

Site-specific management of soil pests in California strawberry production

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Fusarium wilt



Bed fumigated
with chloropicrin

M. phaseolina in
Summer-
planted
'Portola',
200lbs/A Pic



Over 15 years of research and extension

- **Precision application based on pathogen distribution**
- **Improvement in fumigant distribution**
- **Anaerobic soil disinfestation (ASD)**
- **Solarization**
- **Biocides (mustard seed meal, cover crops)**
- **Resistant cultivars**
- **Substrate production**
- **Production when soils are cool = slow disease development**
- **Steam**

Acknowledgements



Grower Cooperators

Matt Conroy and Dave Murray (Good Farms)

Pal Halsted and Aaron Fukutomi (*Fukutomi Farms*)

Henry Ito (Ito Bros.)

Jaime Lopez (Mixtekz Berries)

Fumigation: 88% of California strawberry acreage

- Often applied uniformly at the high label rate when perceived risk is high
 - Broadcast/flat
 - Drip
- Soilborne diseases usually occur in clusters or hot spots



Southern California strawberry fields:

- 15-19% less fumigant used in variable rate vs. standard fumigation
- No fruit yield differences among treatments
- Variable rate: at least 6% greater net returns (even with costs of pathogen sampling)
- 90%+ decrease in pathogen-related mortality in both standard and variable rate blocks

USDA-ARS Areawide Pest Management Project - SITE-SPECIFIC SOIL PEST MANAGEMENT IN STRAWBERRY AND VEGETABLE CROPPING SYSTEMS

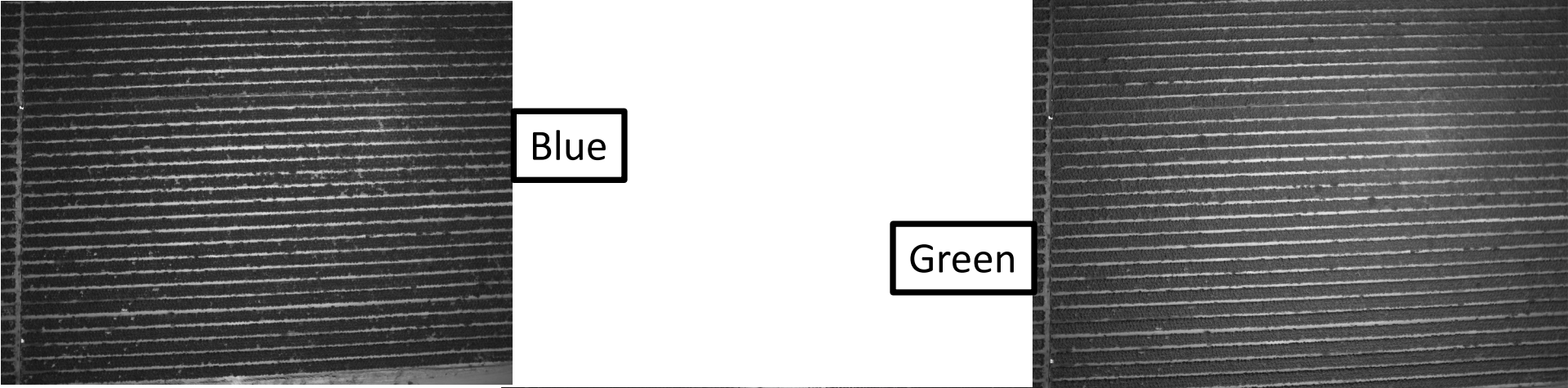
- F. Martin, S. Fennimore, D. Racano, M. Matson, A. Putman, M. Hang, F. Melton, R. Goodhue, P. Henry, S. Vougioukas, N. Dorn, C. Greer, O. Daugovish, A. Biscaro, M. Earles, T. Magneyand, M. Stanghellini



