Irrigation scheduling for improved tree performance of HLB-affected trees

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Key points and takeaways

- Reduced water amounts can result in smaller trees and increased time to initial harvest.

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

- Higher irrigation amounts could result in loss of nutrients and herbicides from citrus root zone through deep percolation and surface runoff.

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- Daily irrigation resulted in improved irrigation management compared with current IFAS or Intermediate irrigation schedule.
- Water uptake or use reduction was proportional to leaf area reduction for HLB affected trees.

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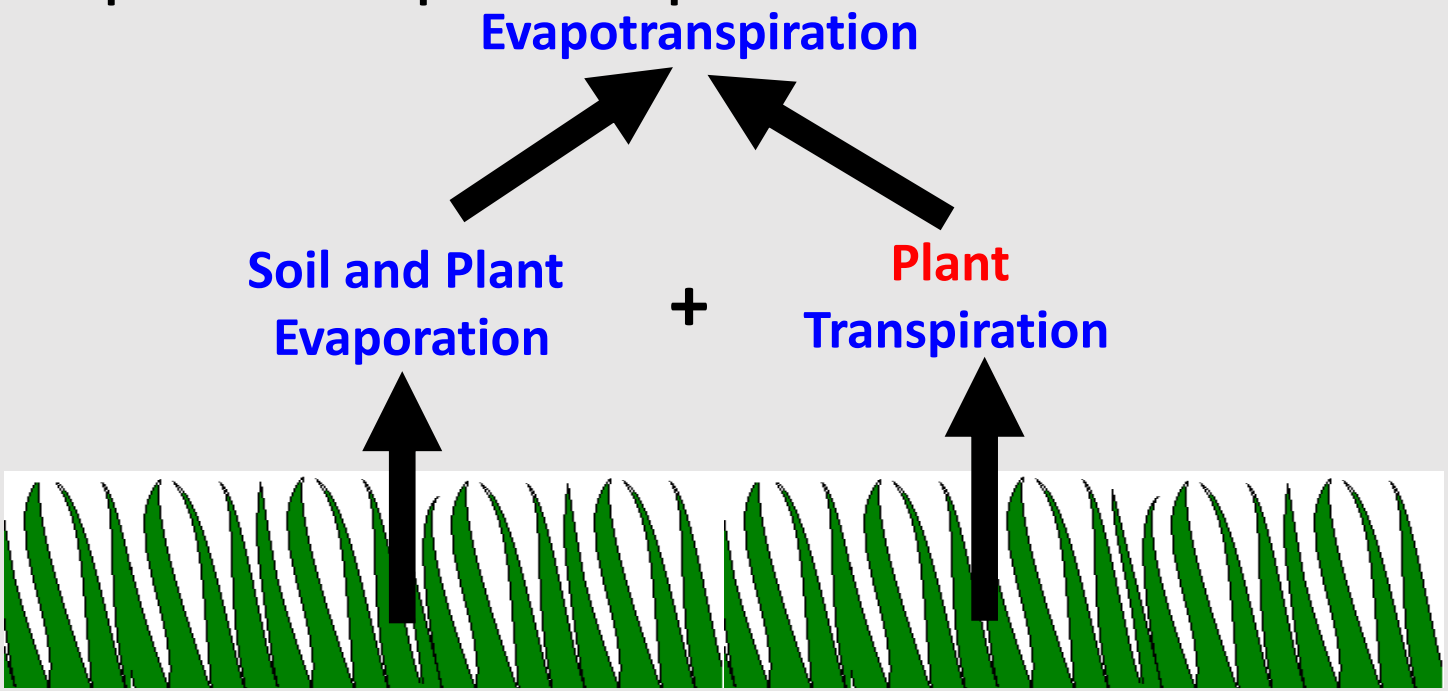
Evapotranspiration (ET)

Definition: The loss of water from a vegetated surface through the combined processes of soil and plant evaporation and plant transpiration



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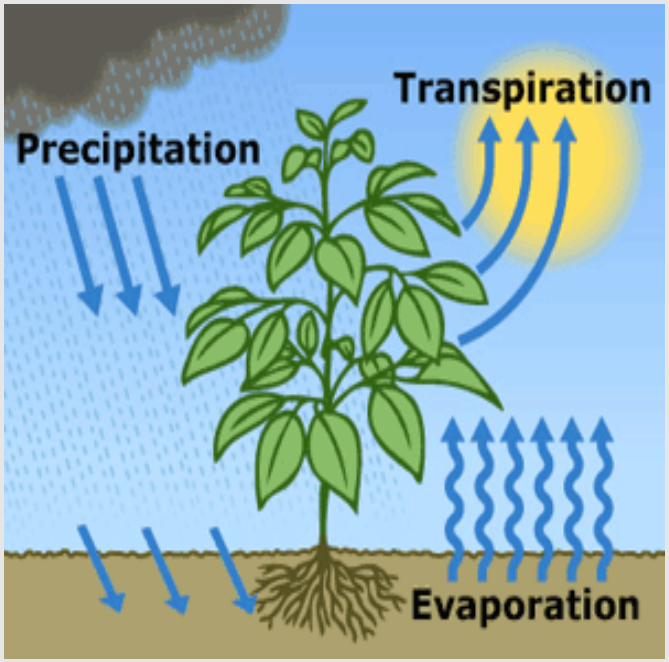
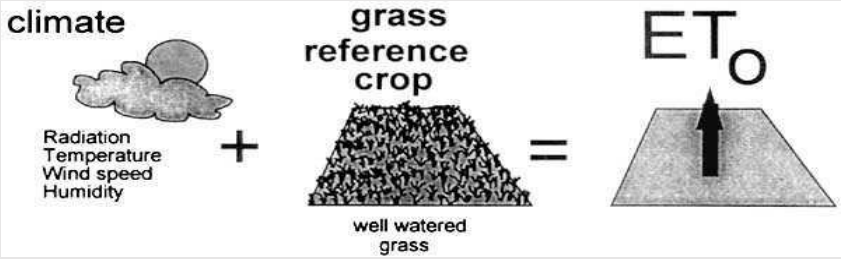
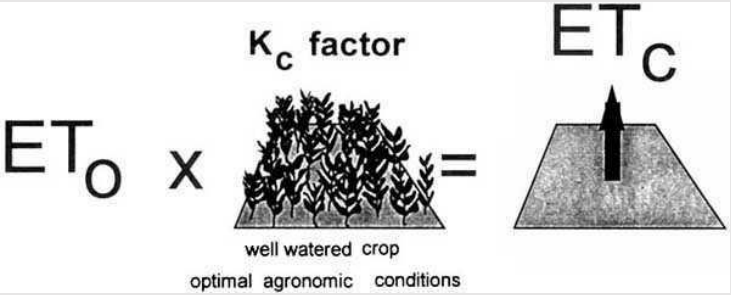


Reference ET vs. Crop ET

Reference ET (ETo): The evapotranspiration from a hypothetical grass reference crop.



