Using Drones to Assess Crop Water Limitations and Irrigation Needs of Blueberry and Raspberry

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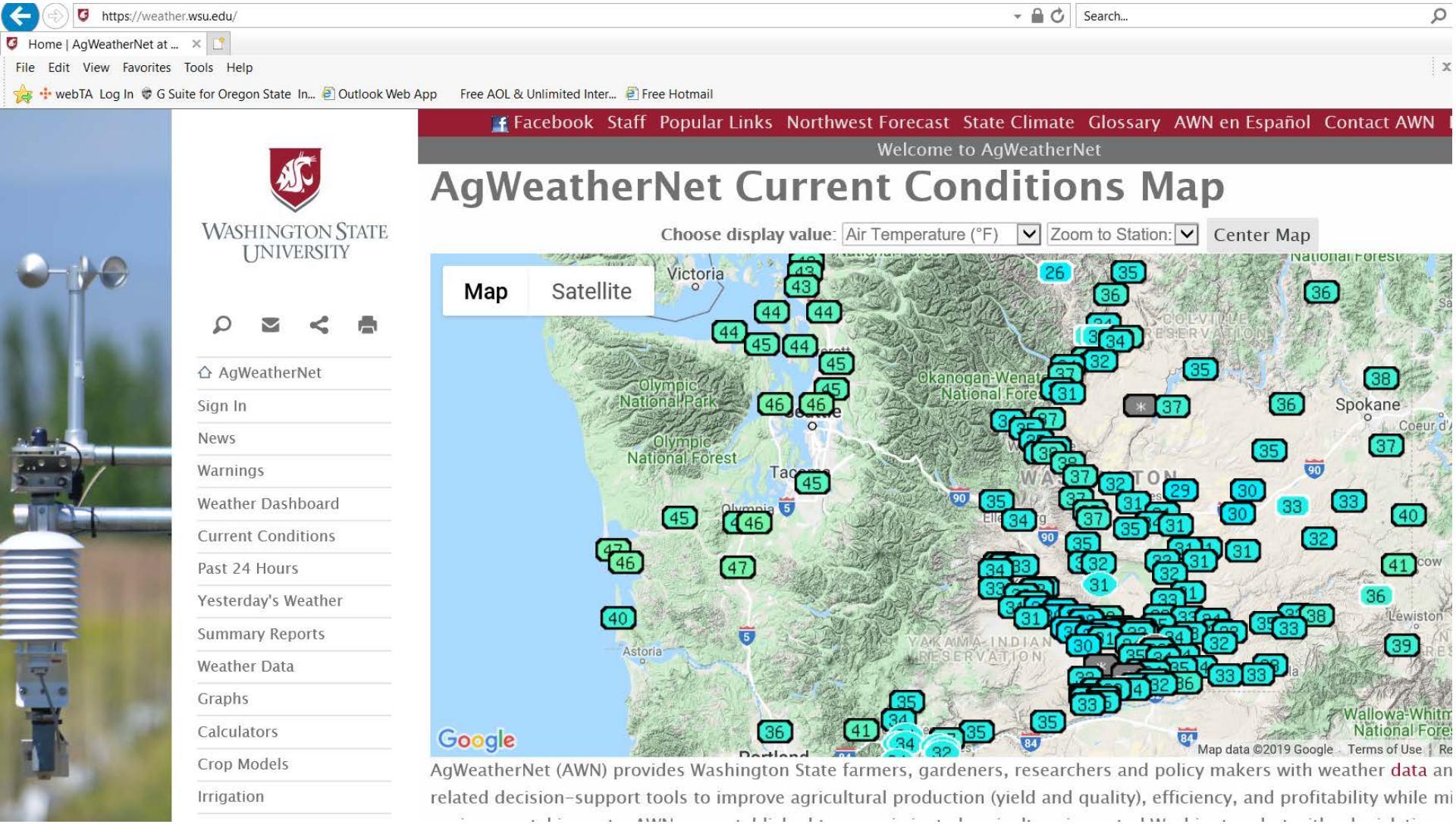
Grower cooperators: Enfield Farms, Curt MaBerry Farm, MaBerry Packing, Sakuma Brothers, Honcoop Farm, Wyckoff Farms, Olsen Brothers

Irrigation Requirements?

Ag Weather Sites

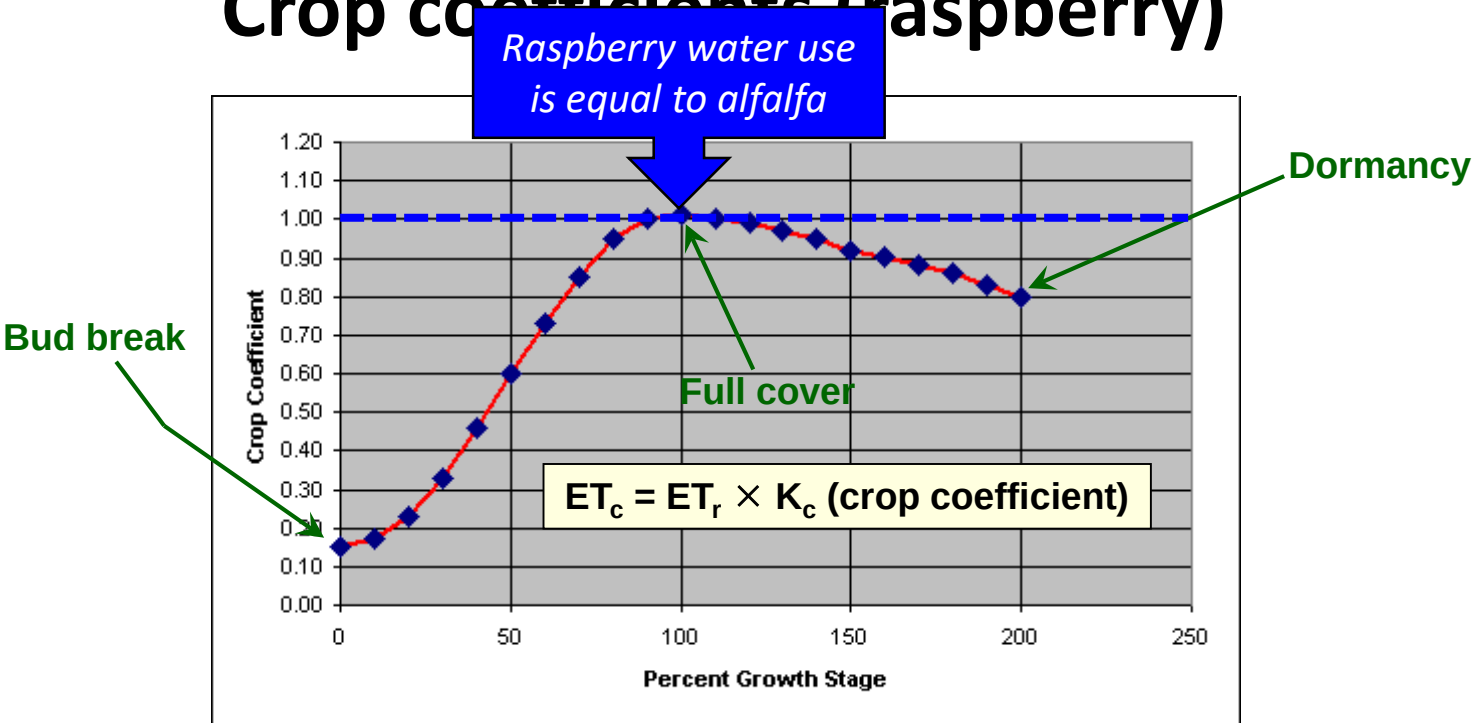


Weather-Based Irrigation Scheduling

$$ET_c = ET_r \times K_c$$

- ET_c = crop evapotranspiration (water use)
- ET_r = reference evapotranspiration
  - From Ag weather station network
- K_c = crop coefficient

Crop coefficients (raspberry)



https://www.usbr.gov/pn/agrimet/

Mar. 23

Apr. 21

May 18

June 15

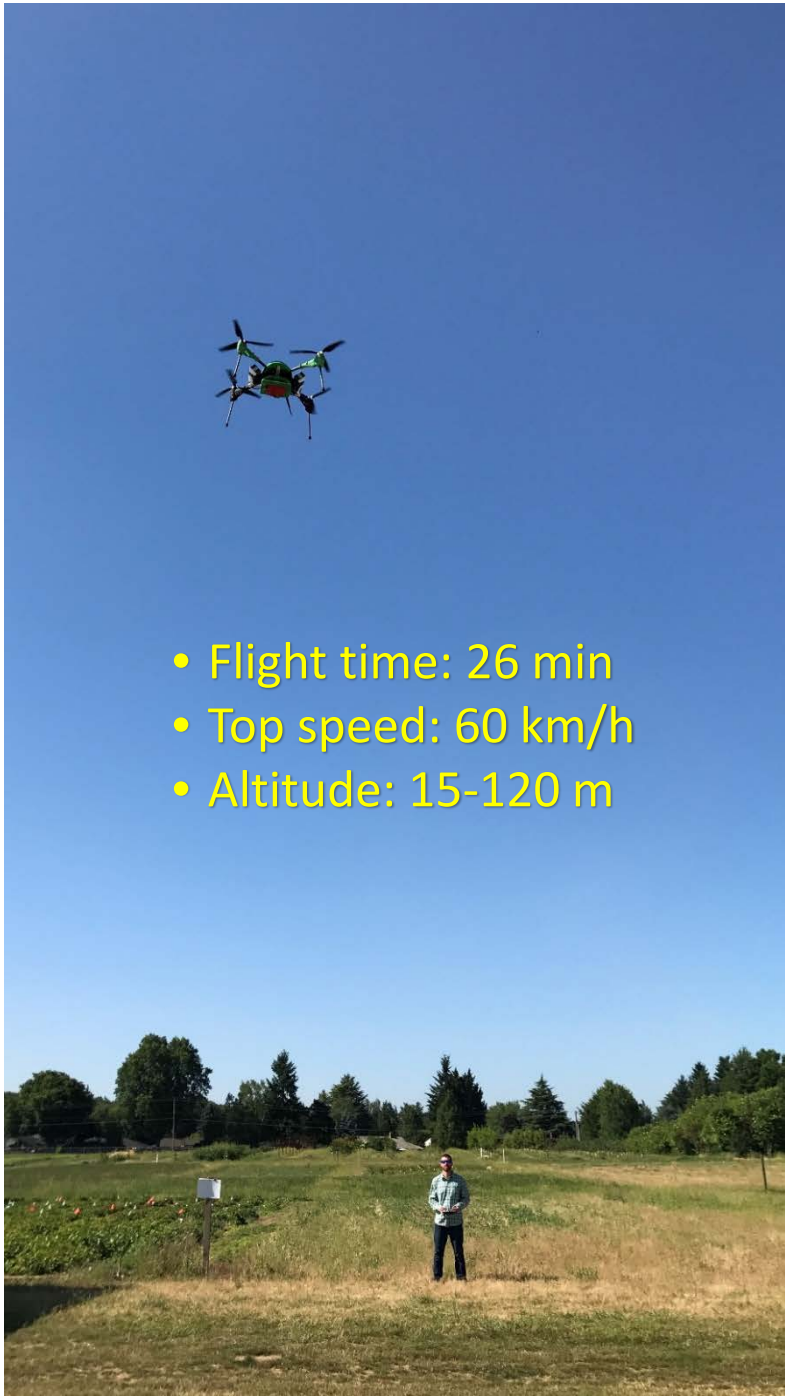
Oct. 10

Funding: WA Specialty Crop Block Grant

Industry support: WBC & WRRC

GOAL:
Develop tools to determine seasonal water requirements & monitor crop water stress in blueberry and raspberry

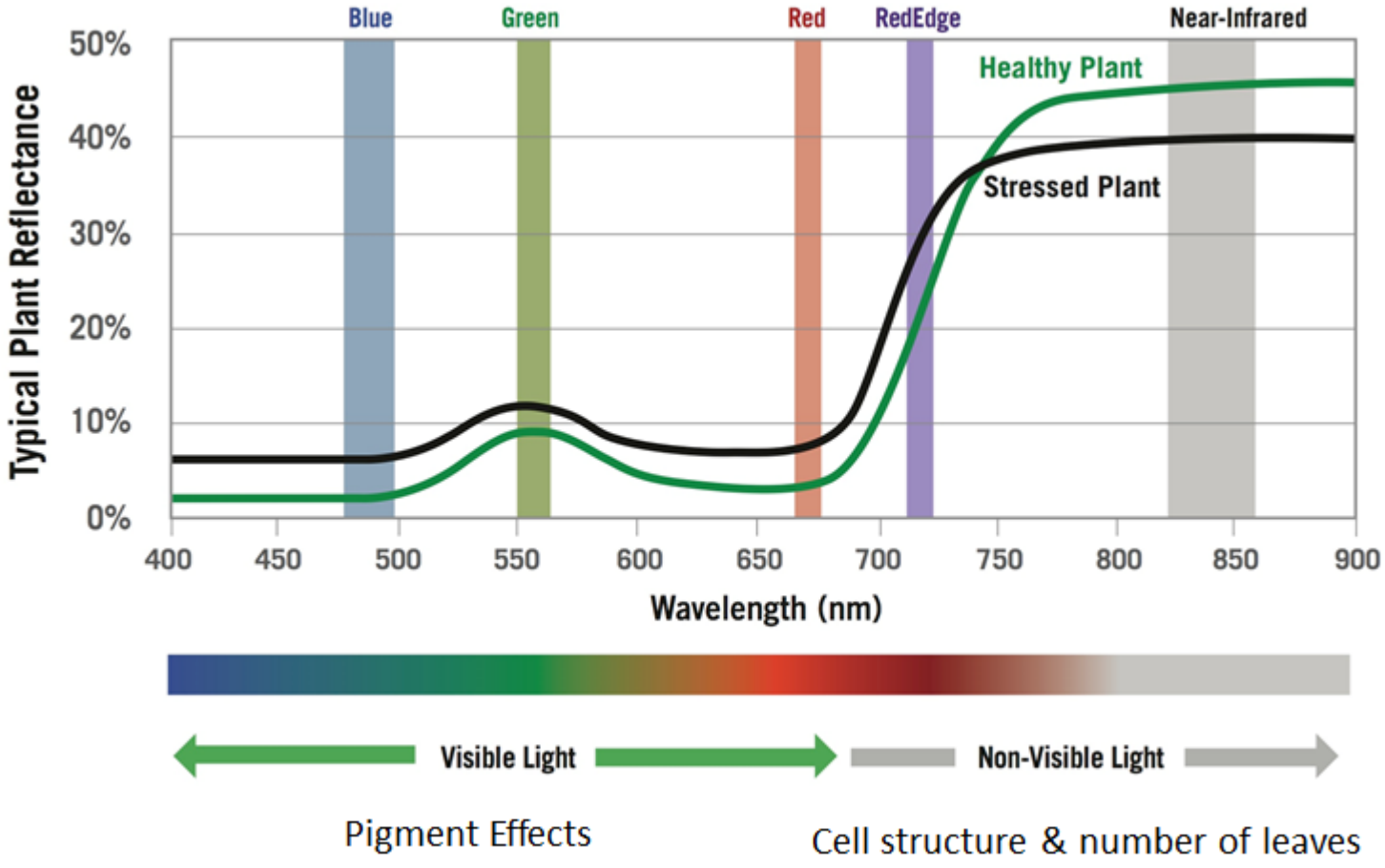

ATI AgBOT


• Flight time: 26 min
• Top speed: 60 km/h
• Altitude: 15-120 m

Multispectral module

IR module (thermal imaging)