DJI Matrice 200v2 sUAS/drone

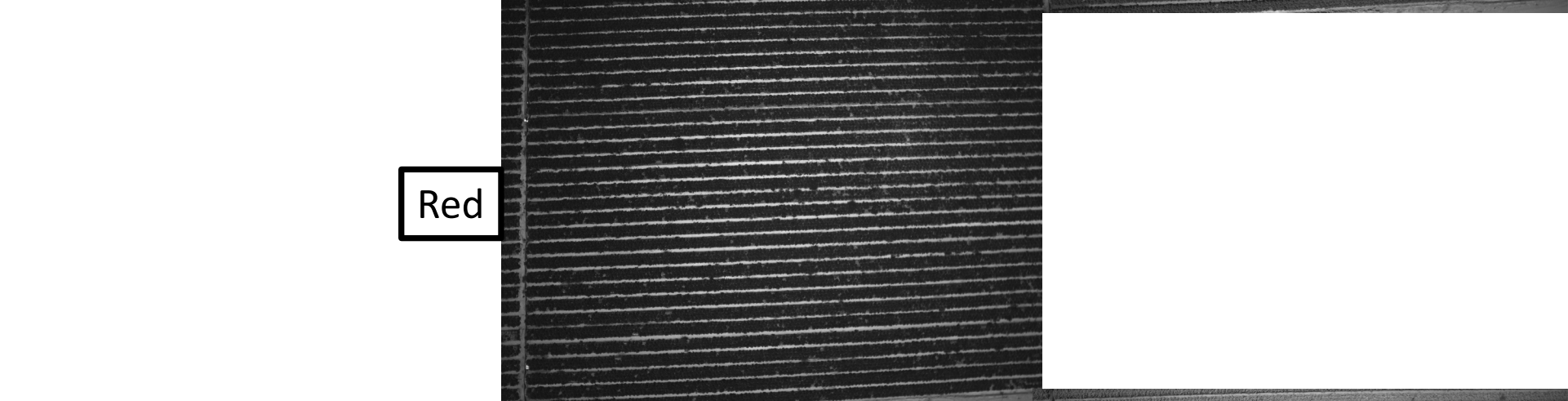


- MicaSense Altum multispectral/thermal camera
 - Captures 6 spectral bands
 - Visible light - Blue, Green and Red bands
 - Non-visible light in the red edge, near infrared and thermal bands

