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Growing Wine Grapes with Less Water

DEEP SUB-SURFACE MICRO-IRRIGATION AND THE ROLE OF EMERGING SENSING TOOLS

HOUSEKEEPING

- 45 minutes of presentation
- 15 minutes for questions
- Use chat pane for Q&A
- Recording/slides will be sent out following presentation

> Introductions

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Deep Sub-Surface Micro-Irrigation and the Role of Emerging Sensing Tools in Growing Wine Grapes with Less Water

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Center for Precision & Automated Agricultural Systems

World Preeminent, Washington Relevant

WASHINGTON STATE UNIVERSITY

Contributions and acknowledgments

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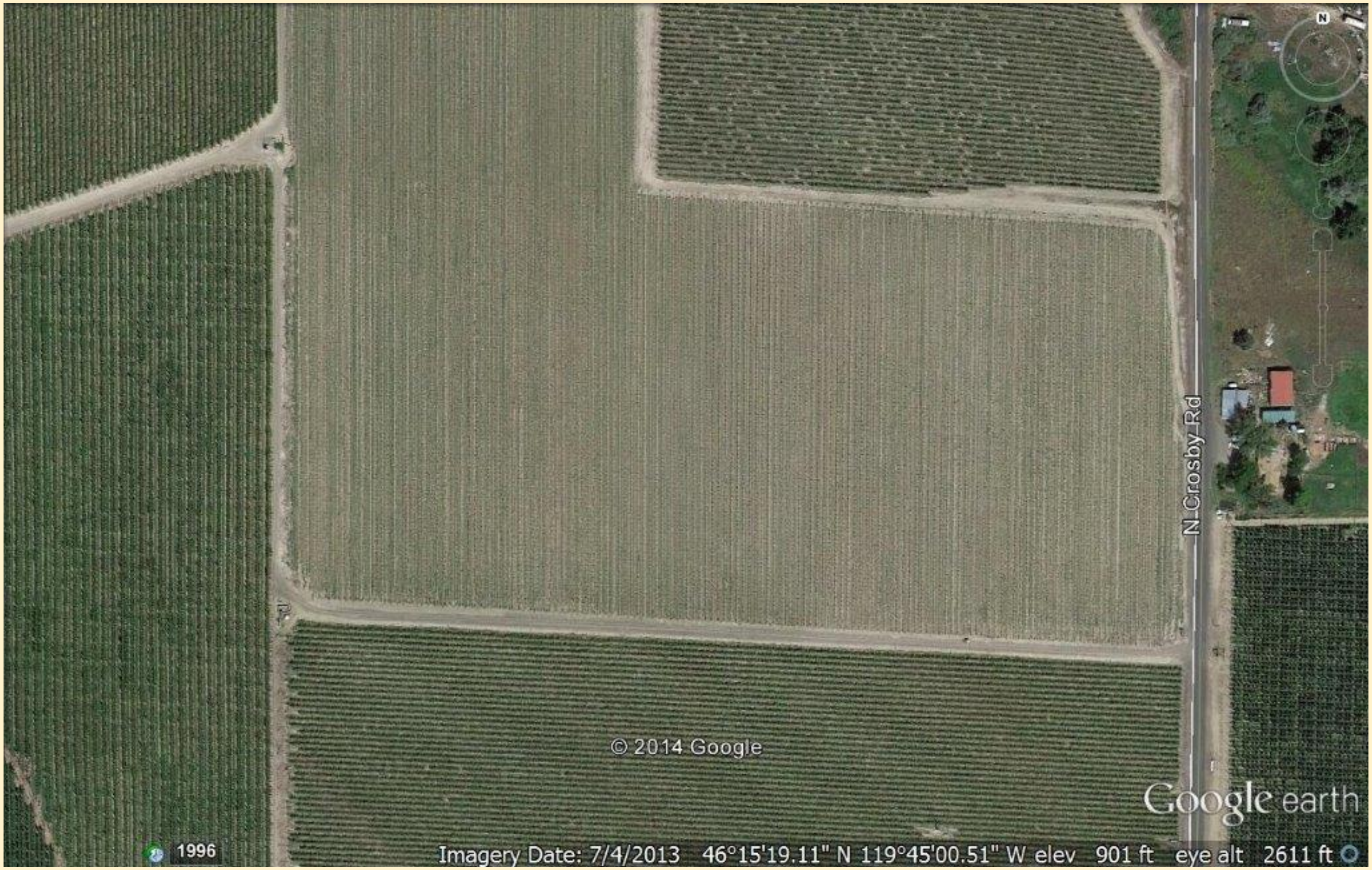
New System
Vertical Delivery Tubes & No Buried Lines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© 2014 Google
Google earth
1996
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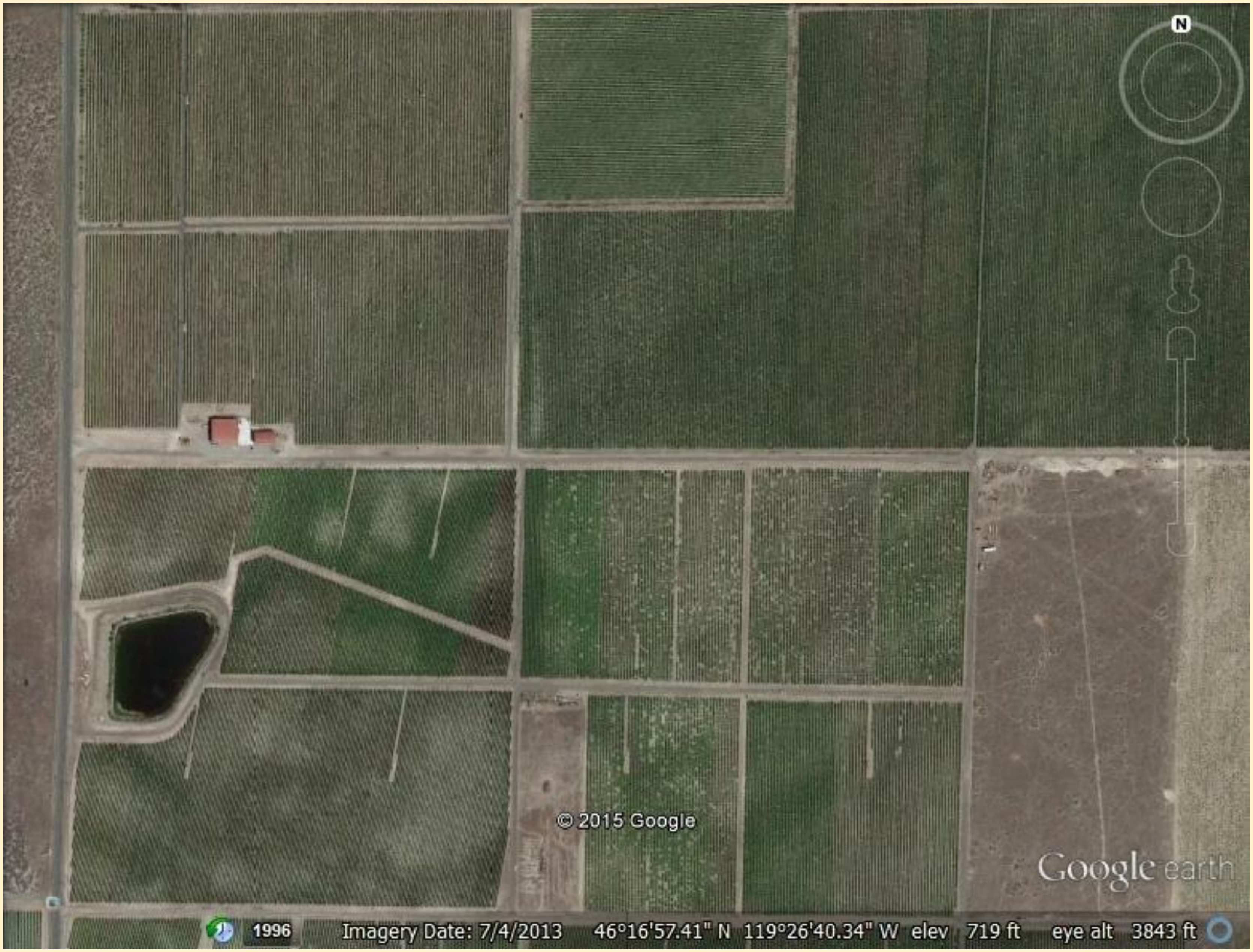

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© 2015 Google
Google earth
1996
Imagery Date: 7/4/2013
46°16'57.41" N 119°26'40.34" W elev 719 ft
eye alt 3843 ft

