Developing Sensor-Based Smart Irrigation Systems for Vegetable Crops

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Irrigation Basics

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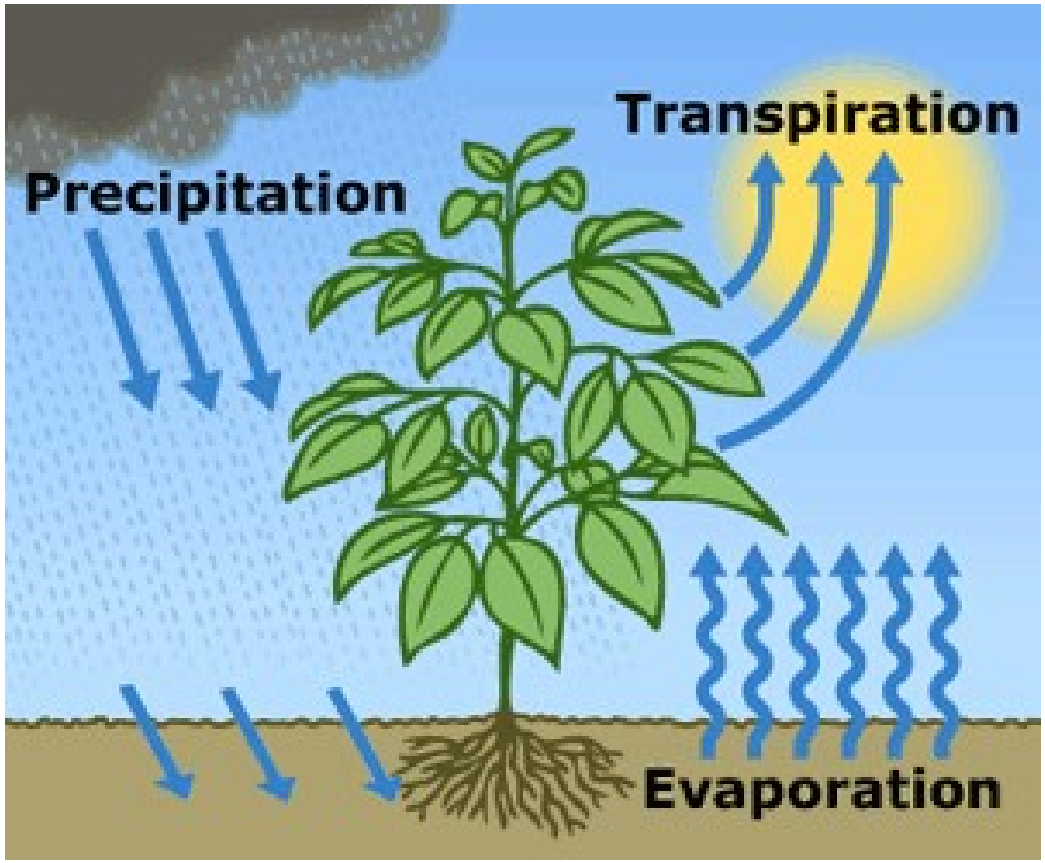
Water Balance



When **Transpiration + Evaporation > Precipitation,**

***Water deficit* occurs,**

Irrigation is needed when the deficit accumulated to certain level to avoid plants stress.

Irrigation Basics

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Irrigation Systems

Irrigation Basics

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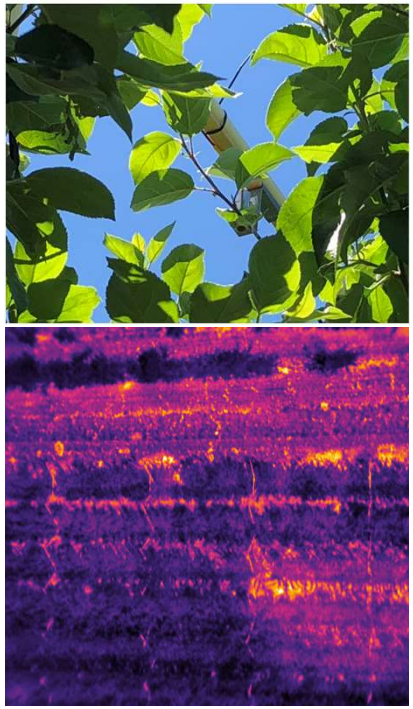
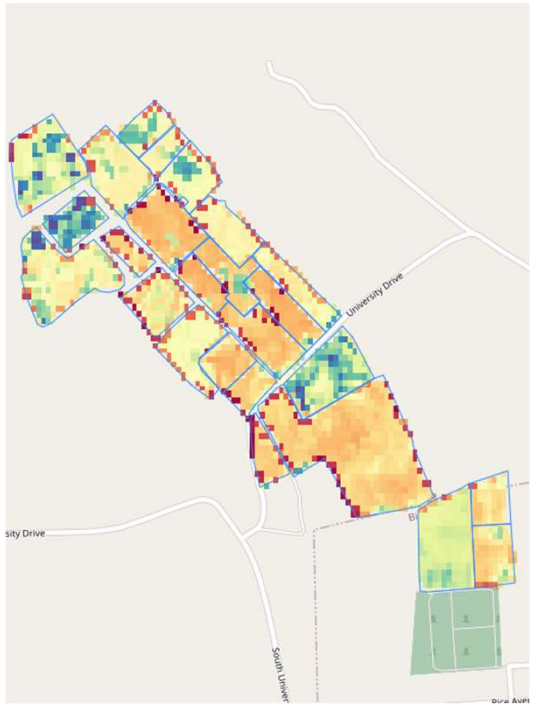
Precision Irrigation Systems

ET Irrigation
Penman–Monteith Model

Soil Moisture Irrigation



Crop Water Stress Index (Thermal Sensor)



Satellite Measurements (SEBAL Model)

