Updates on Precision Agriculture Program

Intelligent Spraying and Sensor-Based Irrigation

Long He

2020 Winter Fruit School

Biglerville, Adams County, PA

February 17th, 2020

PennState College of Agricultural Sciences

PennState Extension

Intelligent Spraying for Tree Fruit Orchards

Overview of Orchard Spraying

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Production Impact

- Spray coverage
- Spray schedule
- Crop yield
- Crop quality

Economic Impact

- Pesticides cost
- Equipment cost
- Operation cost
- Income/return

Environmental Impact

- Ground water
- Soil
- Beneficial insects
- Residents

Operation/Maintenance

- Operator-friendly
- Easy to maintain
- Good service
- Educational programs

Orchard Sprayers

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Need of Intelligent Sprayer

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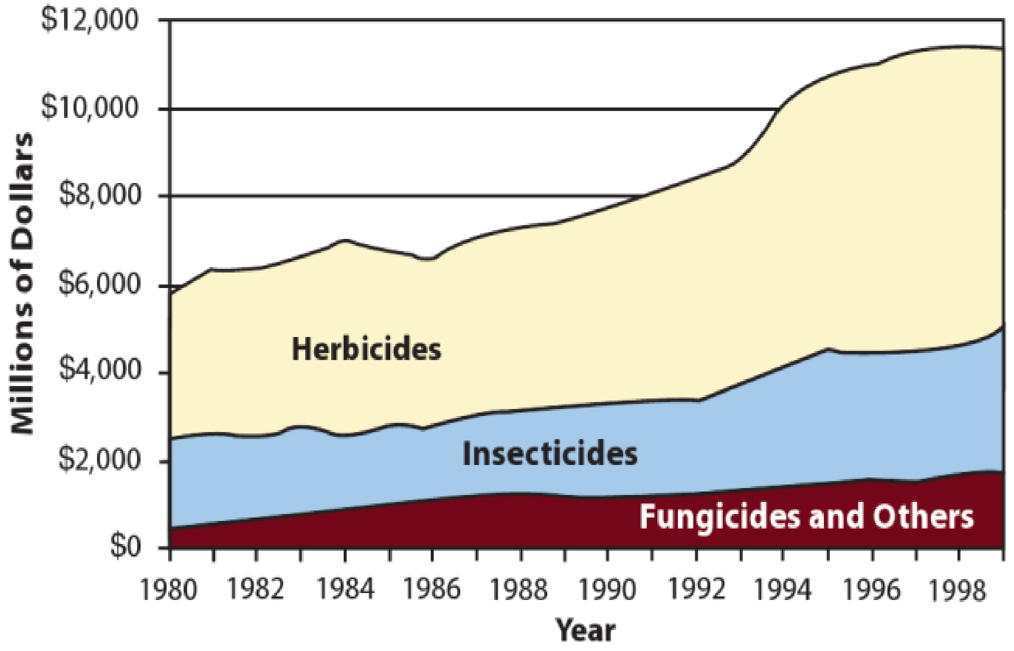
Conventional Methods:

- Non-precision and non-targeted
- Waste some chemicals (drift to air/ground, gaps) (~ 30% of chemical on the tree canopy)
- Cause environmental issues

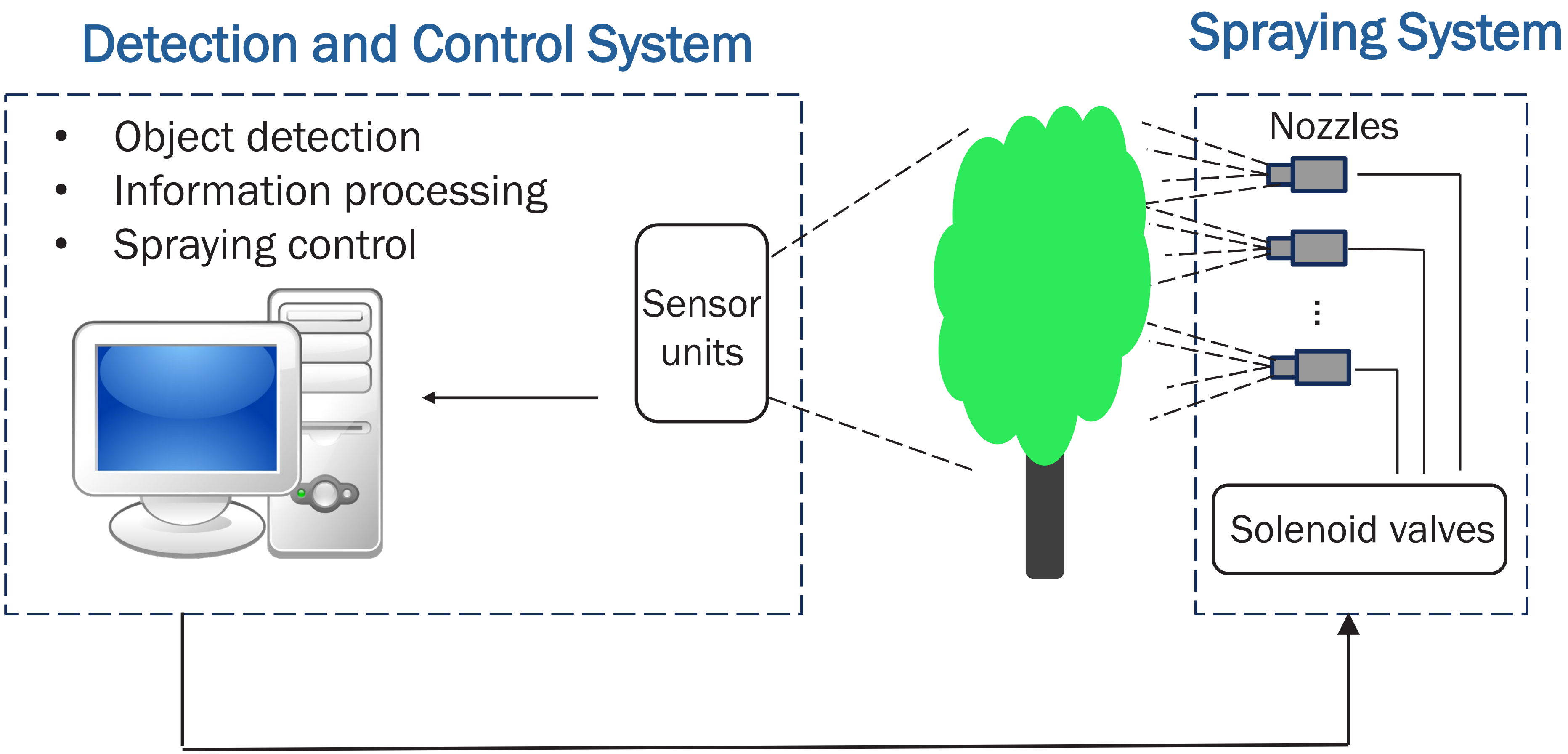


Intelligent Sprayer:

- Targeted spraying
- Save chemical
- Reduce production cost

If the average of cost for pesticides is ***$300-500 per acre*** for a growing season, and ***20%*** of saving is **$60-100**, and **40%** of saving is **$120-200**.

