Optimizing Citrus Fertigation

Arnold Schumann
(UF/IFAS, CREC)

Florida Citrus Growers' Institute
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UF UNIVERSITY of FLORIDA
IFAS Research
Citrus Research and Education Center

Introduction

- ***Fertigation*** **is used to apply soluble fertilizer and irrigation water simultaneously to the grove**

- **Scheduling fertigation is therefore complicated by the need to supply both water and nutrient requirements of citrus trees in the correct amounts during the growing season**

- **Optimally implemented fertigation reduces water and nutrient requirements and increases growth rates and yield of trees; all are desirable attributes in HLB-affected groves**

- **A Decision Support Program (DSP) was developed to help growers optimize their fertigation systems**

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The origin of soil fertility and the role of fertigation in Florida

Typical agricultural soils

Soil solution

FAST

Readily available nutrient pool (CEC, fertilizer)

N,P,K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo

SLOW

Slowly available nutrient pool (e.g. OM-N, fixed P)

N,P,K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo

VERY LONG TERM

Nutrient in soil minerals (e.g. mica, feldspar)

P, K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo

Florida's sandy soils

Low water-holding capacity

Low CEC

Low organic matter reserves

Predominantly quartz

- **Florida soils in agricultural production benefit from *frequent* additions of irrigation water and nutrients as fertigation**

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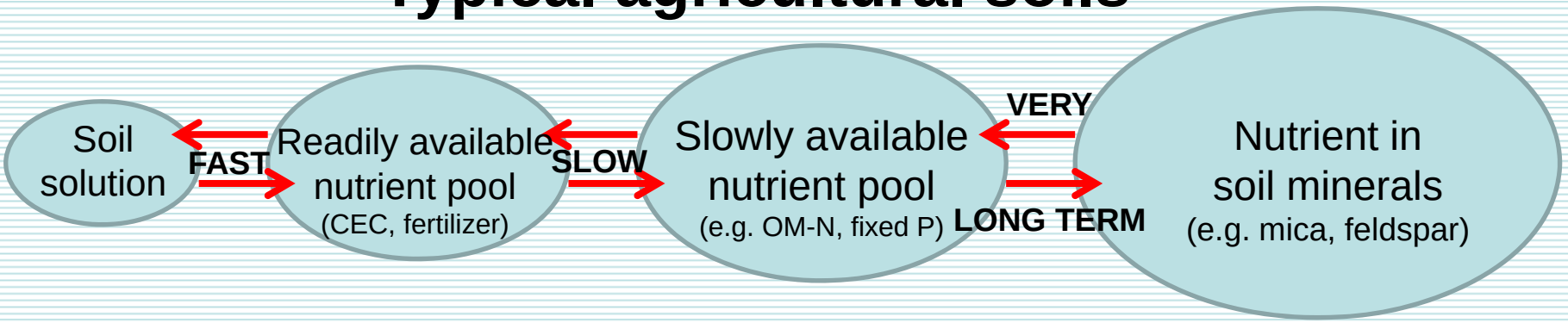
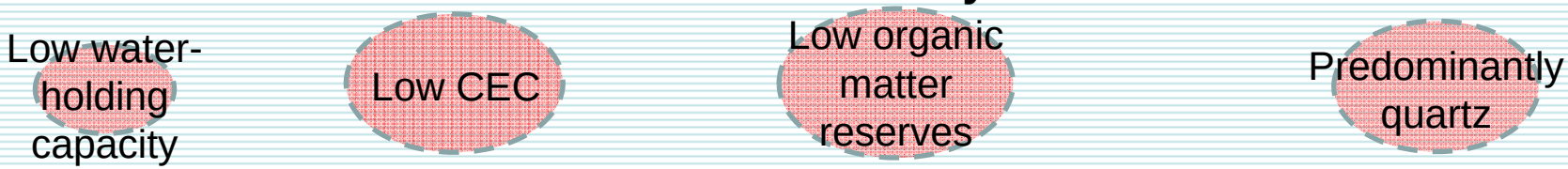
Open hydroponics diminishes the role of soil and increases efficiencies

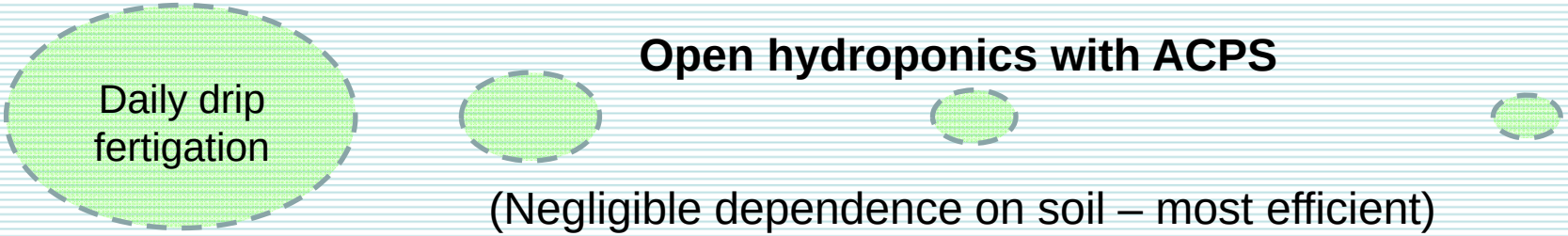
Typical agricultural soils



Florida's sandy soils



Open hydroponics with ACPS



(Negligible dependence on soil – most efficient)