Soil Moisture Measurement

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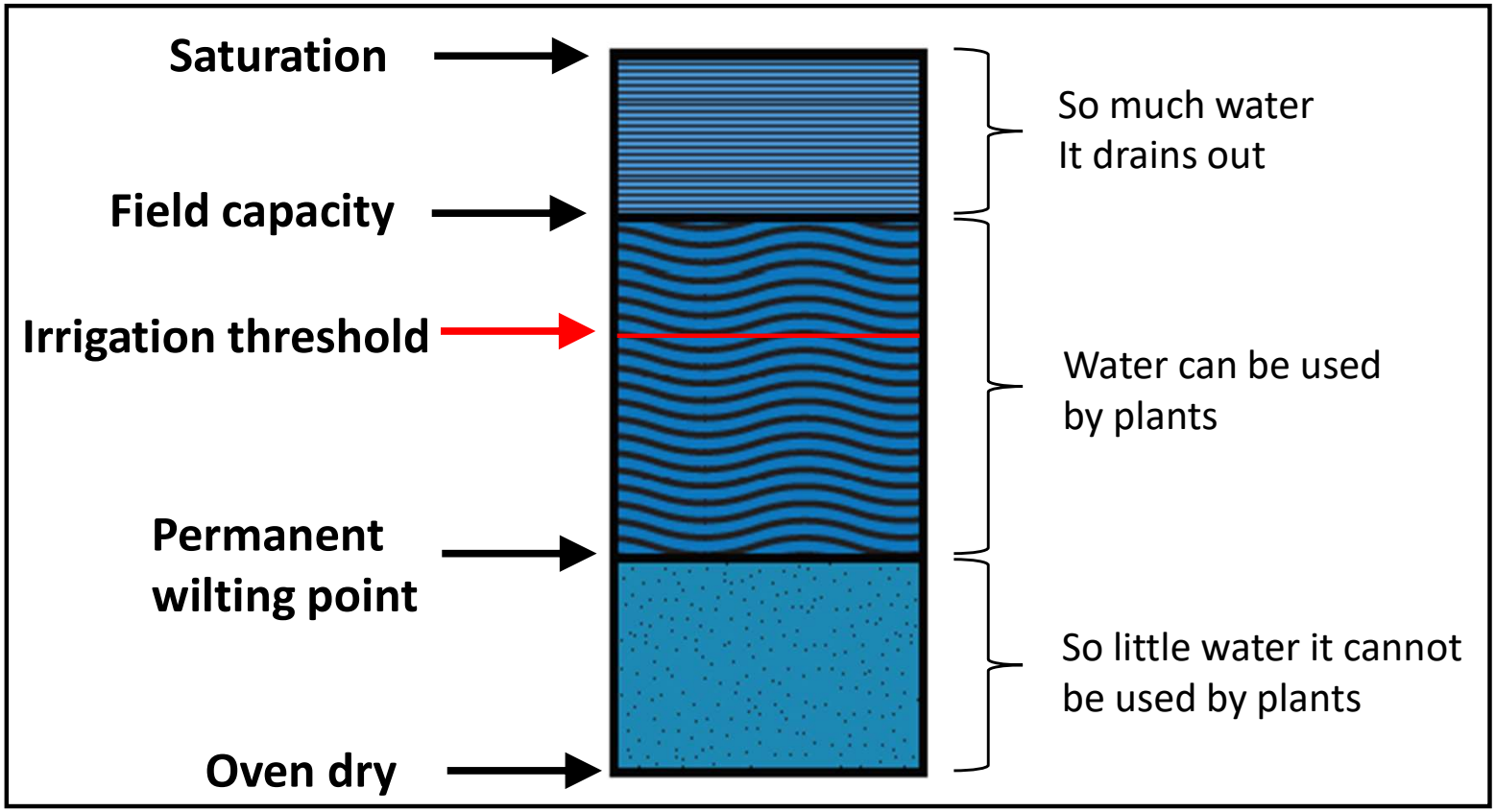
Water Status in the Soil



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

Soil Moisture Measurement

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Sensor Systems

Soil Moisture Sensors

Meter or Dataloggers

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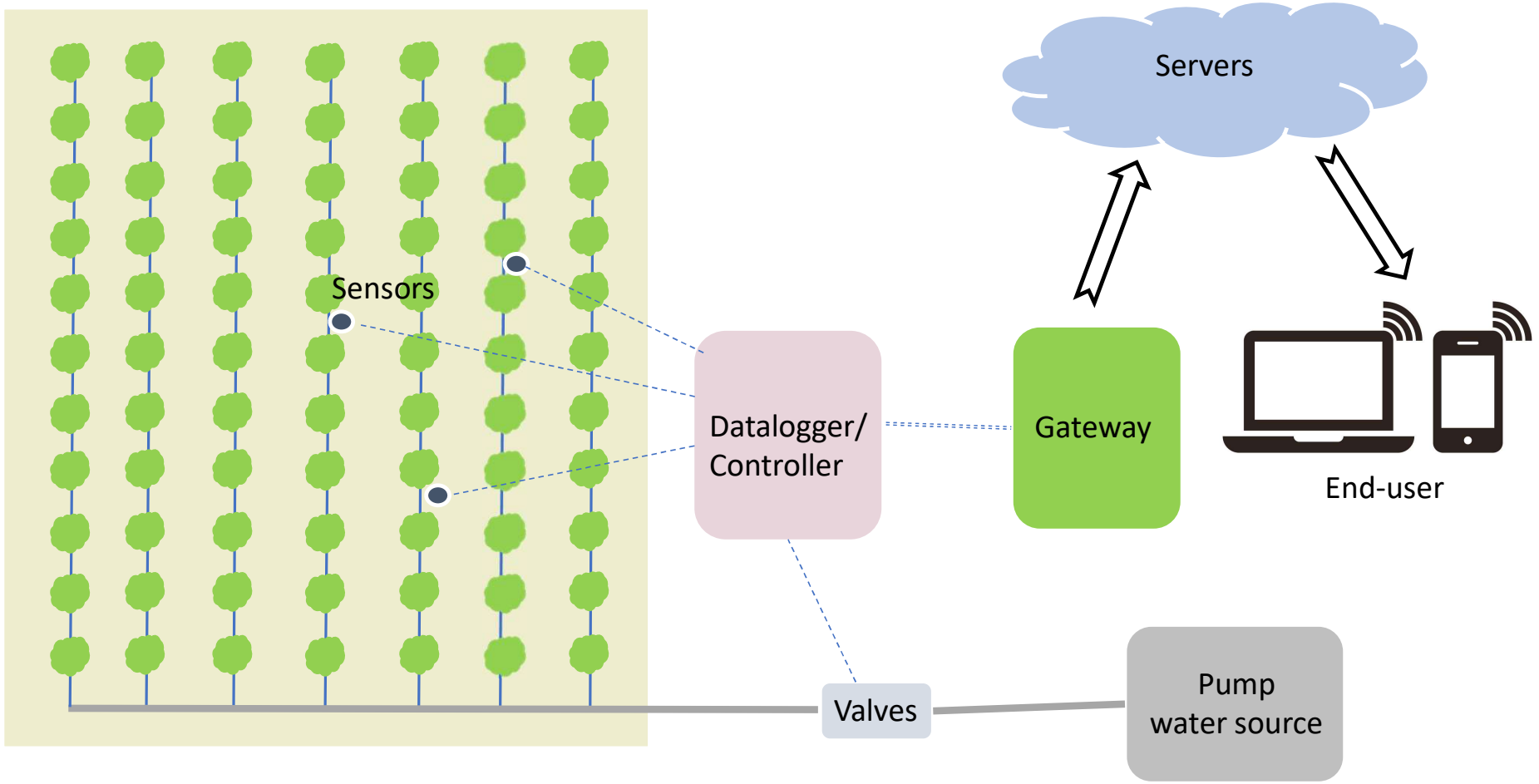
Internet of Things (IoT) for Irrigation



