IRRIGATION MANAGEMENT CONSIDERATIONS IN CITRUS

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OUTLINE

- Soil characteristics
- Soil water balance
- Irrigation scheduling
- Irrigation system maintenance
- Cold protection
- Water use measurements
- Some highlights of irrigation management studies

SOIL PHYSICAL & CHEMICAL CHARACTERISTICS

Typical root zone soil physical and chemical properties for common soil orders found in Florida citrus groves (Source: Obreza and Morgan, 2008).

Common soil orders for citrus groves	Soil texture			Organic matter	Water-holding capacity		pH	Cation exchange capacity
	sand	silt	clay					
	------------ %--------------			%	Inches per ft	Inches in the root zone		meq/100g
Entisols	97-98.5	0.5-1.25	0.75-1.5	0.5-1	0.3 – 0.8	0.6-2.1	3.6-7.3	2-4
Alfisols	85-96.5	2-6	1.5-9	0.5-3	0.3-1.2	0.5-1.8	4.5-8.4	2-18
Spodosols	96-98.5	1-3.5	0.5-1	1-3	0.3-1.0	0.5-1.2	3.6-7.3	2-6

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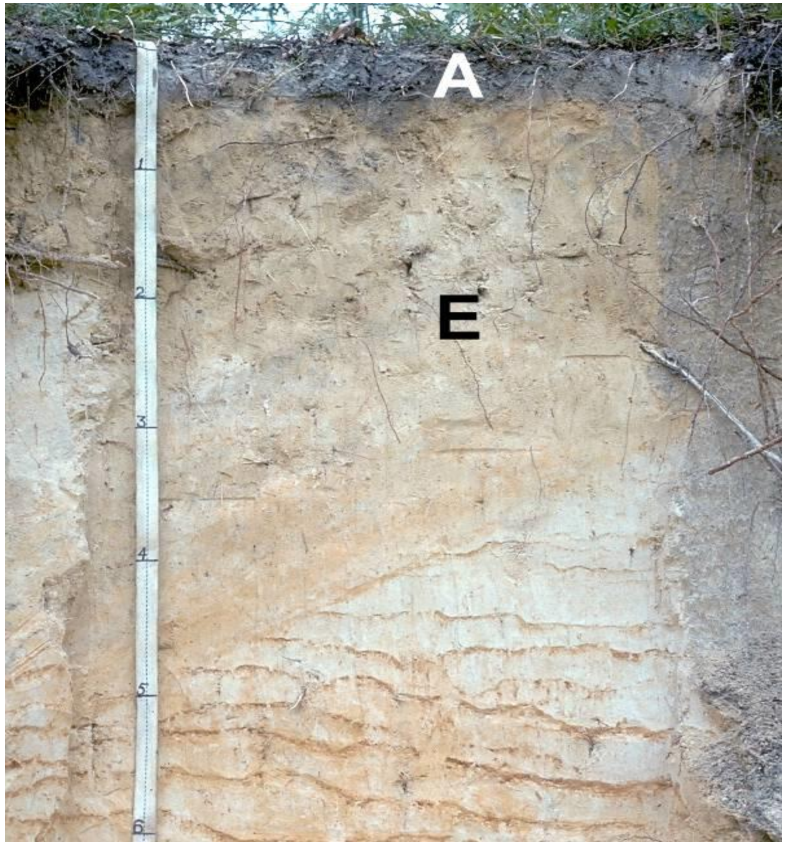
SOIL PHYSICAL & CHEMICAL CHARACTERISTICS (2)

- **Entisols:**
  - Very common in central Florida ridge
  - Extremely well drained
  - Have low organic matter
  - Have low cation exchange capacity
  - Have low water holding capacity
  - Mostly acidic soils
  - Examples include Astatula, Basinger, Candler, Tavares soil series.



Profile of Astatula sand, an Entisol, showing surface (A) and subsurface (E) horizons. Sources: SL253

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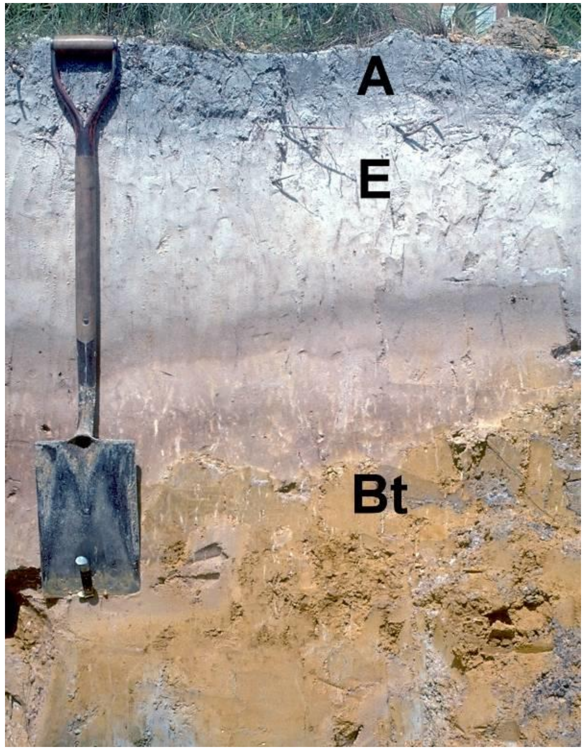
SOIL PHYSICAL & CHEMICAL CHARACTERISTICS(3)