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Lake Alfred:
'Valencia'
@ 1.5 years
drip fertigation:
2 drippers/tree
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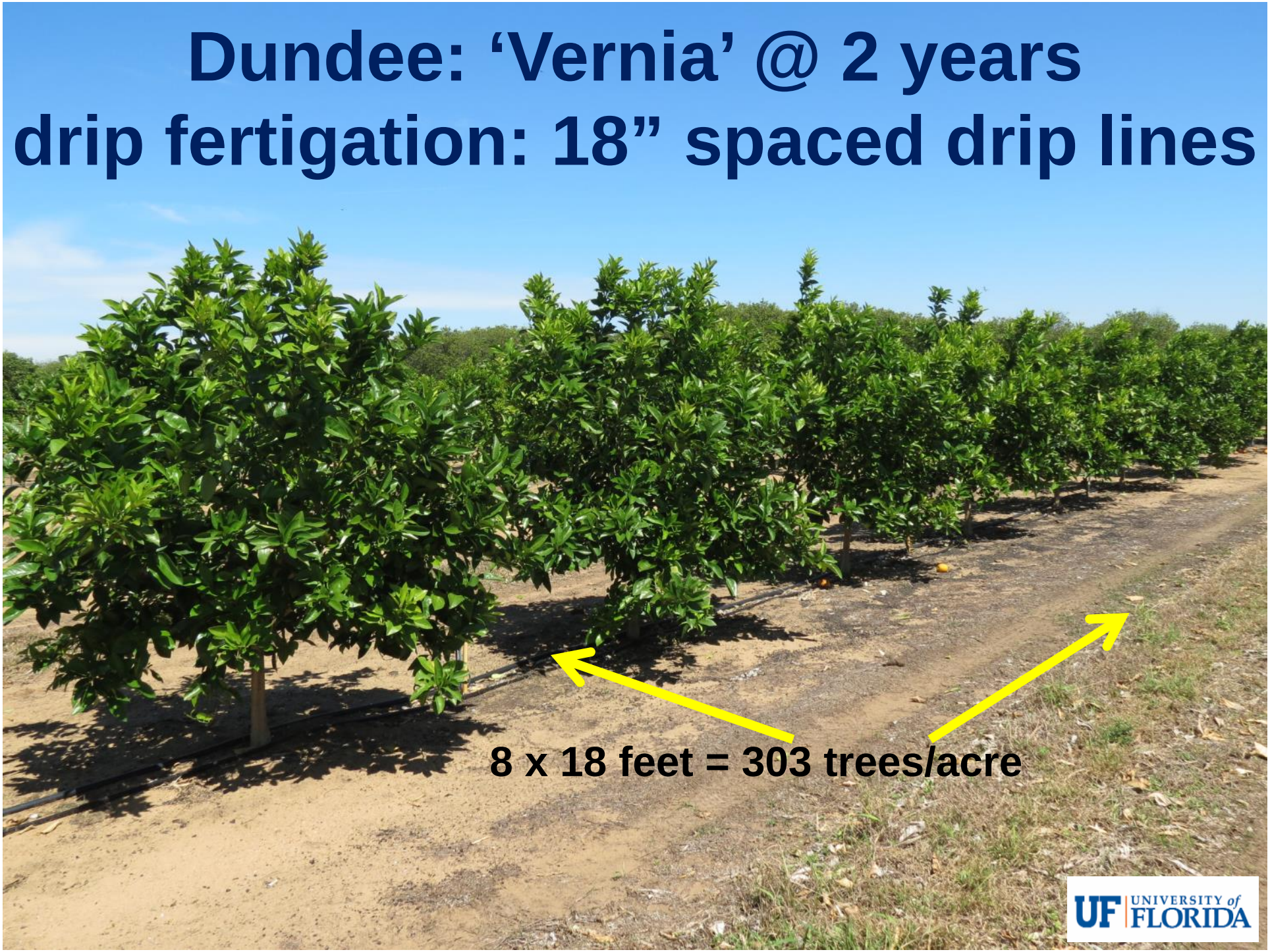
Dundee: ‘Vernia’ @ 2 years
drip fertigation: 18” spaced drip lines



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Lake Placid: 'Vernia' @ 3 years
drip fertigation: 18"
spaced drip lines
OR
Microsprinkler fertigation: 7.7 gph
47% HLB+ in March 2014
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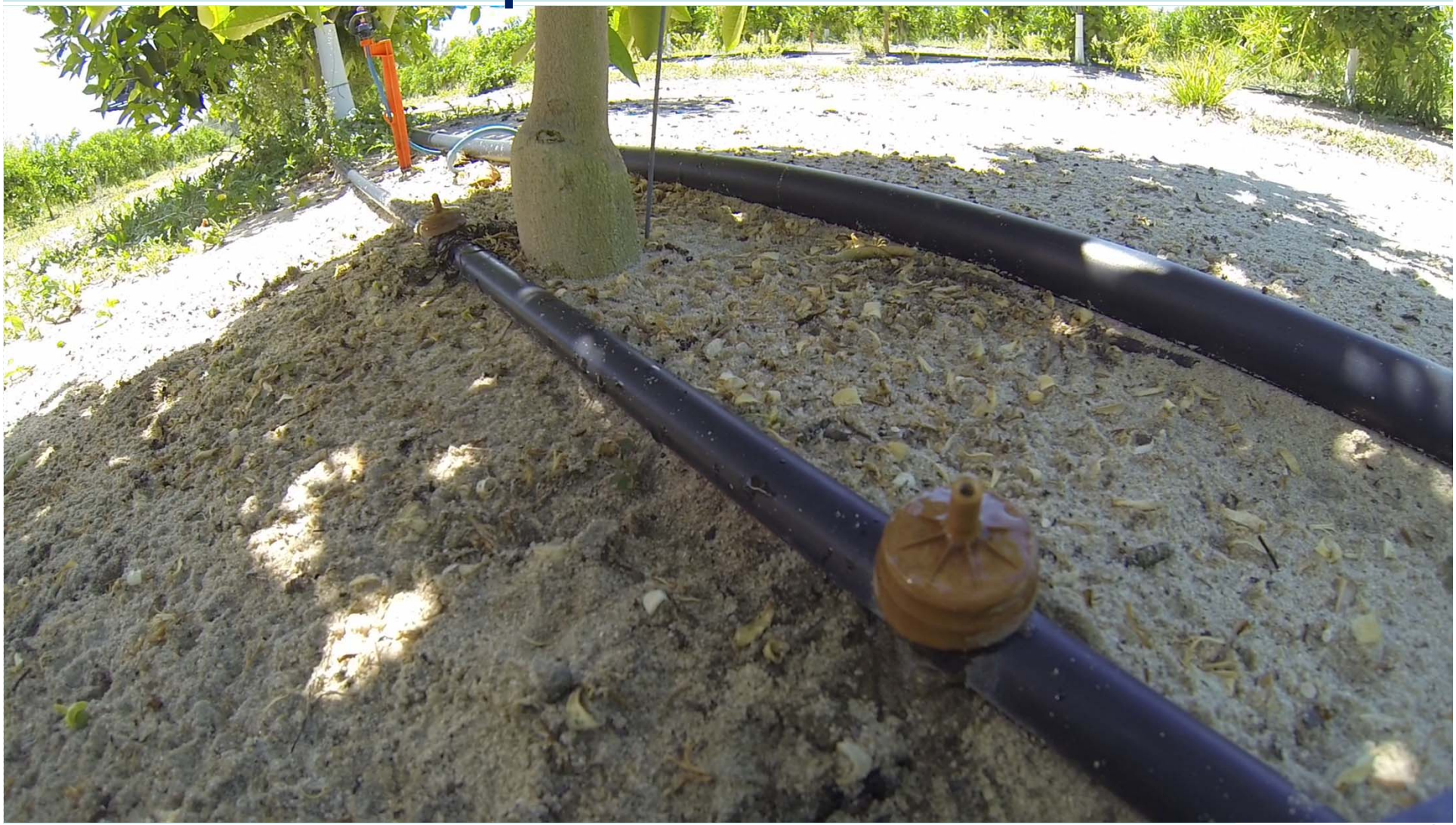
Auburndale: healthy ‘Hamlin’ yield in year 5:
Drip fertigation: 2 drippers/tree
OR
Microsprinkler fertigation: 10.5 gph

Common threads in these illustrated fertigation examples:

- **Increased growth and early, high yields (Lake Placid is somewhat later)**
- **Increased water and nutrient use efficiency**
- **Minimal reliance on soil for water and nutrient storage = *daily* fertigation**

Proper targeting of water and nutrients to the root zone ensures high efficiencies: drip emitters are ideal



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Drip fertigation develops healthy, dense feeder roots

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Properly designed microsprinkler irrigation systems can achieve similar high efficiencies: target the root zones of trees appropriate for their size

e.g. inverted emitters for young trees

Upright microsprinkler emitters spray a water pattern that is too large for small trees; only a portion of the wetted zone is occupied by roots