Actual ET (ETc): The crop evapotranspiration under standard conditions



Adopted from: Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. *Crop Evapotranspiration. Guidelines for Computing Crop Water Requirements*. FAO Irrig. and Drain. Paper No. 56, Rome, Italy.

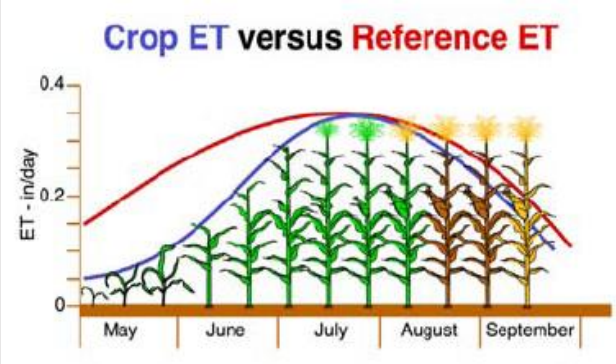
Crop Evapotranspiration (ET_c)

- $ET_c = ET_o * K_c * K_s$

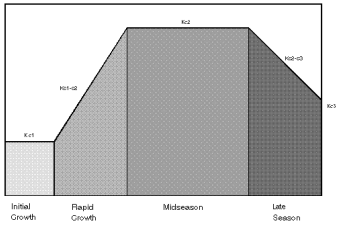
- Where,
- ET_o = Reference ET.
- K_c = Crop Coefficient,
- K_s = Soil water extraction factor.

Crop Evapotranspiration

- ET provides reference measure of water use based on plant water demand
- Scalable for specific crop, growth stage, climate, and season of year
- $ET_c = ET_o * K_c$

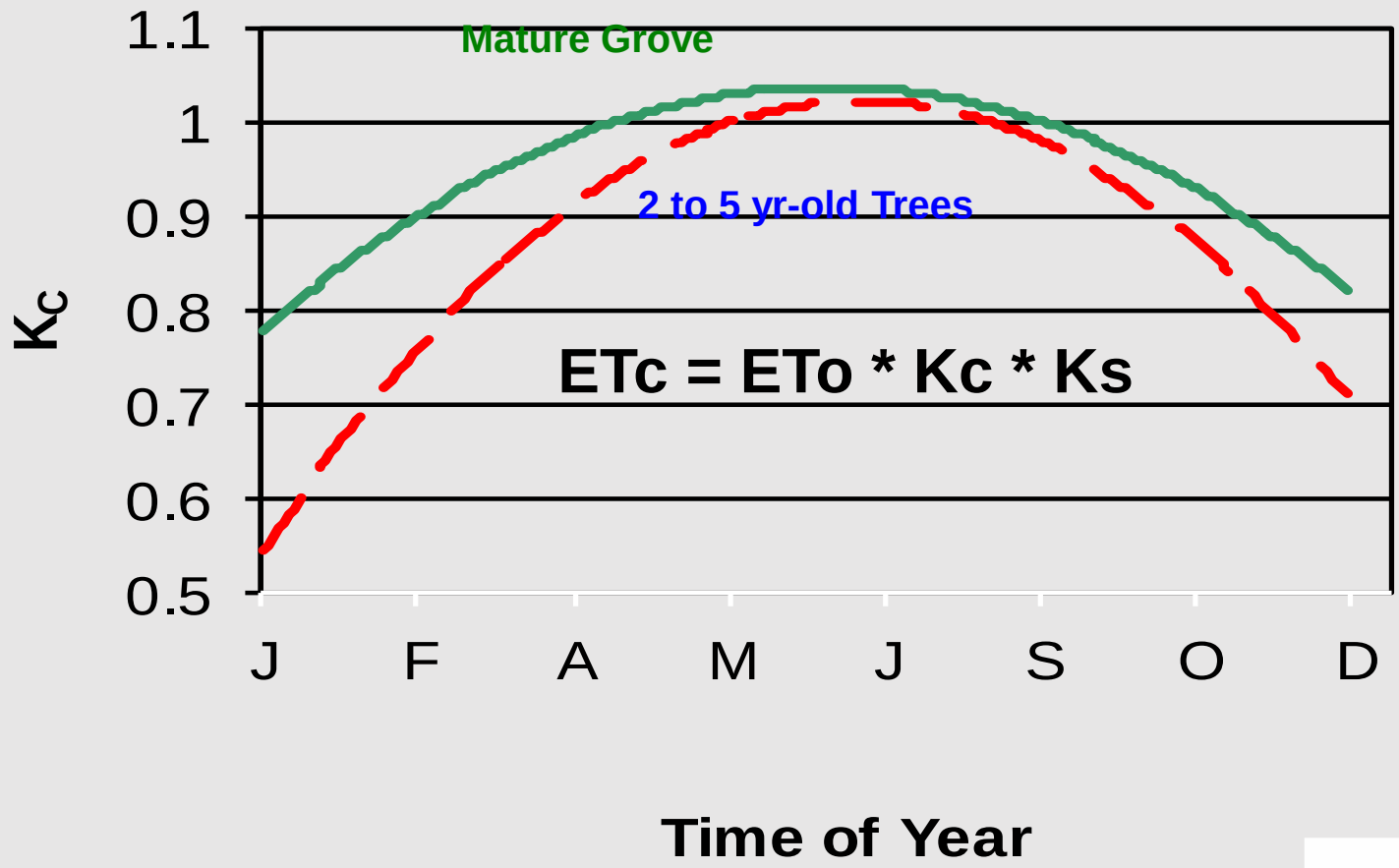


Generalized Crop Coeffecients and Crop Growth Stages



K_c Values	Growth Stage	Description
K_{c1}	Initial	The average K_C value from planting to about 10% ground cover.
K_{c1}-K_{c2}	Rapid Growth	From 10% ground cover to 75% cover or to peak water use, which ever comes first.
K_{c2}	Midseason	The average value from the end of the rapid growth stage until water use begins to decline due to crop aging.
K_{c2}-K_{c3}	Lateseason	From when K_C begins to decline until harvest or when water use ceases or becomes minimal.

