OPTIMIZING CITRUS IRRIGATION MANAGEMENT WITH SOIL AND PLANT-BASED SENSORS

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Outline

General Soils of Florida

Weather-based tools and apps

Examples of applications

Sensors:

- Soil-based sensors
- Plant-based sensors

Take home messages

Soil Physical & chemical Characteristics

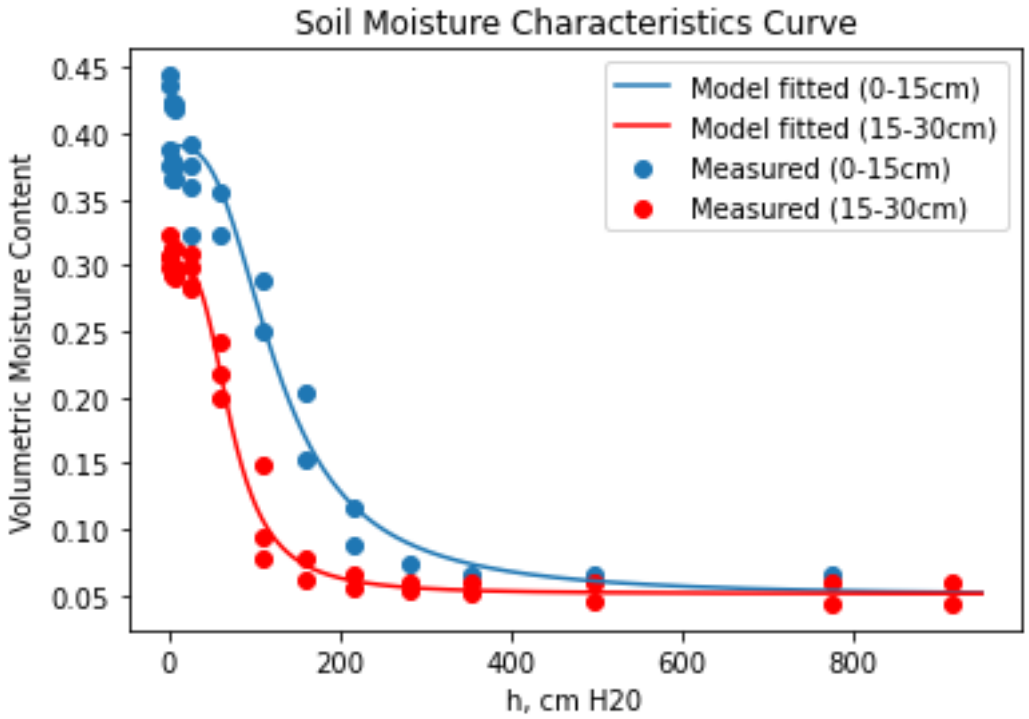
Typical root zone[1] soil physical and chemical properties for common soil series found in citrus groves in Florida. Adapted from Obreza and Collins (2008).

Soil orders([2])	Soil texture			Organic matter	Water-holding capacity		pH	Cation exchange capacity
	sand	silt	clay					
	---------- g kg^{-1} ----------			g dm^{-3}	cm m^{-1}	cm in the root zone		$mmol_c$ dm^{-3}
Entisols	970-985	50-125	75-125	5-10	2.5-6.6	1.5-5.3	3.6-7.3	20-40
Alfisols	850-965	20-60	15-90	5-3	2.5-10.7	1.3-4.6	4.5-8.4	20-180
Spodosols	960-985	10-35	05-10	10-30	2.5-6.6	1.3-3.8	3.6-7.3	20-60

([1]) top 90 cm of soil for central Ridge Entisols and top 45 cm of soil for flatwoods Alfisols, Spodosols, and Entisols.
([2]) according to the USDA Soil Taxonomy (Soil Survey Staff, 2014).

Tensiometric moisture content

- Estimates water content on pressure basis



Computer Programs

- Web based
  - Schedule based on nearest FAWN station (http://fawn.ifas.ufl.edu.)
  - 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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FAWN Florida Automated Weather Network

Database | Climate | Tools | Focus | News | Tour

Search Database

chill hours are available from our new temperature threshold tool by clicking Temperature Threshold. values in the summary reports are in error. The summary reports will be completely replaced soon.