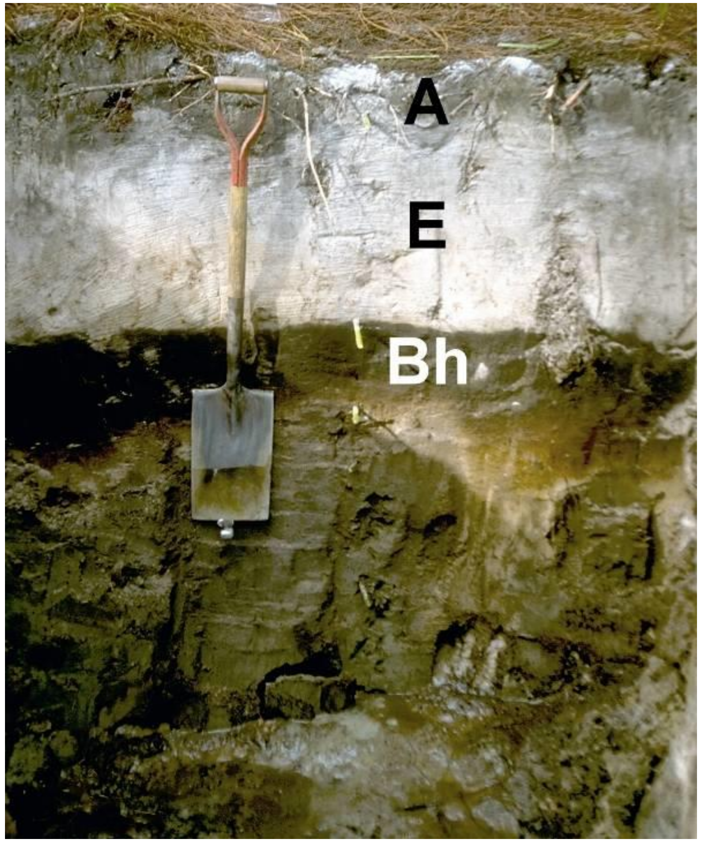
- **Alfisols:**
  - Very common on the southeast Florida Flatwoods
  - Poorly drained due to a restricting subsurface layer called the argillic horizon, always in need of good drainage
  - Have low organic matter,
  - Have low cation exchange capacity
  - Have low water holding capacity
  - Mostly moderately acidic to alkaline pH due to high Ca or carbonate content
  - Examples include Boca, Holopaw, Pineda, Riviera, Winder soil series.



Profile of Riviera sand, an Alfisol, showing surface (A), leached (E), and restrictive (Bt) horizons. Source: SL253

SOIL PHYSICAL & CHEMICAL CHARACTERISTICS(4)

- **Spodosols:**
  - Very common on the southwest Florida Flatwoods
  - Poorly drained due to a restricting subsurface layer called the spodic horizon, always in need of good drainage
  - Have low organic matter,
  - Have low cation exchange capacity
  - Have low water holding capacity
  - Mostly acidic to moderately acidic
  - Examples include Immokalee, Myakka, Oldsmar, Pomona, Smyrna, and Wabasso soil series.



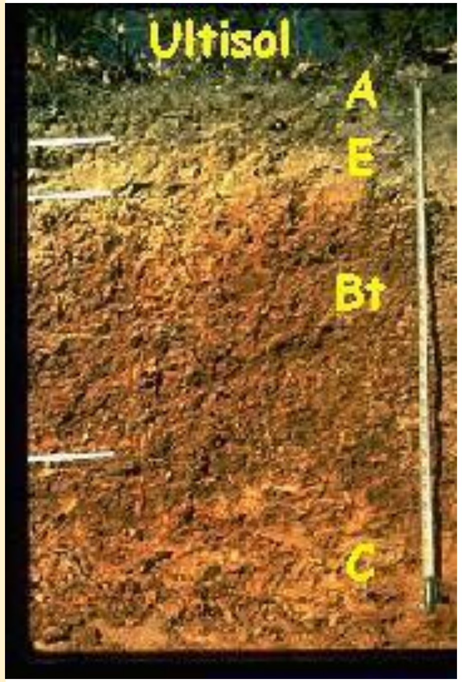
Profile of Myakka sand, a Spodosol, showing surface (A), leached (E), and restrictive (Bh) horizons. Source: SL253

SOIL PHYSICAL & CHEMICAL CHARACTERISTICS (5)

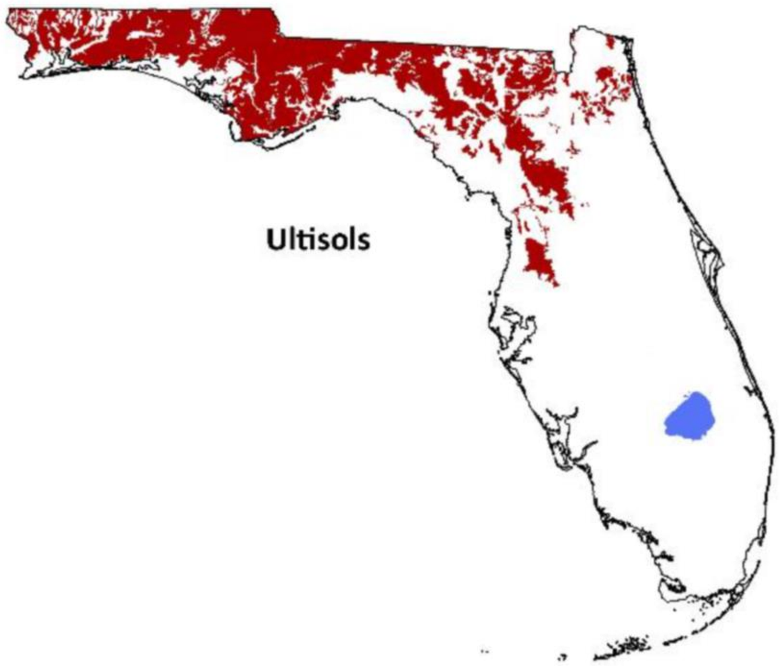
Ultisols have an argillic or kandic horizon (layer in the sub soil with higher clay content) and a low level of bases due to leaching.

Well-drained soils on upland ridges, rises and knolls to very-poorly-drained soils.

Examples of Ultisols in Florida include the Apopka, Arredondo, Blanton, Millhopper, Orangeburg, and Troup soils.