Principle of Intelligent Spray



Core Tech. – Object Detection

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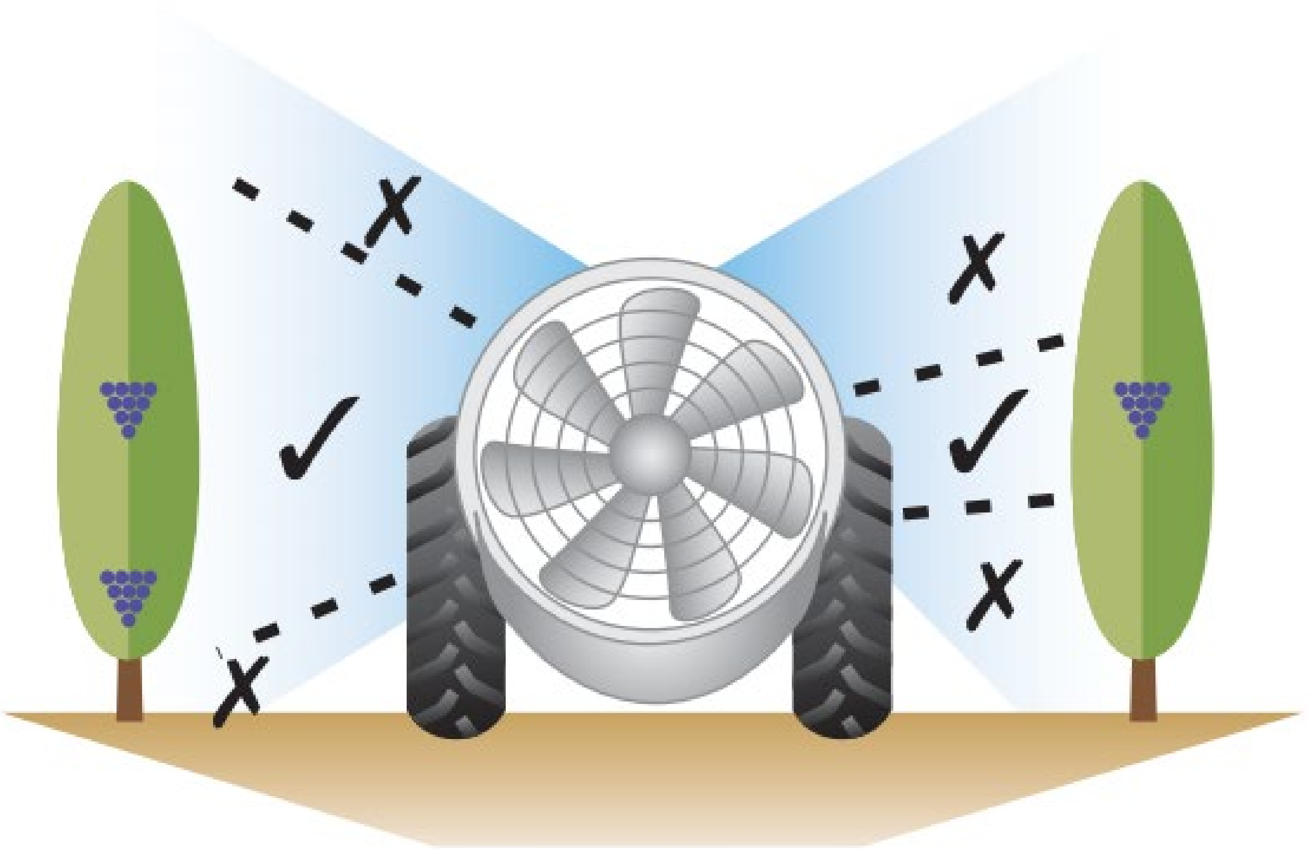
Canopy location, shape, volume, density



Blossoms, fruits, insects/ diseases

Airblast 101: Turn off nozzles that are not spraying the target.

Core Tech. – Object Detection

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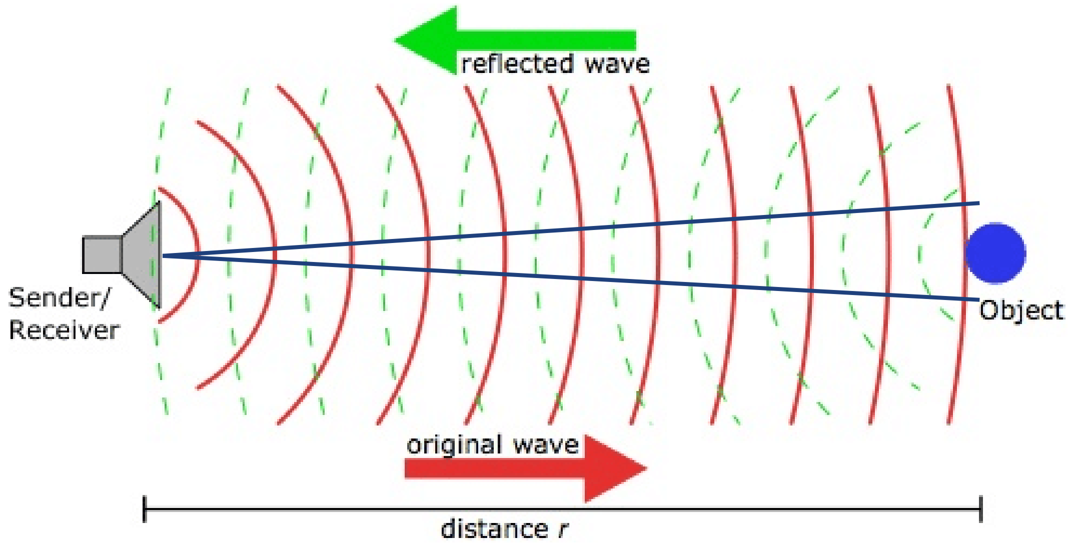
Tree Canopy Detection – Ultrasonic Sensors



Measurement of distance to objects using sound waves

Pros

- Inexpensive
- Mid - long range
- Reliable in varying environment

Cons

- Small area detection
- Inaccurate at soft surface

Detection range: 20 mm to 8 m.

Core Tech. – Object Detection

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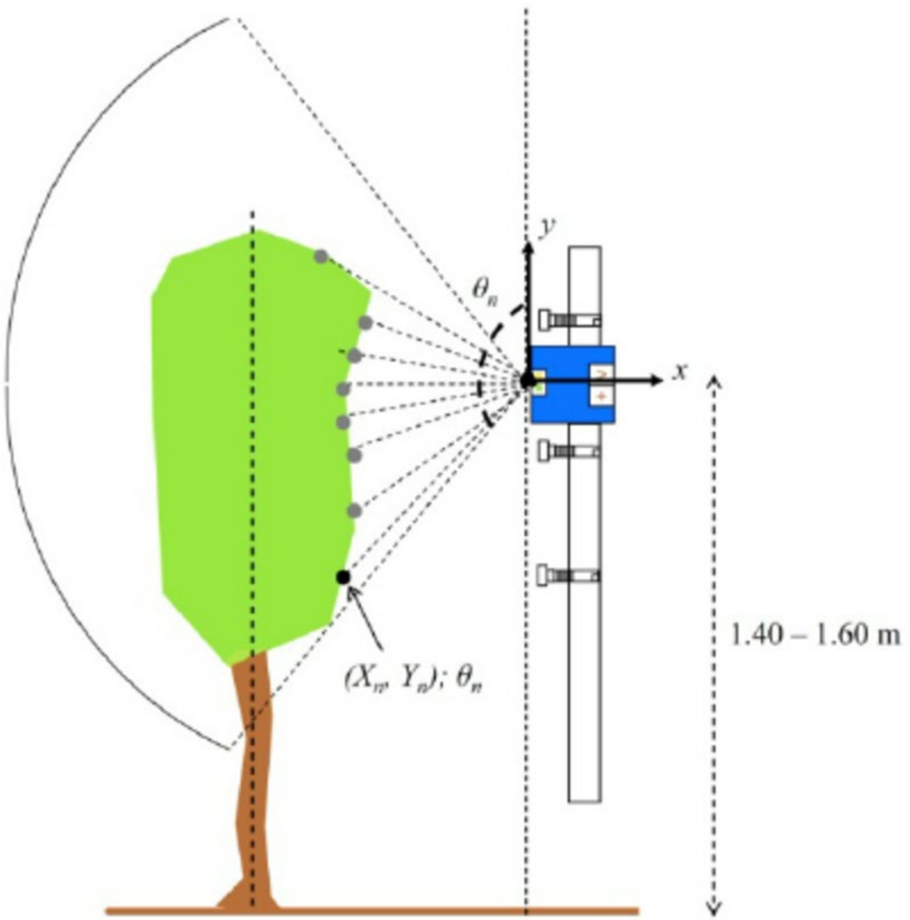
Tree Canopy Detection – Laser Sensors