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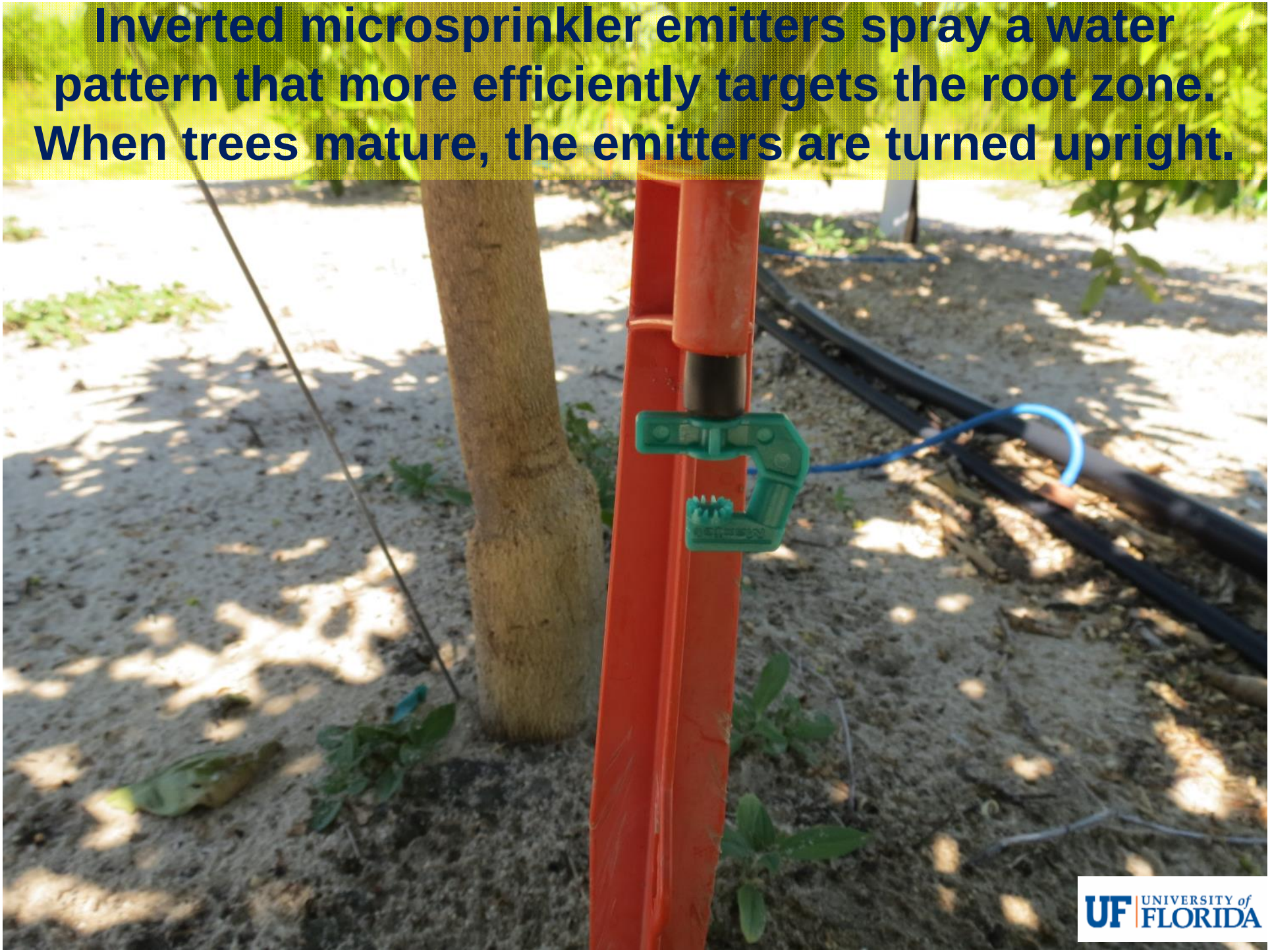
Inverted microsprinkler emitters spray a water pattern that more efficiently targets the root zone. When trees mature, the emitters are turned upright.
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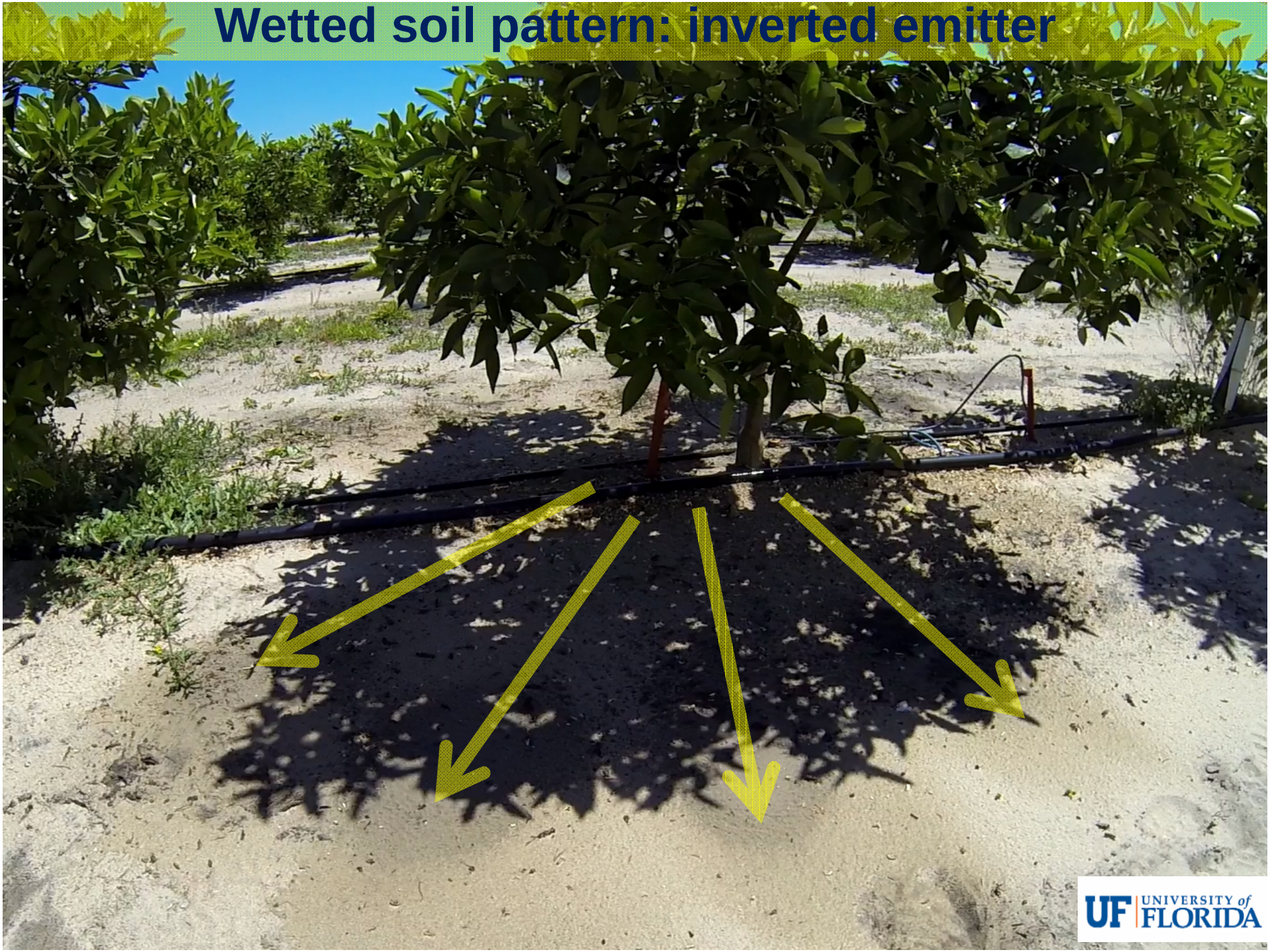
Wetted soil pattern: inverted emitter