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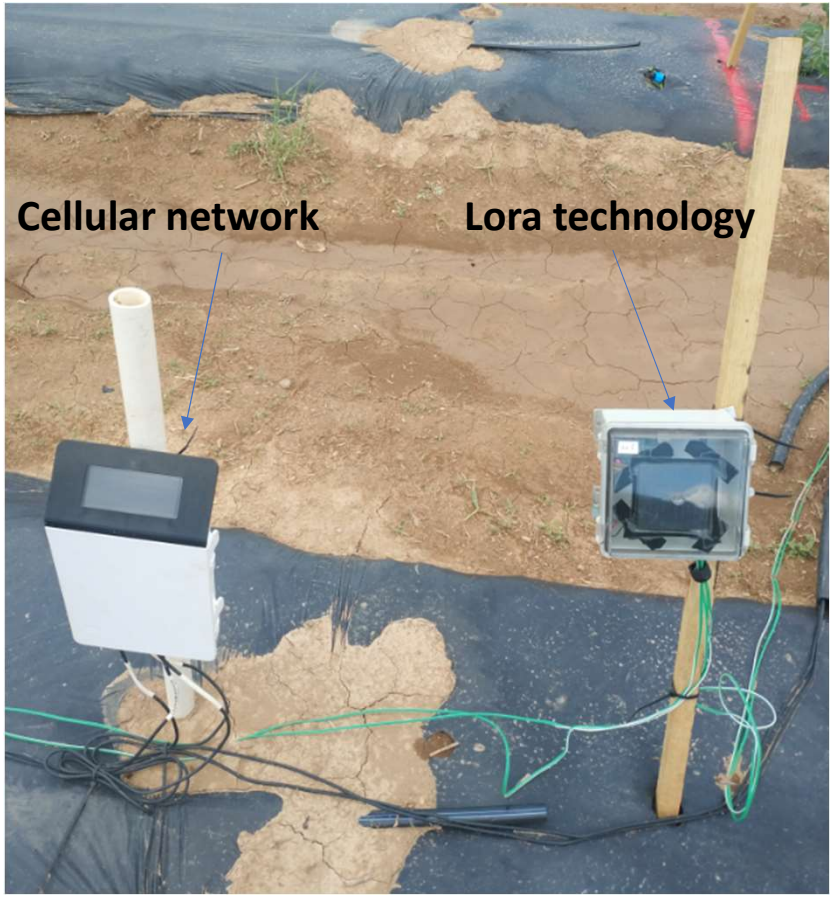
Internet of Things (IoT) for Irrigation



- **Cellular network**
  - Based on GSM network (2G/3G)
  - Long distance application
  - Remotely data access
- **LoRa technology**
  - Long Range low power network
  - Communication through internet
  - Remotely data access
  - Remote/automated irrigation operation

Precision Irrigation Field Test

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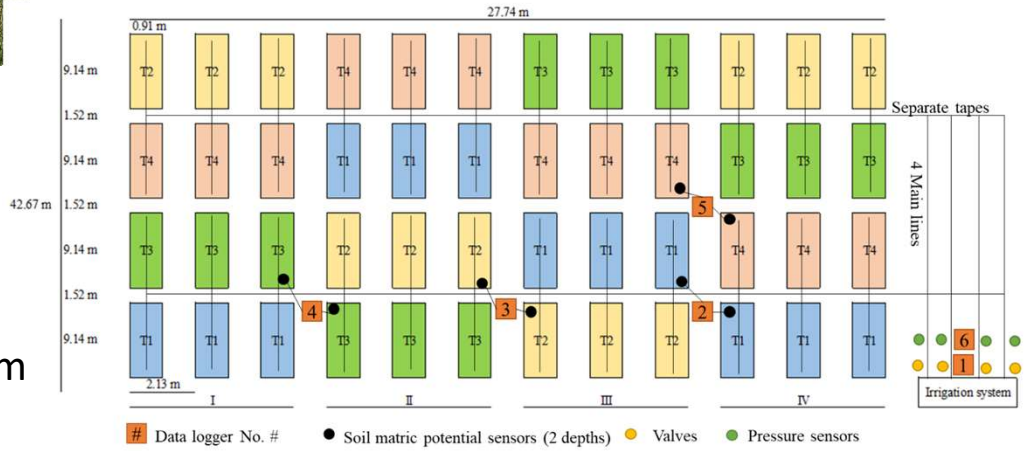
Overall Experimental Setup

- Tomatoes were transplanted on May 21st, 2020
- There were 48 sections with 20 plants at each section
- Sub-surface drip irrigation
- Same nutrient level applied to the whole field
- Harvest dates: 8/7; 8/19; 9/1; 9/11; and 9/23

- Four Treatments:
  - Treatment #1 (T1): ET based irrigation
  - Treatment #2 (T2): Soil water potential (-40 kPa)
  - Treatment #3 (T3): Soil water potential (-60 kPa)
  - Treatment #4 (T4): GesCon decision support system



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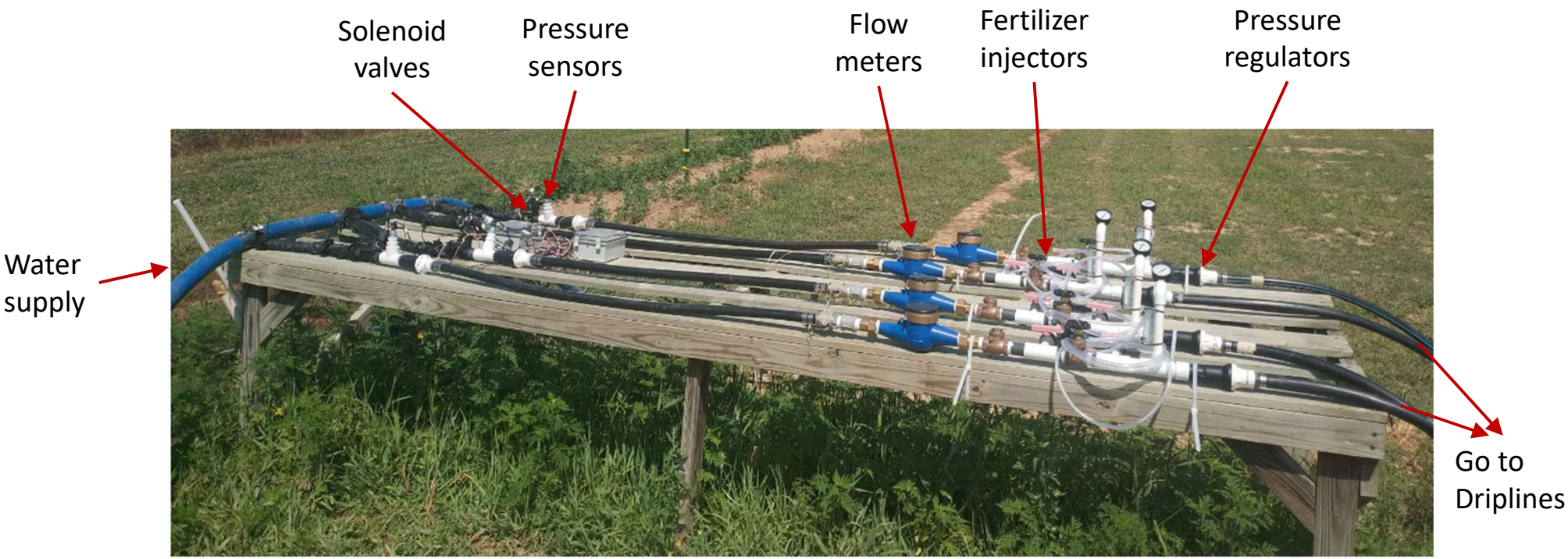
Irrigation System Setup