Site: LAKE ALFRED | Type: Daily Summary | From: 04/15/2006 | To: 04/22/2006 | Search

Attention: Date/Time in this table is East Standard Time.

LAKE ALFRED Weather Daily Summary:

Date (EST)	Air Temp (°F)		Rainfall	TotalRad	ET	Hours Below Certain Temperature (hours)							
	Min	Max	(inches)	(cal/inch^2)	(inches)	40°F	45°F	50°F	55°F	60°F	65°F	70°F	75°F
Apr 15, 2006	57.5	86.9	0.00	3586.6		0.0	0.0	0.0	0.0	5.1	1.9	-7.0	-4.0
Apr 16, 2006	59.1	84.0	0.00	3514.0	0.159	0.0	0.0	0.0	0.0	0.8	10.5	-6.8	-2.8
Apr 17, 2006	65.6	86.4	0.00	3547.3	0.173	0.0	0.0	0.0	0.0	0.0	0.0	-9.6	-4.9
Apr 18, 2006	67.8	86.3	0.00	3087.9	0.159	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-6.3
Apr 19, 2006	67.3	88.6	0.01	2972.9	0.156	0.0	0.0	0.0	0.0	0.0	0.0	9.2	-6.3
Apr 20, 2006	68.5	92.0	0.00	3282.4	0.174	0.0	0.0	0.0	0.0	0.0	0.0	6.9	-7.3
Apr 21, 2006	68.9	92.5	0.24	2640.0	0.151	0.0	0.0	0.0	0.0	0.0	0.0	3.4	-2.8
Apr 22, 2006	68.2	87.8	0.09	2469.3	0.138	0.0	0.0	0.0	0.0	0.0	0.0	7.1	-6.3

FAWN Partners...
Location Info...

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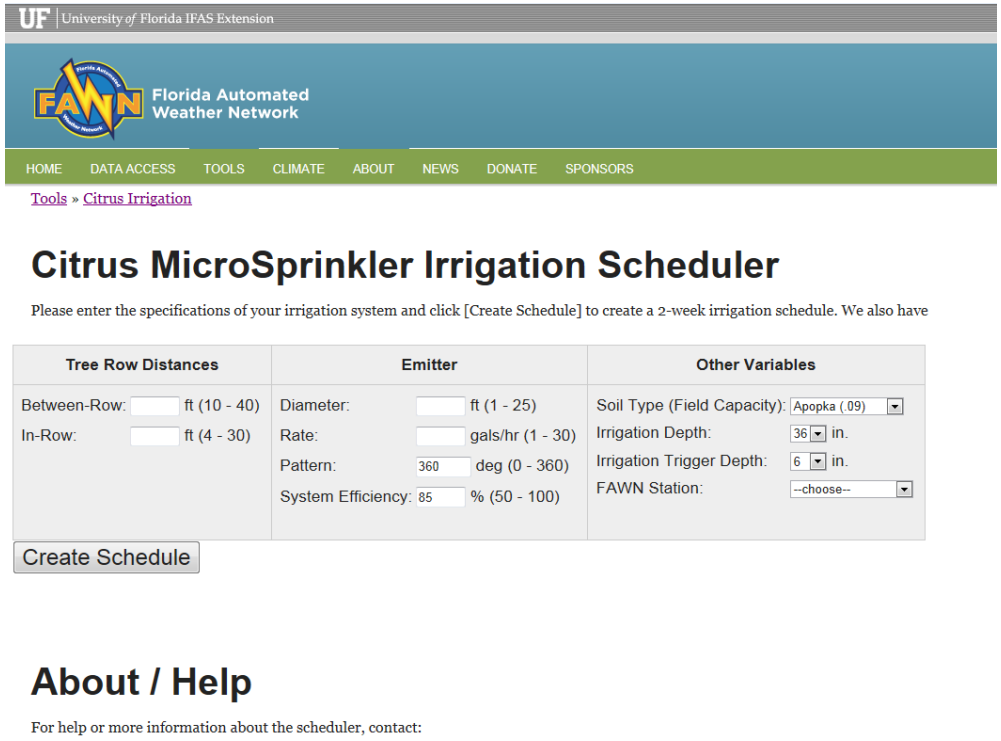
Irrigation Scheduler - Input



