Franklin County Fruit School

Precision Farming: Progress with Sensing and Irrigation Technologies

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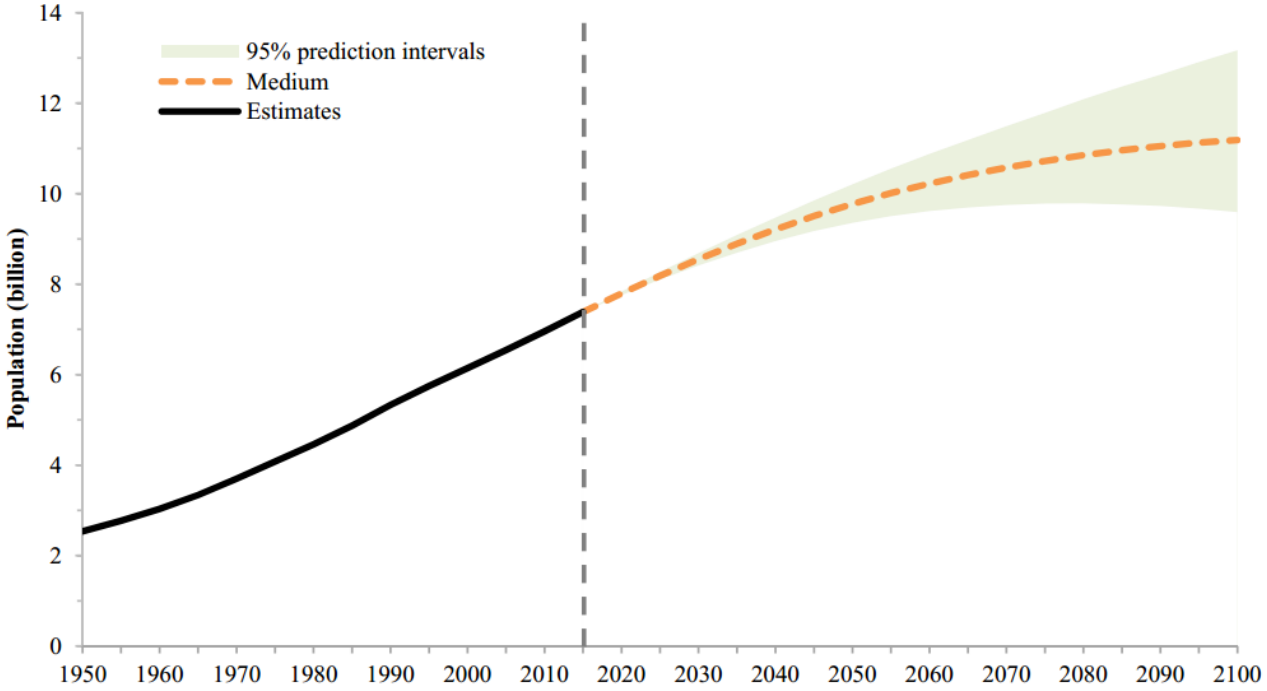
Introduction

Why Precision Farming?



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017). *World Population Prospects: The 2017 Revision*. New York: United Nations.

- Population increase
- More food required
- Less available resources
- Precision farming is needed

Precision Farming

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Precision farming aims to develop a decision support system to improve efficiency and optimize returns with minimal inputs.

Minimize Inputs

Water Use
Energy Consumption
Labor Needed
Environment Impact

Maximize Outputs

Production yield
Crop Quality
Efficiency

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Precision Farming

Crop Sensing

- Sensors
- Cameras
- Drones
- Plants
- Soil
- Environment

Decision Making

- Data
- Models
- Expert
- Algorithms
- Network
- Interface

Field Operating

- Machinery
- Robotics
- Control system
- Automation
- Field operations

Crop Sensing

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- Crop coverage detection
- Crop water stress detection
- Real-time crop load estimation
- Identification of pests and diseases infestation
- Soil mapping
- Crop nutrient deficiency detection

Crop Sensing

In-Field Sensing

Soil moisture sensor @ Meter Group Inc

Soil nutrient sensor @ Re:char

Crop Sensing

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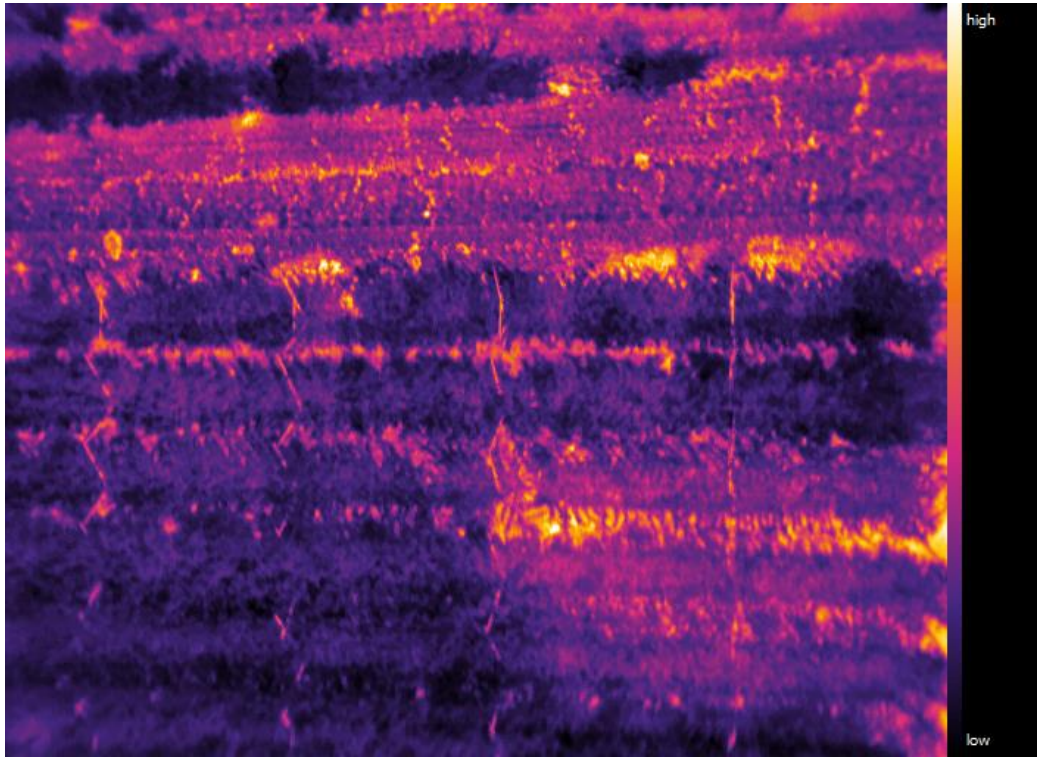
UAV Based Sensing