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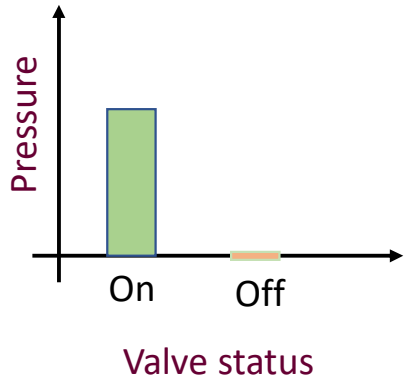
Solenoid Valves and Pressure Sensors

- Solenoid Valves
  - One for each treatment
  - DC power

- Pressure Sensors
  - After each valve
  - Indicate the water pressure



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Fertilizer Injectors, Pressure Regular Valves, and Gauges

- Fertilizer was applied evenly for the four treatments
- Pressure was set to 13 psi to the driplines

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Flow Meters

- Water use amount was recorded for every irrigation event

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Soil Moisture Sensors

- Soil moisture sensors at two depths: 20 and 40 cm
- Two locations for each treatment

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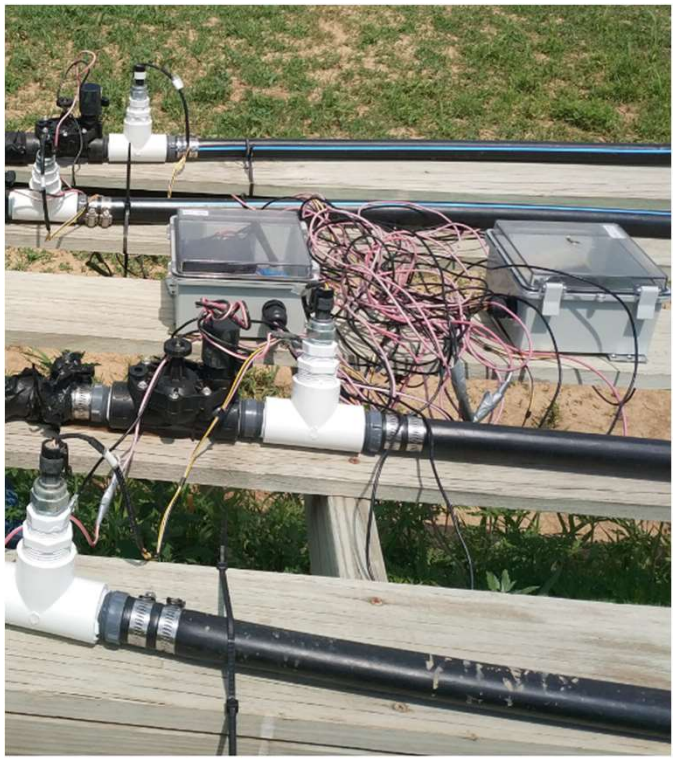
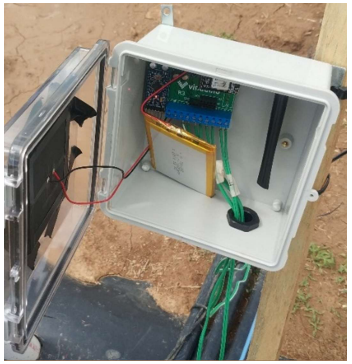
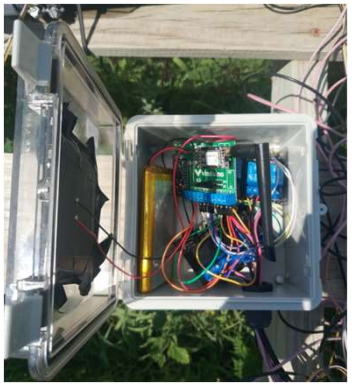
Dataloggers/Controllers

Connect to soil moisture sensors



Connect to valves and pressure sensors





Wire connections

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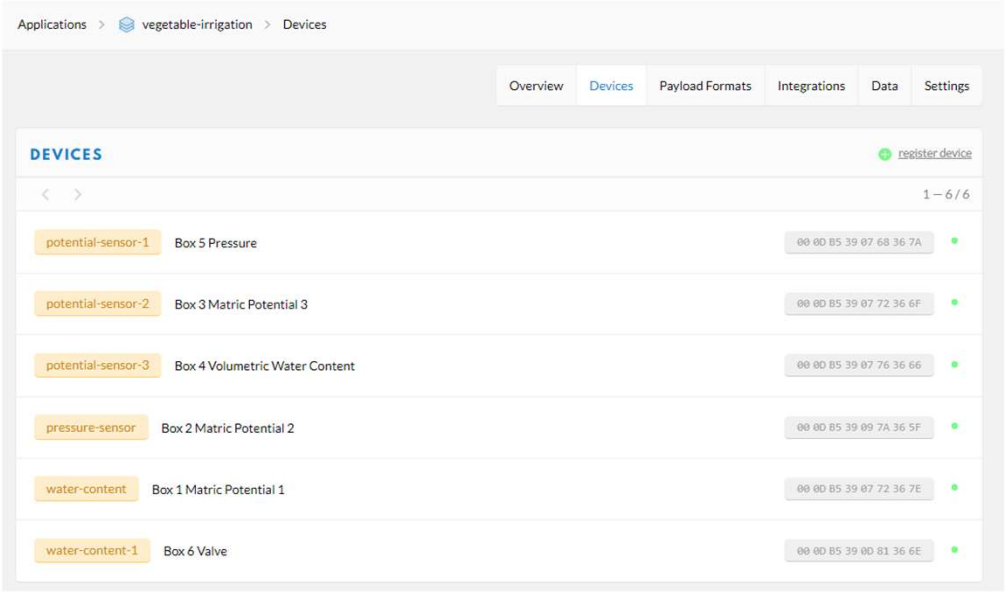
Internet of Things (IoT) System Configuration