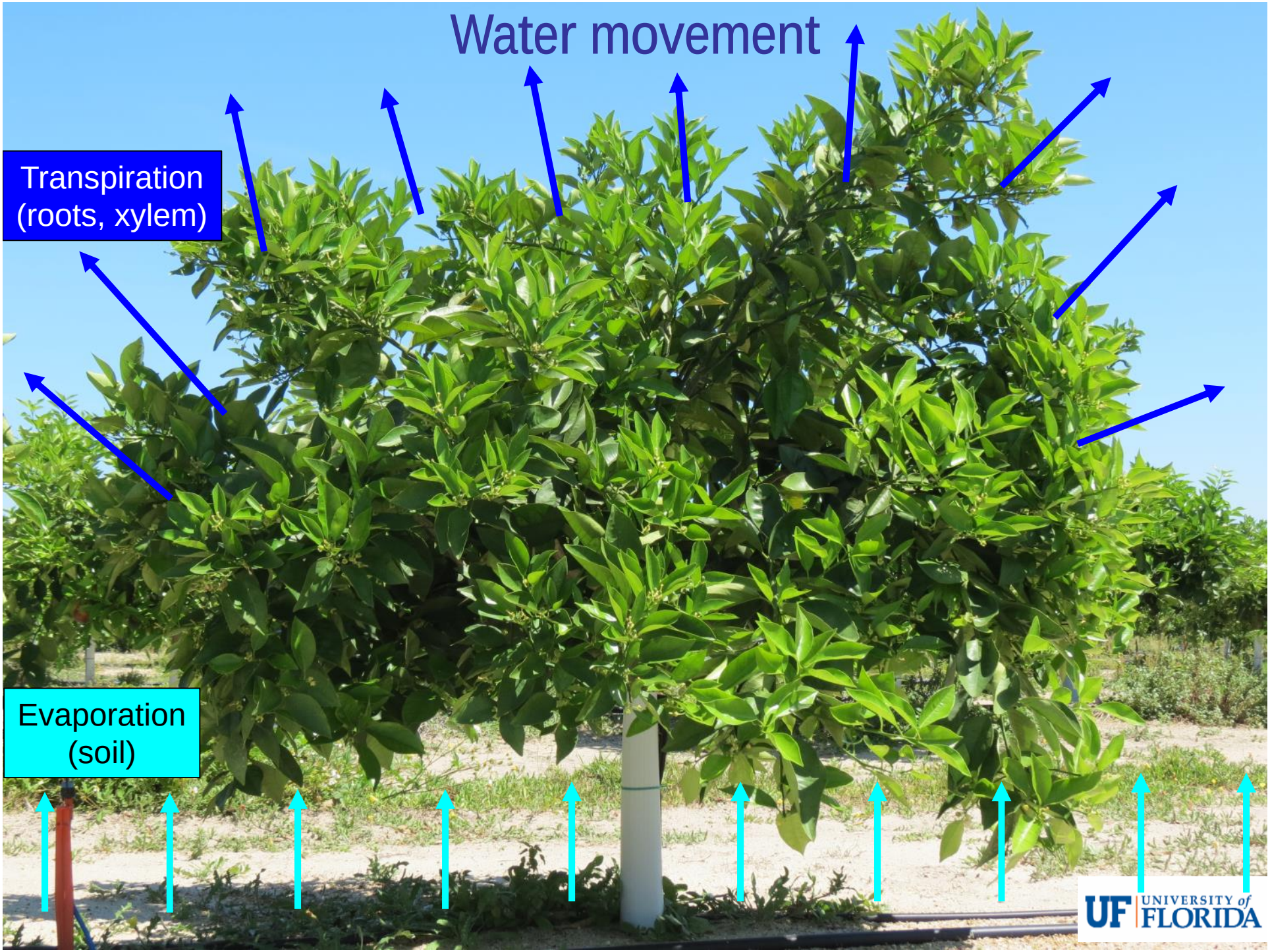
Design of the DSP

- ***Assumption:*** **With daily fertigation only enough water and nutrients are applied each day to match the needs of the trees (no storage in the soil necessary)**

- **Soil water content is maintained near field capacity, thus maximizing crop evapotranspiration and growth**

- **Irrigation requirements for trees of different sizes [ages] are calculated from average historical daily ET_0 and the proportional ground coverage by canopies**

- **Nutrient uptake patterns of citrus trees are inextricably related to transpiration patterns BUT the two are not necessarily dependent on each other at all times**