Source: Soil Survey Staff



https://edis.ifas.ufl.edu/ss655

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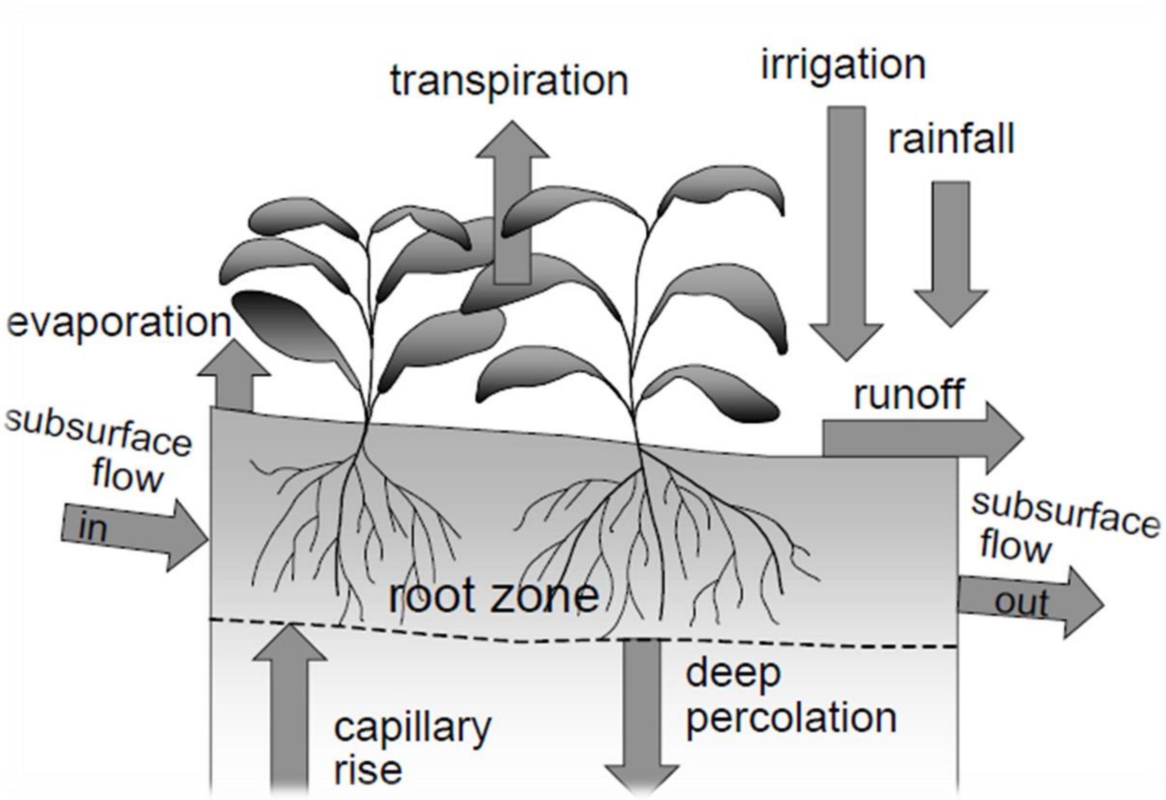
SOIL WATER BALANCE

Soil water balance of the root zone



Irrigation (I) and rainfall (P) add water to the root zone.

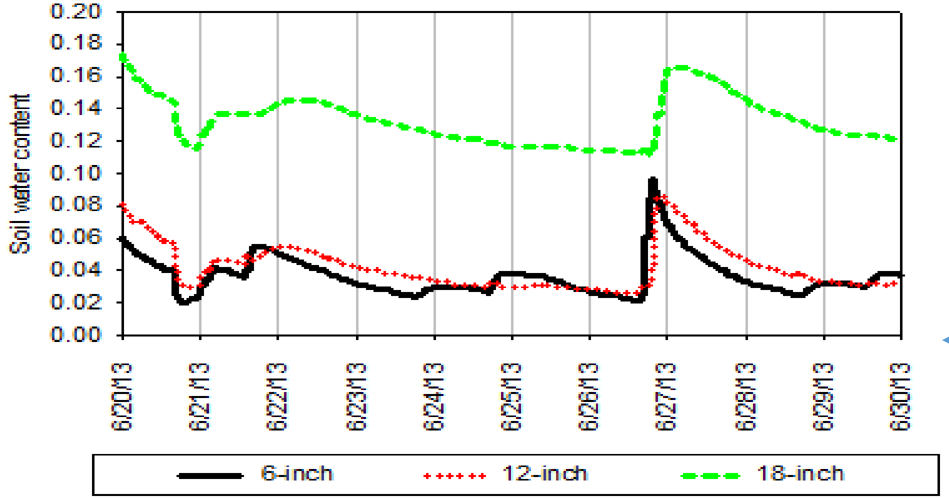
Part of I and P might be lost by surface runoff (RO) and by deep percolation (DP) that will eventually recharge the water table.

Water might also be transported upward by capillary rise (CR) from a shallow water table towards the root zone or even transferred horizontally by subsurface flow in (SFin) or out of (SFout) the root zone (**this is common on the Flatwoods soils**).

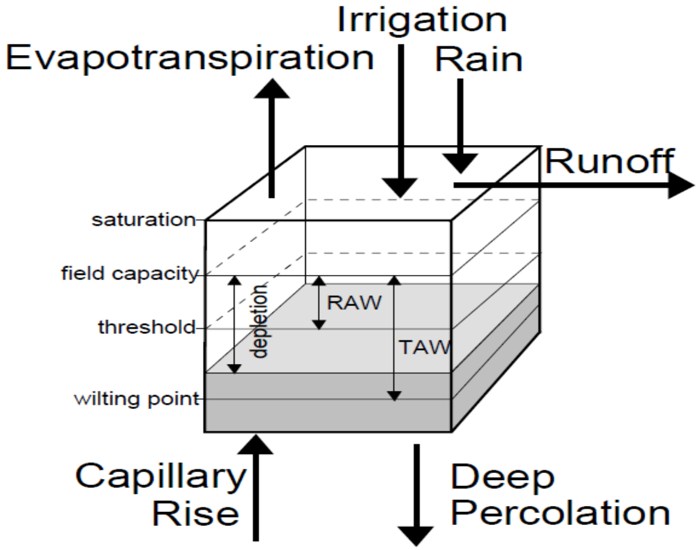
SOIL WATER BALANCE (2)

If all fluxes other than evapotranspiration (ET) can be assessed, the evapotranspiration can be deduced from the change in soil water content (ΔSW) over the time period using the equation:

$$ET = I + P - RO - DP + CR \pm \Delta SF \pm \Delta SW$$



Continuous monitoring of soil moisture at 6, 12, and 18-inch depths in the soil by a multi-level capacitance probe installed in the root zone of a mature citrus tree.



