IMPLEMENTING FULL AND DEFICIT IRRIGATION PRACTICES USING SOIL MOISTURE AND SAPFLOW SENSORS FOR WATER SAVINGS IN CITRUS PRODUCTION SYSTEMS

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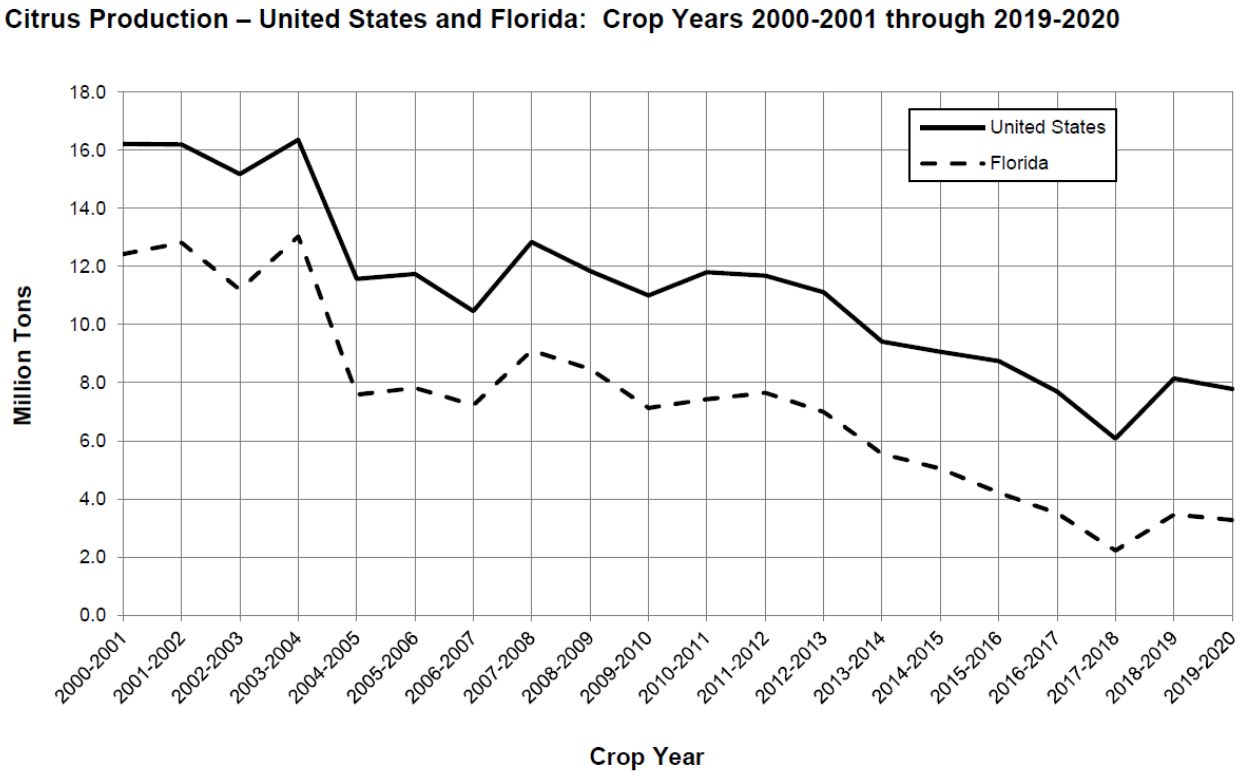
Current Status

Citrus contributes about $7 billion annually, employs about 33,000 workers in Florida (USDA-NASS, 2021)

72% decline in citrus production from 13.5 million tons about 3.2 million tons (USDA-NASS, 2021)

Citrus production decline has been ascribed largely to huanglongbing (HLB) (Hall et al., 2012)



Current Status (2)

Need for:

- Optimal water management: water savings and conservation, e.g. partial root zone drying (PRD), regulated deficit irrigation (RDI)
- Effective irrigation schedules
- Frequent fertigation practices

Objectives

- ***Objective 1:*** Develop robust and appropriately-scaled methods of irrigation scheduling using one or more soil-, plant- or weather-based approaches.
- ***Objective 2:*** Compare irrigation rates for citrus trees affected by Huanglongbing or citrus greening.

