Dirt, Fert and Squirt

(2) Irrigation

"The person at the end of the hose is the most important person in the greenhouse"

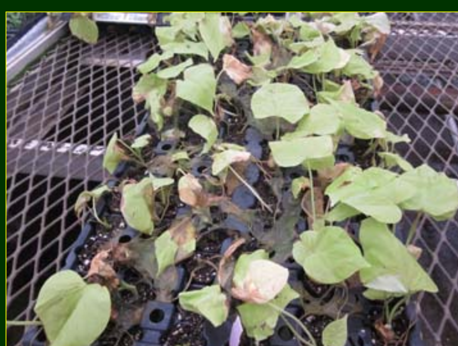
Paul Fisher
pfisher@ufl.edu

UF UNIVERSITY of FLORIDA
IFAS Extension

Greenhouse Irrigation

- Objectives:
  - Be able to communicate to irrigate plants without overwatering
  - Understand how irrigation interacts with porosity in a root substrate

Overwatering leads to disease



Overwatering in Ipomea leading to rot

Overwatering leads to poor root growth

overwatered normal

Overwatering leads to anaerobic conditions, and poor nutrient uptake

However, don't stress your plants by excess drying

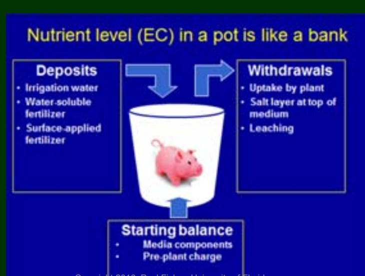
Overwatering causes “leaching”, which is the water, fertilizer and nutrients that flow through the substrate

Leaching washes out nutrients

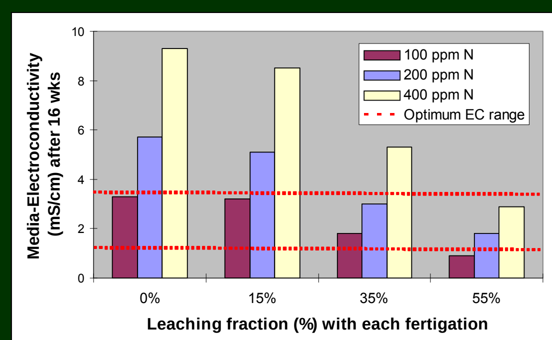
- 4500 kg nitrogen/hectare in greenhouse production (Nelson, 2003)

Interpreting EC: you move from (a) overhead sprinklers to (b) subirrigation or drip.

How will EC in the substrate change?



Fact: The more you leach (withdraw), the more fertilizer you must apply (deposit)



Yelanich and Biernbaum (Michigan State University)

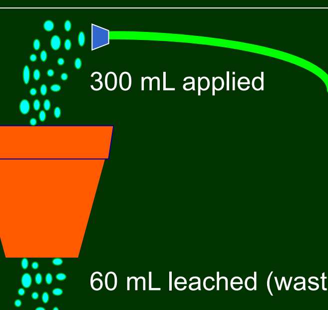
Nutrient level in a container is like a bank

Deposits
- Irrigation water
- Water-soluble fertilizer
- Surface-applied fertilizer

Withdrawals
- Uptake by plant
- Salt layer at top of medium
- Leaching

Starting balance
- Media components
- Pre-plant charge

Calculating leaching fraction



10 oz 300 mL applied

2 oz 60 mL leached (waste)

2/10 60/300 = 20% leaching fraction

10-2 = 8 300-60 = 240 mL taken up by substrate

Pros and cons of leaching

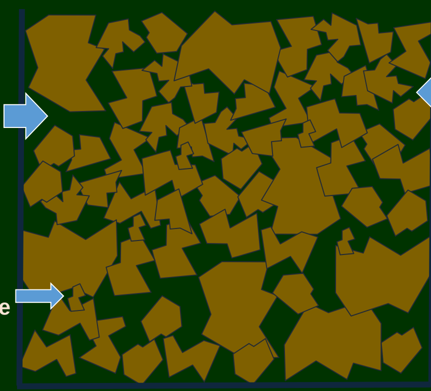
Pros	Cons
Evens out non-uniform watering from sprinklers and drippers	Increases fertilizer and water cost
All plants get enough water	Some plants get too much water
Easy to avoid substrate EC increasing over time because salts are washed through	Increases runoff to environment or need to capture and treat
Low management thought/skill required	Increases greenhouse humidity, root diseases

