Developing Sensor-Based Irrigation Systems for Sustainable Vegetable Crops

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The Successes and Challenges of Sensor-Based Irrigation for Crops in Pennsylvania

Penn State Extension webinar - May 19, 2020 – State College, PA

Objective

- ✓ Importance of irrigation for vegetable crops
- ✓ Application of sensor-based irrigation:
  - alternative strategies
  - pros and cons

resource use efficiency & sustainability

Rational **resource management** is fundamental for the success and long-term sustainability of any vegetable cropping systems because it affects:

- **Yield**
- **Quality**
- **Sustainability**

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irrigation & vegetable yield

Photo by
Di Gioia

irrigation & vegetable quality

Photo by
Di Gioia

irrigation & vegetable quality

BER

Blossom End Rot, Calcium deficiency & Irrigation management

resource use efficiency & sustainability

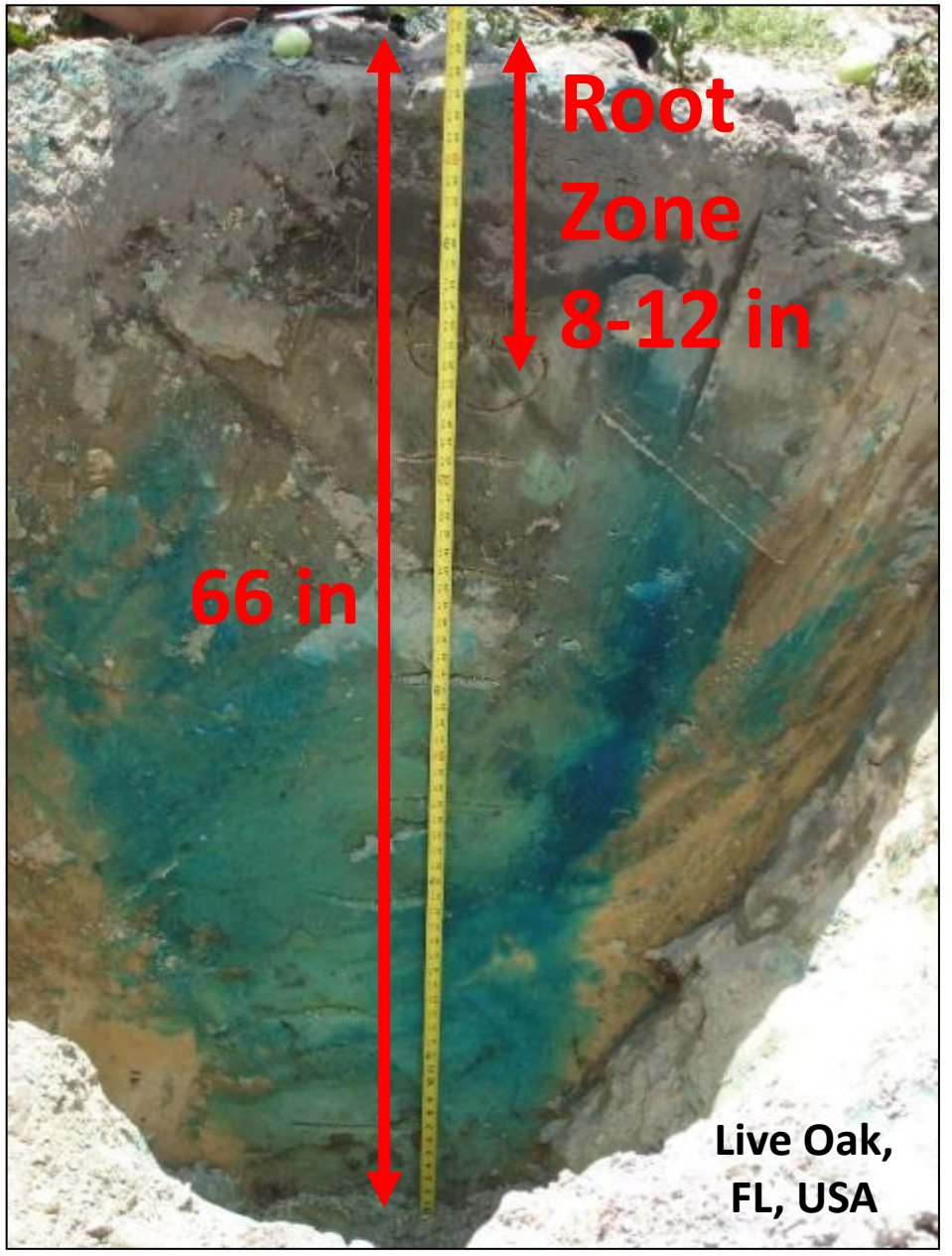
- **Federal Clean Water Act** (US EPA, 2010):

  Federal Total Maximum Daily Load

  have been defined, requiring the

  implementation of **BMPs**

- **BMPs**: tools and important practices, including **irrigation** and **fertilization management practices** aimed at reducing vegetable crop environmental impact while assuring optimal yields and quality



Eutrophication

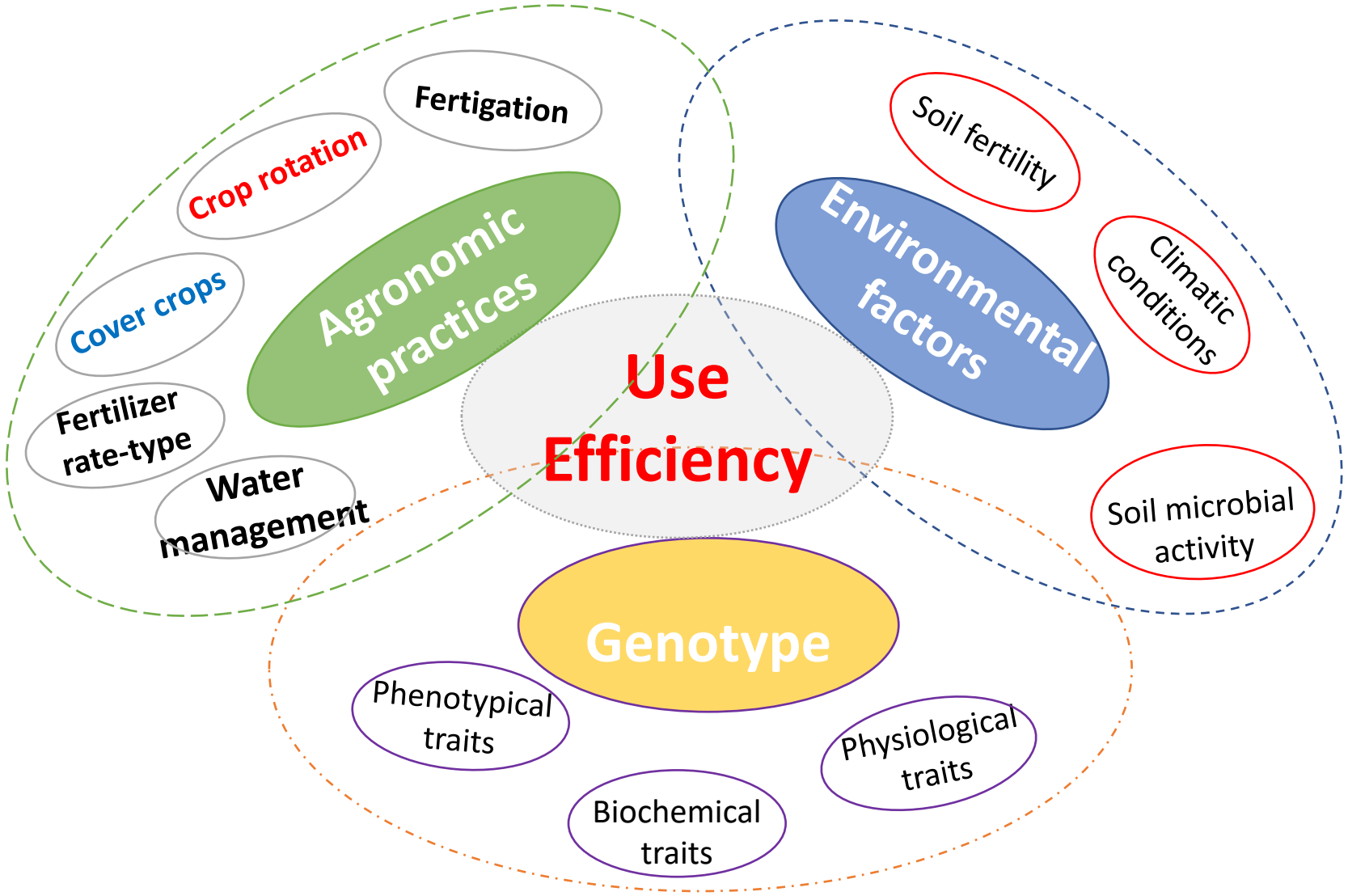
Excess of nutrients (especially nitrates and phosphates) in a body of water causing excessive plant and algae growth