Irrigation strategies for managing citrus with HLB

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Studies on irrigation conducted in Florida:

- Irrigation studies at 3 sites: Ave Maria, Avon Park, Arcadia

➡ Comparison of Daily, IFAS and Intermediate Irrigation Schedules based on FAWN evapotranspiration

- Advanced Citrus Production Systems (ACPS) studies:

Two Sites: Immokalee SWFREC, and CREC, Lake Alfred

➡ Comparison of drip and modified microsprinkler irrigation with grower practices

- Greenhouse studies conducted at Immokalee, SWFREC & CREC

➡ Comparison of HLB vs non-HLB affected citrus

Irrigation strategies for managing citrus with HLB

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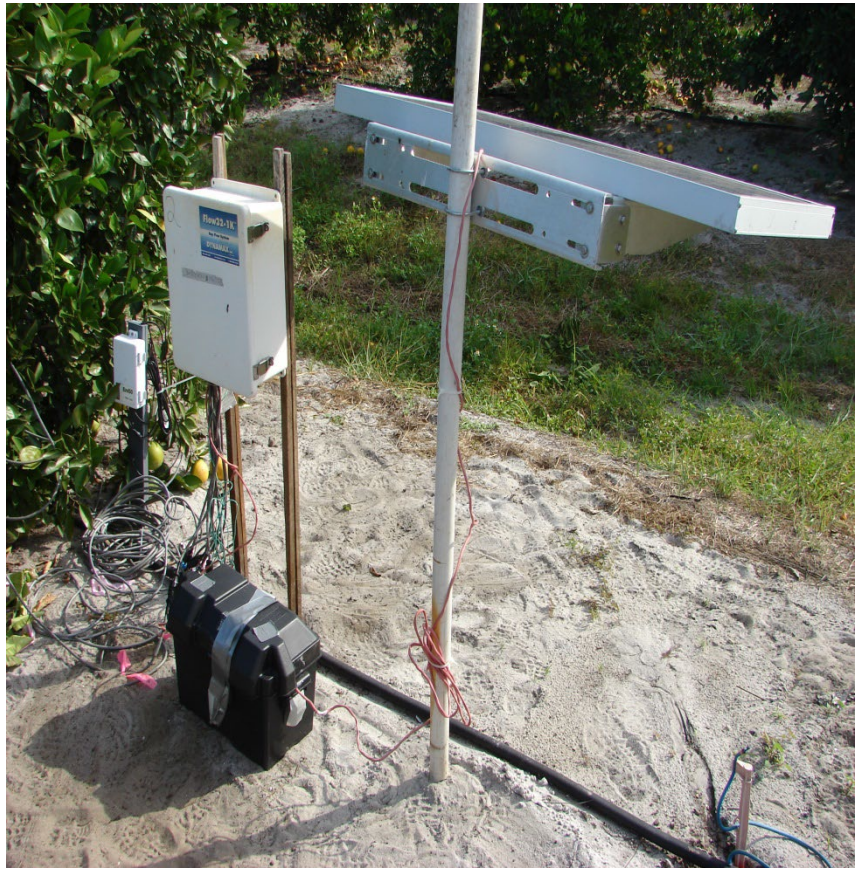
Field studies on irrigation:

Downloading soil moisture data

Decagon and CR1000 data loggers



Irrigation strategies for managing citrus with HLB

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Greenhouse studies on irrigation conducted in Florida (SWFREC)

Factorial Treatments

1. Valencia vs Hamlin
2. HLB positive vs. HLB Negative

Methods:

Automated weighing lysimetry using CR1000

Automated soil moisture monitoring

Weather recording

Irrigation strategies for managing citrus with HLB

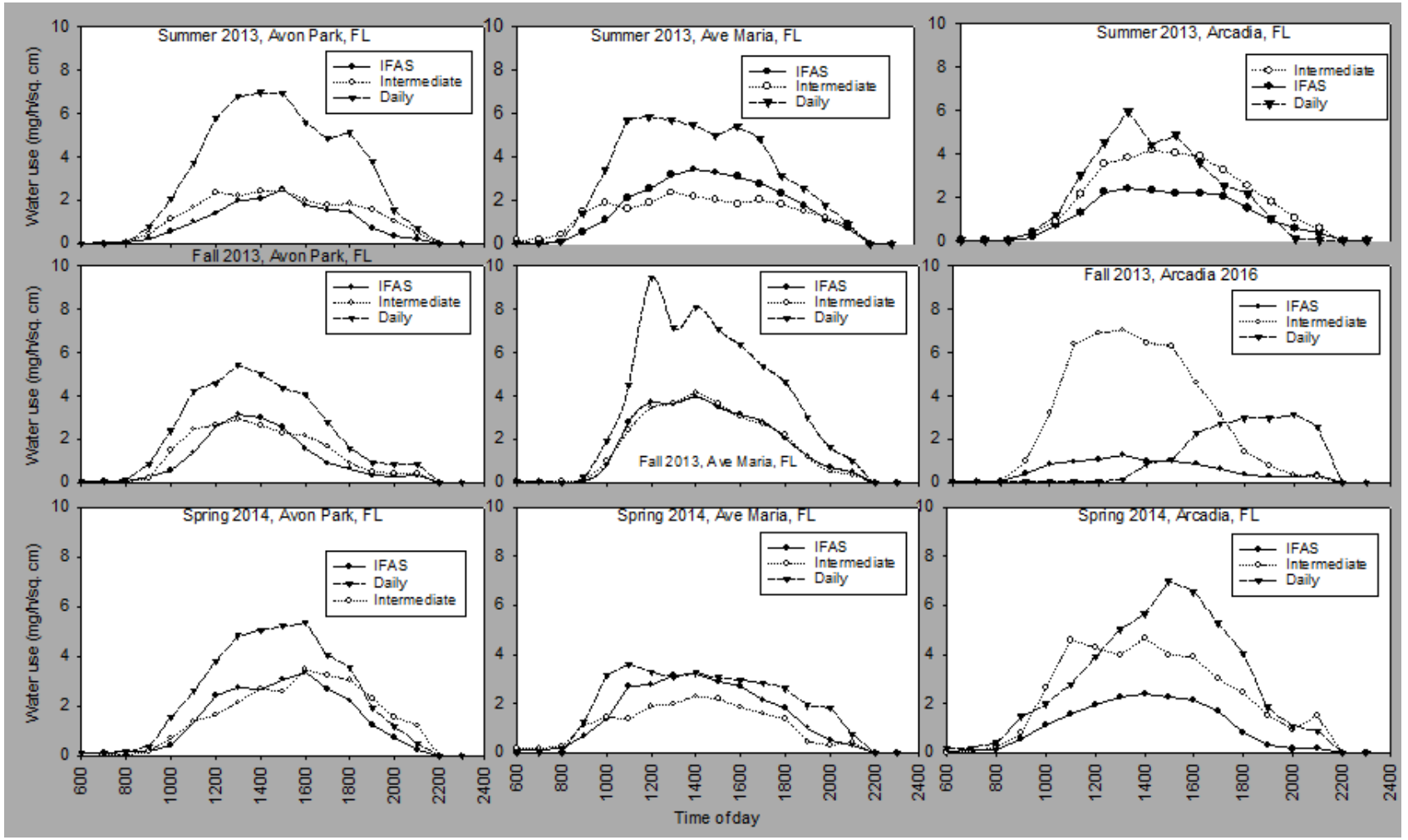
Treatments and experimental design at CREC