Leaching should only be needed because of:

- Rain on uncovered crops
- Uneven drip emitters or sprinklers
- Poor wettability or water holding of substrate
- Removal of sodium & chloride if poor water quality

Leaching because fertilizer and/or water are over-applied is wasteful

Irrigation interacts with porosity in substrates

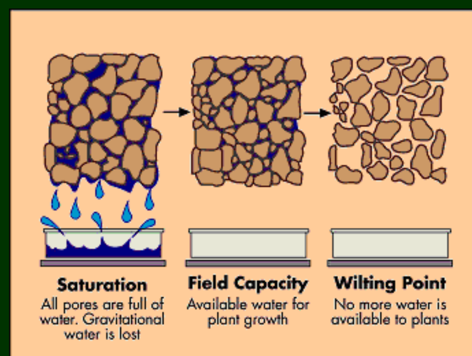


Would field soil make a good container substrate?

Porosity in substrates

- Water + Air + Solid + Plant make up the Total Container Volume
- Of these, Water + Air = Porosity
- Water volume after complete irrigation and draining is called "water-holding capacity"
- Water holding/container differs with container size, so it is also called "container capacity"
- We will show how to test porosity in the greenhouse

Irrigation interacts with the root substrate - avoid saturation or excess wilting

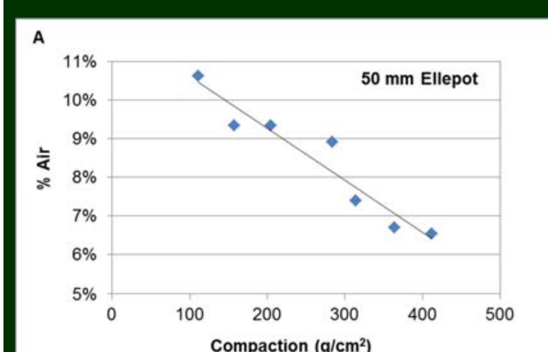


http://www.tankonyvtar.hu/en/tartalom/tamop425/0032_talajtan/ch07s02.html

Fine particles have small pores which easily fill with water

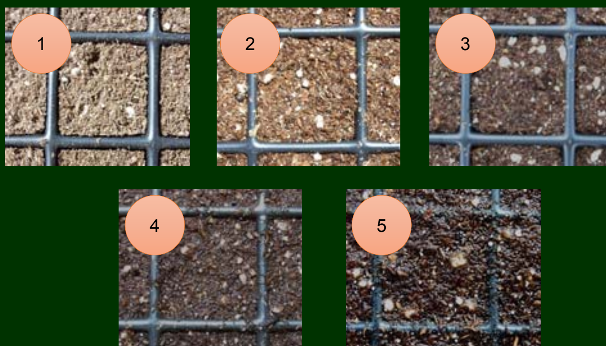
- Water held on particle surface and between particles
- Pores are filled with water or air
  - Large particles = less water holding capacity, more air
  - Small particles = more water holding capacity, less air

Compaction of substrate drives out air



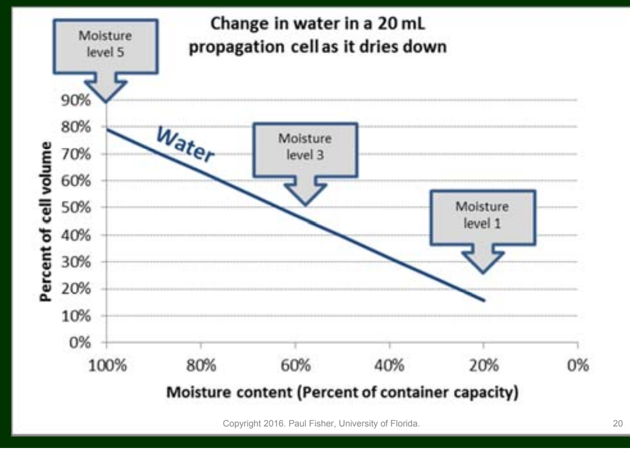
1 to 5 moisture scale

The language of watering: how wet is wet?