Red Mountain
Cabernet Sauvignon

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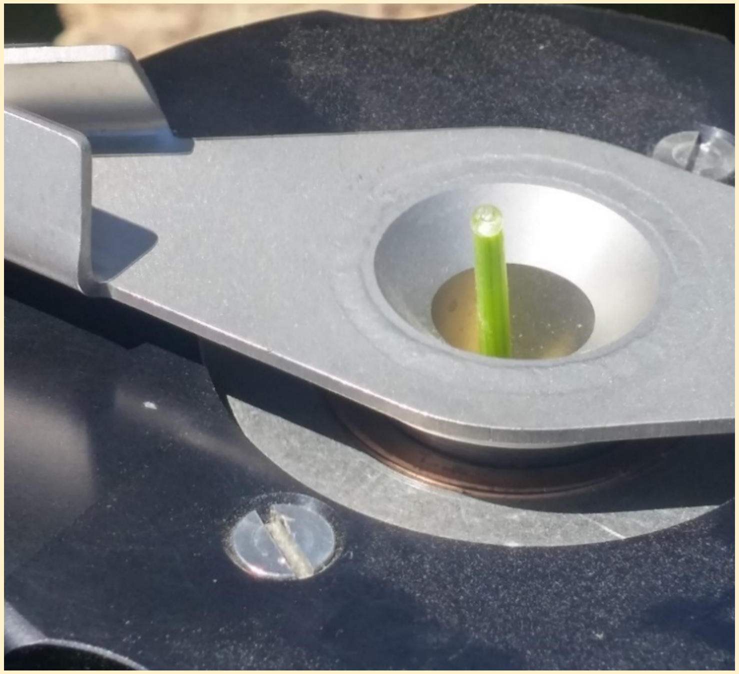
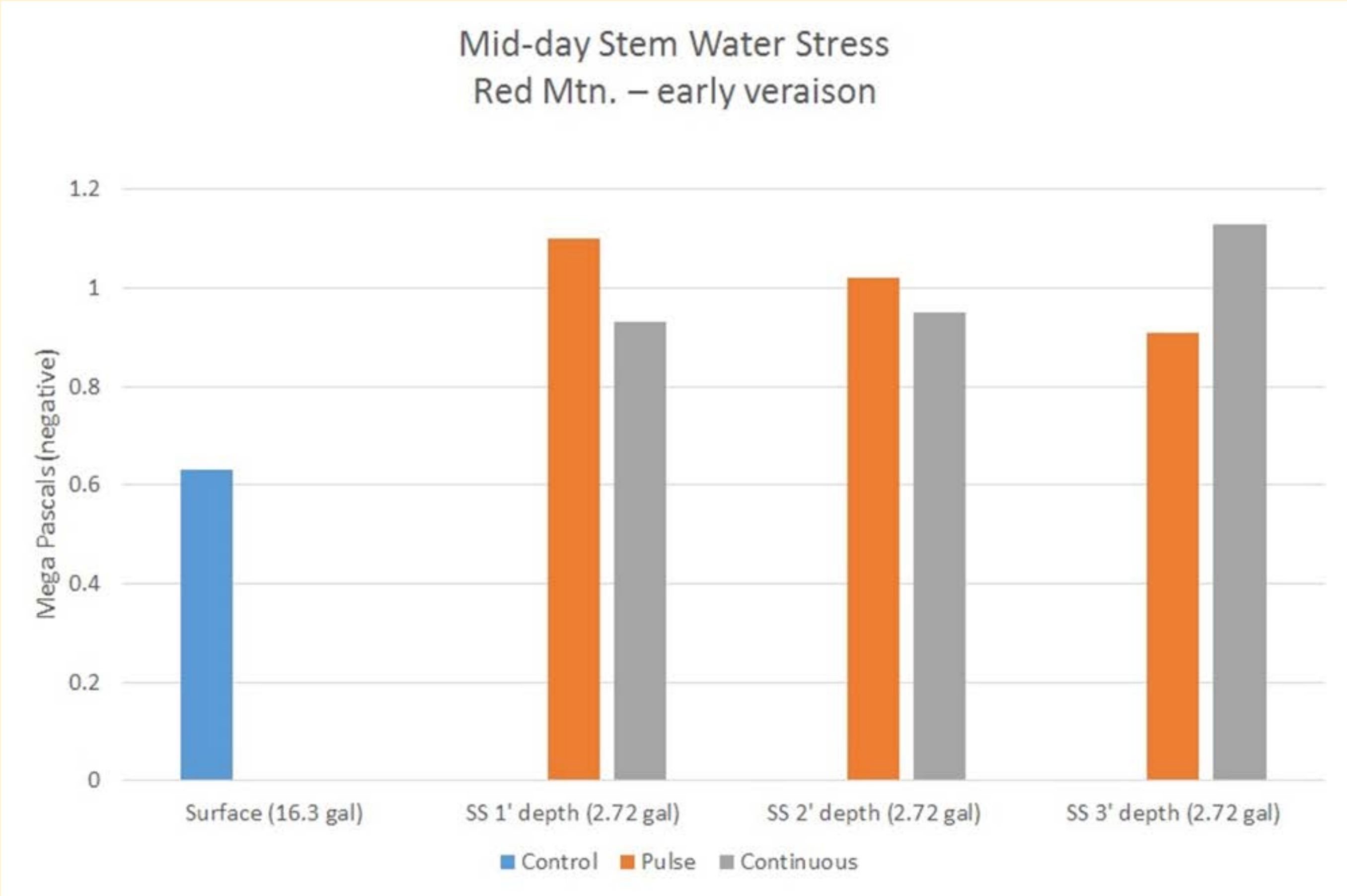
Plant Water Status
Mid-day Stem Water Potential





Mid-day Stem Water Stress
Red Mtn. – early veraison
Mega Pascals (negative)
1.2
1
0.8
0.6
0.4
0.2
0
Surface (16.3 gal)
SS 1' depth (2.72 gal)
SS 2' depth (2.72 gal)
SS 3' depth (2.72 gal)
Control
Pulse
Continuous

Table 1. Seasonal irrigation delivery and water use efficiency based on grape production during 2015 and 2016 comparing commercial surface drip irrigation with season-long deficit irrigation imposed by direct root-zone micro-irrigation delivered subsurface from 1-3' depths at rates of 60, 30, or 15% the rate of surface drip irrigation.

	Surface Drip (DI)	Irrigation Treatments DRZ		
	(100%)	(60%)	(30%)	(15%)
2015 Water Use (acre ft.)	1.35	0.81	0.40	0.20
Water/vine each event	16.25	9.75	4.88	2.44
Grape production (tons/ac)	4.54	4.08	3.40	3.18
Production Efficiency (lbs./acre inch applied)	560	840	1400	8271
Relative Efficiency	1.0	1.5	2.5	4.7
2016 Water Use (acre ft.)	1.37	0.84	0.43	0.23
Water/vine each event	17.59	10.27	5.13	2.57
Grape production (tons/ac)	6.73	3.79	2.96	2.20
Production Efficiency (lbs./acre inch applied)	818	752	1147	1598
Relative Efficiency	1.0	0.9	1.4	2.0

Table 2. Plant water stress as determined by leaf stem xylem potential during 2016 growing season contrasting commercial surface drip irrigation with season-long deficit irrigation imposed by direct root-zone micro-irrigation delivered subsurface from 1-3' depths at rates of 60, 30, or 15% the rate of surface drip irrigation.

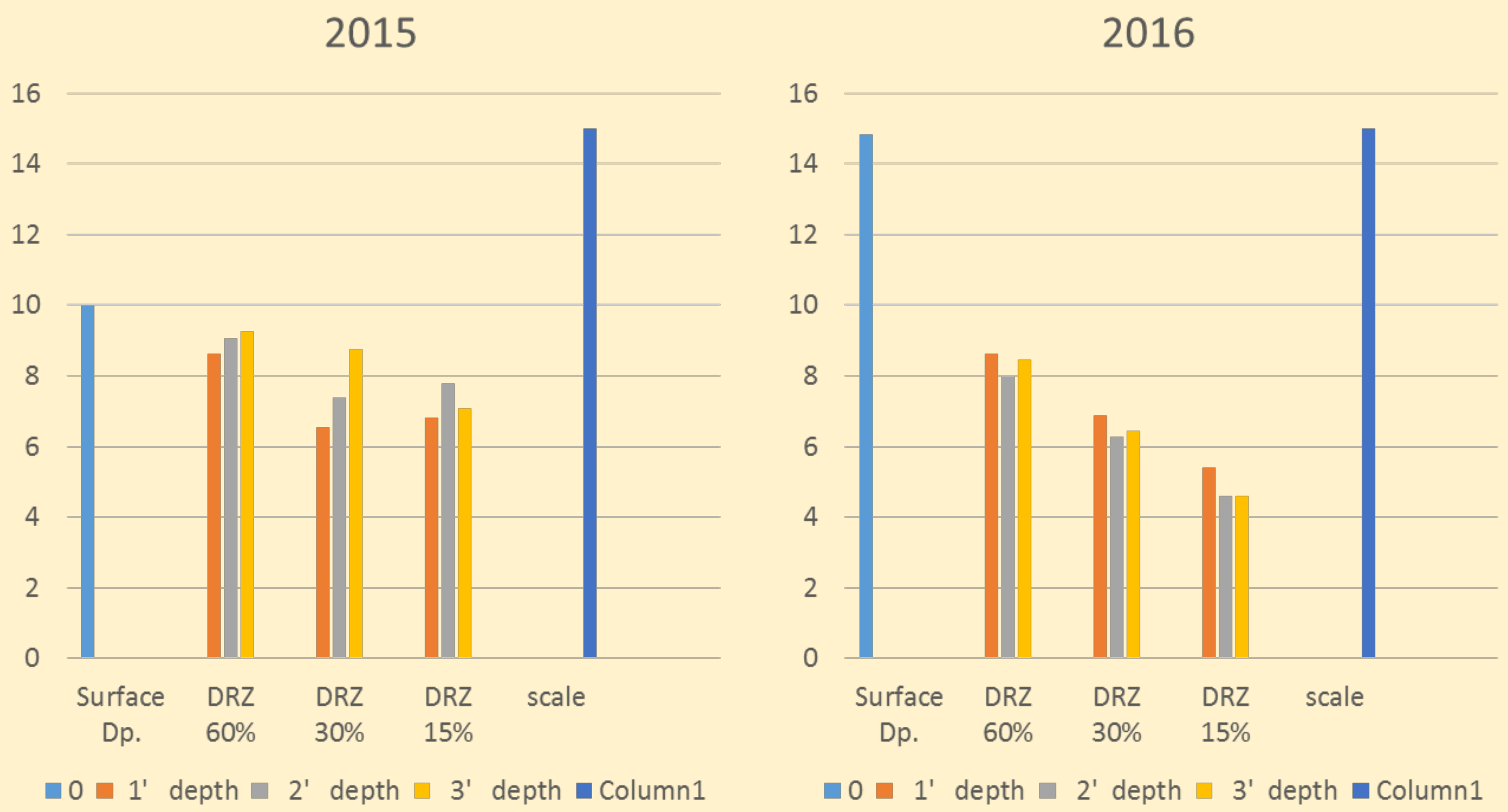
	Irrigation Treatments			
	Surface Drip (DI)	DRZ		
	(100%)	(60%)	(30%)	(15%)
Date	Xylem Pressure Potential (MPa)			
June 3	-.53	-.59	-.64	-.78
July 7	-.64	-.83	-.93	-1.19
August 10	-.87	-1.18	-1.52	-1.59