Treatment structure

- HLB
  - 100% ET
  - 80% ET
- Healthy (NHLB)
  - 100% ET
  - 80% ET

Experiment setup in the greenhouse

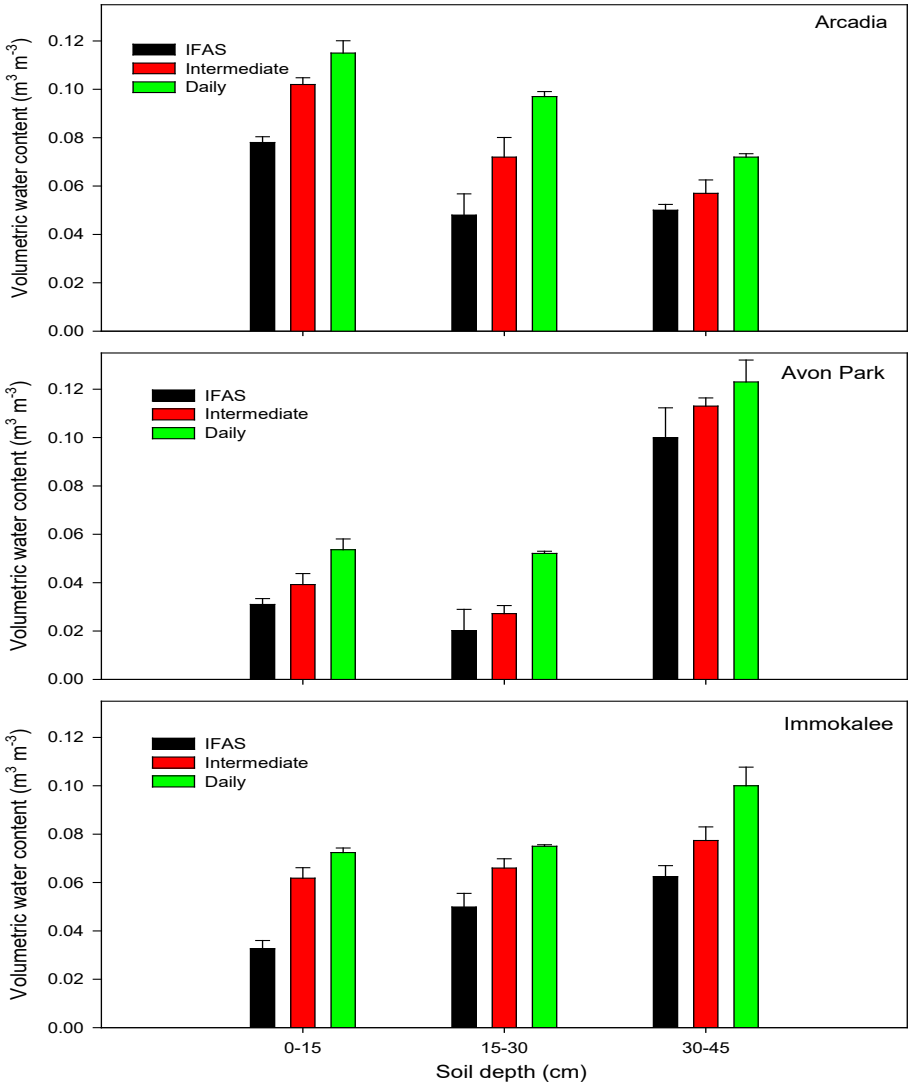
Irrigation studies

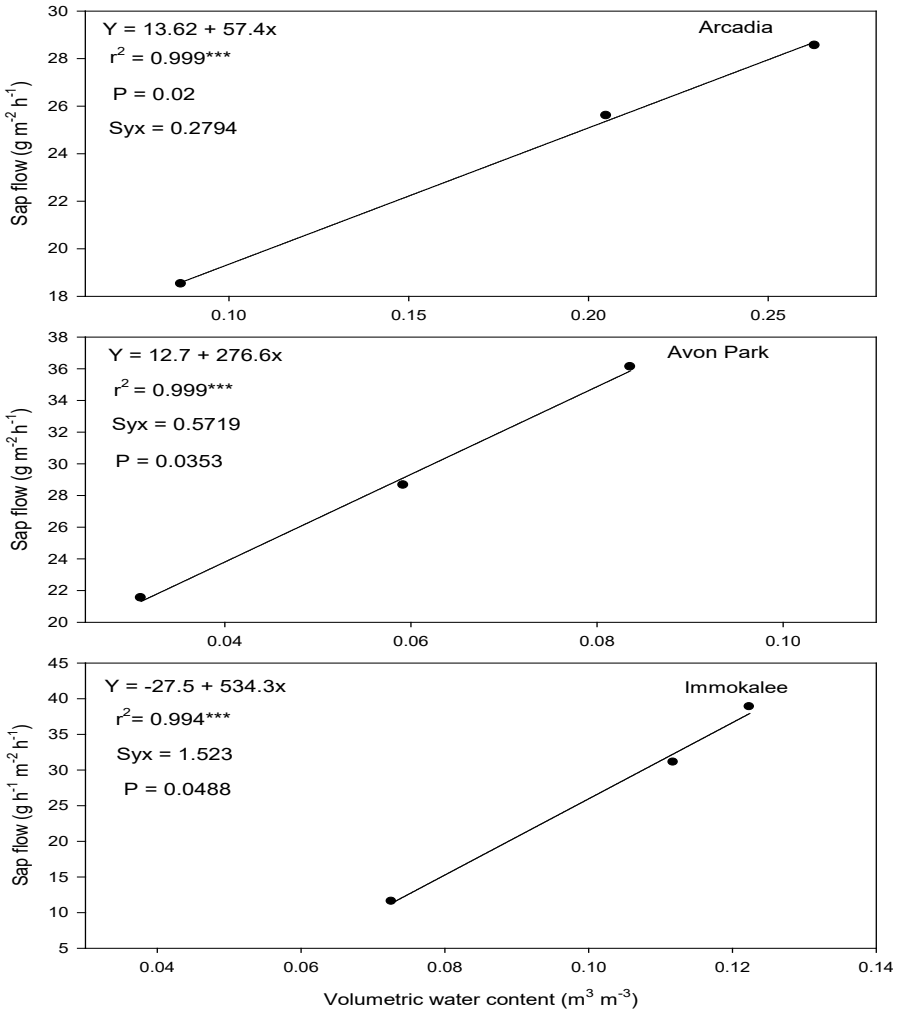


Water use of HLB affected trees in southwest and central Florida

- Daily > Intermediate > IFAS irrigation scheduling
- Daily irrigation could help in managing HLB affected trees, reduce tree water stress
- Kadyampakeni and Morgan (2017), Scientia Horticulturae

Irrigation studies (3)