Effect of Time of Year



Computer Programs

- Web based
  - Schedule based on nearest FAWN station
  - Enter: Field capacity, spacing, irrigation specifications
- PC Irrigation program
  - Same information required
  - Stores irrigation data
  - Print reports
- Smart Phone Apps
  - Use real-time data
  - Irrigation schedule in units of time
  - Send notifications and forecasted probability of rainfall

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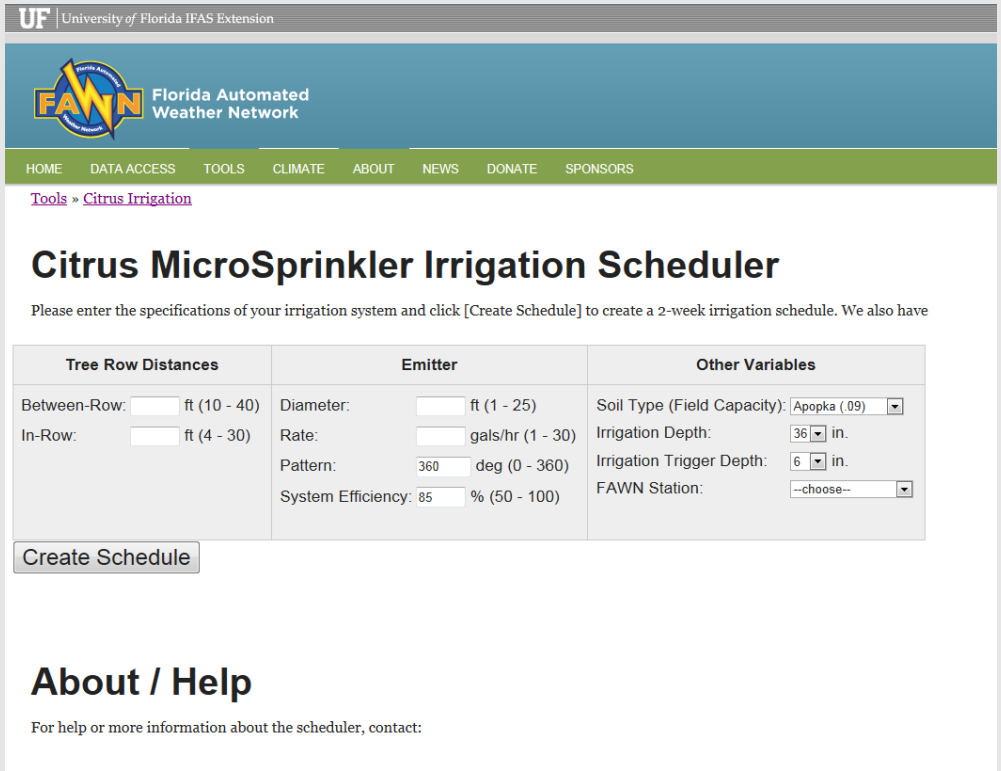
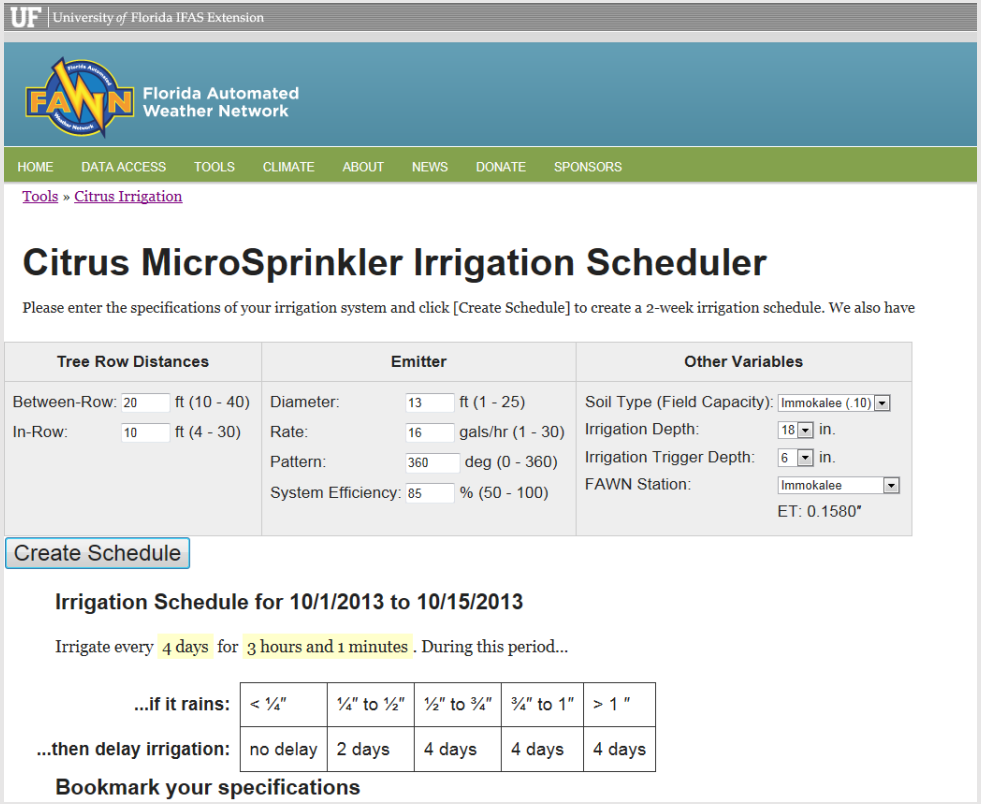
Irrigation Scheduler - Input



- Irrigation Schedulers
  - Citrus
  - Vegetable,
  - Strawberry
  - Row crops
  - Turf grass

Irrigation Scheduler - Output



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Florida Automated Weather Network

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Tools » Citrus Irrigation

Citrus MicroSprinkler Irrigation Scheduler

Please enter the specifications of your irrigation system and click [Create Schedule] to create a 2-week irrigation schedule. We also have

Tree Row Distances		Emitter		Other Variables	
Between-Row:	20 ft (10 - 40)	Diameter:	13 ft (1 - 25)	Soil Type (Field Capacity):	Immokalee (.10)
In-Row:	10 ft (4 - 30)	Rate:	16 gals/hr (1 - 30)	Irrigation Depth:	18 in.
		Pattern:	360 deg (0 - 360)	Irrigation Trigger Depth:	6 in.
		System Efficiency:	85 % (50 - 100)	FAWN Station:	Immokalee
					ET: 0.1580"

Create Schedule

Irrigation Schedule for 10/1/2013 to 10/15/2013

Irrigate every 4 days for 3 hours and 1 minutes. During this period...

