Sensor-Based Irrigation System for Apple Orchards and Vegetable Fields

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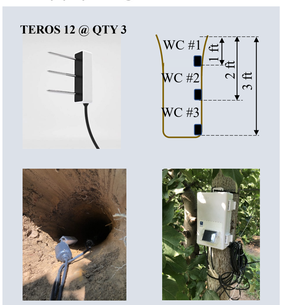
Soil Moisture Sensor and ET Irrigation in Apple Orchard

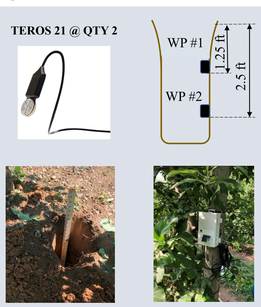
- ❖ Irrigation is supplemental water supply in PA
- ❖ Irrigation is critical in hot summer days
- ❖ Irrigation is important for intensive orchards
- ❖ Current irrigation is based on experience or 'feel'
- ❖ Precision irrigation plan is required
- ❖ Irrigation improves fruit production and quality

Sensor-Based Irrigation

- ❖ Soil moisture measurement: Soil water content sensors
- ❖ Soil moisture measurement: Soil water potential sensors
- ❖ Apply irrigation based on the setting threshold of soil moisture



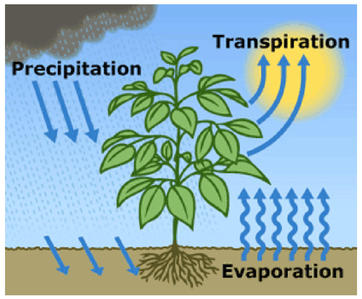
Soil water content sensor



Soil water potential sensor

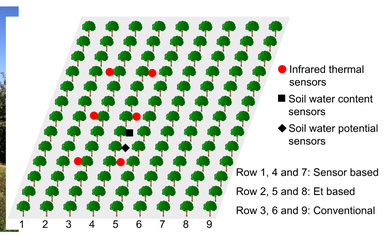
ET Irrigation

- ❖ ET – Evapotranspiration (Evaporation + Transpiration)
- ❖ A set of weather data is required
- ❖ Calculate daily ET using Penman-Monteith model
- ❖ Set up a water deficit threshold for starting the irrigation



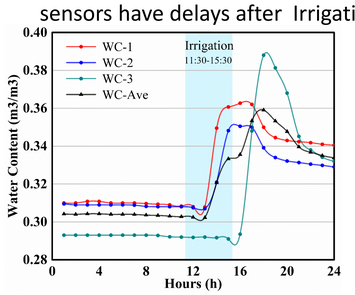
Experimental Setups in Orchard

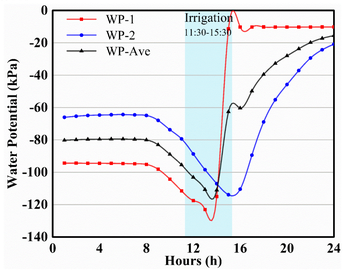
- ❖ A 0.9 acre tall spindle apple orchard at FREC
- ❖ Tested irrigation strategies in the orchard
  - Evapotranspiration based irrigation
  - Soil moisture based irrigation
  - Canopy water stress based irrigation (only in 2018)
  - Conventional method based on experience



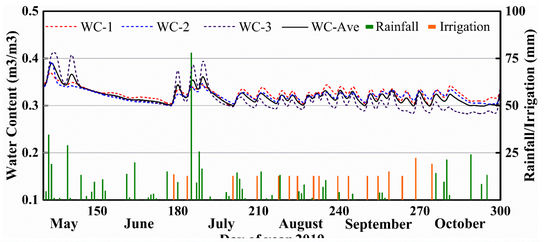
Soil Water Content and Potential in an Irrigation Event

The sensitivity of sensors was affected by depth, and all of sensors have delays after Irrigation.

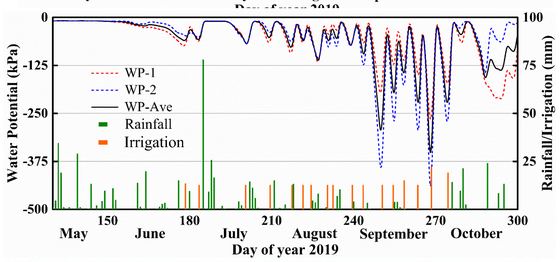




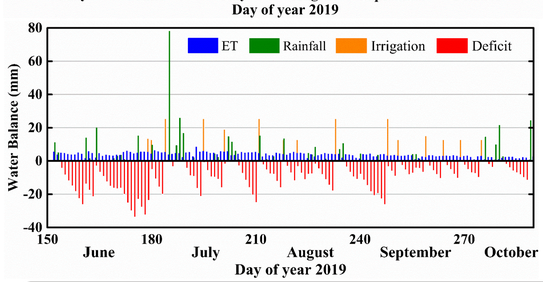
Soil Moisture, ET, Irrigation and Rainfall over the Season