Pennsylvania high tunnel vegetable production

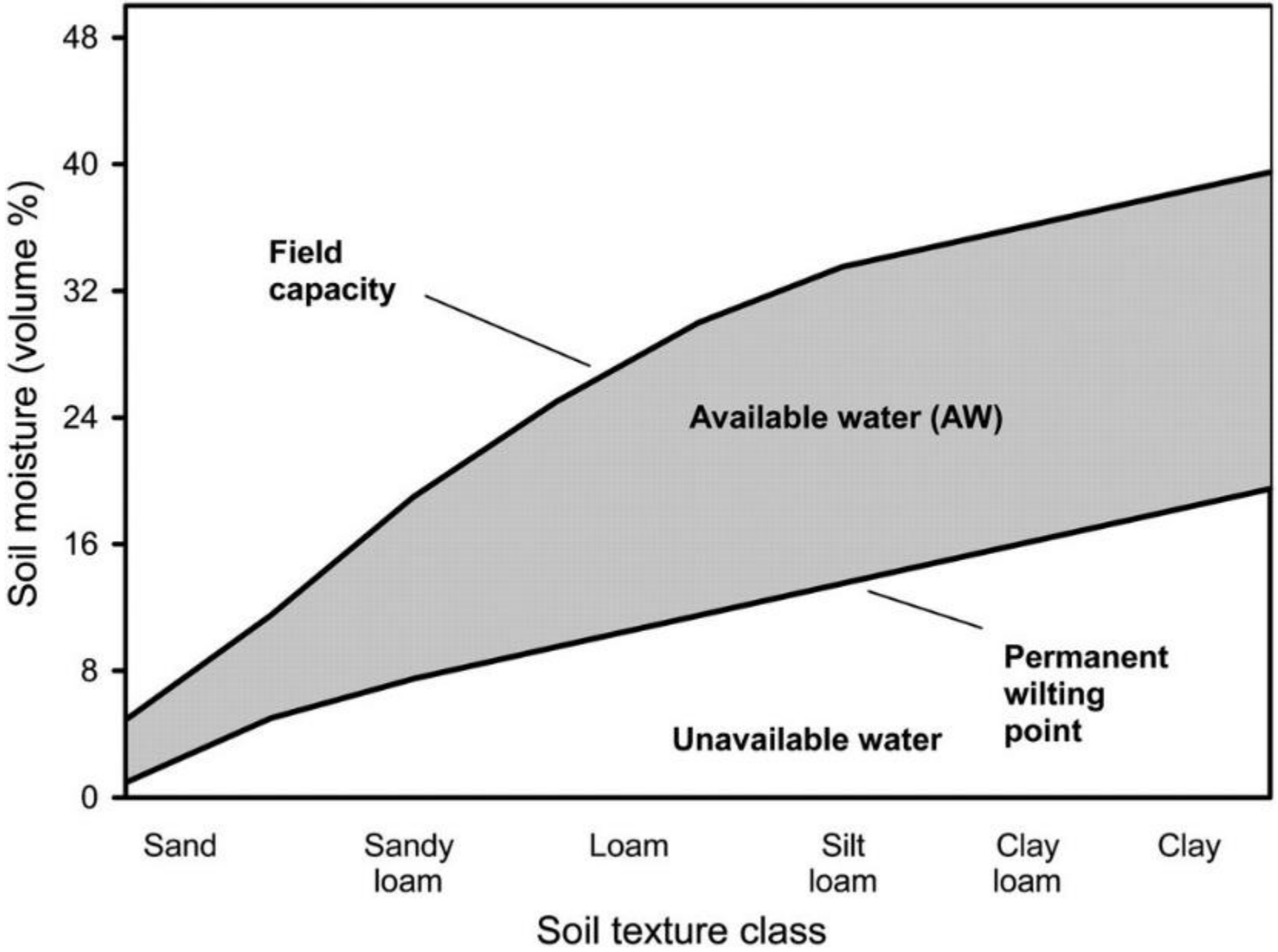
Rational decisions: monitoring tools

resource use efficiency & sustainability

Best management practices and resource use efficiency



IoT & Smart Application technology



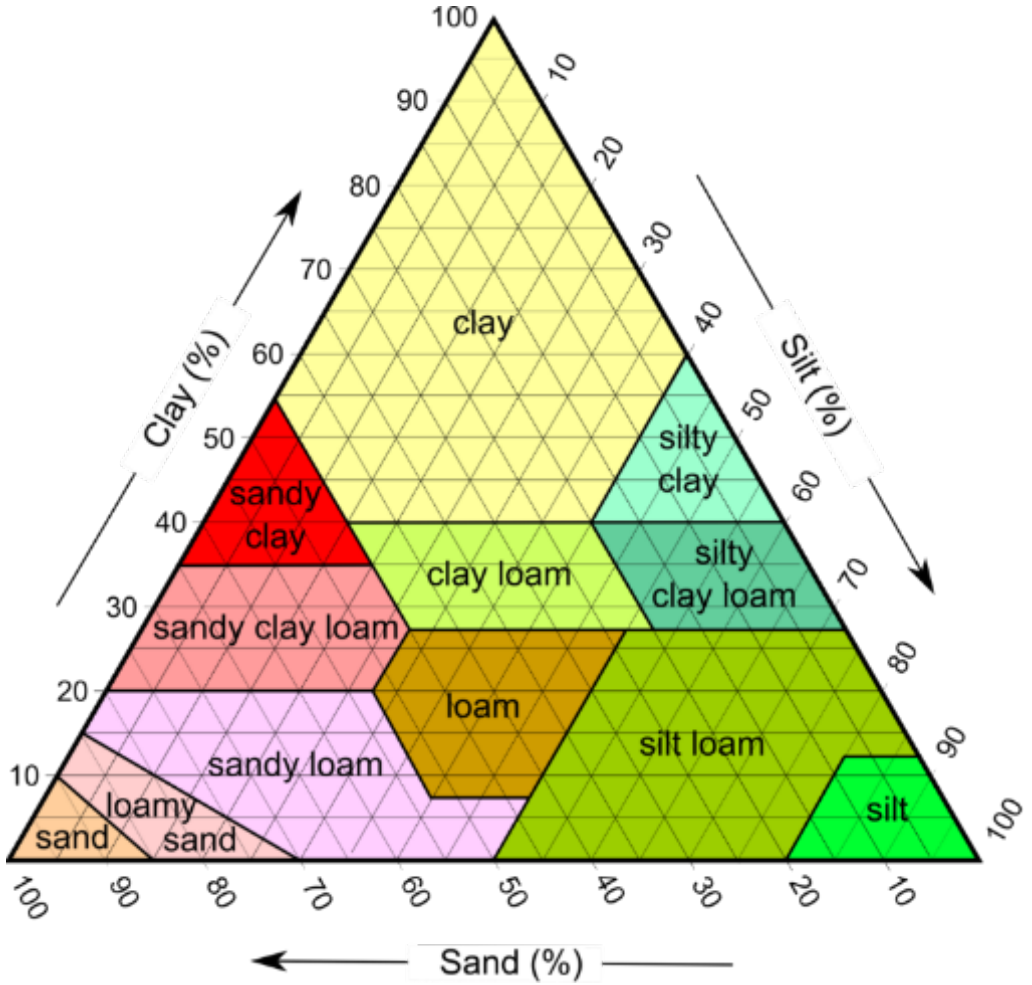
When and for how long should I irrigate my crop?