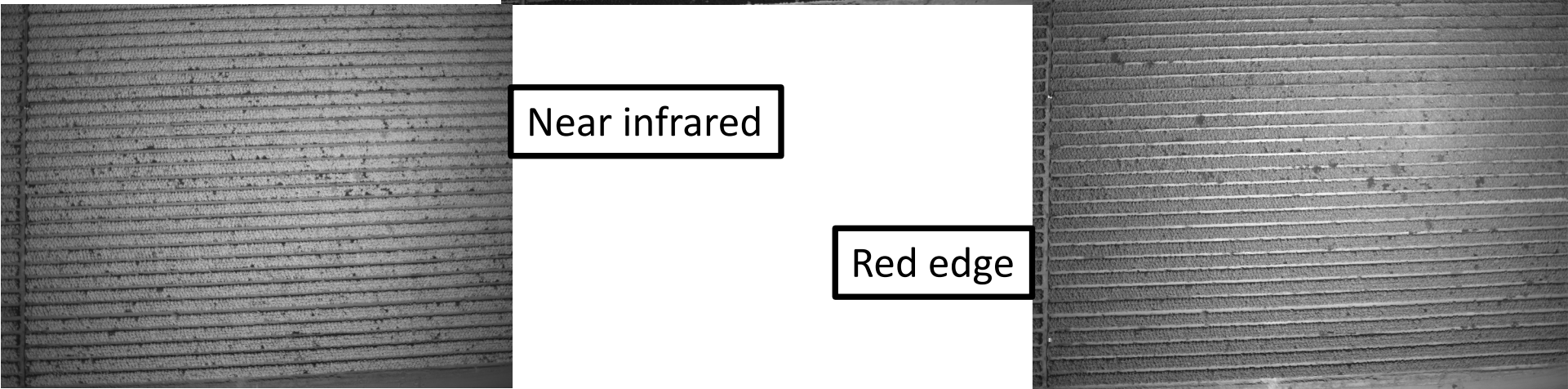


Blue

Green

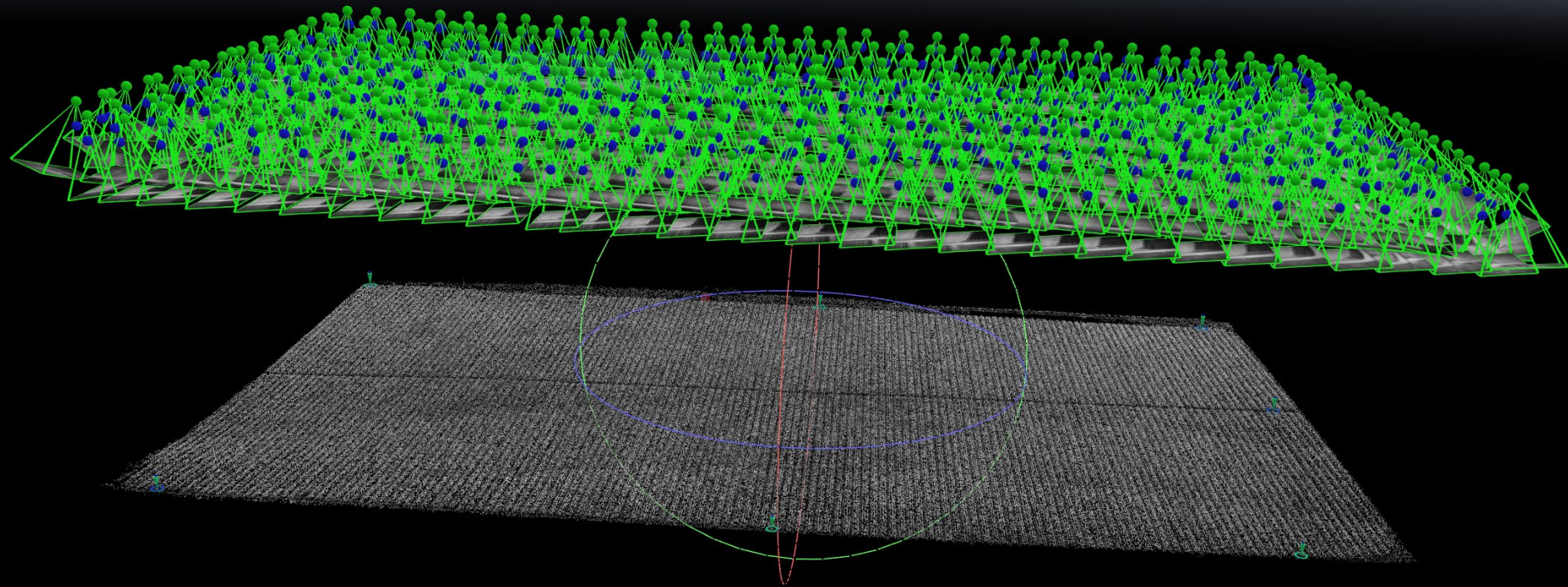


Red



Near infrared

Red edge



Processing performed using Pix4DMapper software (Pix4D SA, Switzerland)