Pros
- Full canopy detection
- Long range
- Reliable in varying environment

Cons
- A bit expensive
- Real-time data processing

- 2D (one channel) and 3D (multiple channels)
- Detection range: up to 100 m or more
- Cost: ~ $1,000 - $10,000 or higher

Core Tech. – Object Detection

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Cameras based Object Detection

Karkee, WSU, 2014

Philipe Ambrozio Dias, 2018

- Very few studies on the camera based for tree orchard sprayer
- Some on the field crop detection (weed control or crop thinning)
- Specific disease/insect detection – Spot/targeted spraying?

Core Tech. – Nozzle Control

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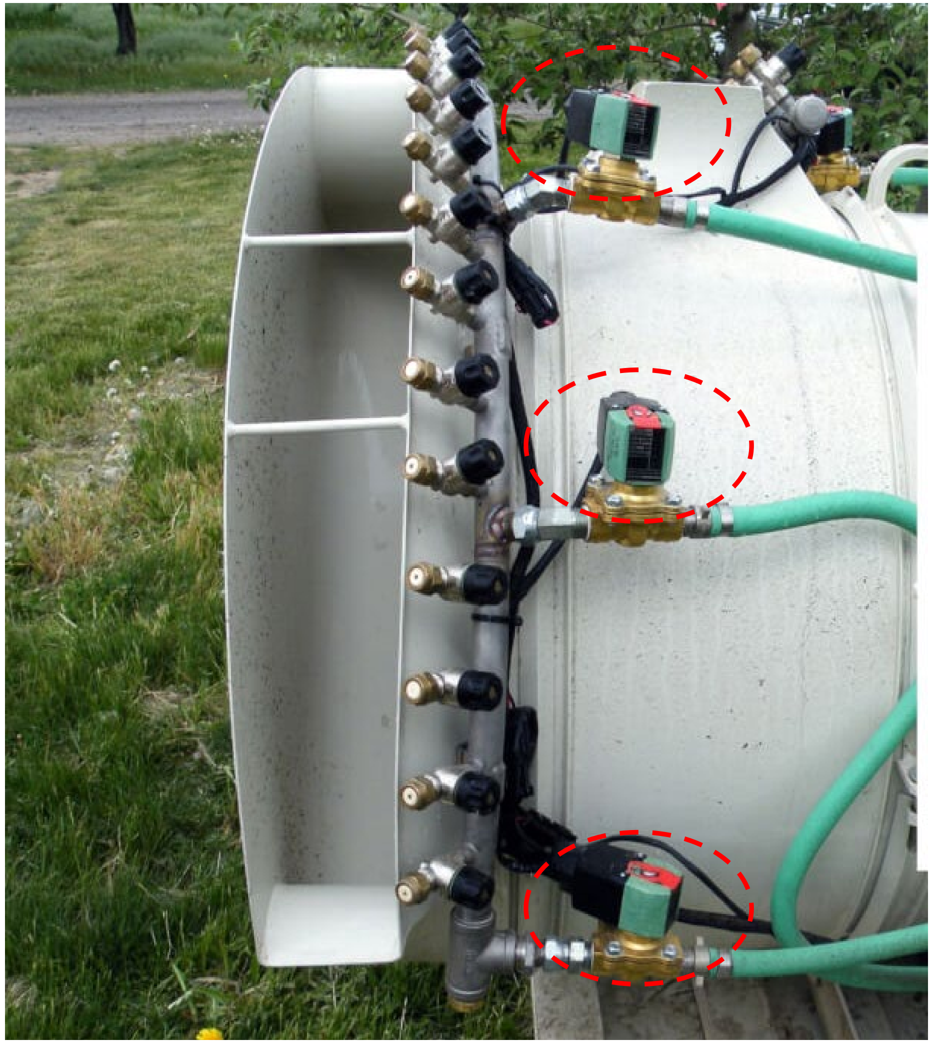

Available Intelligent Sprayers

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Smart Sprayer - Ultrasonic Sensor

- **Stajnko et al., 2012- apple orchard**
  Save up to 48% pesticides
- **California almond and plum tests- Giles et al., 2011**
  Reduced pesticides by 15-40%, and non-targeted orchard floor deposition by 5-72%.
- **Florida citrus tests- University of Florida Extension**
  Average of 14% reduction in pesticides use.

Problems: valve clogged, control system failure, little saving on some sites.

Available Intelligent Sprayers

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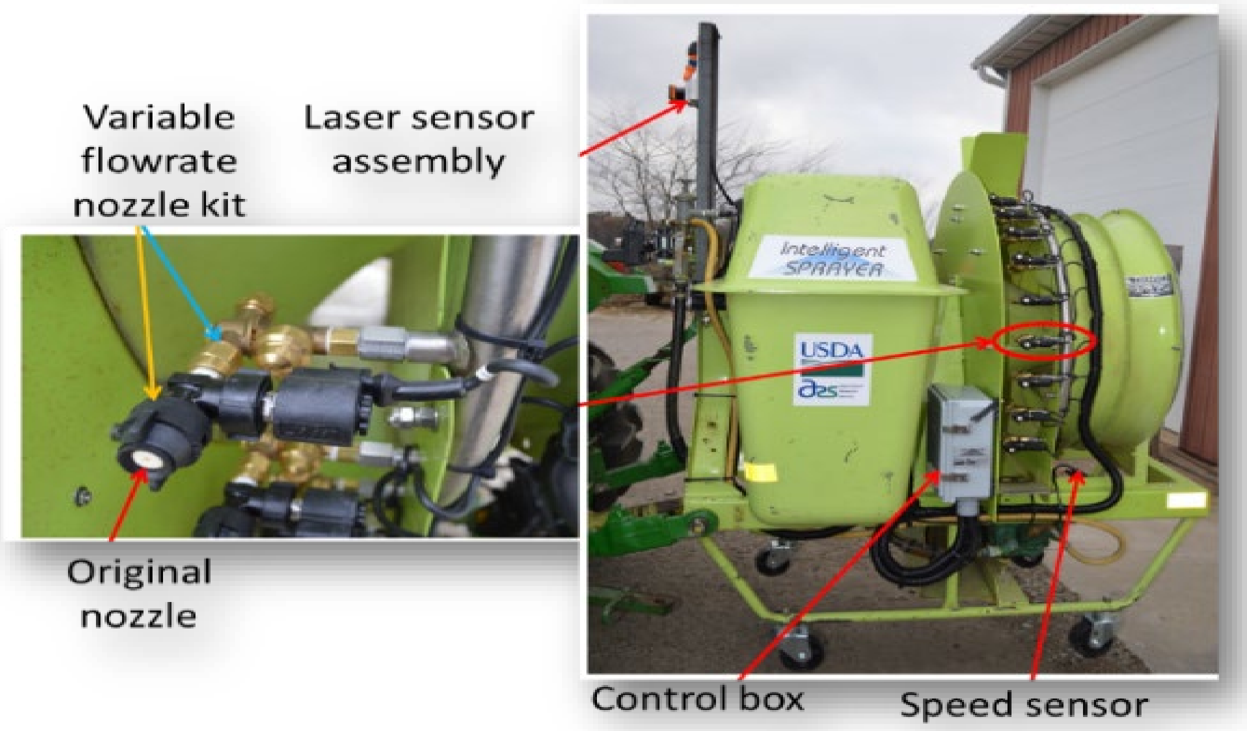
Smart Sprayer - Lidar Sensor



Intelligent sprayer kit

- *Studies from Dr. Heping Zhu's team: ~30-70% of chemical saving*
- *The intelligent sprayer kit could be retrofitted to existing sprayers.*

What We Are Doing?

