Precision Irrigation Technologies for Specialty Crops

Long He

2020 Mid-Atlantic Fruit and Vegetable Convention

Hershey, Pennsylvania, United State

January 29th, 2020

PennState College of Agricultural Sciences

PennState Extension

Importance of Precision Irrigation

Challenges for Conventional Method:

- Rely on human experiences
- Cause over- or under-irrigation

Precision Irrigation:

- Rely on data
- When and how much to irrigate

Benefit of Precision Irrigation:

- Improve crop yield and quality
- Conserve water and save energy
- Reduce nutrient leaching and environmental impact

Irrigation Scheduling Methods

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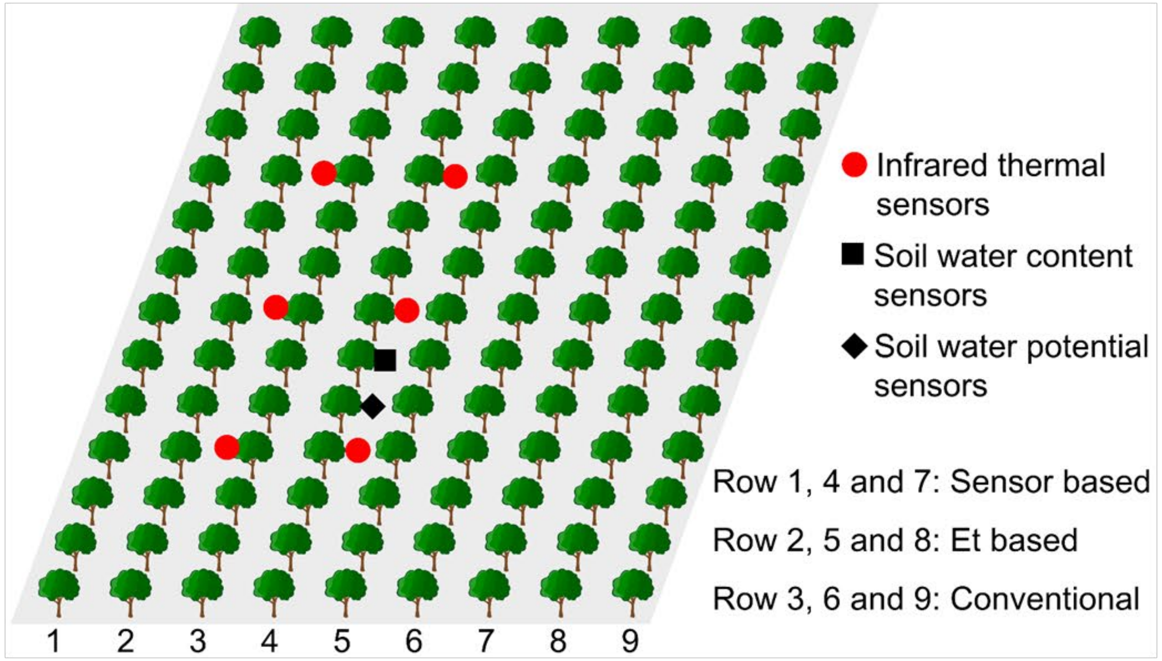
Primary Goal

Investigate an efficient sensor-based irrigation scheduling strategy for apple orchards in Mid-Atlantic region.

Experimental Setup



Irrigation Scheduling Methods

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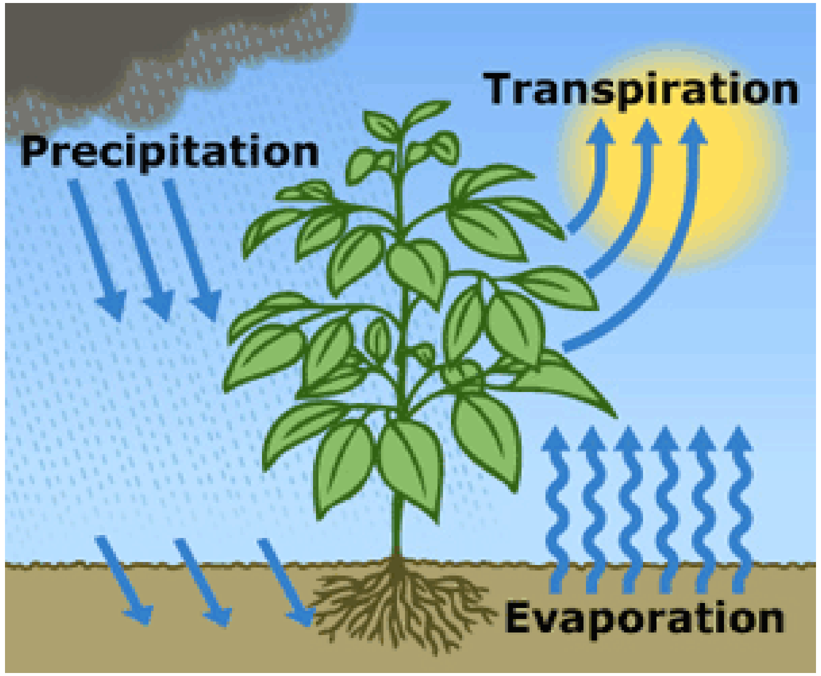
Evapotranspiration (ET)



When **Transpiration + Evaporation** > **Precipitation**,
Irrigation is needed.

Penman–Monteith Model (P-M)

- Reference ET_0
- Estimated $ET = K_c \times ET_0$

Parameters:

- Maximum air temperature
- Minimum air temperature
- Relative humidity
- Wind speed
- Solar radiation

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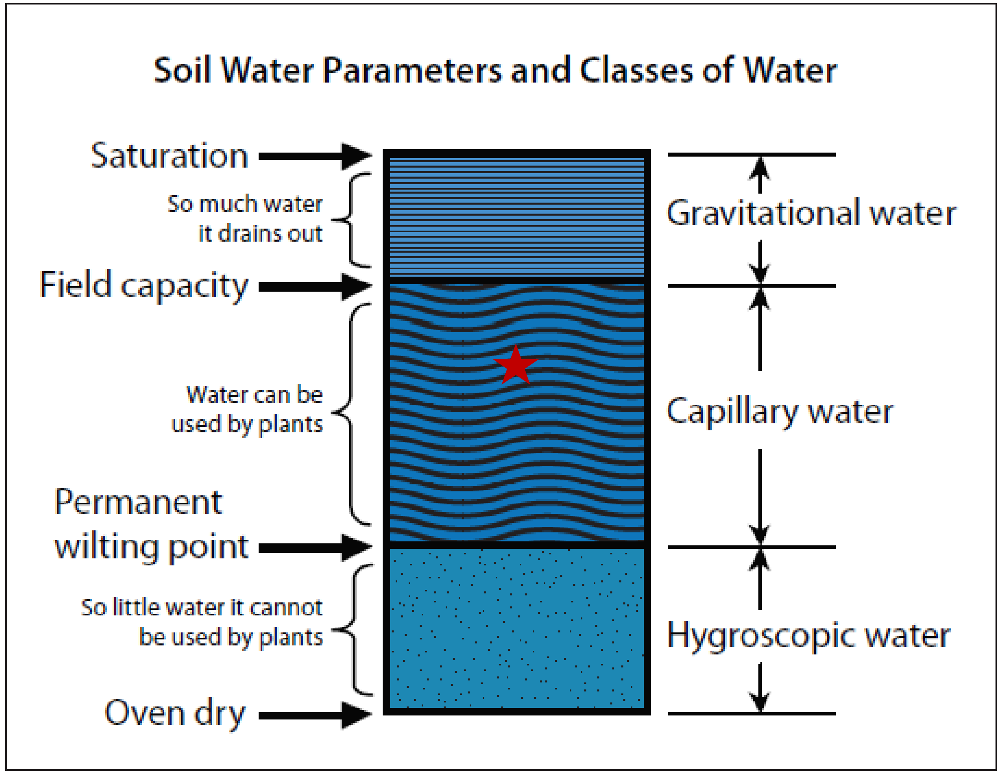
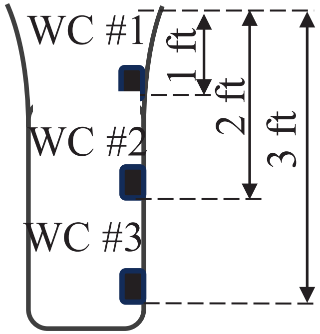
Fundamental Principles