Dukes et al. 2010

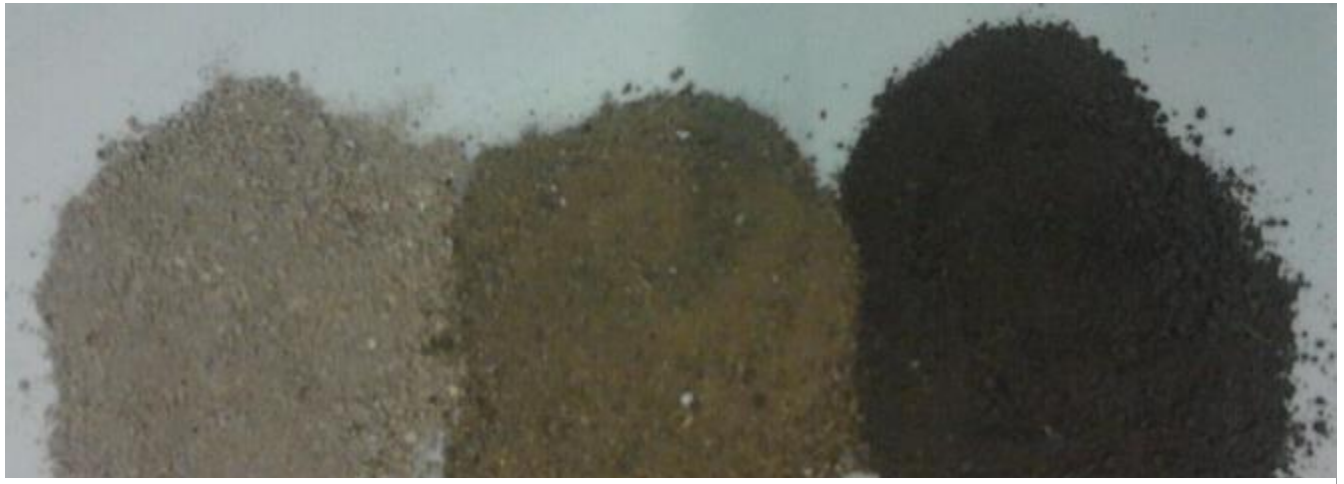
Soil texture & Irrigation management

Analysis of the Soil

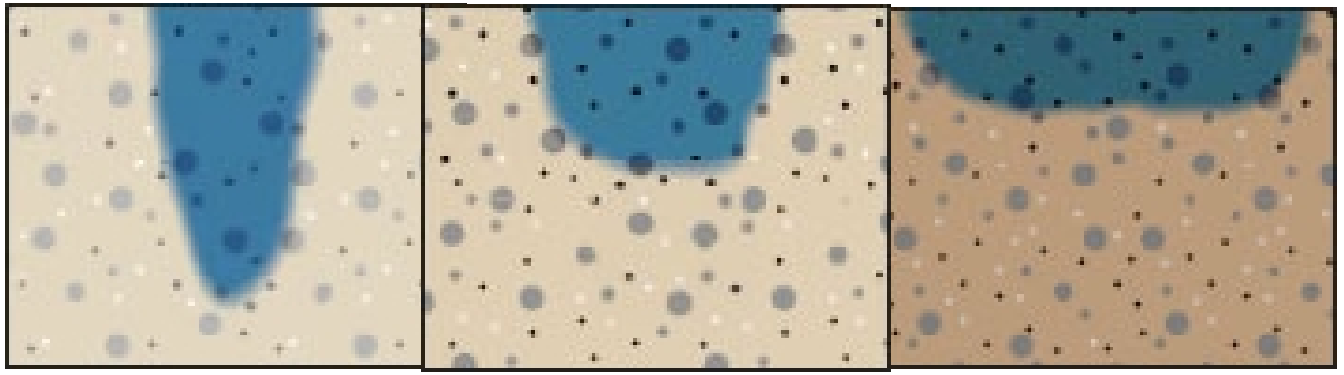
Physical properties: soil texture



Hydrological properties:
water holding capacity, air capacity,
water management



sand **loam** **clay**



Sensor based automated irrigation systems

Sensor-based irrigation study

USDA-NIFA 2019 NE SARE Research and Education grant:
"**Sensor-based precision irrigation system for tree fruit and vegetable crops**"
PI: Long He. Co-PI: Francesco Di Gioia, Daniel Weber, James Schupp, Tara Baugher

Sensor-based irrigation study

Experimental location: **Russell E. Larson Agricultural Research Center**
Test crop: Fresh-market tomato cv: **Red Deuce F1** (HM Clause)
Crop cycle: June-October 2019 (Planting 6-6-2019)

Objective: to compare different irrigation strategies and sensor-based irrigation systems
Treatments:

- T1: Irrigation based on experience
- T2: Irrigation based on estimated evapotranspiration
- T3: Irrigation based on soil moisture sensors
- T4: Irrigation and nitrogen fertilization based on a Decision Support System

Experimental design: Randomized complete block design with 4 replications
Data collection: Environmental data, water consumption, crop yield