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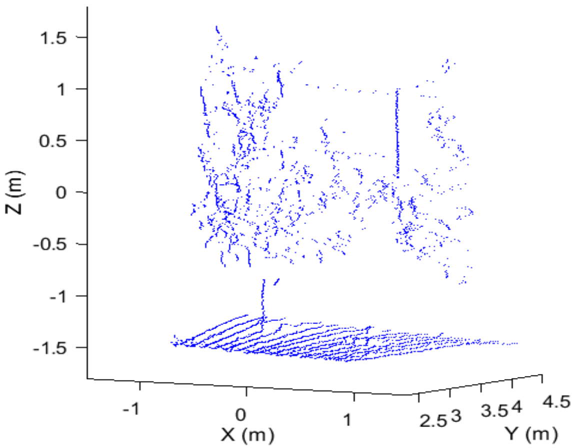
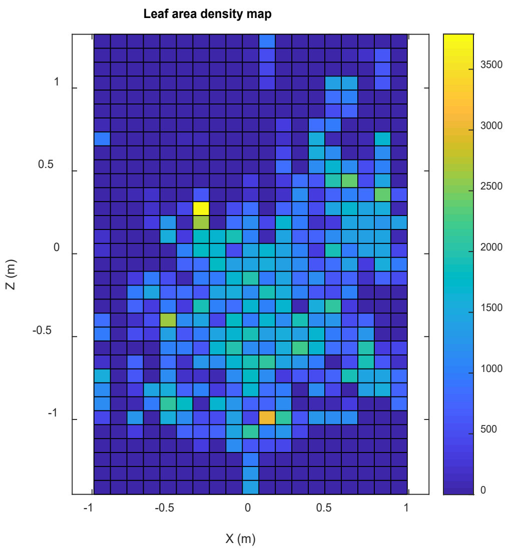
Tree Canopy Detection





Geo-reference and Orchard Terrain

- Initial measurement Unit (IMU) – orchard terrain
- RTK GPS – Geo-reference

Intelligent Sprayer Integration and Evaluation

- Ordered an intelligent sprayer unit
- Integrate the sprayer and intelligent unit (March 2020)
- Orchard evaluation (2020 season)

Soil Moisture Sensors for Precision Irrigation

Importance of Precision Irrigation

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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:

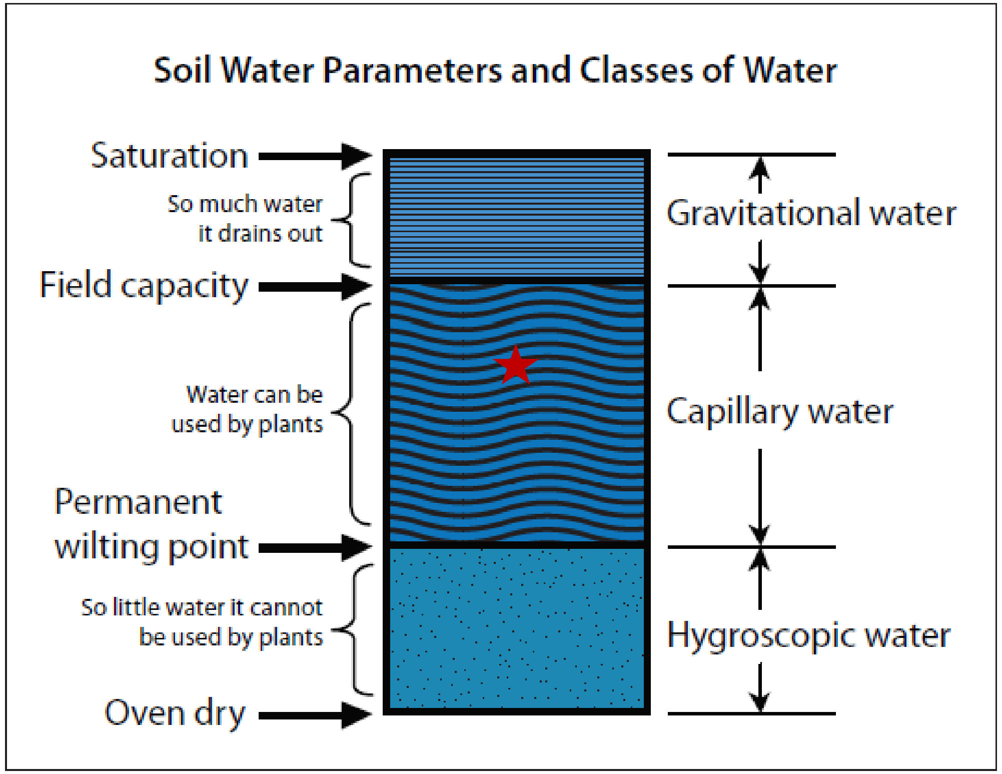
- ❖ Improve crop yield and quality
- ❖ Conserve water and save energy
- ❖ Reduce nutrient leaching and environmental impact


Photo: Rayies Altaf


Photo: FarmersTrend, 2017

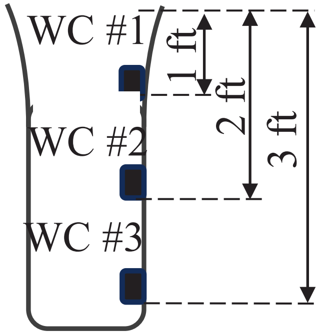
Soil Moisture Measurement

Fundamental Principles

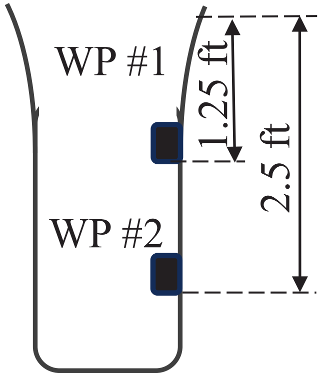


Soil Water Parameters (From: Texas A&M AgriLife Extension, E-618)