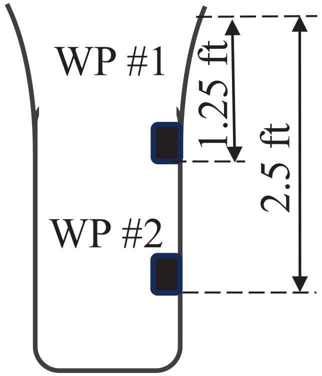


Soil Water Parameters (From: Texas A&M AgriLife Extension, E-618)

Soil Moisture Sensors



Soil water content sensor: TEROS 12 @ QTY 3



Soil water potential sensor: TEROS 21 @ QTY 2

Irrigation Scheduling Methods

Sensor System Setup




- Soil water content and Potential sensors
- Datalogger to record sensor data
- Cellular network for data communication (cloud server)

Irrigation Scheduling Methods

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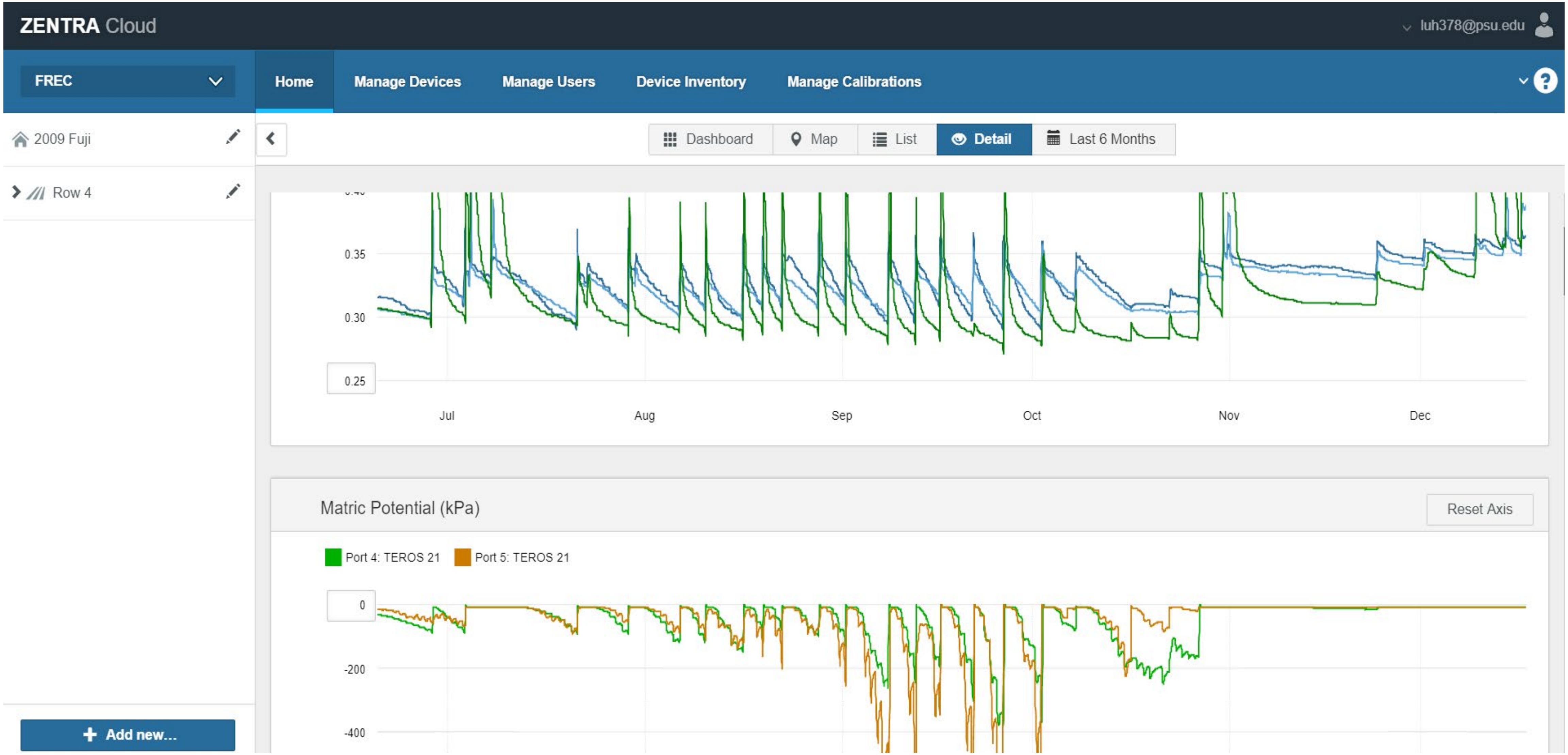
Soil Moisture Sensor Data Recording



Results – Irrigation Strategies

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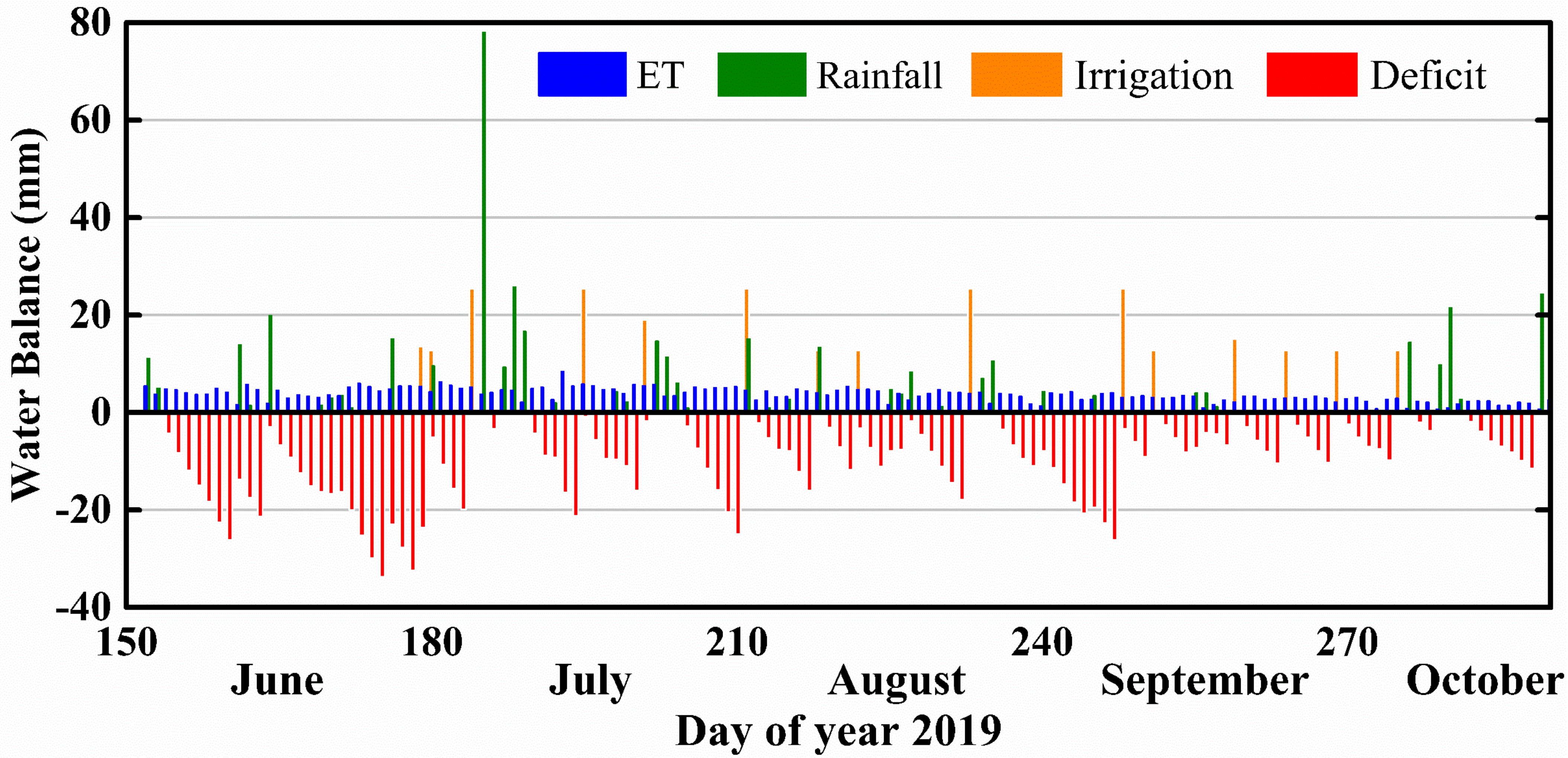
Evapotranspiration (ET)