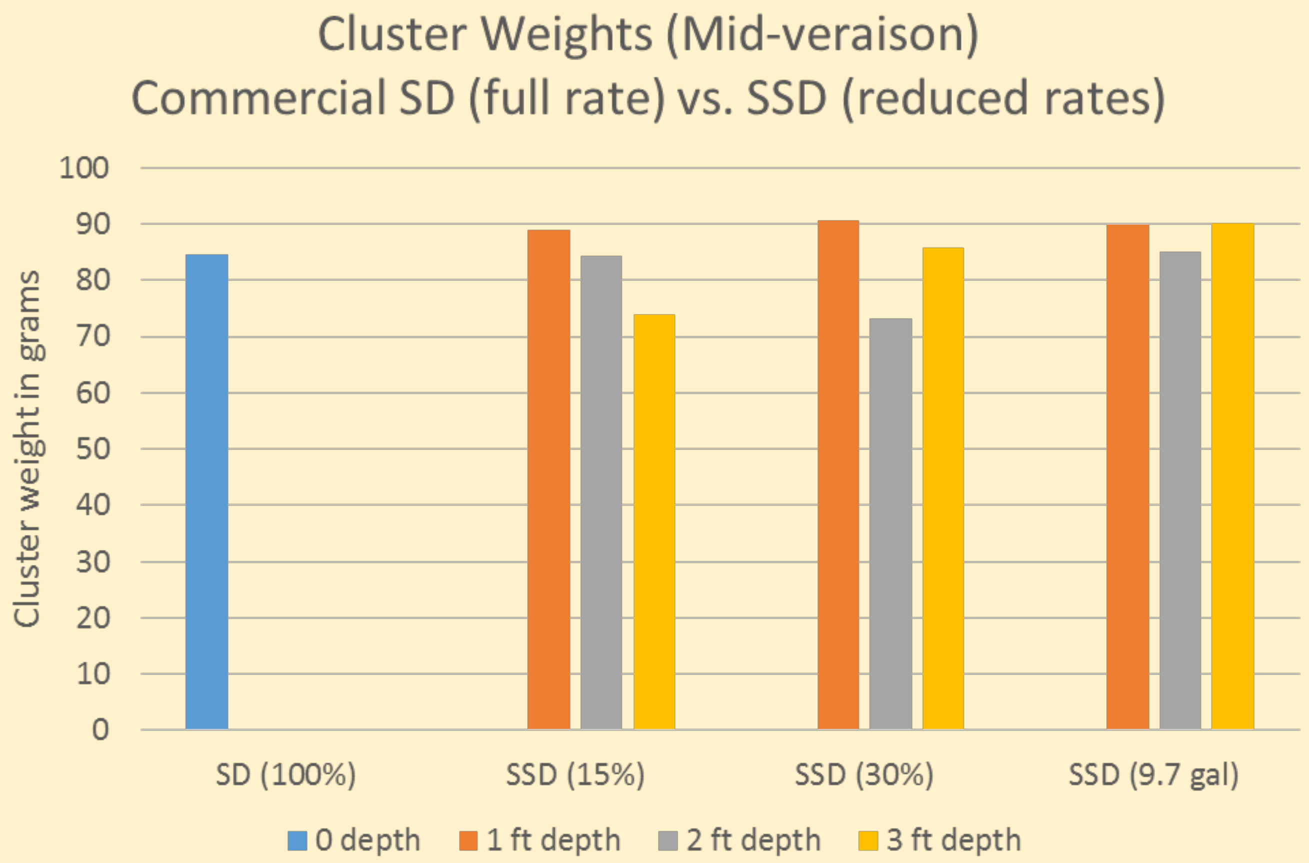
Table 3. Grape production from plots receiving full commercial irrigation applied as surface drip (SD) and applied as direct root-zone micro-irrigation (DRZ) at season-long reduced rates of ca. 60, 30, and 15 % of full commercial rate during 2015 and 2016.

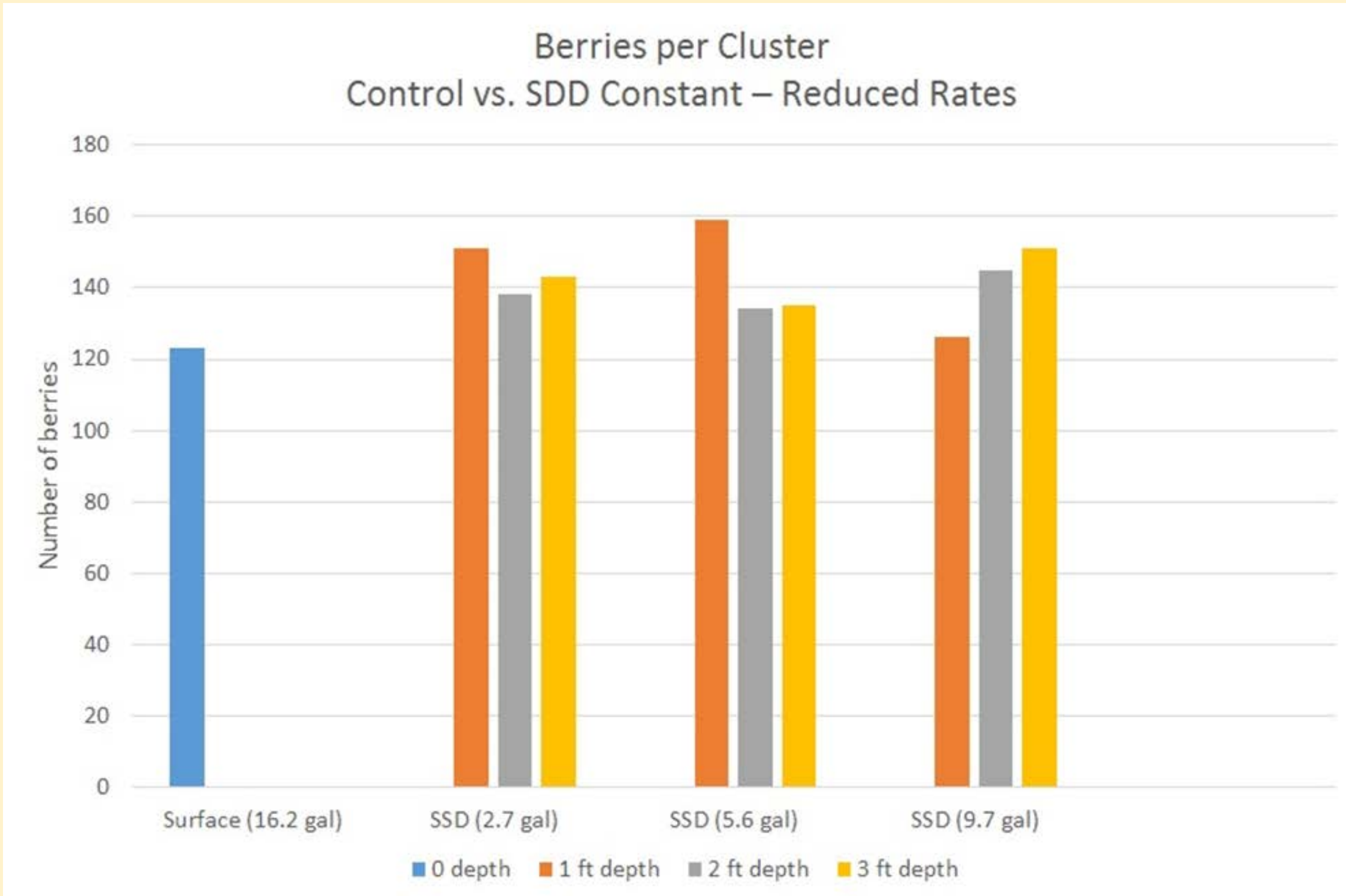
	Irrigation Treatments							
	Surface Drip (DI)		DRZ					
	(100%)		(60%)		(30%)		(15%)	
2015	Wt. per Vine							
	Lbs.	kg.	Lbs.	kg.	Lbs.	kg.	Lbs.	kg.
Surface Drip	10.0	4.55						
DRZ at -1’			8.6	3.92	6.6	2.98	6.8	3.09
DRZ at -2’			9.1	4.11	7.4	3.36	7.8	3.55
DRZ at -3’			9.3	4.21	8.8	3.99	7.1	3.21
Mean	10.0	4.55	9.0	4.08	7.6	3.44	7.2	3.28
2016								
	Lbs.	kg.	Lbs.	kg.	Lbs.	kg.	Lbs.	kg.
Surface Drip	14.8	6.73						
DRZ at -1’			8.6	3.90	6.9	3.11	5.4	2.45
DRZ at -2’			8.0	3.62	6.3	2.85	4.6	2.09
DRZ at -3’			8.5	3.84	6.4	2.92	4.5	2.08
Mean	14.8	6.73	8.4	3.79	6.5	2.96	4.9	2.20


clueless

Average Harvest Weight per Vine (lbs.)