...if it rains:	< ¼"	¼" to ½"	½" to ¾"	¾" to 1"	> 1 "
...then delay irrigation:	no delay	2 days	4 days	4 days	4 days

Bookmark your specifications

- **Provides record of inputs**
- **Two week schedule based on ET**
- **Delay for rainfall**

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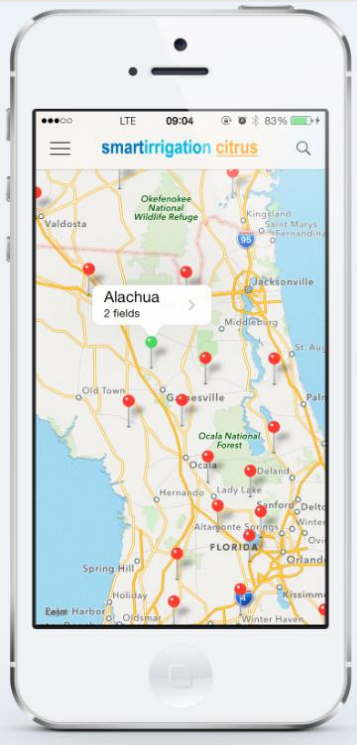
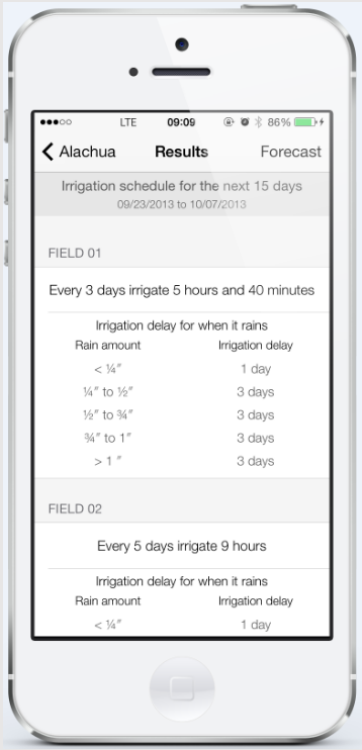
Smartphone Apps





- I phone or Android
- FAWN ET, expand to grower weather stations
- Real-time data
- Citrus, Strawberry, Turf, expand to row crops, vegetable

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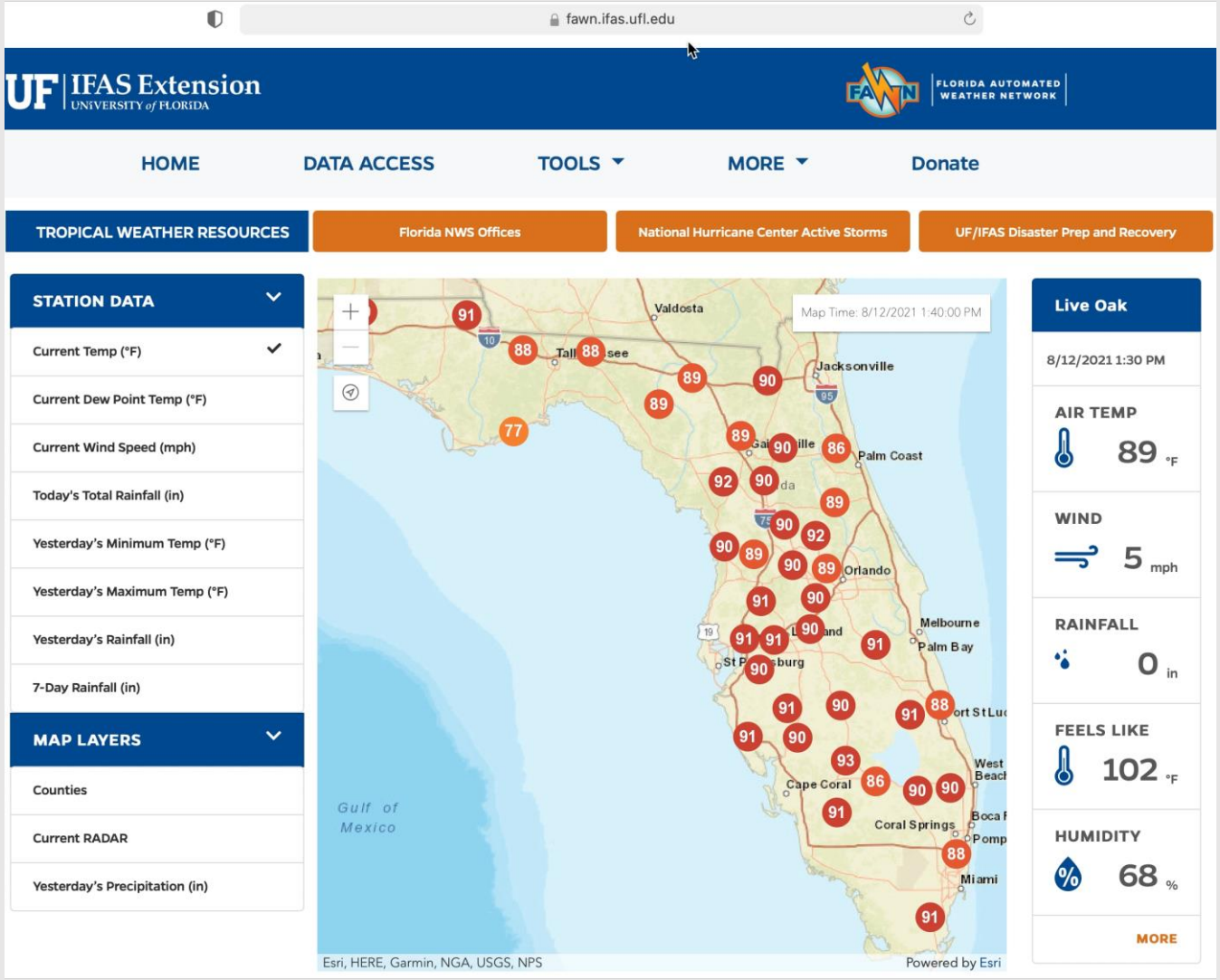
Irrigation: Helpful tools to meet tree water requirements

- FAWN weather stations can be used along with irrigation apps to schedule irrigation and reduce nutrient leaching.
- FAWN-based irrigation scheduling prevented soil NO_3 leaching below 15 cm (6 inches)

https://fawn.ifas.ufl.edu



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Factors impacting irrigation decisions

- Irrigation decisions should be based on use of soil moisture sensors recommended for Florida sandy soils to minimize nutrient leaching.
- It is good to also use soil moisture sensors to help determine if enough water is maintained in the root zone.

