USING SENSOR FEEDBACK WITH VARIABLE RATE IRRIGATION

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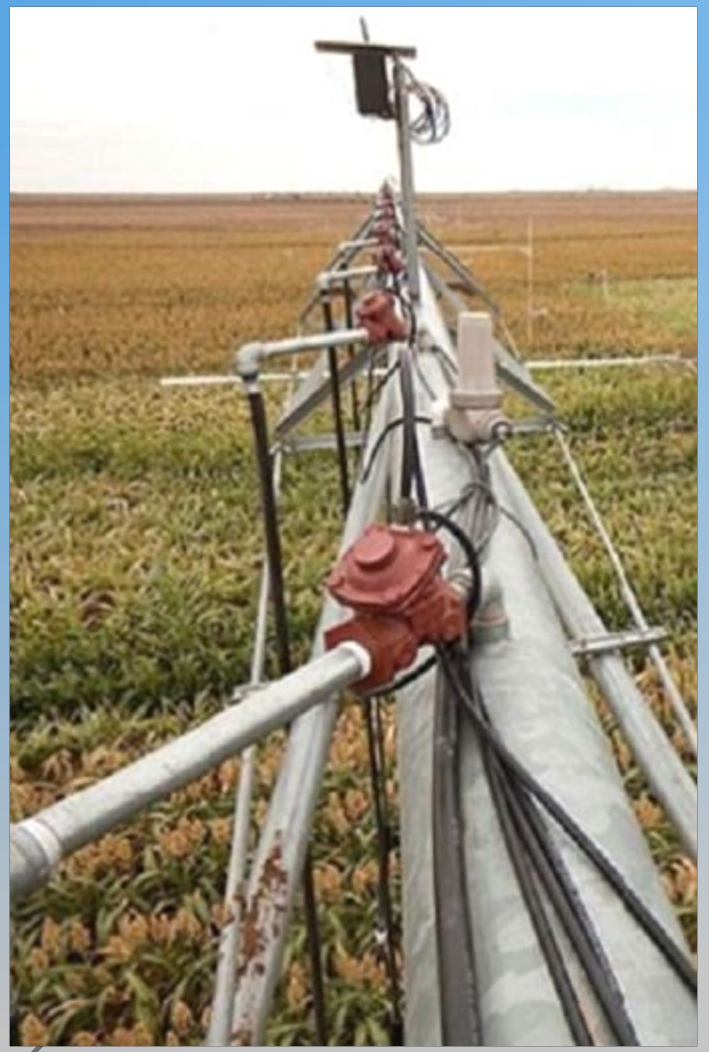
USDA United States Department of Agriculture
Agricultural Research Service

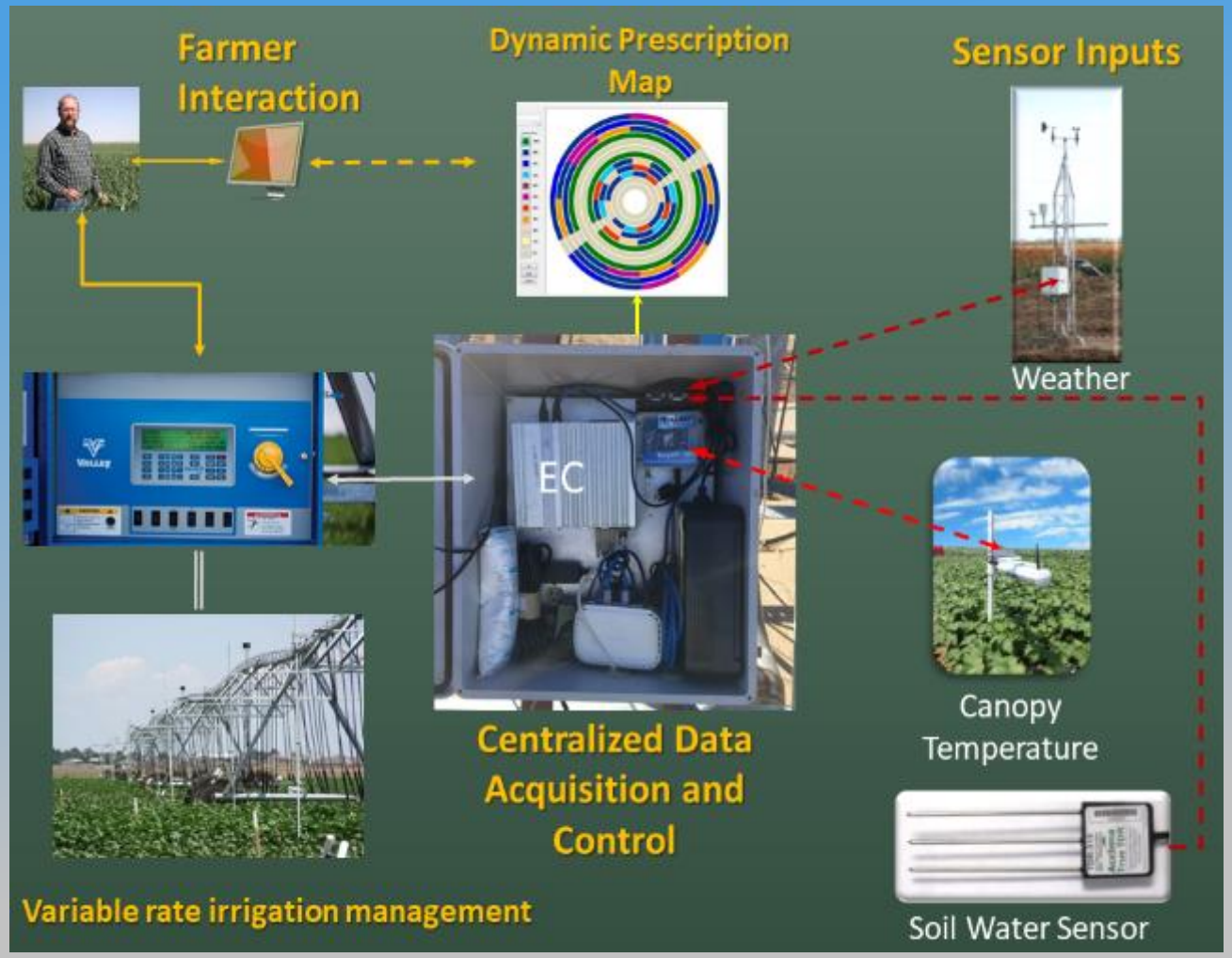
BACKGROUND



- Variable rate irrigation systems for center pivots and linear move sprinklers are reliable and accurate in applying irrigation in the amounts and location prescribed by prescription maps.
- Dynamic prescription maps are appropriate for VRI management with the goal to meet the changing spatiotemporal variability of crop water needs.
- However these changes must first be detected and the information fed into the sprinkler control system