Soil water balance as seen in a big cube and including measurements of readily available water (RAW) and total available water (TAW). (Source, FAO, 1998)

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IRRIGATION SCHEDULING

- **Soil moisture measurement**

Current electronic sensors may be fixed in one location, portable, or hand-held, and these sensors can be connected wirelessly to computer systems.

These advanced sensors may also measure soil moisture at one depth or at multiple depths.

General categories include time domain reflectometry (TDR), time domain transmission (TDT) and capacitance probes.

Capacitance probes

TDT Acclima sensor

IRRIGATION SCHEDULING (2)

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

IRRIGATION SCHEDULING (3)

- **Water Budgeting**

An alternative method to schedule irrigation uses a computer program that estimates tree water consumption also known as evapotranspiration (ET) from weather data.

Reference ET and convenient irrigation scheduling management tools for all Florida citrus production regions can be found on the Florida Automated Weather Network (FAWN) website at:

http://fawn.ifas.ufl.edu.

IRRIGATION SCHEDULING (4)

- **Smartphone Apps**

Mobile smart devices (e.g., smart phones, tablets) disseminate information on a regular basis with real-time data.

The App has been developed by UF/IFAS that uses FAWN weather data for the iPhone and Android platforms that allows users to view data from grower-owned weather stations.

The goal is to provide users with an easy-to-use mobile app to access information that would improve irrigation scheduling for a wide range of crops, including citrus.

Using the apps to modify the irrigation schedule has the potential of reducing water and fertilizer use. This could result in reduced irrigation and fertilizer costs and the potential of further reducing nutrient leaching.

The irrigation scheduling apps are available to download in the App Store and Play Store at no cost (smartirrigationapps.org/).

IRRIGATION SYSTEM MAINTENANCE

Common causes of problems

Dripper or microsprinkler plugging is often caused by the presence of sediments or soil from the water source.

Presence of algae, bacteria, small plants, arthropods (e.g. ants) and other aquatic animals that can pass through filters. If such living organisms multiply, they can form clumps in the tubing or clog emitters or microjets.

Scaling is caused by the presence of calcium carbonate, iron or manganese oxides. The presence of such compounds can form precipitates with liquid fertilizers and ultimately plug emitters and limit the efficiency of the irrigation system.

IRRIGATION SYSTEM MAINTENANCE (2)

Table 1. Interpretations to be used with laboratory water testing results, indicating the potential hazard from plugging of micro-irrigation systems (Source: Obreza et al. 2017)

		Plugging hazard based on concentration		
Measurement	**Units**	**Slight**	**Moderate**	**Severe**
Suspended solids[1]	ppm	<50	50-100	>100
pH		<7.0	7.0-7.5	>7.5
Total dissolved solids[1]	ppm	<500	500-2000	>2000
Iron[1]	ppm	<0.1	0.1-1.5	>1.5
Manganese[1]	ppm	<0.1	0.1-1.5	>1.5
Calcium[1]	ppm	<40	40-80	>80
Alkalinity as $CaCO_3$[1]	ppm	<150	150-300	>300
Hydrogen sulfide[1]	ppm	<0.2	0.2-2.0	>2.0
Bacteria	#/mL	<10,000	10,000-50,000	>50,000

It is very important to stay within the slight range!!

[1]Concentration as mg/L or parts per million (ppm). It is recommended to measure pH, iron, alkalinity, and hyd sulfide in the field to account for field conditions as much as possible.

IRRIGATION SYSTEM MAINTENANCE (3)

An example of a filtration system in use along with microsprinkler irrigation and fertigation.

IRRIGATION SYSTEM MAINTENANCE (4)

Use of a very efficient filtration system is the first line of defense against any particles entering an irrigation system.

- **Screen filters help in removing particles from the water source before entering the pipes and tubing.**
- **Disk filters target inorganic particles by trapping them in adjacent disks and letting filtered water flow in a central conduit and leaving the debris between the disks.**
- **Sand media filters help in removing inorganic and organic materials.**
- **Routine acidification of the irrigation water to reduce the pH to about 6.5 and to neutralize bicarbonates will effectively prevent calcium carbonate scale formation (prevention is better than cure).**
- **The common strategy for solving the problem of living organisms in irrigation water is the use of chlorine.**

Before injecting chemicals for removing chemical scale or biological debris from the irrigation system, it should be thoroughly flushed and please use safety precautions.

COLD PROTECTION IN CITRUS

https://edis.ifas.ufl.edu/ss509; https://edis.ifas.ufl.edu/cg095

Use of cold tolerant varieties e.g. mandarins>oranges>grapefruit

Frequent irrigation cycles and good use of sensors to monitor soil moisture

Row middle management

Good nutrition for better tree resilience

Use Cold Protection Tool Kit and Citrus Microsprinkler Irrigation Scheduler along with a reliable weather station on grove site!!