Crop Sensing

Proximal Sensing

Phenotyping sensing platform (Washington State University)

Crop load estimation (Dr. Daeun Choi, Penn State)

Decision Making

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Sensing, Data, Networks

Energy, Control signal

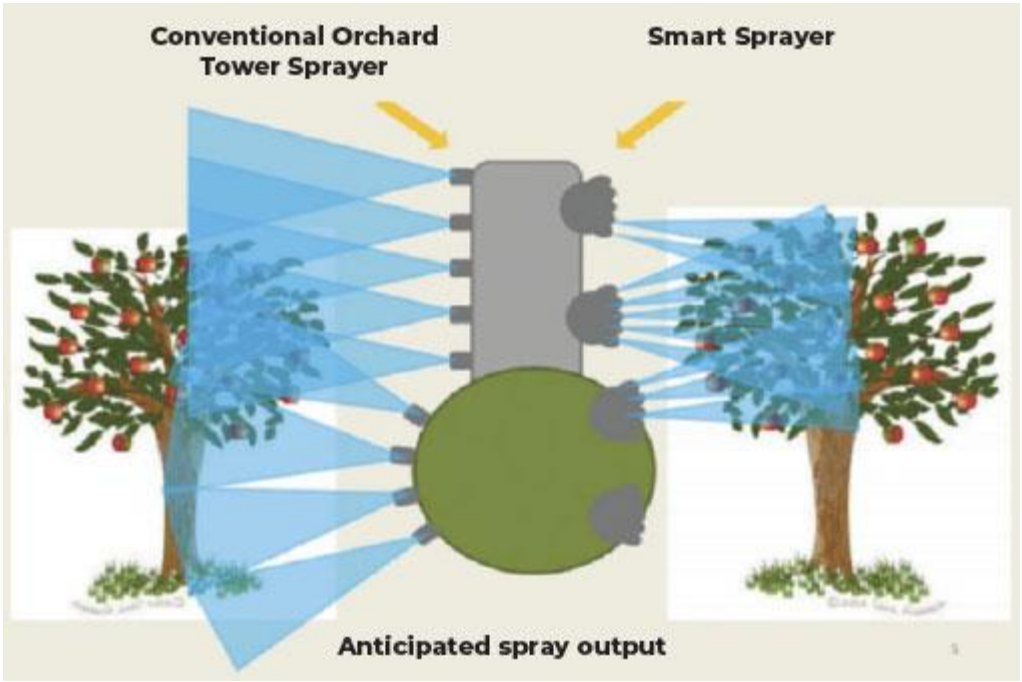
Expert

Algorithms, Models, Rules

Controller, Actuating system

Field Operating

Time to start/stop the irrigation



From: Ozkan, E. 2018. (Ohio State University)

Case I: Sensor-Based Irrigation

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Importance of Irrigation

Necessity:

- Mandatory for dry and semi-arid area
- Supplemental for drought days/uneven rainfall in humid area

Proper irrigation:

- Increase yield
- Improve quality
- Conserve water
- Save energy
- Decrease fertilizer
- Reduce environmental impact

Case I: Sensor-Based Irrigation

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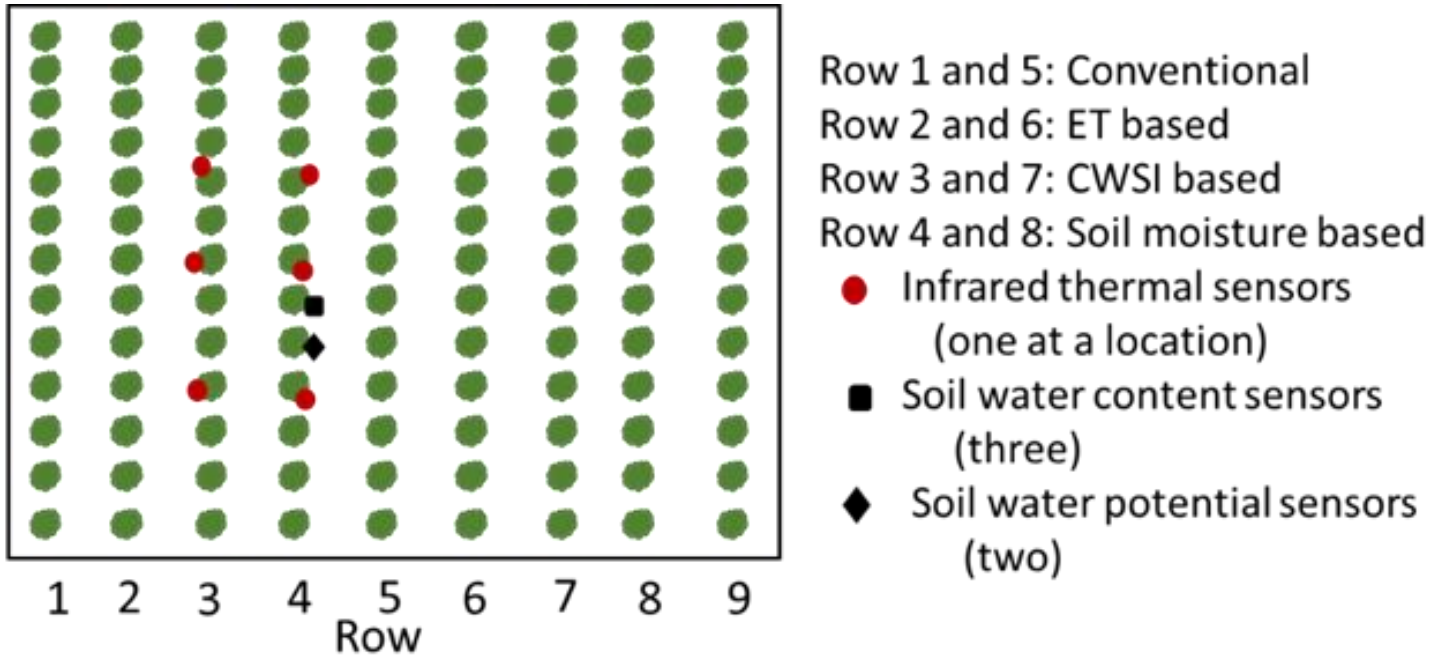
When to irrigate, and how much to irrigate?