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

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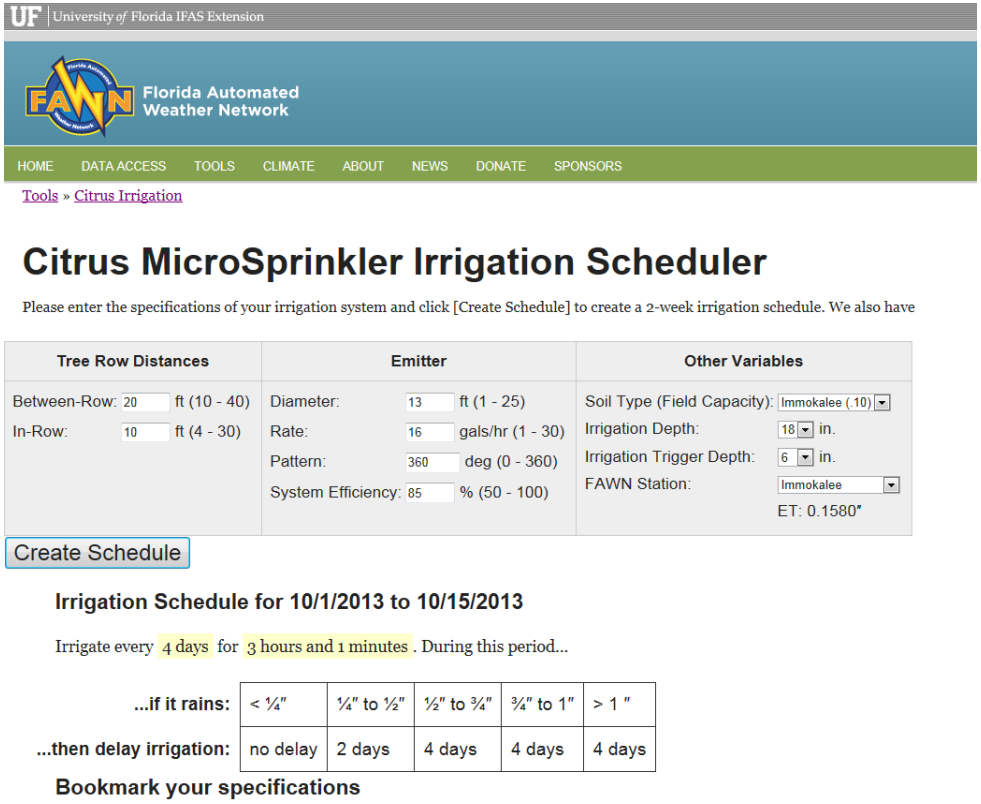
Irrigation Scheduler - Output