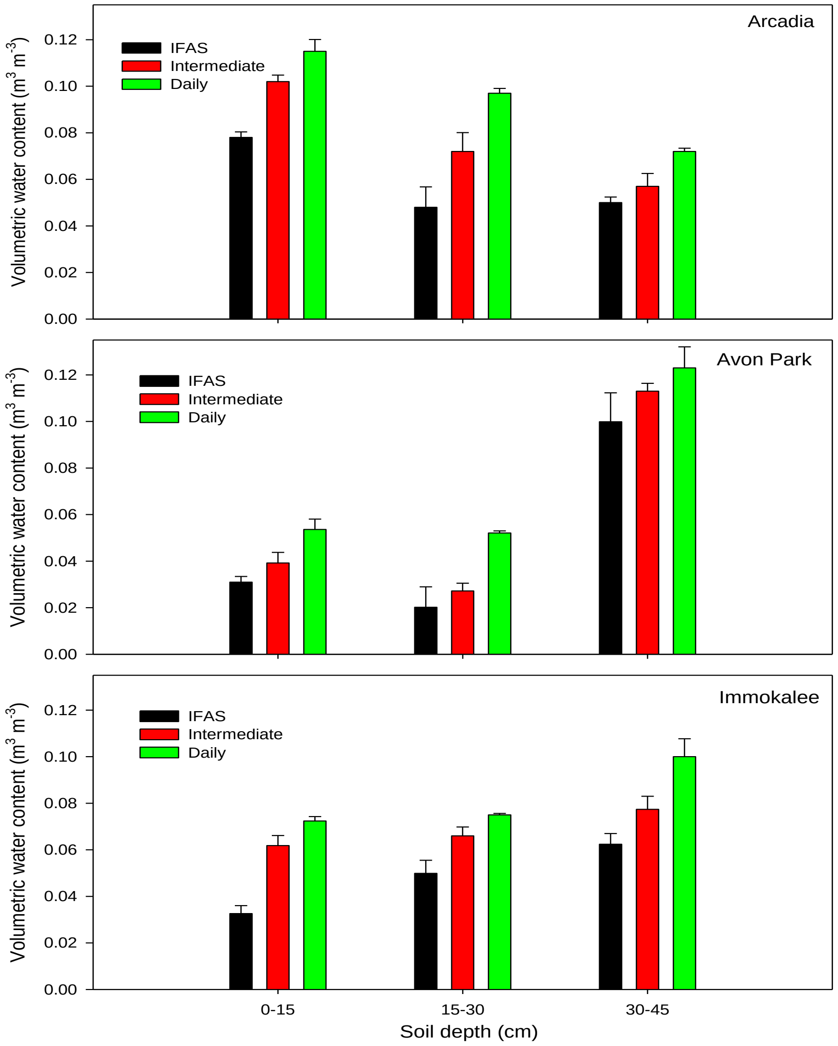
WATER USE MEASUREMENTS

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)

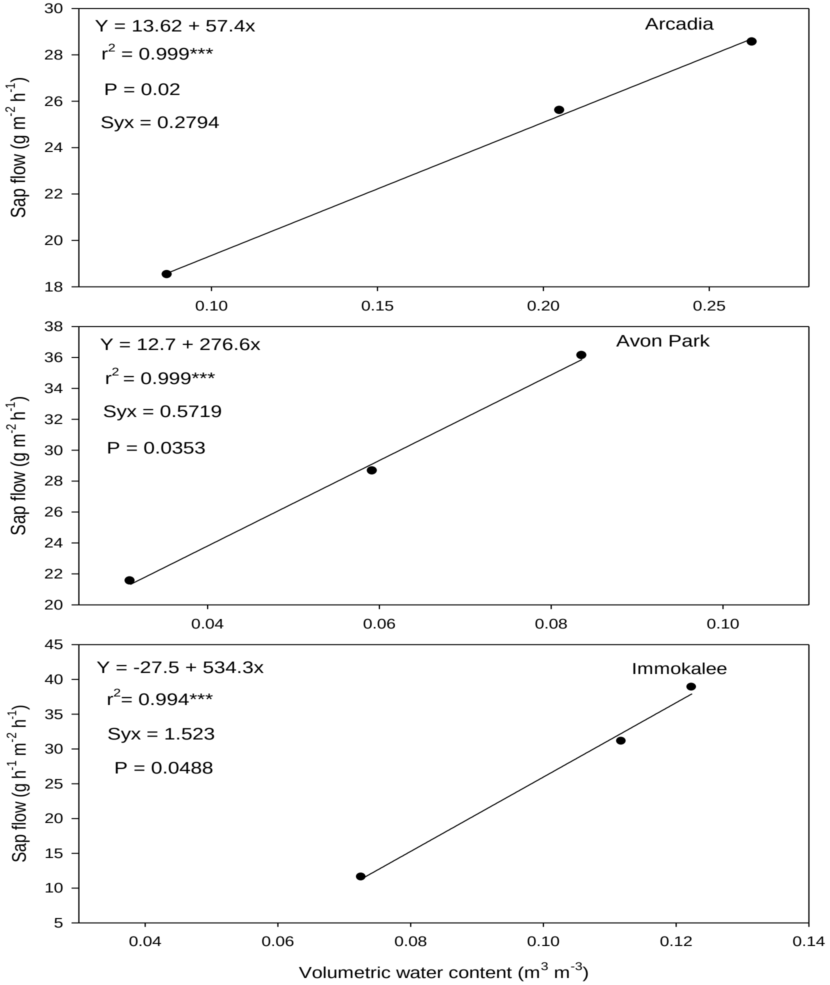
IRRIGATION STRATEGIES



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

Keeping water in the top 0-12 inches 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.



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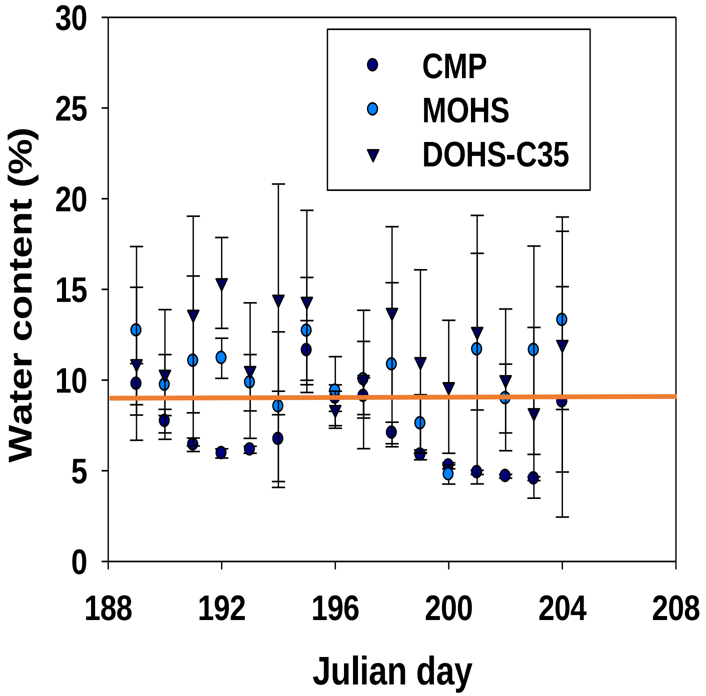
IRRIGATION STRATEGIES (2)

Increasing total available water (TAW) with depth, greater uptake in the top 6 inches due to constant availability of water in the root zone.