Dataloggers (Devices)
- Soil moisture sensors
- Solenoid valves
- Pressure sensors

Gateway
- Internet connection
- Signal checking

THE THINGS NETWORK



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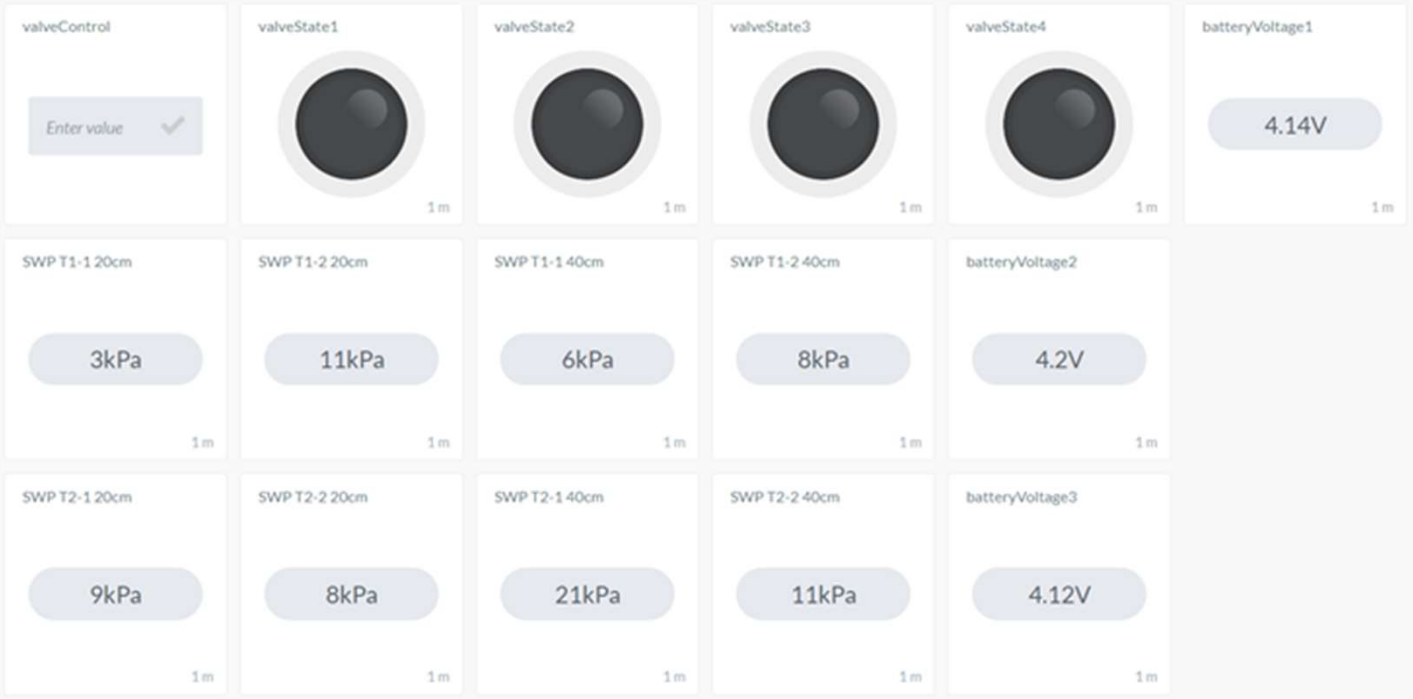
Internet of Things (IoT) Platform Interface



'AllThingsTalk' IoT platform

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Irrigation Operation

- Solenoid valves for all treatments were controlled remotely
- Alerts were received for T2 and T3 (Soil moisture irrigation)
- Irrigation scheduling for T1 is based on the ET calculation
- Irrigation scheduling for T4 is based on the Gescon (App)

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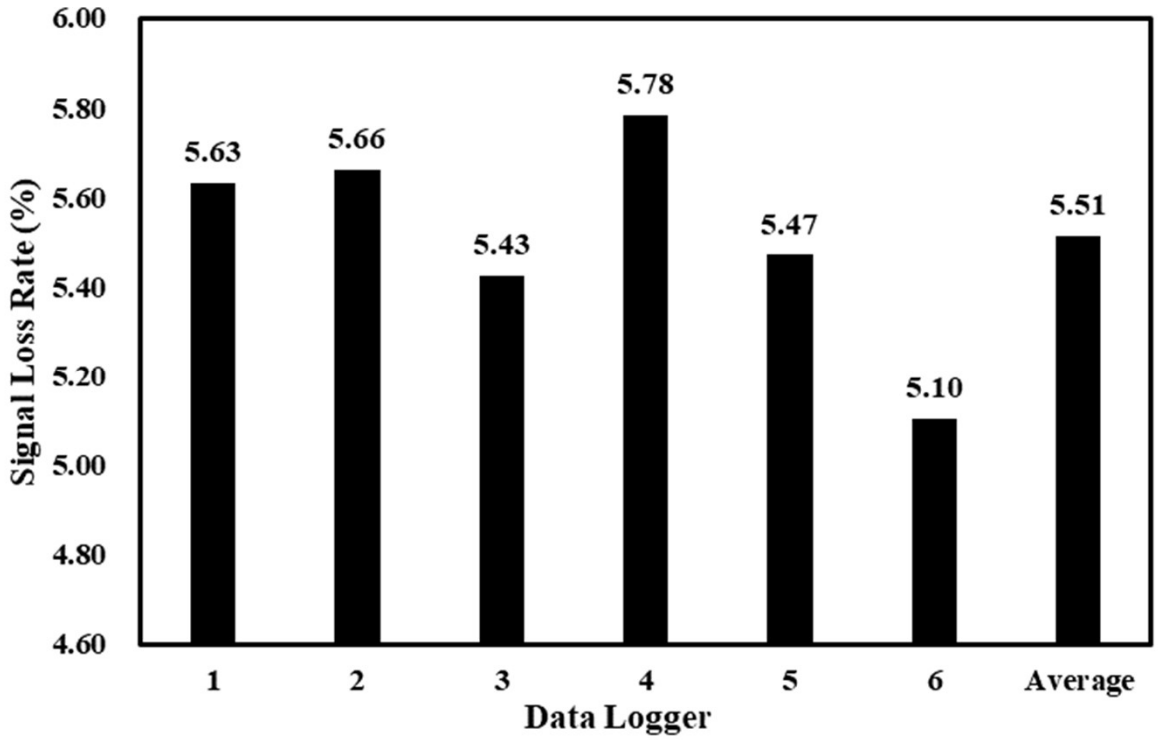
IoT System Feasibility



