

# **Living with HLB: nutrition and irrigation management can improve tree health and productivity**

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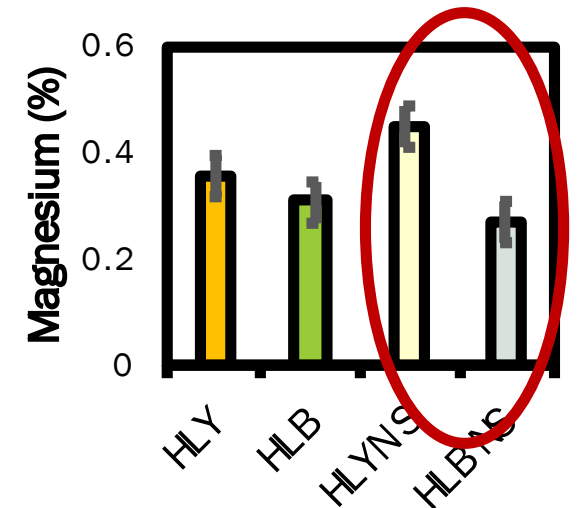
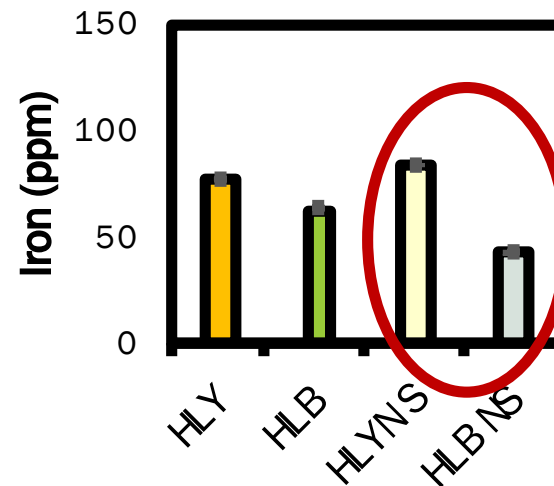
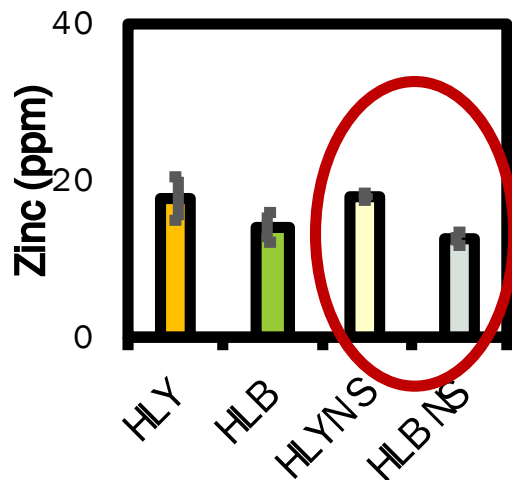
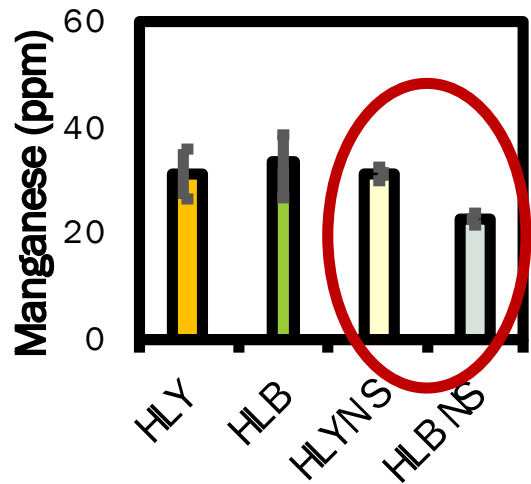
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# Nutrition Management

HLB-affected trees often show deficiency of nutrients in leaves as compared to healthy or asymptomatic trees

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



# Micronutrient Field Trial

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Two locations: Fort Meade and Arcadia  
Valencia/Swingle; 10 to 15 year

Completely Randomized Block Design

Trial was initiated in February 2016 and will end with 2019  
harvest

All the fertilizer treatments are applied 3 times a year by hand  
in the wetted zone



# Treatments

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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

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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
- 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 so far...

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As expected, no significant effect on yield was observed in first harvest (2017)

- Ground applied nutrition takes a long time to show any differences

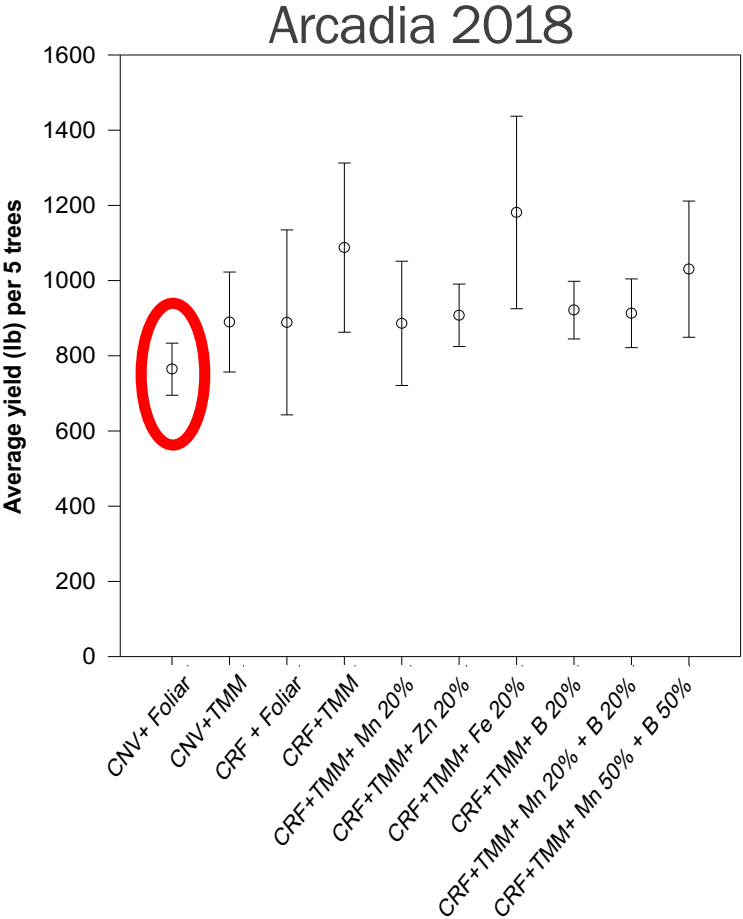
Treatments	2017 Yield (lb)/5 trees	
	Ft. Meade	Arcadia
CNV+ Foliar	278	891
CNV+TMM	406	1113
CRF+ Foliar	313	939
CRF+TMM	428	1103
CRF+TMM + Mn 20%	381	1051
CRF+ TMM + Zn 20%	359	978
CRF+ TMM + Fe 20%	266	1208
CRF+TMM+ B 20%	336	1434
CRF+TMM + Mn 20%+B 20%	428	968
CRF+TMM+ Mn 50%+ B 50%	379	1114

**Approximately,  
310 boxes per  
acre**

Large tree to tree variability!

