Sensor Technologies for Irrigation Management

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WFC Presentation
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Precision Canopy and Water Management of Specialty Crops through Sensor-Based Decision Making

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Plant Water Status Sensing
Field Computer
Soil Water Status Sensing
Variable Rate Irrigation Management
Canopy PAR Absorption Management
Canopy Reflectance Measurement by Drone Copter
Canopy Shape Measurement by LIDAR
Precision Irrigation

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Mr. Jed Roach (Development Engineer)
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UC Davis
Why Precision Irrigation?

Fresh water consumption as a percentage of local annual precipitation
Precision Agriculture is the farming practice of applying the right amount of input, at the right place, at the right time to enhance yield, improve quality, and/or protect the environment.

When that input is water then we have Precision irrigation.
Experimental Plan

Because of extensive root zone of orchard/vineyard crops, soil moisture measured at a particular depth may not indicate the moisture available for crop growth.

On the other hand, Plant Water Status indicates the current stress level in the plant.
Pressure Chamber

Standard method- Pressure chamber (pressure bomb) to measure Stem Water Potential (SWP)
Objectives

- To develop and evaluate a sensor suite system to predict plant water status based on leaf temperature and microclimatic variables in the vicinity of the leaf.

- To validate the applicability of sensor suite for almonds, walnuts and grapes.
Measuring Plant Water Status

- Plant is under no water stress
  - Opens leaf stomata to assimilate carbon (photosynthesis)
    - Less resistance to water loss from leaf surface
      - More transpiration and more cooling of leaf
        - Reduced leaf temperature compared to surrounding air

Leaf temp. compared to air temp.

Indicator of Plant water stress

Is it that simple?
Sensor Suite System

- Leaf temperature
- Air temperature + RH
- PAR
- Wind speed

Data logger
Multiple Linear Regression Results of Extensive Field Tests during 2010 and 2011

Almonds

\[ T_L = -2.619 + 0.809T_a - 2.487 \text{SWP} + 0.044\text{RH} \quad R^2=0.90 \]

Walnuts

\[ T_L = -3.028 + 0.817T_a - 2.424 \text{SWP} + 0.050\text{RH} \quad R^2=0.86 \]

Grapes

\[ T_L = -15.92 + 1.38T_a - 3.81 \text{SWP} + 0.029\text{PAR} \quad R^2=0.86 \]
Some Observations

- Although sensor suite worked well, it was still not very convenient to use (bulky) and there were drifts in the calibration equations as the season progressed.
Mobile sensor suite

- Works just as good!  But .......
Hand-held sensor suite

Continuous monitoring of leaf temperature

Leaf Temperature

PAR

Air Temp. and Relative humidity

Wind speed

Still need to go to field every time you want to collect data!
Installation of Leaf Monitor

- Leaf monitor in almond orchard
- Leaf monitor in walnut orchard
- Almond leaf close up
- Walnut leaf close up
First look at data

PAR sensor data

(Tair – Tleaf) data

Irrigation event before after
Preliminary results

Almonds

Walnuts
### Economics

#### Effect of Trees/Acre and Trees/Node

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#### Effect of Price per pound and yield/acre

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</table>

PI: Shrini Upadhyaya, Professor
Brad Arnold, Rajat Saha and John Oliveira: Graduate Student Researchers
Jed Roach, Development Engineer
Holtz and Needham Development LLC
Parasappa Kanannavar and Narendra S. Raghuwanshi, Visiting Professors

Collaborators:
Daniel Putnam, Extension Specialist
Wes Wallender, Professor
David Slaughter, Professor
Problem/Need

- **Alfalfa is a major crop in the Western United States [Putnam. 1996]**
  - Single greatest water user of all crops (20% to 27% of irrigation water usage).
  - Grown on 1.1 million acres in California.

- **Border check or flood irrigation is predominant type of irrigation system utilized in alfalfa production.**
  - Used for its simplicity and low capital costs.
  - Subject to large inefficiencies such as surface runoff or deep percolation
    - Around 60% water use efficiency, lowest among irrigation methods [FAO. 1989].
  - Proper cutoff strategy can reduce runoff and other water losses to as little as 2% of applied water [Bali. 2001]
Project Goal

- To Develop a wetting front monitoring system for check or bordered irrigated alfalfa,
- To interface the monitoring system to a communication system to alert the irrigators to enhance irrigation efficiency.
- To Transfer the Technology.

Transfer of Technology

SIMATECH ➔ Sustainable AgTech Innovation Center (SATIC) ➔ CERMETECH
Surface Irrigation Sensing and Alerting Technology (SIMATECH)
Field setup

Central Module

Wetting front advance monitor and transmitter
Cell Phone Text

Irrigation Monitor AT&T: Water arrived at sensor 7 at 01:58 PM
01/03/2012
Sent: 1:57PM

Irrigation Monitor AT&T: Water arrived at sensor 7 at 02:43 PM
01/03/2012
Sent: 2:43PM

Irrigation Monitor AT&T: Water arrived at sensor 14 at 02:45 PM
01/03/2012
Sent: 2:44PM

Irrigation Monitor AT&T: Water arrived at sensor 1 at 02:45 PM
01/03/2012
Sent: 2:45PM

Type to compose
What can a Network of wireless wetting front monitoring and communication system do for you?

- For the Farmer: Saves money, time, and labor
- For the Environment: Reduces tail discharge
- For the Future: Conserves a valuable resource

Transfer of Technology

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Sustainable AgTech Innovation Center (SATIC) ➔

CERMETECH

Thank you for your attention!