THE ISSCADA SYSTEM

- Bushland-ARS developed and patented an irrigation scheduling supervisory control and data acquisition (ISSCADA) system (Evett et al., 2014) to provide decision support and irrigation control for variable rate irrigation sprinkler systems (Andrade et a., 2015; 2017).
- The ISSCADA system has been beta-tested in South Carolina, Missouri, Mississippi and Texas and by farmers in different parts of the U.S. over the past four years.
- Feedback from users has been used to improve the system.



SENSORS USED IN VRI DECISION SUPPORT

- **Soil water sensing**
  - Continuous measurements using Time Domain Reflectometers (TDRs)
    - Installation of multiple sensors in one location (various depths) to provide information from the profile of the root zone
    - TDRS are providing a response to soil permittivity, can be converted to volumetric water content
    - Measure the travel time of an electronic pulse generated in the sensor head and sent along the wave guides
    - Wireless data transfer to a base computer or the Cloud
- **Canopy temperature sensing (infrared thermometers-IRTs)**
  - Continuous measurements using wireless network, install on moving platform or make stationary
  - Weather data used in conjunction with canopy temperature data to calculate water stress level of areas within a field or compared with well-watered crop (normalize information)

SENSOR FEEDBACK FOR ACTIVE SITE-SPECIFIC VARIABLE RATE IRRIGATION

SOIL WATER SENSORS-

TDDR specifics–

- SDI-12 connected to datalogger, transmission to base computer with RF telemetry
- Readings taken every 1 min, averaged every 15 min, Transmitted every 1 hour.
- Sampling and averaging times are programmable
- ISSCADA software average data daily

CANOPY TEMPERATURE SENSORS- PLUG AND PLAY

IRT specifics-

- Measure surface temperature
- Field of view is 3:1
- Easy to install and relocate, mounted off pipeline
- Measure temperature every 6 s, average and send every 1 min. to base station computer

INSTALLATION OF SOIL WATER SENSORS

Install soil water sensors to cover the average rooting depth of the crop

Convert water content values to equivalent water depth values and plot soil water storage depth

(Evett et al., 2019)

Sprinkler

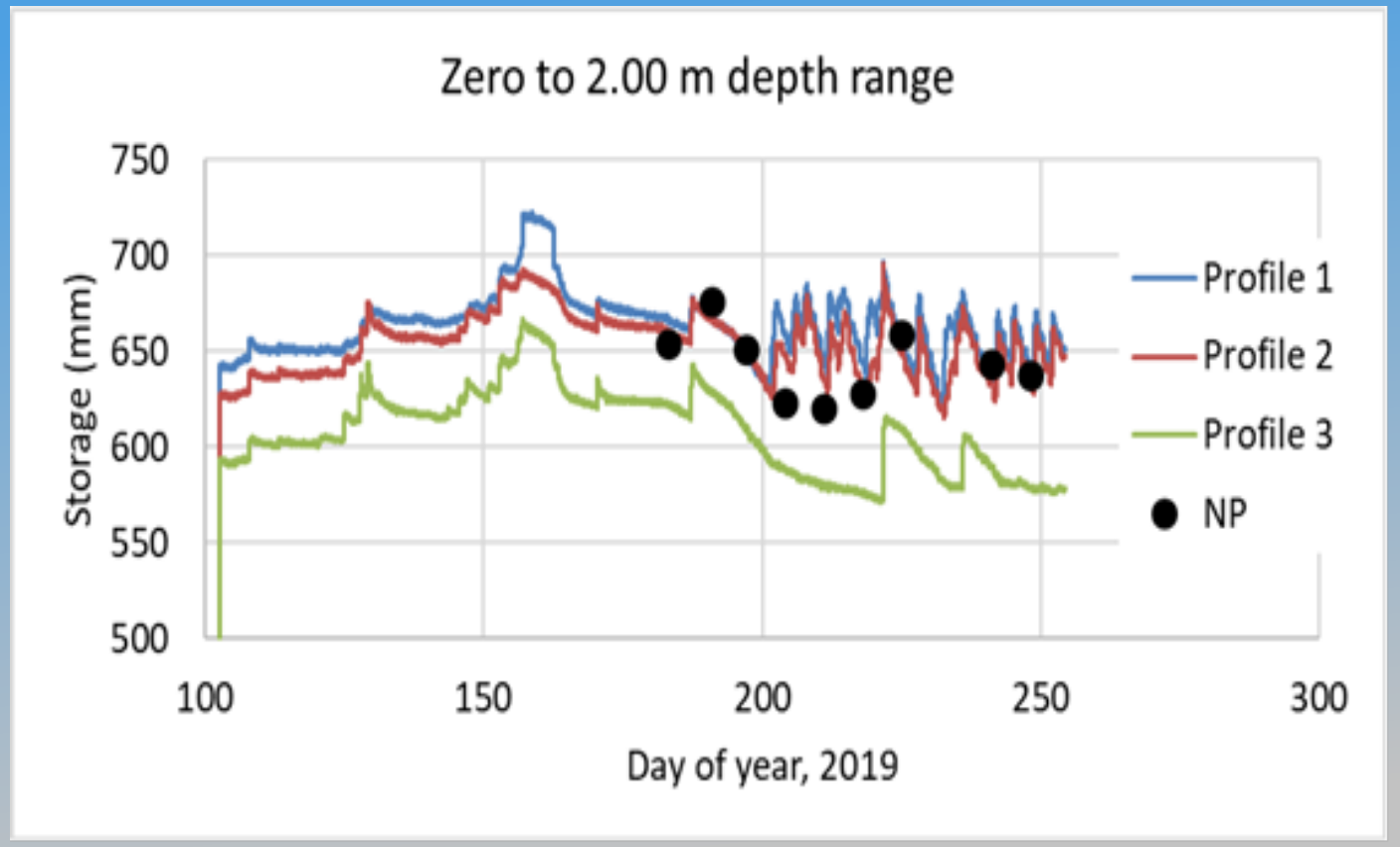
- Install in plant bed on side where the drop hose travels
- Top two sensors were installed horizontally in the plant bed
- Two deepest were installed vertically so the mid-point of the steel probes was located at the desired depth.