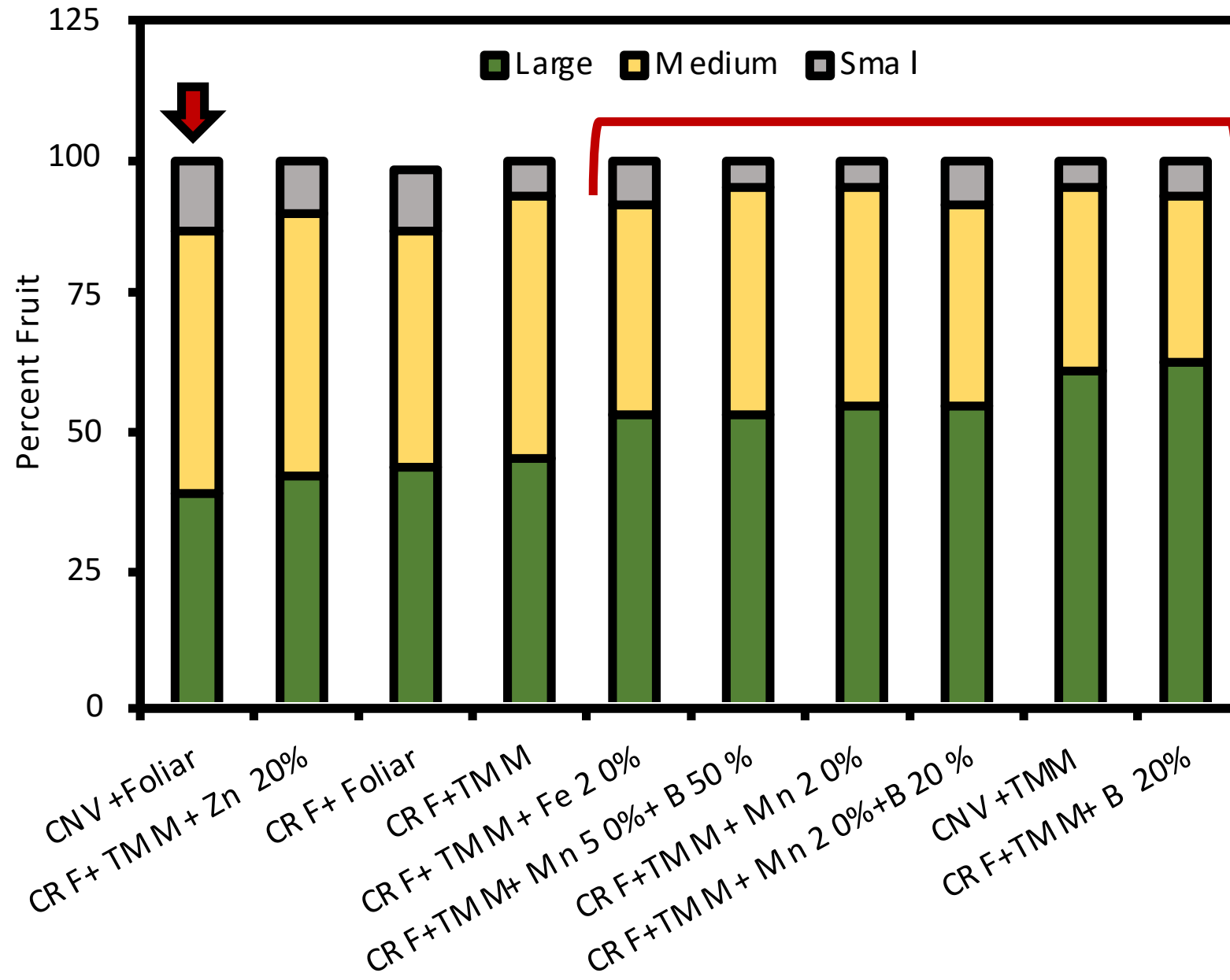
However, at 90% confidence interval....