Results – Irrigation Strategies

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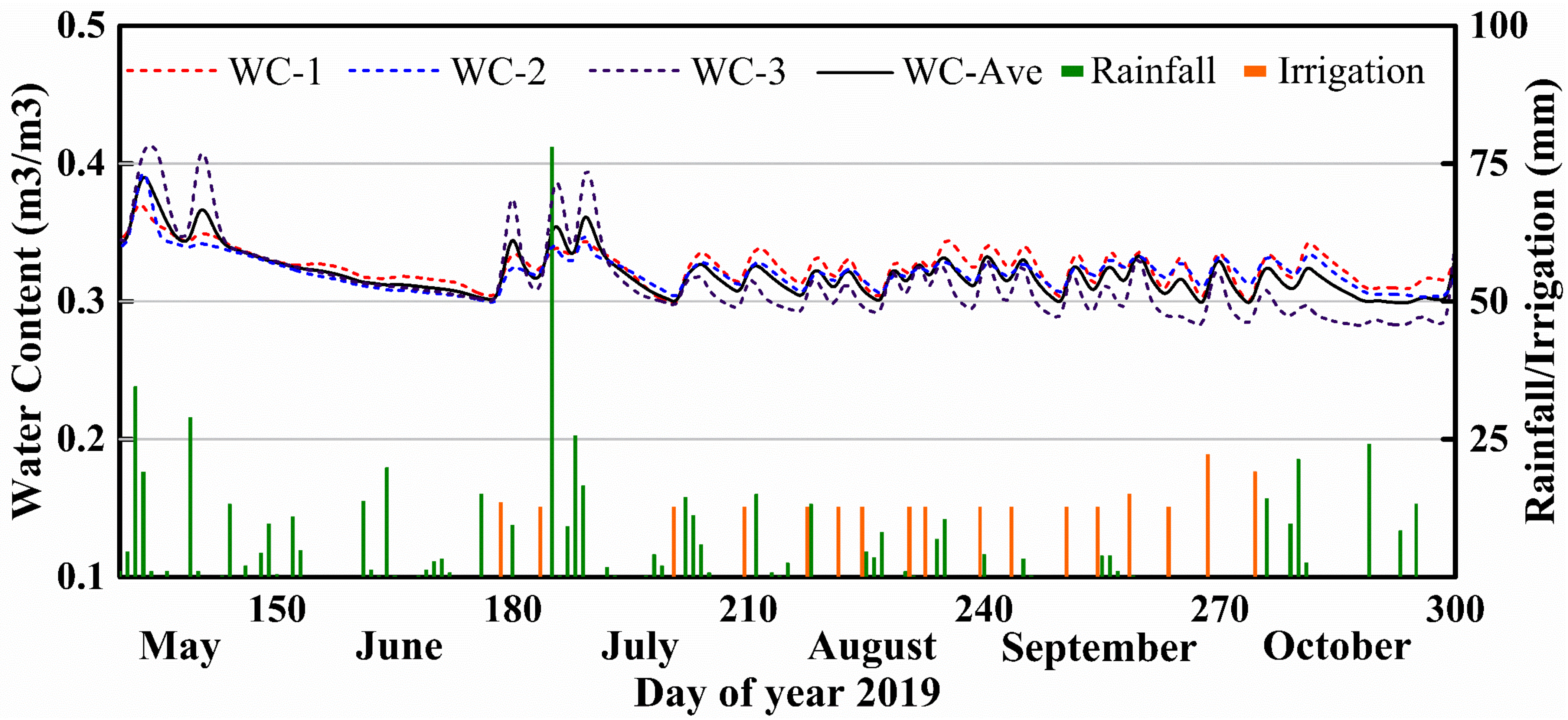
Soil Water Content



Results – Irrigation Strategies

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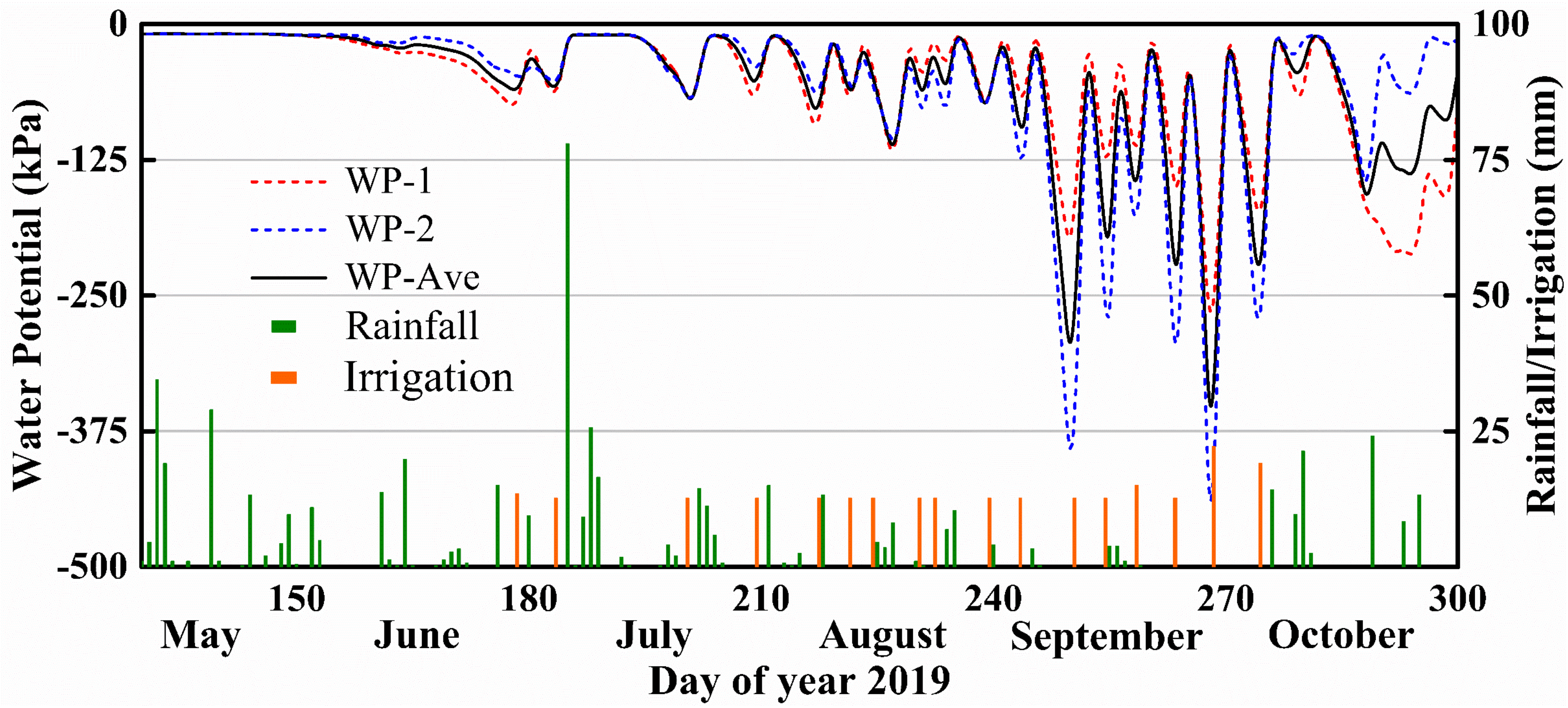
Soil Water Potential