Cluster Weights (Mid-veraison)
Commercial SD (full rate) vs. SSD (reduced rates)
Cluster weight in grams
100
90
80
70
60
50
40
30
20
10
0
SD (100%)
SSD (15%)
SSD (30%)
SSD (9.7 gal)
0 depth
1 ft depth
2 ft depth
3 ft depth


Berries per Cluster
Control vs. SDD Constant – Reduced Rates
Number of berries
180
160
140
120
100
80
60
40
20
0
Surface (16.2 gal)
SSD (2.7 gal)
SSD (5.6 gal)
SSD (9.7 gal)
0 depth
1 ft depth
2 ft depth
3 ft depth

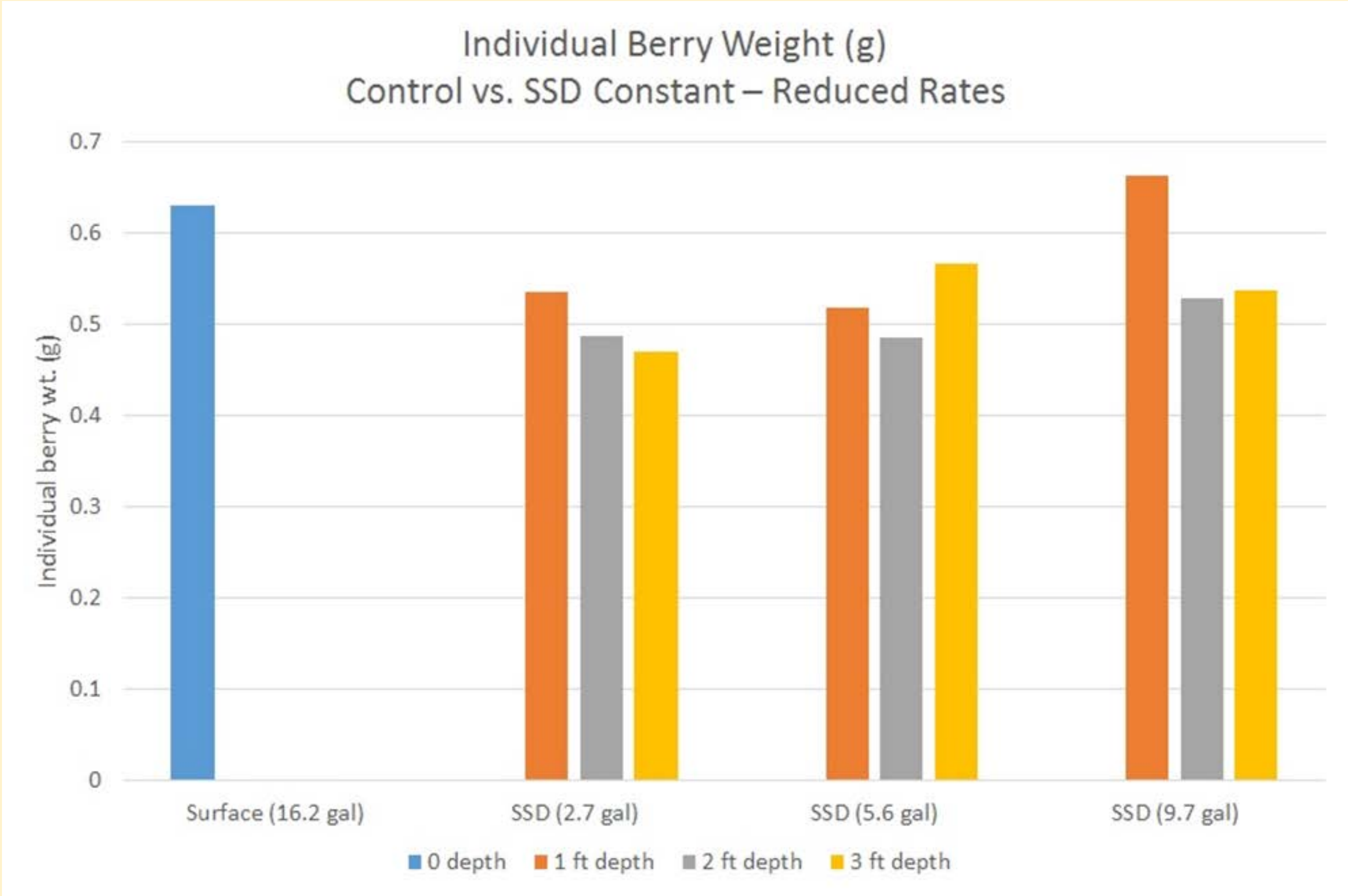

Individual Berry Weight (g)
Control vs. SSD Constant – Reduced Rates
Individual berry wt. (g)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Surface (16.2 gal)
SSD (2.7 gal)
SSD (5.6 gal)
SSD (9.7 gal)
0 depth
1 ft depth
2 ft depth
3 ft depth

Table 4. Comparison of selected chemical components influencing red wine quality. Analyses of Cabernet Sauvignon grapes grown under full and reduced rates of irrigation season-long during 2016. Reduced irrigation rates were applied via direct root-zone micro-irrigation (DRZ) delivered 2 feet (61 cm) subsurface.

Component	Surface drip (DI)	--------------------------	DRZ	--------------------------
	Control (100%)	High (60%)	Moderate (30%)	Low (15%)
pH	3.41	3.36	3.48	3.55
Brix	25.5	27.1	27.6	28.6
Tannins	403	594	600	741
Anthocyanins	1015	1242	1298	1480

Summary

- 70-90% production as under full irrigation
- Higher numbers of berries per cluster
- Smaller individual berries
- Berry and wine quality?

Objective

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- ✓ Evaluate the applicability of **aerial multispectral and thermal imaging** to characterize **plant response** and usefulness of such data in **assessment of different irrigation treatments**

Sub-surface Irrigated Plot

Low Altitude Remote Sensing

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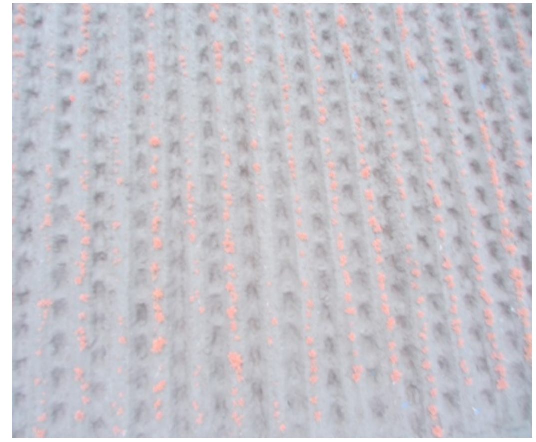

Resolution: ~30 m/pixel **~2 m/pixel** **~2 cm/pixel**



UAS benefits:

- Low cost, timeliness, high spatial resolution
- High temporal resolution, insensitivity to cloud cover
- Access to inaccessible areas, control of data ownership

Khot et al., 2016; Sankaran et al., 2015; Paneque-Gálvez et al., 2014

Types of UASs

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UAS	Max Weight (lb)
Group 1 & 2 (small UAS)	55
Group 3	<1320
Group 4 & 5	>1320








Source: WSU State Magazine, Fall 2014

Sensors

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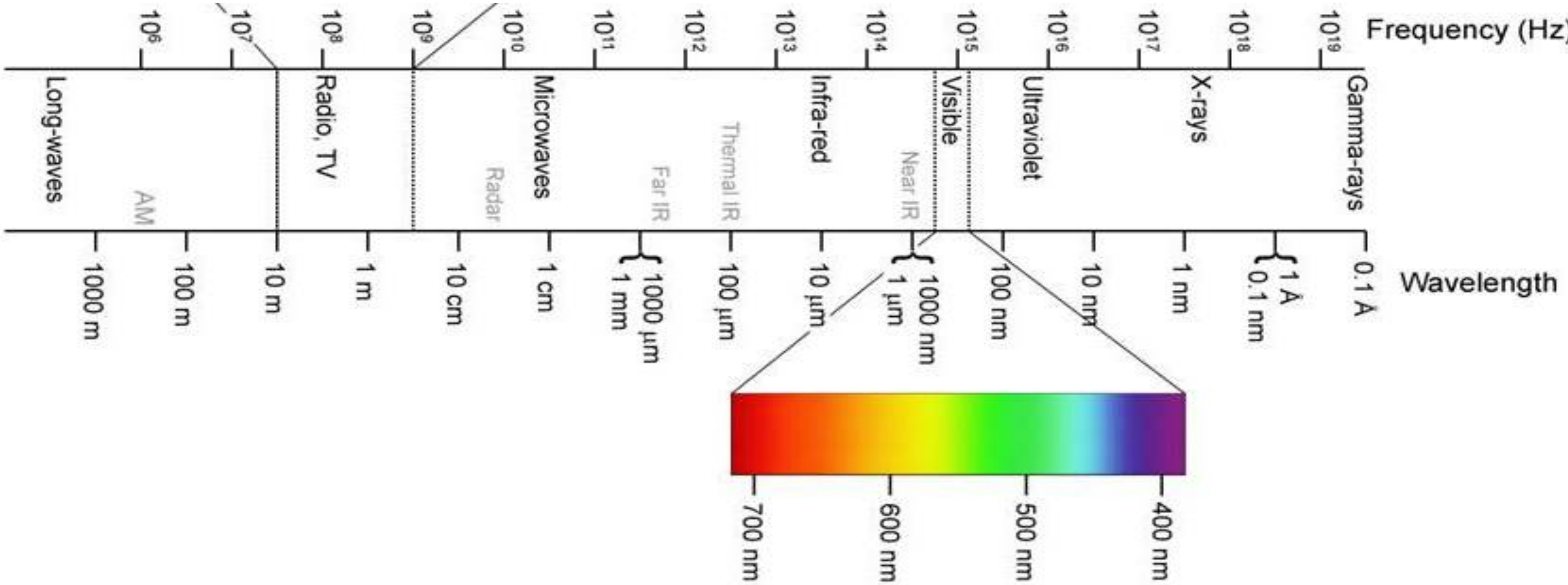