No significant results at 95% confidence interval



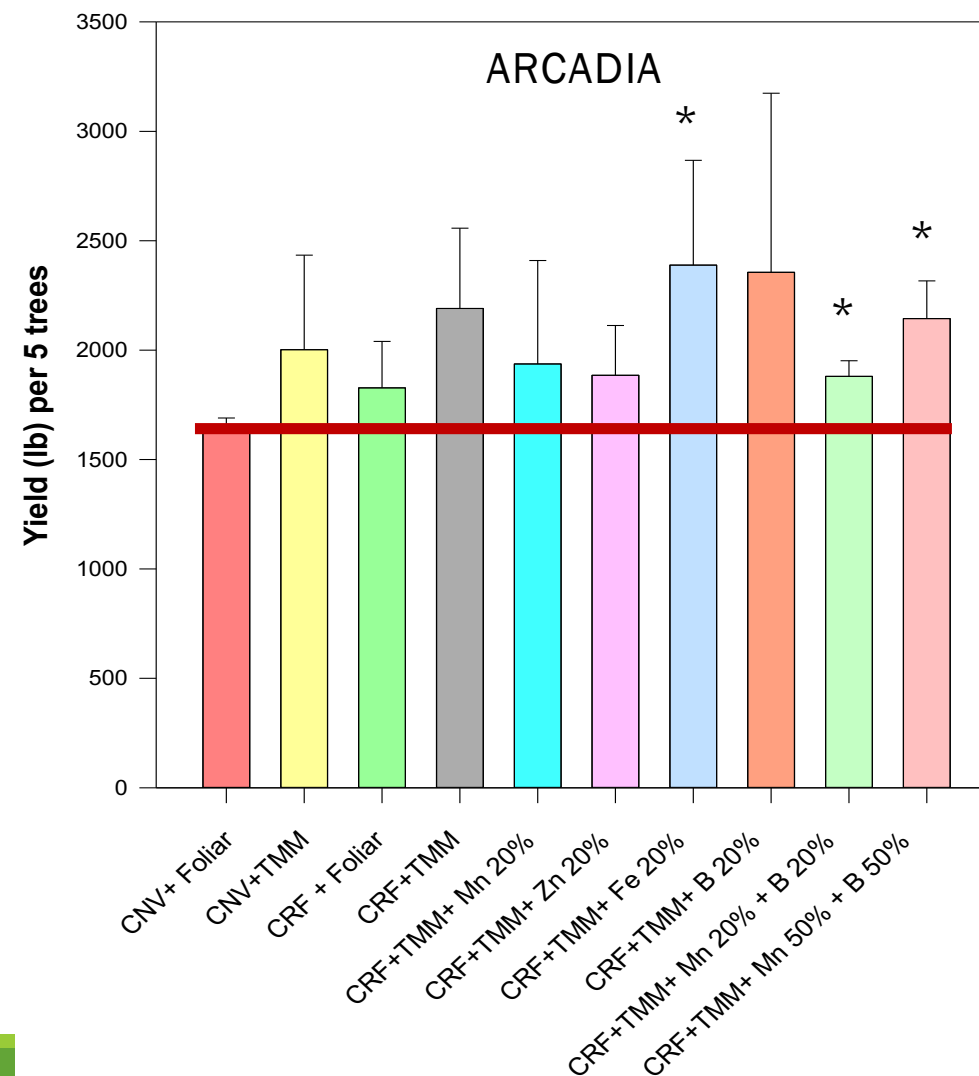
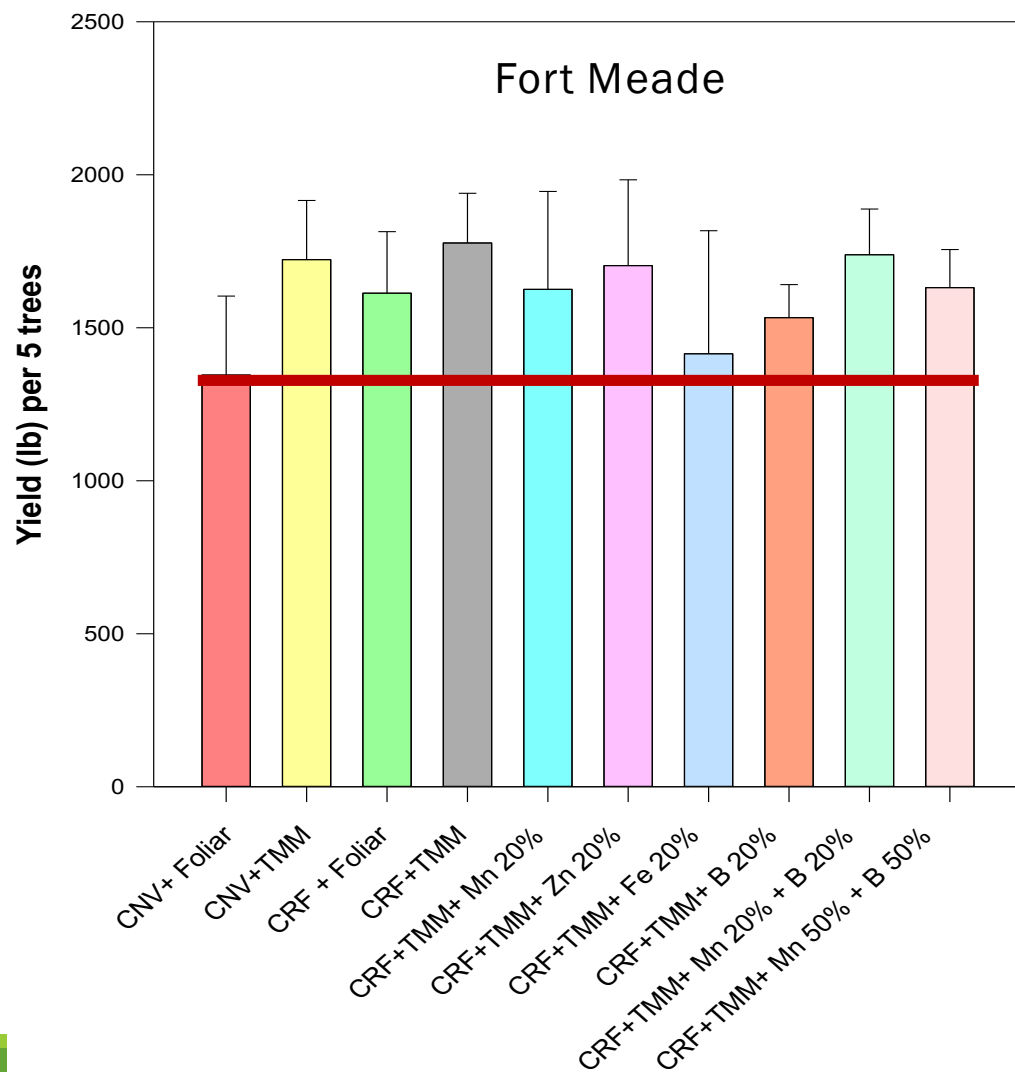
Treatments	2018 Yield (lb)/5 trees	
	Ft. Meade	Arcadia
CNV+ Foliar	1068	764
CNV+TMM	1317	890
CRF+ Foliar	1301	889
CRF+TMM	1350	1088*
CRF+TMM + Mn 20%	1245	886
CRF+ TMM + Zn 20%	1344	908*
CRF+ TMM + Fe 20%	1149	1181*
CRF+TMM+ B 20%	1198	922*
CRF+TMM + Mn 20%+B 20%	1311	913*
CRF+TMM+ Mn 50%+ B 50%	1252	1030*

# Significant improvement in fruit size at Arcadia both years





- 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 and 2018 was analyzed



# Yield 2017 and 2018 ranking

Treatments	Ft. Meade			Arcadia			Total
	2017	2018	Cumulative	2017	2018	Cumulative	
CNV+ Foliar	9	10	9.5	10	10	10	9.8
CNV+TMM	3	3	3	3	7	5	4.0
CRF+ Foliar	8	5	6.5	9	7	8	7.3
CRF+TMM	1	1	1	5	2	3.5	2.3
CRF+TMM + Mn 20%	4	7	5.5	6	9	7.5	6.5
CRF+ TMM + Zn 20%	6	2	4	7	6	6.5	5.3
CRF+ TMM + Fe 20%	10	9	9.5	2	1	1.5	5.5
CRF+TMM+ B 20%	7	8	7.5	1	4	2.5	5.0
CRF+TMM + Mn 20%+B 20%	1	4	2.5	8	5	6.5	4.5
CRF+TMM+ Mn 50%+ B 50%	4	6	5	3	3	3	4.0