Results – Irrigation Strategies

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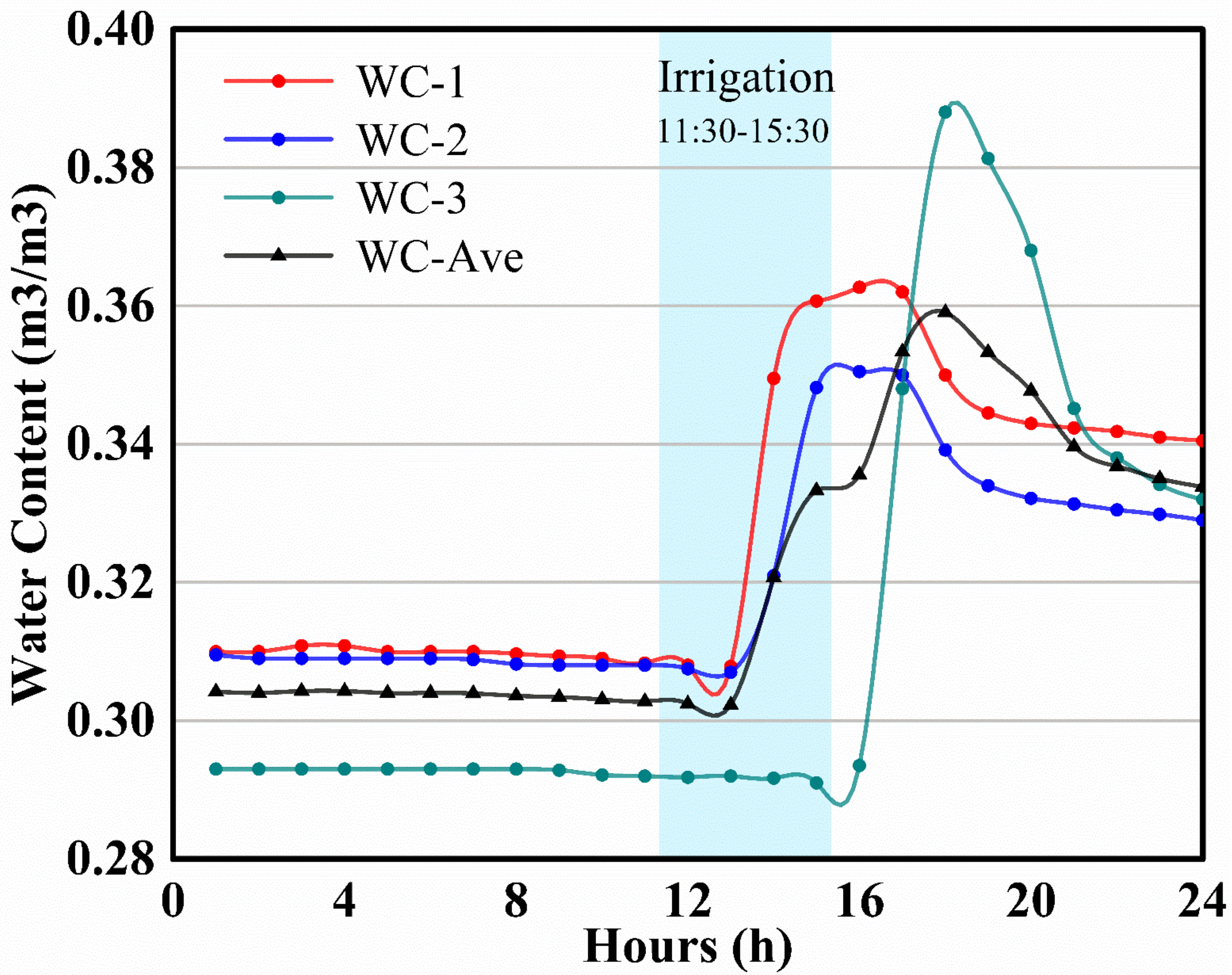
Soil Water Content (Irrigation Event)



Results – Irrigation Strategies

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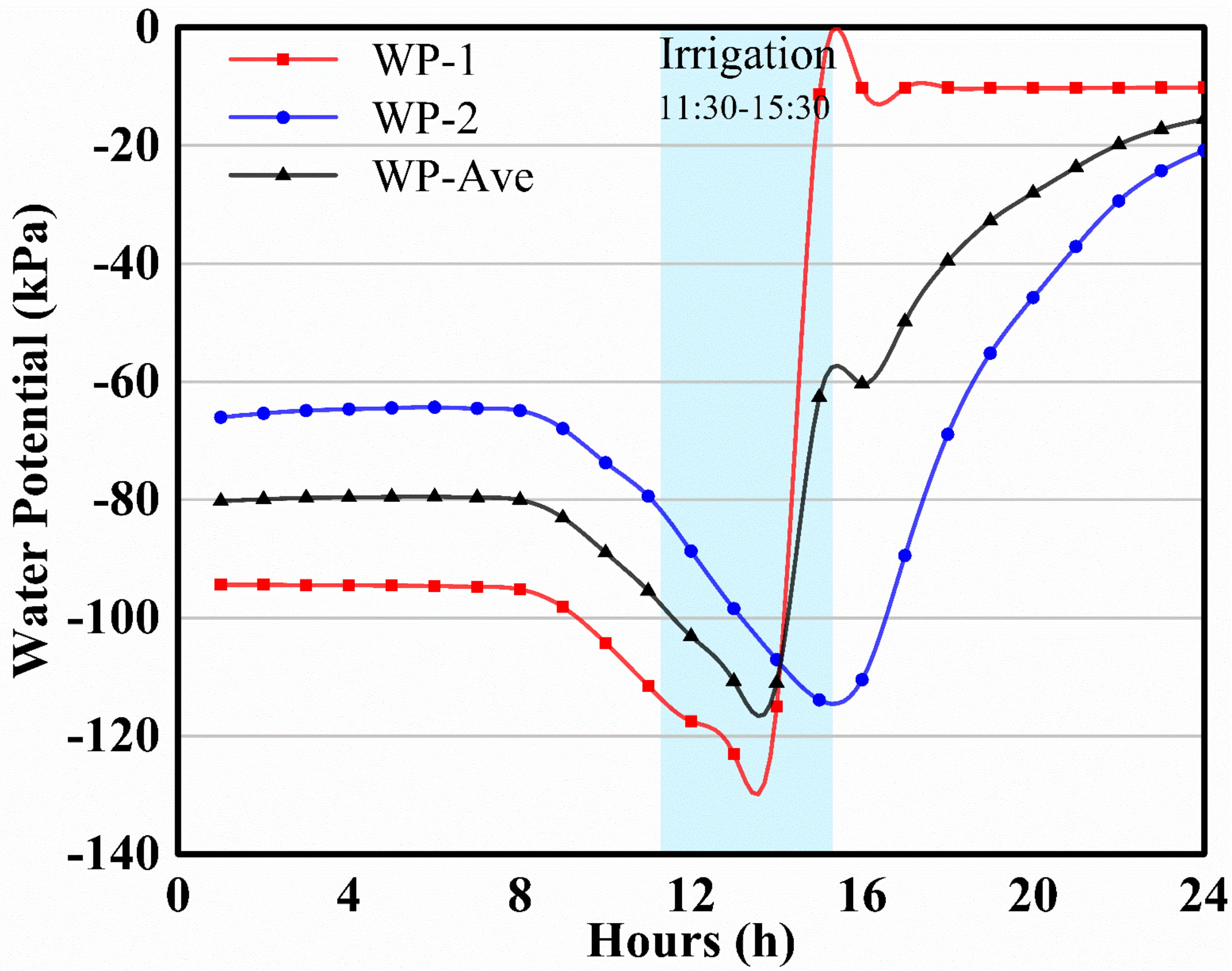
Soil Water Potential (Irrigation Event)