SDI

- Soulis and Elmaloglou (2018)report the optimal horizontal distance from the line source to be 11 cm
- Optimal vertical depth was 12 to 18 cm below dripline

INSTALLATION OF TDRs FOR SDI

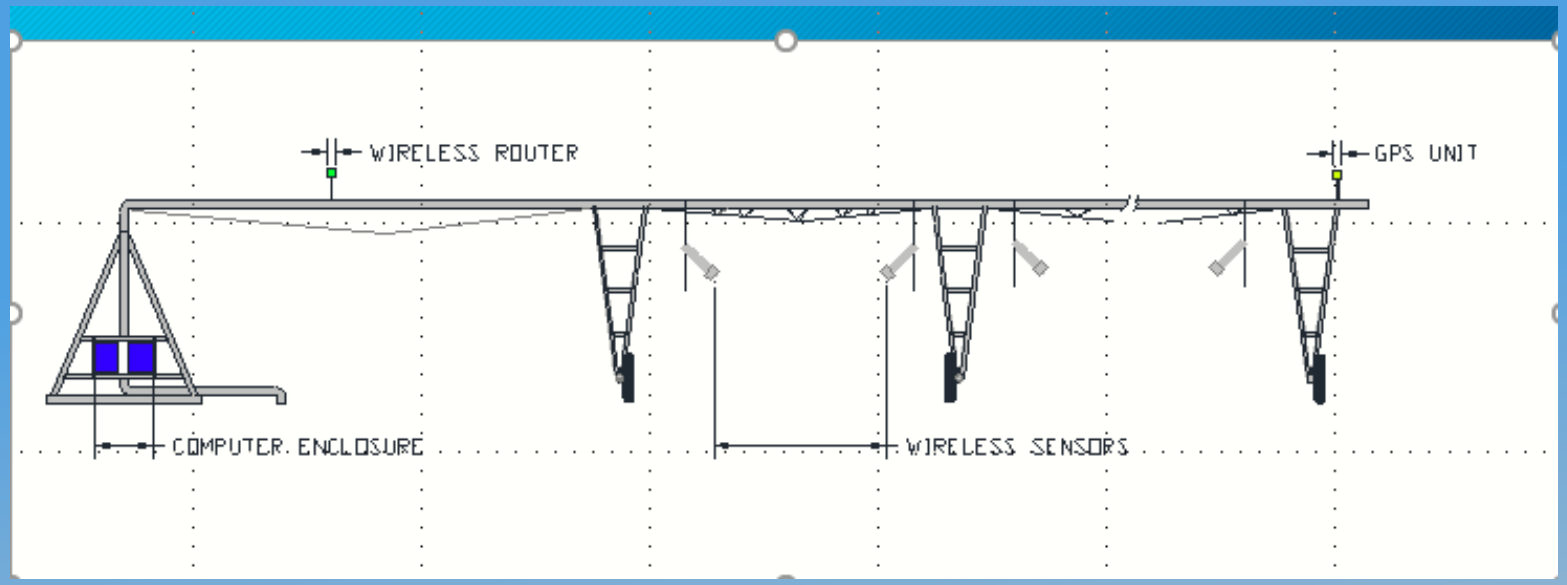
- Soil water profiles from three sets of TDRs installed in a large weighing lysimeter in Bushland, TX.
- Profiles 1 and 2 were relatively close to the drip tape. They responded to the drip irrigation and precipitation events.
- Profile 3 was in the interrow. It responded only to precipitation events.



NP = neutron probe

INSTALLATION OF IRTS FOR IRRIGATION SCHEDULING:

- Can be used with a SDI system (Evett et al., 1996) or on a moving sprinkler irrigation system (O'Shaughnessy et al., 2010; 2012; 2013; 2015; 2017)
- Infrared thermometers detect crop water status at a greater scale than soil water sensors if mounted onto a moving platform
- Weather and temperature data can be combined to formulate stress indices and used to guide when, where and how much to irrigate



STRATEGIC LOCATION AND NUMBER OF CANOPY TEMPERATURE SENSORS

CONSIDER:

Spatial layout of within field variability

Crop type/value

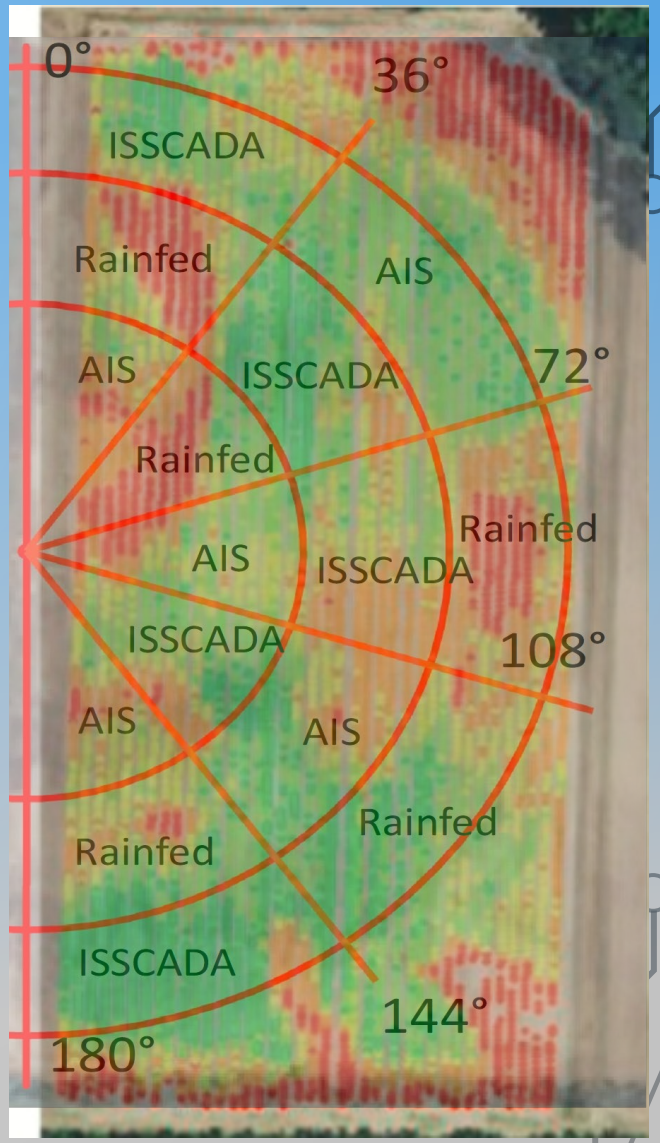
Producer's goals for using VRI zone or sector control