Orchard for test – Tall spindle Fuji trees



Schematic illustration of the experimental setup

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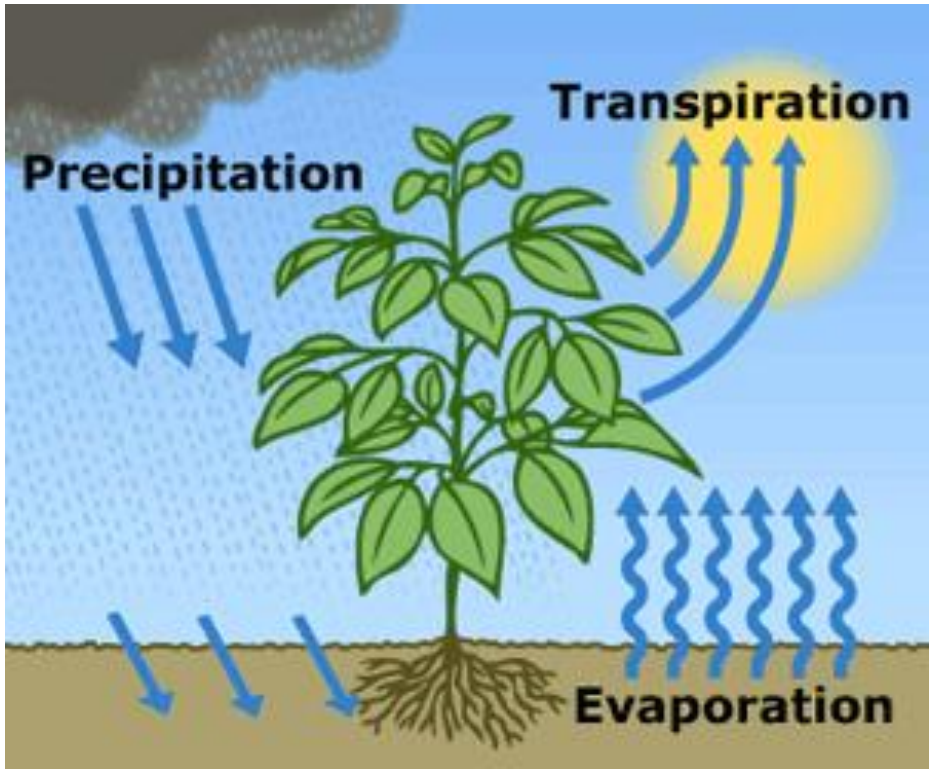
Evapotranspiration (ET)-Base Irrigation



Penman–Monteith Model (P-M)

- Reference ET_0
- Estimated ET = Kc x ET_0

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

Case I: Sensor-Based Irrigation

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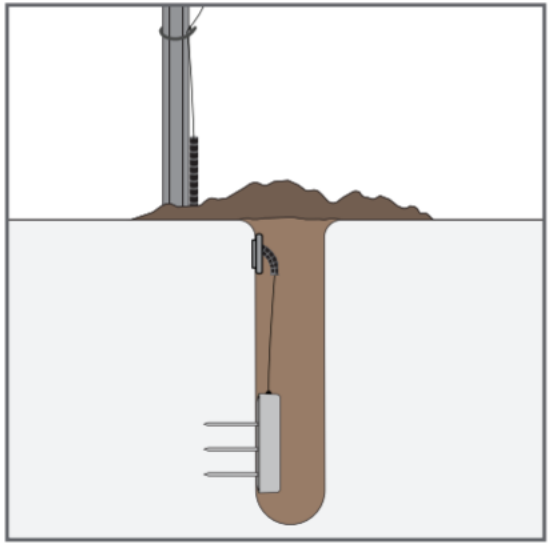
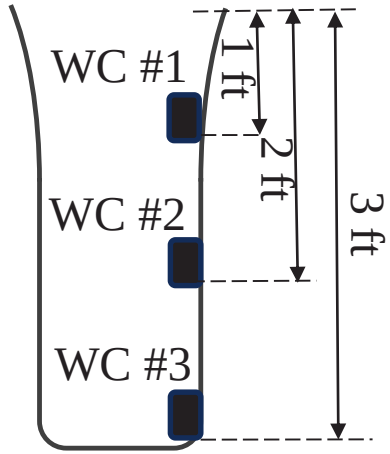
Soil Water Content-Based Irrigation





Case I: Sensor-Based Irrigation

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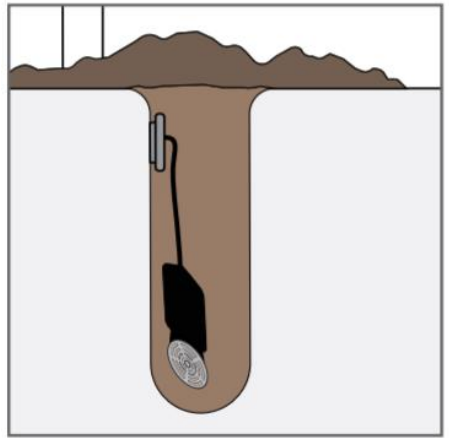
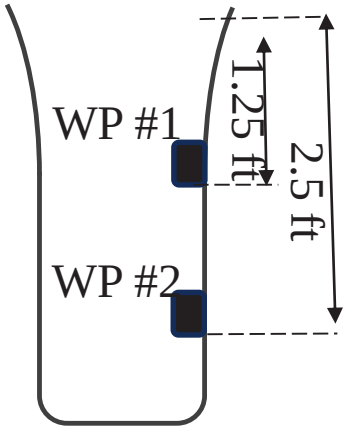
Soil Water Potential-Based Irrigation

TEROS 21 @ QTY 2





Case I: Sensor-Based Irrigation

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Canopy Temperature-Based Irrigation (Crop Water Stress Index)