Soil water content, irrigation, and rainfall in 2019



Soil water potential, irrigation, and rainfall in 2019



ET, daily water deficit, irrigation, and rainfall in 2019

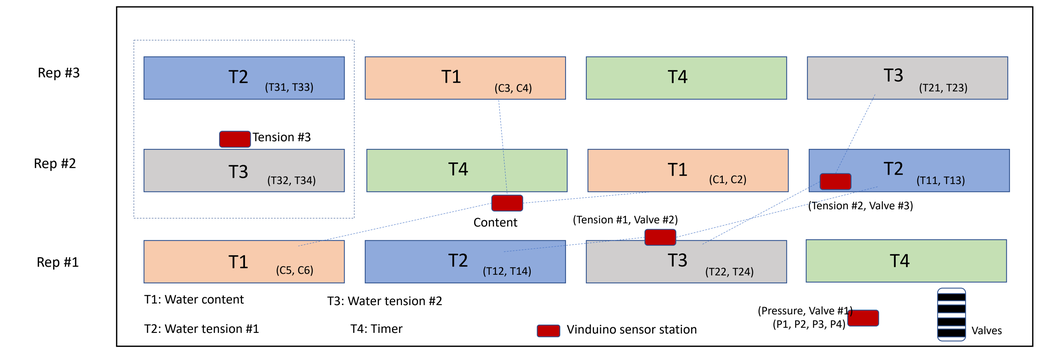
Water Consumption, Yield and Quality

Irrigation strategies	Overall water use (inch)	Crop yield/tree (kg)	Crop size (g)	Hardness (Kg)	Soluble solids (Brix)
Sensor-based	8.7	28.2	247	8.0	16.1
ET	11	23.1	260	7.9	16.0
Conventional	9.2	18.8	265	8.2	16.0

IoT-Based Precision Irrigation

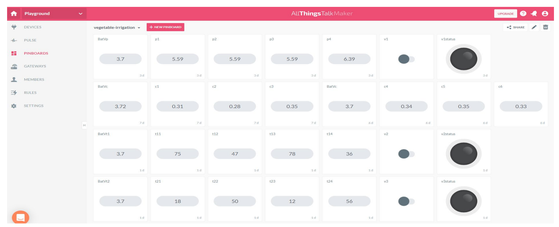
- ❖ IoT – Internet of things
  - Wireless communication
  - Cloud based data access
  - Automated control
- ❖ IoT components for irrigation
  - Sensors
  - Solenoid valves
  - Sensor datalogger
  - Valves controller
  - Internet gateway
  - IoT platform/interface

Experimental Setup

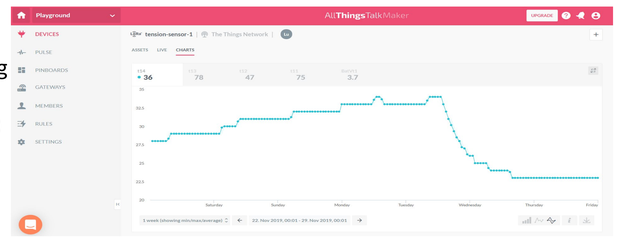


Content: C1, C2, C3, C4, C5, C6 are water content sensors, odd numbers are at 15 cm, and even numbers are at 30 cm.
Pressure: P1, P2, P3, P4 are pressure sensors (psi) for treatment T1, T2, T3, T4 respectively. Valve #1 is in this box.
Tension #1: T11, T12, T13, T14 are tension sensors, T11, and T12 are at 15 cm, and T13 and T14 are at 30 cm. Valve #2 is in this box.
Tension #2: T21, T22, TS23, T24 are tension sensors, T21 and T22 are at 15 cm, and T23 and T24 are at 30 cm. Valve #3 is in this box.
Tension #3: T31, T32, T33, T34 are tension sensors, T31 and T32 are at 15 cm, and T33 and T34 are at 30 cm.

Interface of IoT irrigation System



- ❖ Lora (Long Rang) technology based IoT system
- ❖ Datalogger/controller configuration in *thethingsnetwork.org*
- ❖ Sensor data monitoring/control in *Allthingstalk.com*



- ❖ Soil moisture data displaying and monitoring
- ❖ Valve control (manual switch or automated)
- ❖ Historical data restore/download

Acknowledgements:
- This work was supported by State Horticultural Association of Pennsylvania (SHAP) and Northeast SARE grant No. 19-378-33243.