Results – Irrigation Strategies

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Water Use, Crop 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

- Soil moisture based irrigation consumed the least water
- Soil moisture based irrigation had a slight higher yield
- Fruit quality in terms of size, hardness and brix is similar

Discussion and Recommendation

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	ET-Based	Soil Moisture-Based	Conventional
Advantages	▪ Easy to apply ▪ No in-field sensors ▪ Low cost	▪ Direct reading of soil moisture ▪ Low-mid cost	▪ No equipment needed
Challenges	▪ Estimated value ▪ Accumulating error ▪ Your own weather station	▪ Root region ▪ Sensor location ▪ Soil type	▪ Risk of over or under irrigation ▪ Varies among operators

Test in Commercial Orchards

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Hollabaugh Bro. Inc
(Honey Crisp)

Mt. Ridge Farms
(Fuji)

Twin Springs Fruit Farm
(Crimson Crisp)

El Vista Orchards
(Gala)

Test in Commercial Orchards

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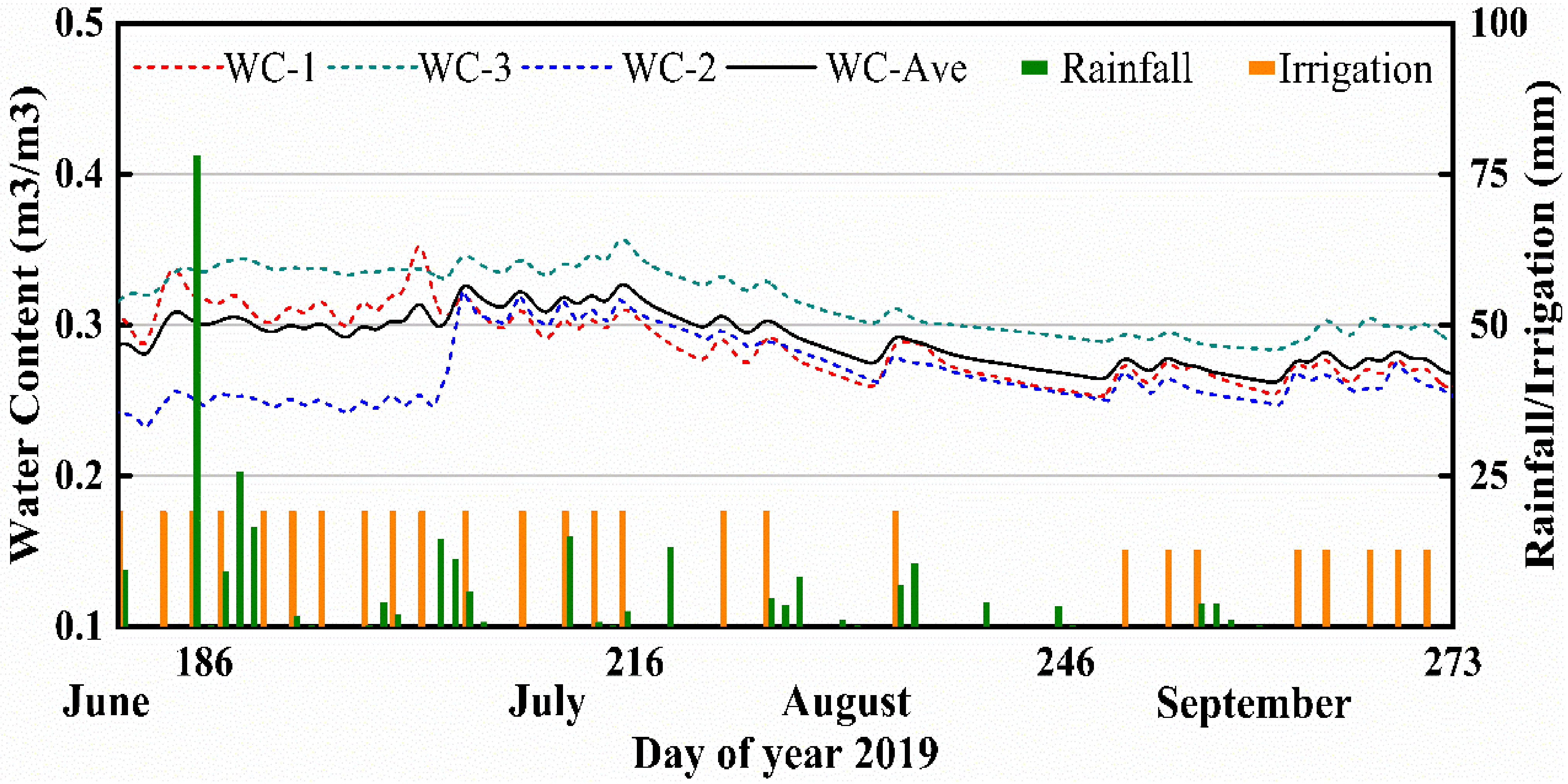