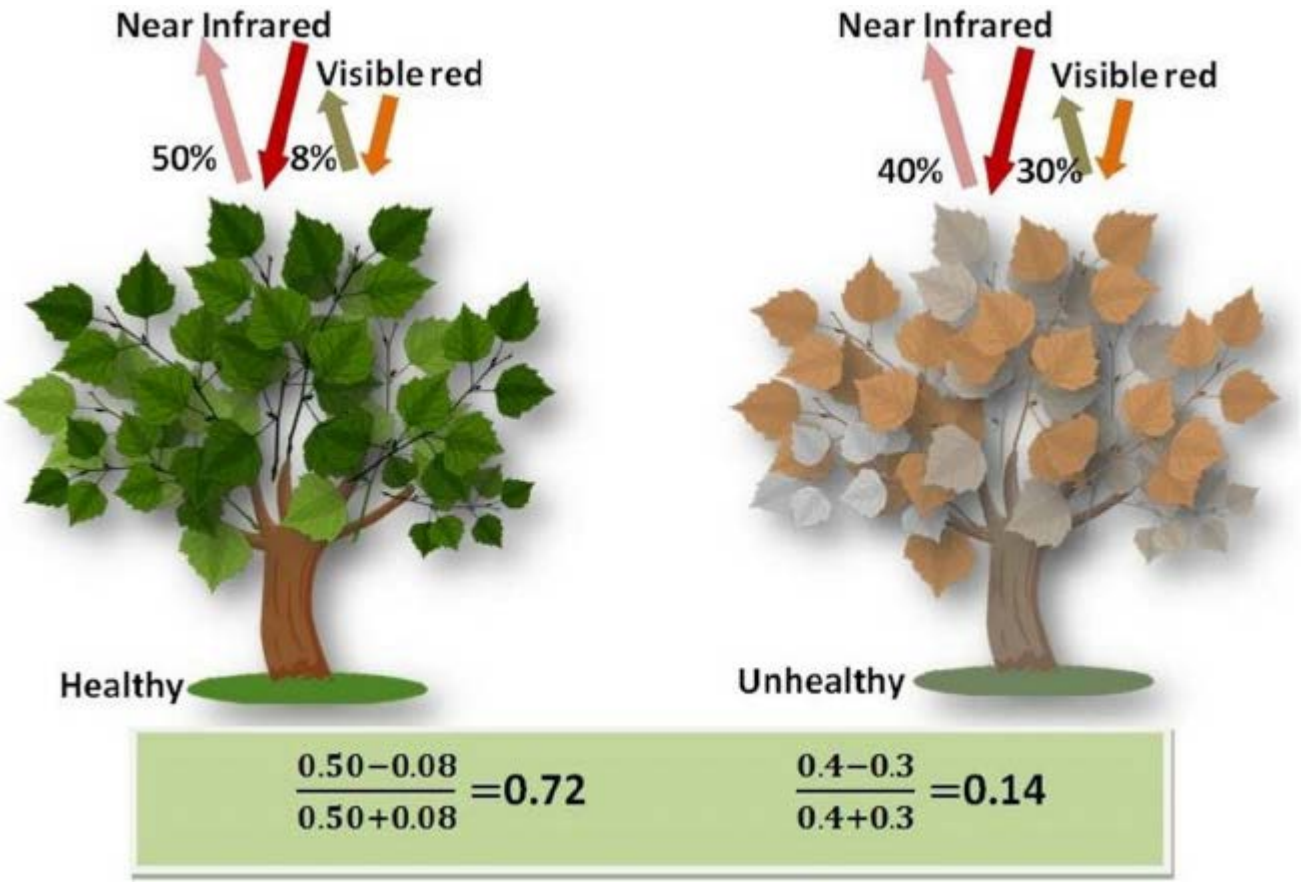
Multispectral module



Source: MicaSense (https://www.micasense.com/rededge-m)

NDVI (Normalized Difference Vegetative Index)

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

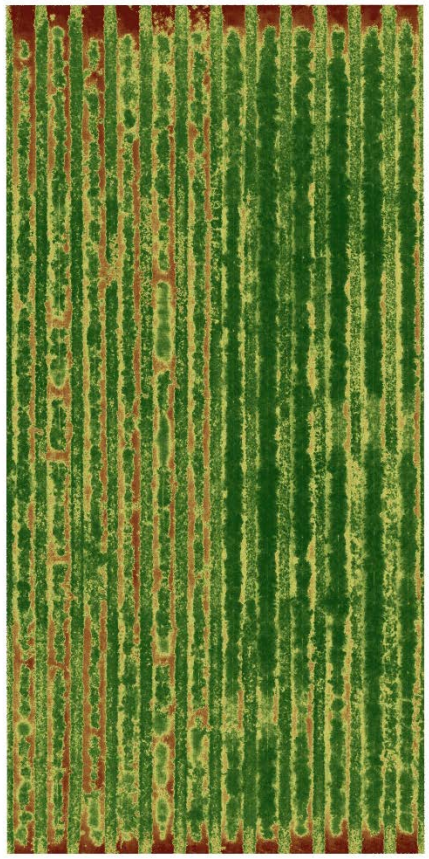


The ratio compensates for changing light conditions, surface slope, and viewing angle

Types of spectral indices

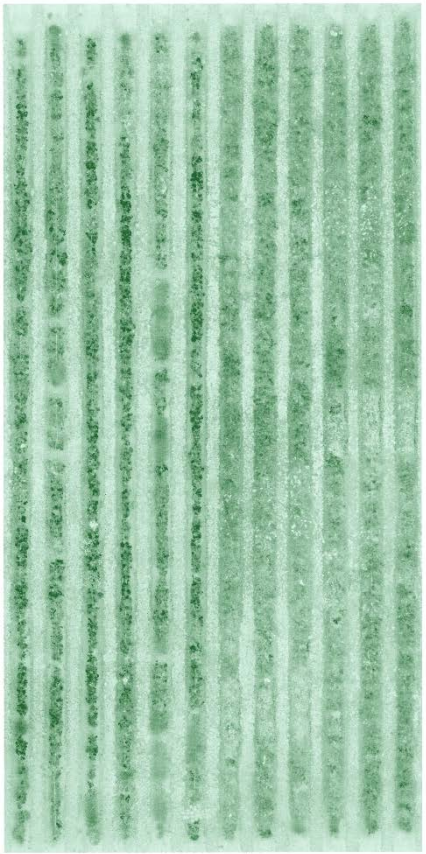
RGB

red, green,
blue composite



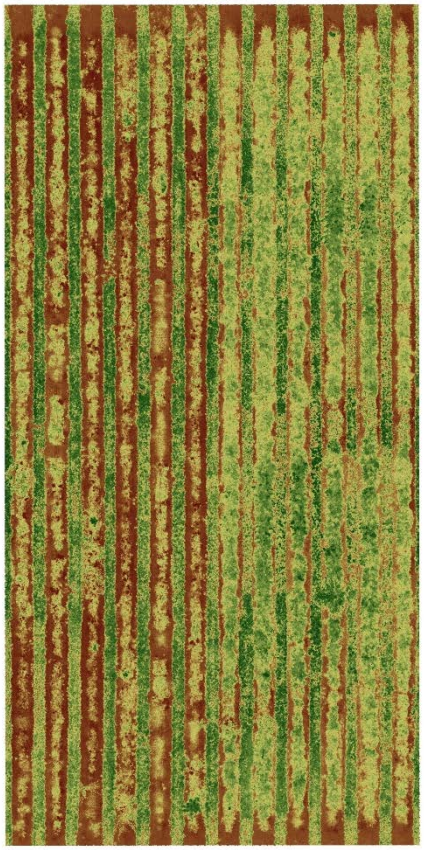
NDVI

$$\frac{(NIR - red)}{(NIR + red)}$$



Chlorophyll

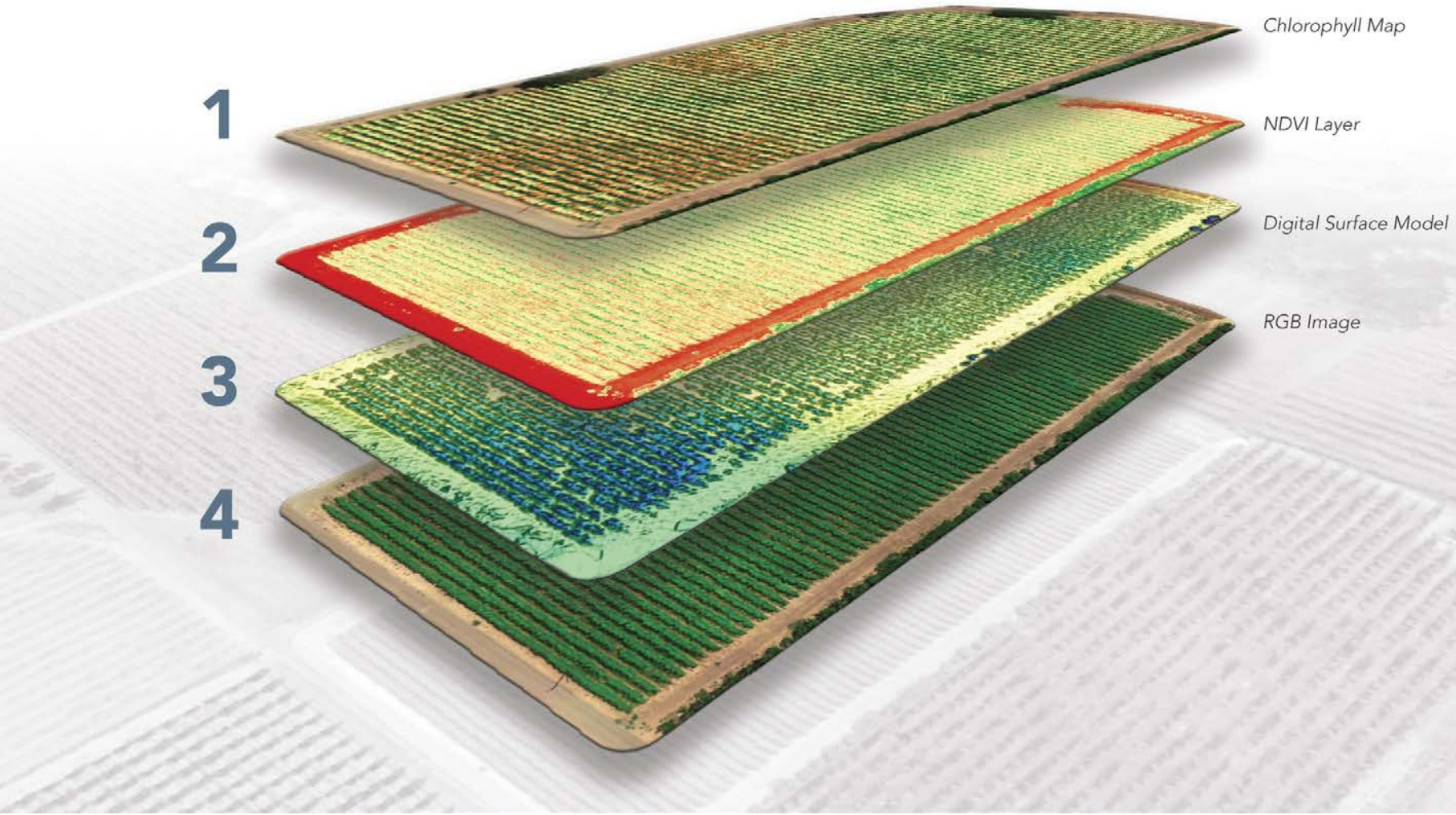
$$\frac{NIR * red}{green^2}$$



VARI

$$\frac{(green - red)}{(green - red + blue)}$$

Types of spectral indices



Source: MicaSense (https://www.micasense.com/rededge-m)