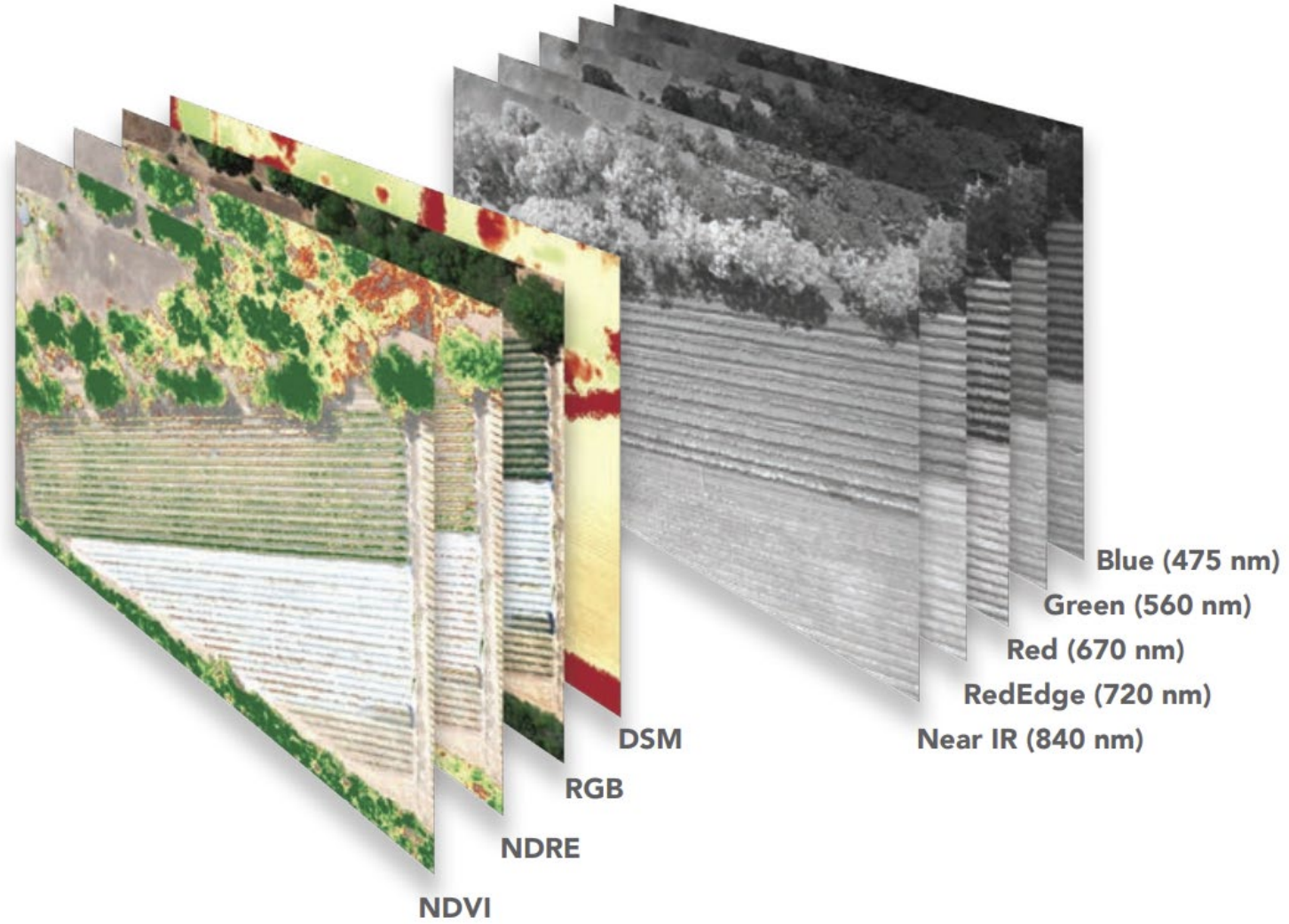
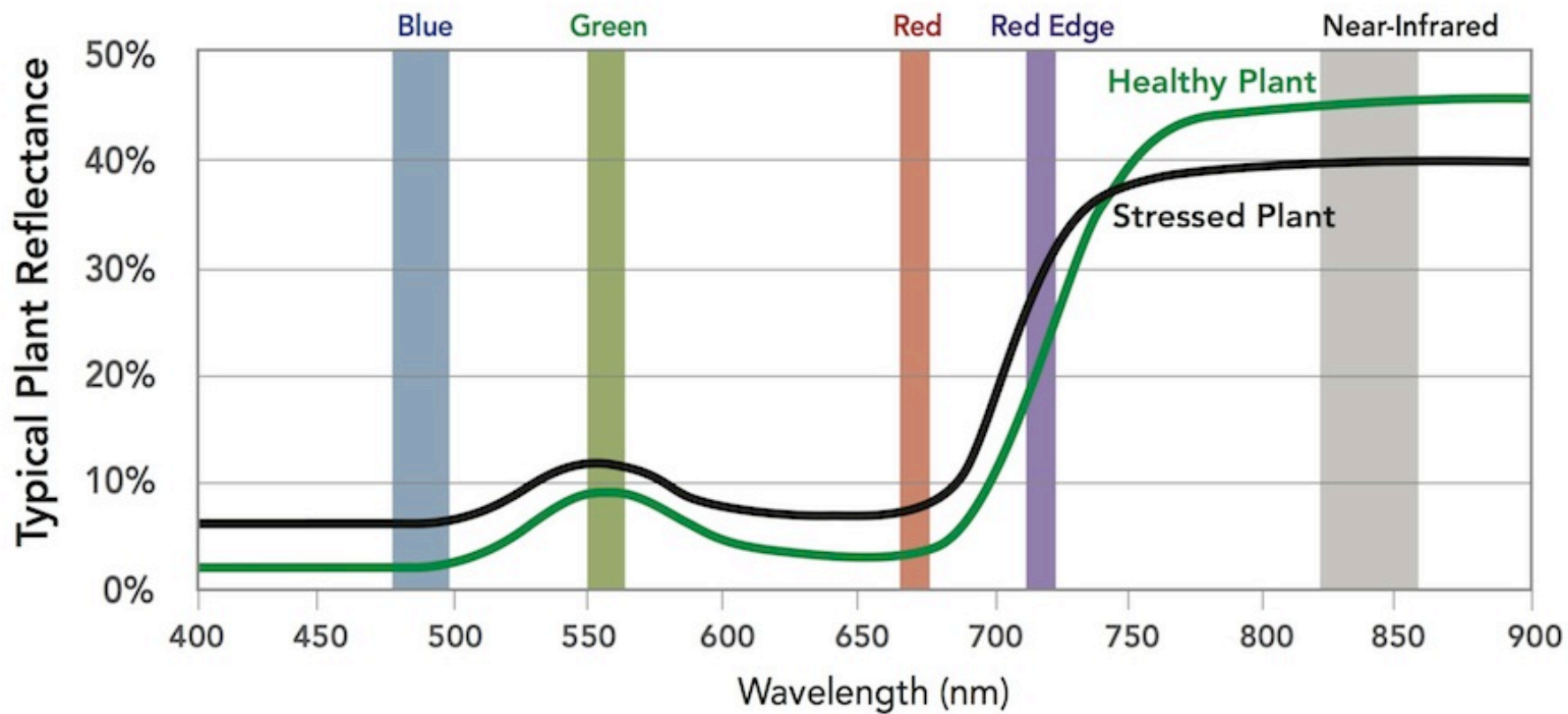