# Effect of irrigation water and growing media pH

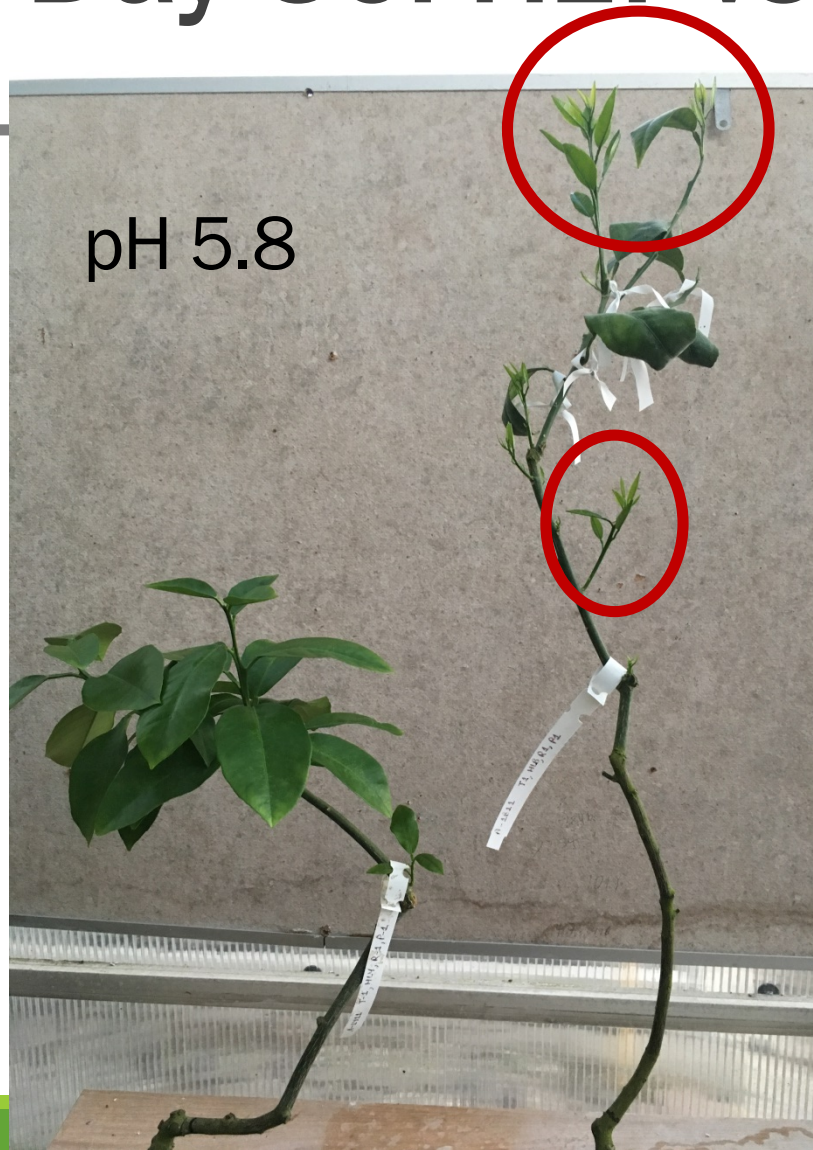
# Irrigation water pH

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- Greenhouse Study
- ‘Midsweet’ on ‘Kuharske’ (HLY and HLB) grown in grove sand
- Water every other day with water at pH 5.8, 7, and 8 for 60 day

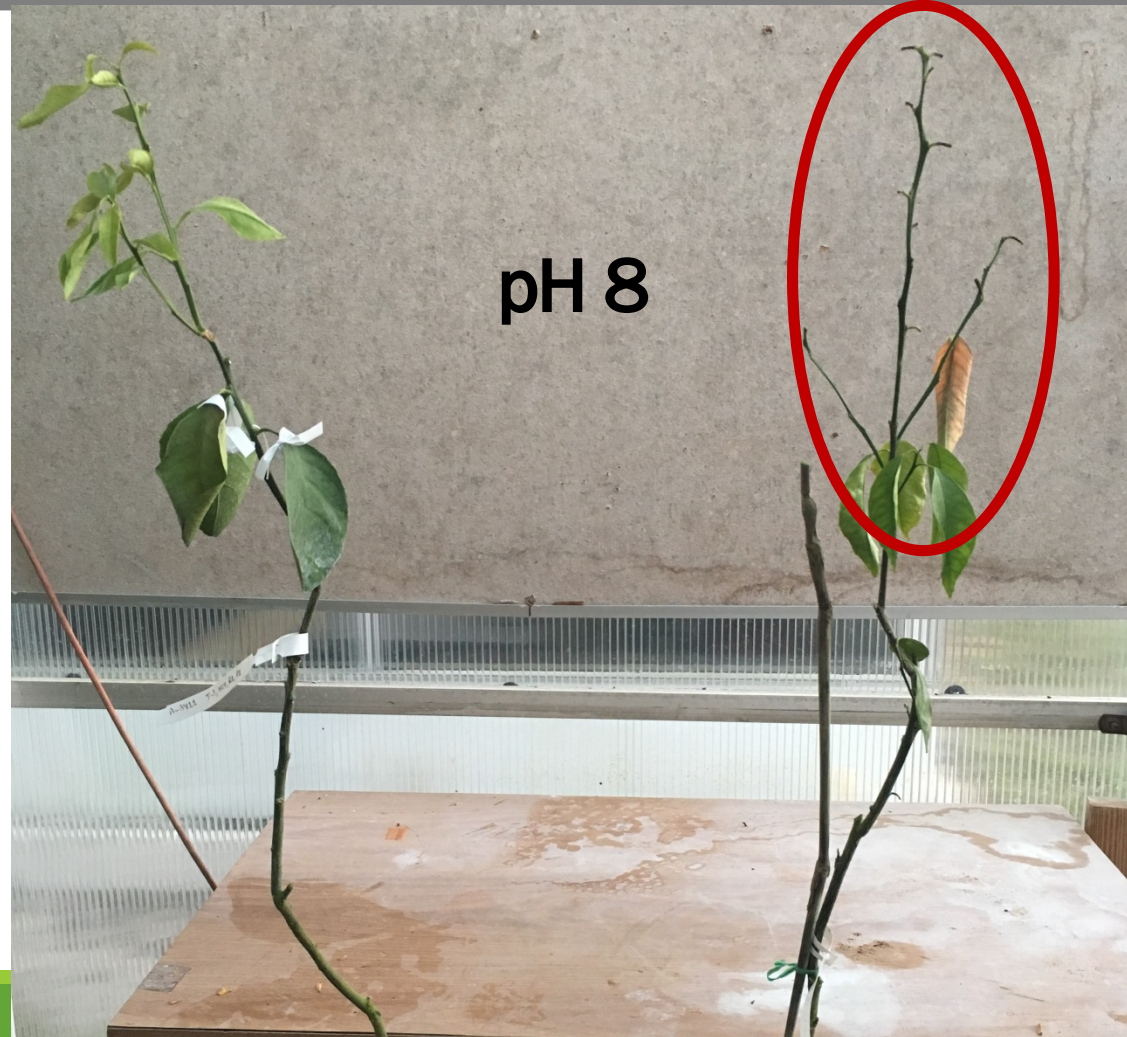
pH	Disease	Percent Dead plant (%)	Leaf Drop (%)
5.8	HLY	0 %	-21d
5.8	HLB	0 %	-16d
7	HLY	0 %	-50c
7	HLB	13 %	-57b
8	HLY	13 %	-60b
8	HLB	38 %	-83a