1

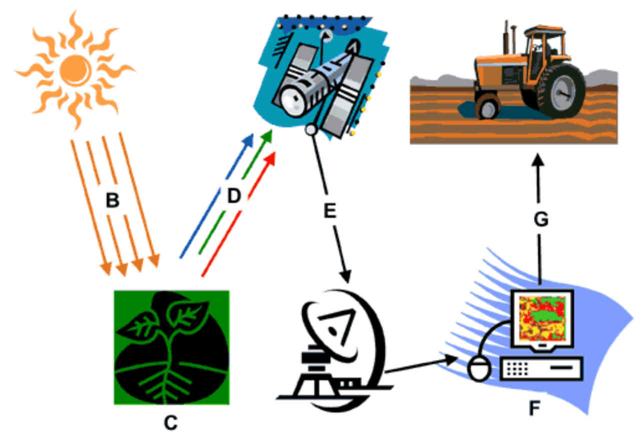
Imaging

Non-imaging

2

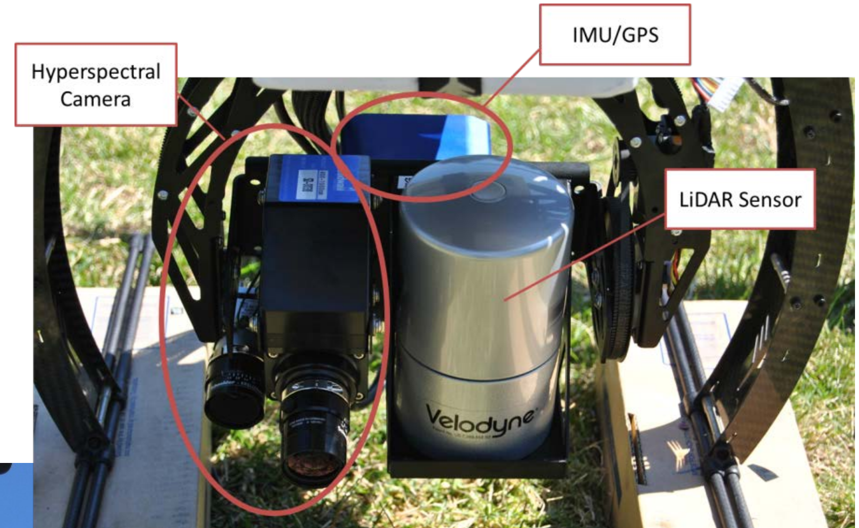
Active

Passive



Sensors

Multi-spectral imaging



3D LiDAR

Infrared Thermal Imaging

Multiband Camera

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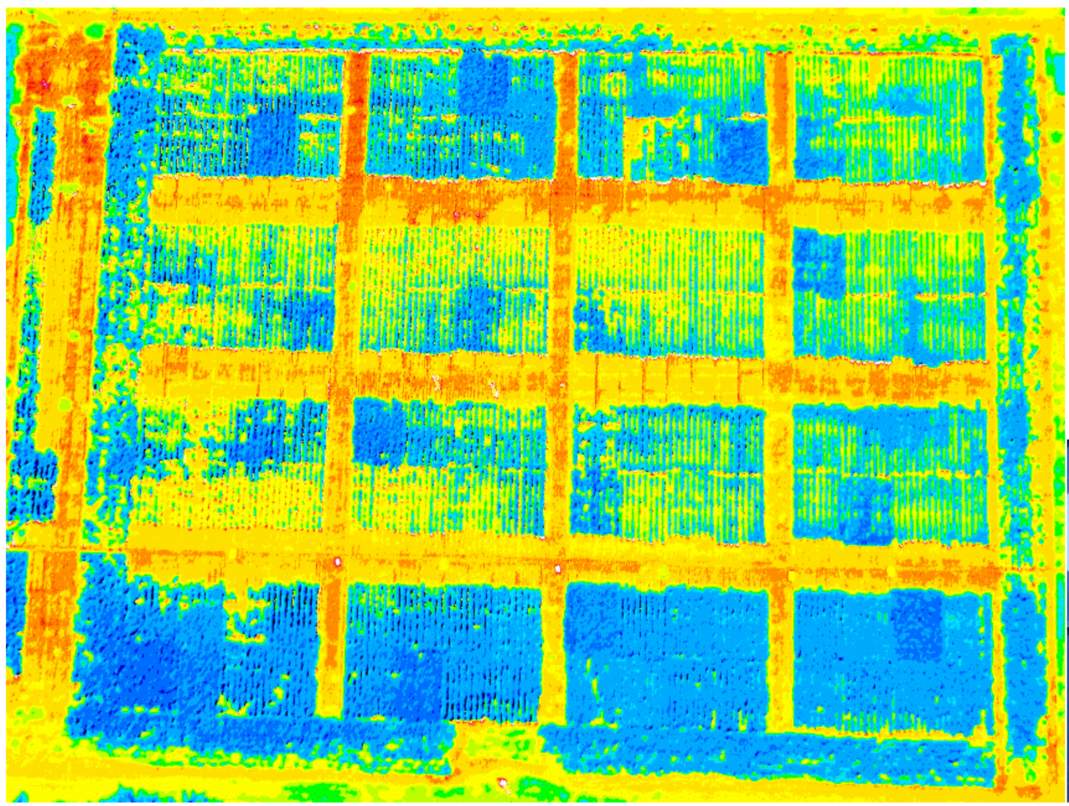
Material and methods

- Unmanned Aerial System
  - ✓ Okto XL 6S12, Mikrokopter, Germany
  - ✓ COA# 2015-WSA-153-COA (Max Height: 400 FT AGL)

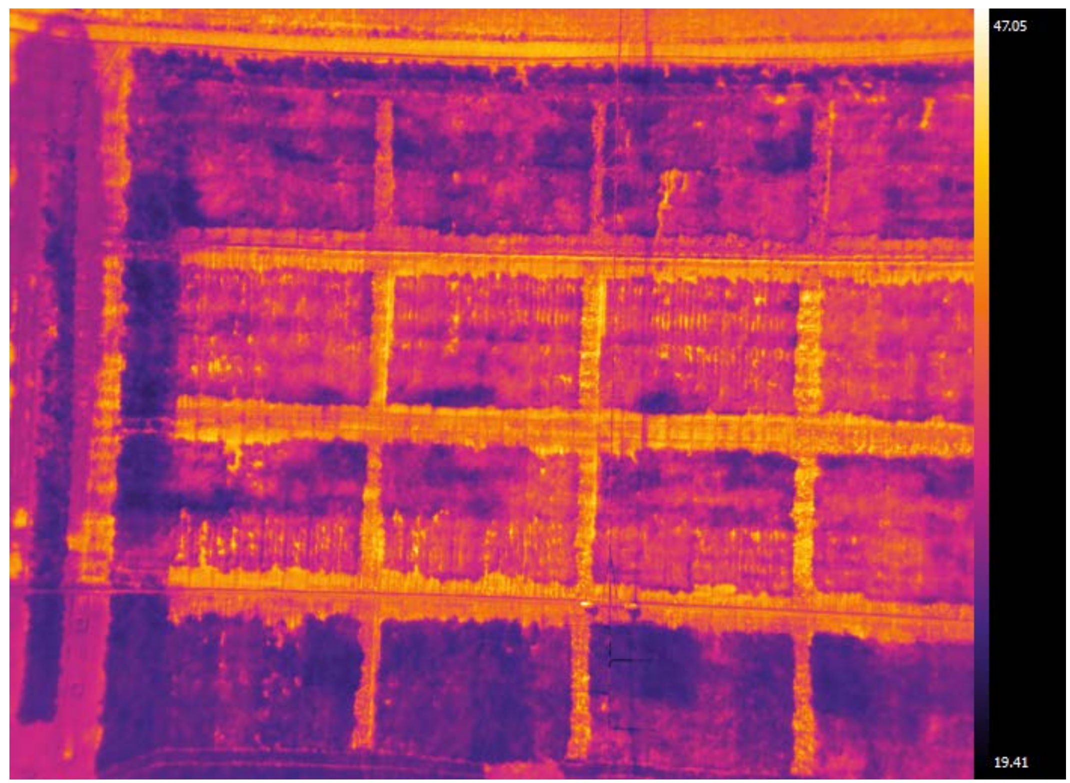
Multi Spectral (3-band)

- Imaging, Passive type
- Range: 380-1000 nm
- Measured: reflectance (few bands [R, G, NIR(680-800 nm)])
- Resolution: 3.5 cm/pixel @ 100 m
- Crop scouting, nutrient deficiency, water stress, diseases
- Issues: few spectral bands



Thermal Infrared Sensor

- Imaging, Passive type
- FLIR Tau2 640: 640×512 pixels
- Resolution: 9.4 cm/pixel @ 100 m
- Range: 7-14 µm
- Measured: pixelated temperature
- Stomatal conductance, Water/diseases stress
- Issues: low resolution



Material and methods

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- **VIS-NIR spectroscopy**
  - SVC HR-1024, Spectra Vista Co., NY
  - Wavelength range: 350-2500 nm
  - Resolution: $\leq 3.5\ nm, 700\ nm$
    $\leq 9.5\ nm, 1500\ nm$
    $\leq 6.5\ nm, 2100\ nm$

- **Multi-spectral sensing platform**

Material and methods

- Stomatal conductance (mmol/m^2s)

  SC-1 Leaf porometer (Decagon Devices, Pullman, WA).

Pressure bomb

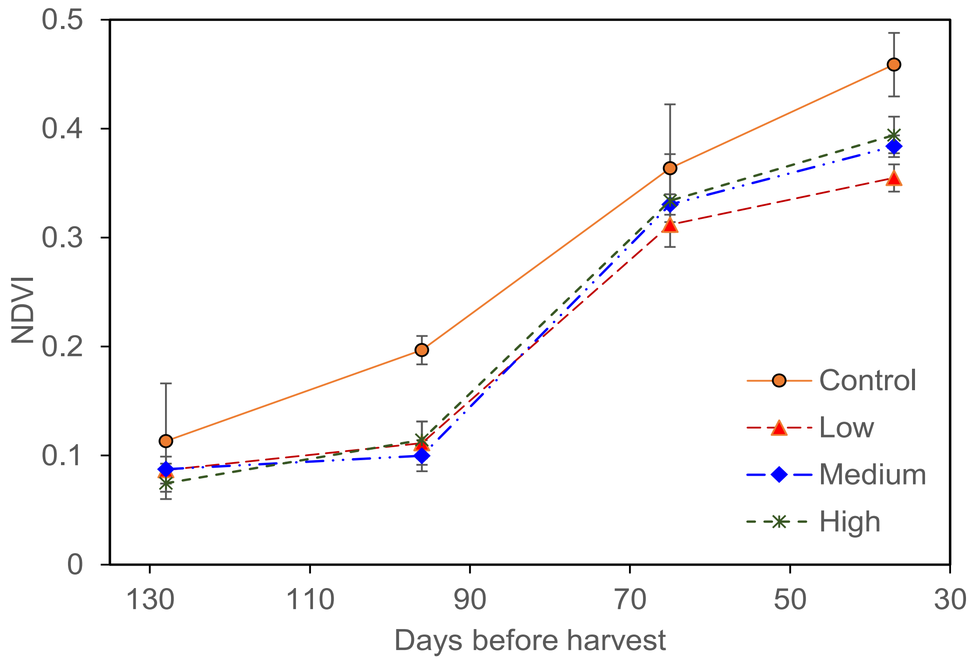
Accuracy	10% of measurement
Conductance range	0 to 1000 mmol m-2s-1
Operating environment	5 to 40°C, 0 to 100% RH, with desiccant chamber
Power	Four "AA" batteries
Measurement units	mmol m-2s-1, m2/s mol-1, s/m
Data storage	4095 measurements in flash memory
Computer interface	9 pin serial RS232 interface
Aperture diameter	6.35 mm
Desiccant	Indicating DrieRite, 10-20 mesh
Measurement time	30 s (in auto mode)