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Sensor-based irrigation

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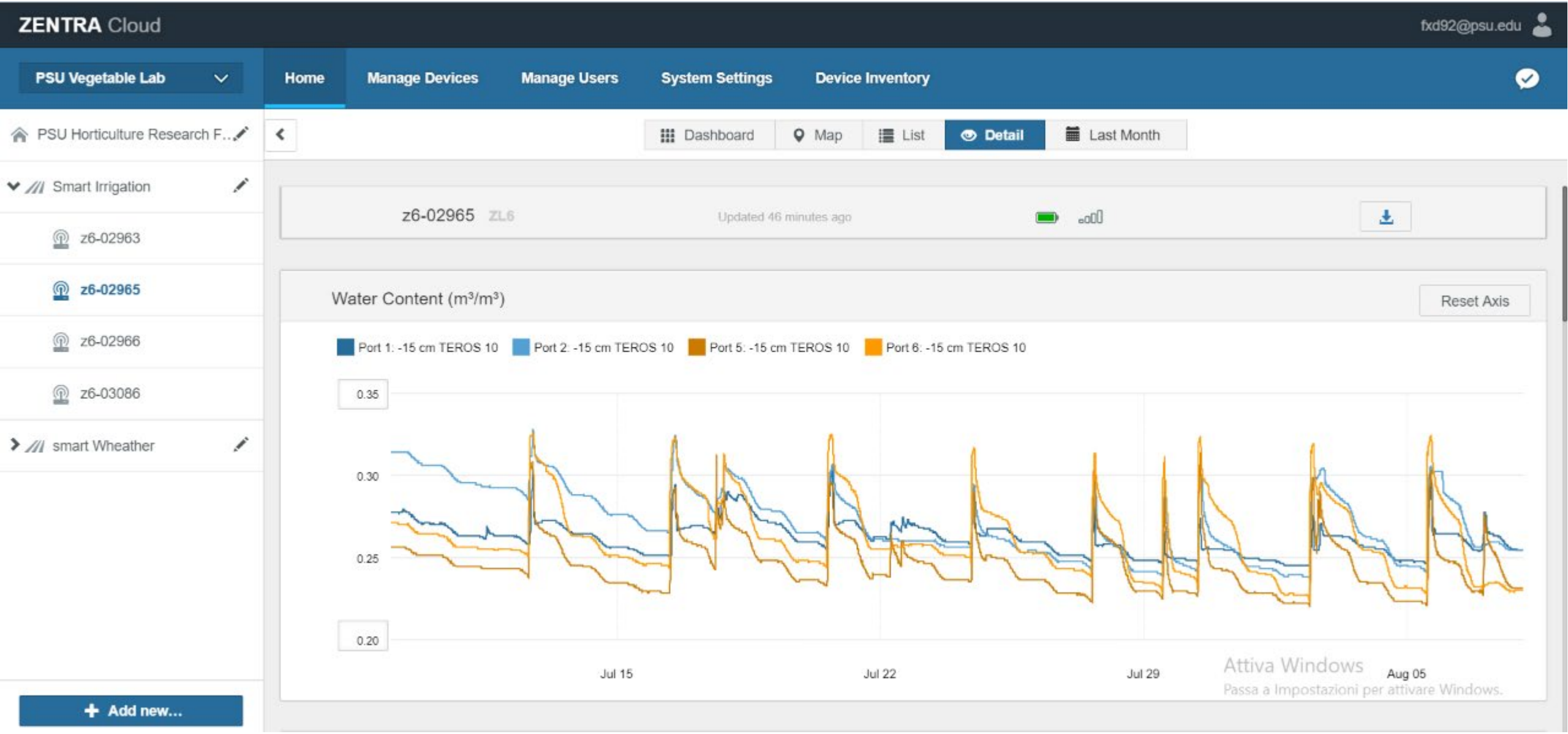
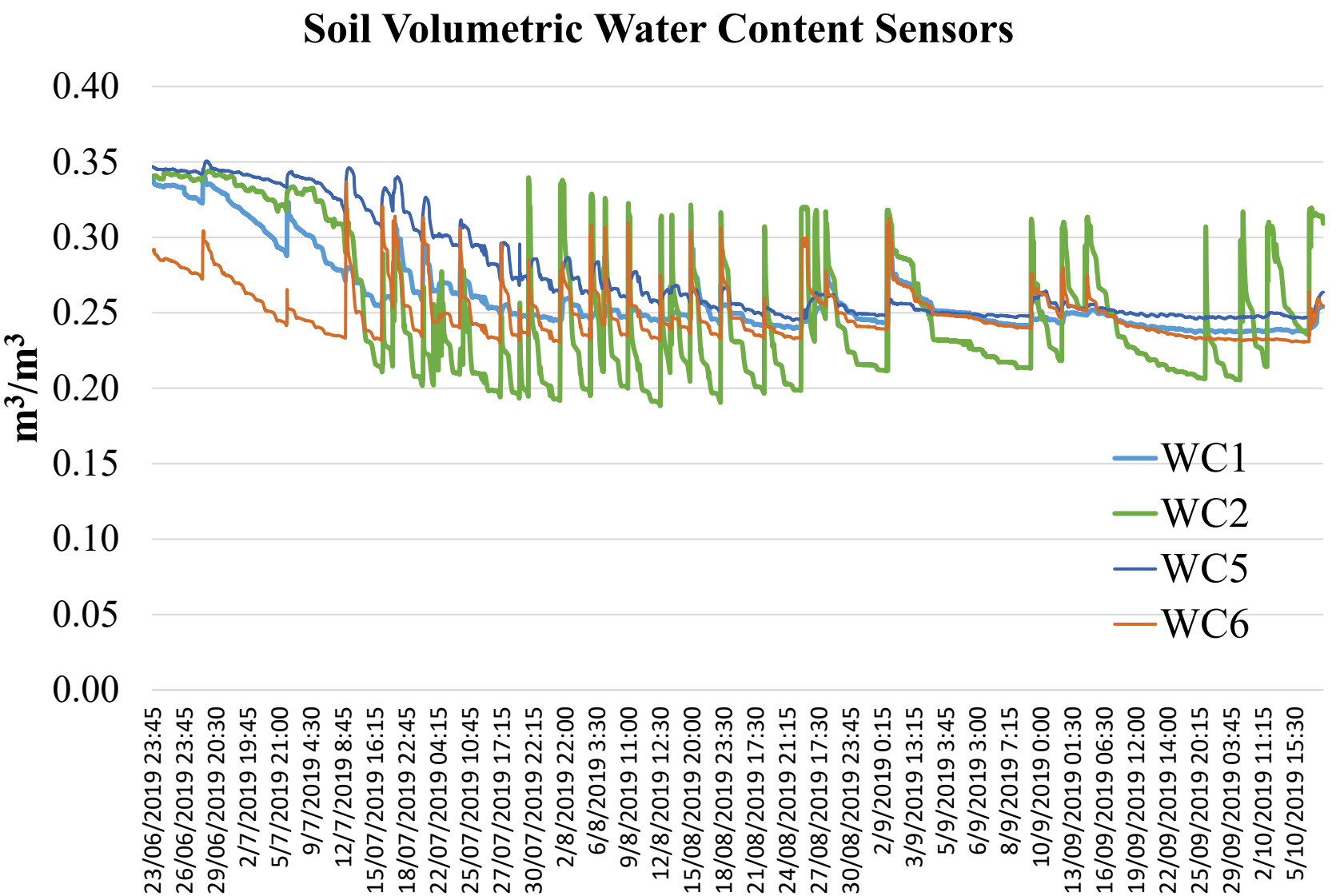
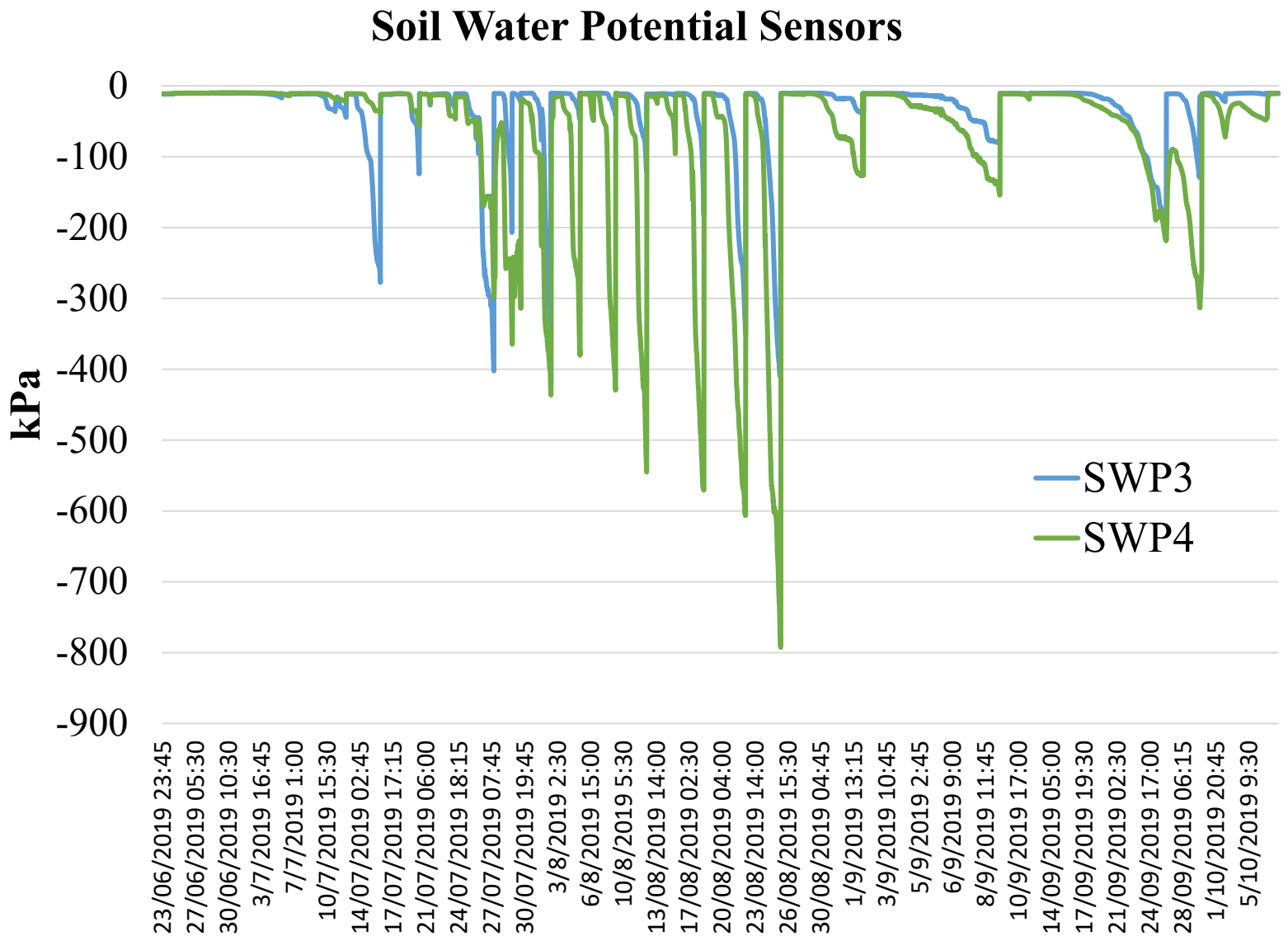
Sensor-based irrigation