Capturing Images

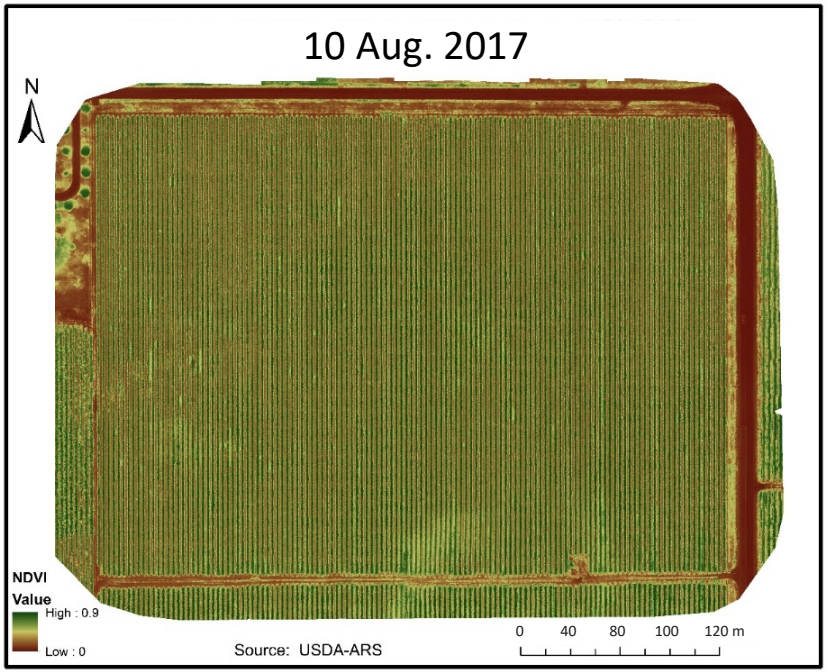
ats

Area:	27.4 acres	Pictures:	630	Flight Time (est):	22:37 Minutes
Distance:	4.52 miles	No of Strips:	18	Photo every (est):	1.79 Seconds
Distance between images:	39 ft	Footprint:	209.5 x 157.1 ft	Turn Dia (at 45d):	43 ft
Ground Resolution:	1.96 inches	Dist between lines:	52.36 ft	Ground Elevation:	72-87 ft

Altitude: 73 m
Speed: 24 km/h
Flight time: 22.5 min
Area: 11 ha

‘Meeker’ raspberry

RGB



NDVI

‘Wake TMField’ raspberry

9 Aug. 2017

Early signs of root rot

N

Altitude: 45 m
Speed: 16 km/h
Flight time: 20 min
Area: 4 ha

0 40 80 100 120 m

Source: USDA-ARS

RGB

9 Aug. 2017

N

NDVI
Value
High : 0.9
Low : 0

0 40 80 100 120 m

Source: USDA-ARS

NDVI

‘Wake TMField’ raspberry

Phytophthora root rot

RGB

NDVI

54.1% cover

NDVI
Value
High : 0.9
Low : 0


‘Meeker’ raspberry
Water requirements?
26 June 2018

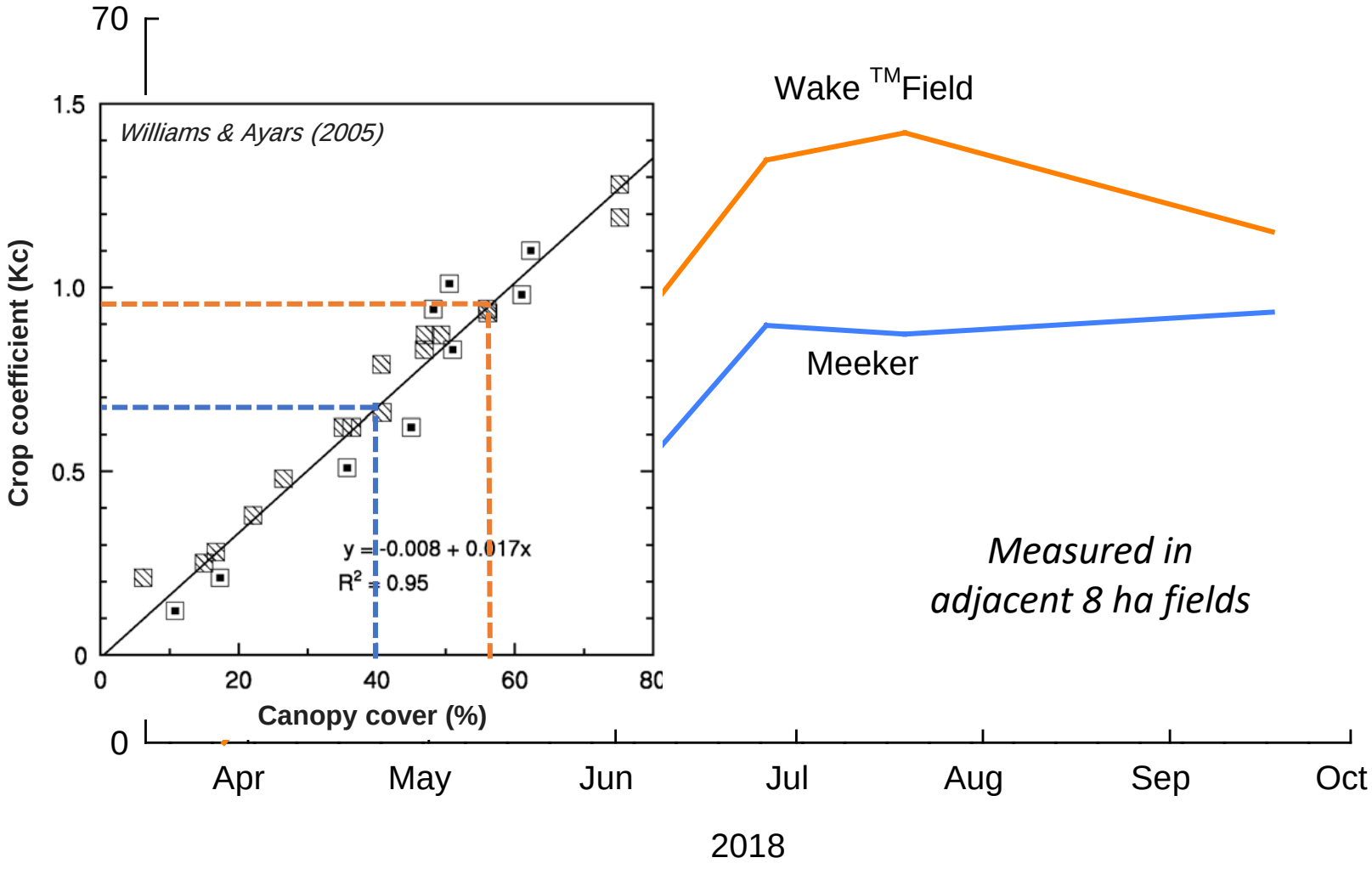
‘Wake TMField’ raspberry

Water requirements?

26 June 2018

‘Meeker’ vs. ‘Wake TMField’

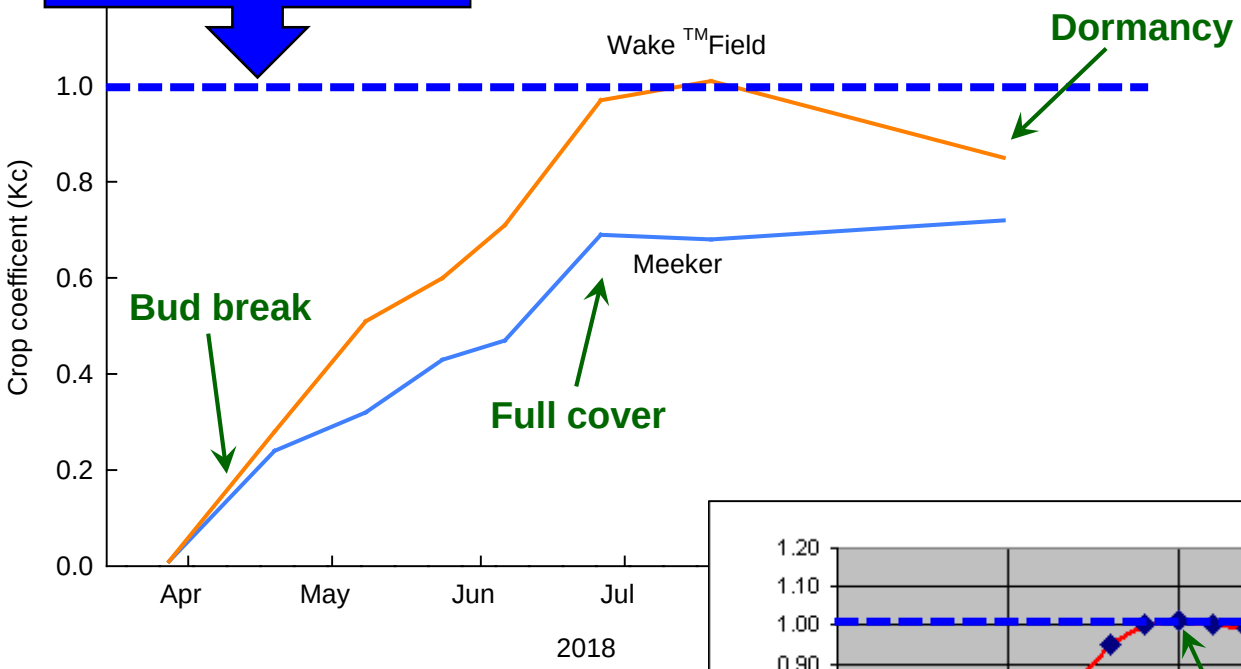
Canopy development

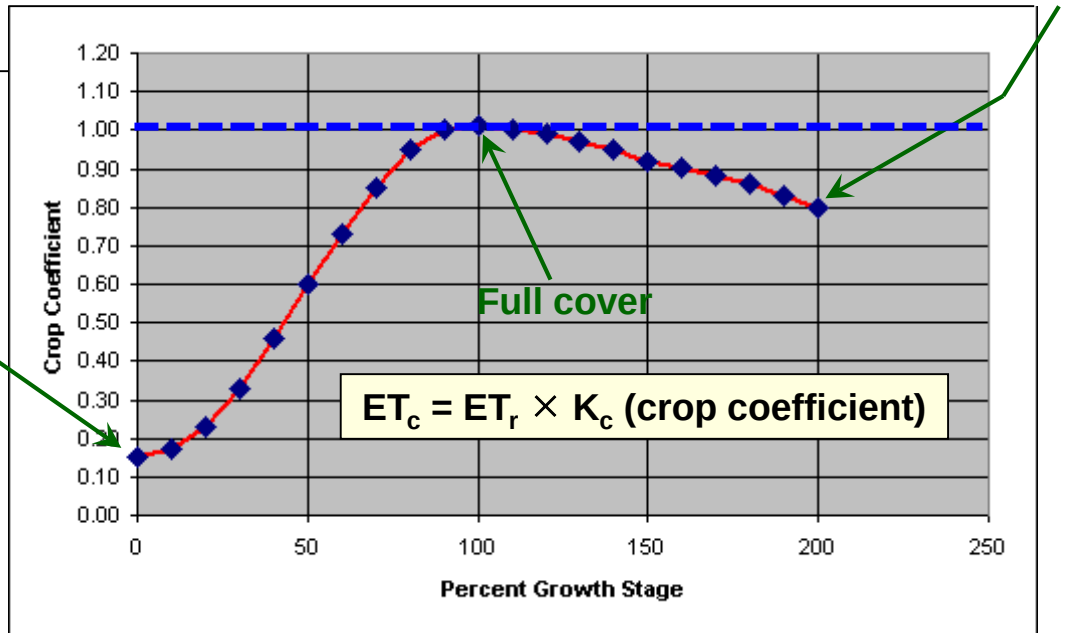


‘Meeker’ vs. ‘Wake TMField’