Soil Moisture Sensors



Soil water content sensor: TEROS 12 @ QTY 3



Soil water potential sensor: TEROS 21 @ QTY 2

Irrigation Scheduling Methods

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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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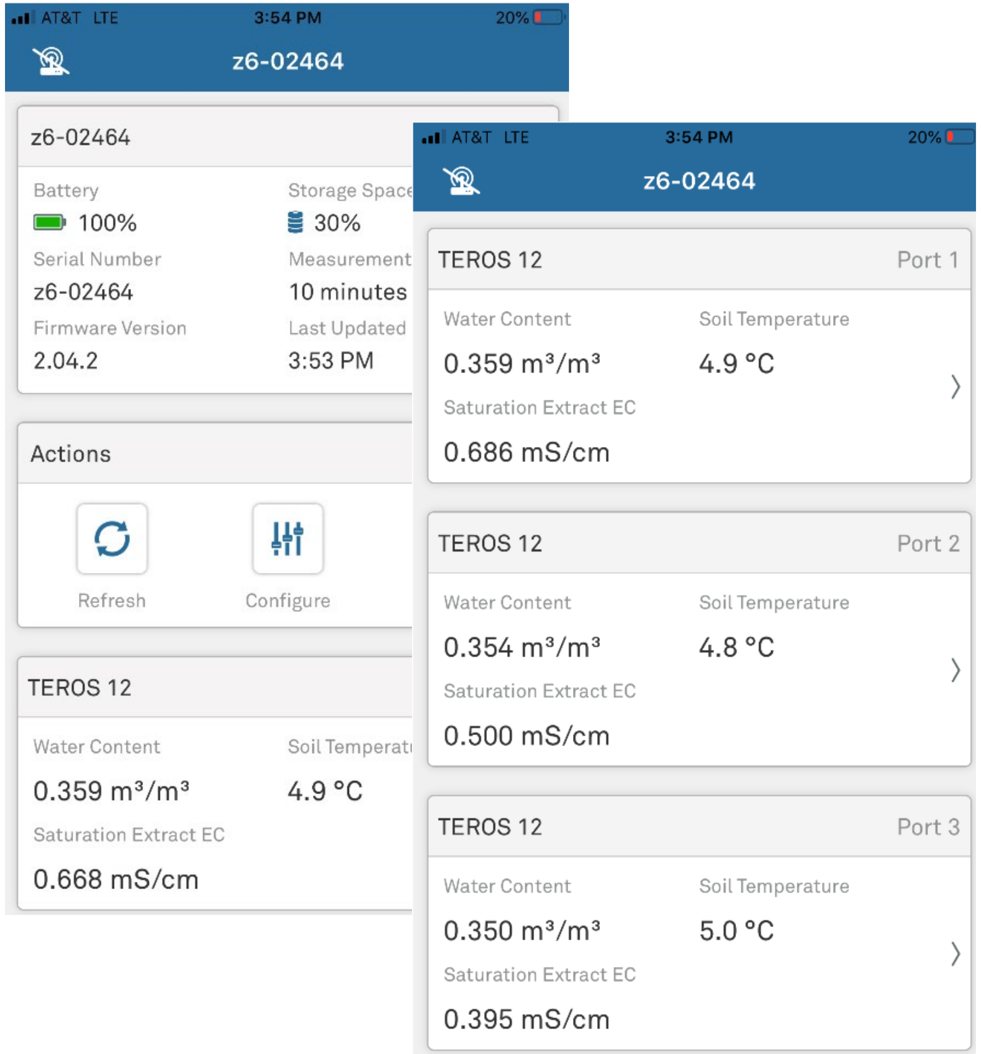
Soil Moisture Sensor Data Recording



Results – Irrigation Strategies

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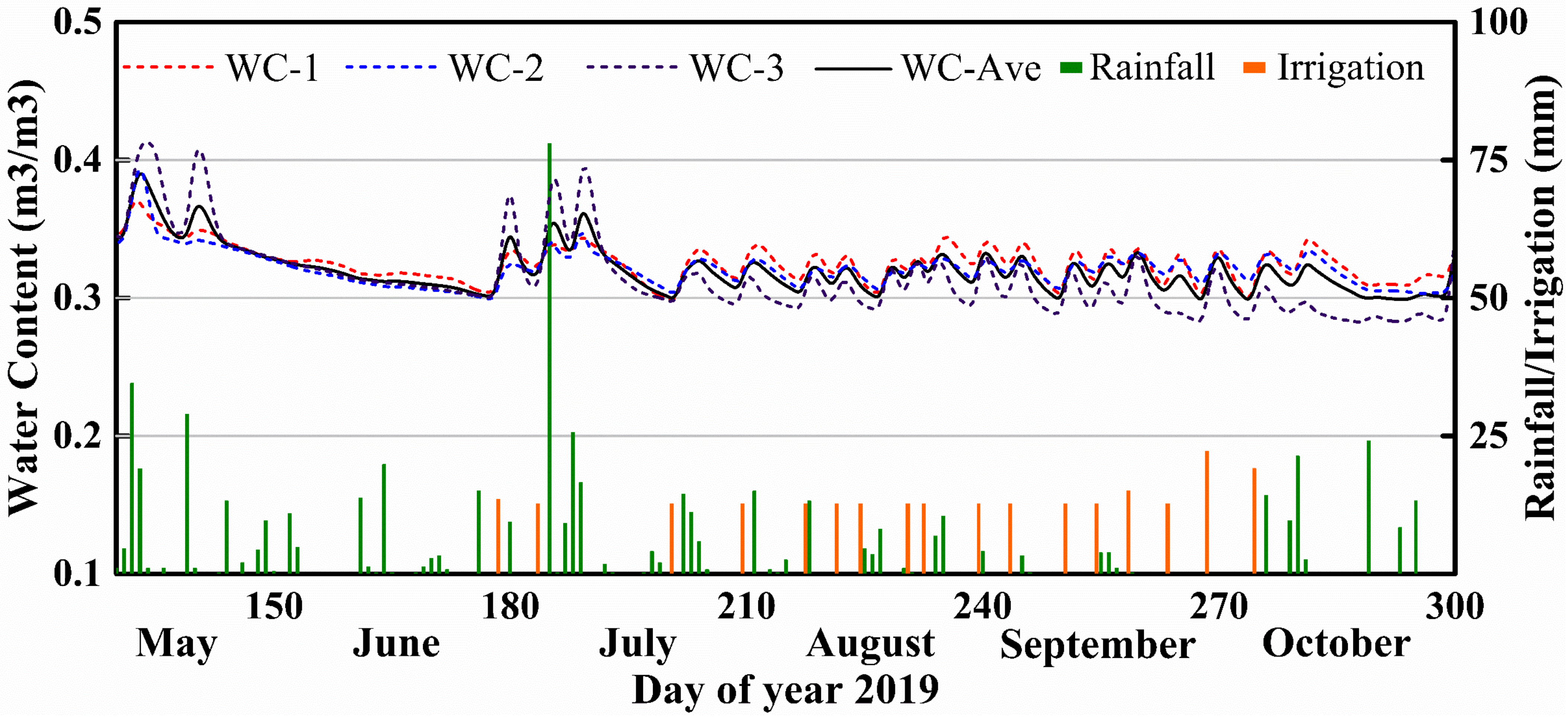
Soil Water Content