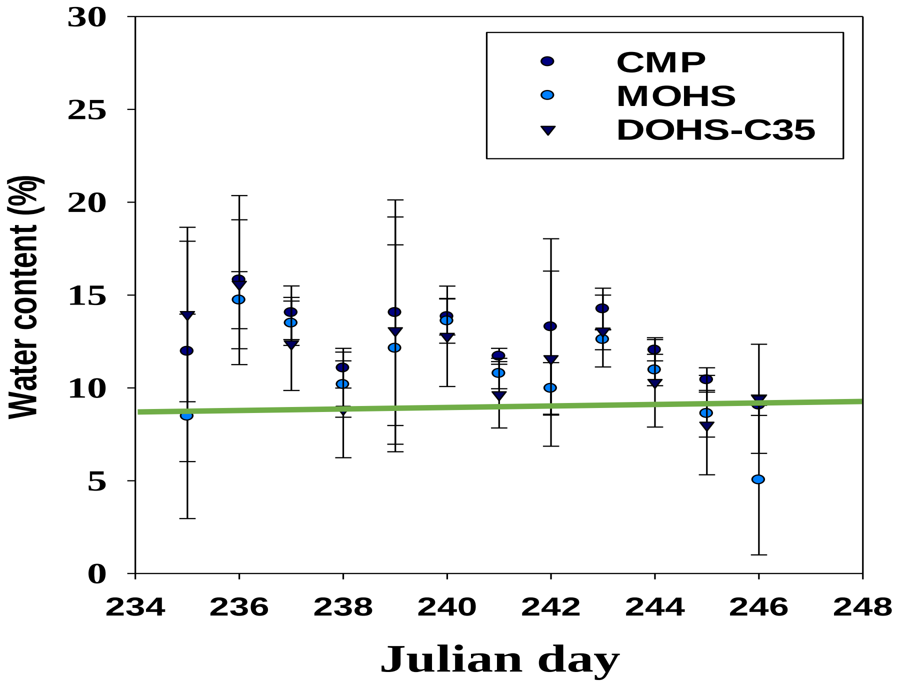
Greater TAW in top 6 inch than lower 6-18 inches for Daily than Intermediate and IFAS irrigation schedule.

Increased root density in wetted zones

IRRIGATION STRATEGIES (3)



July 2010



Aug-Sept 2011

CMP-Conventional microsprinkler irrigation
MOHS-Microprinkler open hydroponic system with daily irrigation and weekly fertigaton.
DOHS-C35-Drip open hydroponic system with daily irrigation and fertigation

Soil moisture at 4-inch depth was close to or slightly above field capacity in the range of 7 and 15%.

Kadyampakeni et al. 2014a, b. Soil Science Society of America Journal 78:645–654; 78:1351–1361

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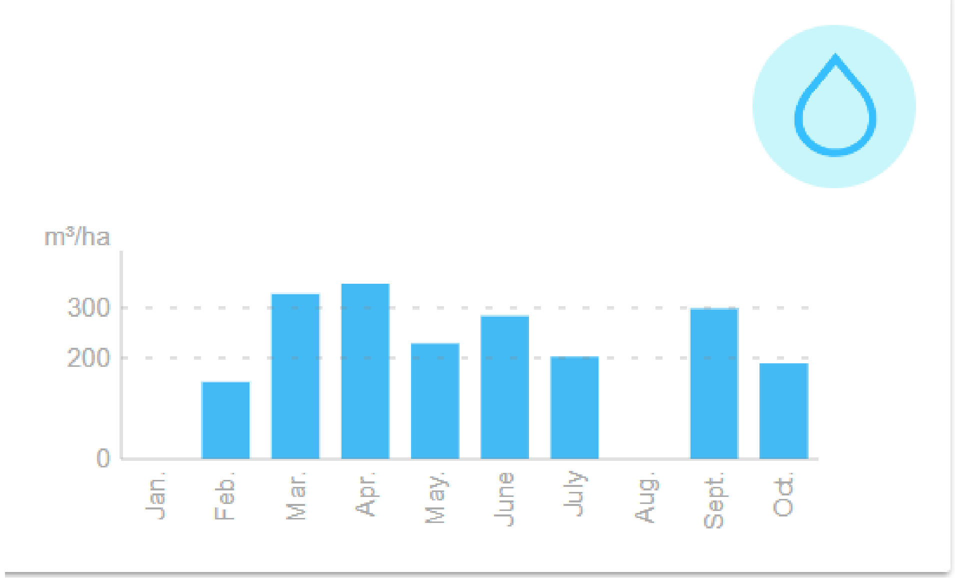
IRRIGATION STRATEGIES (4)