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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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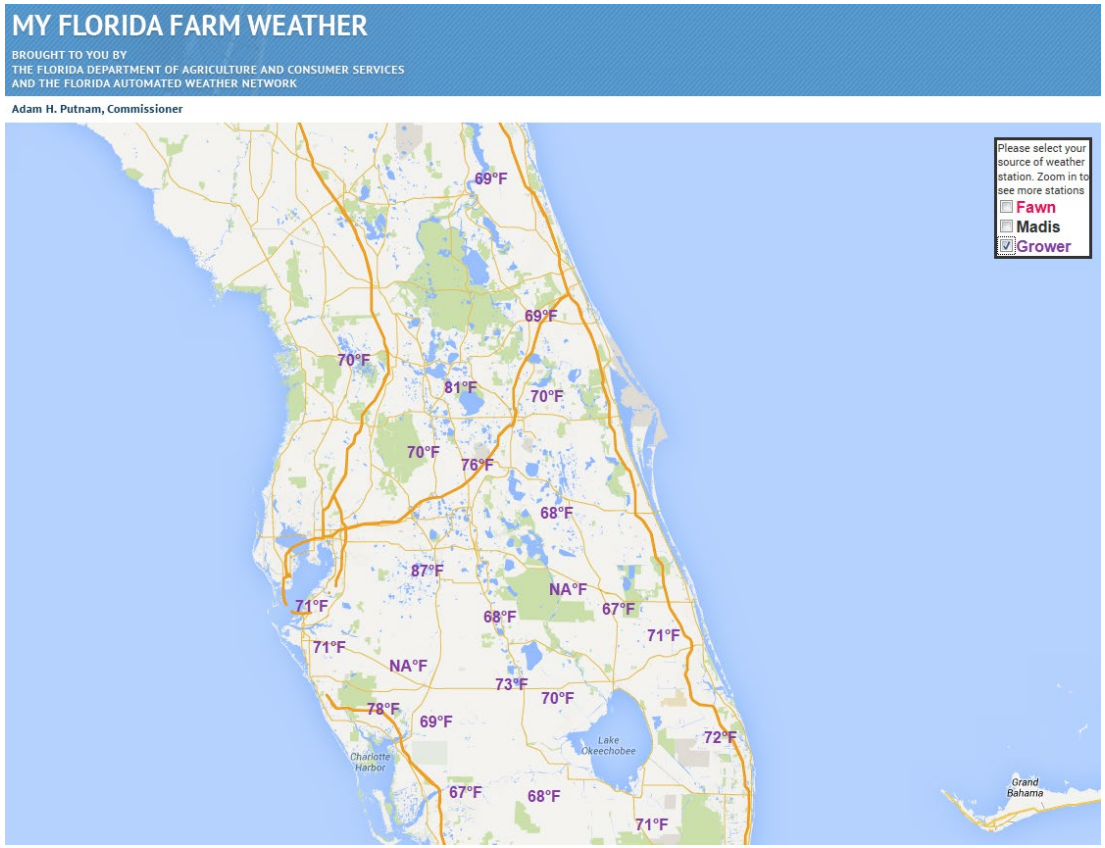
FDACS/IFAS – My Florida Farm Weather Program



- Cost share for weather stations
- Real-time data
- Frost protection and irrigation scheduling

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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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Merits and demerits of some soil moisture sensors

Main features, advantages and disadvantages of selected soil water sensors for use in Florida citrus groves. Desirable features are shown in green, with orange and red colors ranked less satisfactory. Source: Schumann et al. 2018. Using soil moisture sensors for citrus irrigation. https://crec.ifas.ufl.edu/extension/trade_journals/2018/2018_july_using_soil.pdf

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
Time domain transmission (TDT)	large	medium-low	low	high	high	no	low
Time domain reflectometry (TDR)	large	medium-low	low	high	high	no	low

Plant-based irrigation scheduling

Water use by plants is via transpiration. This can be measured in different ways such as sapflow sensors and lysimeters.

Use of sapflow sensors supported by a datalogger, solar panel, and 12-V battery (right and top)

Weighing lysimetery for measuring water use (left)

Plant-based irrigation scheduling

Dendrometers used for tracking changes in stem water potential in real time

Pressure bomb method for tracking water stress

Example of Applications

Use of reflective mulch and plant covers to enhance water use.

Soil-water parameters measurement:

Soil probes (AquaSpy Inc, San Diego, CA)

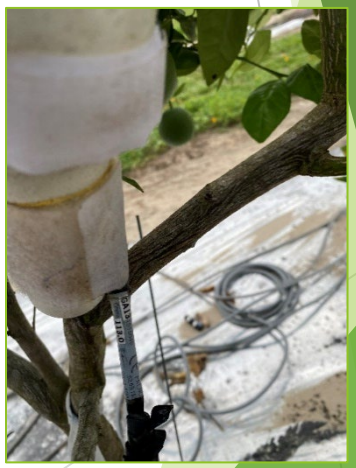
AquaSpy

- Proven TDR capacitance soil moisture sensing technology.
- High definition digital probes with sensors positioned every 4 inches for a more detailed and dynamic view of entire soil profile.
- Capacity for soil specific calibration
- Continuous data collection and logging.
- 20”, 40” & 60” Probe lengths.