# Day 30: HLY vs HLB





# Day 30: HLY vs HLB



# Day 60: pH 5.8

HLY



HLB





# Day 60: pH 7.0

HLV



HLB





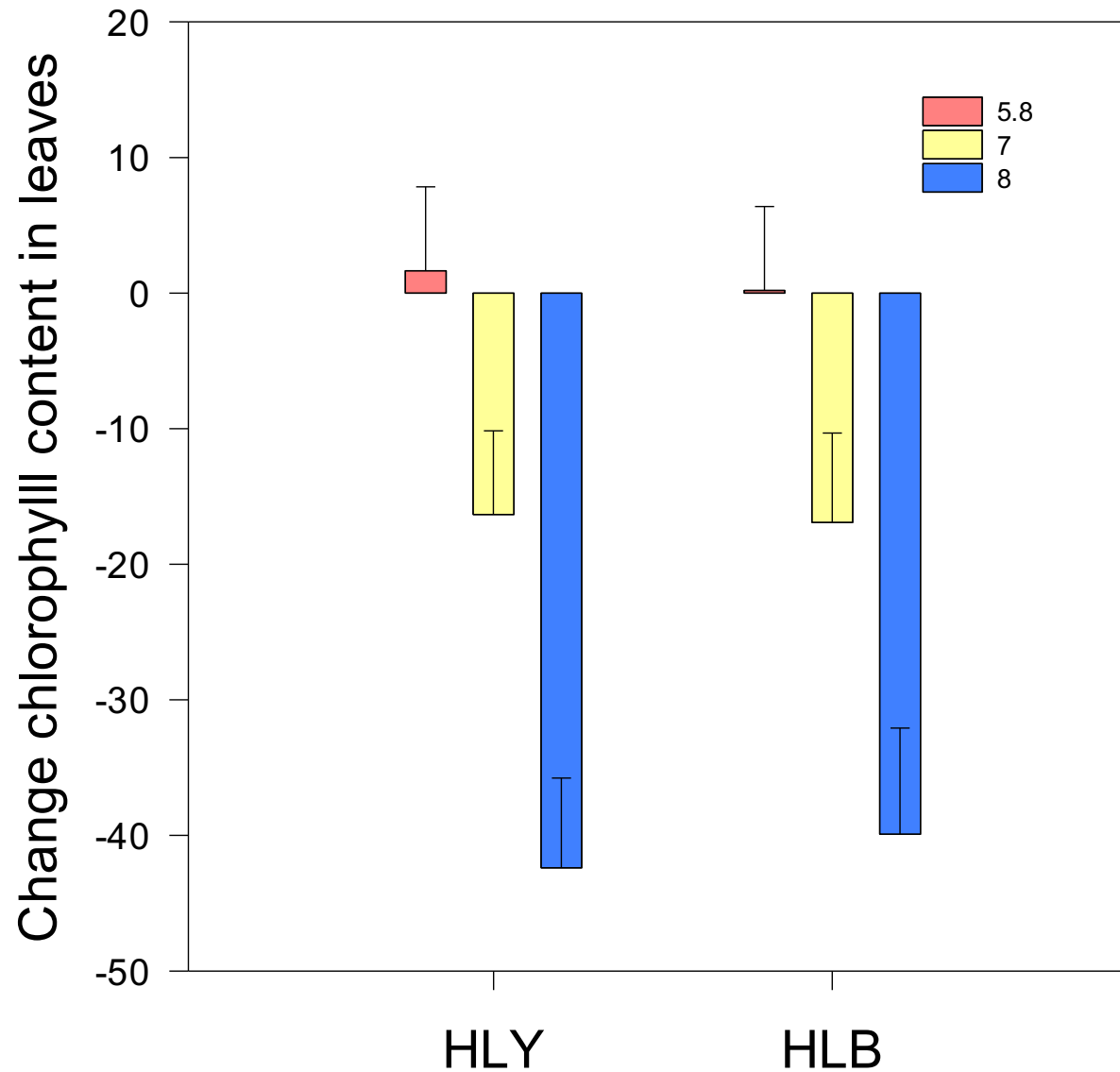
# Day 60: pH 8.0

HLV