Test in Commercial Orchards

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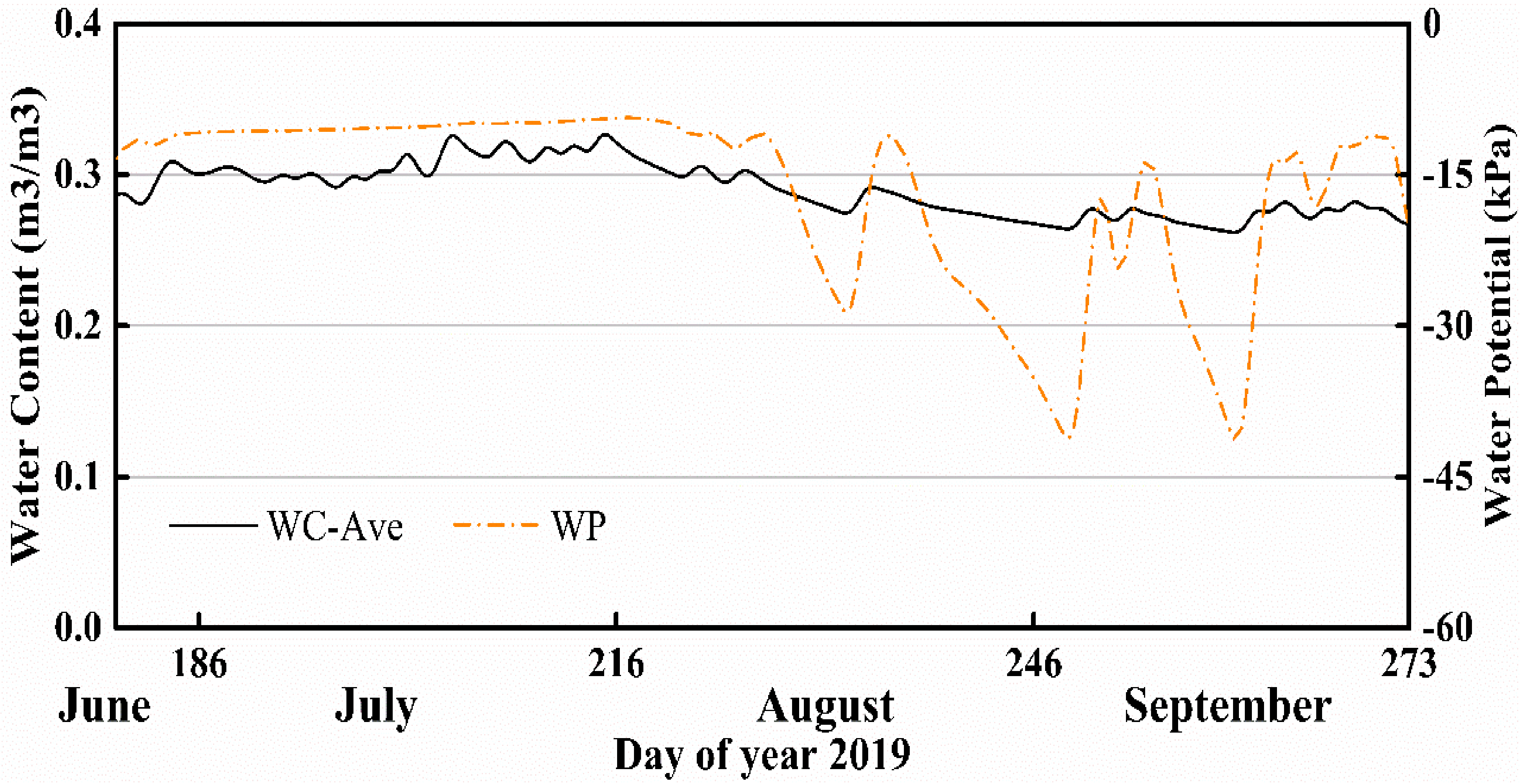

Internet of Things (IoT) Basics

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IoT Fundamental

Internet of things (IoT) is the interconnection through the internet of computing devices embedded in everyday objects.

Crop + Machines + Sensors + Data + Expert + User

IoT Systems

- Common wireless technologies

  Wi-Fi, Bluetooth, ZigBee, Sigfox, cellular network, LoRa
- Long range IoT systems

  Cellular network

  LoRaWAN: low power, Low cost, Long range, Low data rate

IoT for Irrigation System

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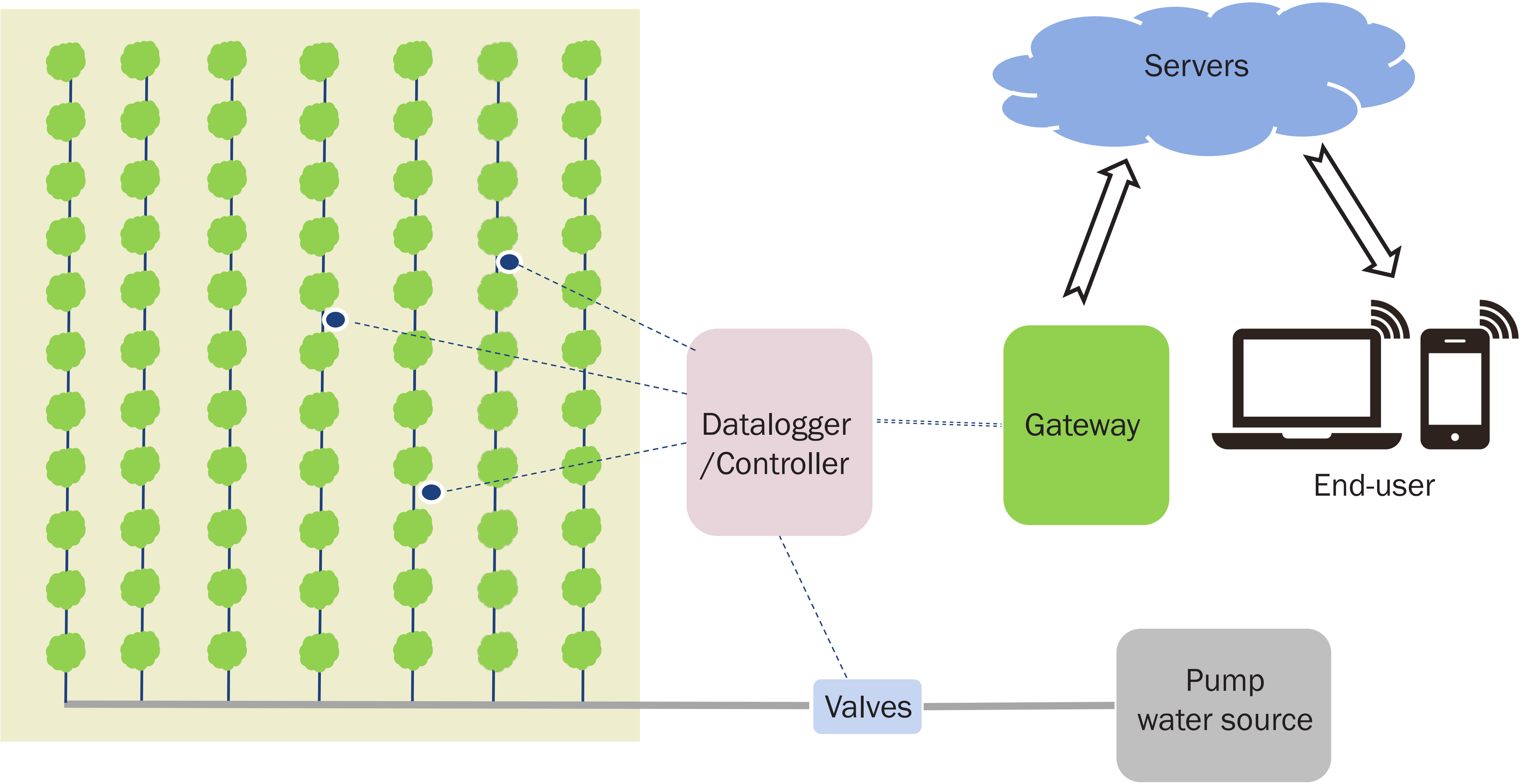

LoRa Based IoT Irrigation

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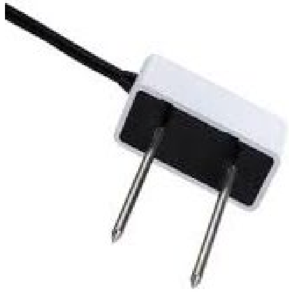
Primary Goal

Investigate an effective Lora-based IoT system for the precision Irrigation management for Specialty Crops.