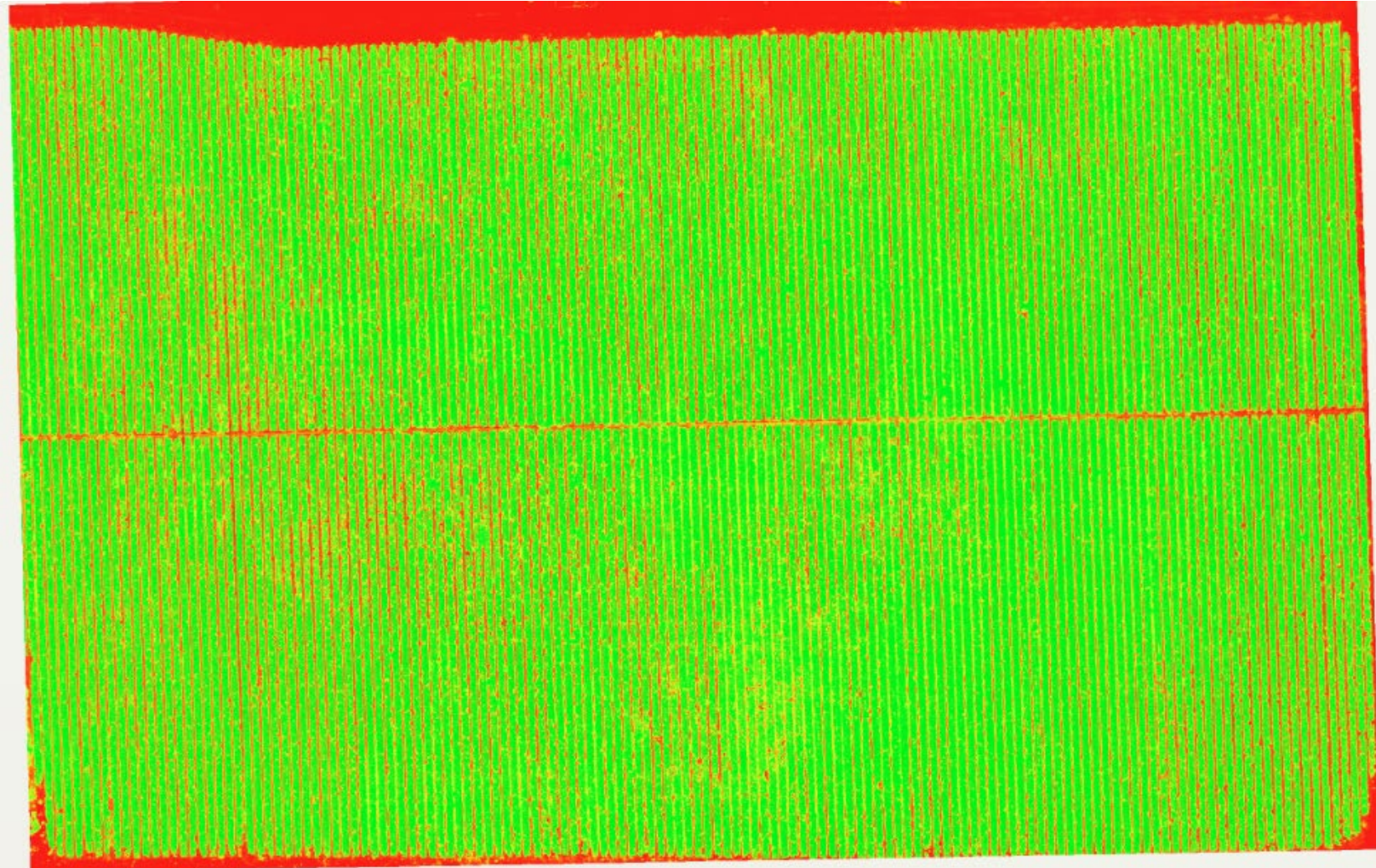