Water movement
Transpiration
(roots, xylem)
Evaporation
(soil)
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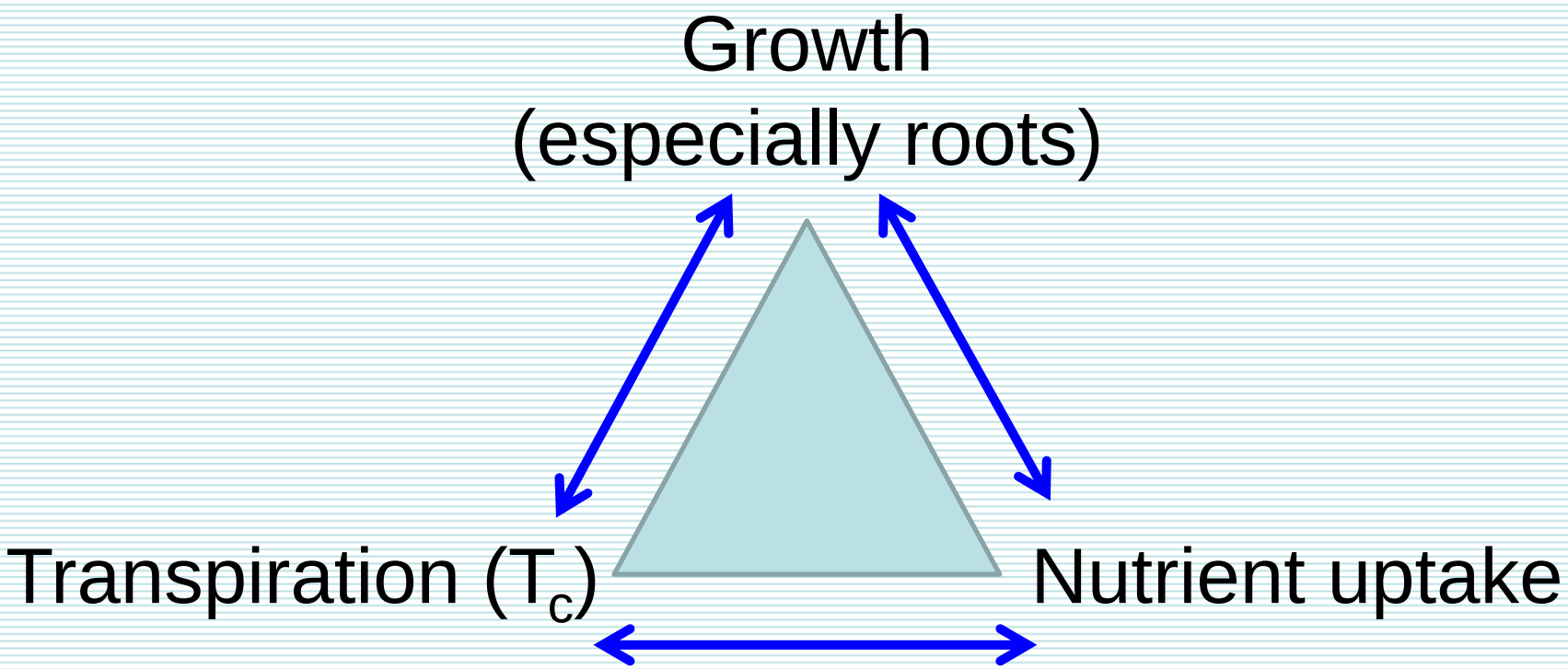
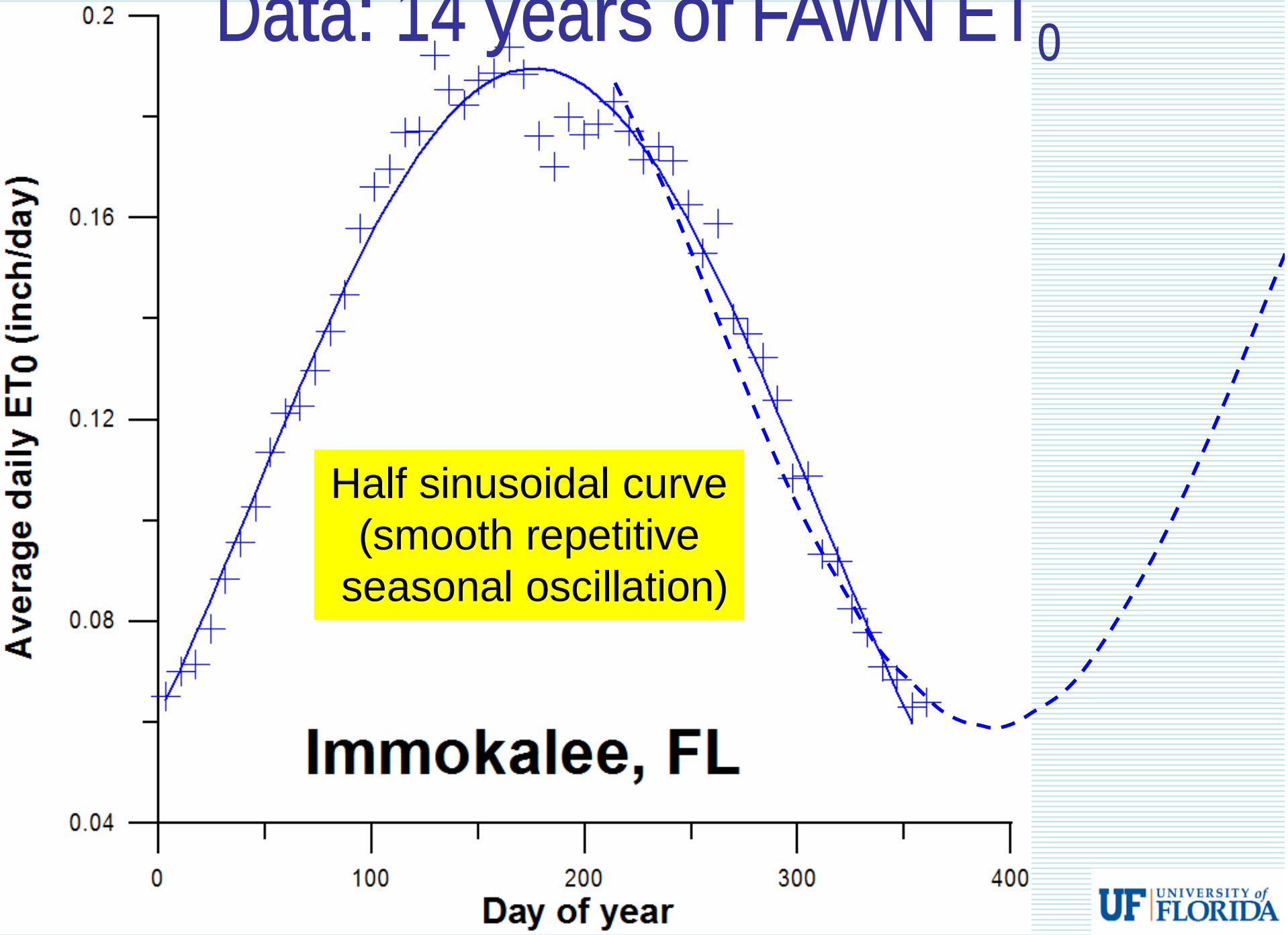