IR/t 3x @ QTY 6

$$\mathrm{CWSI} = \frac{\Delta T_m - \Delta T_l}{\Delta T_u - \Delta T_l}$$

Case I: Sensor-Based Irrigation

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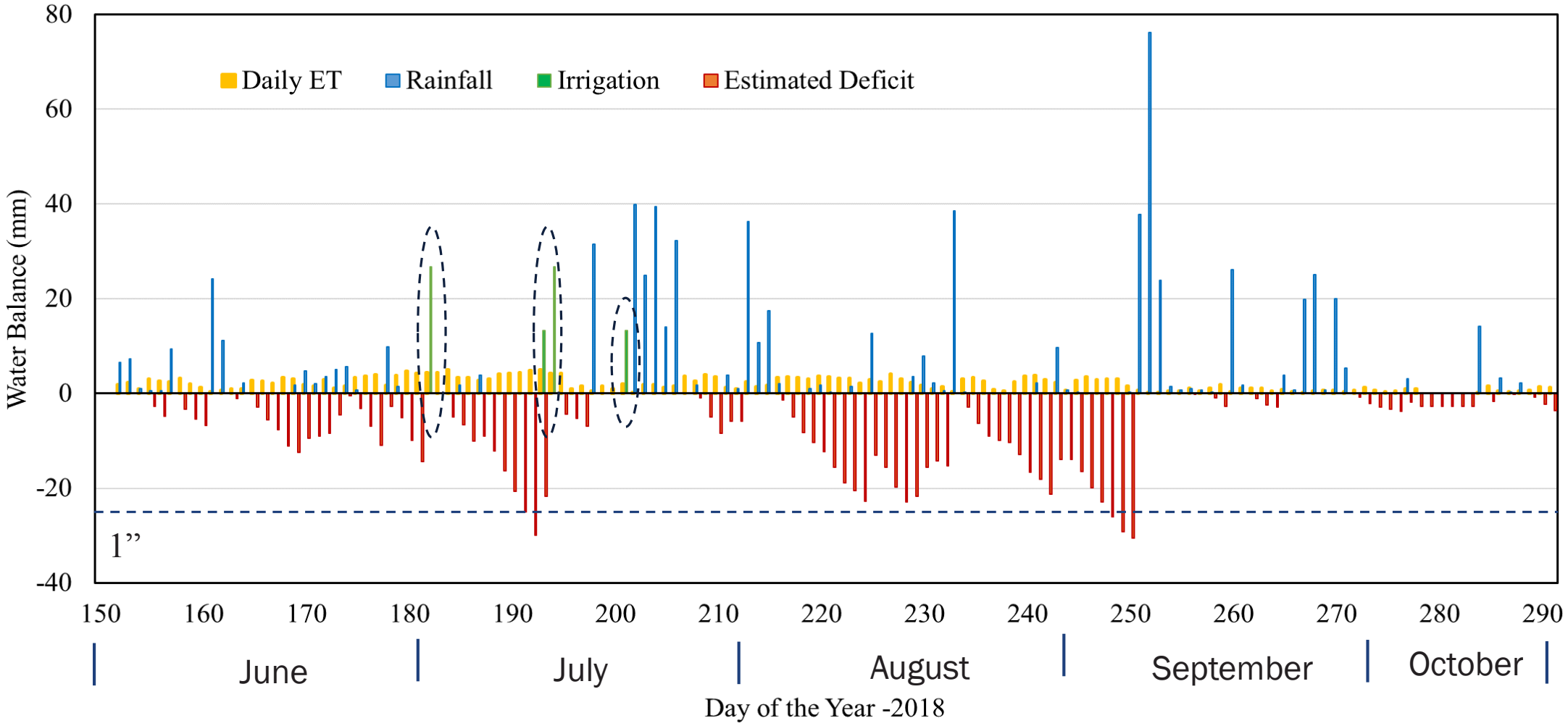
Evapotranspiration (ET)-Based Irrigation



Case I: Sensor-Based Irrigation

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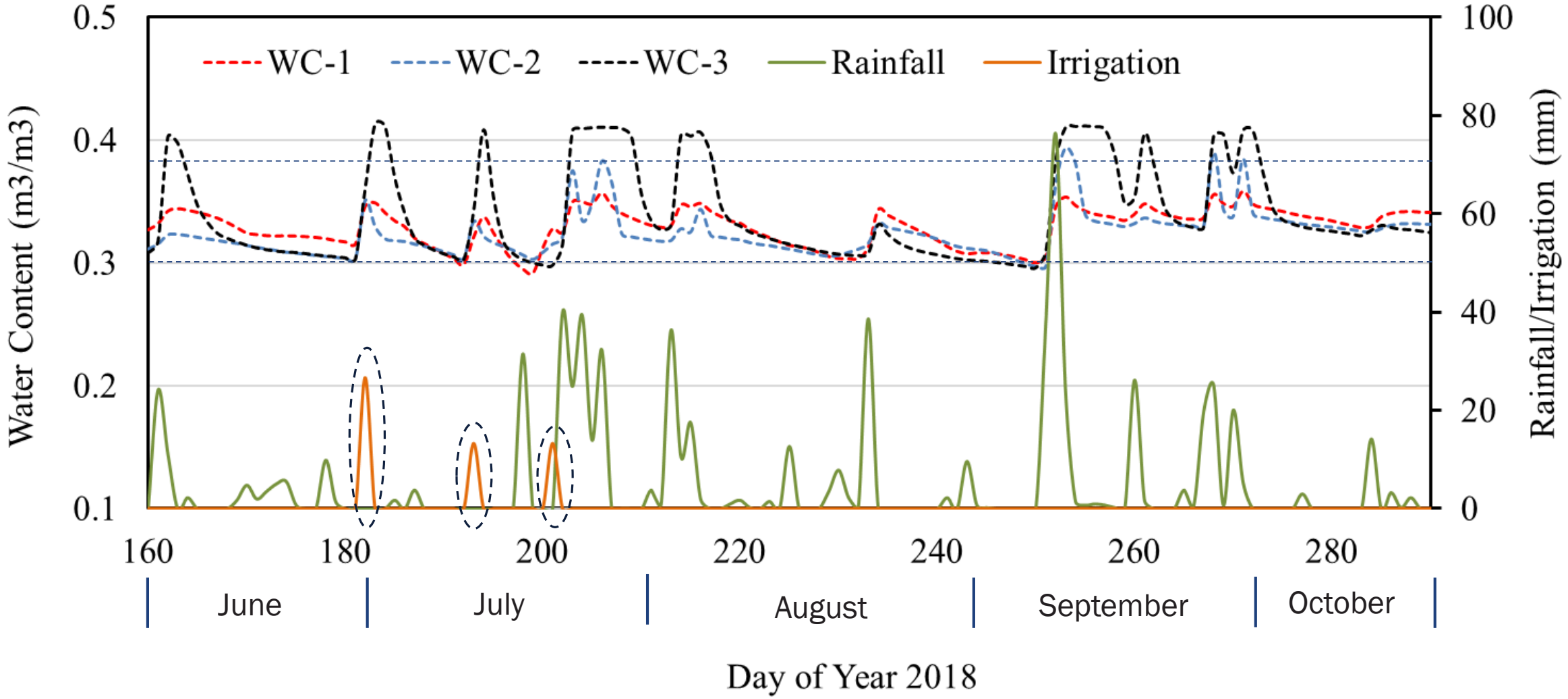
Soil Water Content–Based Irrigation



