Irrigation Through The Cloud: Using Wireless Irrigation Systems to Schedule and Control Irrigation for Container Crops

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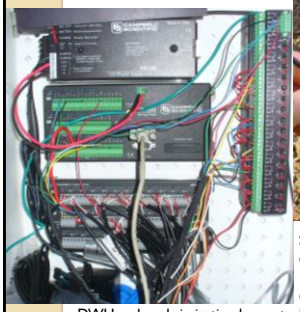
Leaching Fraction (LF) =
(amt of water leached with plant / amt without plant) * 100

Types of Moisture Sensors

Plant Daily Water Use Determination (DWU)
2006 - 2009

- Substrate volumetric moisture measured with Theta-probe
- 1 hour and 24 hours after irrigation
- Irrigation applied at rate of lowest DWU Taxa
- Additional Irrigation applied by Hand
- Measured every 10-14 days



Substrate volumetric moisture content determined with Decagon 10HS sensors via a Campbell datalogger programmed to calculate DWU and apply irrigation by controlling solenoid valves. Irrigation applied based on the highest plant DWU.

Irrigation and Runoff

Application Rates: N = 123 lb/ac, P = 15 lb/ac (35 lb P2O5)

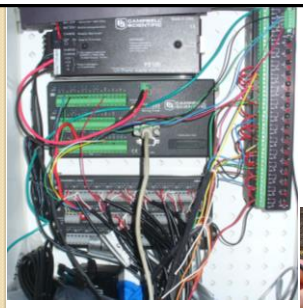
Amount recovered based on 100% land use with #3 containers spaced 1.5 ft on-center over 4 months.

Treatment	Irrigation Applied (gal/acre)	Runoff volume (gal/acre)	Nitrate recovered (lb/acre)	Phosphate recovered (lb/acre)
Control	2.4 million	1.04 million (43%)	12 (10%)	3.1 (21%)
100% DWU	1.6 million	0.48 million (31%)	7.2 (6%)	1.7 (11%)
100-75% DWU	1.4 million	0.29 million (29%)	5.9 (5%)	1.2 (8%)
100-75-75% DWU	1.3 million	0.37 million (29%)	5.7 (5%)	1.2 (8%)

Viburnum dentatum 'Ralph Senior' September 2006

Control **100 DWR** **100a75** **100a75a75**

Nutrition Problems?



Wireless sensor networks

Cost of Water

- For 160 irrigation events per year = $0.032 per plant
- Reduce water use by 30% = $0.022 per plant
- Reduce water use by 70% = $0.009 per plant
- Reduce fertilizer leaching by 6% = $0.005 per plant
- Saving $0.015-$0.028 per plant, Whoopee!!
- About $225-$420 per acre
- Water is cheap!
  …..at least east of the Mississippi

McCorkle Nursery, GA

- Gardenia crop: 20,000 sq ft area with 23,400 plants (50,965 plants per acre)
- Reduced production time from 11-22 to 8-11 months
- Improved survival from 10% loss to zero loss

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Van Iersel, Chappell, Ruter, Lichtenberg, Majsztrik, U's of GA and MD

Economic Impact

Costs	
Control node	$6,75
Sensors (4 @ $90)	$3,60
Rain gauge	$3,00
Base station, computer & software	$1,000
Installation	$1,500
Total Cost	$3,835
Savings/Profit	
Fewer plant losses	$13,000 ($6.50 per plant)
Time/interest (avg 6 months shorter production cycle @ 8%)	$500
Less fertilizer, pesticides, maintenance, labor	$7,700
Total Savings/Profit	$21,200 ($0.90 per plant)
Net	$17,365

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Van Iersel, Lea-Cox,Chappell, Ruter, Lichtenberg, Majsztrik, Belayneh; U's of GA and MD

Cost of Water

- Cheap! But not the consequences of over-irrigation
- For 160 irrigation events per year = $0.032 per plant (or $0.022 or $0.009 for more efficient irrigation)
- Less shrinkage, shorter production cycle, less fertilizer applied, less fertilizer lost, less labor, less pesticides used = save up to $0.90 per plant (remember this example is with a "problem" crop)
- Less off-site movement of water and contaminants