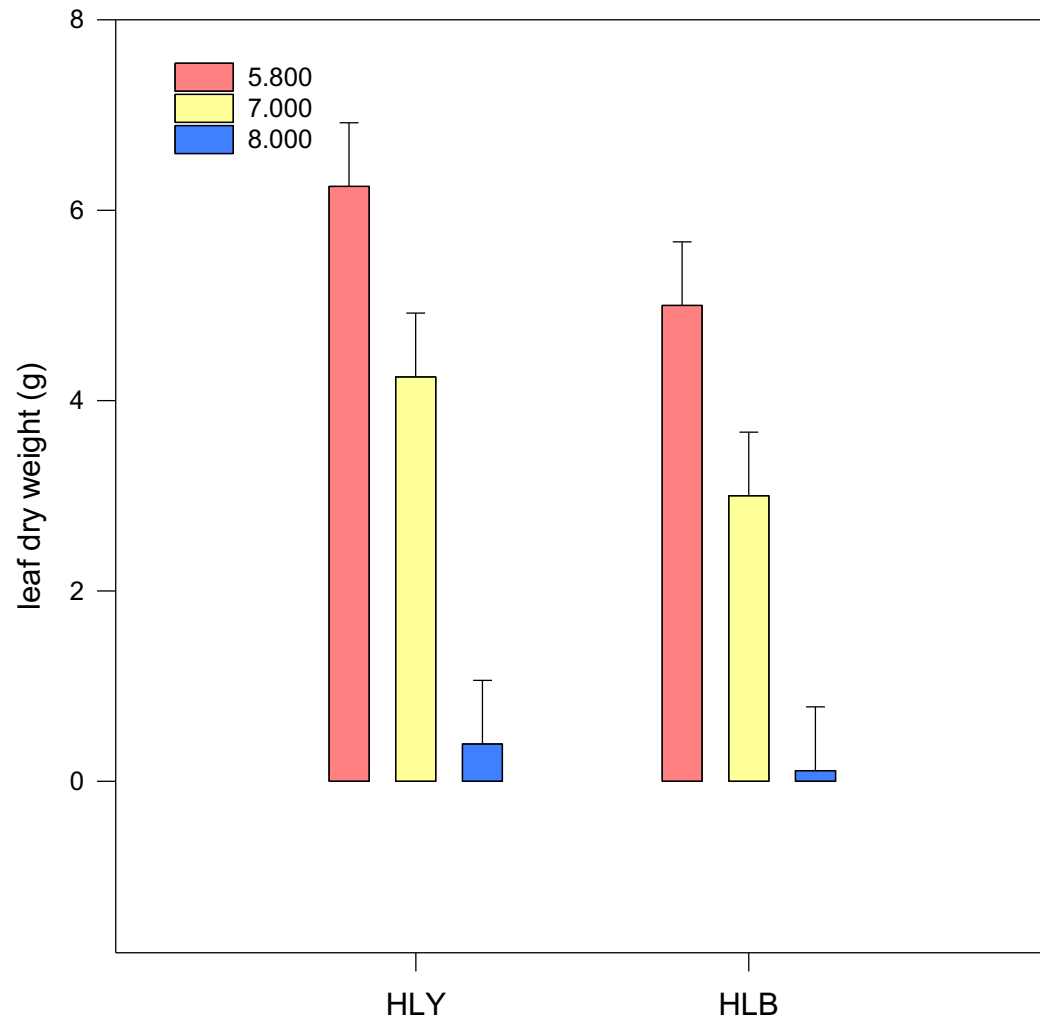


HLB

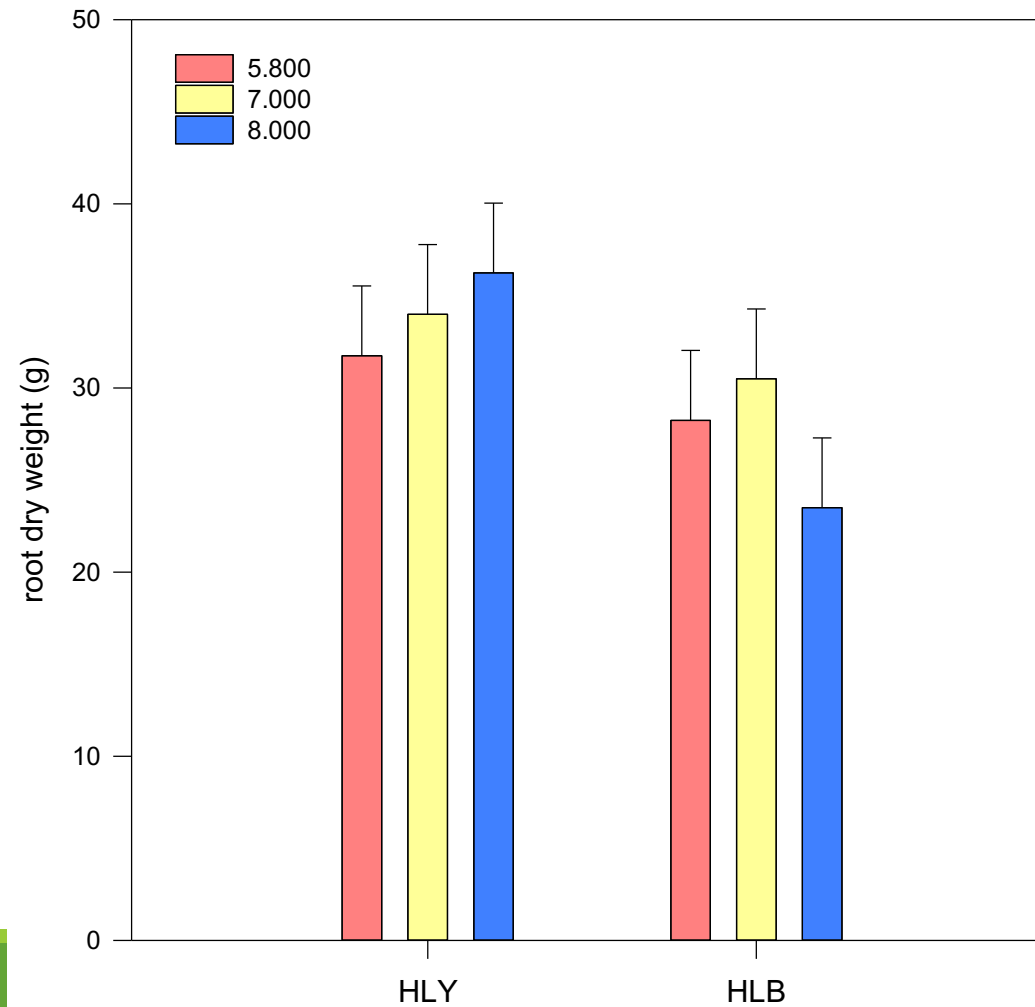


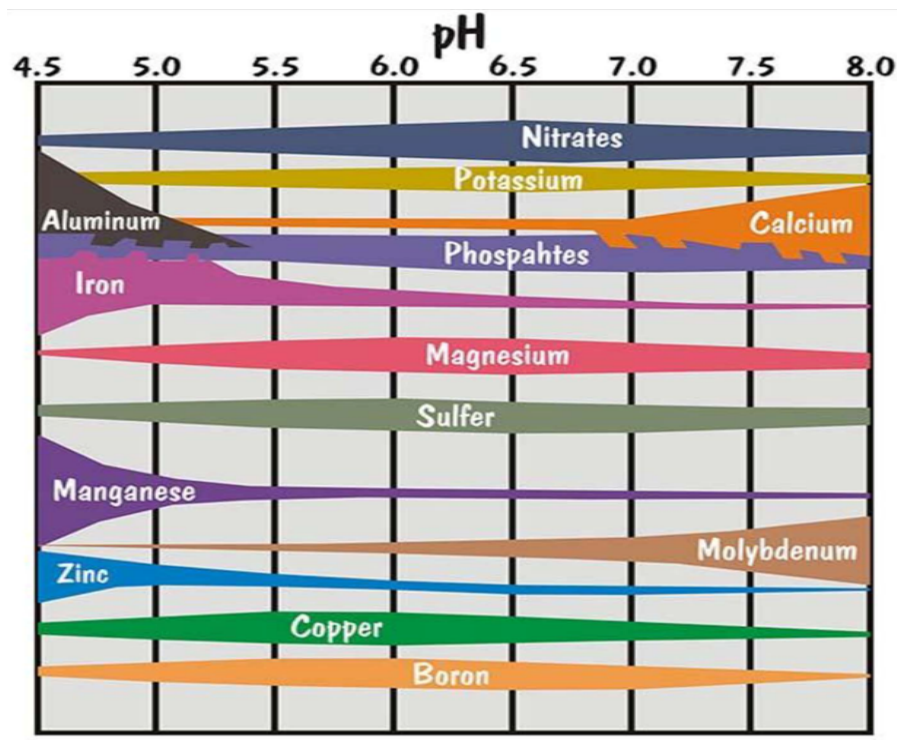


With higher pH, leaf chlorophyll content decreased significantly!