Crop coefficients

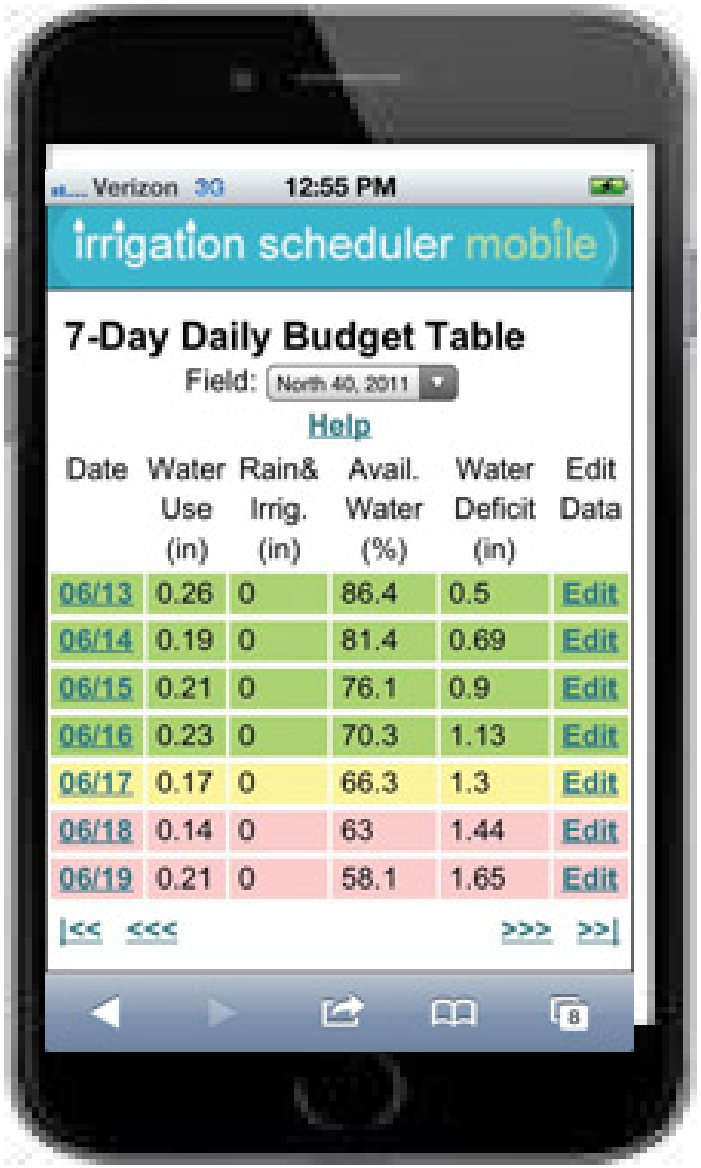
Raspberry water use is equal to alfalfa

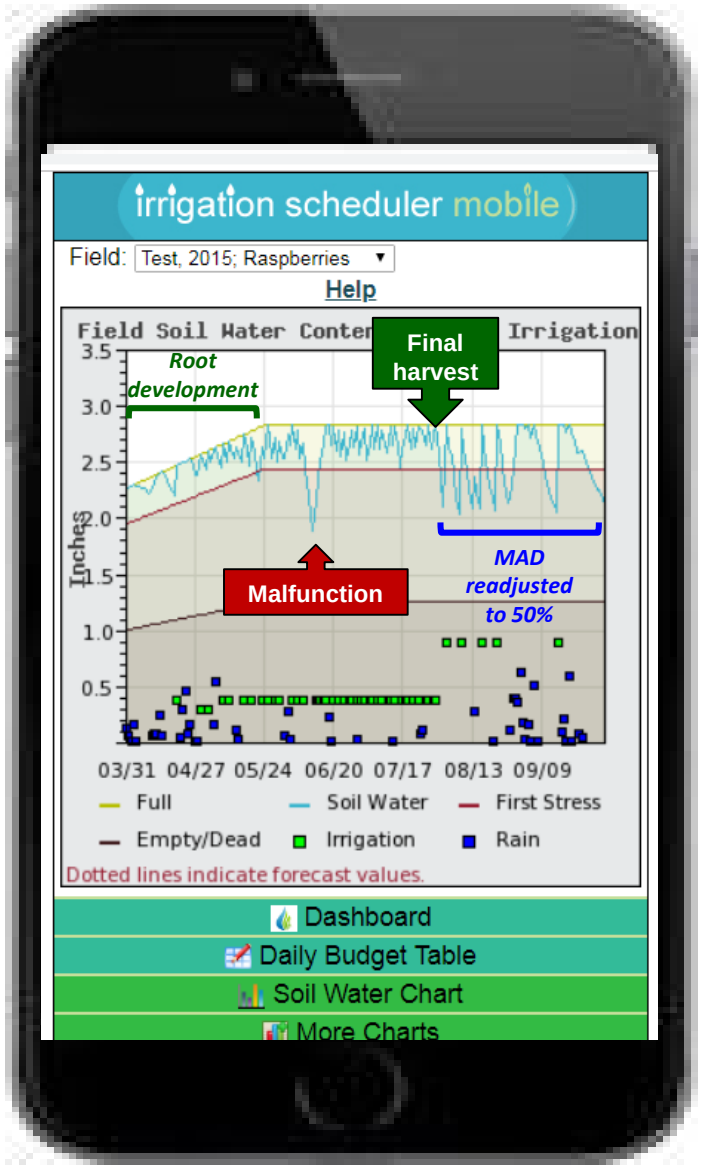




https://www.usbr.gov/pn/agrimet/

Mobile App (*Irrigation Scheduler*)





Developed by Troy Peters (Washington State Univ.) – http://weather.wsu.edu/is/


‘Draper’ blueberry

‘Draper’ blueberry

Canopy development

Bud break (Apr. 19)

Early green (May 8)

Late green (June 6)

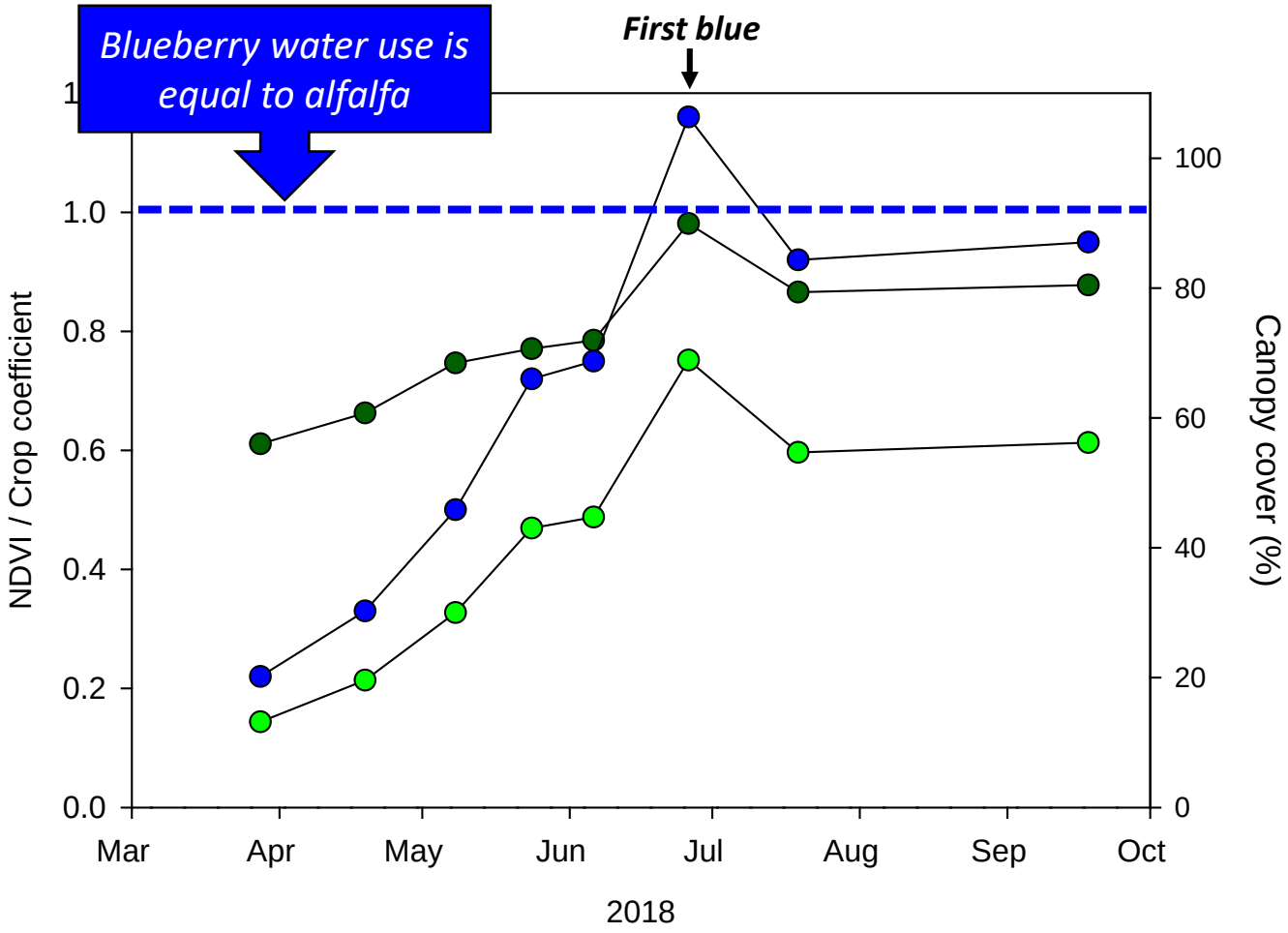
First blue (June 26)

Harvest (July 19)

Pre-senescence (Sep. 18)

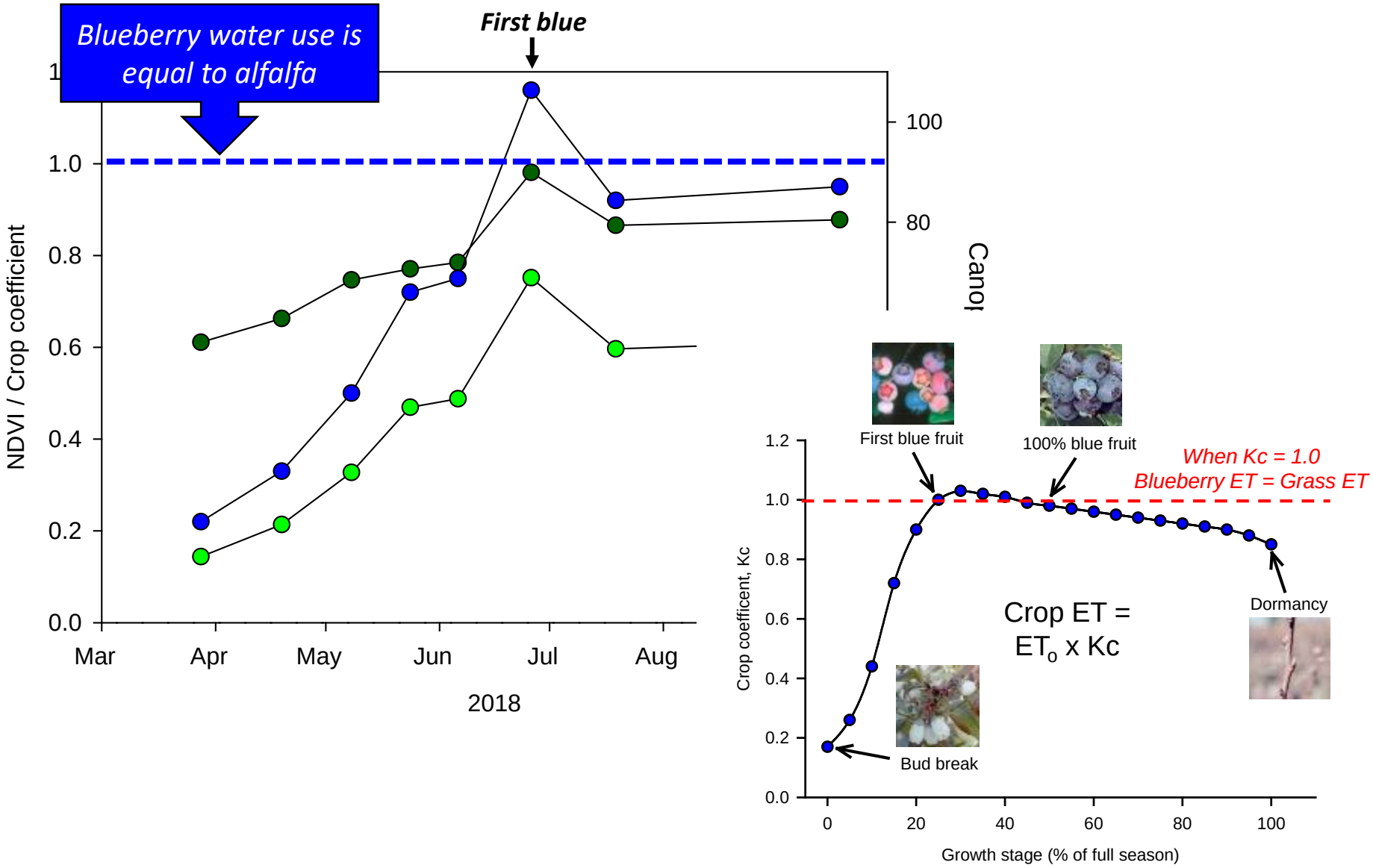
‘Draper’ blueberry

Canopy development



‘Draper’ blueberry

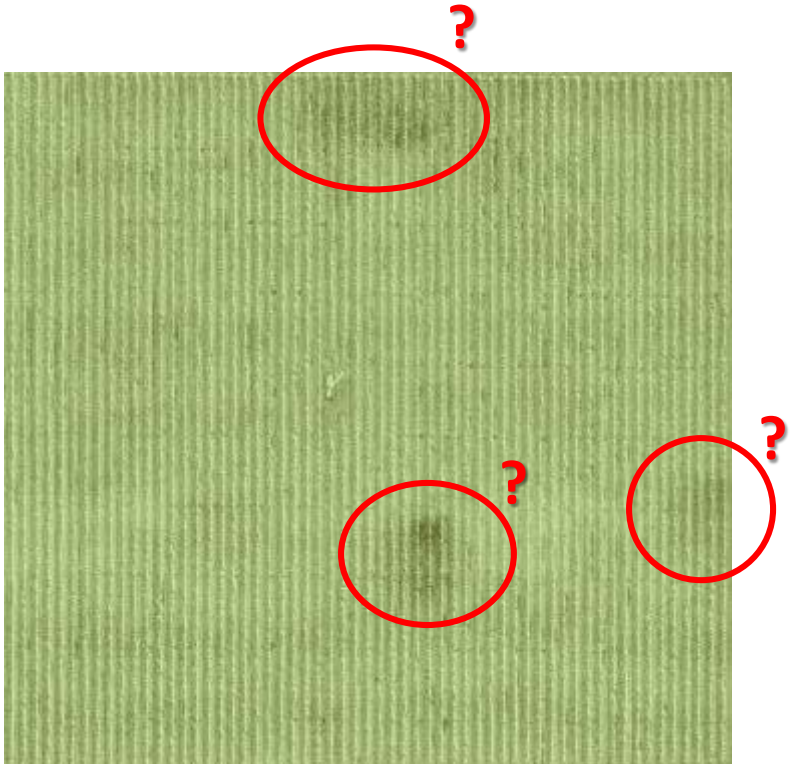
Canopy development



‘Draper’ blueberry

Other indices?