Results – Irrigation Strategies

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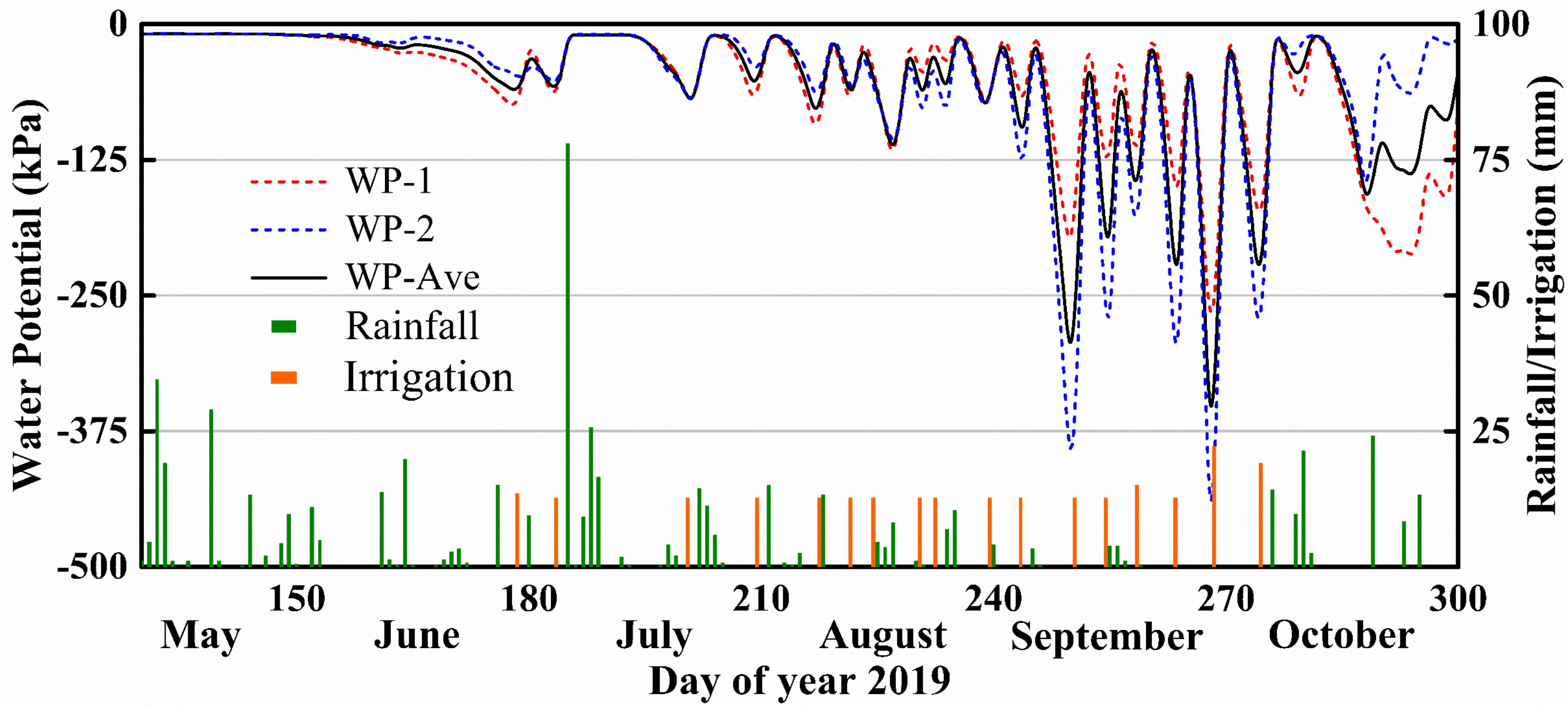
Soil Water Potential



Test in Commercial Orchards

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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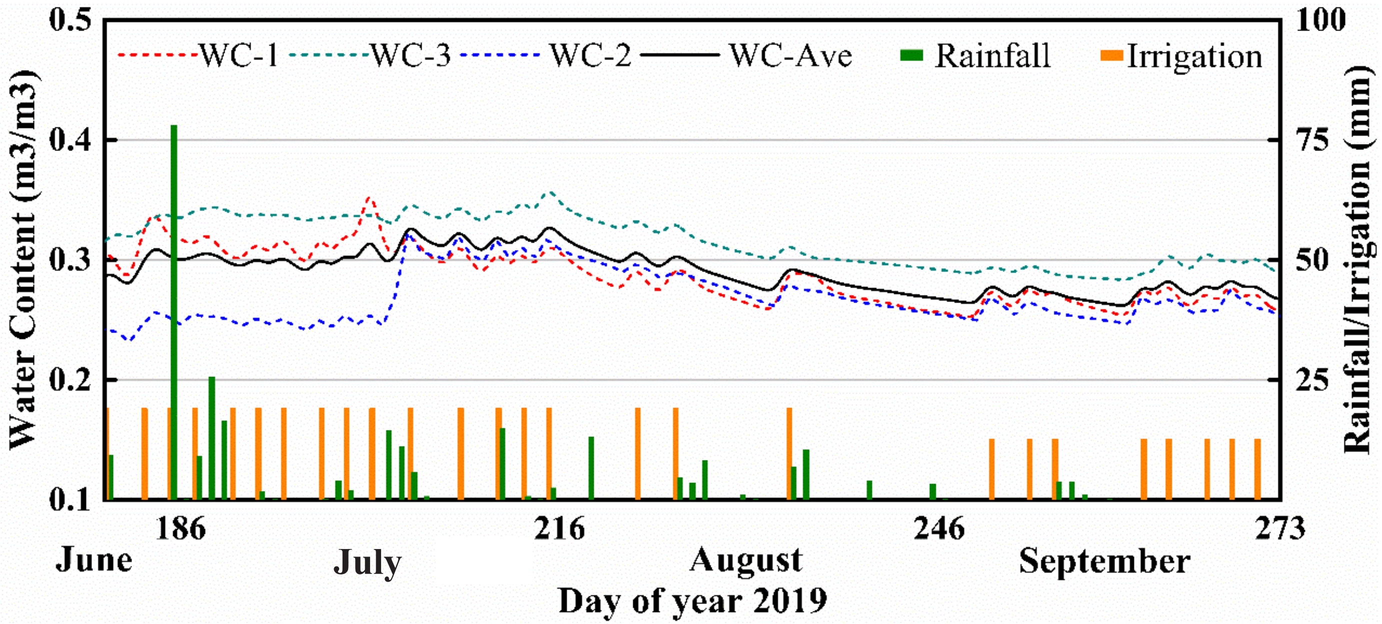
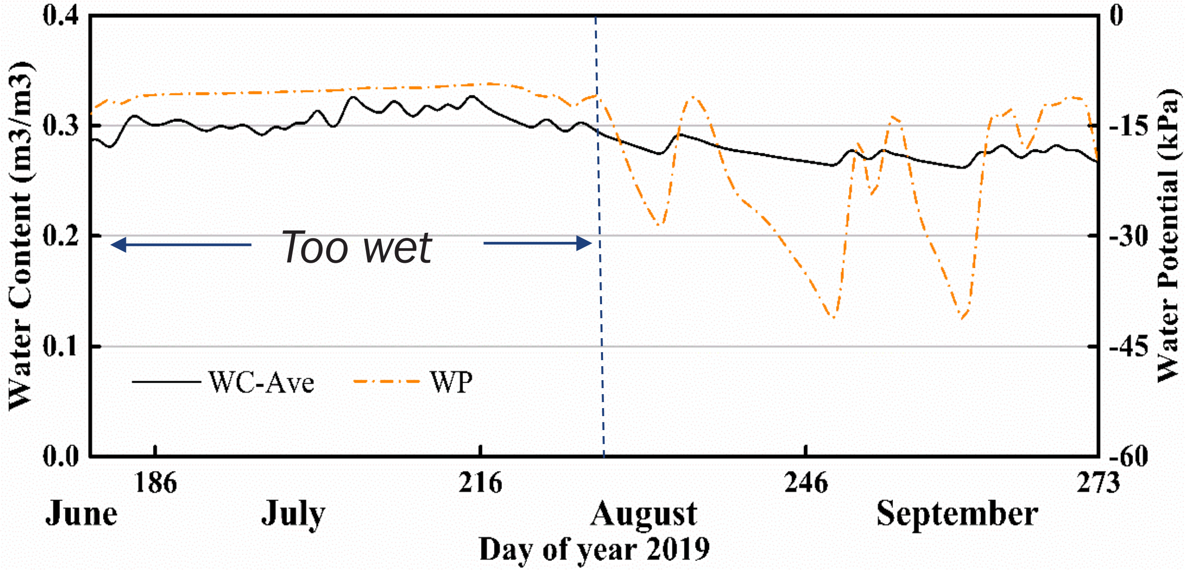


Twin Springs Fruit Farm (Crimson Crisp)