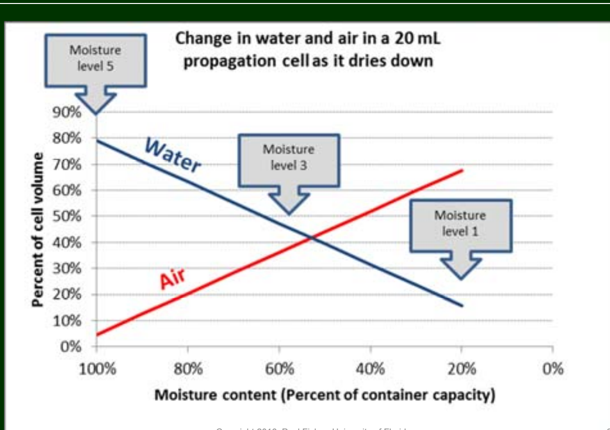


- BackPocketGrower.ORG > Training > Irrigation

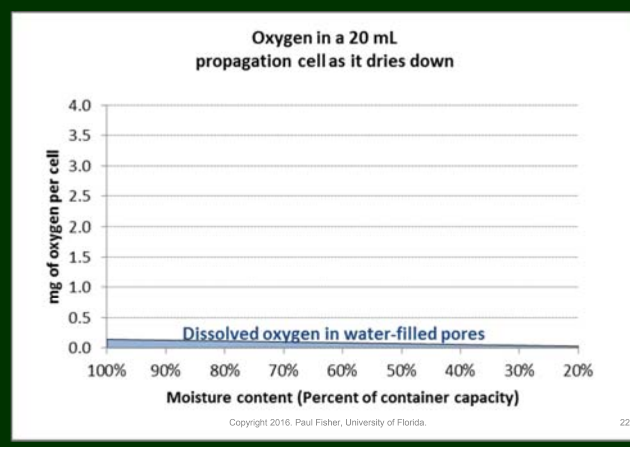
Manage water with the moisture scale



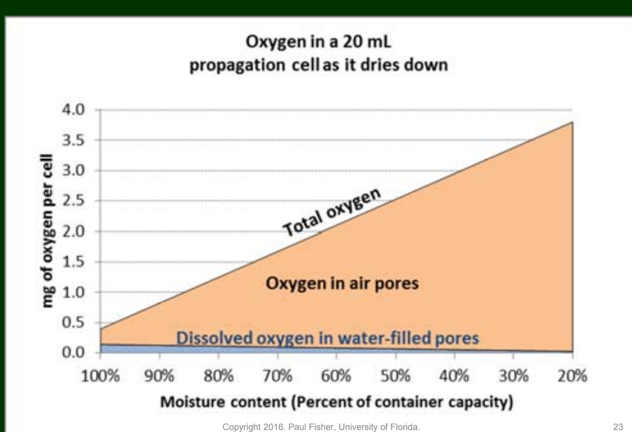
Manage water & air with the moisture scale



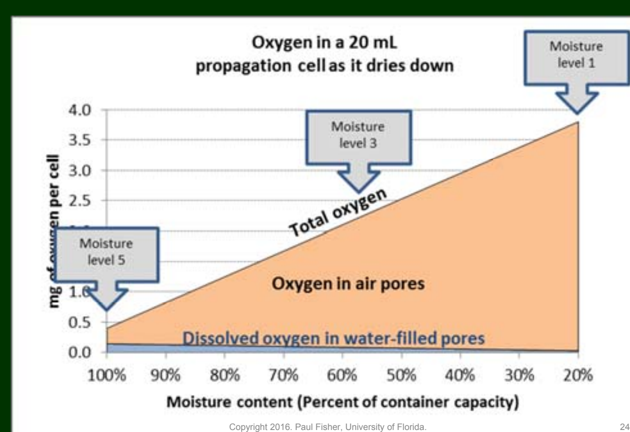
The best way to supply oxygen to roots is to allow the root substrate to dry down



