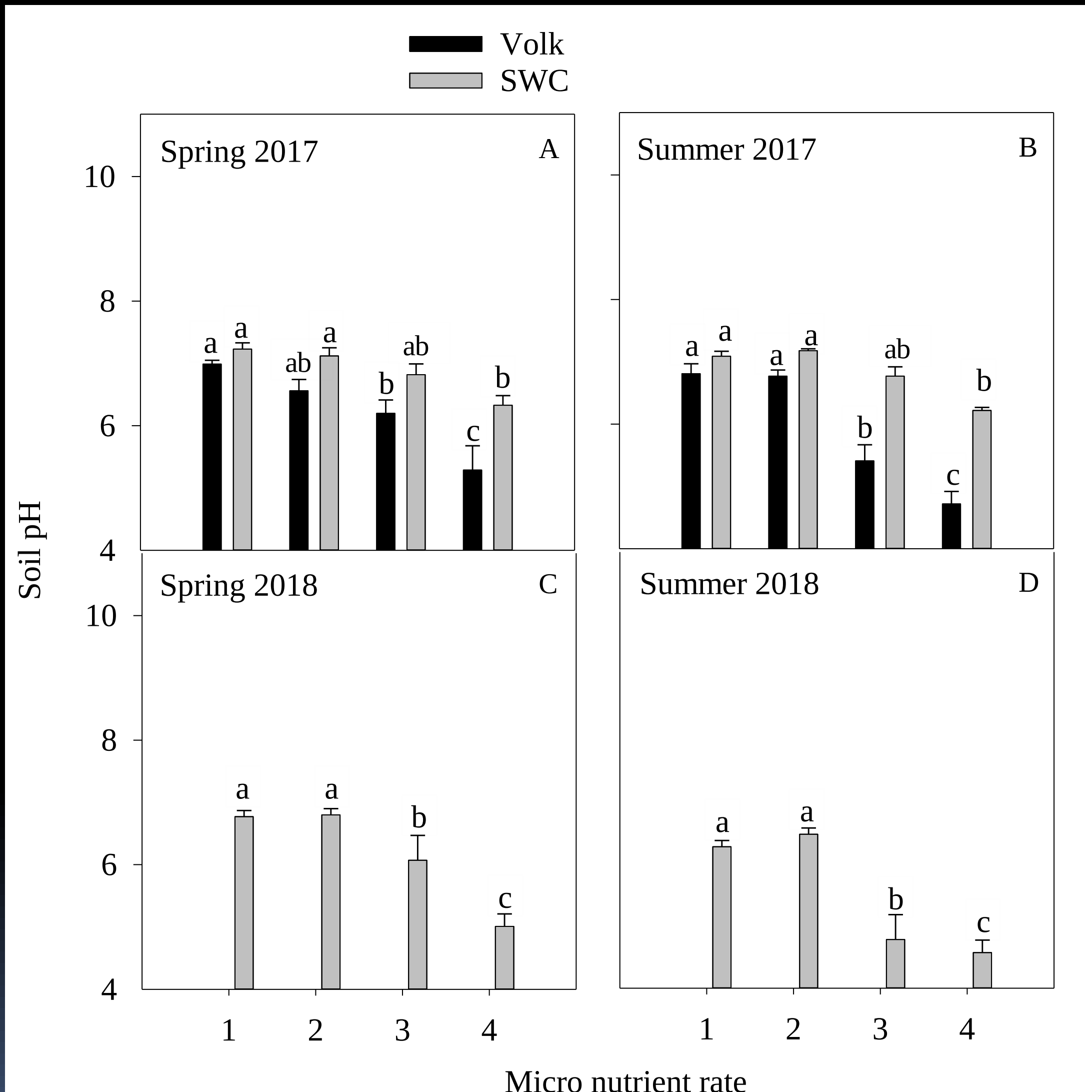
- The highest Mn rate had the highest leaf Mn concertation, above the critical ranges (horizontal dashed lines) at the beginning of the experiment.
  - ✓ Dilution effect
- Single soil applied-micronutrients in addition to foliar applications following
  - ✓ Seasonal leaf drop or
  - ✓ Crop nutrient removal.



- Foliar application of Zinc could fulfill the annual requirement of HLB-affected citrus trees.
- Soil application of Zn did not increase to leaf nutrient concentration.



- The root growth increased more during late summer that spring season when trees received both soil and foliar at (1 × foliar and 1 × soil) rate.
- With the highest micronutrients created antagonistic effect on root growth due to the decrease in soil pH.



- Soil acidity significantly increased on the top (0–15 cm) soil profile than the lower depths (15–30 and 30–45 cm).
- The highest rate (1 × foliar and 2 × soil) had the highest soil acidity than the rest of the treatments.
- Adding dolomite (dolomitic limestone) will amend the decrease in soil pH.

- Split nitrogen applications fulfill N requirement after a year and half.
- Trees showed leaf Mg deficiency, Mg nutrition need close flow up.
- Calcium and Mg nutrients increased above and belowground vegetative growths than the untreated control trees.

- Trees treated with the highest micronutrient rate had the highest leaf Mn, Zn concentrations, & the highest soil acidity.
- The lowest micronutrient rate had higher vegetative and root growth than the highest rate.
- Soil acidity management (dolomitic limestone) is necessary to avoid antagonistic impact of soil acidity on tree growth.

Thank you