Transpiration is proportional to crop ET (ET_c) because $ET_c = T_c + E$

ET_c for a grove acre is related to canopy size and its ground coverage

Data: 14 years of FAWN ET_0



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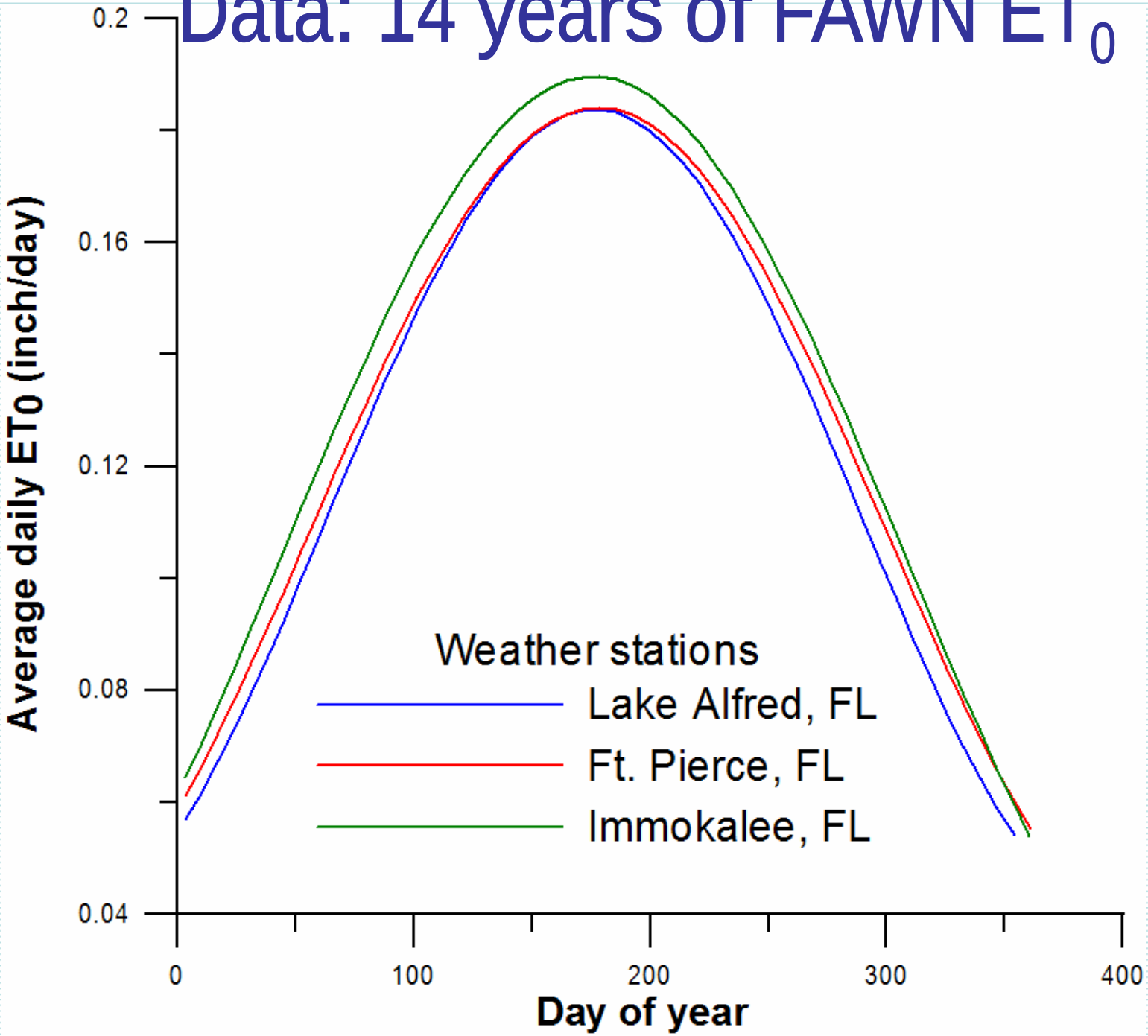

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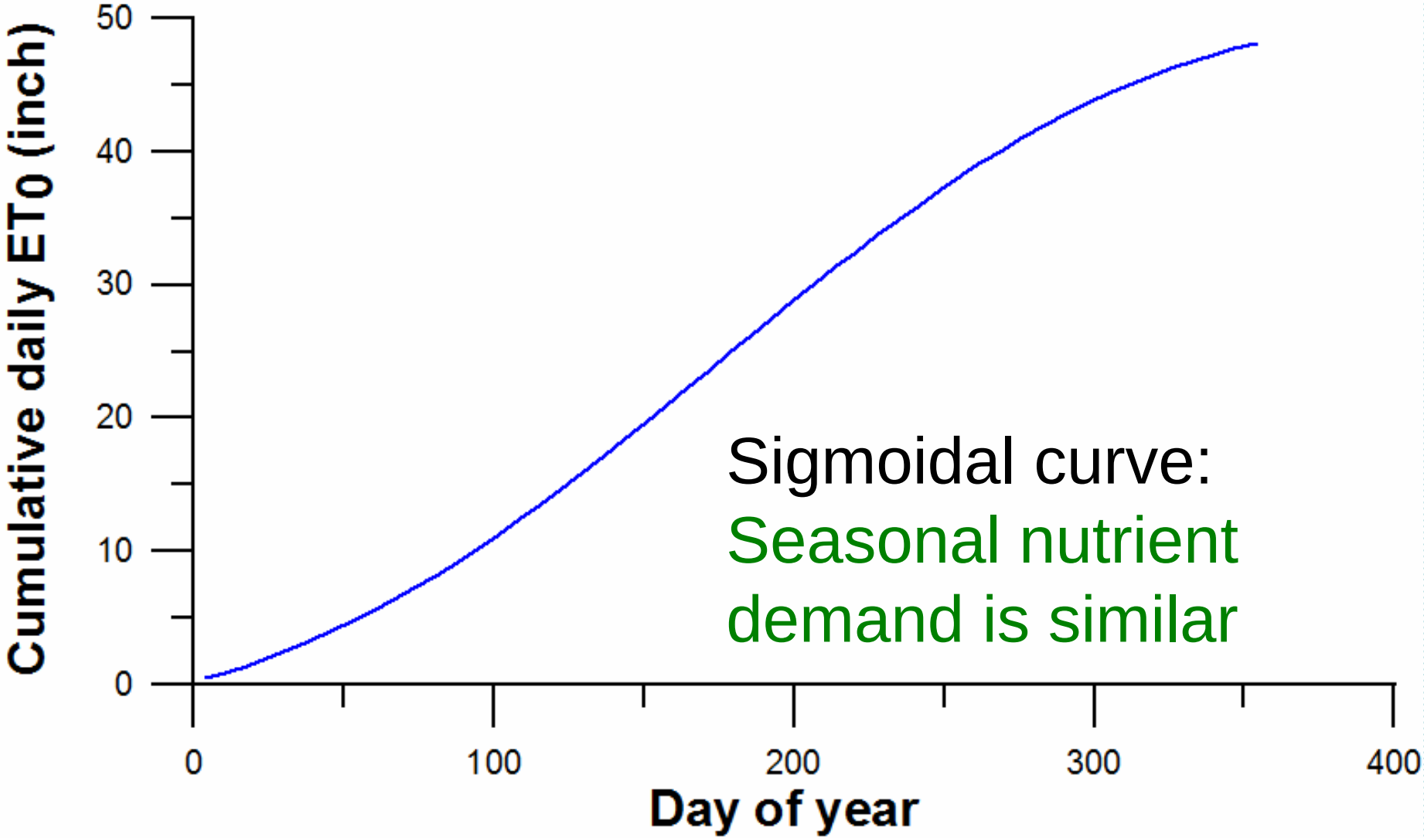