Irrigation water pH had significant effect on leaf dry weight however did not affect root biomass





Majority of the nutrient were in optimum to high level in treatments

However, no conclusion can be drawn from nutrient analysis as the leaf biomass was lower in HLB and higher pH treatments

		N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
5.8	HLY	2.8	1.0	3.4	0.3	1.9	0.4	66.4	30.7	65.7	147.8	8.9
5.8	HLB	3.1	1.1	3.8	0.3	1.6	0.5	80.3	35.8	98.3	146.6	8.5
7	HLY	2.8	0.5	2.7	0.3	1.6	0.5	55.7	25.1	51.8	137.7	7.9
7	HLB	3.5	0.5	3.2	0.3	2.0	0.6	90.8	33.3	110.2	170.2	9.3
8	HLY	2.7	0.62	2.61	0.34	1.6	0.42	54	28	74	106	8
8	HLB	3.2	0.22	2.03	0.17	0.9	0.26	46	11	85	99	4

# Growing media pH

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Midsweet grafted on Kuharske rootstock

Healthy plants (HLY)

HLB plants (HLB)

Nutrient solution

pH maintenance by  
adding acid & base  
(alternate days )

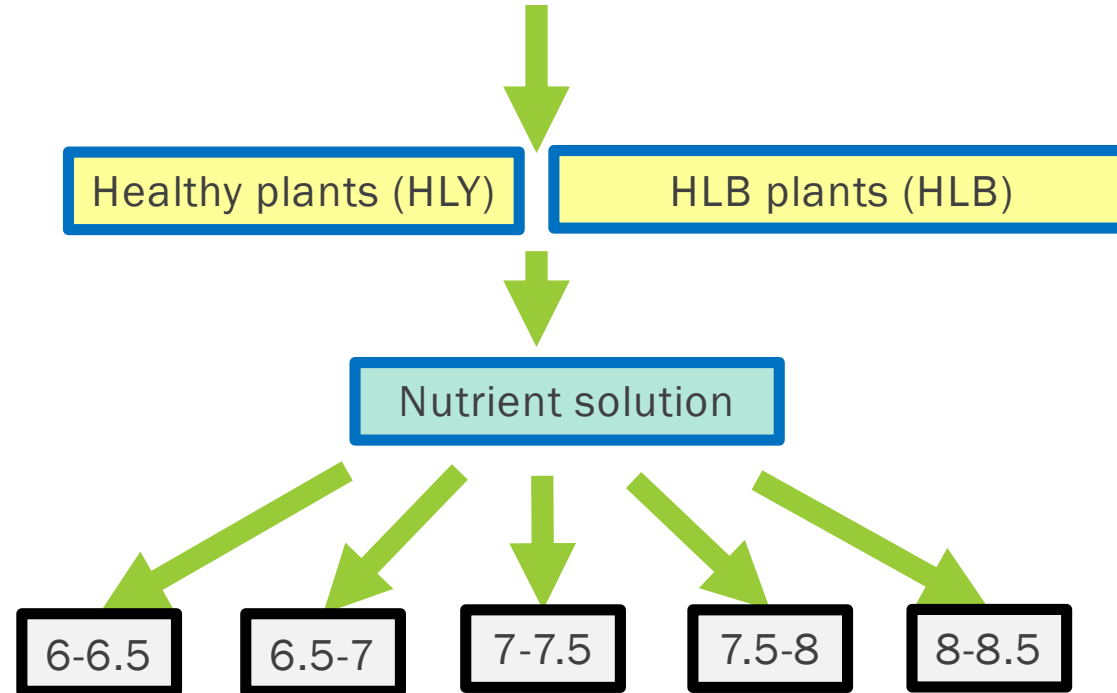
6-6.5

6.5-7

7-7.5

7.5-8

8-8.5





# At day 35, Healthy (HLY) and HLB plants at pH 6





HLB

pH 7

HLB

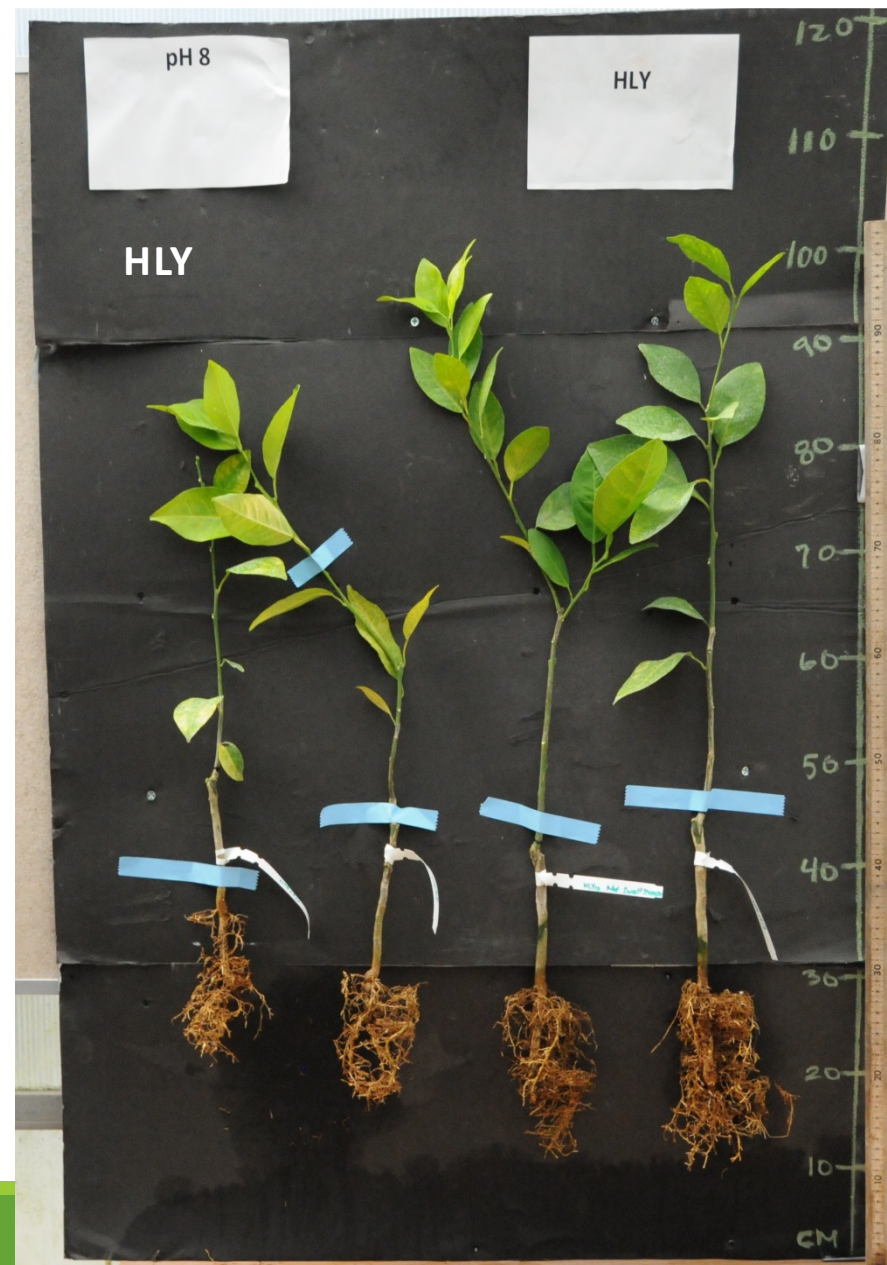
120  
110  
100  
90  
80  
70  
60  
50  
40  
30  
20  
10  
CM

This image shows four citrus seedlings arranged vertically against a black background. A ruler on the right side indicates height in centimeters, ranging from 0 to 120. The seedlings are labeled 'HLB' (Huanglongbing) and 'pH 7'. The seedlings show varying degrees of HLB symptoms, including yellowing and mottling of the leaves. The roots are visible at the bottom of each seedling.