SMALL SIZE FIELD WITH ZONE CONTROL VRI: YIELD MAPS INDICATE A HIGH AMOUNT OF VARIABILITY

RECOMMENDATION: ONE PAIR OF IRTS LOCATED IN EACH SPRINKLER MZ

Seed Cotton Yield (kg/ha)

- < 1160
- 1160 - 2108
- 2108 - 2881
- 2881 - 3606
- > 3606



Seven management zones, two were combined in each span, management of the sprinklers in the overhang were combined with the ones in the last span

Vories et al. (2019)

2019 FIELD EXPERIMENT: USING SENSOR FEEDBACK FOR SITE-SPECIFIC IRRIGATION MANAGEMENT

OBJECTIVES: COMPARE YIELDS AND IWUE FOR POTATOES IRRIGATED AT THREE TREATMENT LEVELS USING SENSOR FEEDBACK METHODS AND IRRIGATIONS SCHEDULED FROM WEEKLY NEUTRON PROBE READINGS

METHODS

- **SENSOR INSTALLATION**
- **THRESHOLDS**
- **DECISION SUPPORT**

2019 – FIELD EXPERIMENT

- Crop: Chipping potato (Frito Lay 1867)
- Planted on April 3, 2019 on 30” rows, seeds were spaced 12” apart
- Treatments:
  - Irrigation levels: 100%, 80% and 60% replenishment of soil water depletion to field capacity

  - Irrigation methods were the:
    - Manual method – replenishing 100%, 80% and 60% soil water depletion to field capacity
    - ISSCADA system using Plant Feedback thresholds
    - ISSCADA system using Plant Feedback and Soil Water Sensing thresholds => Hybrid

Neutron probe access tube and TDR installations

Installing neutron access tubes, 10’ long X 1.5” o.d.

Installation of TDRs-
top TDRS were at 10 cm and 20 cm.

Bottom two TDRS were located at 40 cm and 80 cm using the wooden jig and wave guide (blue material) for proper installation.

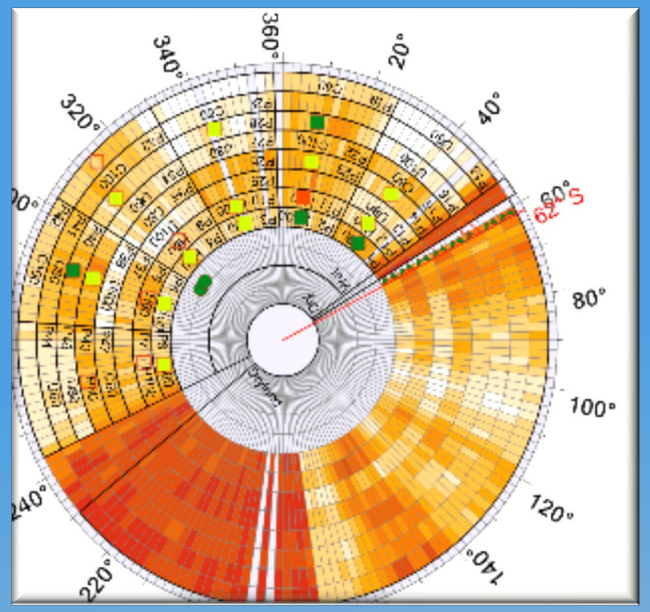
Thresholds for Irrigation Scheduling with the Plant Feedback Method

	Minimum Threshold	Medium Threshold	Maximum Threshold
Plant feedback	0< iCWSI ≤ 200	200< iCWSI ≤ 350	iCWSI > 350
Irrigation Treatment Levels	Irrigation amounts to apply (in)		
C100	0.50	0.65	0.80
C80	0.40	0.52	0.65
C60	0.30	0.40	0.50

Thresholds for the Irrigation Scheduling with the Hybrid Method

	If SWD ≤ 0.10	If 0.10 < SWD < 0.35	If SWD ≥ 0.35
Irrigation Treatment Levels	Apply irrigation amount (mm)	Use iCWSI Threshold and apply irrigation levels shown in Table above	Apply irrigation amount (in)
H100	0.0		0.80
H80	0.0		0.65
H60	0.0		0.50