Soil Water Sensors (pros/cons)

Tensiometer

Granular matrix

Capacitance

TDT

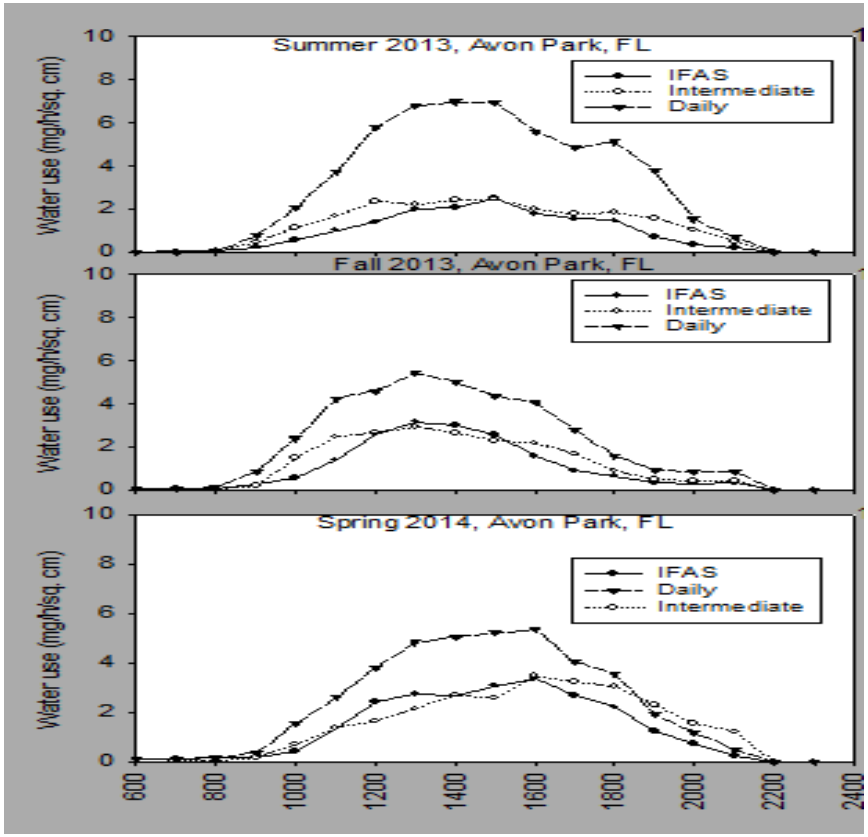
TDR

Soil water sensor type	Measured soil volume	Sensitivity to air gaps/loose soil	Sensitivity to salinity	Suitability for sandy soils	Accuracy	Calibration for different soils	Maintenance
Tensiometer	large	high	low	low	high	no	high
Granular matrix	large	high	medium-high	low	low	no	high
Capacitance	medium	high	medium-high	medium	medium	yes	low
TDT	large	medium-low	low	high	high	no	low
TDR	large	medium-low	low	high	high	no	low

Water management strategies for HLB-affected citrus trees

Water monitoring at grove scale and soil moisture measurement at 6-, 12- and 24-inch soil depth

Water management strategies for HLB-affected citrus trees



Water use of HLB affected trees in south west and central Florida

- Daily irrigation > Intermediate (irrigating every 1.5 days) > IFAS irrigation (irrigating every two days) scheduling
- Daily irrigation could help in managing HLB affected trees and reduce tree water stress
- More details: Kadyampakeni and Morgan, 2017. Scientia Horticulturae 224:272-279

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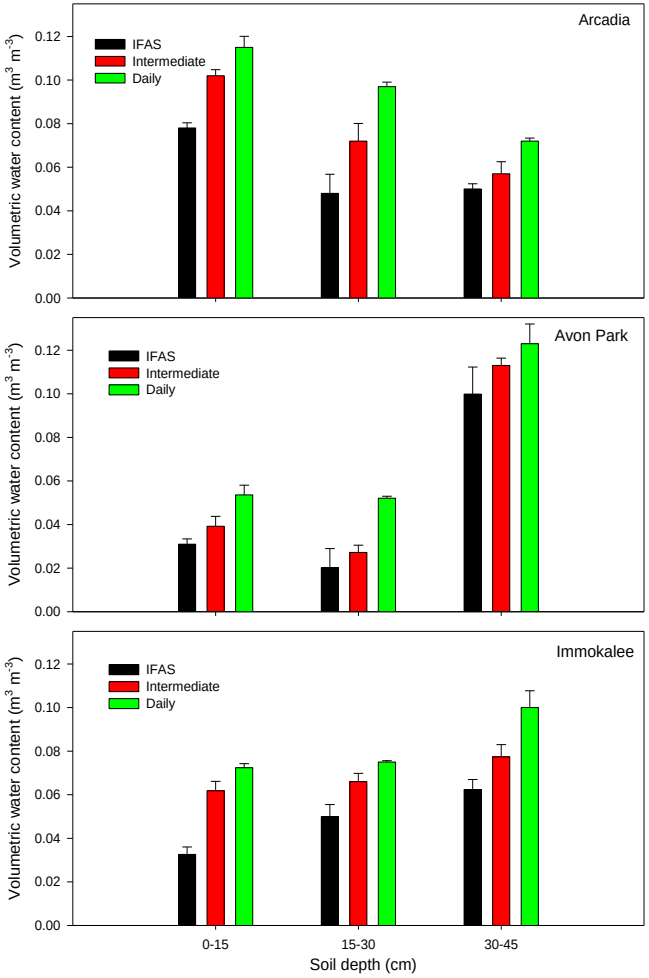
Water management strategies for HLB-affected citrus trees