Case I: Sensor-Based Irrigation

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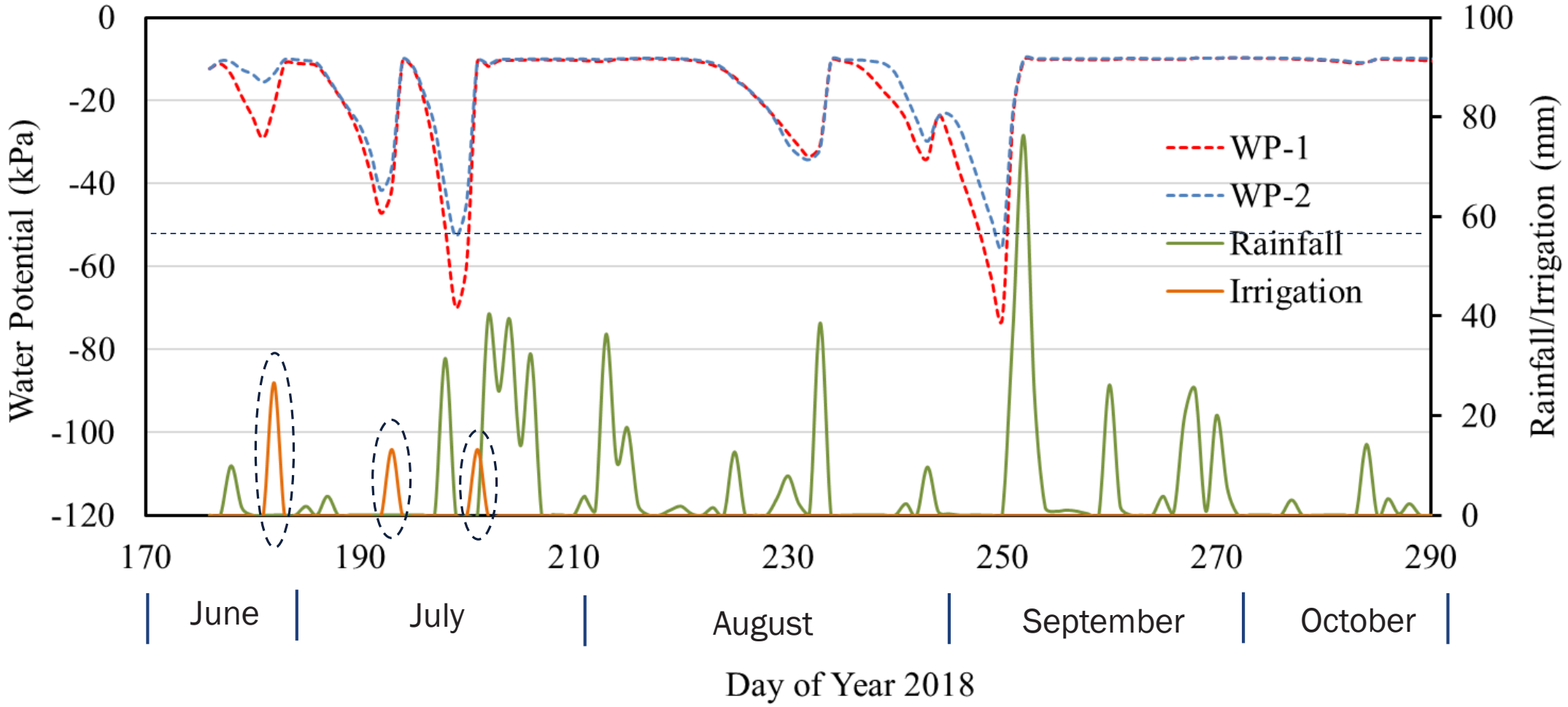
Soil Water Potential-Based Irrigation



Case I: Sensor-Based Irrigation

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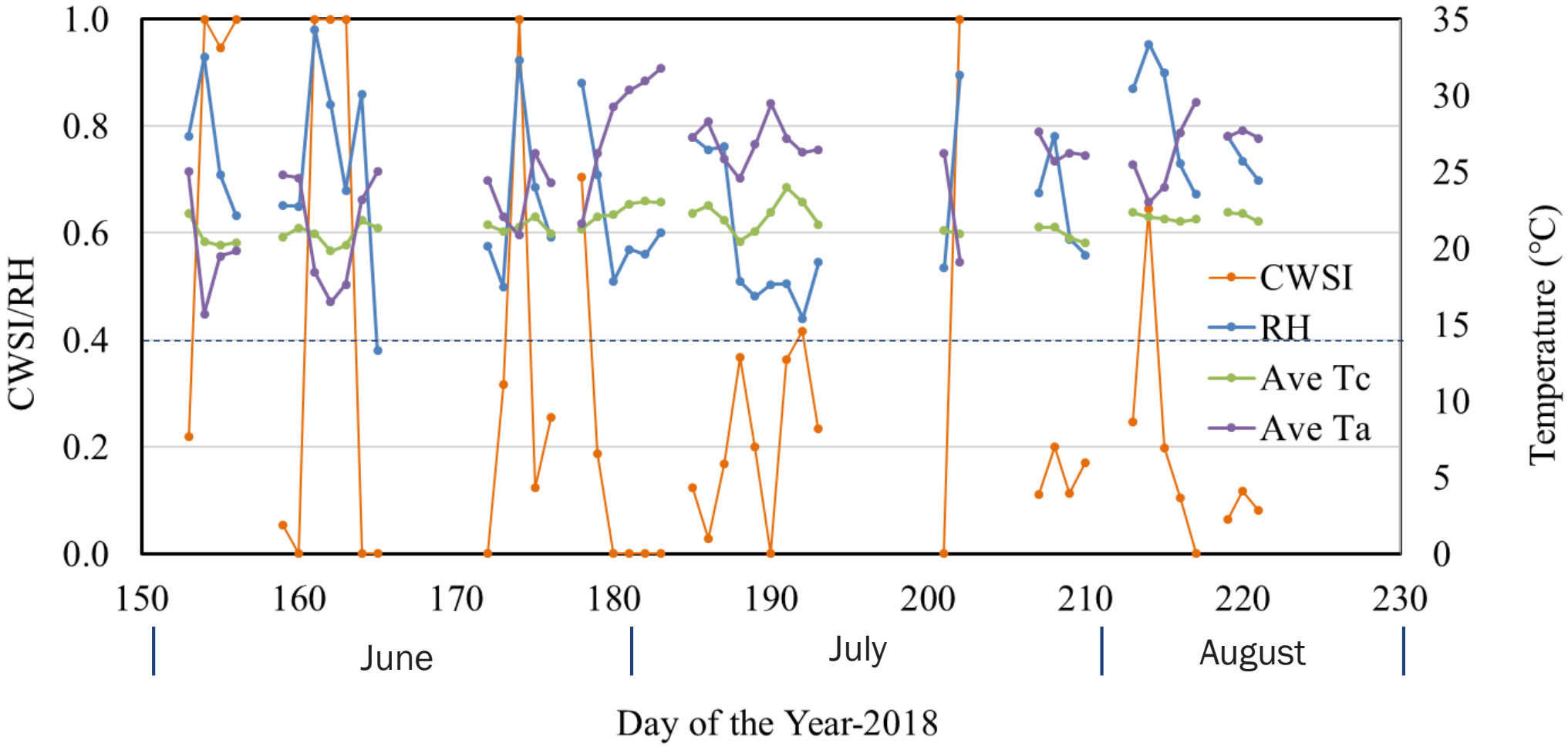
Canopy Temperature–Based Irrigation