Test in Commercial Orchards

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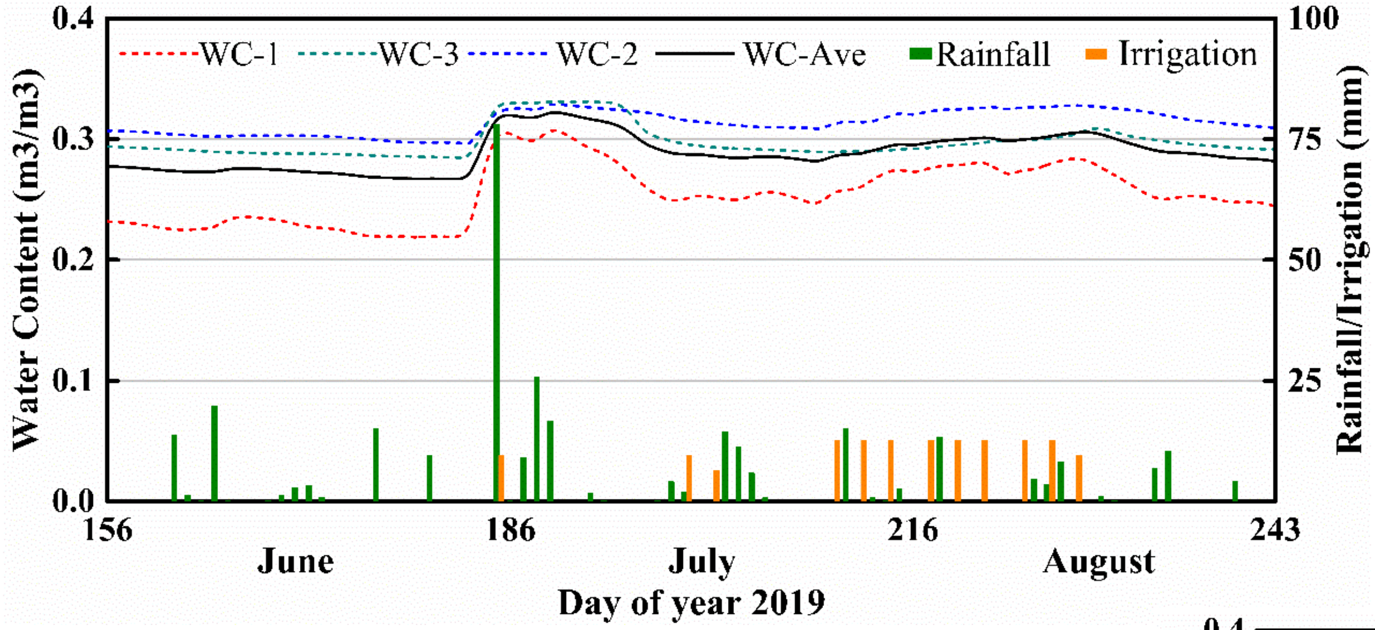
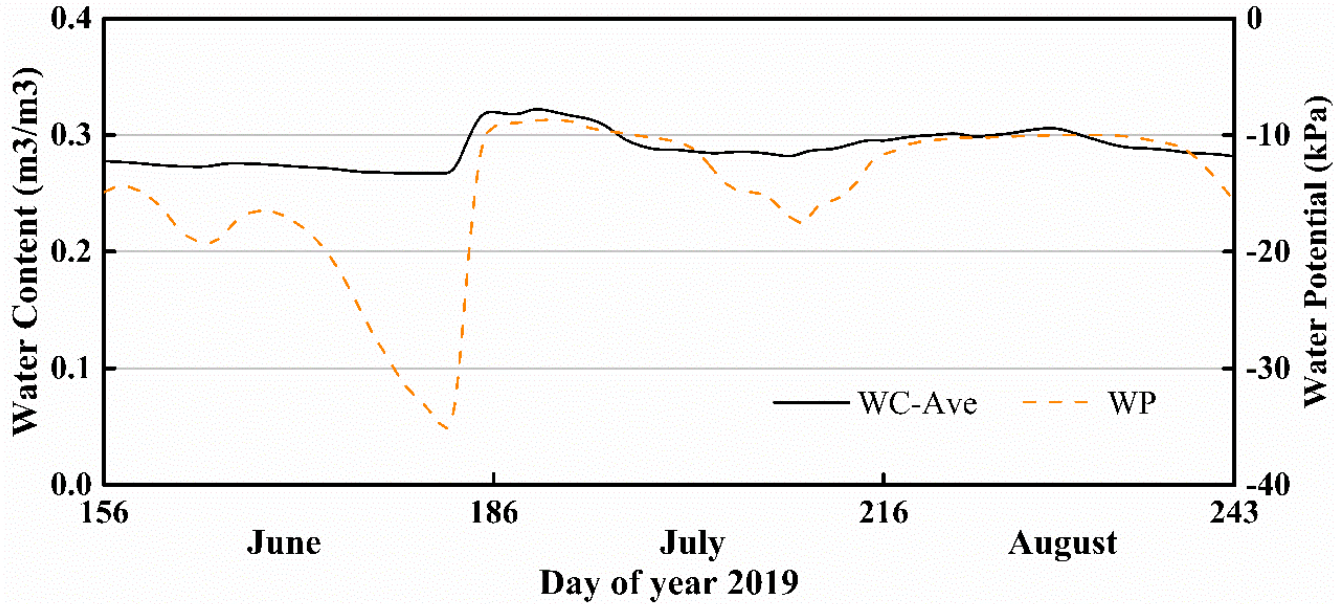


Hollabaugh Bro. Inc
(Honey Crisp)



Automated Irrigation System

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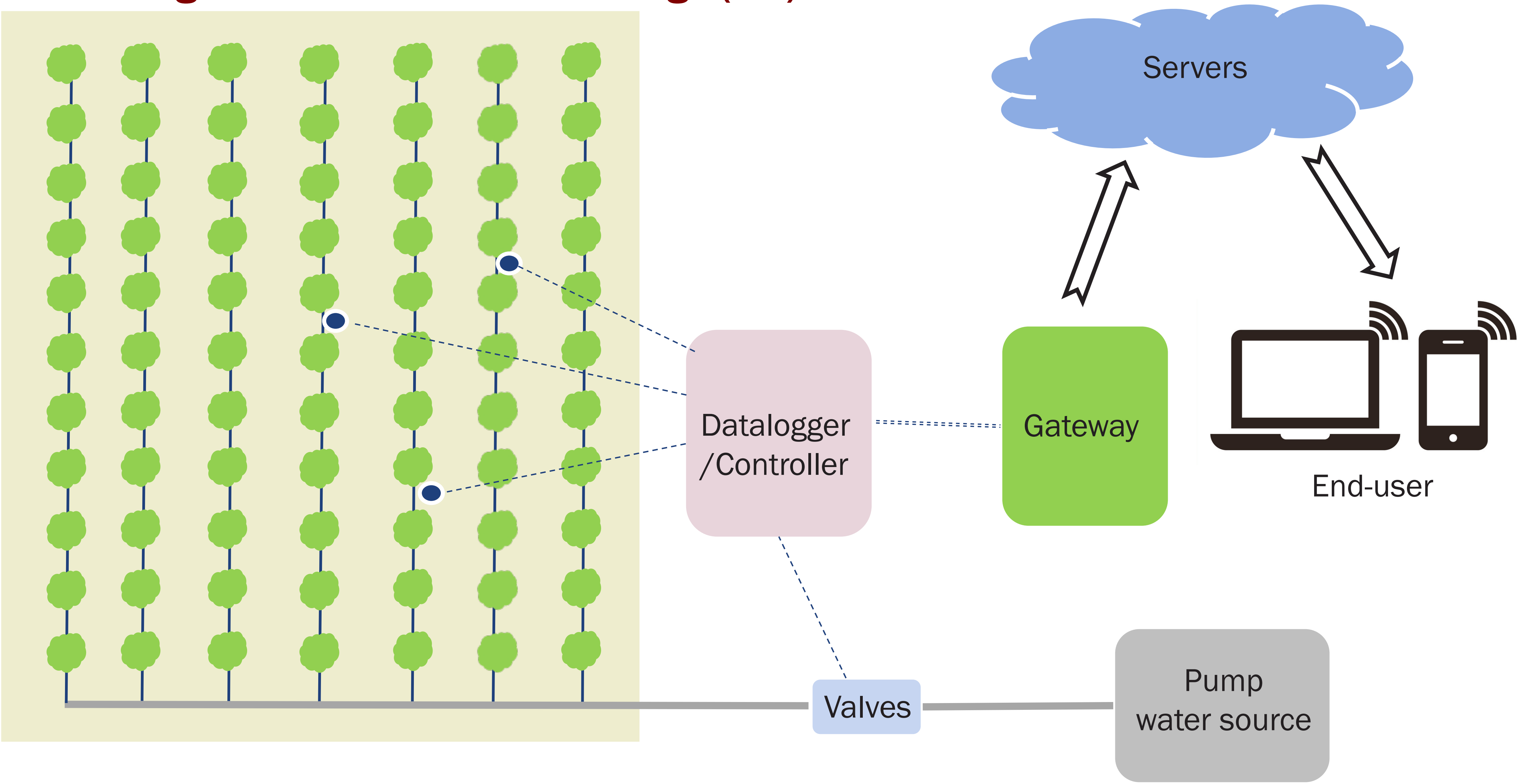
Automated Irrigation with Internet of Things (IoT)