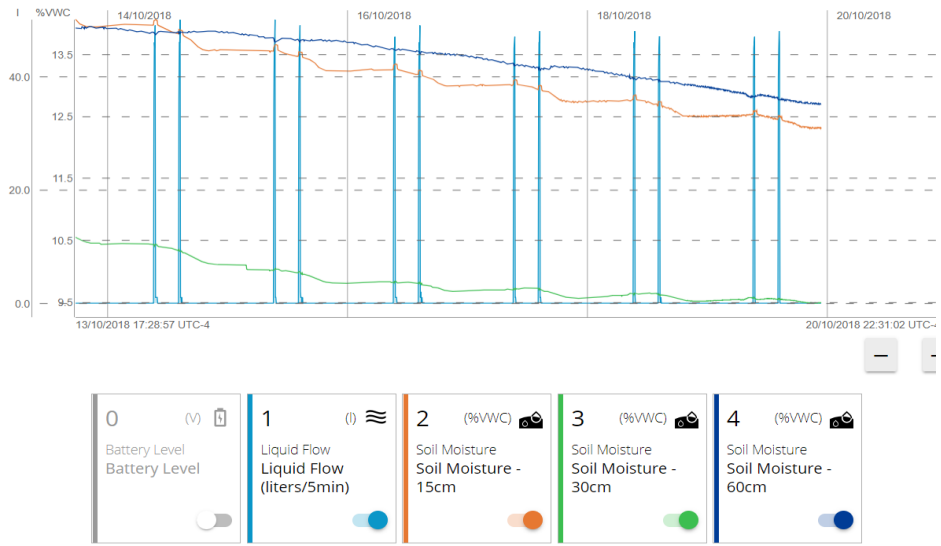
Moisture contents (left) and significant relationships with sapflow (right)

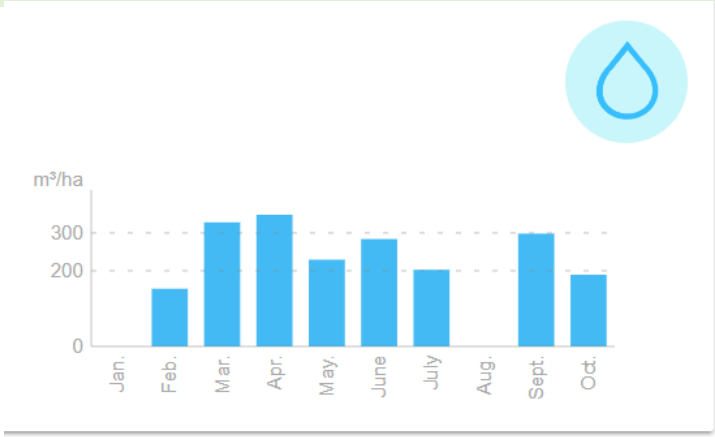
Keeping water in the top 0-30 cm improved water use for HLB affected trees. Greater moisture content beyond the root zone (at 45 cm) in Immokalee could be due to capillary rise since the soils have a high water table and in Avon Park could be due to deep percolation because those soils are well drained.

More details: Hamido et al. 2017a. HortScience 52(6):916-921.

Water management strategies for HLB-affected citrus trees

Water monitoring at grove scale and soil moisture distribution at 15, 30 and 60 cm soil depth





~217,238 gal/acre since Feb 2018

Irrigation scheduling experiment

- The aim of the study was to determine the amount of water required to grow young trees at higher tree densities.
- Initiated in November 2017 with eight-month-old sweet orange ‘Valencia’ (Citrus sinensis) trees grafted on the ‘US-897’
- Two and three rows of five-540-foot-long beds with drainage swales on each side.
- Two irrigation treatments (62% and 100%) of daily crop evapotranspiration (ETc) were adjusted during 2019 to (81%, 53%, 40.5%, and 26.5% of ETc).

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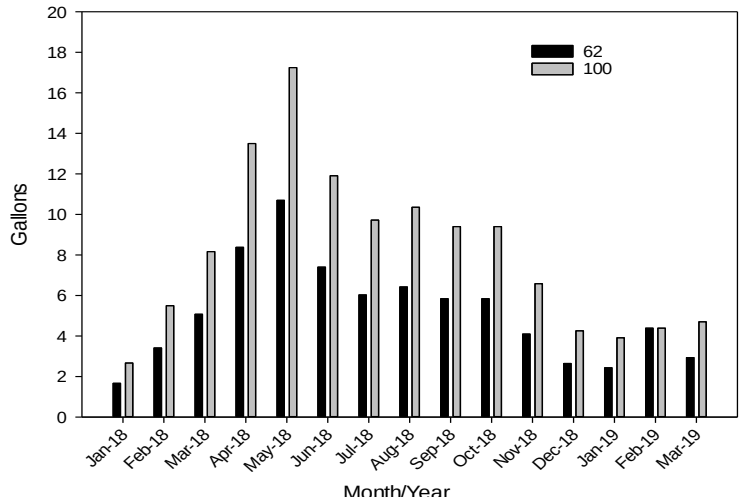
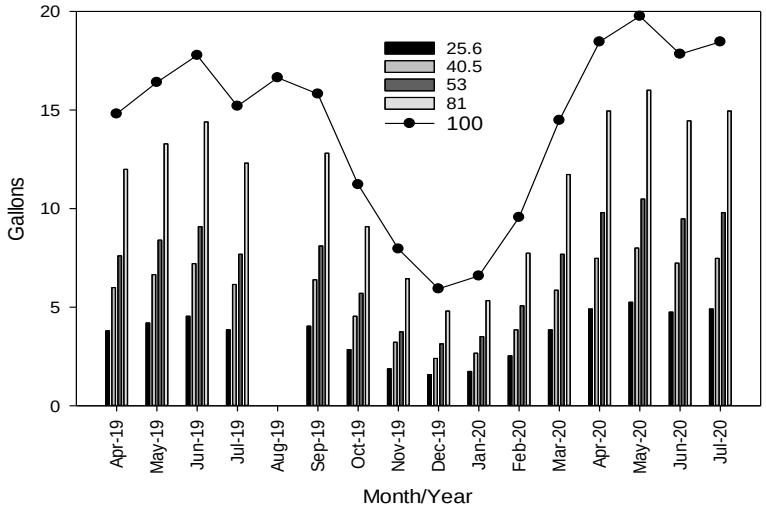
Water applied per tree