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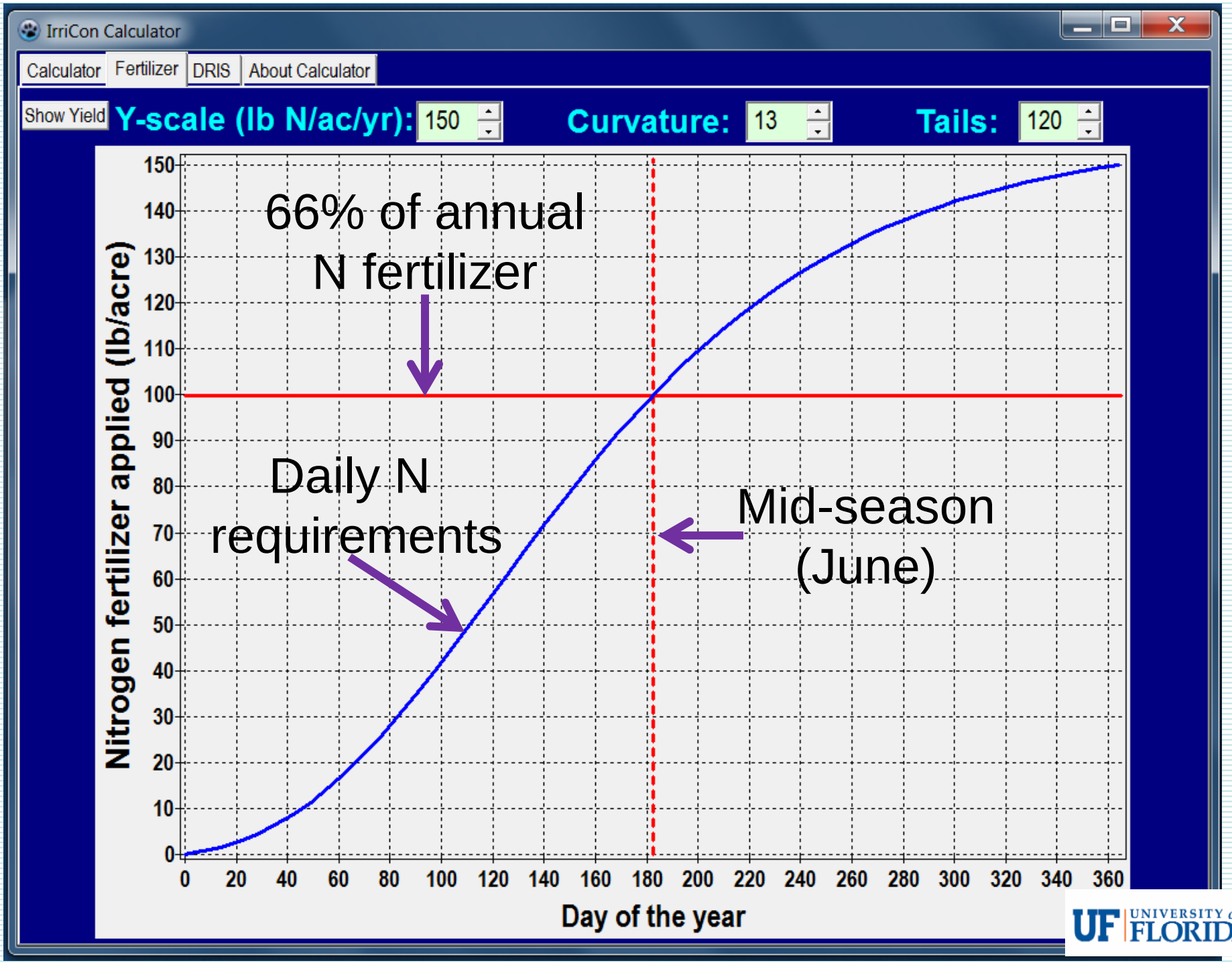
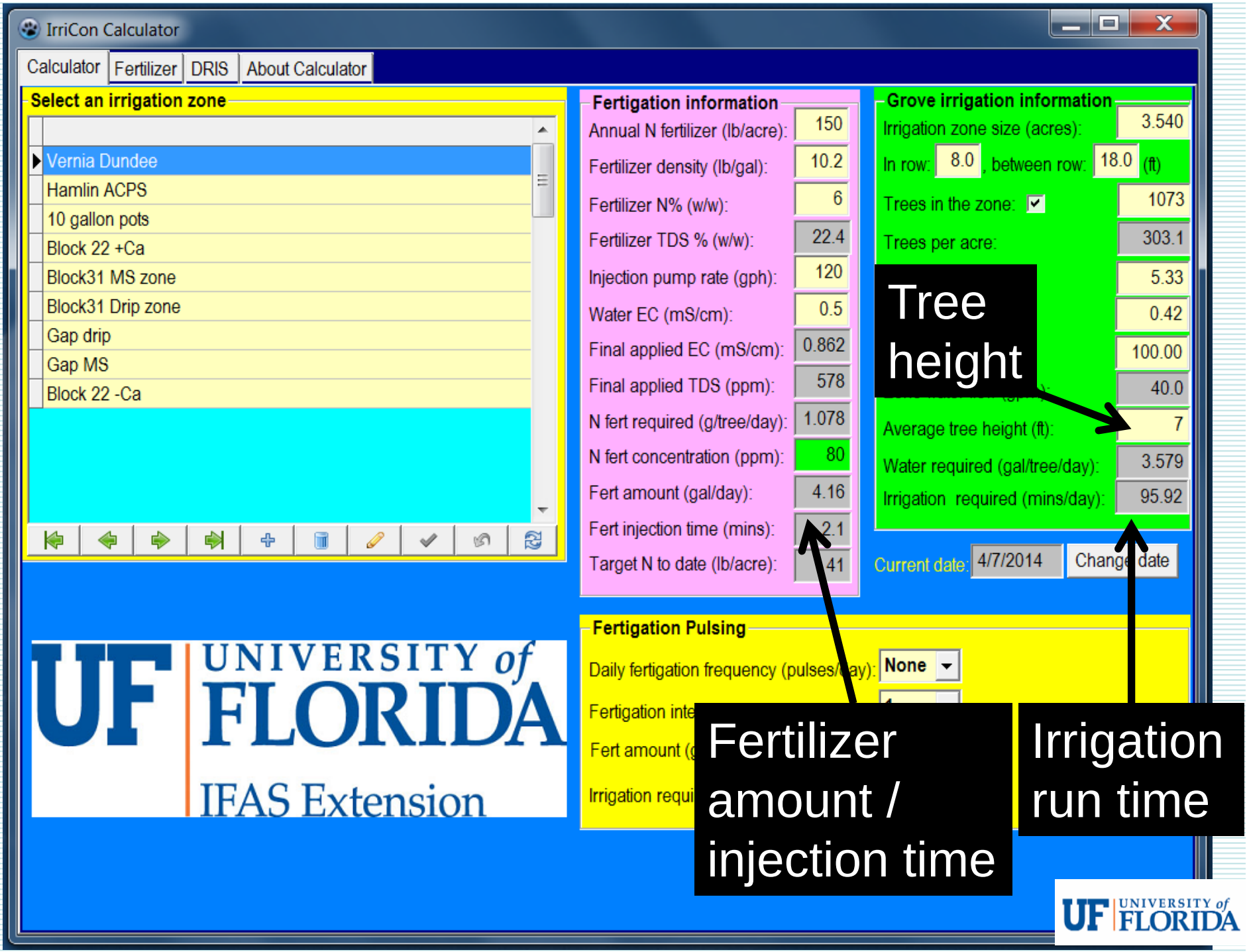

IrriCon Calculator
Calculator
Fertilizer
DRIS
About Calculator
Show Yield
Y-scale (lb N/ac/yr):
150
Curvature:
13
Tails:
120
66% of annual
N fertilizer
Daily N
requirements
Mid-season
(June)
Nitrogen fertilizer applied (lb/acre)
Day of the year
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360