Case I: Sensor-Based Irrigation

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Comparation of the Tested Methods

	ET-Based	Soil Moisture-Based	Canopy Temperature-Based	Combination
Advantages	▪ Easy to apply ▪ No in-field sensors ▪ Low cost	▪ Direct reading of soil moisture ▪ Low cost	▪ Direct measuring plant stress ▪ Can be little bit costly	▪ ET + Soil Moisture ▪ Soil moisture + Canopy Temperature
Challenges	▪ Estimated value ▪ Accumulating error ▪ Your own weather station	▪ Root region ▪ Sensor location ▪ Soil type ▪ Real canopy stress	▪ Targeted area of sensor ▪ Climate (too humidity)	

Water use?

Crop production?

Case II: Canopy Estimation using 3D LiDar

3D Canopy Reconstruction

- ❖Mechanical summer pruning
- ❖Precision spraying
- ❖Orchard platform auto guidance

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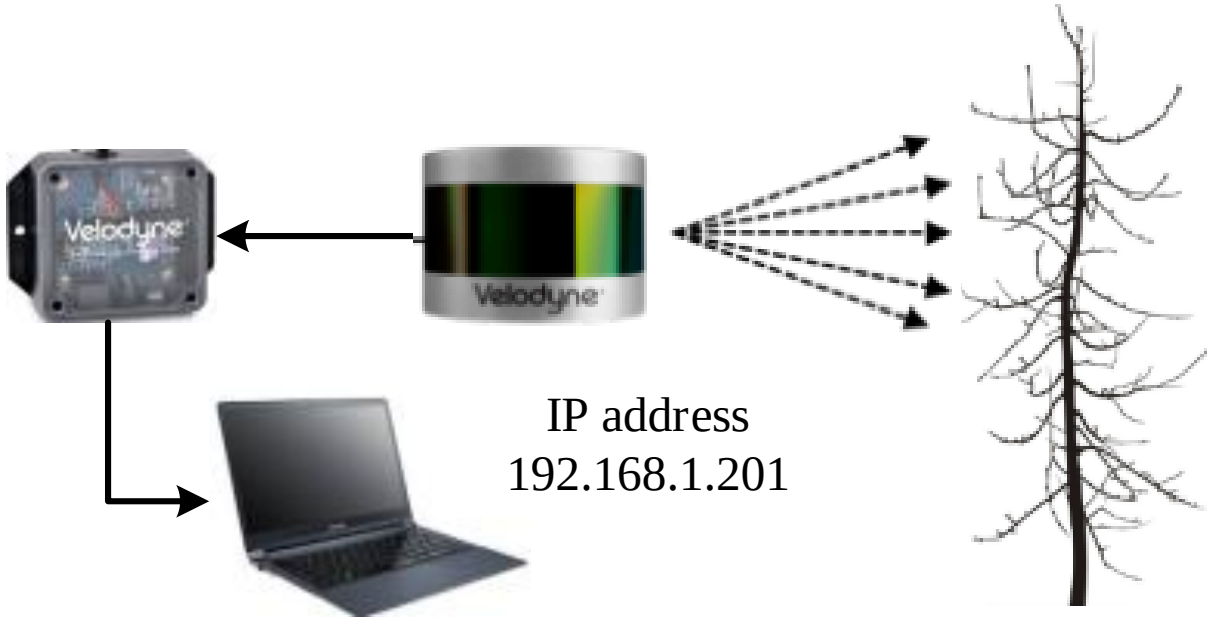
Case II: Canopy Estimation using 3D LiDar

Experimental Setup



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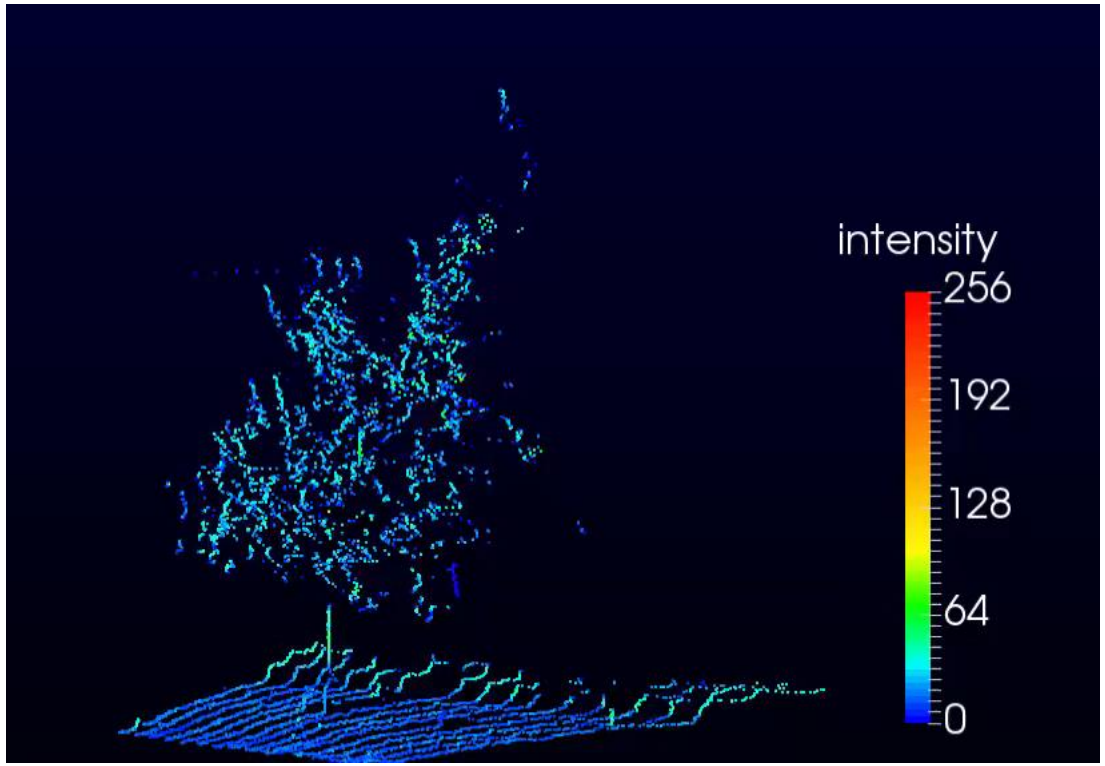
Case II: Canopy Estimation using 3D LiDar