The volume of water applied per young citrus trees under different irrigation rates on daily bases

- **Water applications were proportional to percentage ETo during the experiment at both two rates and four rates**
- **100% line is the amount of water that would have been applied if ETo was applied each day**

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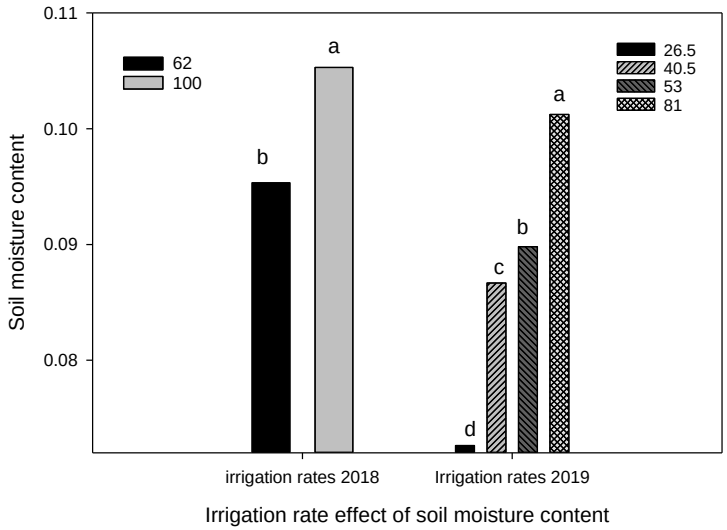
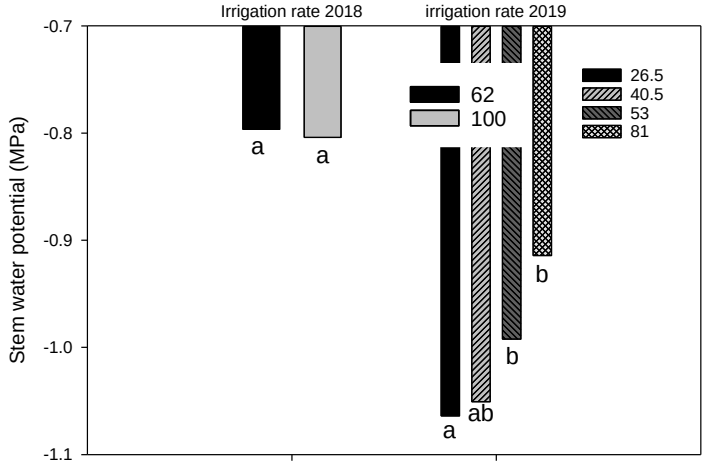
Soil moisture contents and stem water potential



Effect of irrigation rates on stem water potential of citrus trees



- **As expected, soil at higher irrigation rate resulted in soil moisture at or above field capacity (0.10).**
- **Stem water potential is used as an indication of stress with lower (more negative) values.**
- **Less stress was indicated at higher irrigation rates.**

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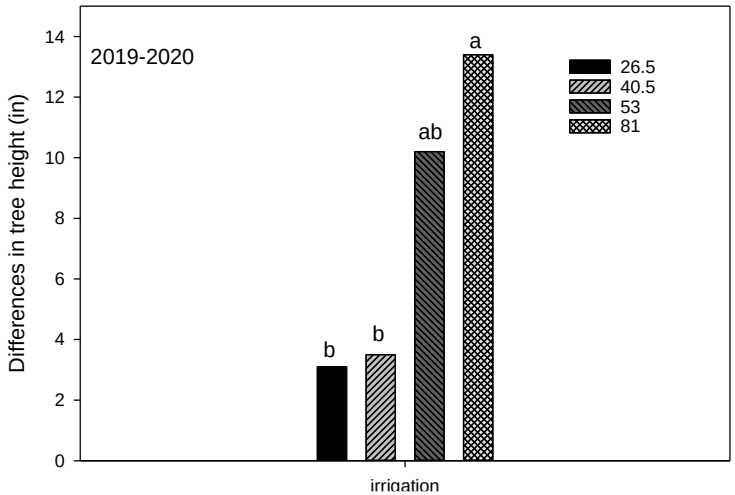
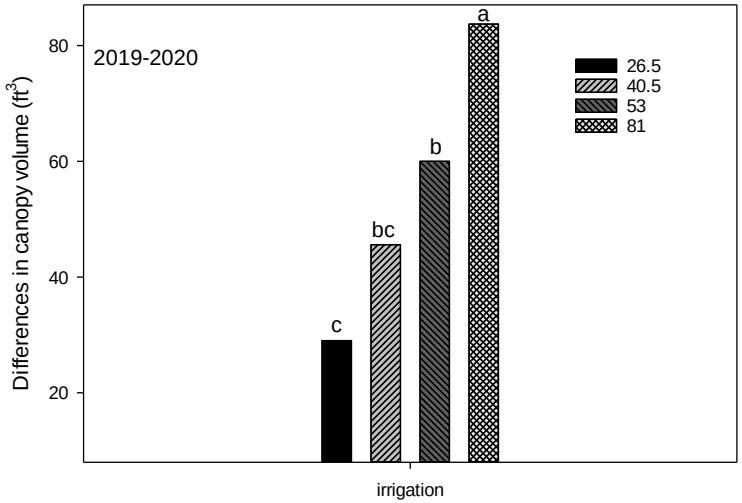
Citrus tree growth (2019-2020)