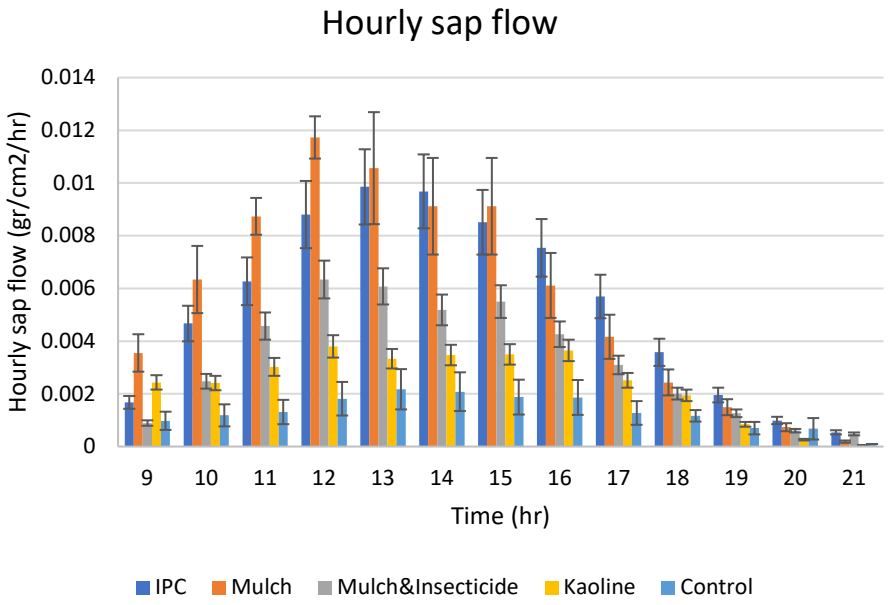
Sap flow (water use) measurement:

Water uptake was measured using sap flow sensors (Dynamax Inc., Houston, TX) on one branch in each of four trees per treatment (each tree serving as a replicate)

The sap flow sensors were connected to a data logger (CR 1000, Campbell Scientific Inc., Logan, UT)



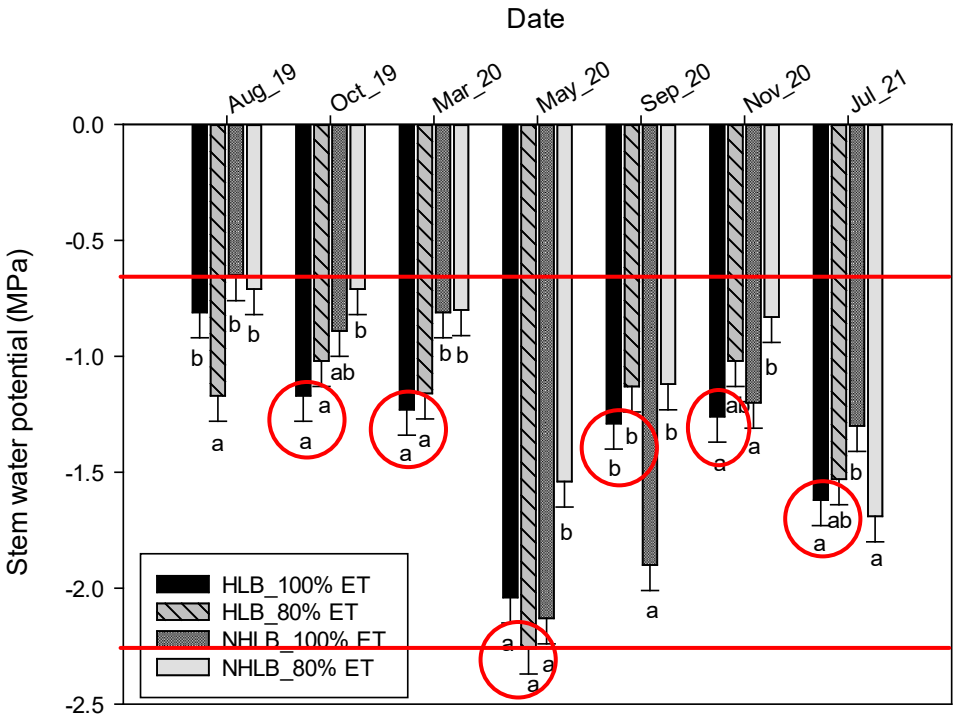
Sap flow (water use) measurement:



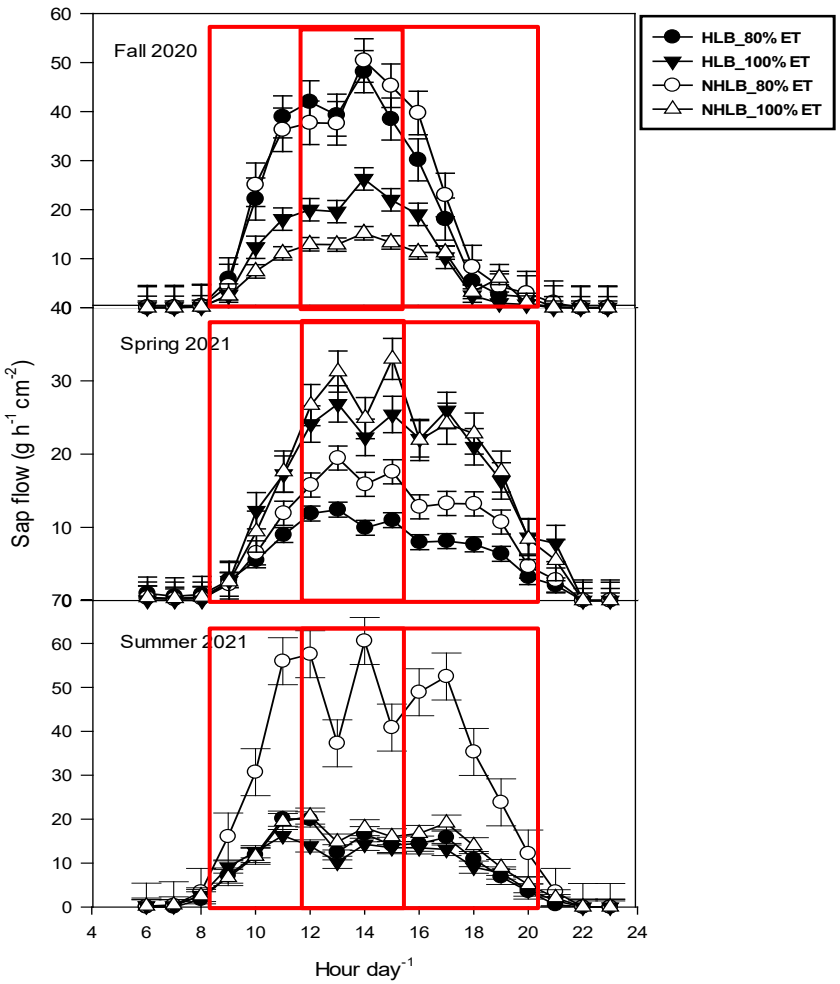
The sap flow data suggest that using Mulch improved water use followed by IPC.

Example of applications (2)

Effect of treatments on stem water potential



- 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



Effect on sap flow

- Generally, sap flow occurred between 8 and 20 h daily.
- Sap flow (g h^{-1} cm^{-2}) peaked around 12 and 15 h
- 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

Summary

Most soils for crop production are sandy and need good management to optimize water use.

Tools are available for irrigation management including plant-based and soil-based sensors.

Optimal irrigation is possible using these tools and can lead to great water savings.

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QUESTIONS/COMMENTS?

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