Automated Irrigation System

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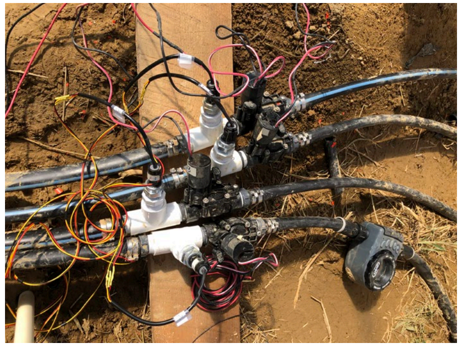

Automated Irrigation System

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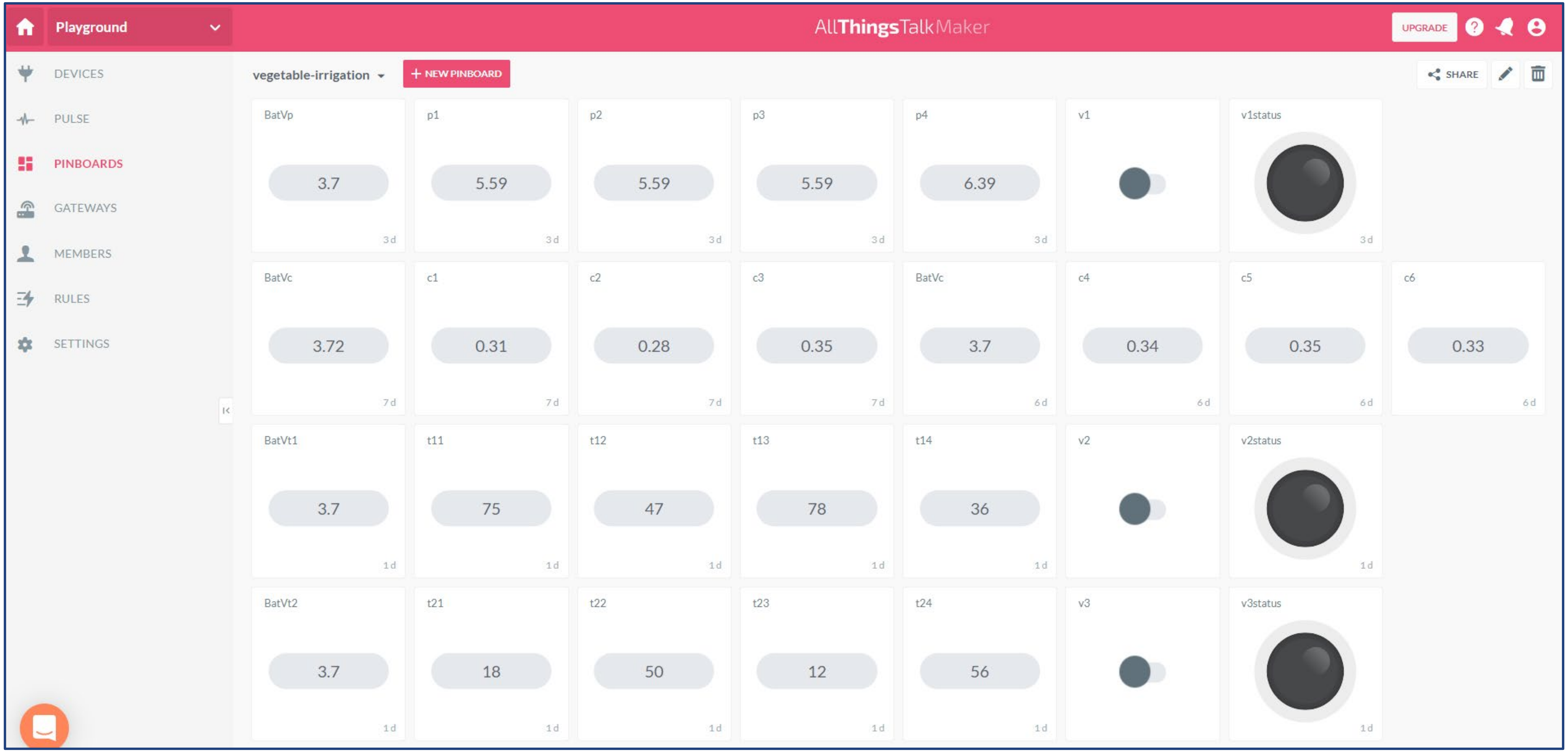
Interface of IoT irrigation System



What Growers Can Use?

Soil Water Potential using Watermark Sensors

$45/piece (Watermark)

+

$250 (Digital meter)

OR

$880 (Monitor + seven sensors)

What Growers Can Use?

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Soil Moisture Measurement (Meters Group, Inc)

Soil moisture sensors

$120/piece (Water content)
$225/piece (Water content + Temp, Water potential)

Sensor datalogger: $650

ZentraCloud

Data service: $180/season

- Three sensors (one node) in different depths for fruit trees
- Number of nodes in an orchard depends on the size and variation of the orchard
- Data can be monitored through ZentraCloud, or can be read and manually downloaded from the datalogger

What Growers Can Use?

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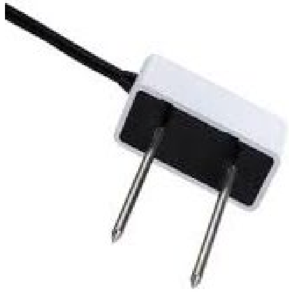
IoT based automated irrigation system

Soil Moisture Sensor



Datalogger &Gateway

Valve Control

IoT Platform

THE THINGS NETWORK

AllThingsTalk

- Soil moisture sensors: $50-$225 per piece
- Datalogger and Gateway: $500-$1,000
- Solenoid valves: ~$100
- IoT platform: Free or data fee if using some commercial services

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

Please contact me or your local extension educator if you are interested in applying sensor-based irrigation or want to know more about it.

Acknowledgement

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Project Personnel:

Long He, Dana Choi, James Schupp, Kari Peter, David Biddinger, Greg Krawczyk
Daniel Weber, Tara Baugher

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Thank you!