- **Tree height and canopy volume increased with irrigation rate.**

Irrigation rates effect on young citrus trees growth during 2019-2020

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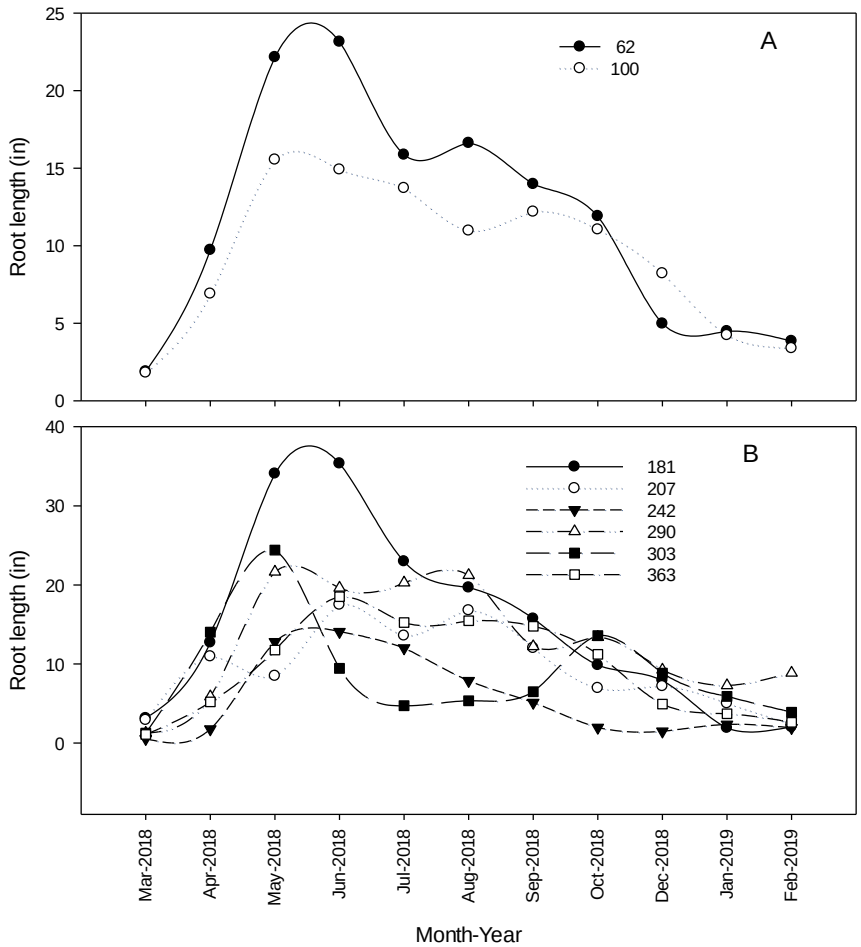
Impact of irrigation rate on citrus tree root growth (2018)



Impact of irrigation rate (A) and planting densities (B) of young citrus trees on root length growth during 2018-2019 at the southwest Florida research and education center demonstration grove.

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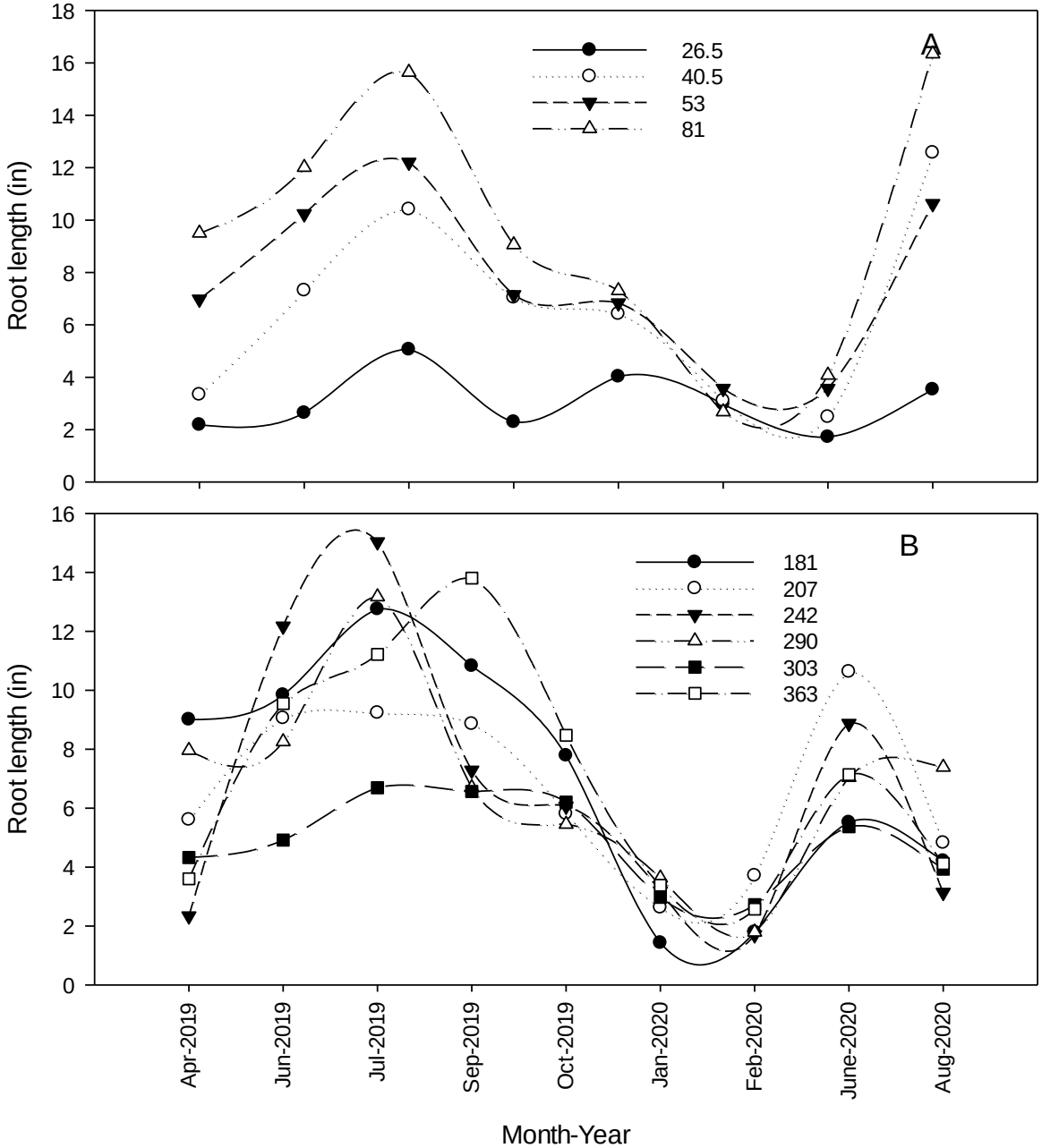

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Acknowledgements

- Collaborators: Drs. Kelly Morgan and Dr. Ali Atta, SWFREC

- UF/IFAS Citrus Initiative and SWFWMD

Thank you!