The best way to supply oxygen to roots is to allow the root substrate to dry down

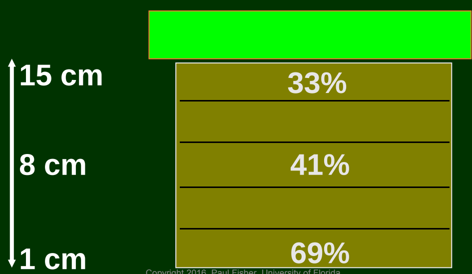


The best way to supply oxygen to roots is to allow the root substrate to dry down

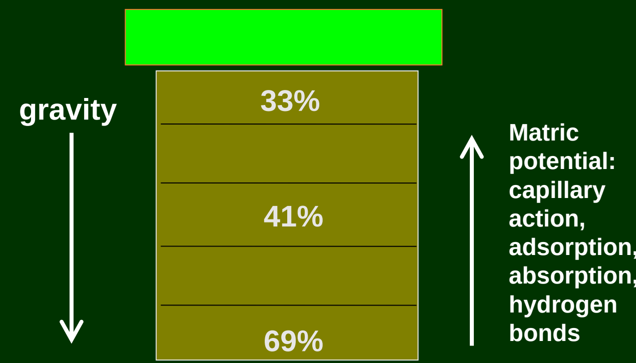


Water content inside a container

- Water content (% of volume) versus container height.



Several forces affect water content

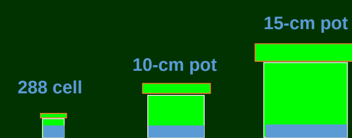


The saturated zone

- A container is a "perched water table" - the saturated zone is similar for a given substrate regardless of container height.

Size of container is important.

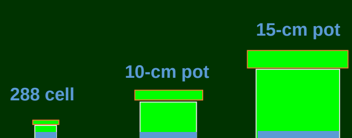
- The proportion of air, water and soil varies with container height.
- These are examples with one peat/perlite substrate:



	288 cell	10-cm pot	15-cm pot
Air (%)	3	13	20
Water (%)	84	74	67
Solid (%)	13	13	13

Size of container is important

- It is therefore particularly important to avoid over-watering (lack of aeration) in small container sizes.

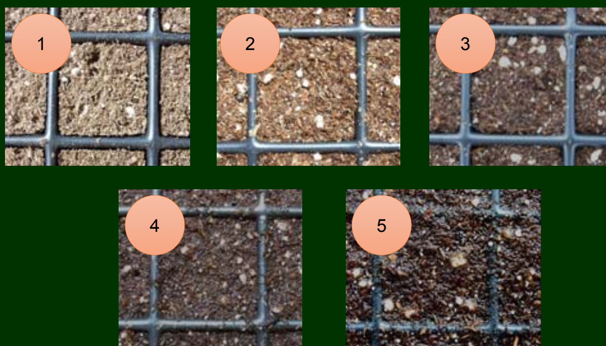


When & how much to water?

- Observation (1 to 5 moisture scale)
- Target leaching fraction
- Substrate moisture sensors
- Climate-based evapotranspiration modeling

When & how much to water: observation (1 to 5 moisture scale)

The language of watering: how wet is wet?