Moisture contents and significant relationships with sapflow, Hamido et al. 2017

ACPS studies

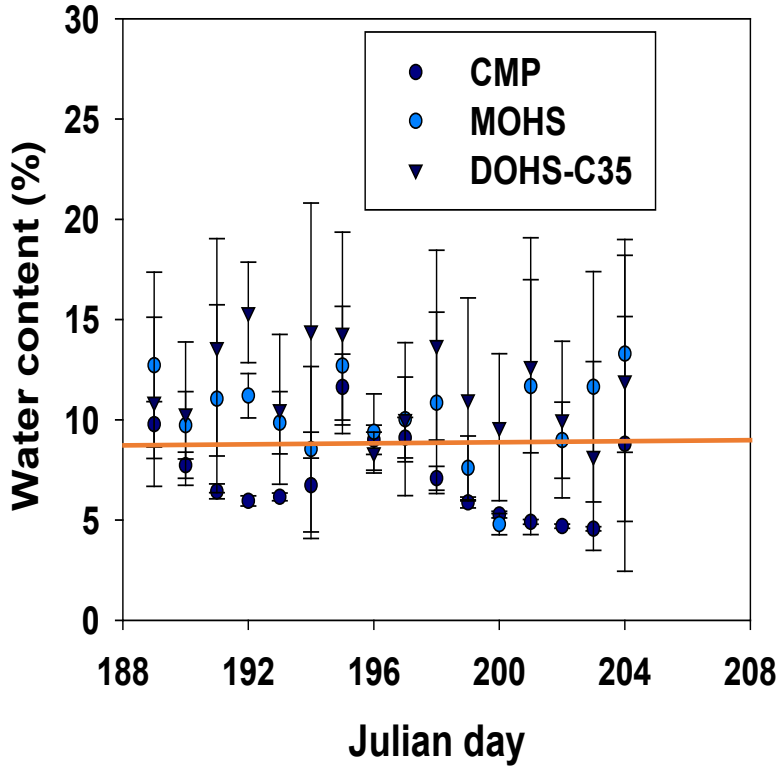
Irrigation method	HLB	Site	Water use per canopy vol. lbs/ft^3/d	Water use per leaf area lbs/ft^2/d
Conventional	-	Ridge	0.28±0.13a	0.35±0.20a
Drip	-	Ridge	0.24±0.01a	0.24±0.01a
RM	-	Ridge	0.20±0.18a	0.23±0.20a
Conventional	+	Flatwoods	0.19±0.05a	0.24±0.04a
Drip	+	Flatwoods	0.28±0.10a	0.29±0.08a
RM	+	Flatwoods	0.19±0.09a	0.46±0.19a

RM=Restricted microsprinkler.

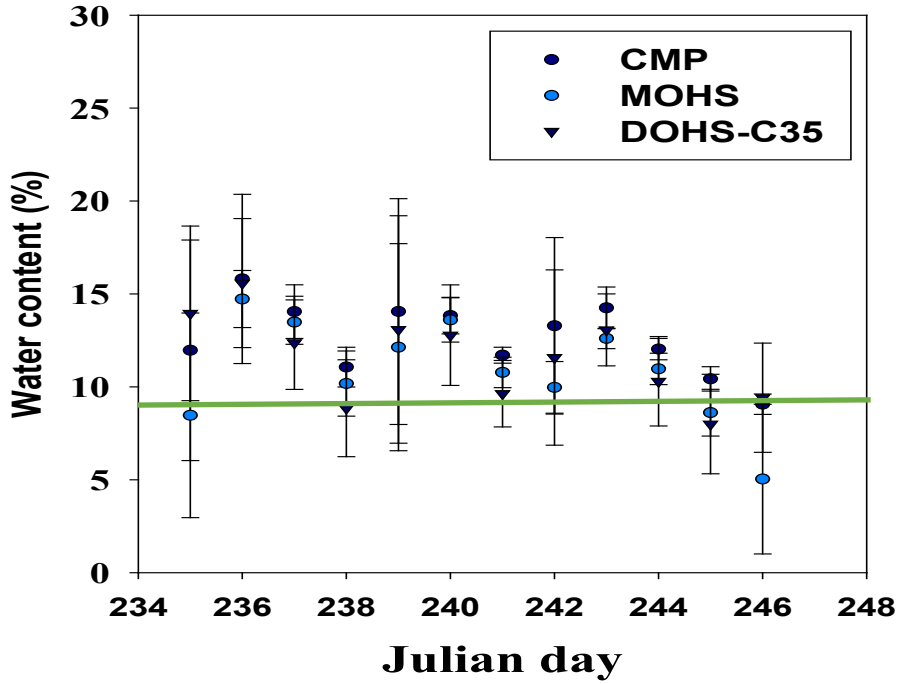
•Daily water use was not statistically different between the ACPS irrigation methods compared with the Conventional grower practices even though irrigated area is smaller. (Kadyampakeni et al. (2014) SSSAJ

ACPS (2)

Soil moisture at 10 cm was close to or slightly above field capacity in the range of 7 and 15%



July 2010



Aug-Sept 2011

Greenhouse studies (1)