Field Test with a Utility Vehicle



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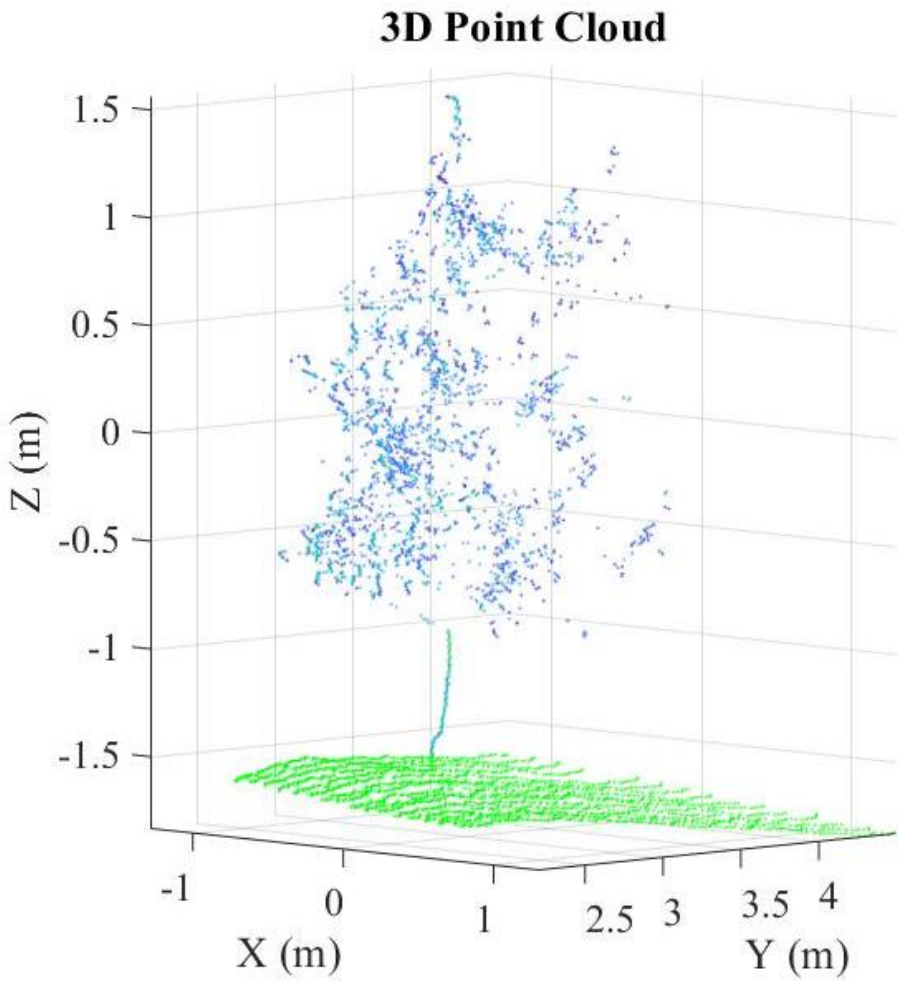
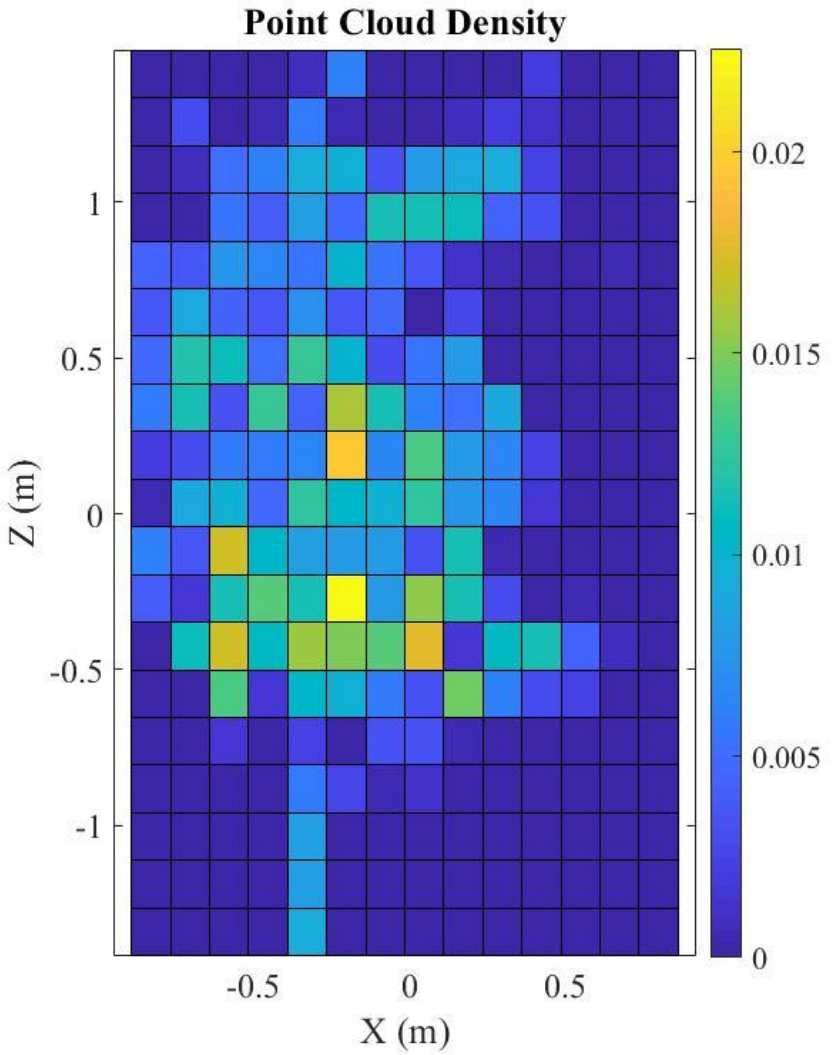
Case II: Canopy Estimation using 3D LiDar