First blue (June 26)



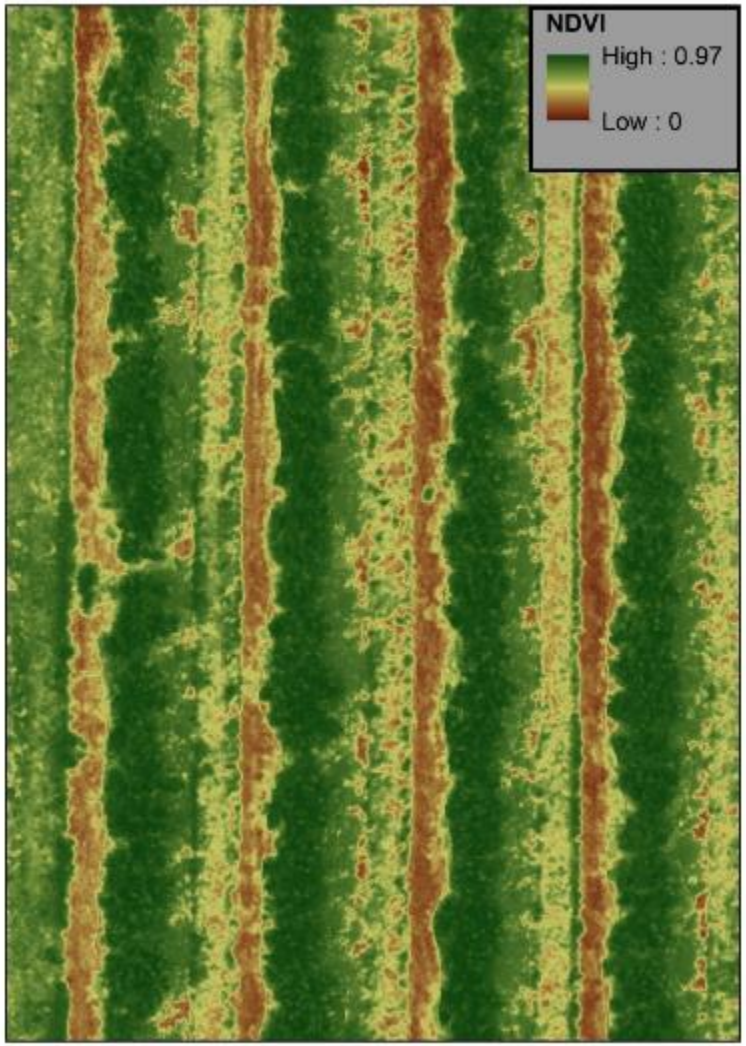
TGI

TGI = triangular greenness index

‘Draper’ blueberry

Nitrogen issues (6/25)

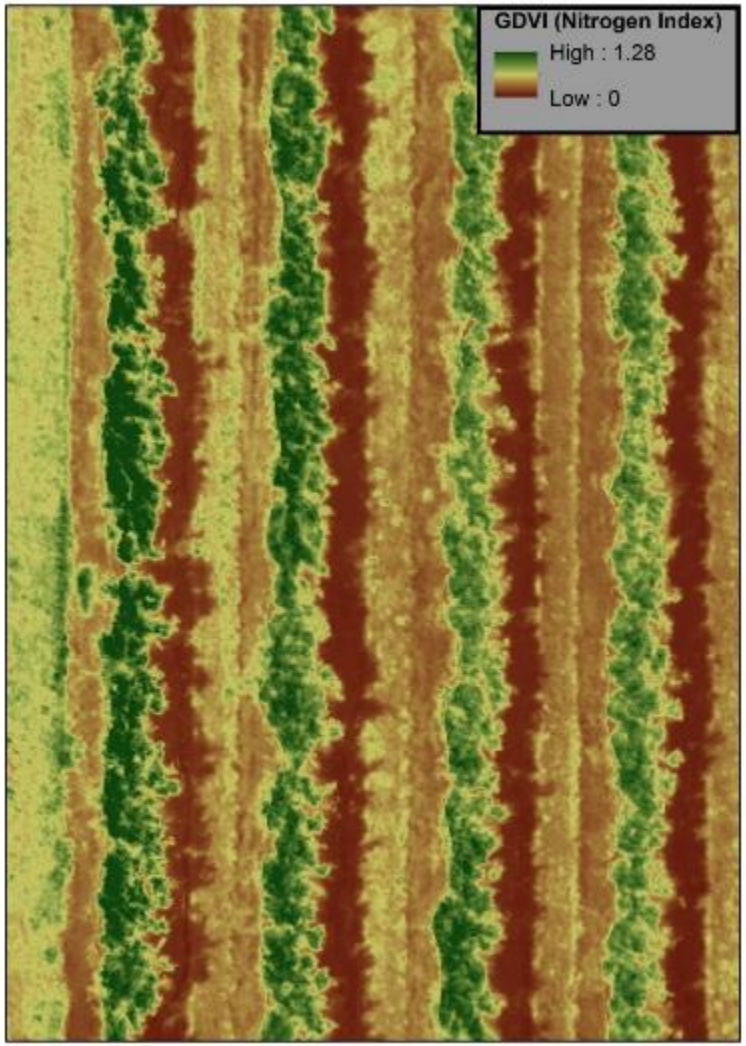
RGB



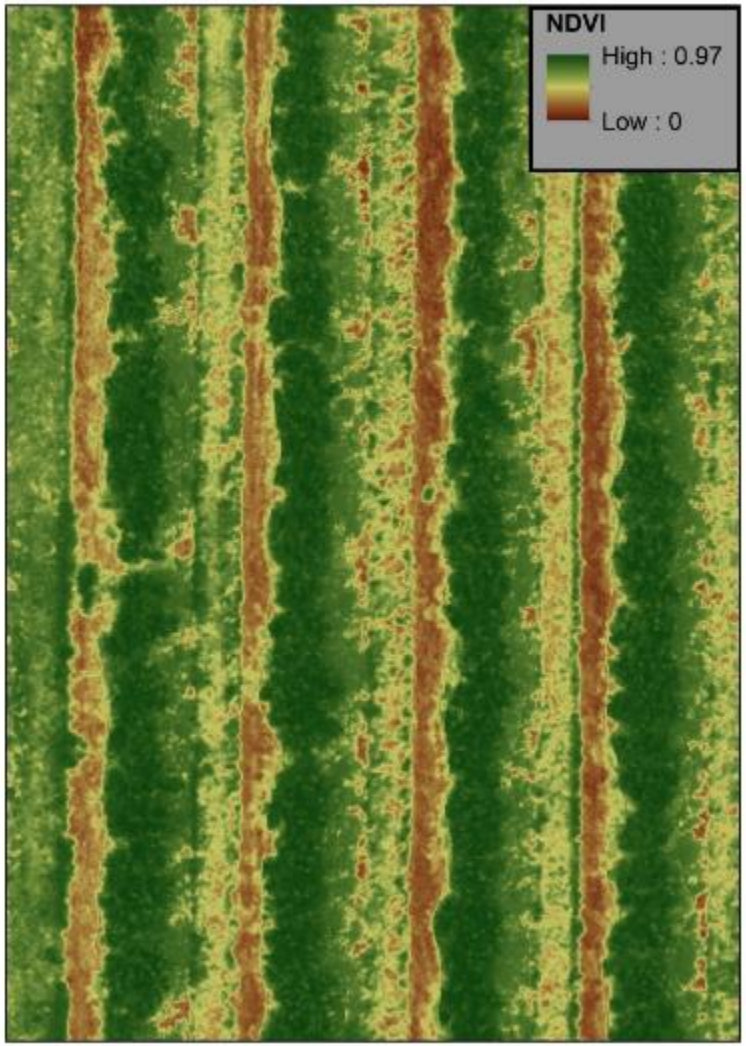
NDVI

‘Draper’ blueberry

Nitrogen issues (6/25)



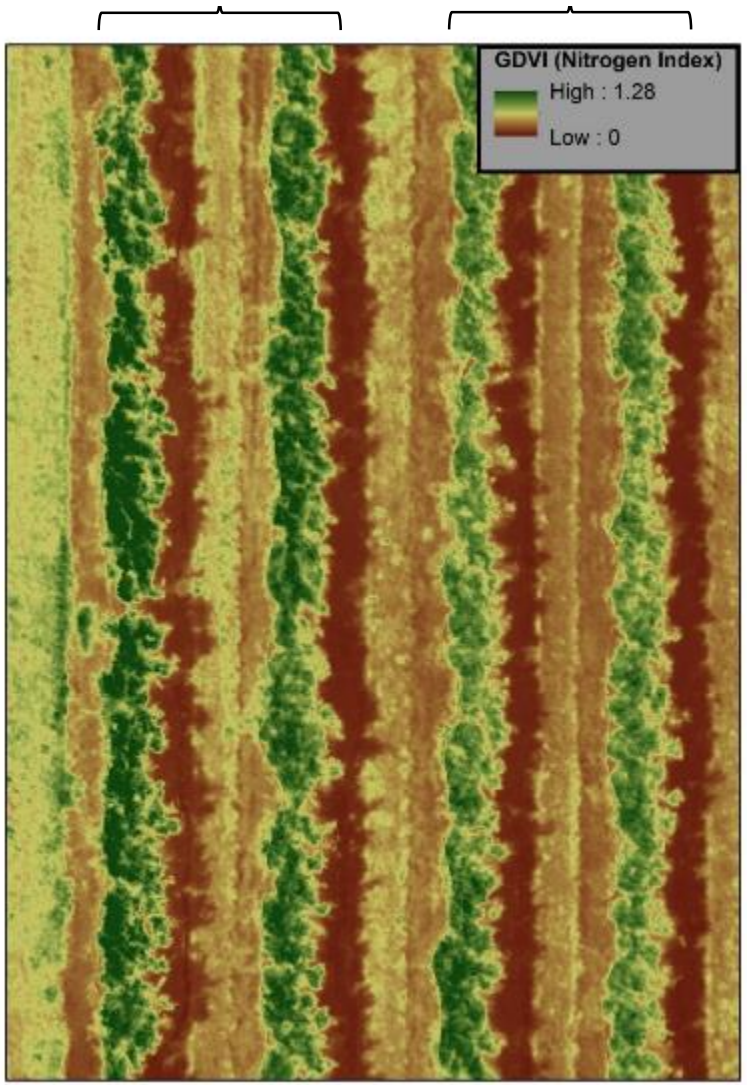
GDVI



NDVI

‘Draper’ blueberry

gen issues (6/25)



GDVI

Green Difference Vegetation Index

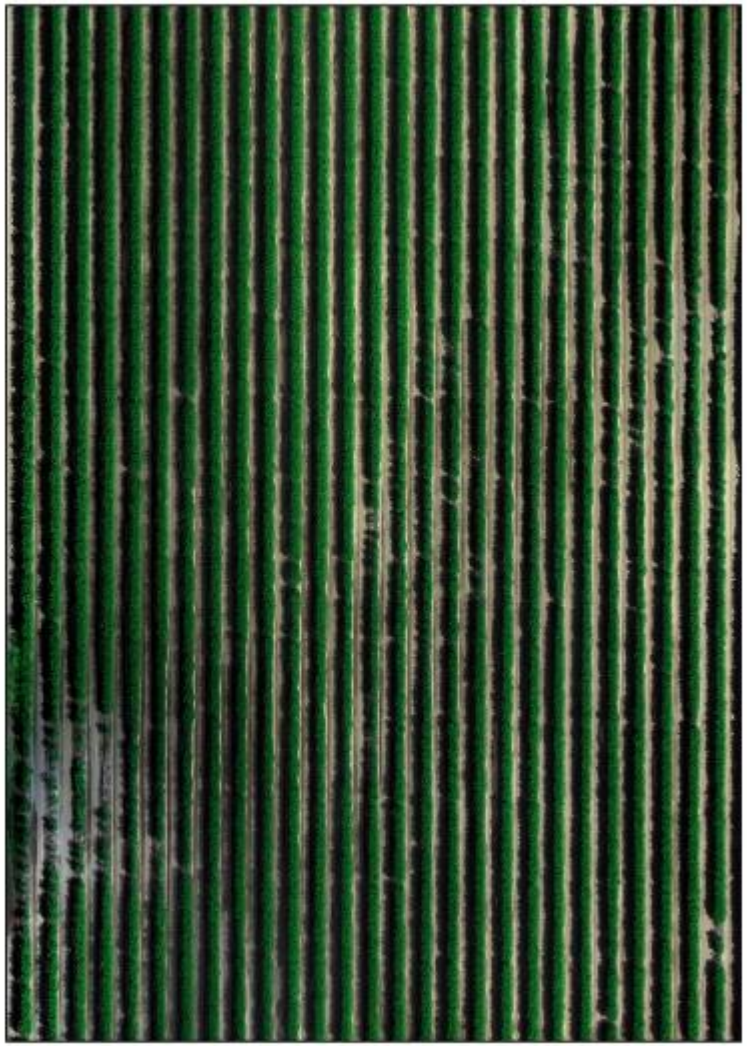
GDVI = NIR - Green

Designed to predict nitrogen requirements for corn

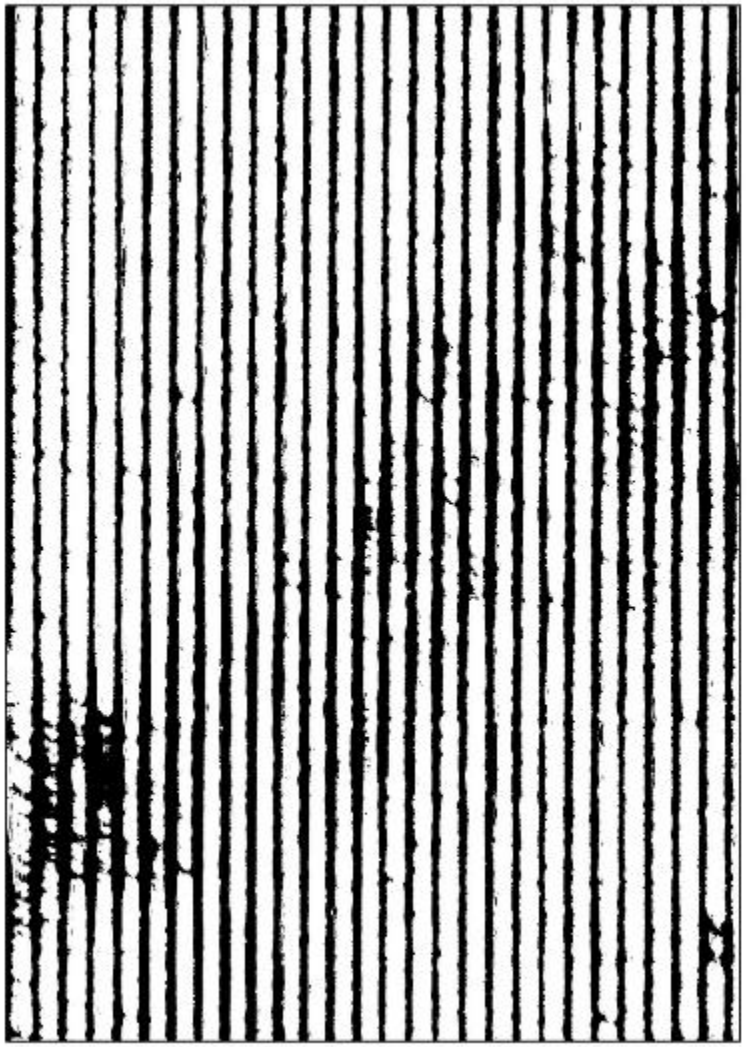
This index is recommended for analyzing crops in early to mid growth stages