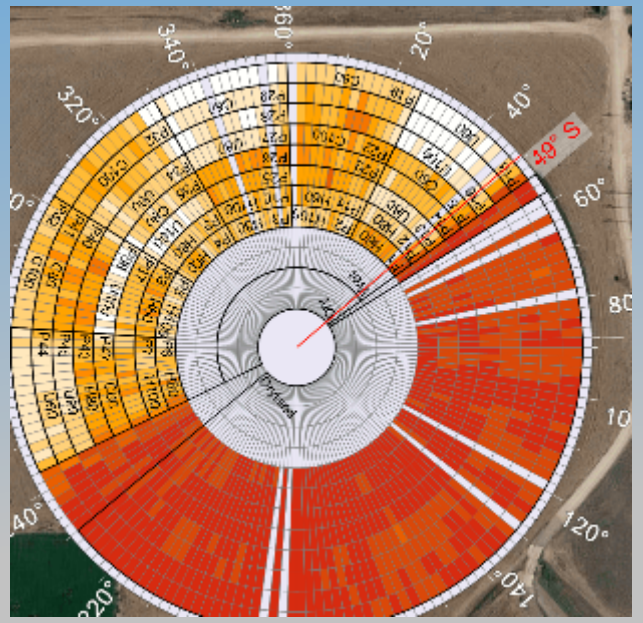
Temperature Scale



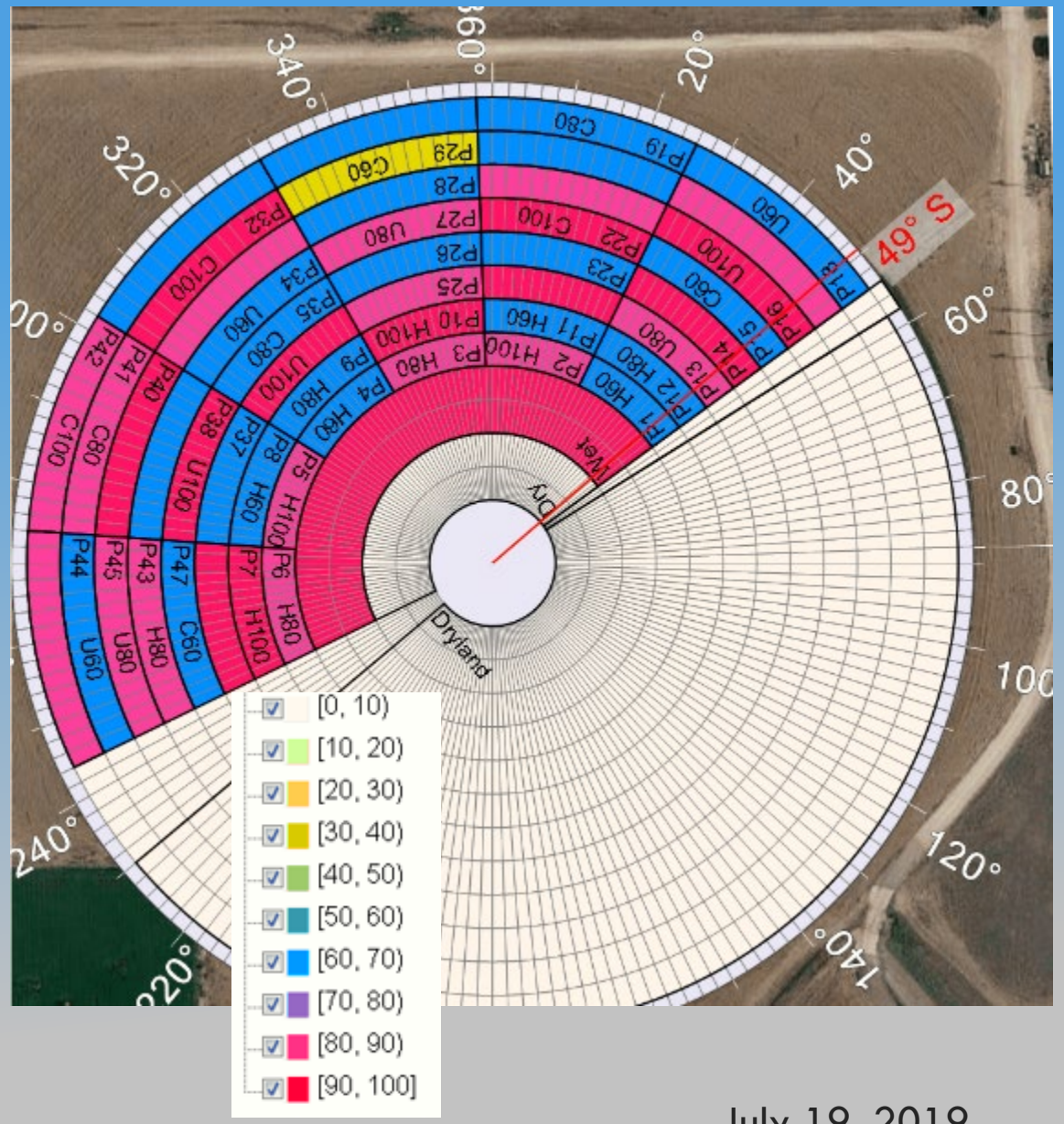
Canopy Temperature Map- same time of day (July 18, 2019)