Soil Moisture Sensor



Datalogger &Gateway

Valve Control

IoT Platform

THE THINGS NETWORK

AllThingsTalk

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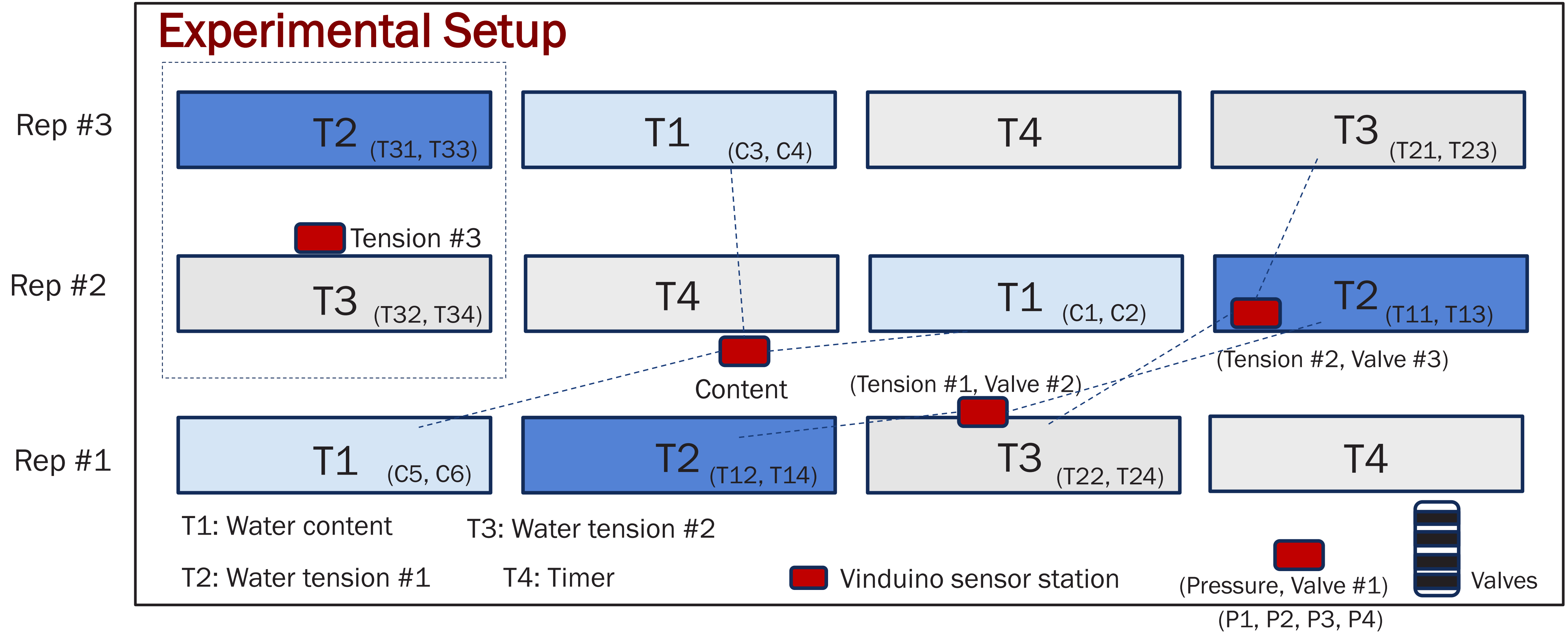
Experimental Setup



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.

LoRa Based IoT Irrigation

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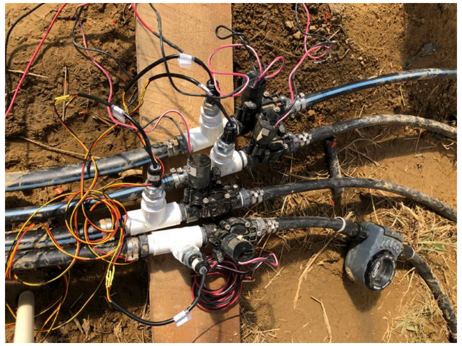
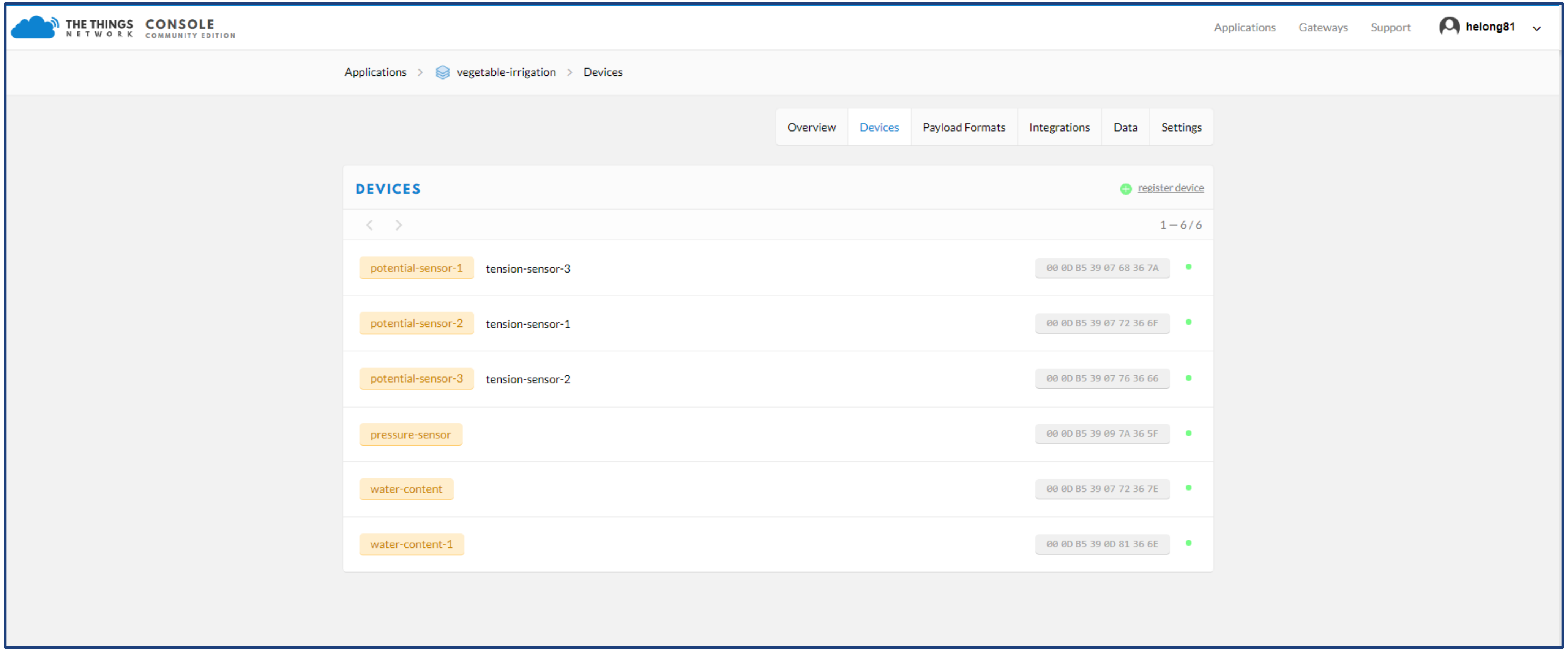


Wireless Communication Configuration



- ❖ Internet gateway + Application (*thethingsnetwork*)
- ❖ Configurate the wireless module (Lora) in *thethingsnetwork*
- ❖ Connect sensors/valves to the wireless module