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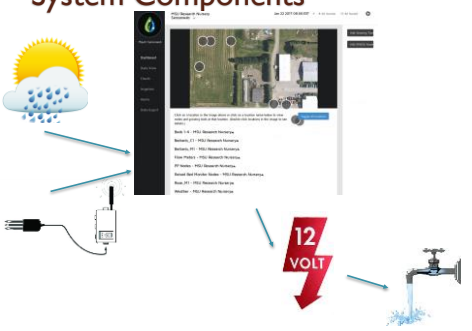
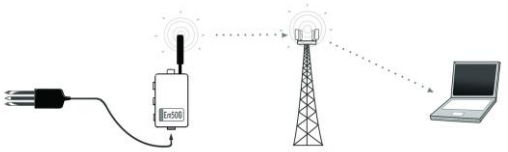
System Components



Schematic of entire system



Monitor Nodes

- Substrate moisture content, EC, and other vital information can be acquired via monitor nodes.
- Ports can be configured for a variety of sensors
- Model Shown:
  - Decagon Em50R

Soil Sensors

- 10HS Sensor
  - VWC
- GS3 Sensor
  - VWC
  - EC
  - Temp

Monitor Nodes

Container Capacity Bed 2	Mon Oct/31/16 12:35 Averaging Tool	45.35 %VWC
Container Capacity Bed 3	Mon Oct/31/16 13:15 Averaging Tool	41.27 %VWC
Container Capacity Bed 4	Mon Oct/31/16 13:55 Averaging Tool	41.77 %VWC
Container Capacity Bed 7	Mon Oct/31/16 13:55 Averaging Tool	36.27 %VWC
Container Capacity Bed 12	Mon Oct/31/16 13:55 Averaging Tool	28.12 %VWC

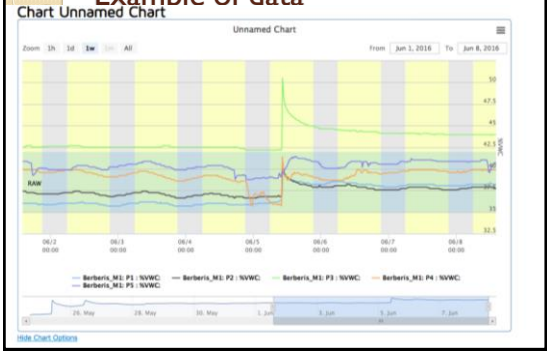
- Enhanced knowledge of substrate conditions
- Averaging tools for localized regions

Monitor Nodes

- Improved record keeping and system management
- MDARD Water Use Report

101	Tue Sep/27/16 12:45 63.0% battery	64905.0Gallons	65530.0Gallons
102	Thu Sep/29/16 09:11 44.0% battery	0.0Gallons	0.0Gallons
103	Mon Sep/26/16 11:30 53.0% battery	65533.0Gallons	0.0Gallons
104	Mon Sep/26/16 11:30 64.0% battery	0.0Gallons	0.0Gallons

Example of data



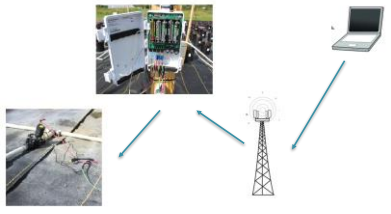
Weather Stations

- Precipitation, wind speed, air pressure data etc., can be collected on a localized level.

Weather - MSU Research Nursery▾

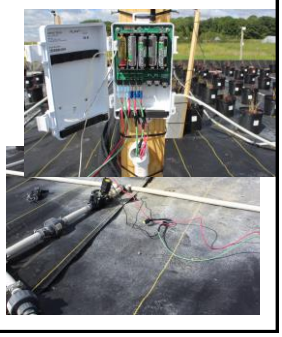
Weather	Fri Jan/20/17 15:40 39.0% battery	151.978umol/(m^2*s) Measures photons of light	0.62kPa 35.6Fahrenheit 87.858%RH Temp and Atmosphere	0.0mm Precip.	309.0Degrees 1.16m/s average 1.7m/s Wind gusting

Schematic of entire system



DC Latching Solenoid Valves

- Wired to control nodes
- Used extensively in timer based irrigation



Irrigation Management