Sensor-based irrigation



Sensor-based irrigation



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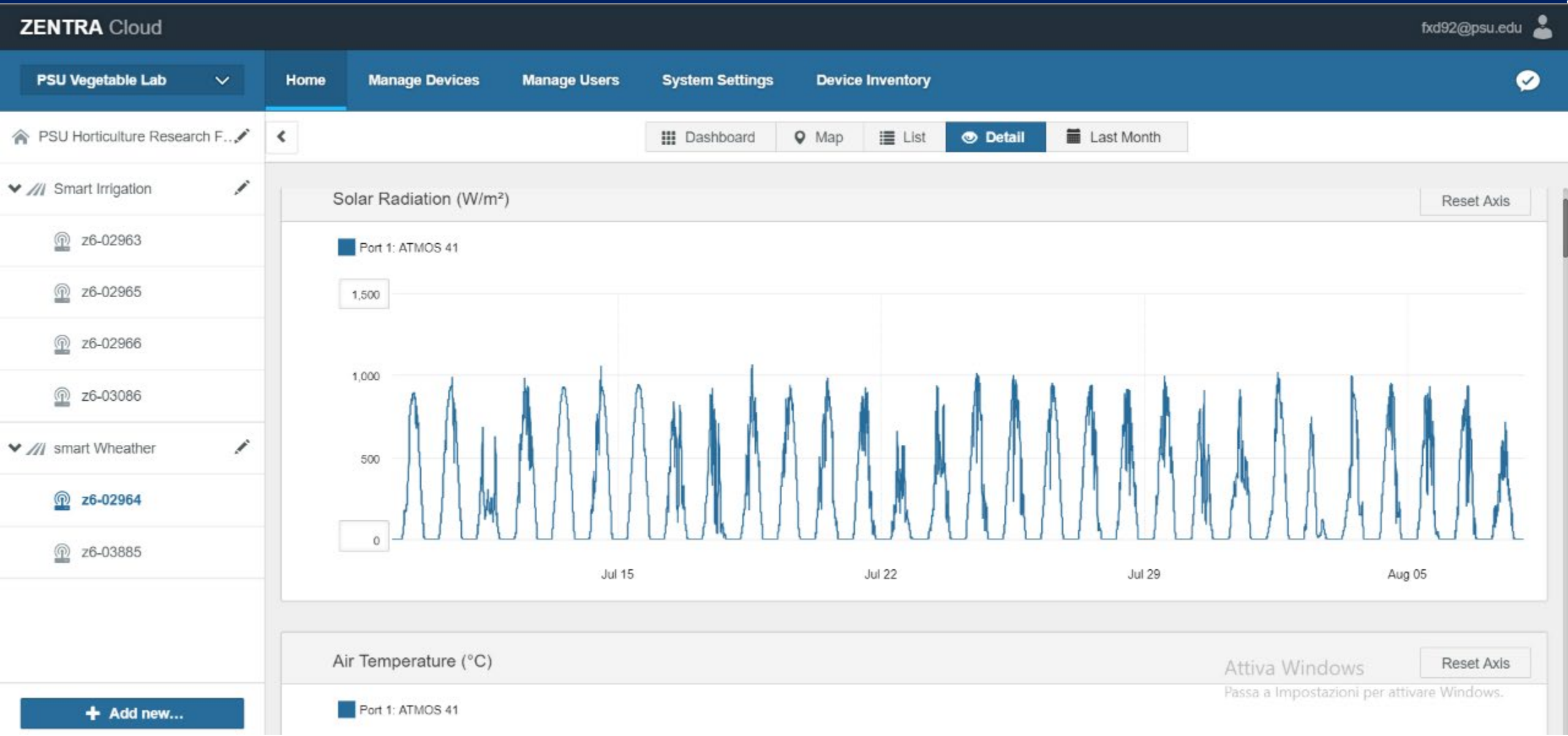