Point Cloud of a Tree Canopy





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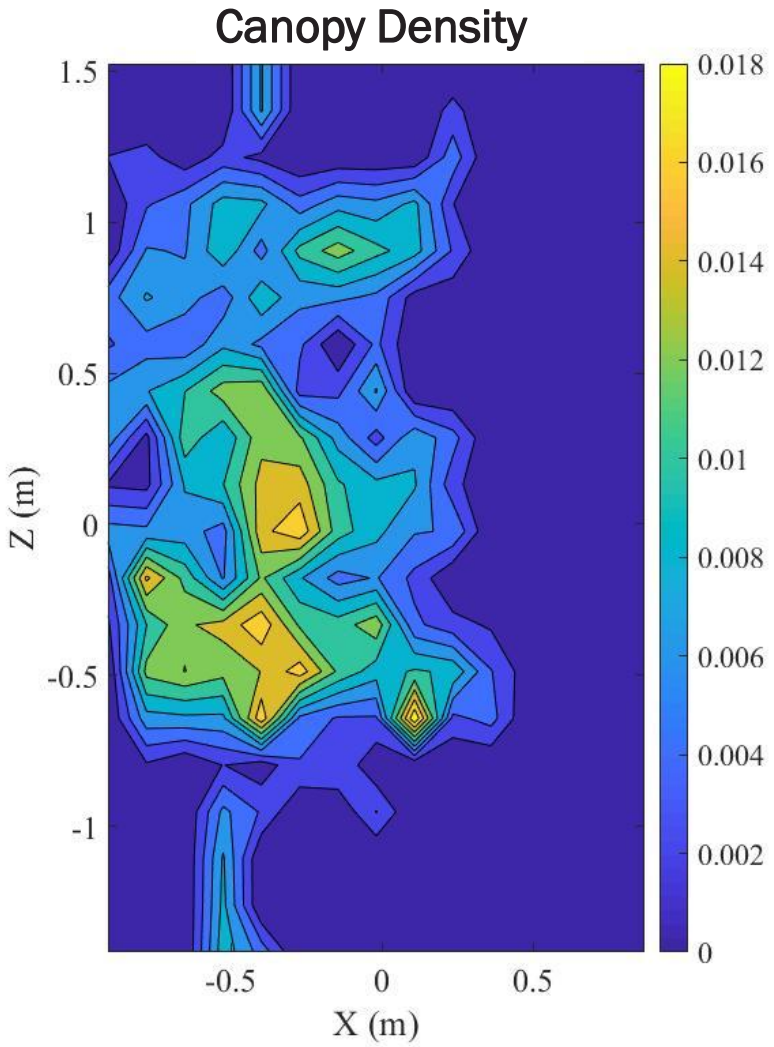

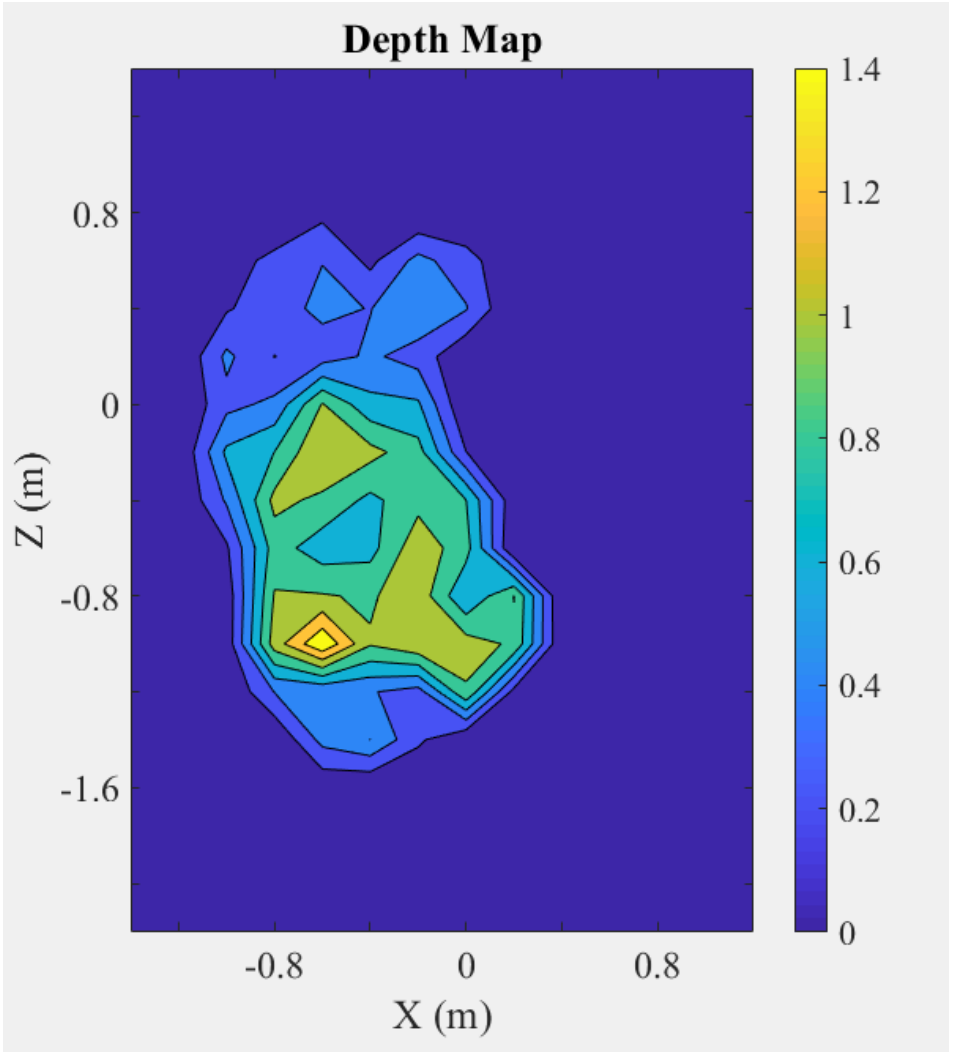

Planning Project

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Precision Spraying Technologies for Pest Management

From: USDA-ARS Dr. Heping Zhu

From: DJI MG-1S Sprayer Drone

❑ Activities

- Preliminary studies: pest/disease detection; variable rate sprayer
- Workshop/seminar: pest management, intelligent spraying, drone sprayer
- Seeking collaboration

Acknowledgement

- **Funding Agency**
  - State Horticultural Association of Pennsylvania (SHAP)
  - Penn State College of Agricultural Science
  - Penn State Extension
- **Project Team**
  - Long He
  - Daeun Choi
  - James Schupp
  - Tara Baugher/Daniel Weber
- **Field Setup/Data Acquisition**
  - Azlan Zahid
  - Lihua Zeng

Precision & Automated Agriculture

Thank you !

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