Figure Credit: MicaSense (<https://micasense.com/>)



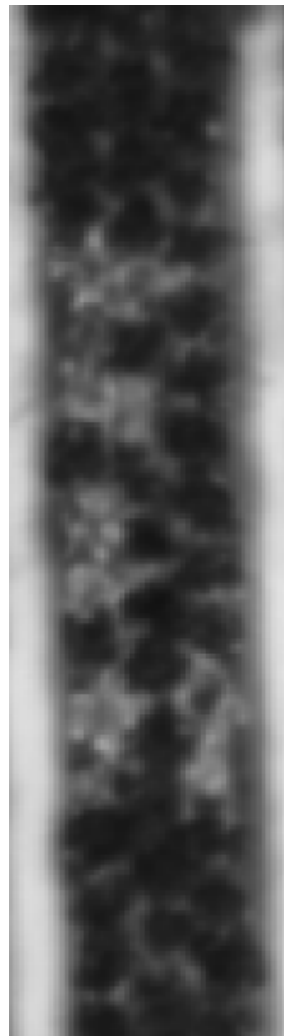
$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

(Normalized Difference Vegetation Index) - quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). High NDVI values = healthier vegetation. Low NDVI = less healthy or no vegetation.





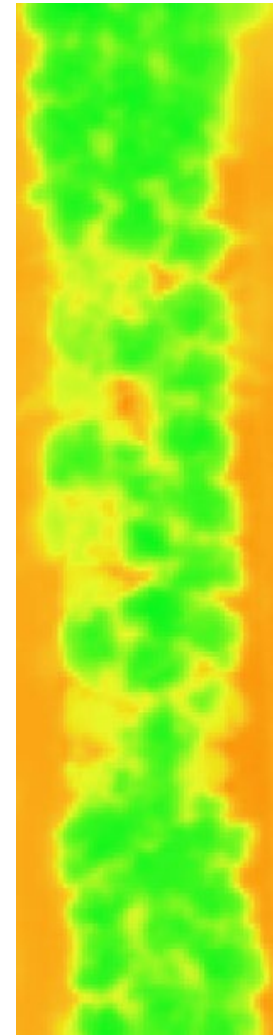
RGB



Red



Near-Infrared



NDVI

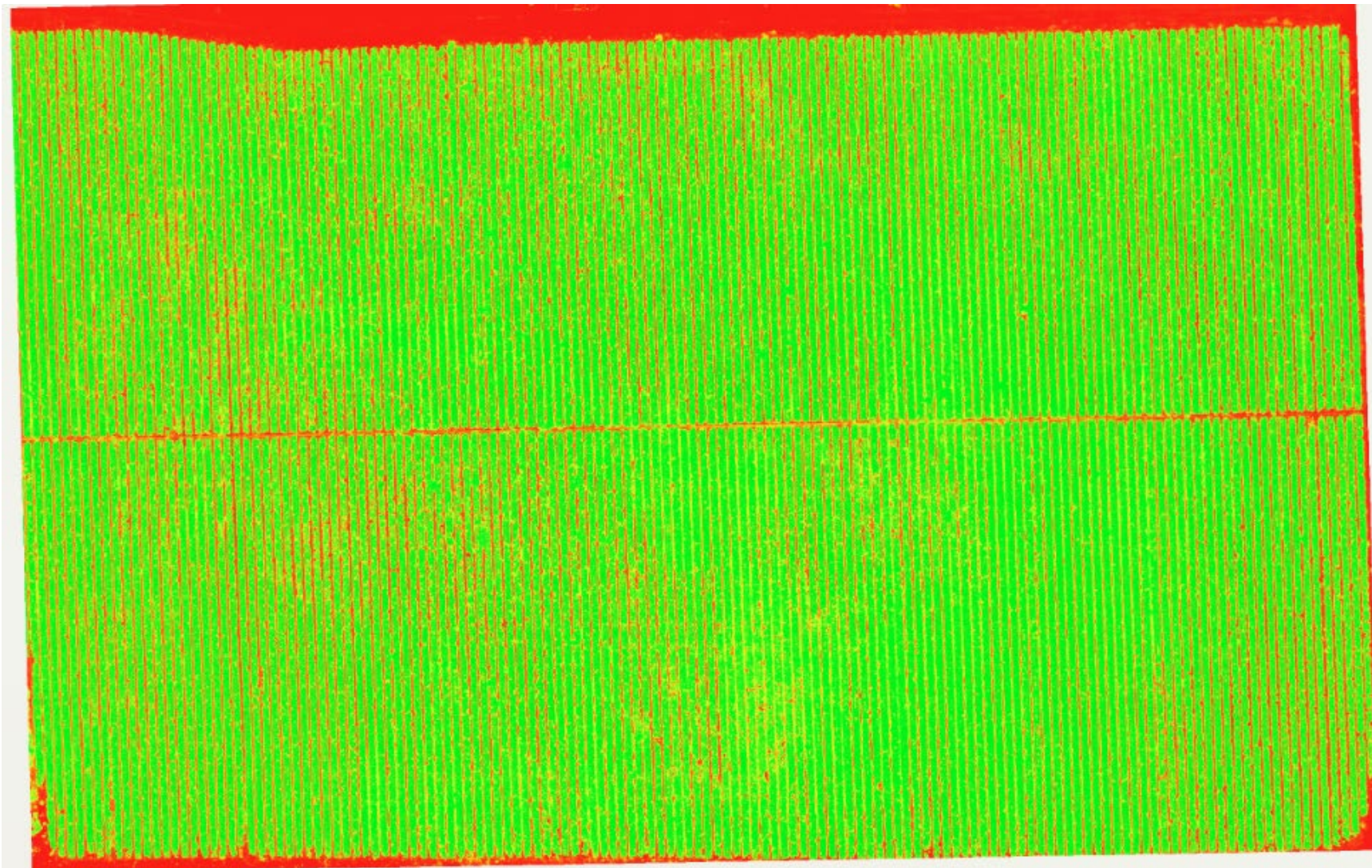
Stressed (0.11-0.14)
Healthy (0.02-0.04)

Stressed (0.33-0.42)
Healthy (0.55-0.61)