- BackPocketGrower.ORG > Training > Irrigation

Moisture levels (Ball Tagawa, Colorado)

Level	Class	Sight	Feel	Culture
5	Saturated	Shiny black; standing water. Soaked	Very heavy; media feels soaked and dripping	No oxygen for roots; few seeds germinate; soak
4	Wet	Dark brown; no standing water.	Heavy; can squeeze out moisture when pressed	Maximum acceptable water level
3	Medium	Brown	Average weight; media will feel moist; maybe squeeze out droplets.	Optimum & transitional level
2	Dry	Light brown	Light weight; no free moisture	Typically do not dry below level; wet / dry cycle develops roots
1	Baked	Tan; media may pull away from cell sides	Very light weight; no moisture, almost dusty	Plants desiccate & die rapidly; only cactus survive at this level

There are other tests of moisture level

Moisture content (water weight/total weight)

Moisture content
Less than 30%
35-45%
50-60%
65-70%
75-80%

Using moisture levels

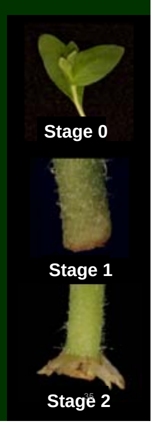
Table 1. Examples of moisture levels when plugs should be watered for optimum growth.

Crop	Stage 1	Stage 2	Stage 3	Stage 4
Pansy	W4	W3	W3	W3
Impatiens	W5	W3	W3	W2
Petunia	W4	W4	W3	W2
Verbena	W2	W3	W3	W3
Vinca	W4	W3	W3	W3

Dr. Will Healy, Ball Horticulture

Moisture levels with cuttings

During misting: low-volume mist or fog nozzles.



Goal to hydrate foliage, not saturate media.
Maintain moisture level 4.

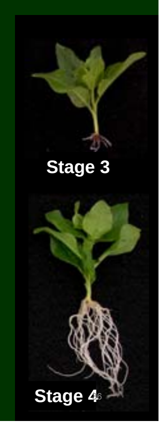
Moisture levels with cuttings

Off mist:

goal is to increase water and nutrient uptake through roots, promote root growth, controlled shoot growth

Transition to moisture level 3.

Finish with wet-dry cycles at levels 2-4.

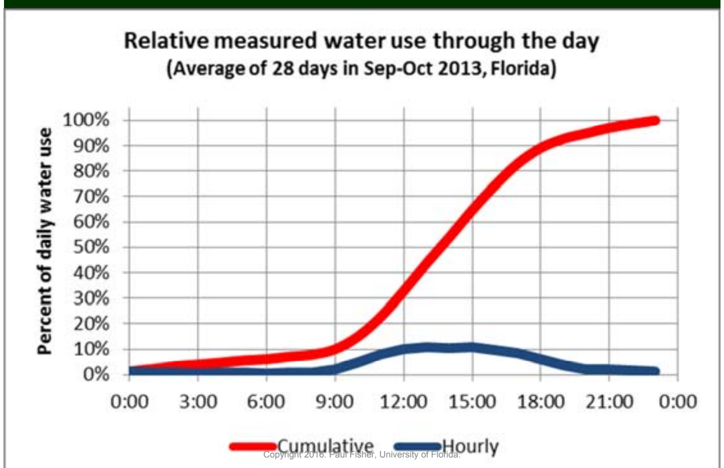


When and how much to water: target leaching fraction

- Typical target 20 - 25% leaching in rock substrate
- Usually much higher in reality

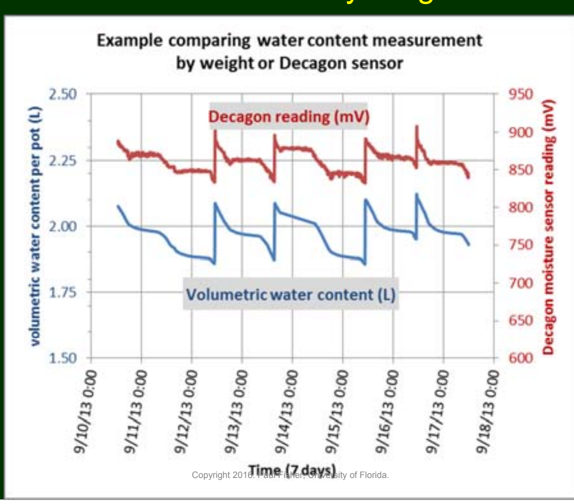
Substrate moisture level: continuous weight measurement and logging