‘Wake TMField’ raspberry

Phytophthora root rot



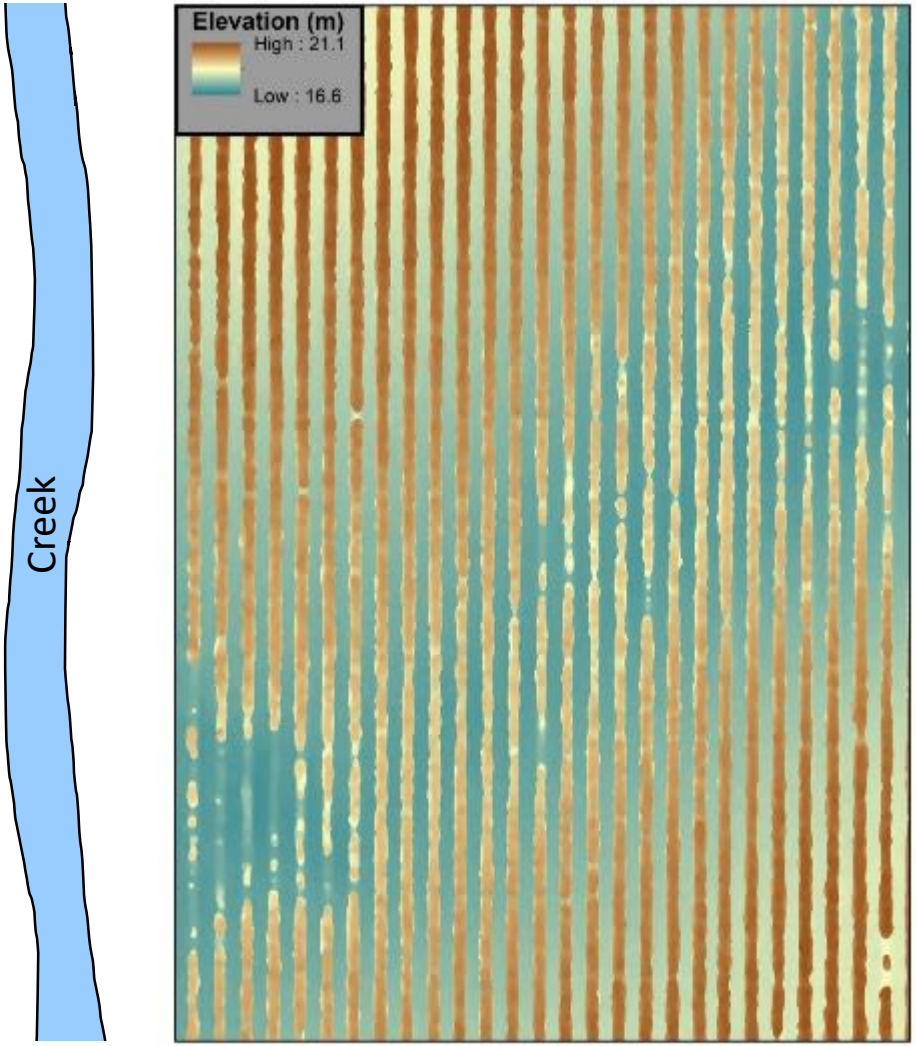
RGB



Reclassified NDVI image

‘Wake TMField’ raspberry

Phytophthora root rot



Elevation

Root rot developed due to flooding in winter and spring

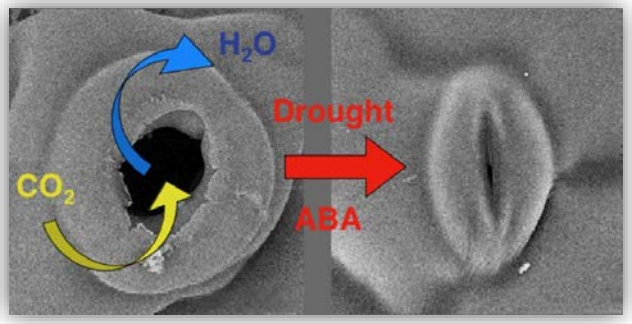
A drone could be used to quickly detect the problem prior to planting

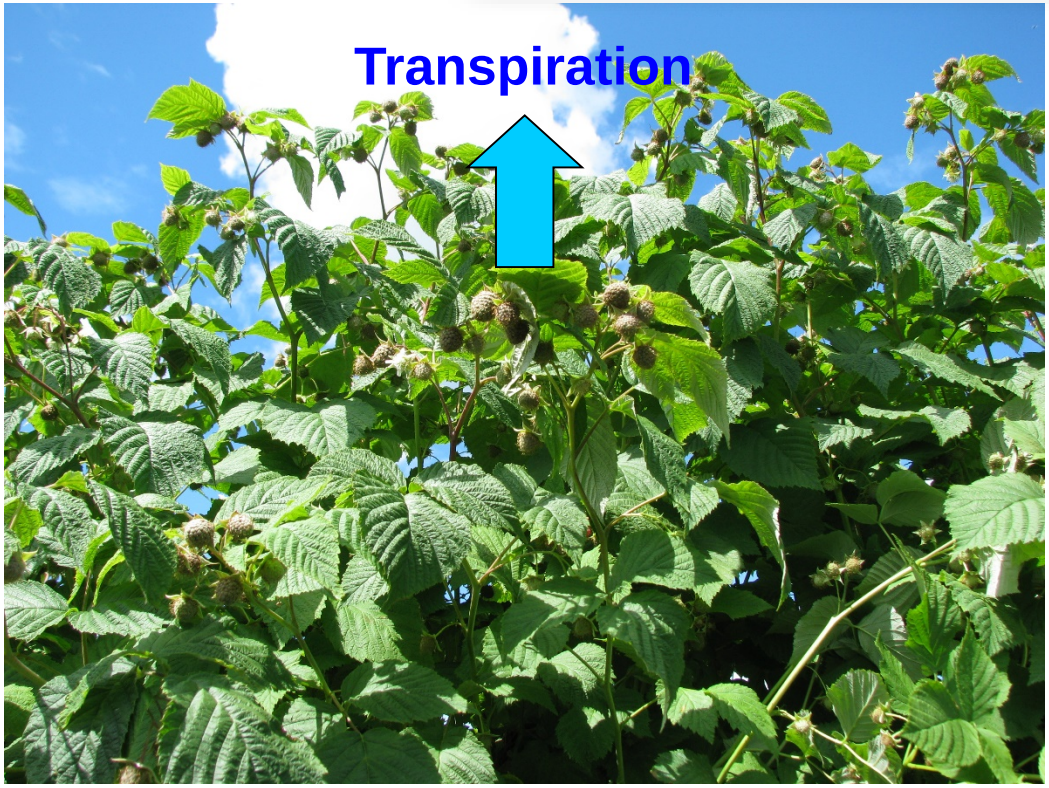
Thermal imaging

Detects and images long-wave infrared radiation. Mapped to a range of 255 colors or shades of gray

IR module (thermal imaging)

Leaf stoma

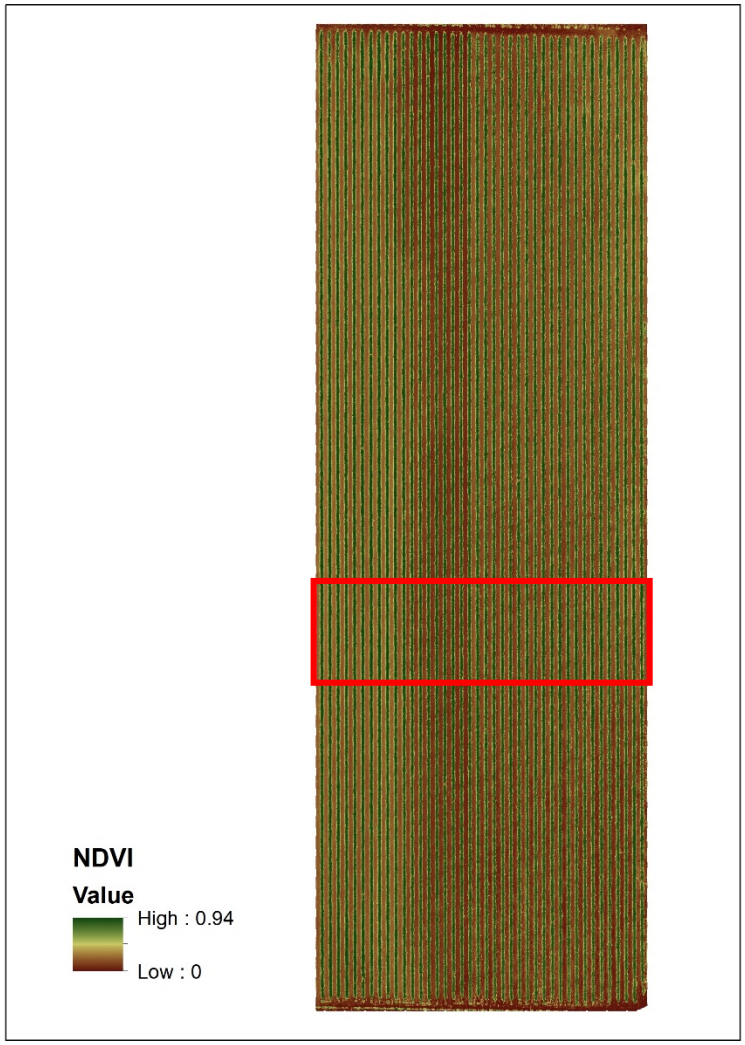




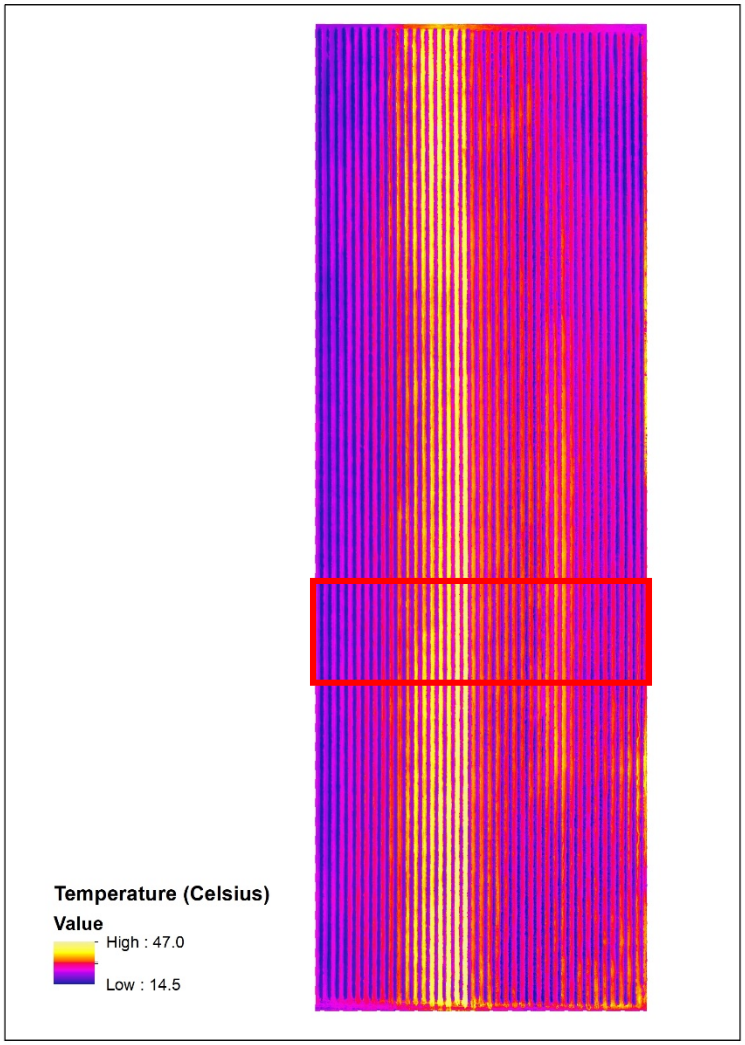
Canopy temperature increases when the stomata close