LoRa Based IoT Irrigation

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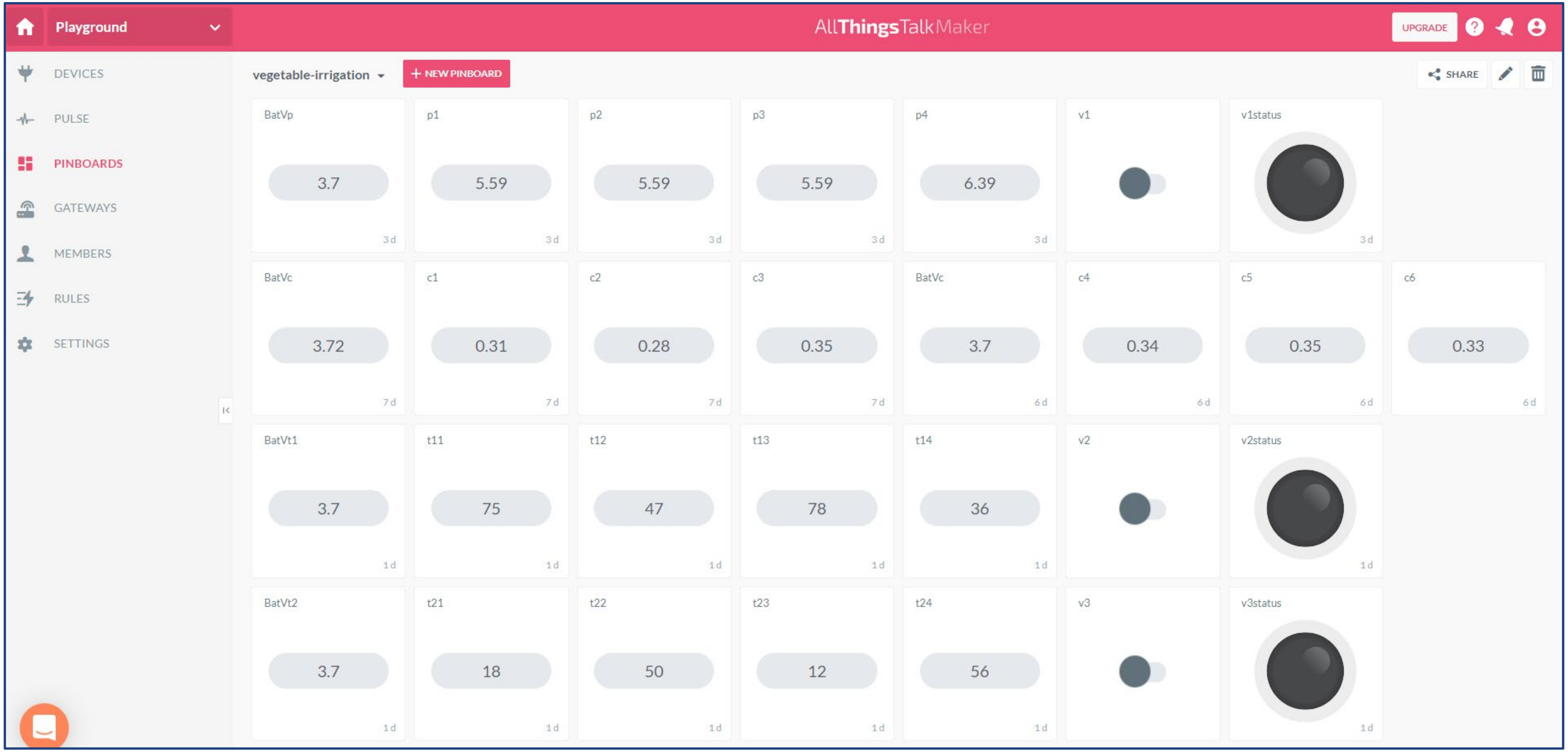
Interface of IoT irrigation System



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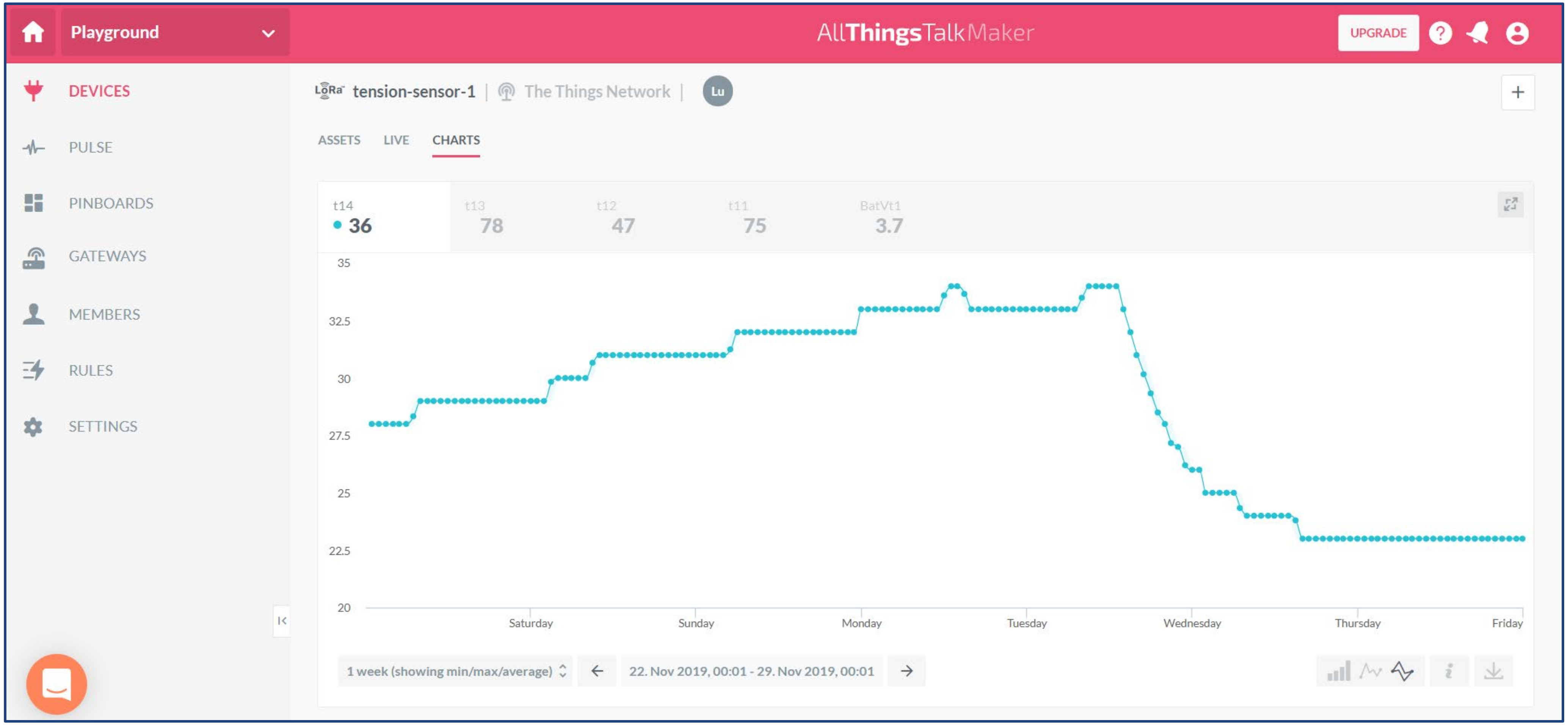
Interface of IoT irrigation System – Sensor Data



Future Work

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Basic Studies

- Sensor testing
- Different irrigation strategies
- Soil moisture sensor installation location

IoT-Based Irrigation

- Communication robustness
- Different IoT systems
- Automated Irrigation system

Extension Activities

- Demonstrations & workshops
- Commercial orchard trials
- Orchard/vegetable fields/greenhouse

Acknowledgement

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Funding Sources:

State Horticultural Association of Pennsylvania (SHAP)
Northeast SARE, Project No. 19-378-33243

Project Personnel:

PIs: Long He, James Schupp, Daeun Choi, Francesco Di Gioia,
Daniel Weber, Tara Baugher
Students: Xiaohu Jiang, Haozhe Zhang

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Thank you!