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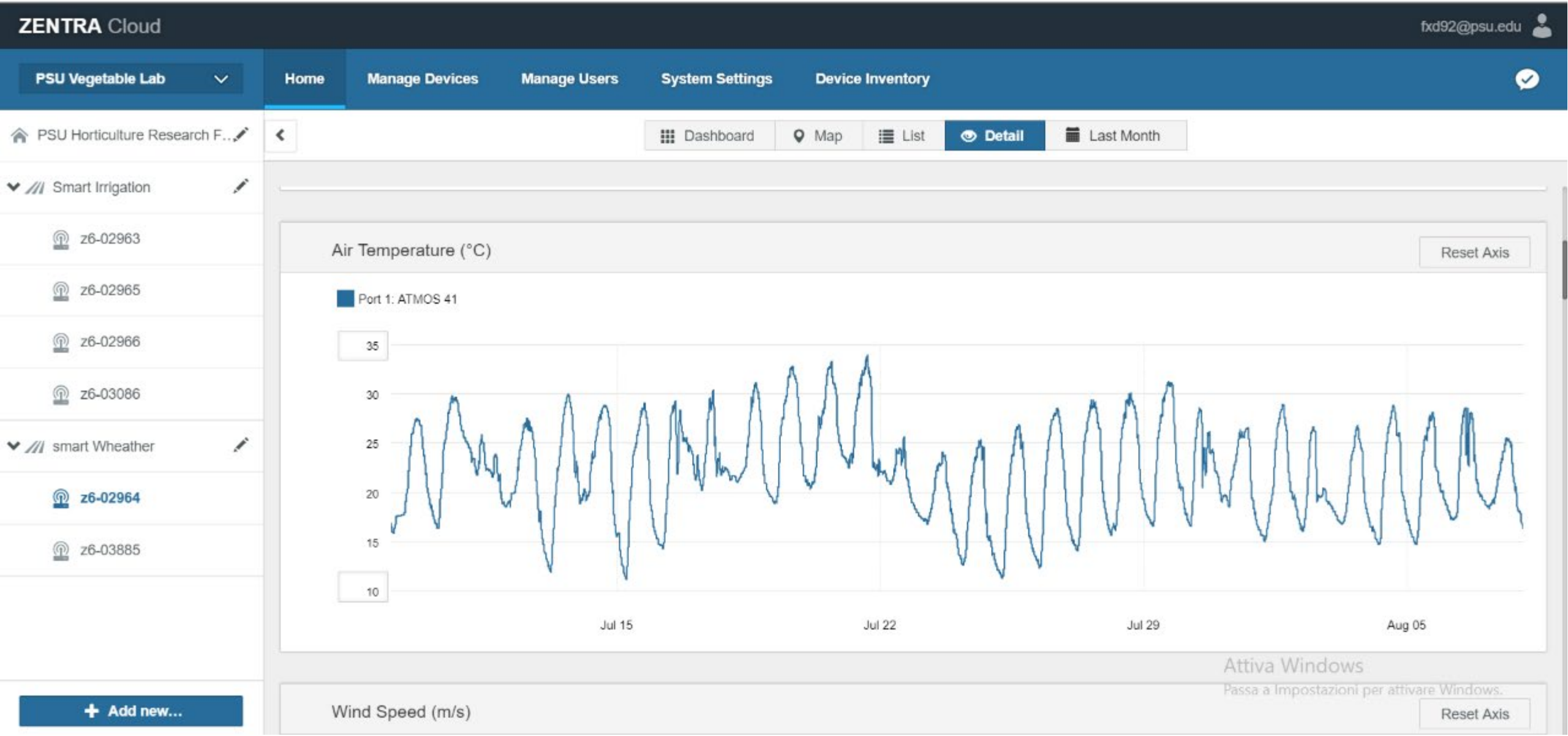

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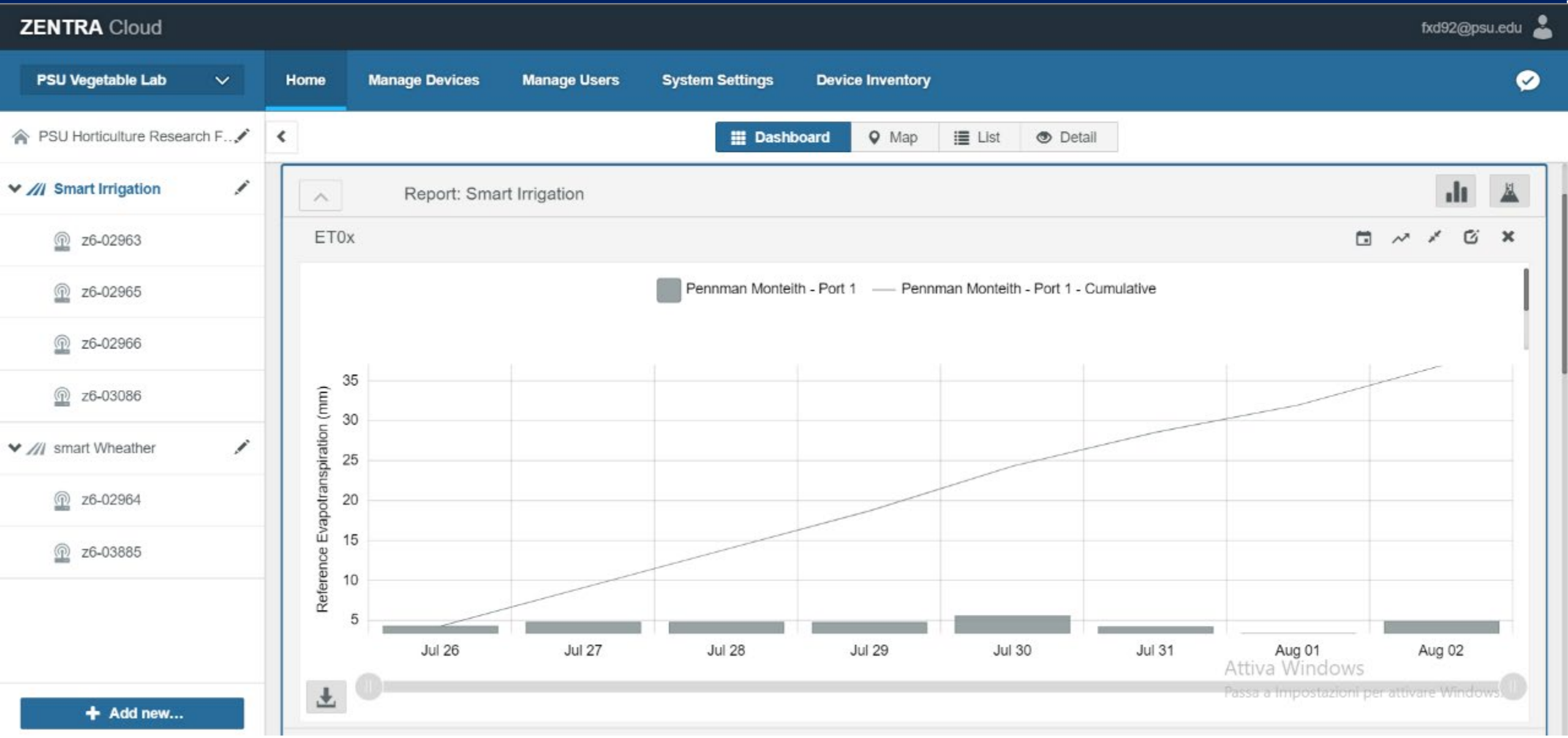

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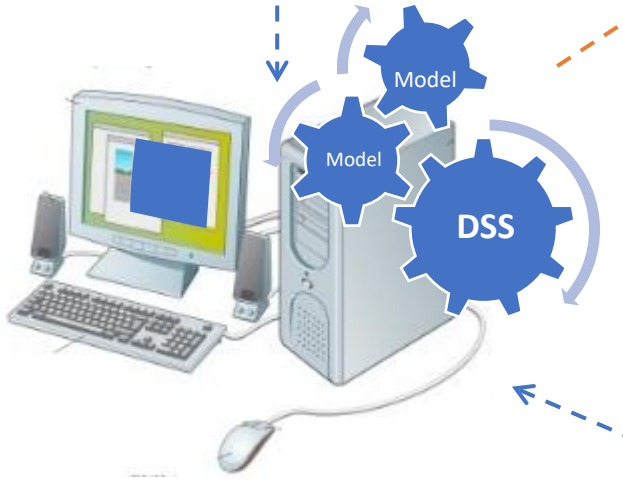
GesCoN Fertigation manager module

Automatic acquisition of meteo data



Pop-up notifications

Web pages

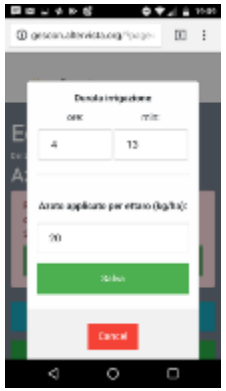
No daily meteo data inputs required by the farmer