Signal loss throughout the time

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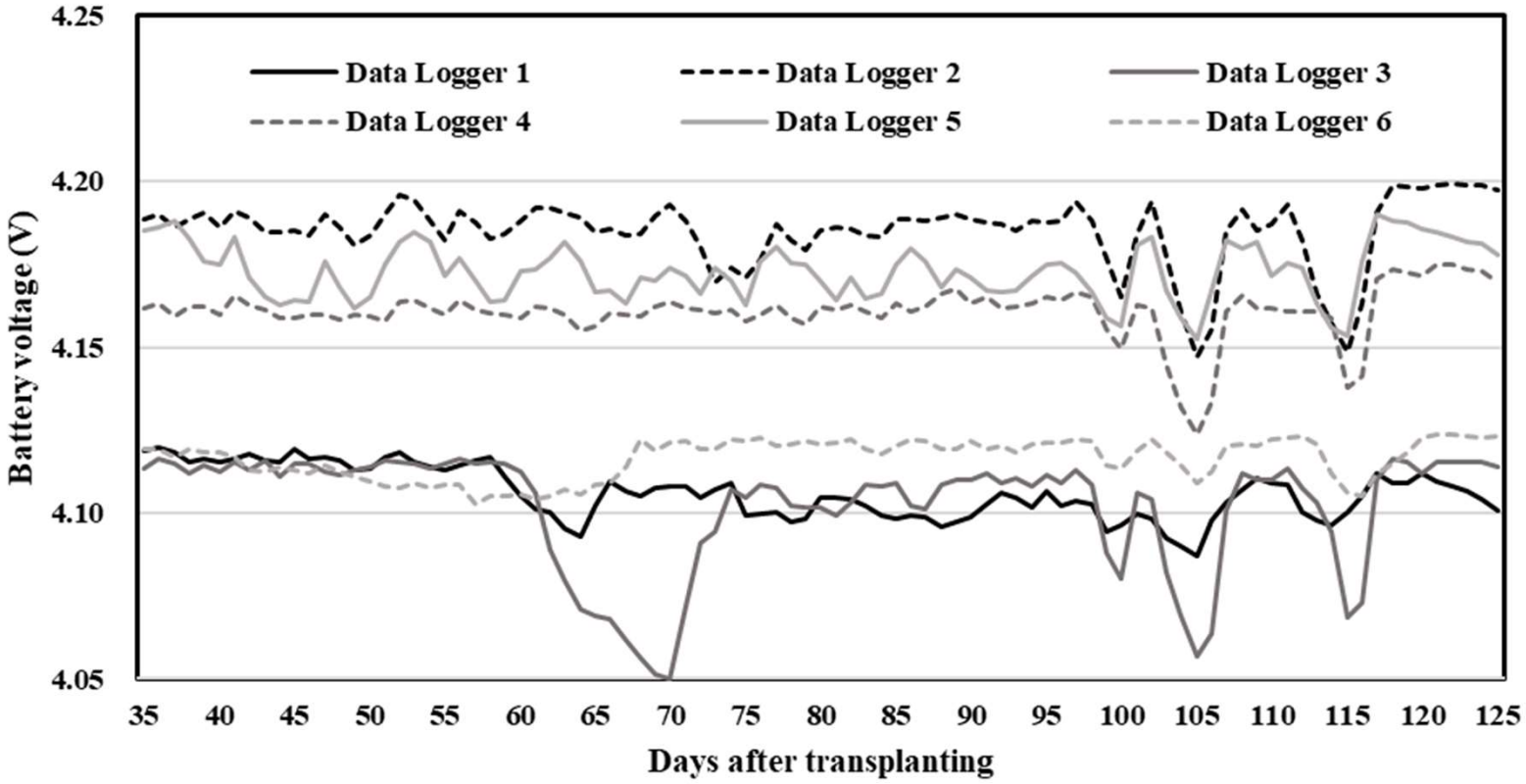
Batteries in the Six Dataloggers



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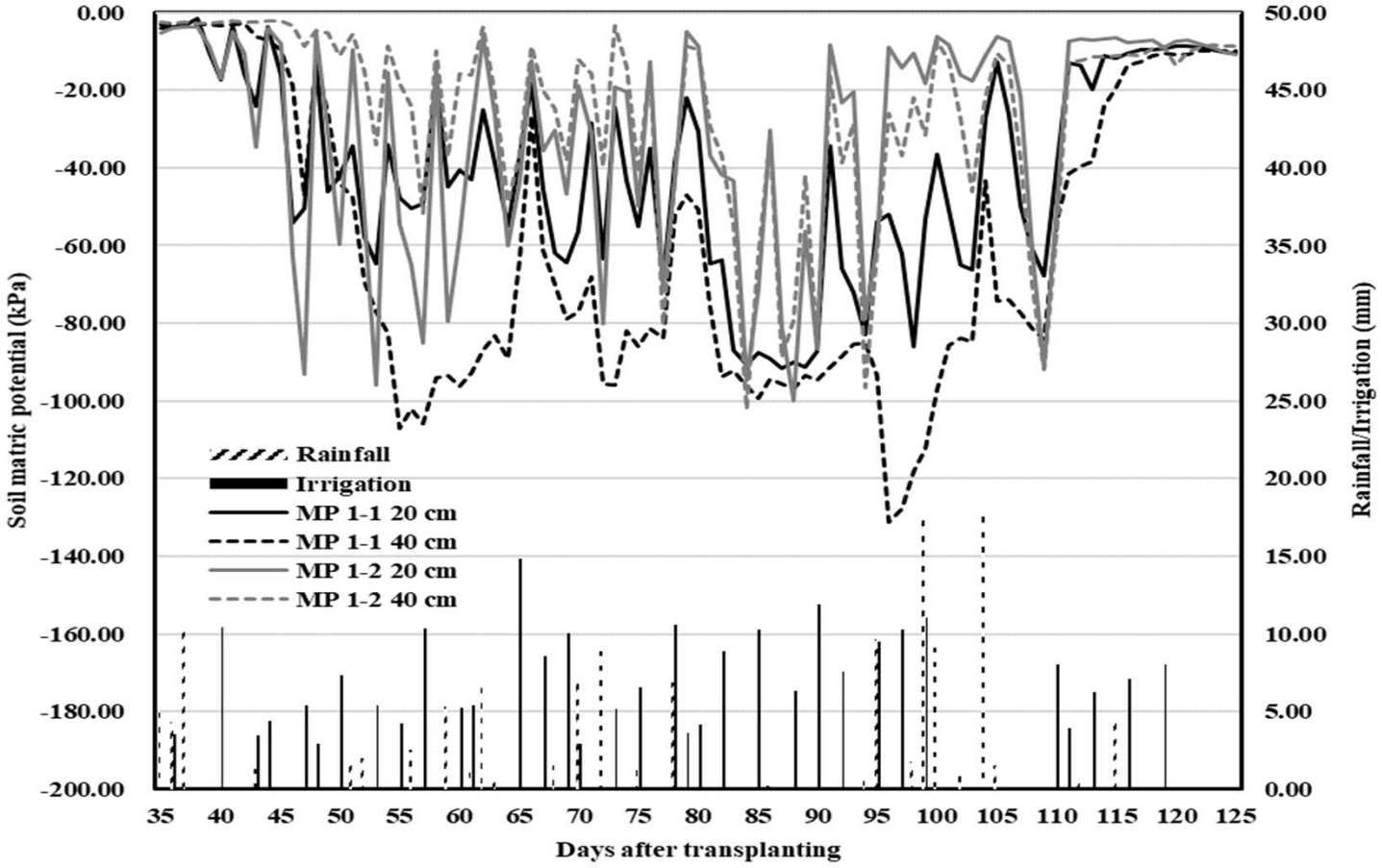
Soil Moisture Level Through the Season (T1)