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

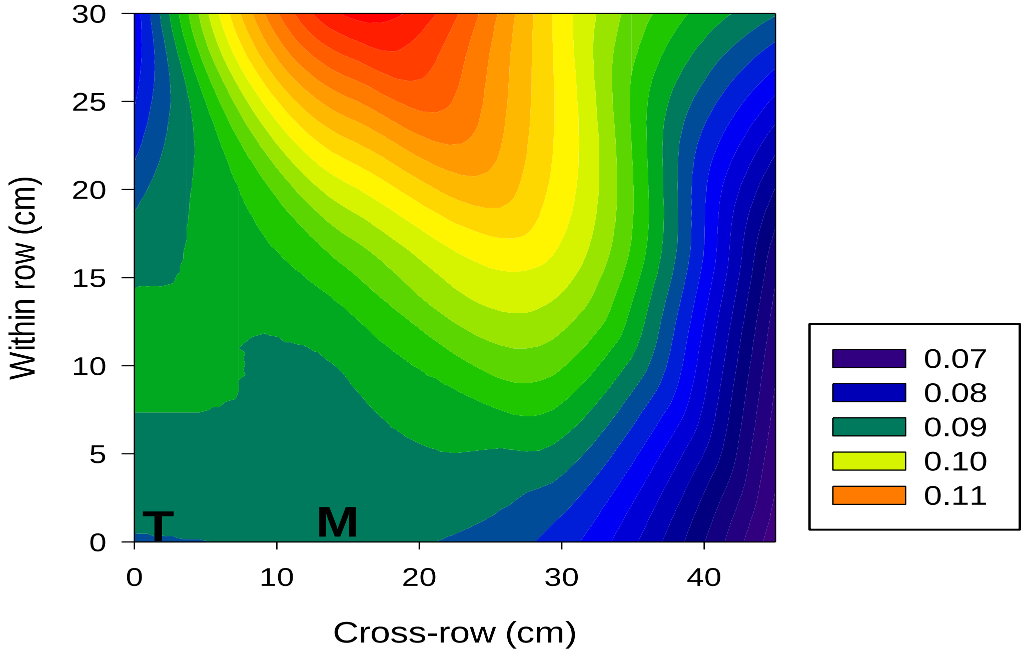


~217,238 gal/acre since Feb. 2018

EFFECT OF CONVENTIONAL MICROSPRINKLER IRRIGATION SYSTEM ON ROOT DENSITY

Positions in the irrigated zones of a conventional microsprinkler showed moderate root density distribution. The root density was about a third or quarter of the density observed with drip or linear microsprinkler irrigating system.

Lateral root density distribution using conventional microsprinkler irrigation

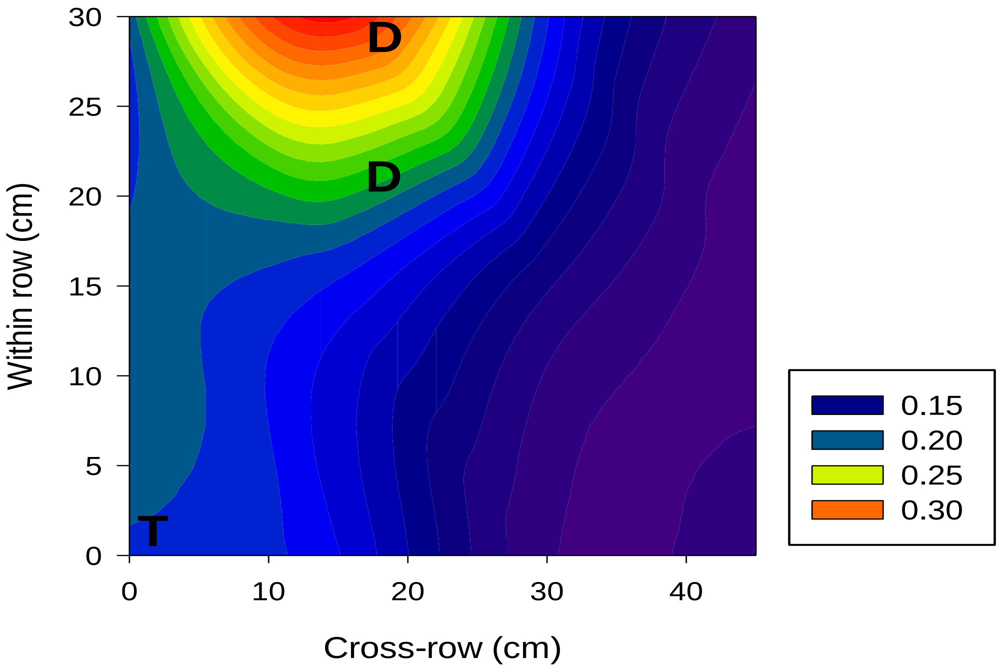


T=tree, M=microsprinkler
Roots uniformly distributed around the tree

EFFECT OF IRRIGATION SYSTEM (MICROSPRINKLER AND DRIP) ON ROOT DENSITY

Lateral root density distribution using drip irrigation.

Positions in the irrigated zones of drip irrigation systems showed higher root density (2 to 3x greater) than non-irrigated zones.