The only input requested

Confirmation of fertigation

Data of comparison sector

Additional feebacks (if any)



www.ecofert.it

Elia, 2019

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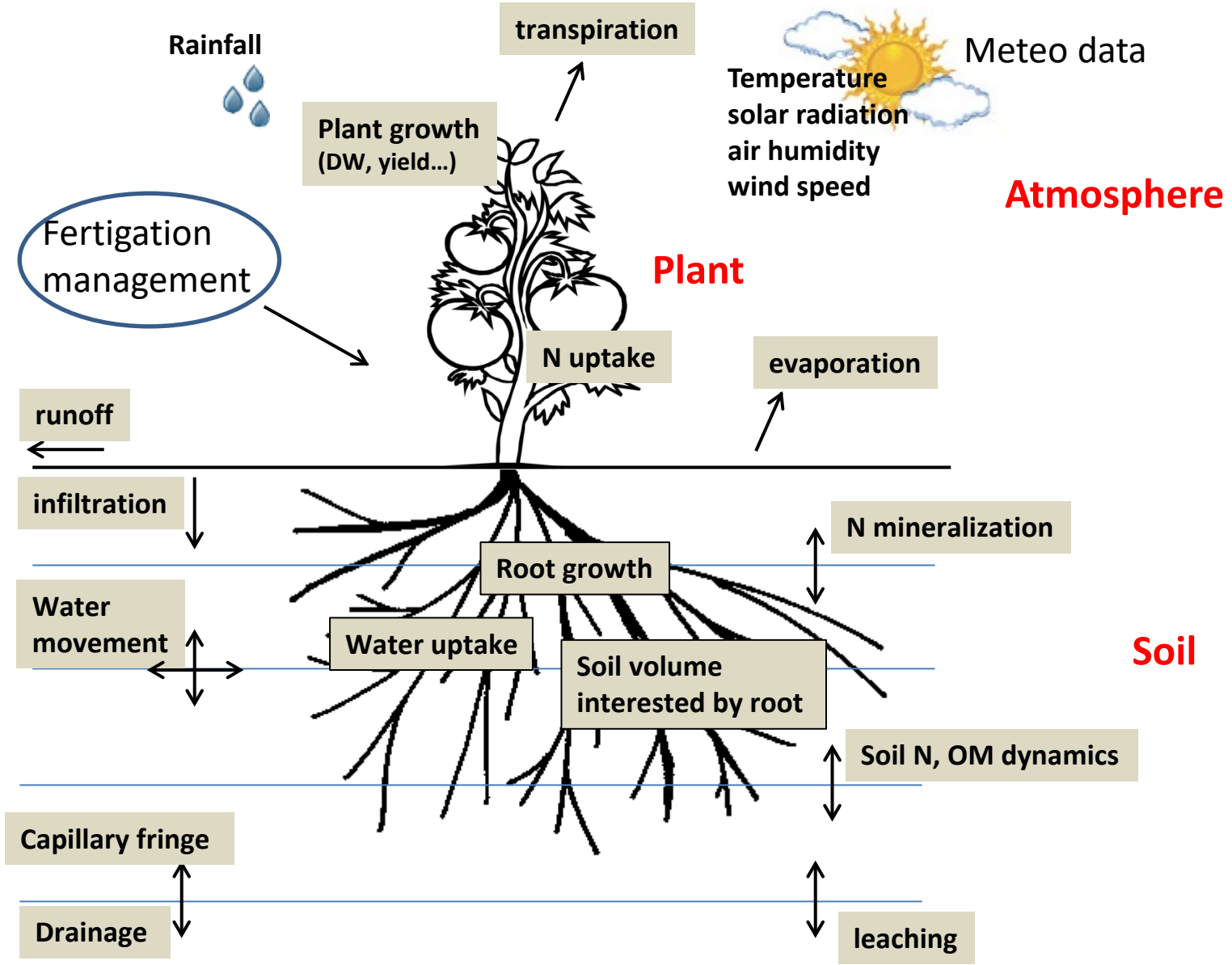

Elia, 2019

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Elia, 2019

Plant growth section

- DW accumulation
- Root growth (geometry and volume)
- Plant height
- % of soil covered

Water balance section

- ET_0 (FAO-PM, PT, Hargreaves)
- Kc (single, dual approach)
- Total Available Water (root vol. in wet soil)
- Water stress

N budget section

- N plant uptake
- N mineralization from SOM
- N mineral in soil

frontiers in Plant Science
ORIGINAL RESEARCH
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A decision support system (*GesCoN*) for managing fertigation in vegetable crops. Part II—model calibration and validation under different environmental growing conditions on field grown tomato

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GesCoN Fertigation manager module

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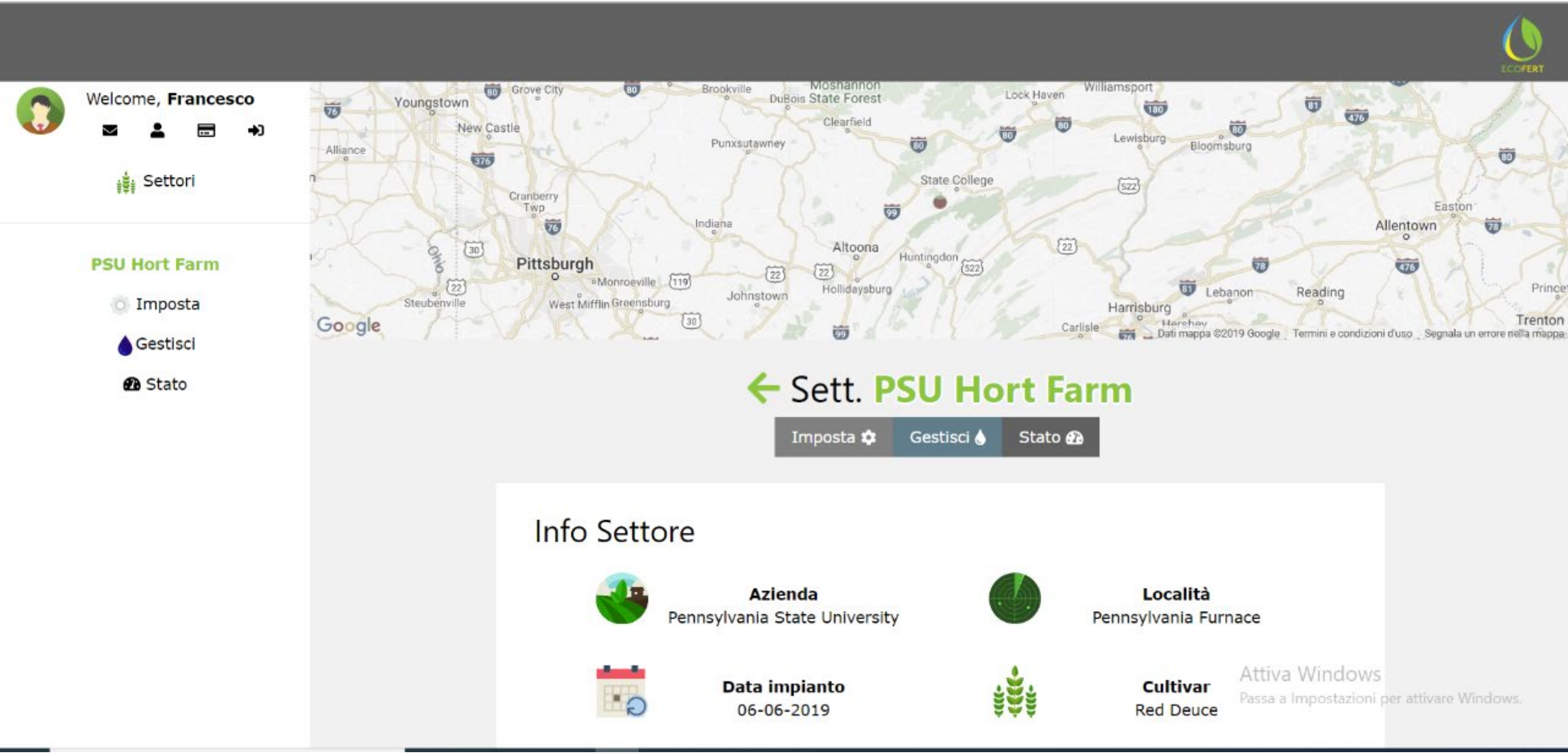