ICWSI Scale

July 18, 2019



iCWSI Map



July 19, 2019

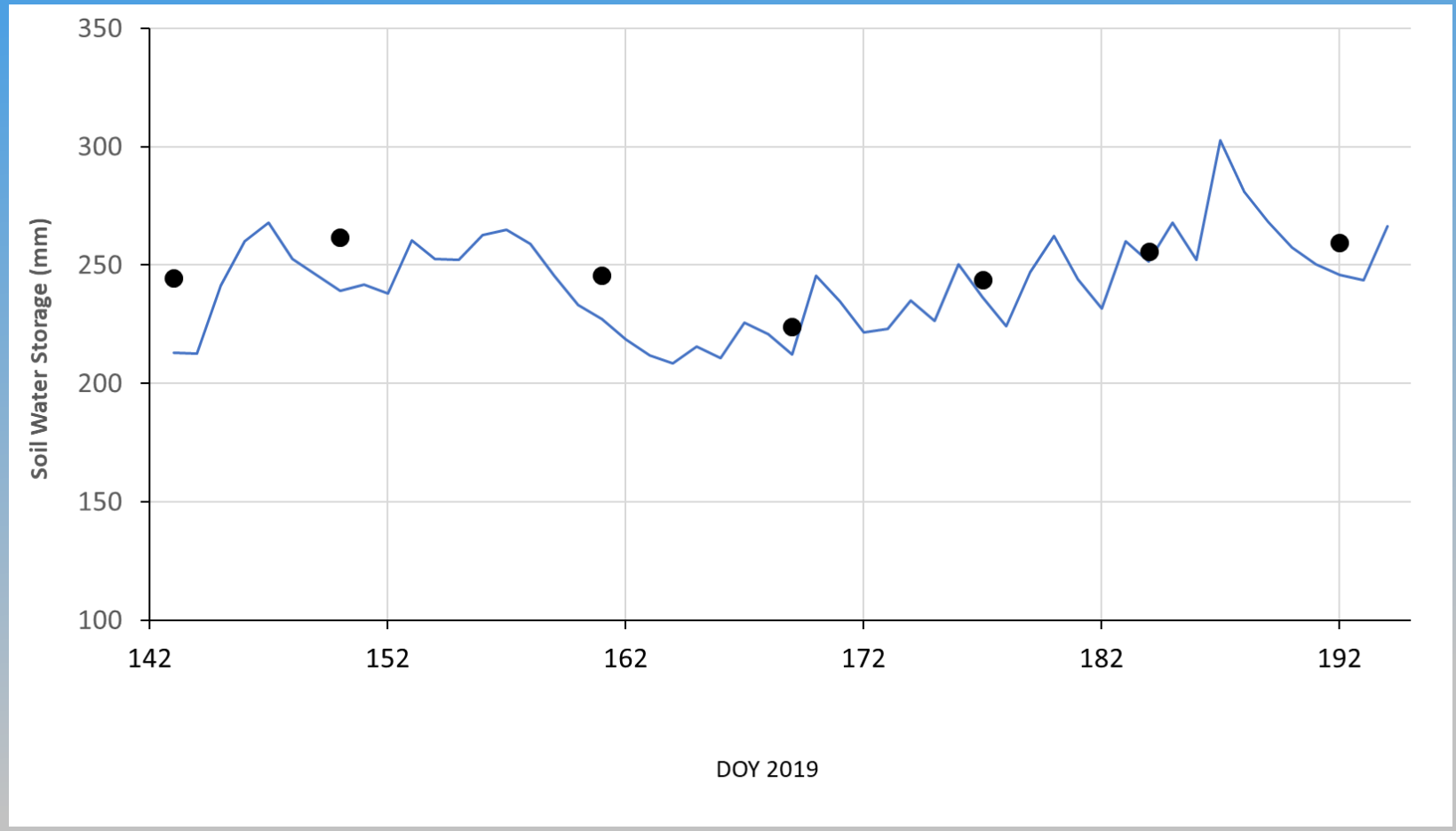
DSS: Prescription Map

RESULTS

NP AND FIELD TDRS-

SOIL WATER STORAGE LEVELS IN POTATO FIELD

PROFILE DEPTH = 80 CM

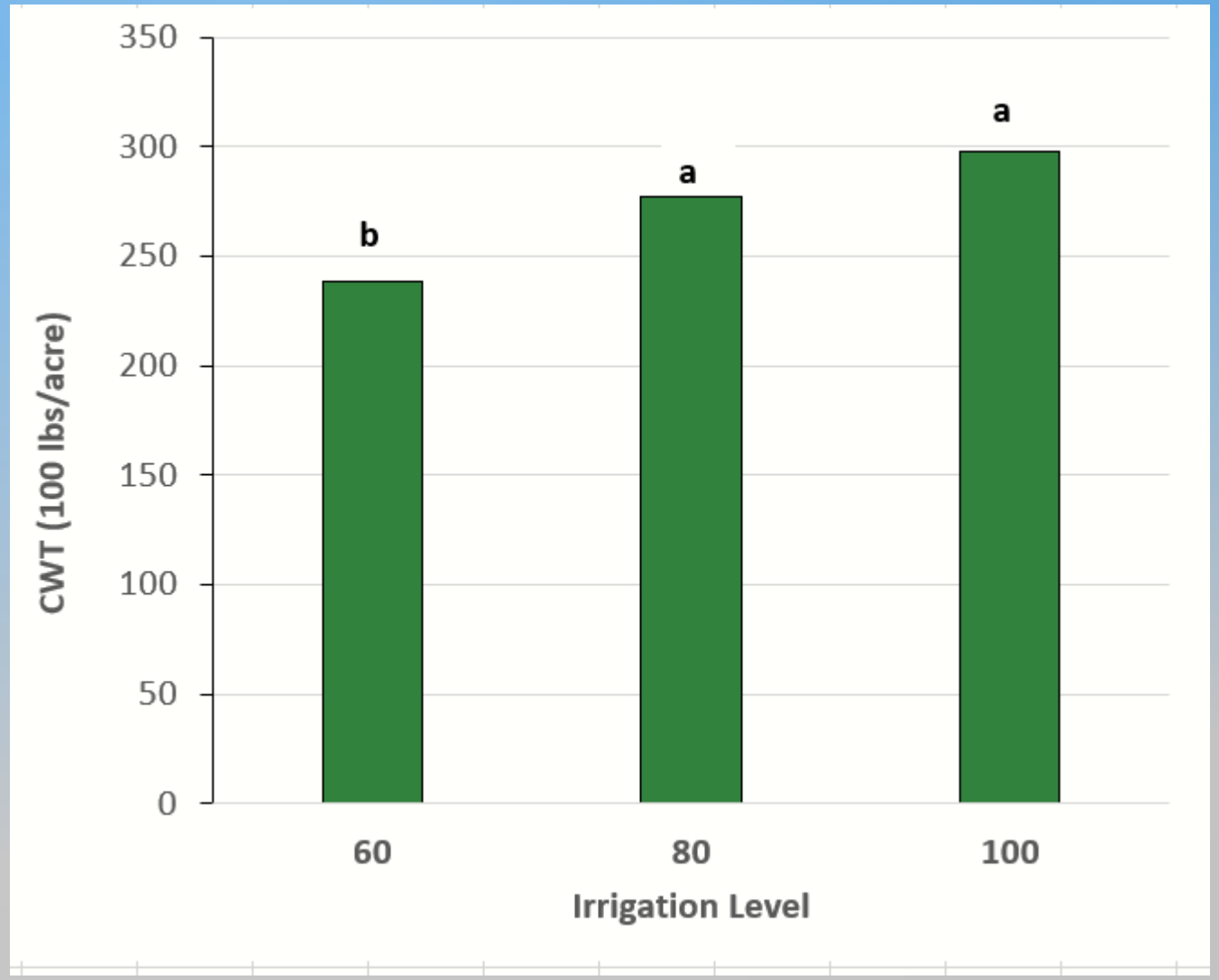


TDR measurements

NP

EFFECT OF IRRIGATION LEVEL ON TUBER YIELDS

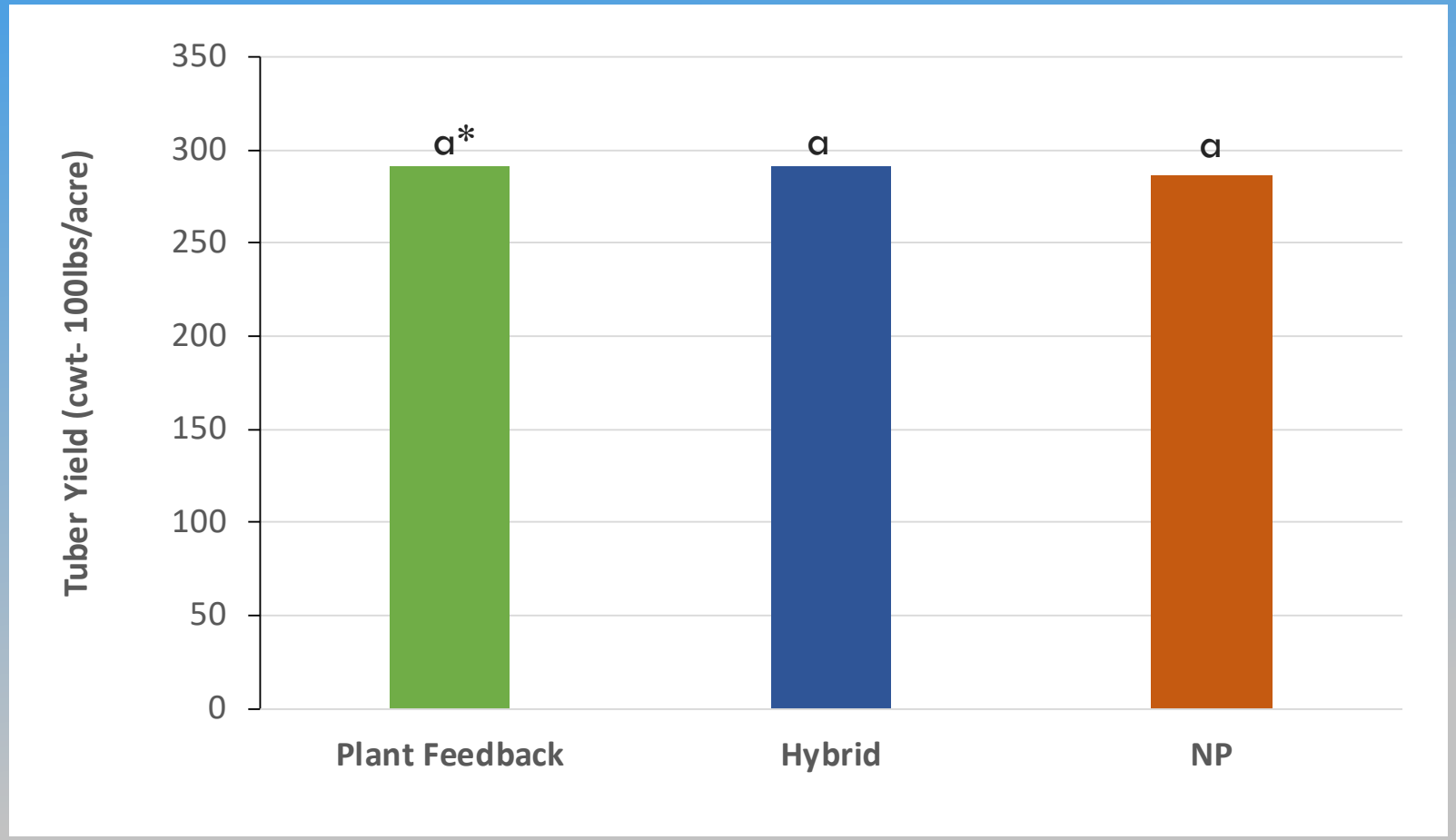
Irrigation at 60% replenishment of soil water depletion to field capacity significantly reduced