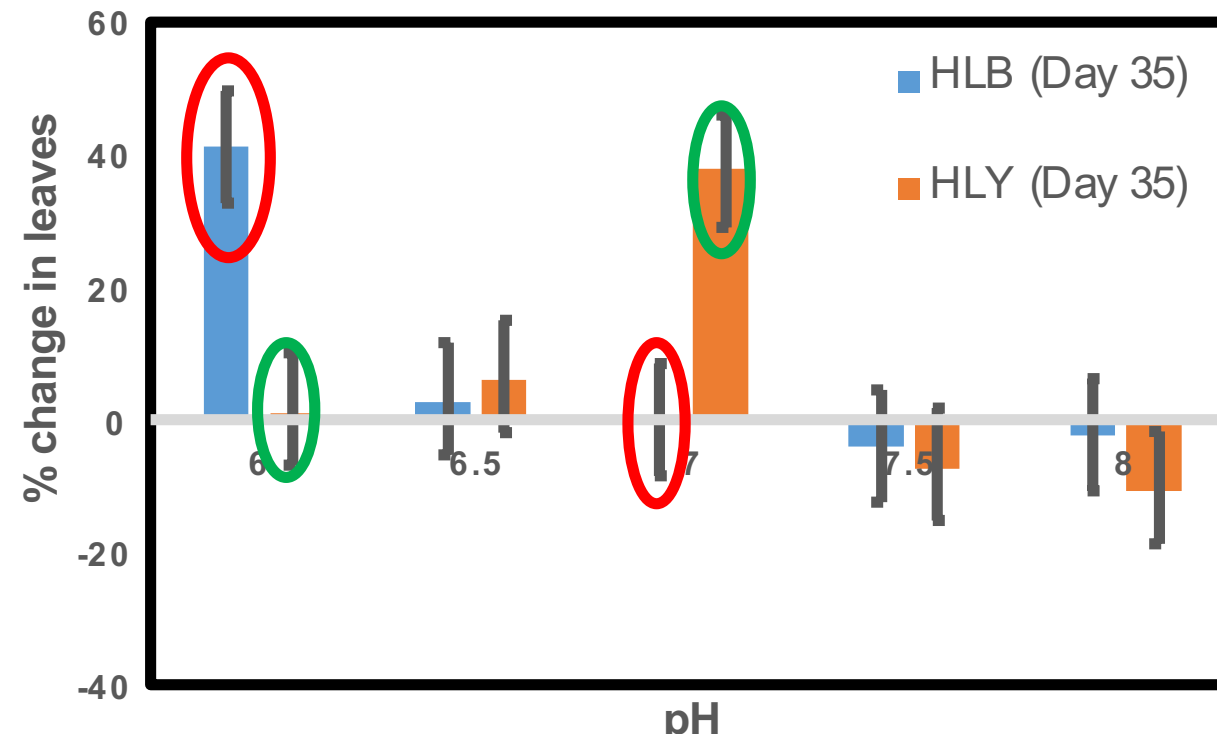
# At day 35, Healthy (HLY) and HLB plants at pH 8





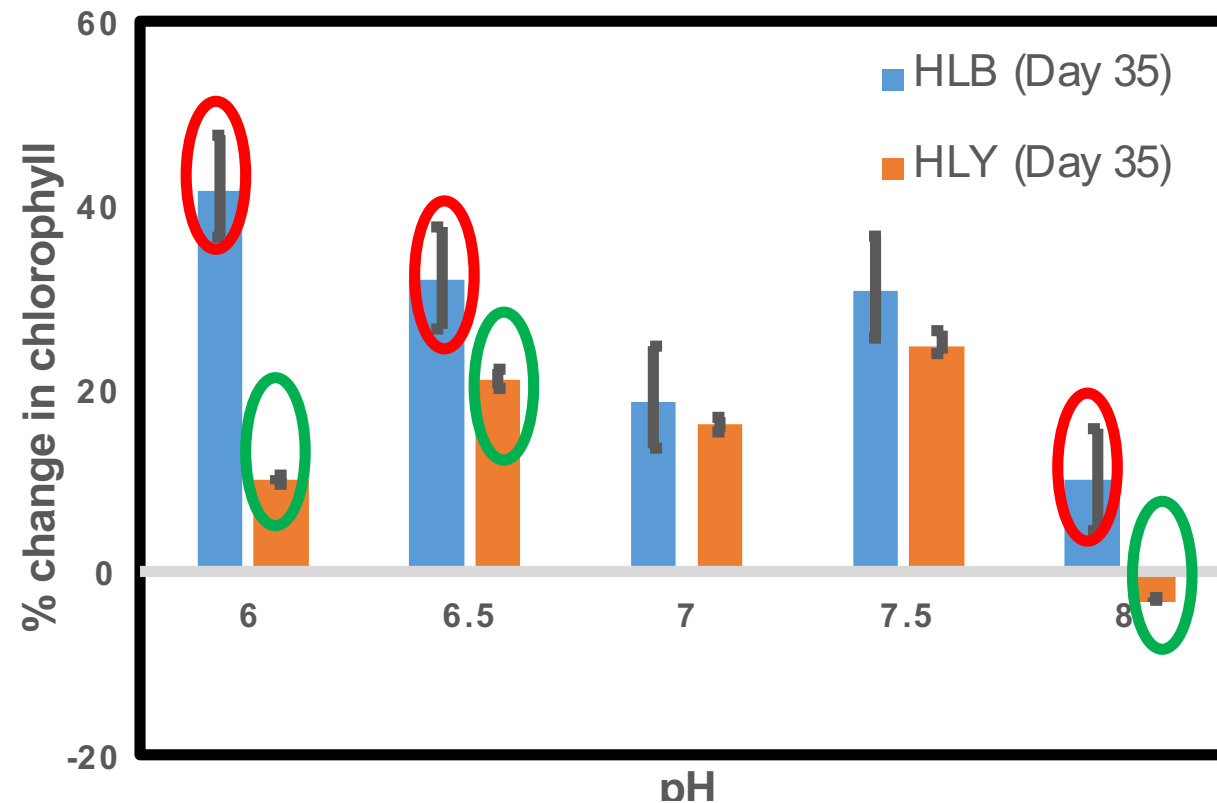
% change in number of leaves was higher for HLB plants at pH 6

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# % increase in chlorophyll content was higher in HLB plants than healthy plants

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# Take home message

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- HLB plants are performing significantly better when pH managed to be around 6
- pH adjustment should be a constant effort
- Constant supply of nutrients with 20-50% elevated levels of Manganese and Boron has shown to improve yield and fruit quality
- Ground applied fertilizer takes time to show effect
- Do not rely on foliar micronutrient as the sole source

# Thank you

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Dr. Jude Grosser

Dr. Davie Kadyampakeni

Peace river packing

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Jack Zorn

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