Utility of thermal imaging

Detecting leaks and emitter plugging



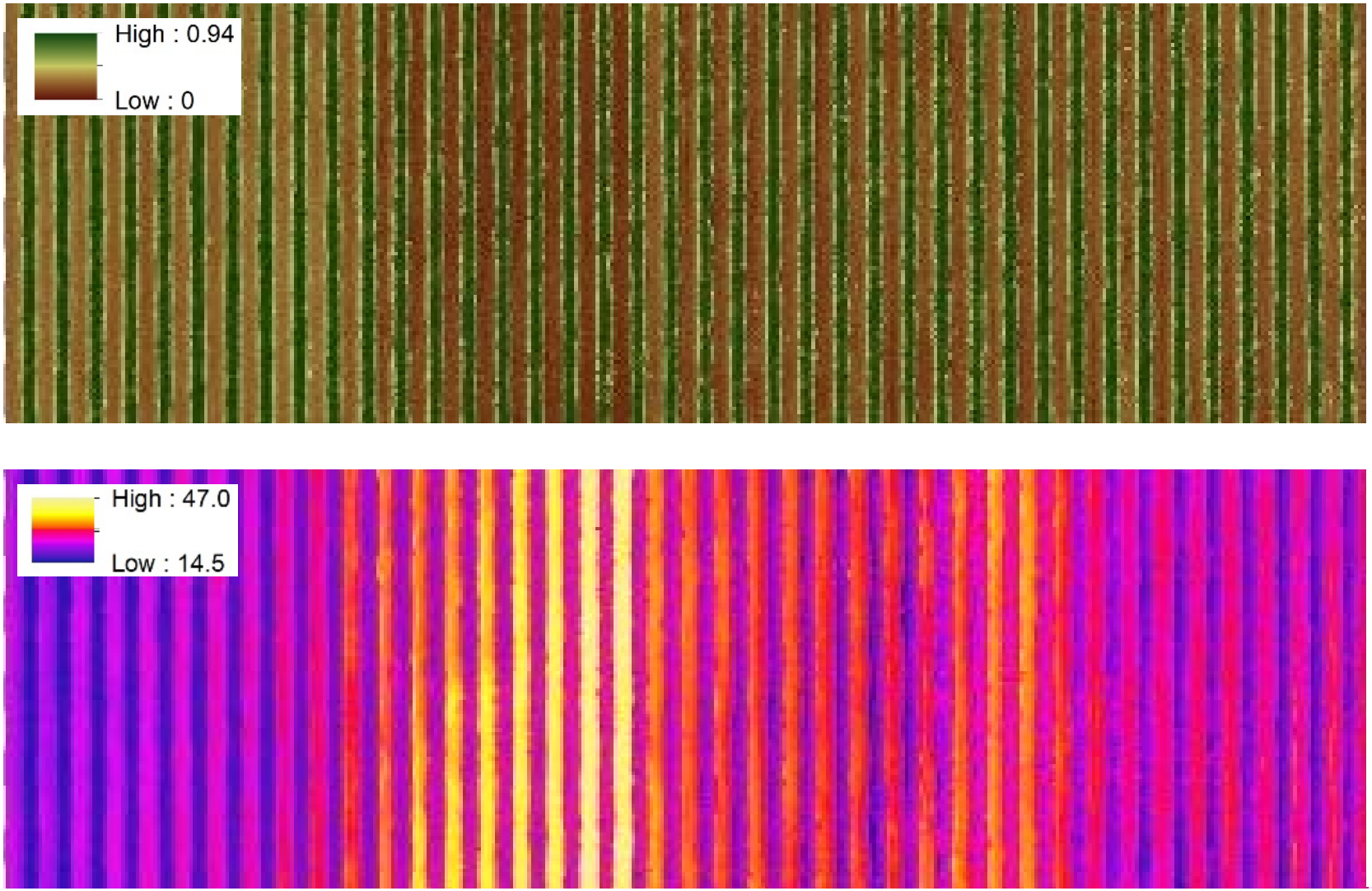
NDVI



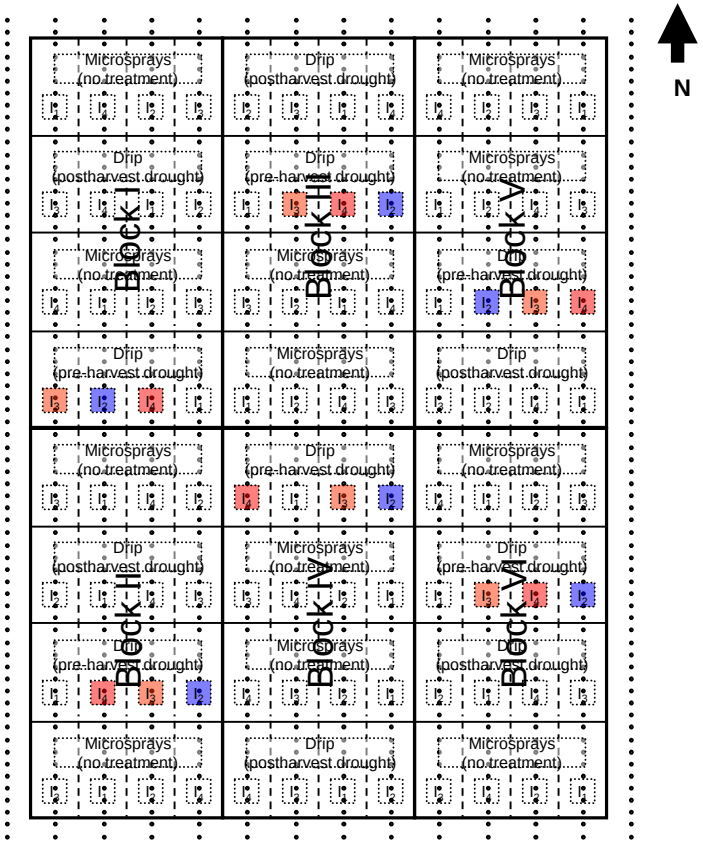
Thermal image

Utility of thermal imaging

Detecting leaks and emitter plugging



Thermal imaging study



Two stages of development

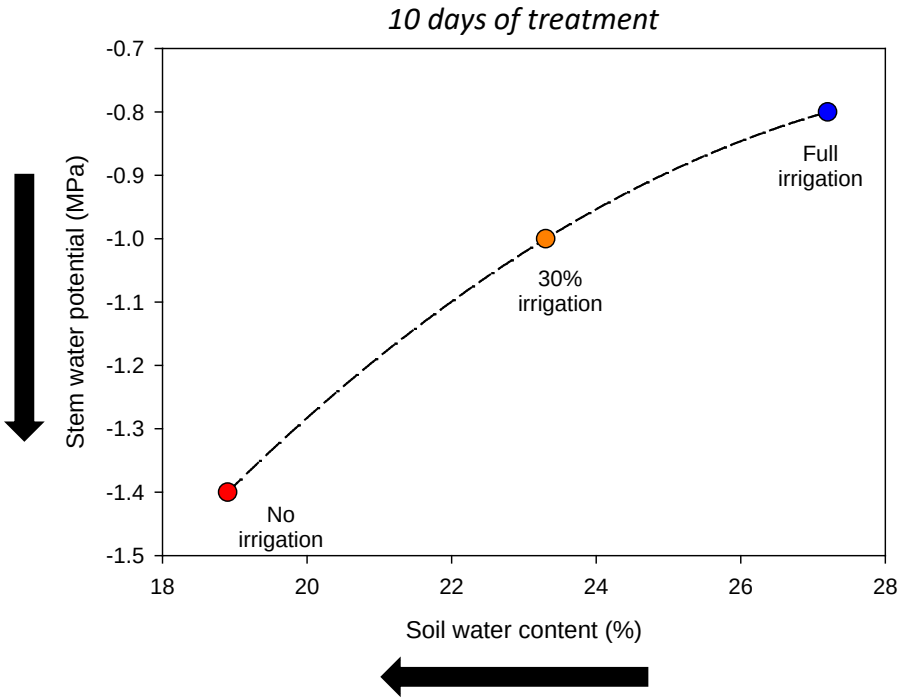
- Pre-harvest (fruit coloring in June)
- Postharvest (mid-late August)

Three irrigation levels

- Full irrigation
- 30% irrigation
- No irrigation)

Also conducted in a commercial field of Draper (Skagit Co.)

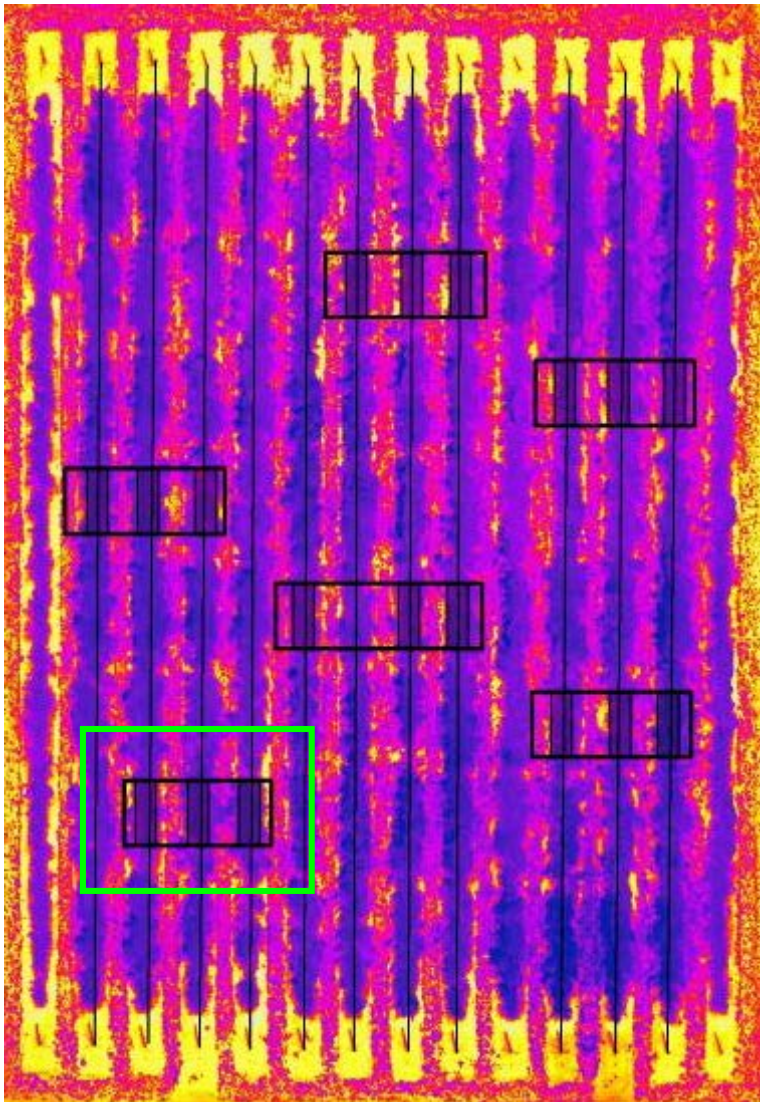
Thermal imaging study



Treatment	Harvest 1 Yield (kg/plant)	Harvest 1 Berry wt (g)	Harvest 2 Yield (kg/plant)	Harvest 2 Berry wt (g)	Total Yield (kg/plant)	Total Berry wt (g)
Full irrigation	3.60 a	1.69 a	2.34	1.48	5.94	1.61 a
30% irrigation	3.80 a	1.67 ab	1.98	1.43	5.78	1.59 a
No irrigation	3.13 b	1.52 b	2.17	1.32	5.30	1.44 b
Significance	***	*	NS	NS	NS	*

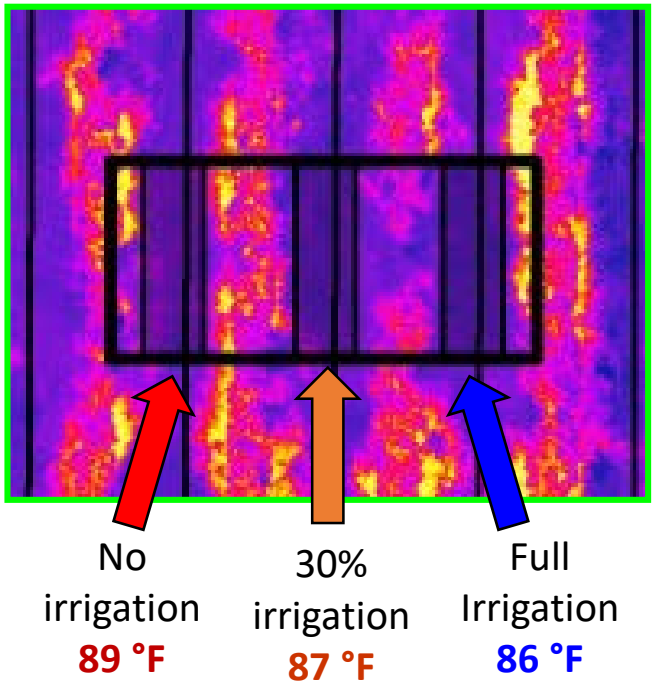
NS, *,***Non-significant and significant at $P \leq 0.05$ or 0.001, respectively.

Thermal image (color map)