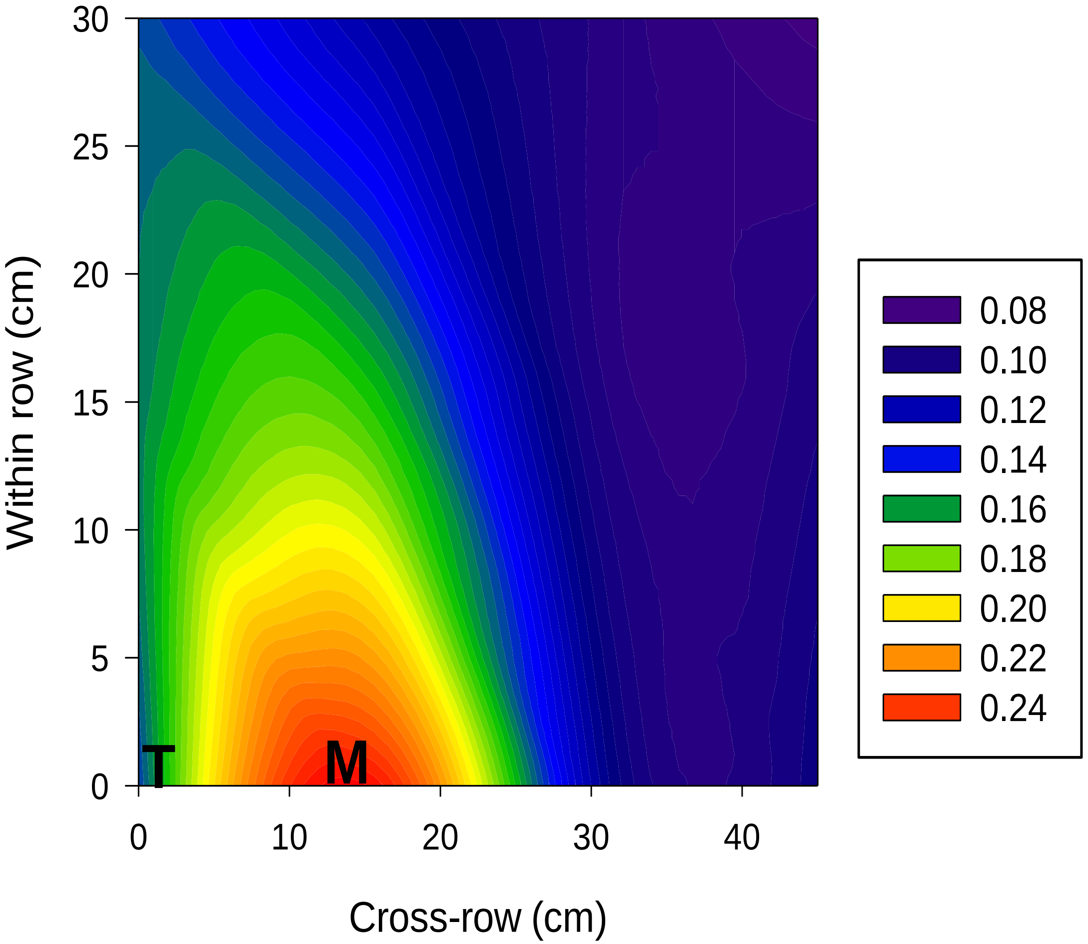


T=tree, D=dripper, Roots concentrated below the drippers

EFFECT OF LINEAR MICROSPRINKLER IRRIGATION SYSTEM ON ROOT DENSITY

Positions in the irrigated zones of linear microsprinkler showed higher root density than non-irrigated zones

Lateral root length density (cm cm^{-3}) distribution using modified microsprinkler irrigation



M = microsprinkler
T = tree

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**

1 inch = 25.4 mm

22 to 35% greater water use for Non-HLB affected trees

Inter-season and annual variability in water use

Comparable water use between varieties

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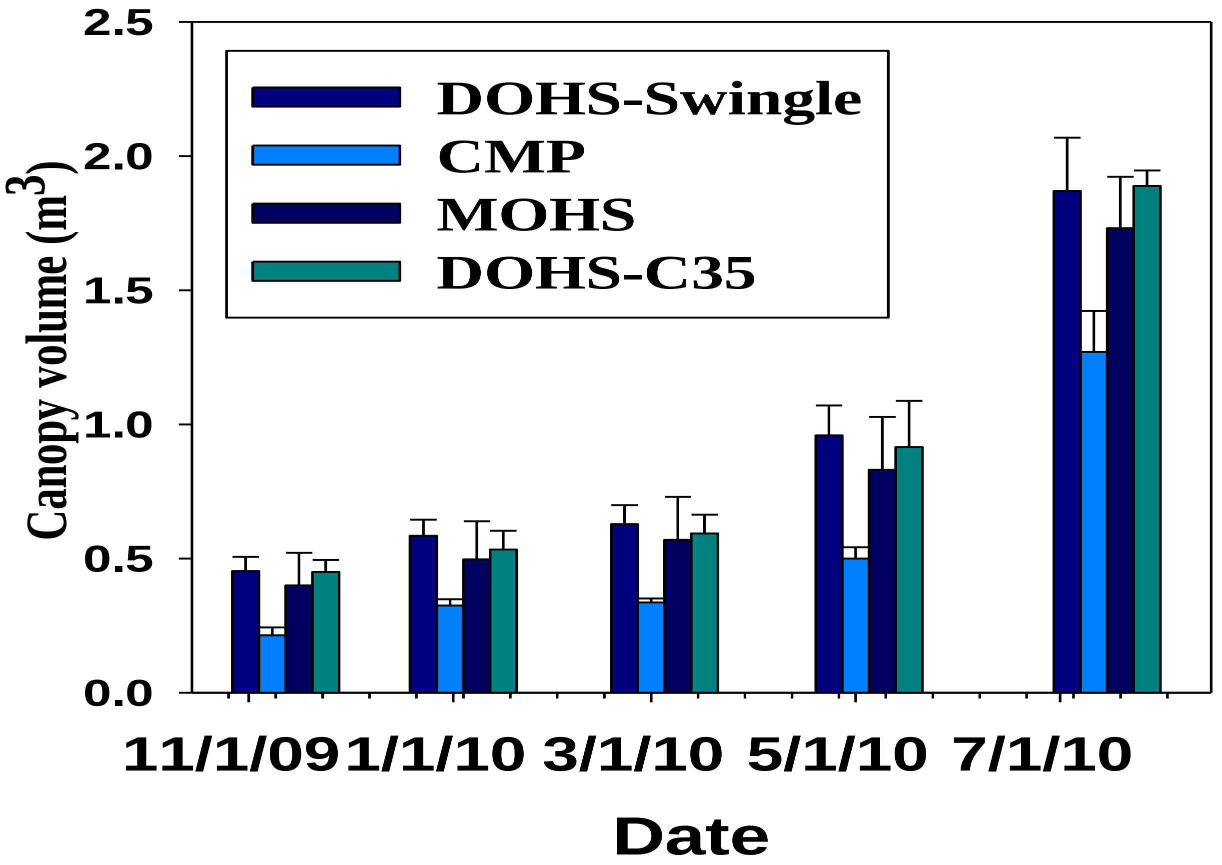
Effect of irrigation practices on canopy size



Canopy volume as a function of irrigation practice at Lake Alfred

Treatments:
DOHS is the drip open hydroponic system on Swingle or C-35 rootstock
CMP is the conventional microsprinkler practice
MOHS is a microsprinkler hydroponic system applying water linearly in the tree row.

Advanced citrus production system (ACPS) fertigation had greater tree size than conventional practice

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SUMMARY

- Daily, frequent irrigation critical for improved tree performance, soil moisture distribution and water use.
- Use available tools such as FAWN for freeze protection.
- HLB affected trees use 22 to 35% less water than the non-affected trees, thus irrigation amount could be reduced without affecting yield. This needs to be validated at field scale since this was a greenhouse study.
- Intensive irrigation practices could be adapted to grower practices for vigorous tree growth, water use, greater root density and nutrient accumulation.

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  - Pacific Inc., Ave Maria, FL
  - Orange Co., Arcadia, FL
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QUESTIONS/COMMENTS