IrriCon Calculator
Calculator
Fertilizer
DRIS
About Calculator
Select an irrigation zone
Vernia Dundee
Hamlin ACPS
10 gallon pots
Block 22 +Ca
Block31 MS zone
Block31 Drip zone
Gap drip
Gap MS
Block 22 -Ca
Fertigation information
Annual N fertilizer (lb/acre): 150
Fertilizer density (lb/gal): 10.2
Fertilizer N% (w/w): 6
Fertilizer TDS % (w/w): 22.4
Injection pump rate (gph): 120
Water EC (mS/cm): 0.5
Final applied EC (mS/cm): 0.862
Final applied TDS (ppm): 578
N fert required (g/tree/day): 1.078
N fert concentration (ppm): 80
Fert amount (gal/day): 4.16
Fert injection time (mins): 2.1
Target N to date (lb/acre): 41
Grove irrigation information
Irrigation zone size (acres): 3.540
In row: 8.0 , between row: 18.0 (ft)
Trees in the zone: 1073
Trees per acre: 303.1
5.33
0.42
100.00
40.0
Average tree height (ft): 7
Water required (gal/tree/day): 3.579
Irrigation required (mins/day): 95.92
Current date: 4/7/2014
Change date
Tree height
Fertigation Pulsing
Daily fertigation frequency (pulses/day): None
Fertigation inte
Fert amount (g
Irrigation requi
Fertilizer amount / injection time
Irrigation run time
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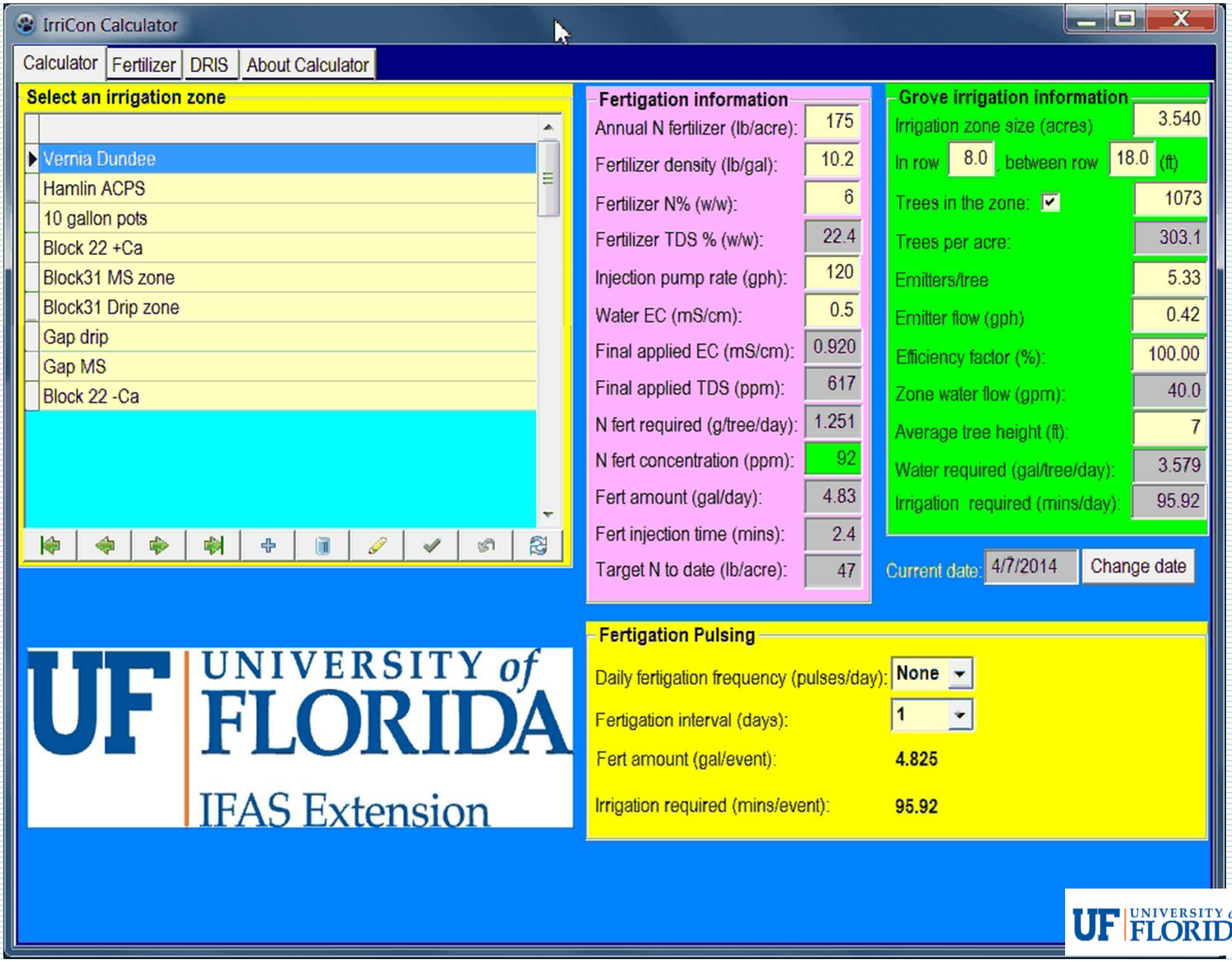
IrriCon Calculator
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About Calculator
Select an irrigation zone
Vernia Dundee
Hamlin ACPS
10 gallon pots
Block 22 +Ca
Block31 MS zone
Block31 Drip zone
Gap drip
Gap MS
Block 22 -Ca
Fertigation information
Annual N fertilizer (lb/acre): 175
Fertilizer density (lb/gal): 10.2
Fertilizer N% (w/w): 6
Fertilizer TDS % (w/w): 22.4
Injection pump rate (gph): 120
Water EC (mS/cm): 0.5
Final applied EC (mS/cm): 0.920
Final applied TDS (ppm): 617
N fert required (g/tree/day): 1.251
N fert concentration (ppm): 92
Fert amount (gal/day): 4.83
Fert injection time (mins): 2.4
Target N to date (lb/acre): 47
Grove irrigation information
Irrigation zone size (acres) 3.540
In row 8.0 between row 18.0 (ft)
Trees in the zone: 1073
Trees per acre: 303.1
Emitters/tree 5.33
Emitter flow (gph) 0.42
Efficiency factor (%): 100.00
Zone water flow (gpm): 40.0
Average tree height (ft): 7
Water required (gal/tree/day): 3.579
Irrigation required (mins/day): 95.92
Current date: 4/7/2014
Change date
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Fertigation Pulsing
Daily fertigation frequency (pulses/day): None
Fertigation interval (days): 1
Fert amount (gal/event): 4.825
Irrigation required (mins/event): 95.92
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DSP irrigation schedules are fine-tuned with soil water sensors

Water / EC sensor

Young citrus tree

Computer control

Drip irrigation line

Sensors:
0-4” depth
18” depth

Wetted soil and roots

Drip emitters 15” apart

Sandy soil

Profile moisture sensor

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Summary and Future Work

- **A DSP based on ET_0 and canopy basal area coverage was developed to schedule daily fertigation for citrus trees of any size in a production season**

- **Less frequent fertilizer injections (e.g. weekly) can be calculated by grouping consecutive daily amounts**

- **A daily / weekly / monthly as-applied tracking database will be added to verify fertigation status and simplify "course-corrections"**

Summary and Future Work

- **The DSP was developed with open-source programming software. Apple Mac-compatible versions can be compiled**
- **In this first version, the irrigation schedules must be manually transferred to an irrigation controller.**
- **By request, the DRIS leaf diagnosis method will be added**
- **A new fertigation controller (FC) is under development that will integrate the DSP into the integral functions of the controller. The controller will make and execute daily fertigation schedules automatically, including "course corrections"**

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Summary and Future Work

- **FC design: color touch screen embedded ARM computer with rugged enclosure; similar to our patented "CC Eye 8000 TreeSense®" used for variable rate agrochemical application**

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Acknowledgements

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Harrell's

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