tuber yield compared with irrigation treatment levels at 80% and 100%



EFFECT OF IRRIGATION METHOD ON TUBER YIELD

The ISSCADA system, using either Plant feedback or the Hybrid method of irrigation scheduling, produced yields that were similar to irrigation management with weekly NP readings.

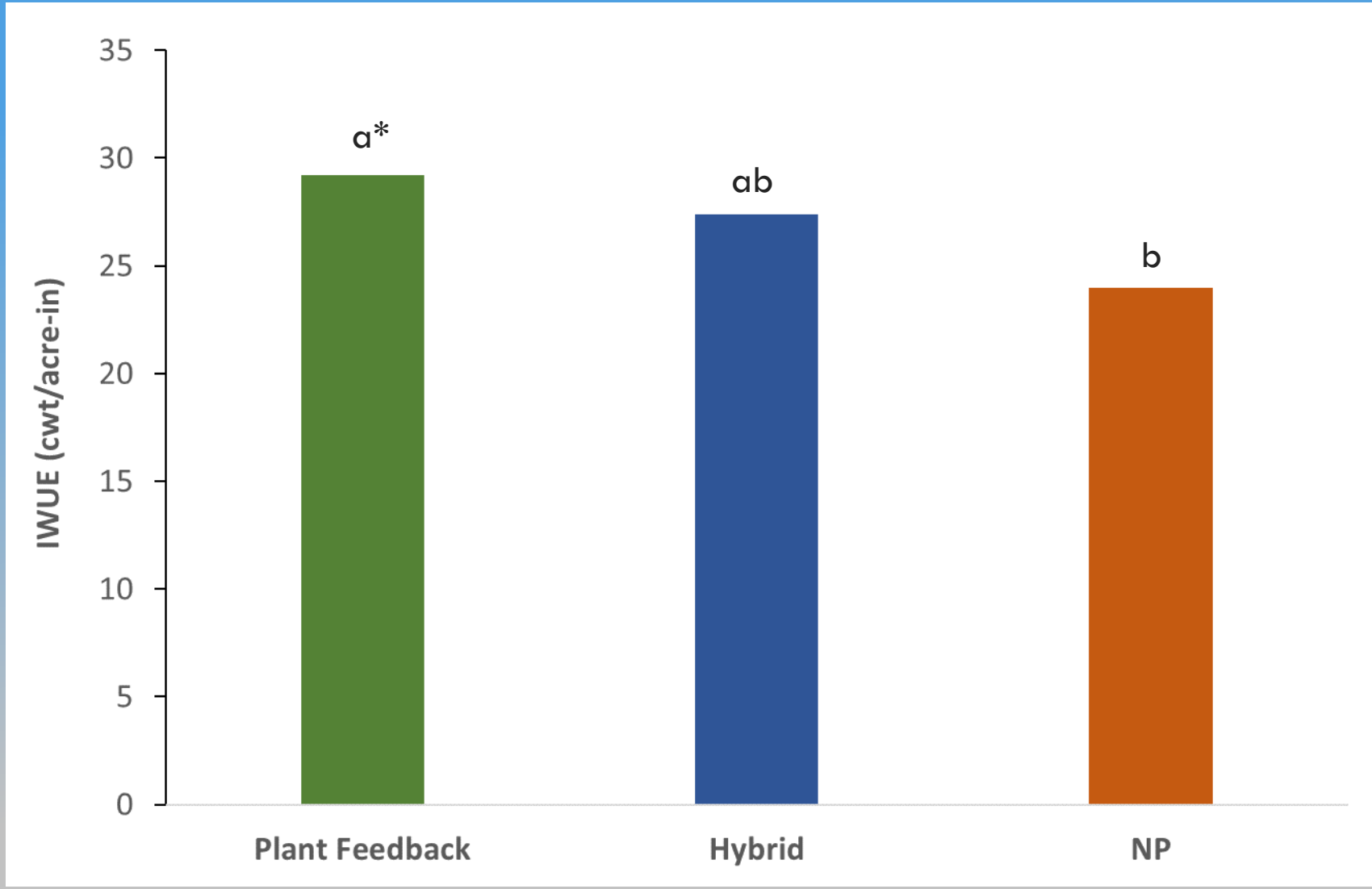
This is a positive result since the ISSCADA DSS is automated and requires less physical labor during the irrigation season.