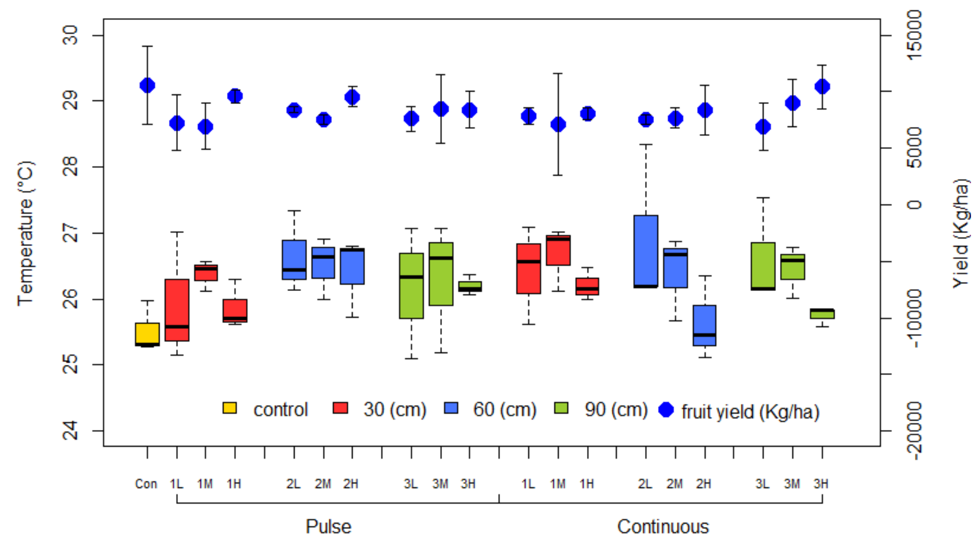
(Source: Decagon Devices Inc.)

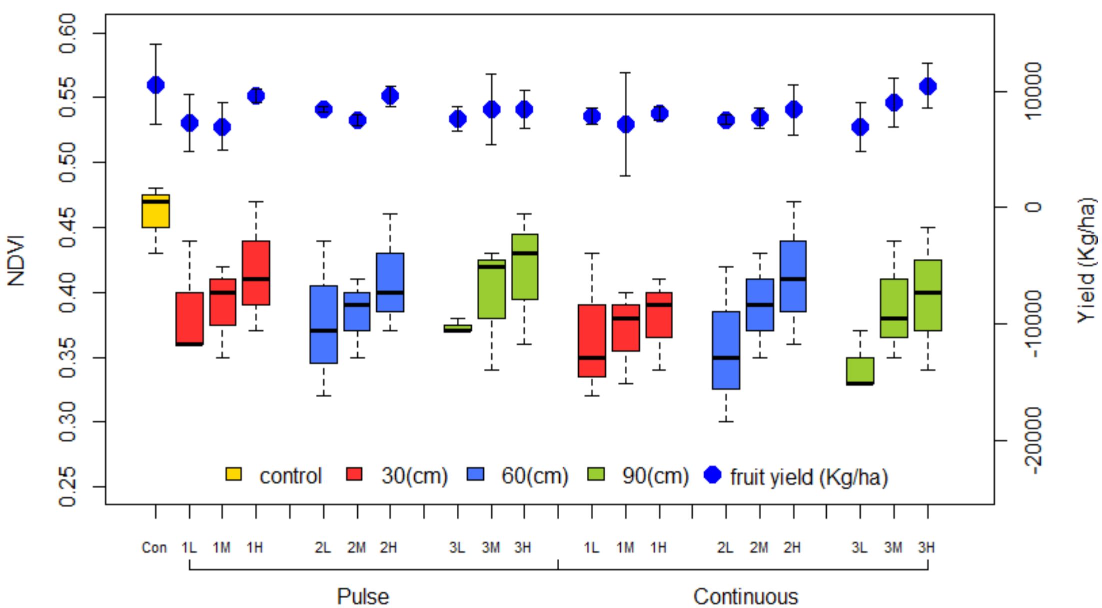
Material and methods

Irrigation type	Pulse, Continuous
Subsurface irrigation depth (cm)	30, 60, 90
Irrigation rate (% ET)	60, 30, 15
Control	100% ET, surface, continuous
Data collection (2016)	Pre-veraison (July 12) Post-veraison (Aug 12)

Results: 2015 season







Material and methods

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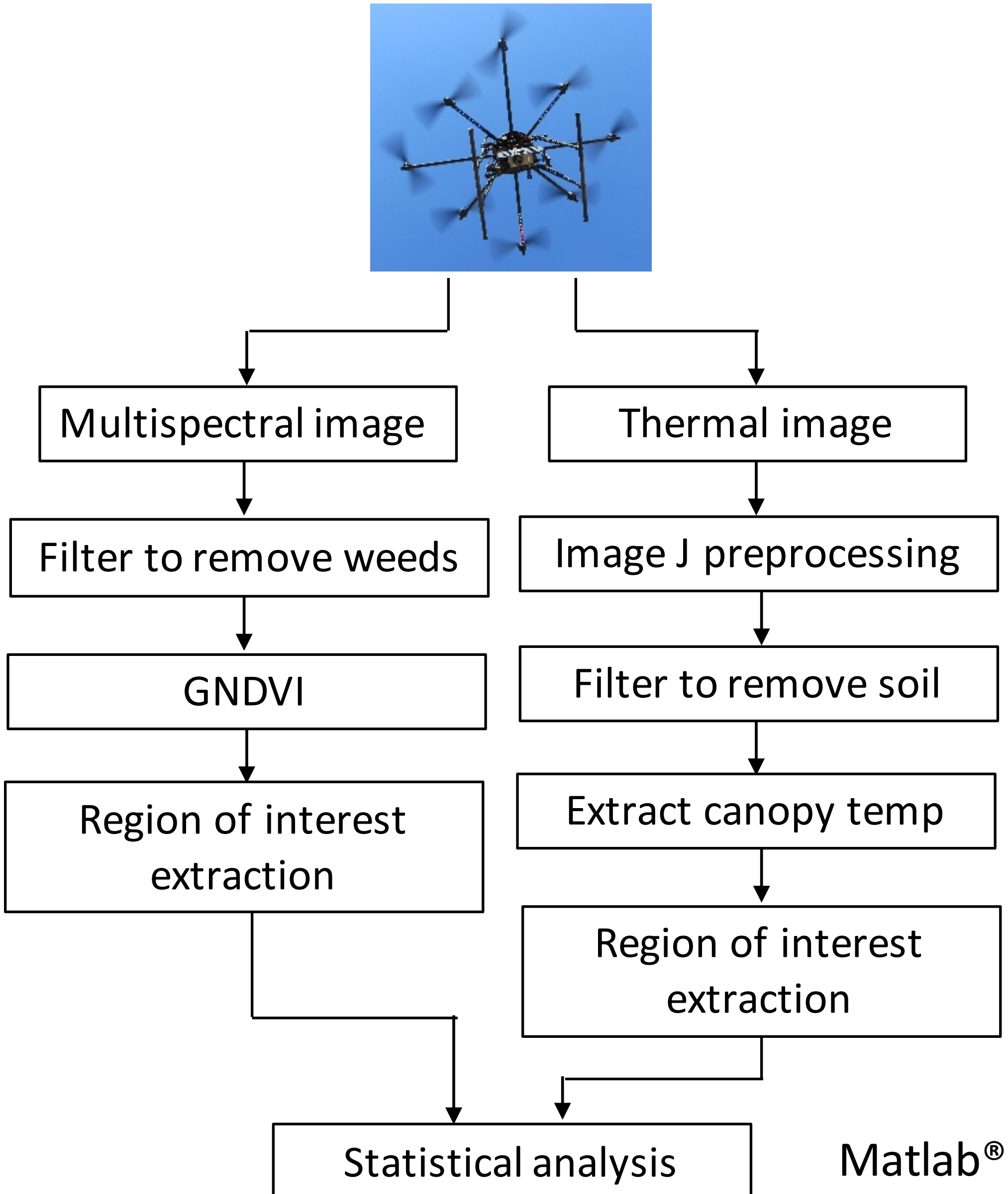
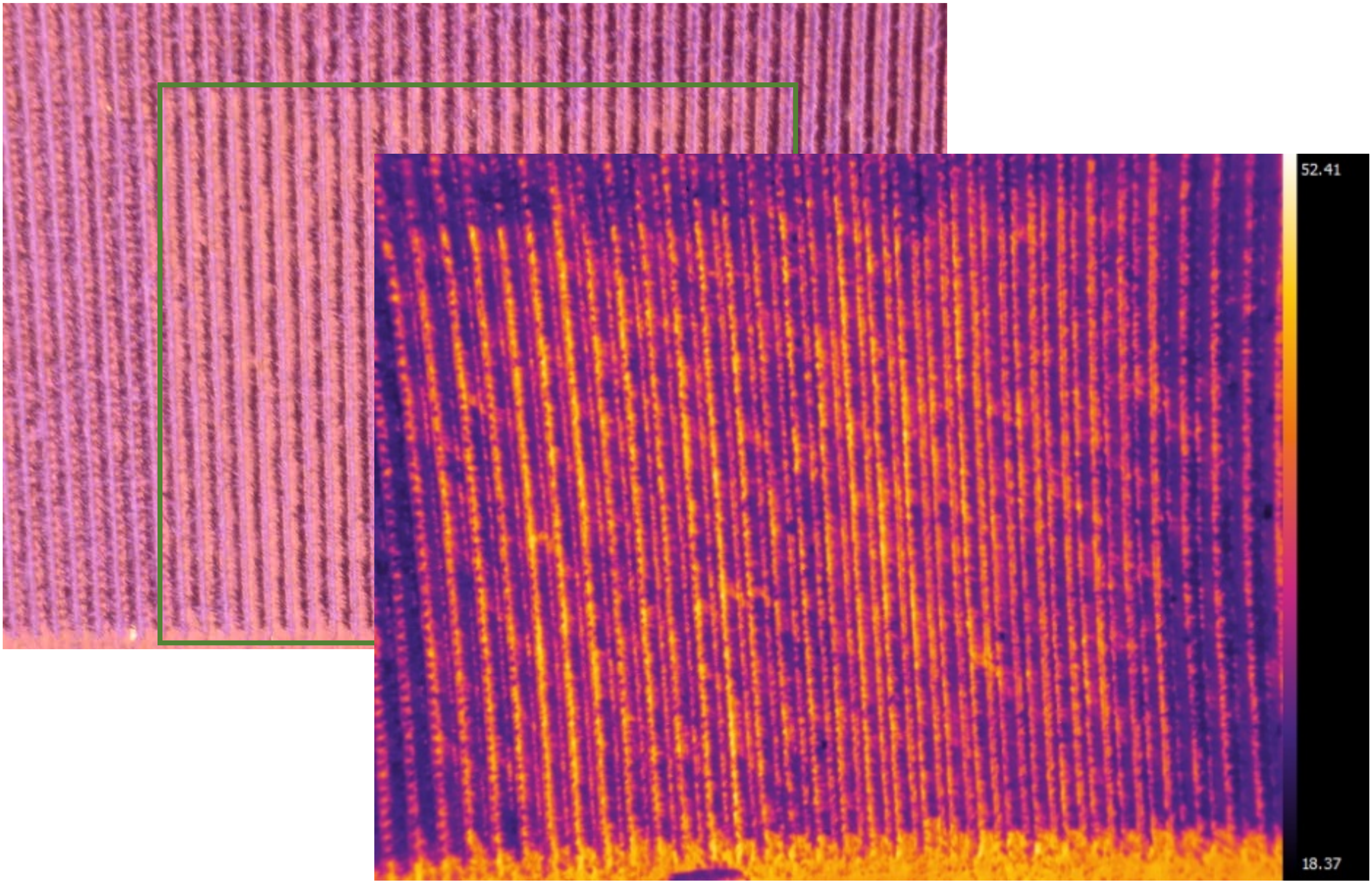