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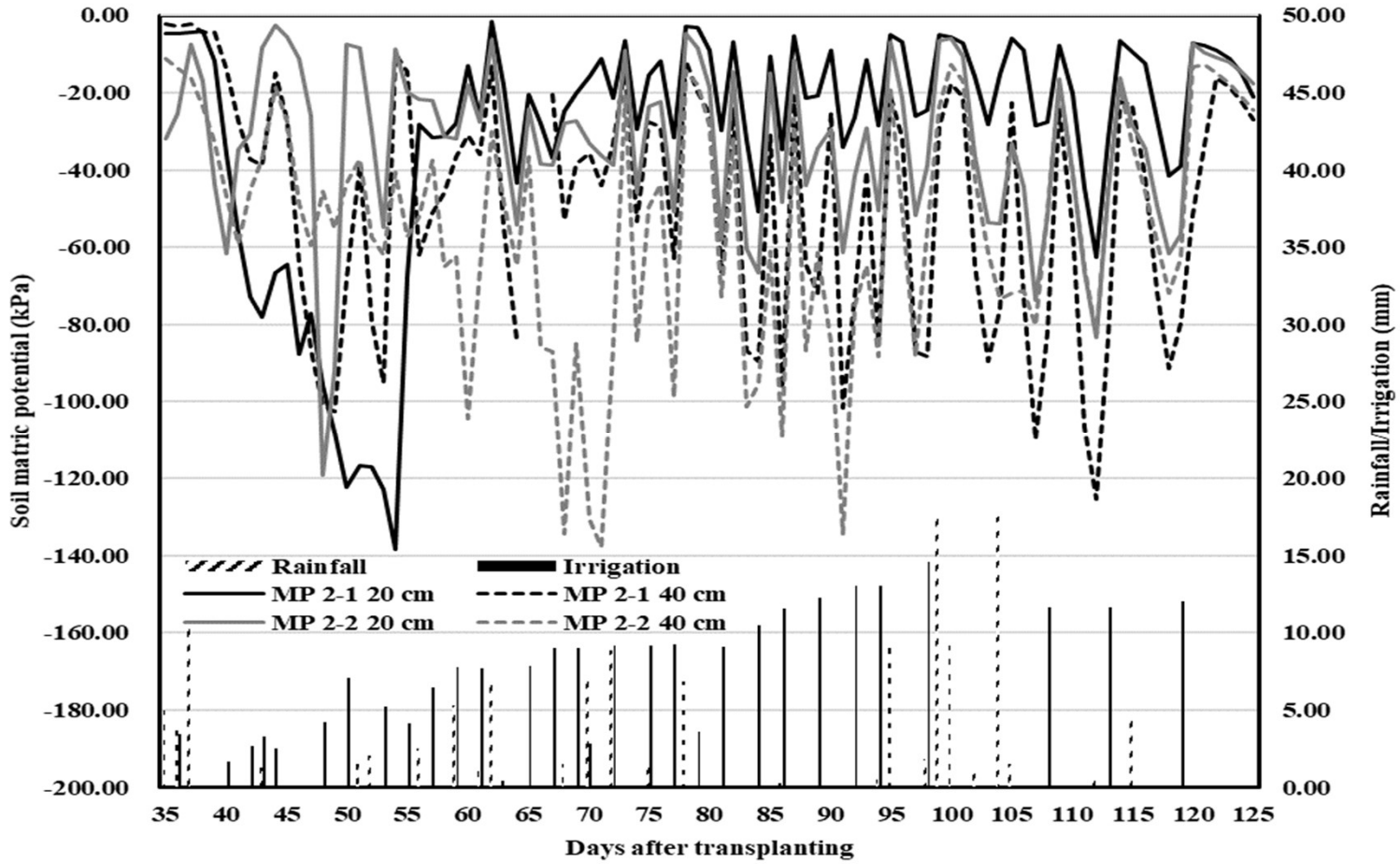
Soil Moisture Level Through the Season (T2)