*Mean values with the same letter are not significantly different

EFFECT OF IRRIGATION METHOD ON IRRIGATION WATER USE EFFICIENCY

IWUE for the ISSCADA-Plant Feedback method was significantly greater compared with the NP method of irrigation scheduling.



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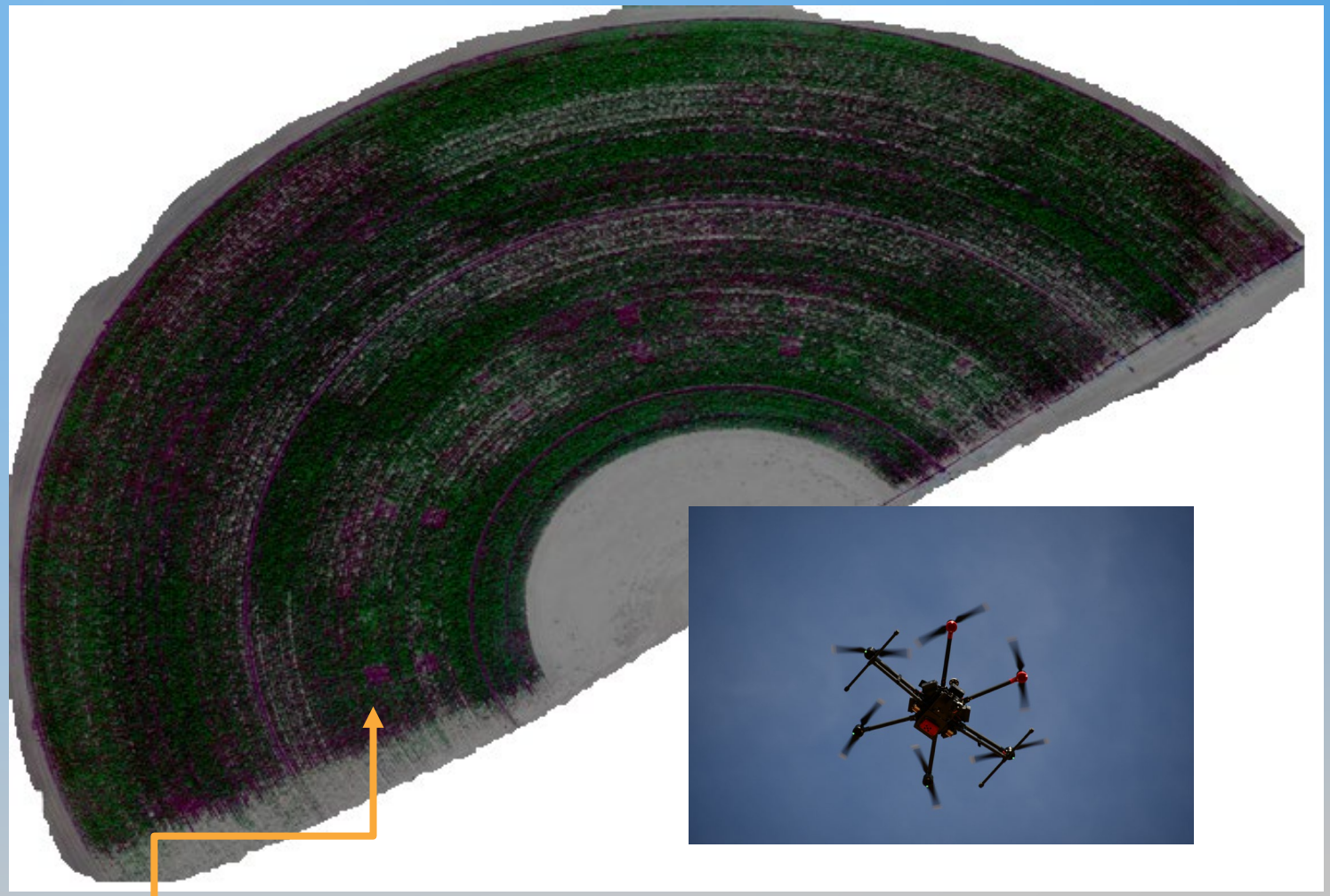
FUTURE WORK

- Include information from UAV fly overs for early detection of Zebra Chip Virus

- Disease detection and DSS- withhold irrigation if yield and WUE will be significantly decreased



RGB image from hexacopter UAV flown over three-span center pivot at Bushland, Texas. June 16, 2019. The pink square shapes represent areas where potatoes were infested with Zebra Chip virus.

KEY POINTS

We have demonstrated the ability to implement site-specific irrigation scheduling using our ISSCADA system

Plant feedback and plant and soil water sensing feedback produce tuber yields that are similar to the yields produced by the best management practice in the THP region, i.e. using weekly neutron probe readings.

The ISSCADA system can control irrigation water use efficiency at a level that is as beneficial or more beneficial than using best management practices for the Texas High Plains region.

Future work will involve automatically integrating information from UAV data into the ISSCADA system for disease detection and irrigation management.

ACKNOWLEDGEMENTS

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- **CRADA Partners**: Valmont Industries, Inc. ; Dynamax Inc.; Acclima Inc.

THANK YOU

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