High : 100 °F

Low : 75 °F



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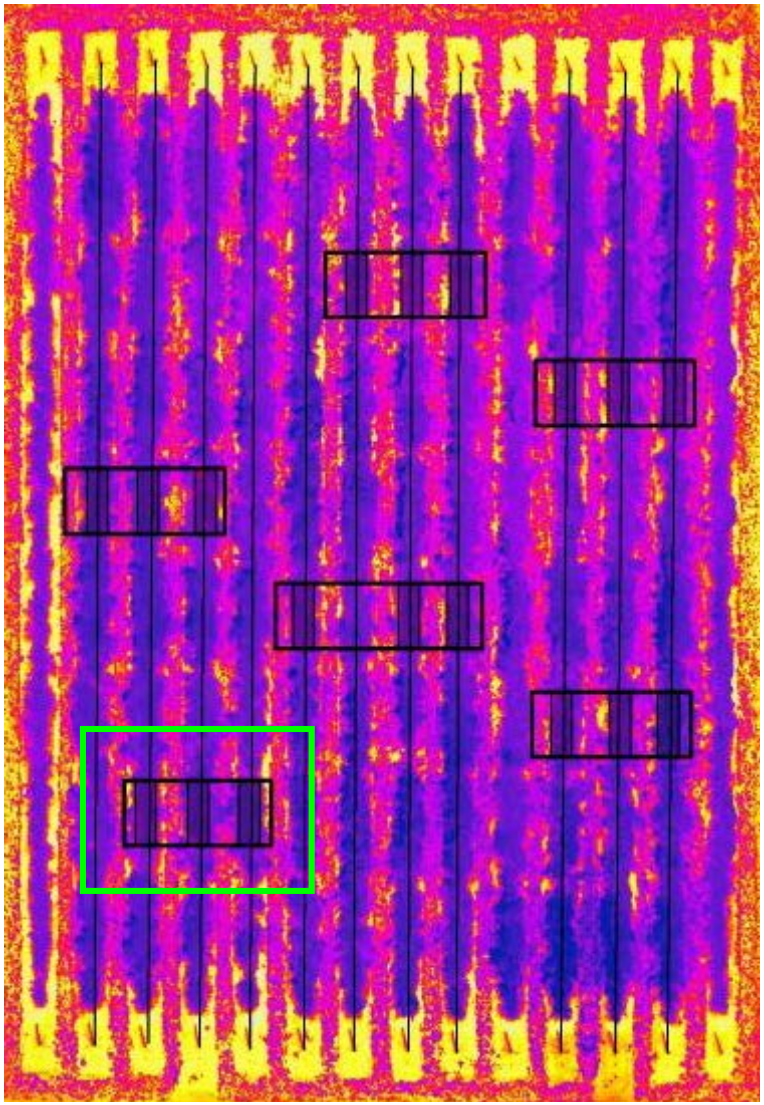
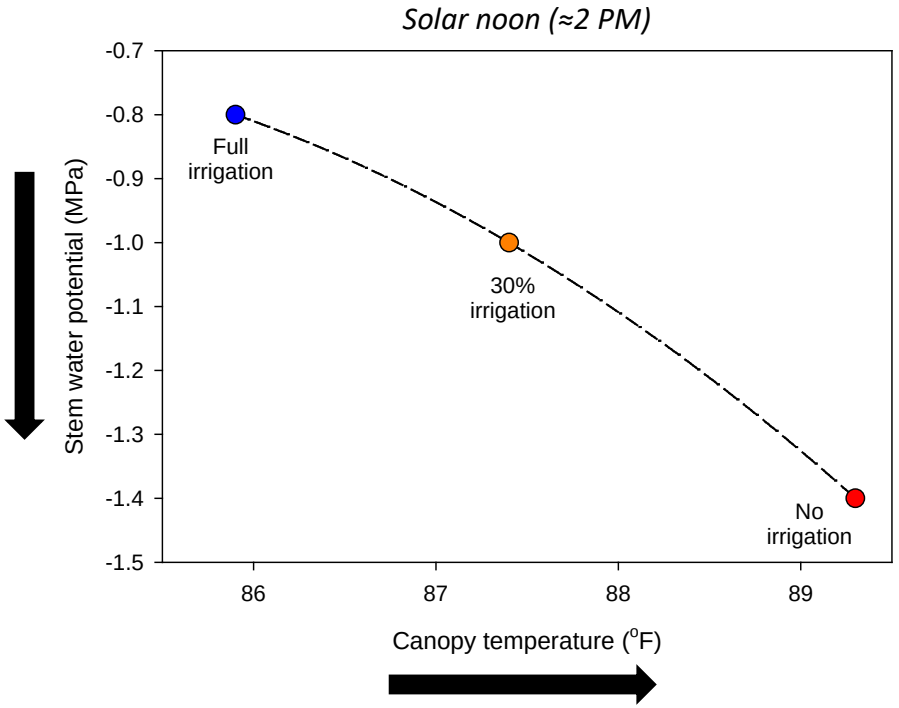
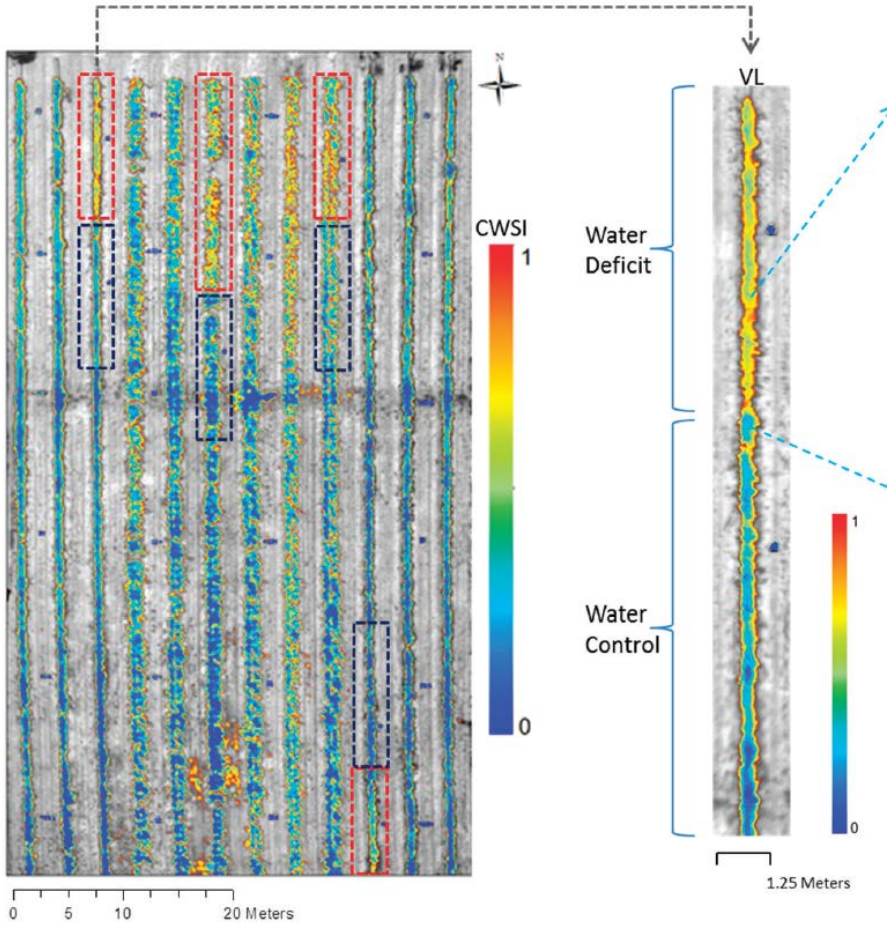


High : 100 °F

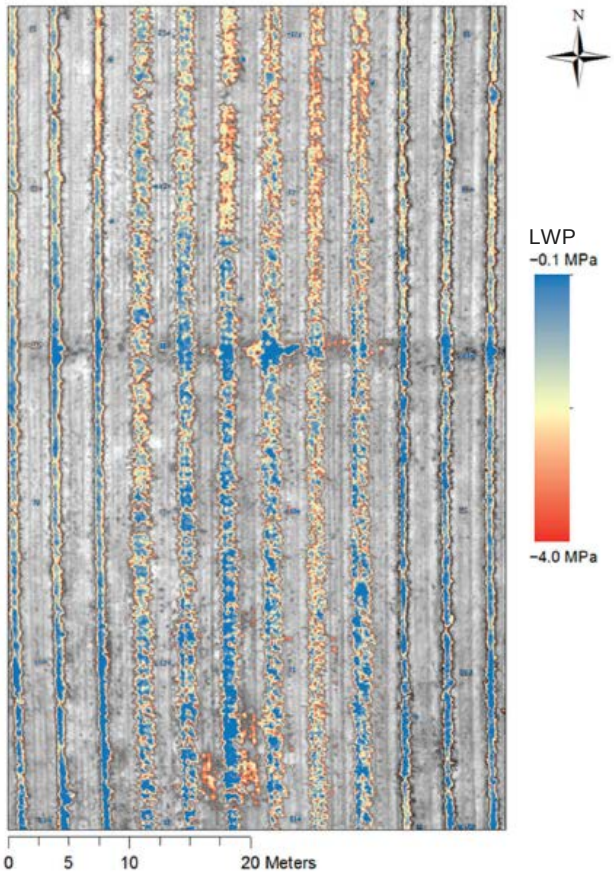
Low : 75 °F



Mapping crop water deficits



Crop water stress index



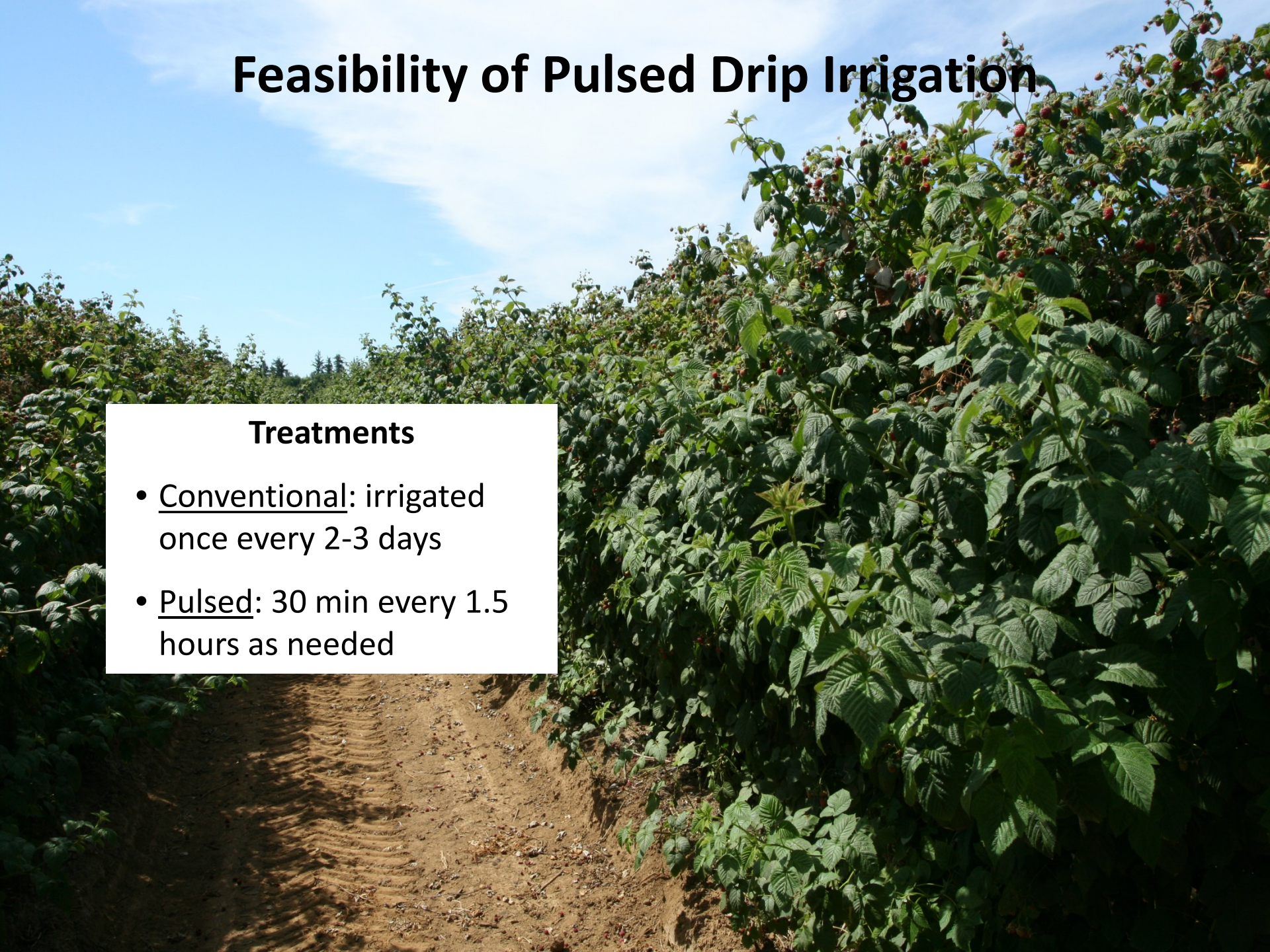
Leaf water potential

Park et al. (2017)

Summary

- Fields can be mapped on a block-by-block basis (irrigation needs, disease assessment, nutrient management, etc.)
- State-of-the-art tool for avoiding water limitations and reducing irrigation and energy use

Feasibility of Pulsed Drip Irrigation

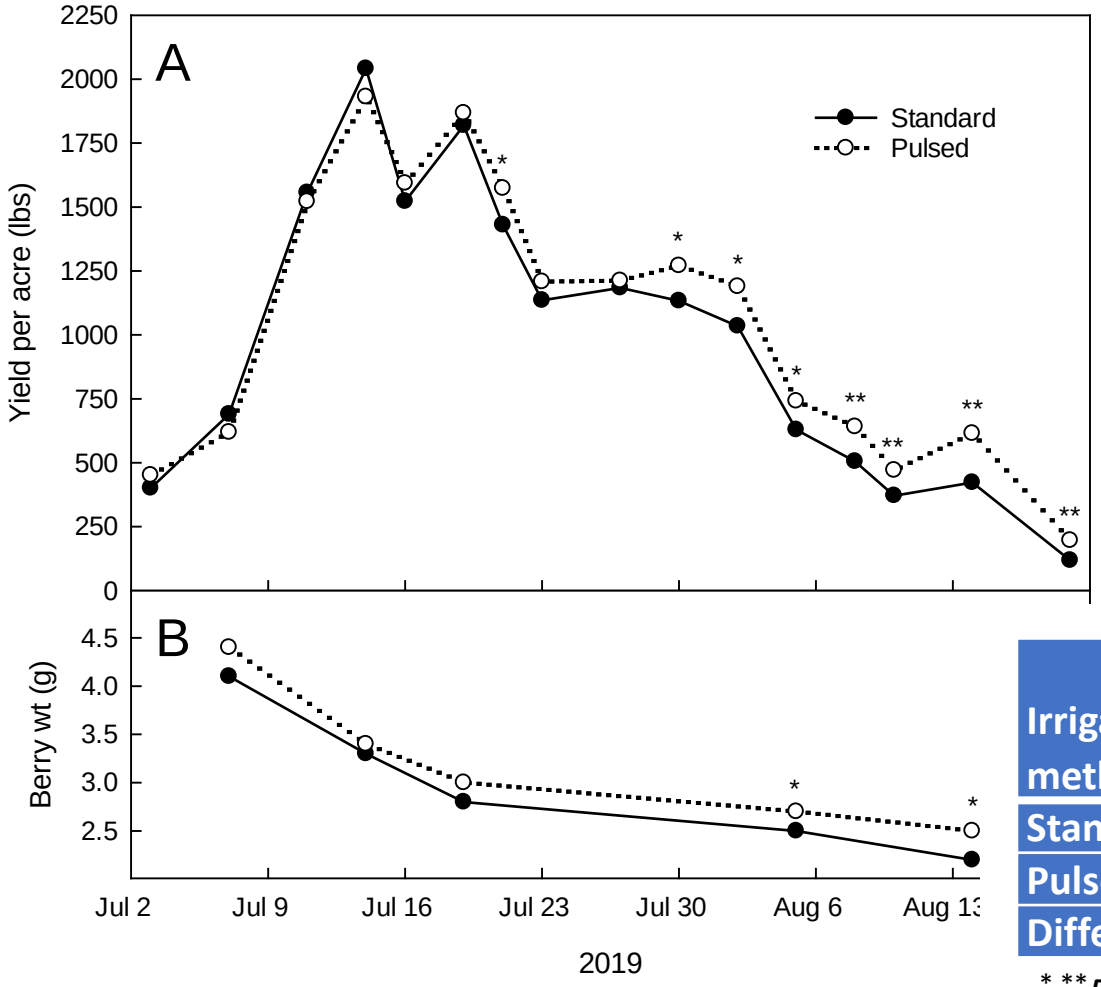


Treatments

- Conventional: irrigated once every 2-3 days
- Pulsed: 30 min every 1.5 hours as needed

Benefits of Pulsed Drip

'Wakefield' raspberry



Irrigation method[z]	Total yield per acre (lbs)	Average berry weight (g)
Standard	16,000	3.09
Pulsed	17,100	3.19
Difference	1,100[†]	0.10[†]

[†]$P < 0.10$.

Irrigation method	Soluble solids (%)	Titratable acidity (%)	Sugar:acid ratio
Standard	10.6	2.17	4.87
Pulsed	10.2	2.24	4.56
Difference	0.4[**]	-0.07[*]	0.31[**]

[*,**]$P < 0.05$ and 0.01, respectively.

Questions?