$$GNDVI = (NIR - G)/(NIR + G)$$

Matlab® (Mathworks, Natick, MA)

R Studio (ver. 0.99.451, R Studio Inc., Boston, MA)

Results and discussion



Results: GNDVI

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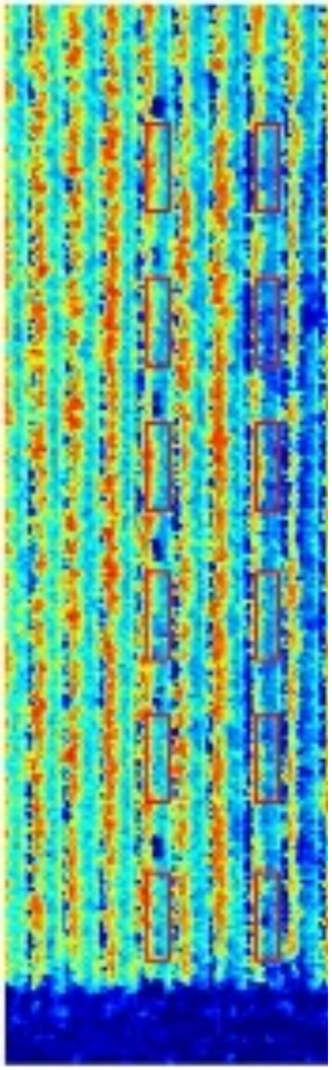
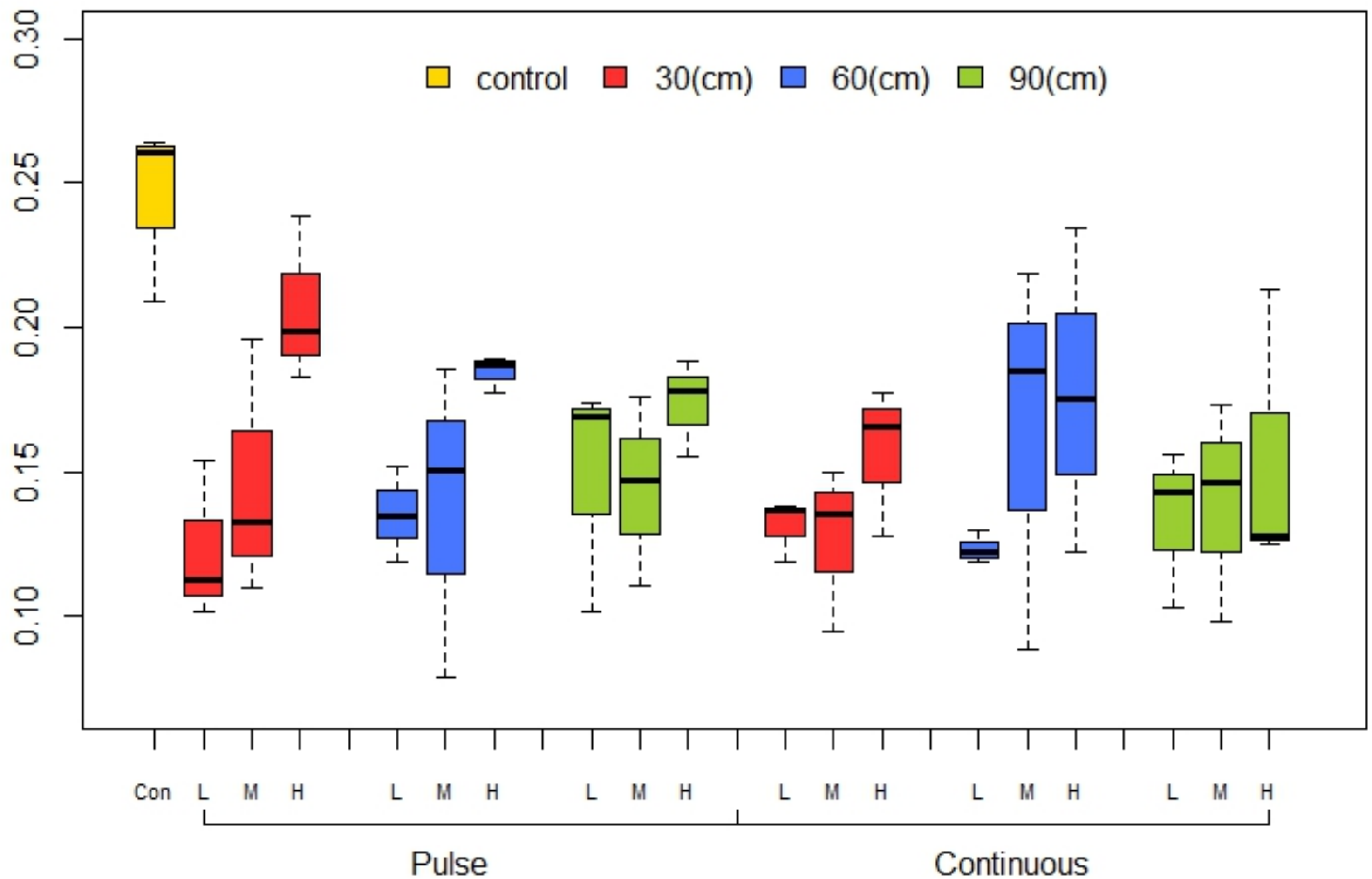
Pre-veraison stage





Results: GNDVI

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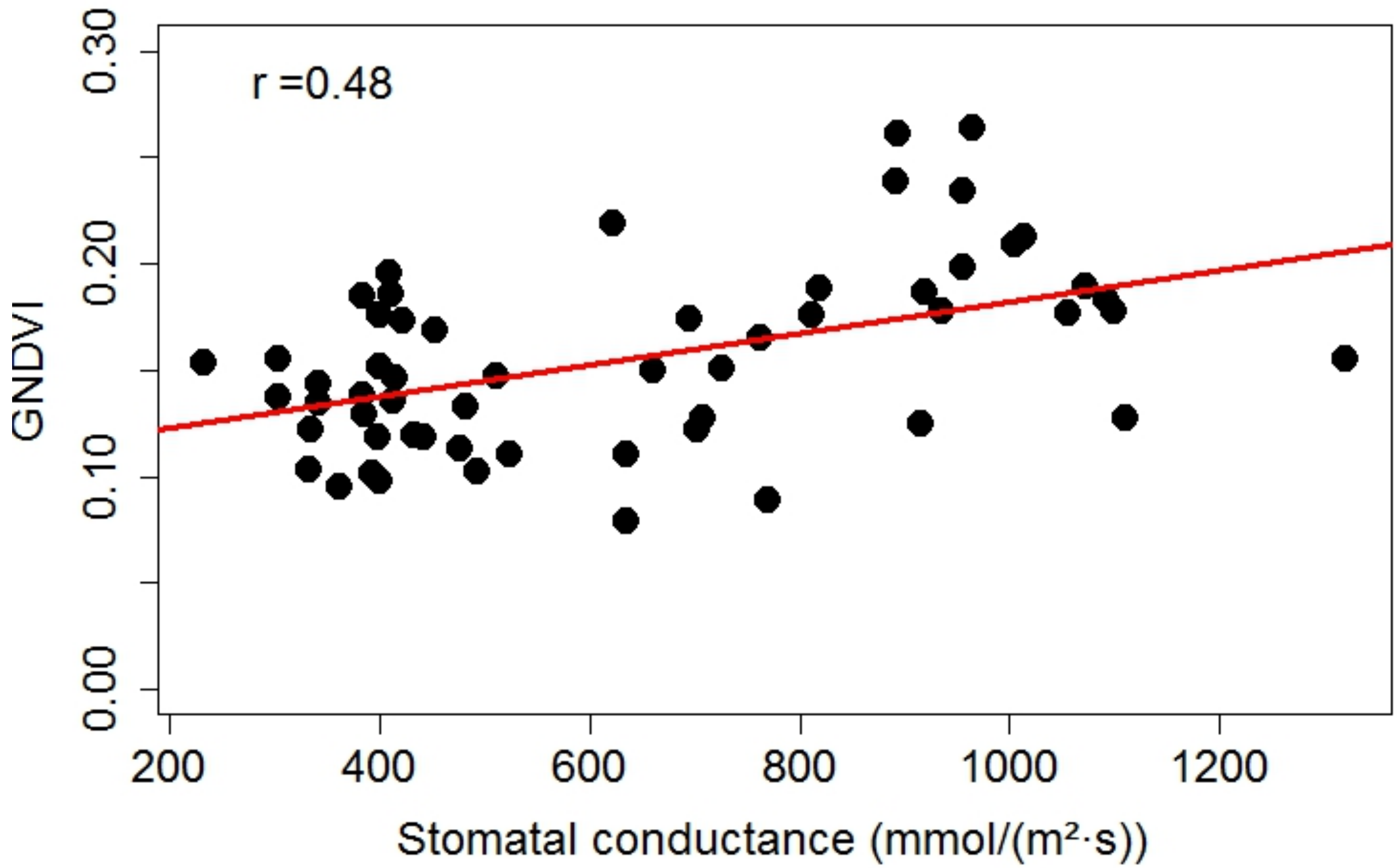
Pre-veraison stage