Weight scale shows 80% water lost during daylight hours

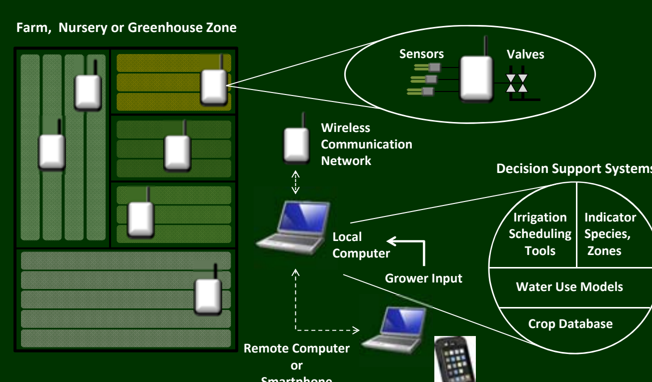


Substrate moisture level can also be measured with sensors

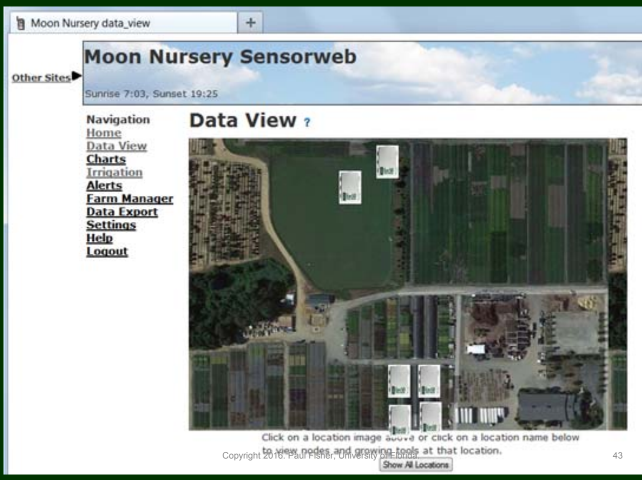
Moisture level measured by weight or sensor



Real-time data can be accessed from wireless sensor networks (smart-farms.net)



Sensor data available on protected website



Water loss (evapotranspiration) can also be modeled

Hot
(Air Temperature)

Wind, fans
(Air movement)

Sunny
(Radiant heating)

Dry air
(Low relative humidity)

Big Canopy
(Large leaf area)

Well watered plant
(turgid, open stomates)

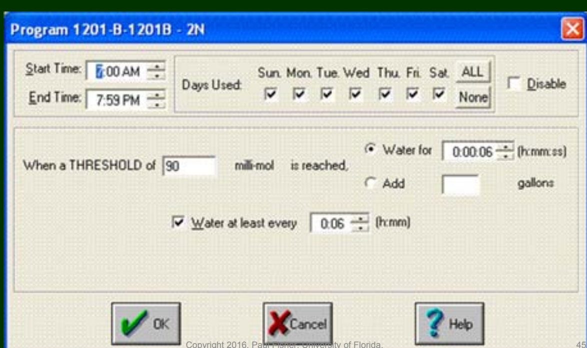
High water content
(total soil water)

Low EC
(low osmotic potential)

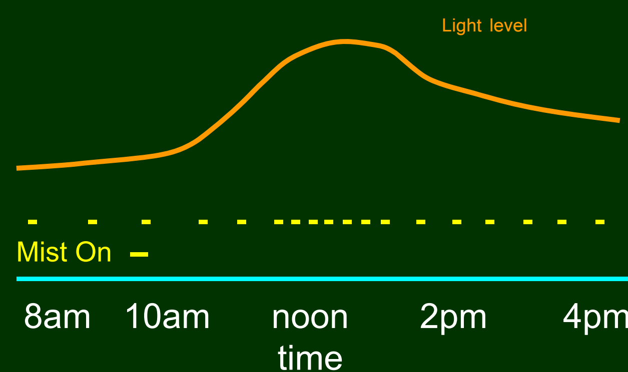
Large soil pores
(easily available water)