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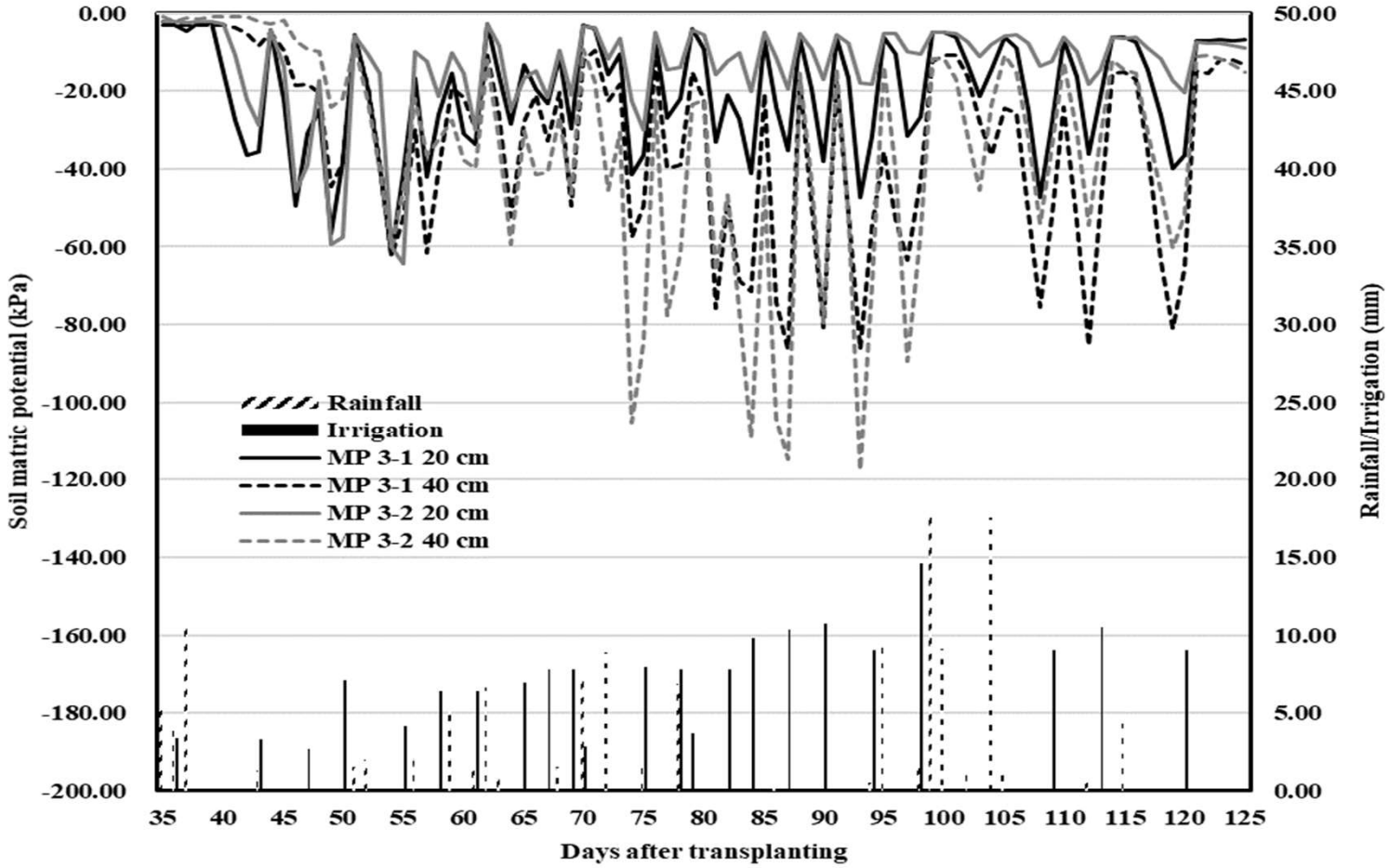
Soil Moisture Level Through the Season (T3)



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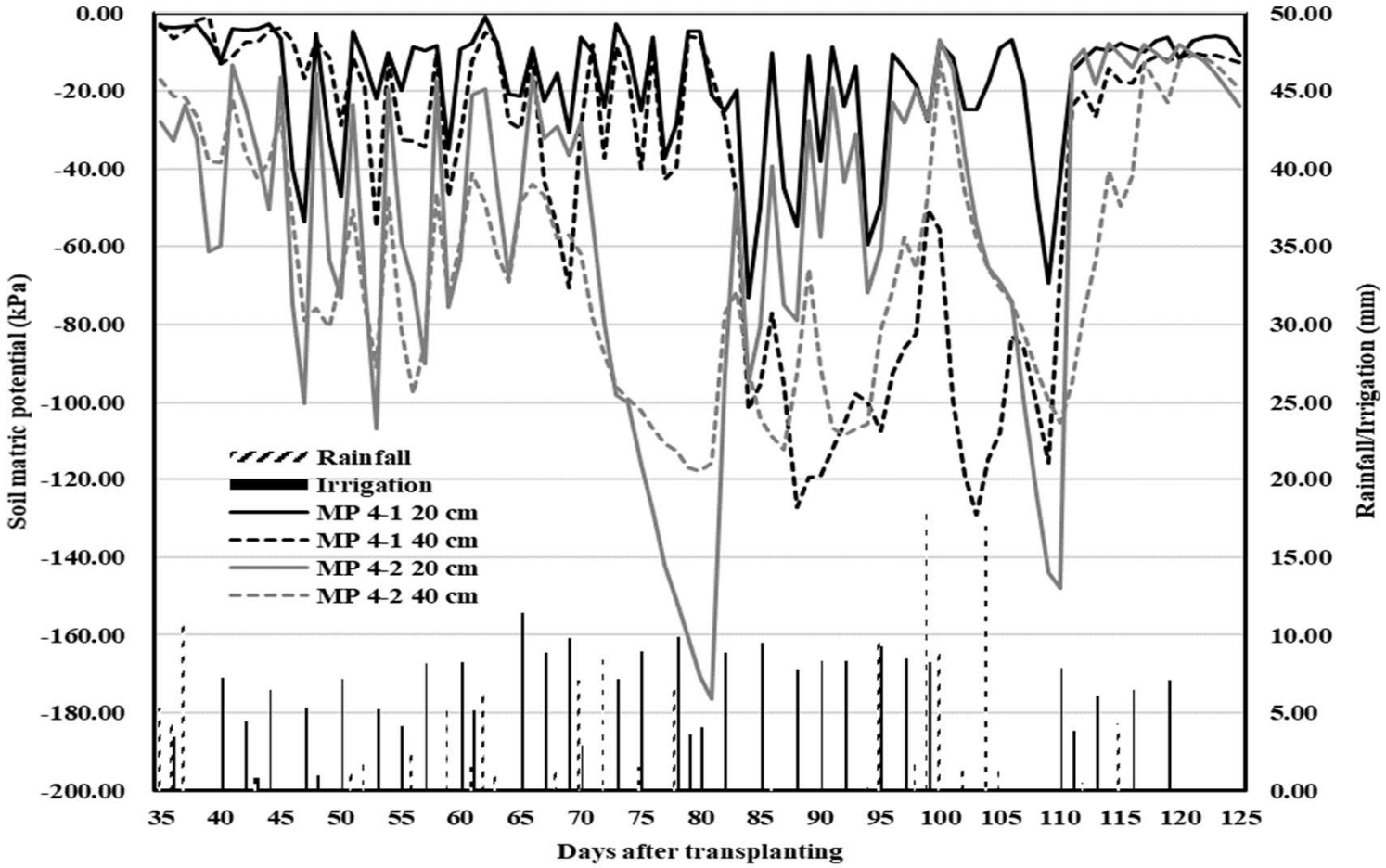
Soil Moisture Level Through the Season (T4)



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Irrigation Application and Water Use Efficiency

Treatments	Volume of Water (m^3 ha^{-1})	WUE (kg m^{-3})
T1	2440	22.22b
T2	2357	26.49ab
T3	1695	27.94a
T4	2339	28.38a

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Summary

- Soil moisture is a direct and convenient indicator for irrigation
- Remote data accessing through App or Website
- Solenoid valves were controlled remotely through the IoT platform
- Precision irrigation was proved to be water saving
- Fully automated irrigation will be tested in the coming season

Acknowledgement

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