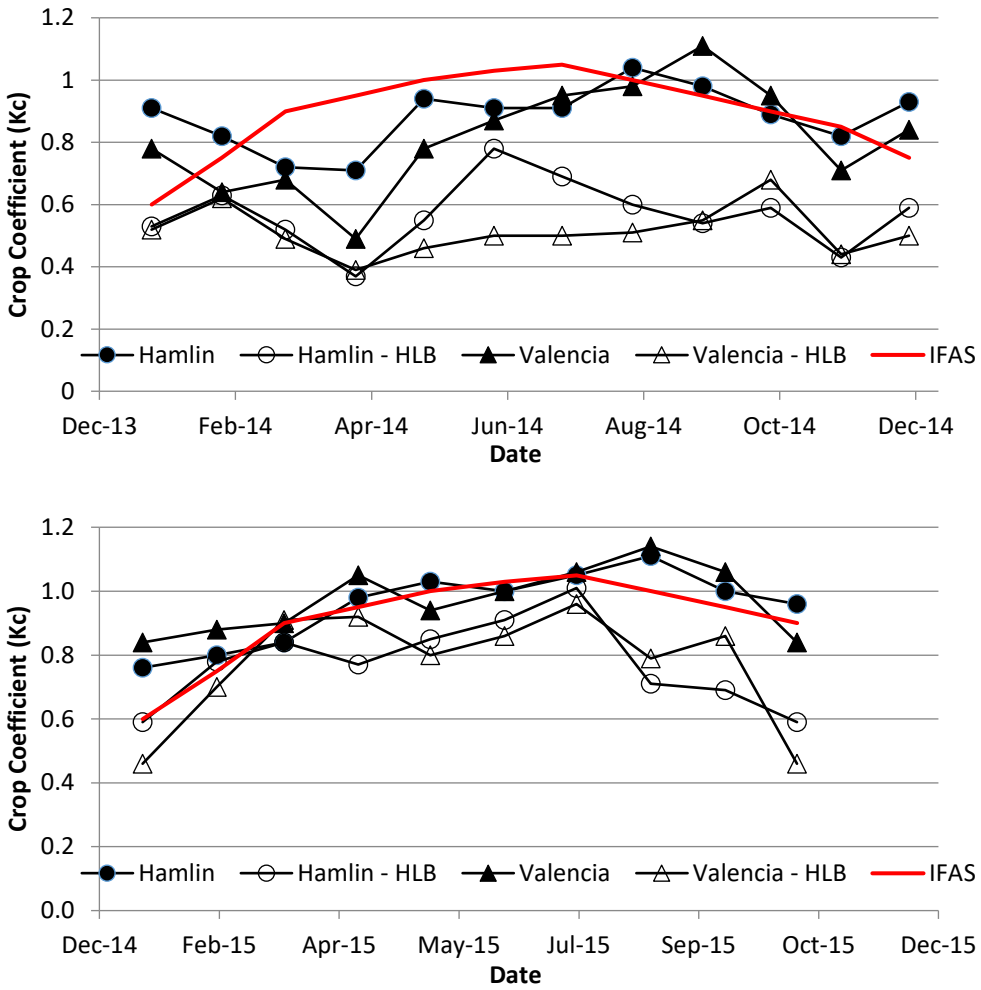
Water use of HLB affected trees in southwest Florida under greenhouse conditions

Month -year	ET_o (mm d^{-1})	ET_c (mm d^{-1})		ET_c diff. (%)‡
		Hamlin-Non HLB	Hamlin-HLB	
Jan-Jun-14	3.57	2.97	2.23	23.73
Jul-Dec-14	4.42	4.16	2.63	34.82
Jan-Jun-2015	3.38	4.08	2.83	29.82
Jun-Oct-15	3.73	4.94	3.18	35.20
Overall Average	3.79	4.00a**	2.69b**	30.75
		Valencia-Non HLB	Valencia-HLB	
Jan-Jun-14	3.57	2.83	2.22	22.28
Jul-Dec-14	4.42	3.97	2.83	28.85
Jan-Jun-2015	3.38	3.85	2.69	30.98
Jun-Oct-15	3.73	4.79	3.56	26.42
Overall Average	3.79	3.82a**	2.80b**	26.99**

- 22 to 35% greater water use for Non-HLB affected trees
- Inter-season and annual variability in water use
- Comparable water use between varieties