Climate-based modeling of ET
Simple: light accumulation

An example mist setting for propagation



Mist scheduling with solar units



More growers are now misting based on Vapor Pressure Deficit (VPD)

- VPD = difference between vapor pressure in leaf (at saturation) and vapor pressure in air.
- More useful than relative humidity when modeling evaporation

More water uptake with warm, dry air

Air **warm**
low relative humidity (**dry**)
Low vapor pressure

High VPD
Rapid drying

Leaf warm,
100% relative humidity (wet)
High vapor pressure

Less water uptake with cool, wet air

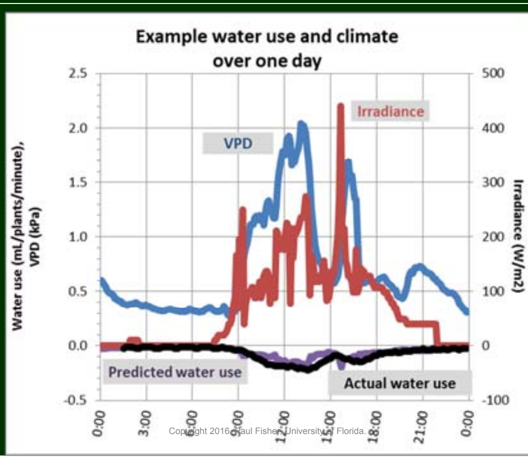
Air **cool**
High relative humidity (**wet**)
High vapor pressure

Low VPD
Slow drying

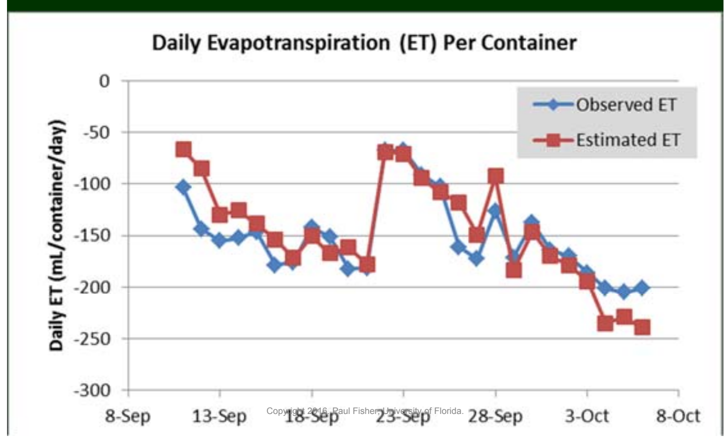
Leaf warm,
100% relative humidity (wet)
High vapor pressure

Climate model-based irrigation:
Predicting evapotranspiration with Vapor Pressure Deficit, Irradiance and Leaf Area

Hourly water use



Daily water use



Climate Modeling to Predict Evapotranspiration (ET)

- $ET = A*(1 - \exp(-0.6*L))*Light + B*L*VPD$
  - ET = evapotranspiration (water loss)
  - A and B are statistical parameters
  - L = leaf area index
  - Light = irradiance in W/m^2
  - VPD = vapor pressure deficit in kPa
- Climate measured with mini weather station
- ET + desired leaching = Volume to apply

It has to be practical!

It has to be practical!

It has to be practical!

It has to be practical!

		Plant size		
		Small	Medium	Large
Climate conditions	Humid, cool (low VPD)	1 cycle 100 mL = 100 mL	2 cycles 75 mL = 150 mL	3 cycles 100 mL = 300 mL
	Average (medium VPD)	2 cycles 100 mL = 200 mL	3 cycles 100 mL = 300 mL	3 cycles 150 mL = 450 mL
	Warm, dry (high VPD)	3 cycles 100 mL = 300 mL	3 cycles 100 mL = 450 mL	4 cycles 150 mL = 600 mL