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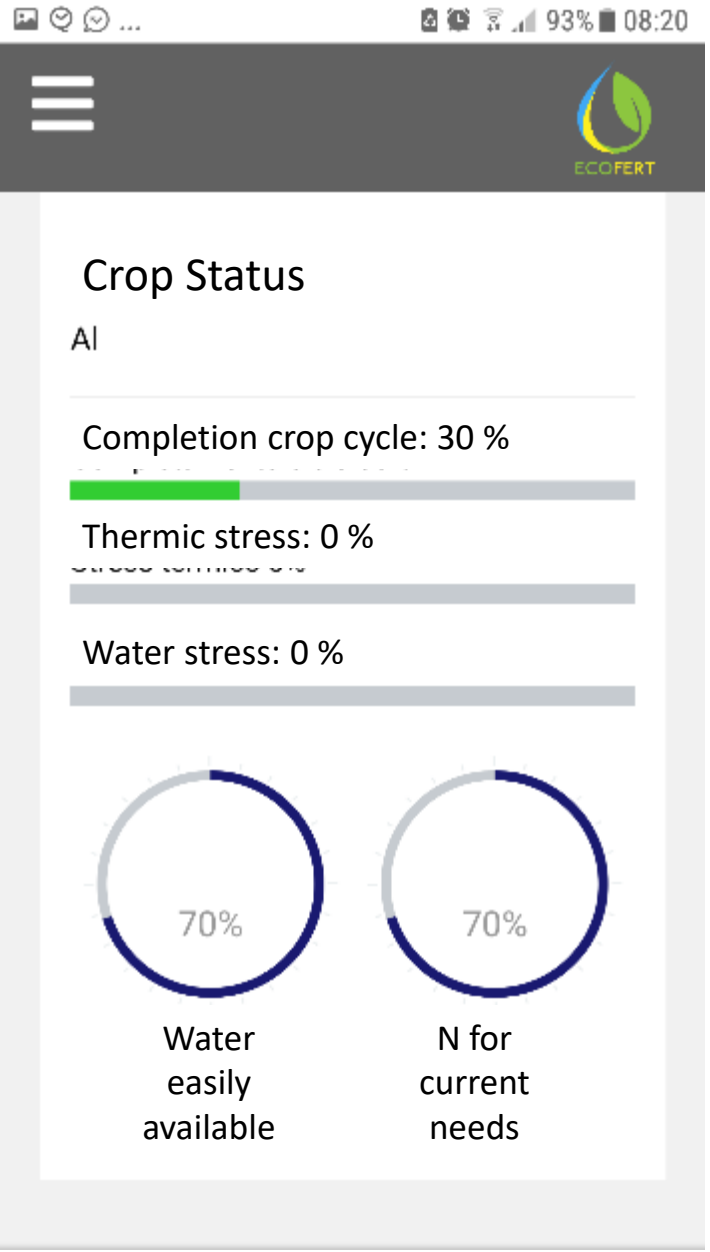

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Sensor based irrigation and water saving

Treatment	Water applied (%)	Water saving (%)	Marketable yield (lb/acre)
T1: based on experience	100		58772
T2: based on ET	89.7	10.3	58771
T3: based on SMS	58.1	41.9	59704
T4: based on DSS	75.5	24.5	60320

Sensor based irrigation pros & cons

Irrigation management strategy	Pros	Cons
T1: based on experience	Standard	Low efficiency
T2: based on ET	Higher efficiency, possibly low cost	Requires lots of daily calculations
T3: based on SMS	Site-specific, very efficient	Cost of investment, limited spatial representativity
T4: based on DSS	Very efficient, possibly site specific	User friendly, potential cost of investment

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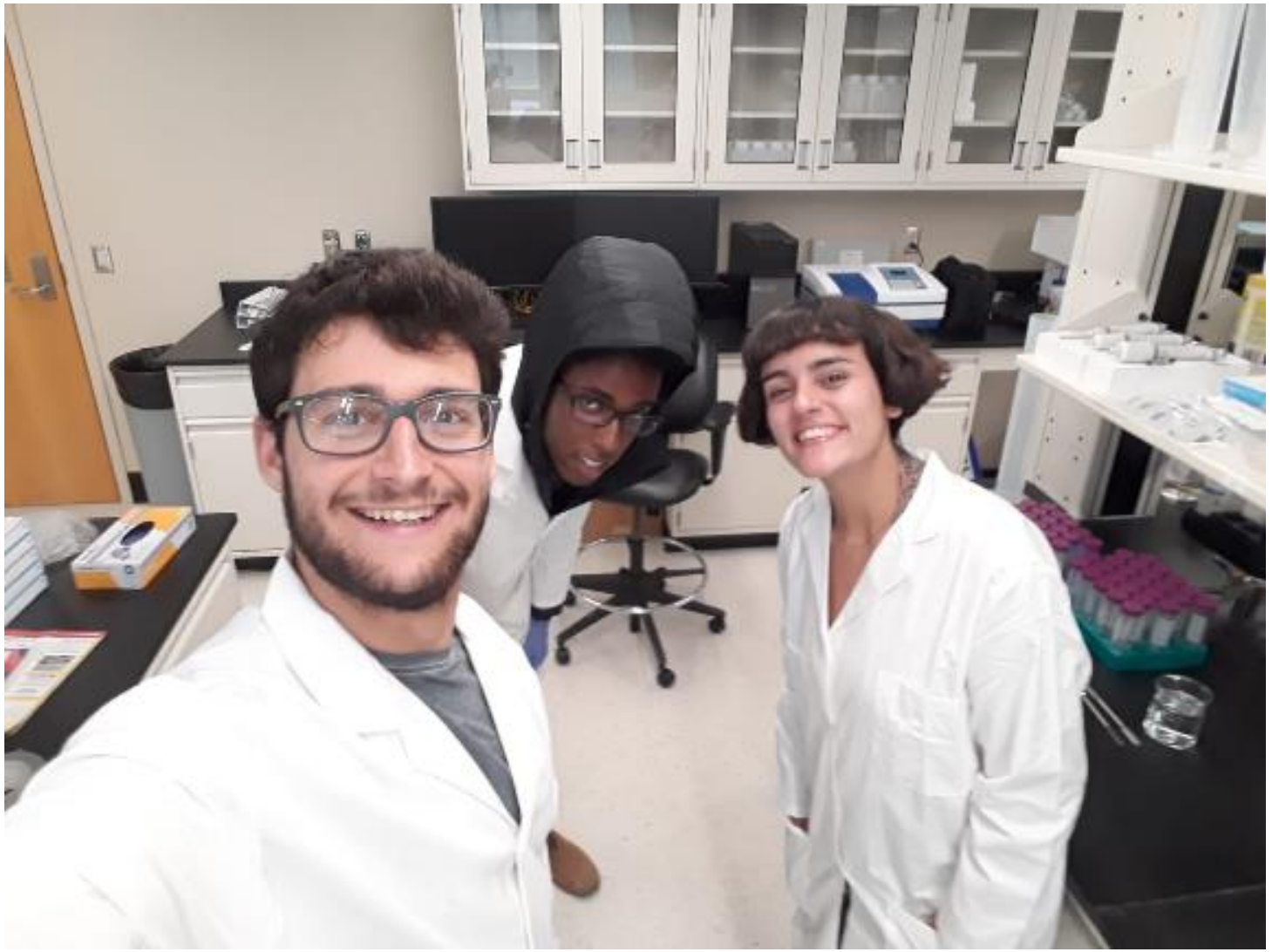

Questions?

Thank You!!!

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