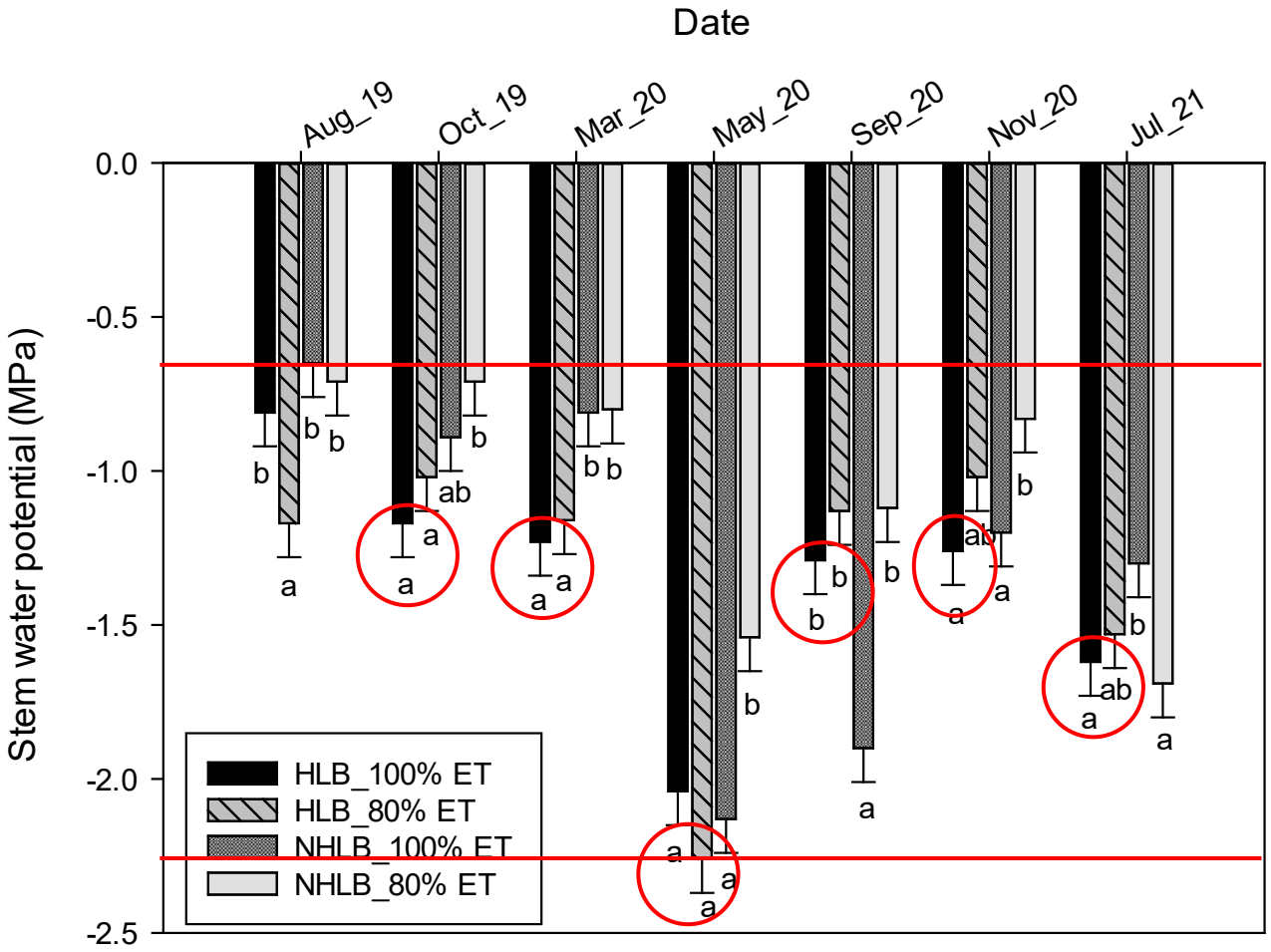
Greenhouse studies (2)

- Patterns of K_c similar for HLB affected and non-affected trees
- Non-affected tree K_c similar to those found to field trees prior to greening
- Infected trees consistently with lower K_c
- 35.2% in 2014 and 20.8% in 2015