Results: GNDVI

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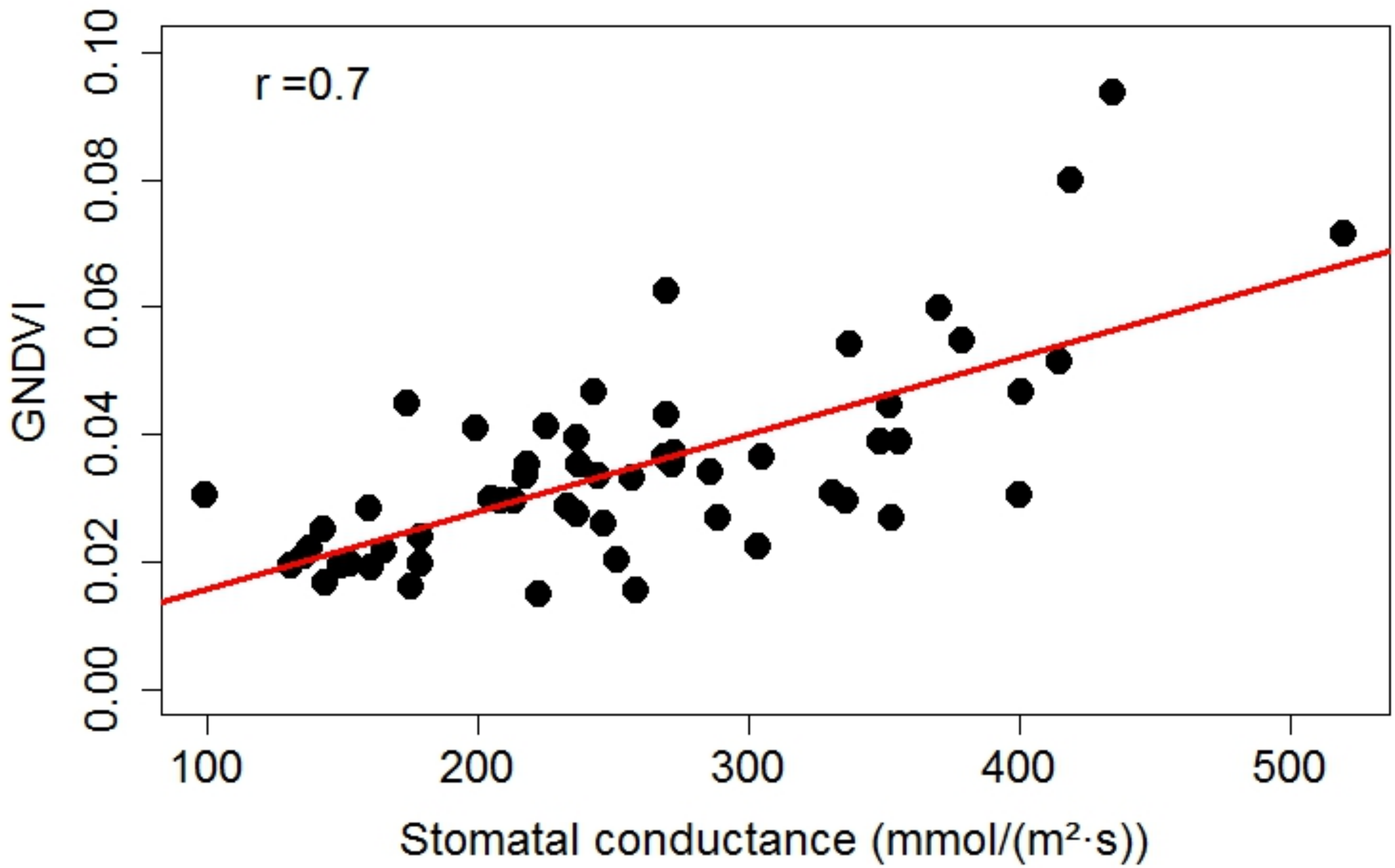
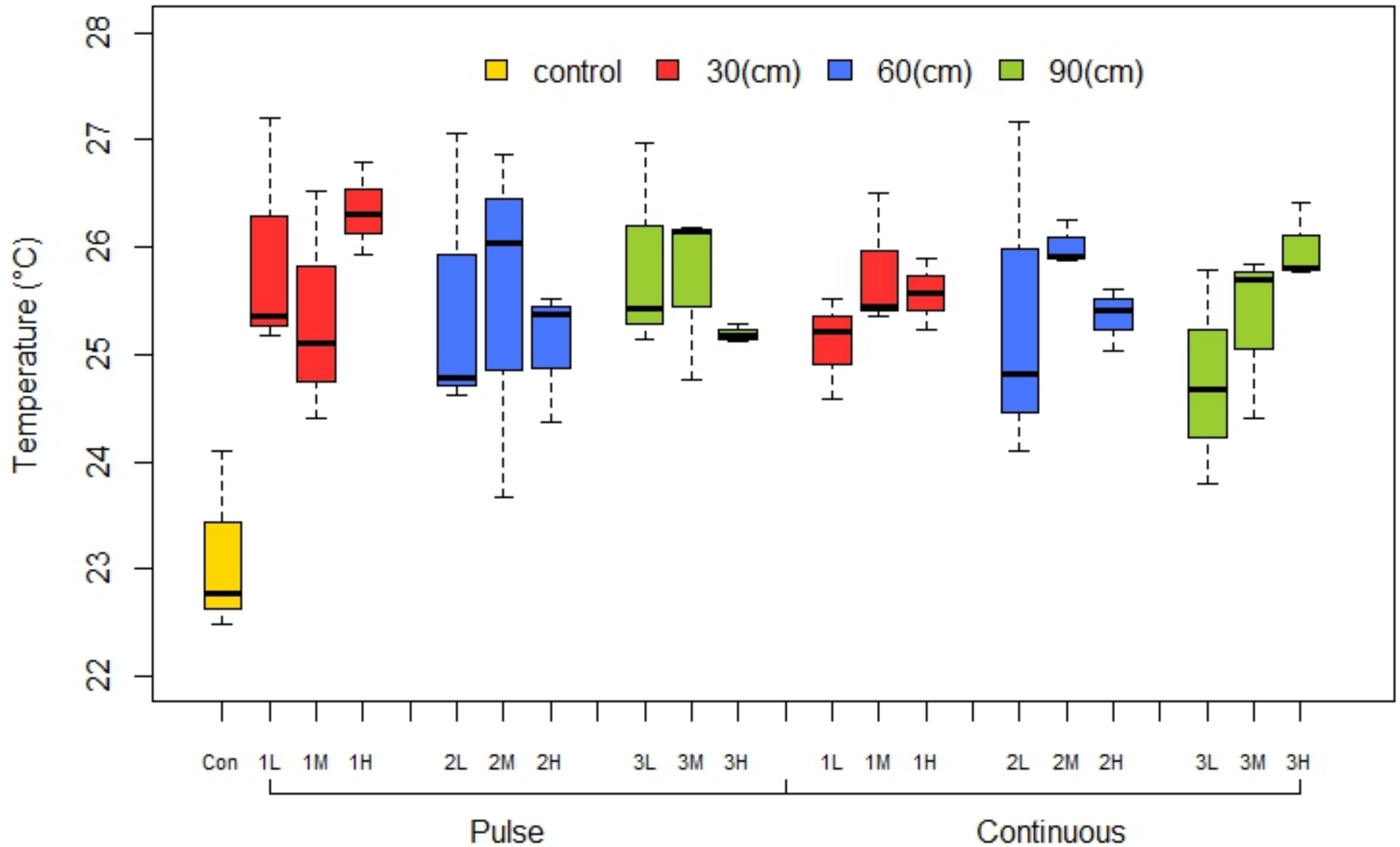
Post-veraison stage



Results: Canopy temperature

Post-veraison stage



Summary

- Treatments showed no yield differences at 5% level (2015 season)
- SSMI has potential to save up to 40% of irrigation water
- UAS based multispectral and thermal infrared images successfully characterized grapevine stress responses; year 2 & 3 data will further confirm this aspect.
- Future work: comparison of aerial sensing data with ground based sensing and reference data (e.g. grapevine stomatal conductance; berry color, acids, sugar, tannins, etc.)

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