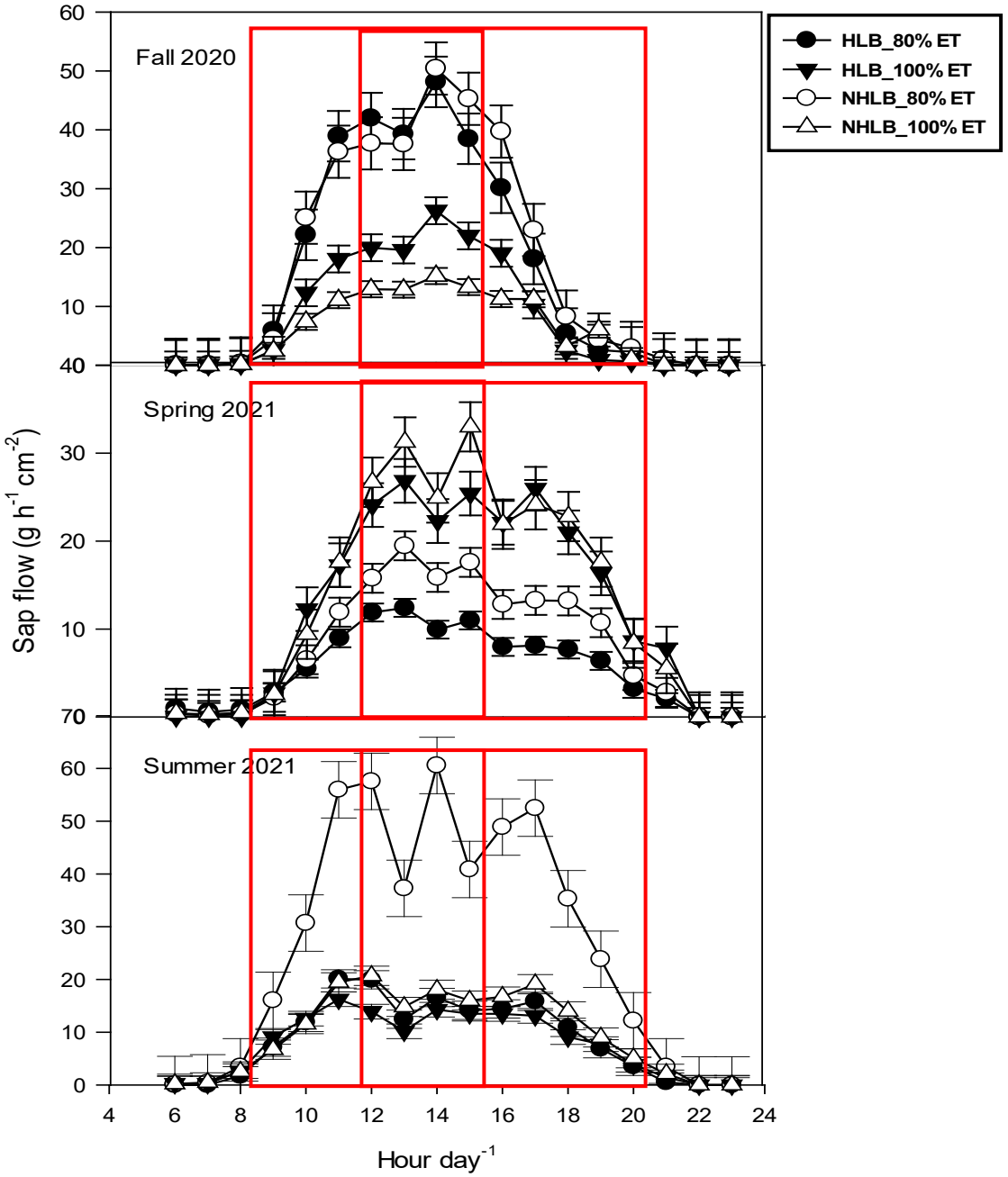


Crop coefficient (Kc) for HLB affected trees in southwest Florida under greenhouse conditions

Effect of treatments on stem water potential (SWP)



- SWP was significantly different (P <0.001) among treatments
- SWP ranged from -2.4 and -0.6 MPa
- The HLB-affected trees under both 80% and 100% ET had similar SWP for all but Aug_2019
- Kwakye (2022), PhD Dissertation



Effect on water use

- Generally, sap flow occurred between 8 and 20 h daily.
- Sap flow (g h^{-1} cm^{-2}) peaked around 12 and 15 h, need to water plants before 9 am to coincide with peak water use.
- Trees under 80% ET had at least 30% greater sap flow than those under 100% ET in Fall 2020
- However, in Spring 2021 trees under 80% ET had at least 28% greater sap flow than those under 100% ET for both HLB and NHLB trees
- Kwakye (2022), PhD Dissertation

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Summary

- Daily, frequent irrigation critical for improved tree performance, soil moisture distribution and water use
- HLB affected trees use 22 to 35% less water than the non-affected trees.
- ACPS practices could be adapted to grower practices for vigorous tree growth, and water use.
- Deficit irrigation practices (80% ET) comparable with full irrigation (100% ET)
- Irrigating trees early in the day is recommended to optimize tree water use and irrigation efficiency.

Future focus for Smartirrigation

- Precision water and irrigation management in row and horticultural crops: quantify savings, fine-tune BMPs and improve efficiency
- Develop new models fitting emerging planting and irrigation system configurations
- Improve water/nutrient management and efficiencies in traditional irrigation systems e.g. seepage and/or flood irrigation
- Scale up variable rate irrigation/nutrient management and automation innovations
- More work needs to be done to increase adoption rates of technologies

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