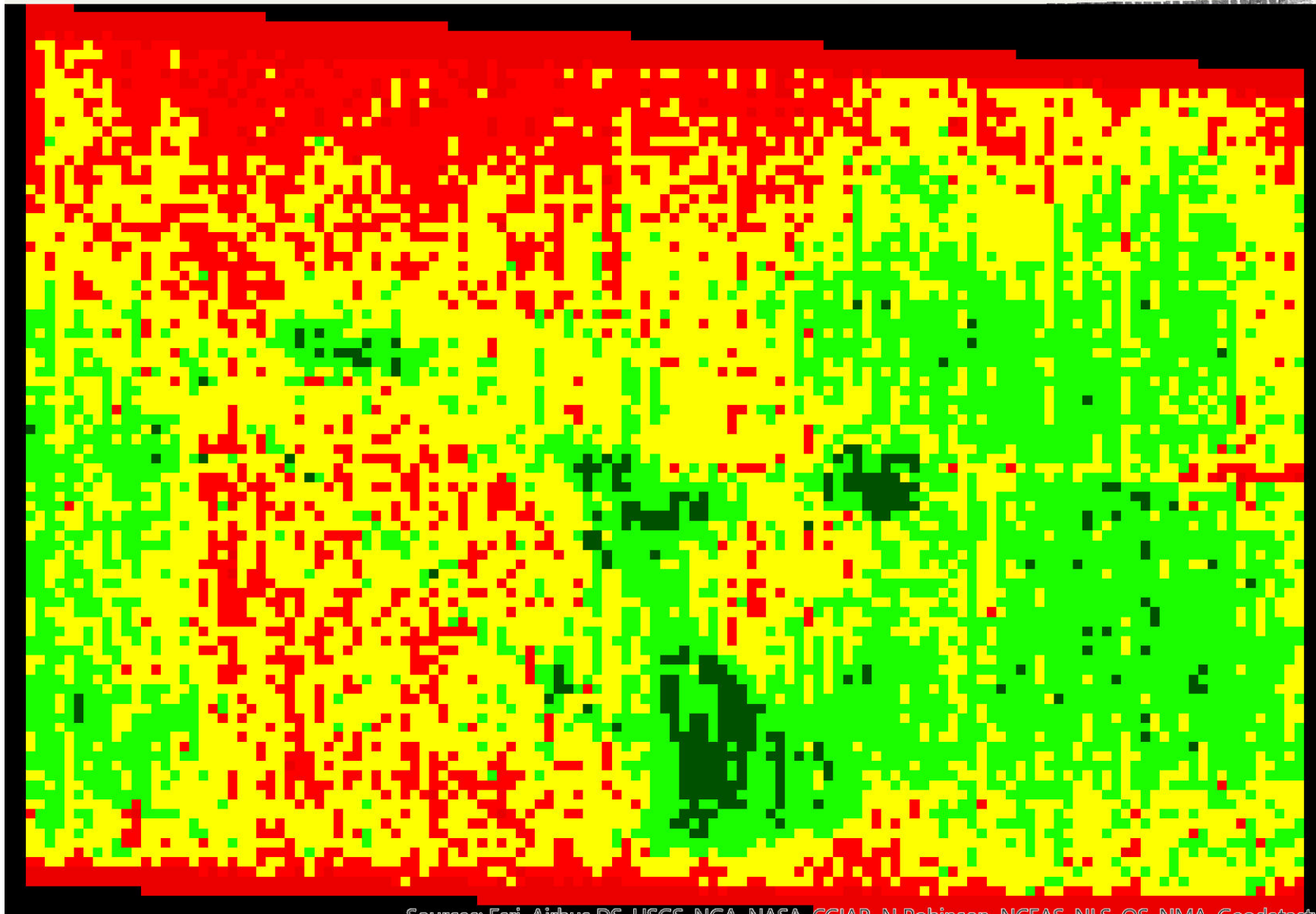
Stressed (0.45-0.55)
Healthy (0.85-0.91)

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

Raw NDVI with 1.07" GSD



July 23, 2020



Source: Esri, Airbus DS, USGS, NGA, NASA, CCIAP, N-Reliance, NCEAS, NLS, CS, NIMA, GeoEye

Mortality map at the end of previous season

2022-23 season:

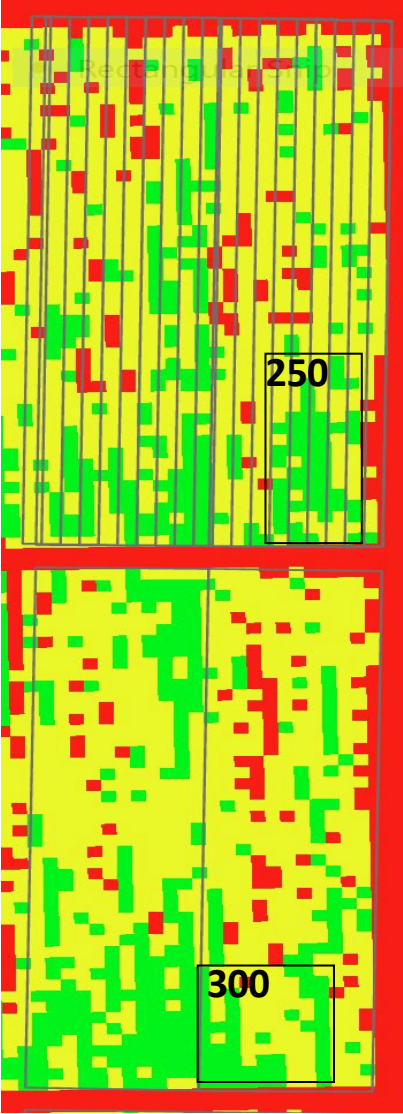
- Four blocks with varied infestation of *M. phaseolina*

VARIABLE RATE PLOTS

- 3 fumigation rates of Pic, lbs/A
 - 250 (low)
 - 300 (medium)
 - 350 (high)

STANDARD

350 lb/A Pic



Color	Upper value	Label
Red	≤ 0.45	0.042 - 0.45
Yellow	≤ 0.6	0.451 - 0.6
Green	≤ 0.88681	0.601 - 0.887

NORTH BLOCKS

Mortality map at the end of previous season

2022-23 season:

- Four blocks with varied infestation of *M. phaseolina*


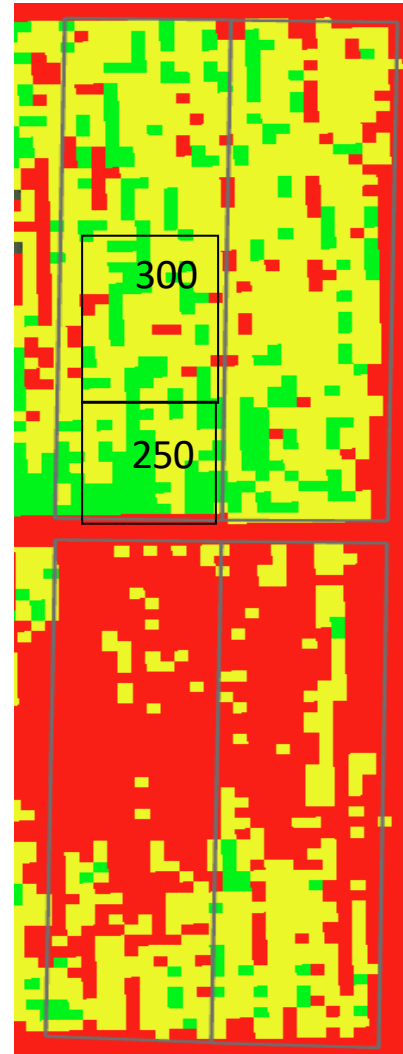
VARIABLE RATE PLOTS

- 3 fumigation rates of Pic, lbs/A
 - 250 (low)
 - 300 (medium)
 - 350 (high)

STANDARD

350 lb/A Pic

Couldn't justify
variable rate in block 4

Color	Upper value	Label
■	≤ 0.45	0.042 - 0.45
■	≤ 0.6	0.451 - 0.6
■	≤ 0.88681	0.601 - 0.887

SOUTH BLOCKS

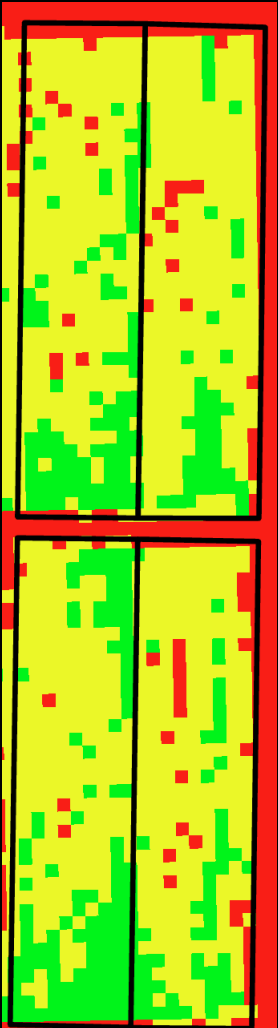
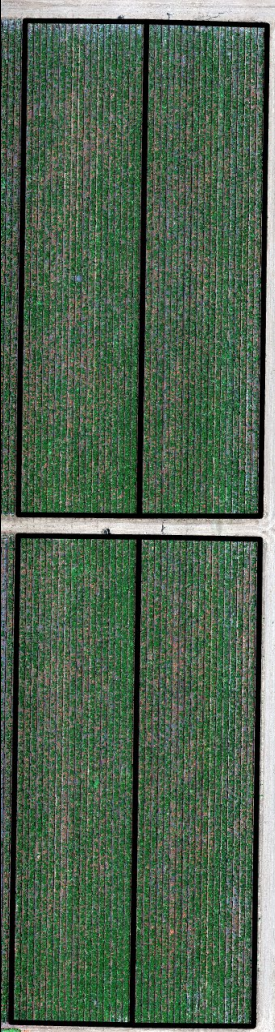
July 2022 - Mortality map at the end of season

RGB

NDVI

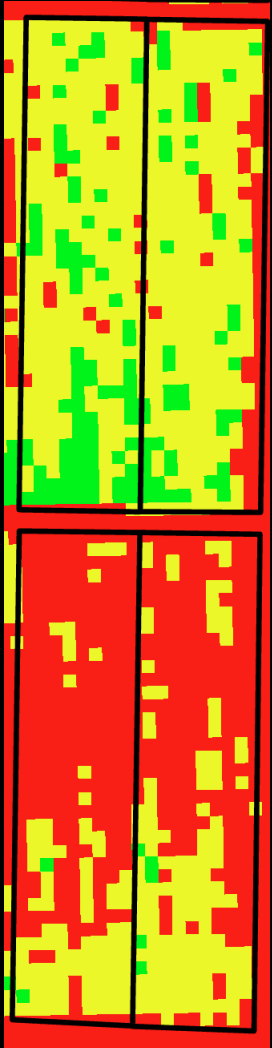
NDVI

RGB






Block 1

Block 3



Block 2

Block 4

Color	Upper value	Label
	≤ 0.45	0.042 - 0.45
	≤ 0.6	0.451 - 0.6
	≤ 0.860611	0.601 - 0.861

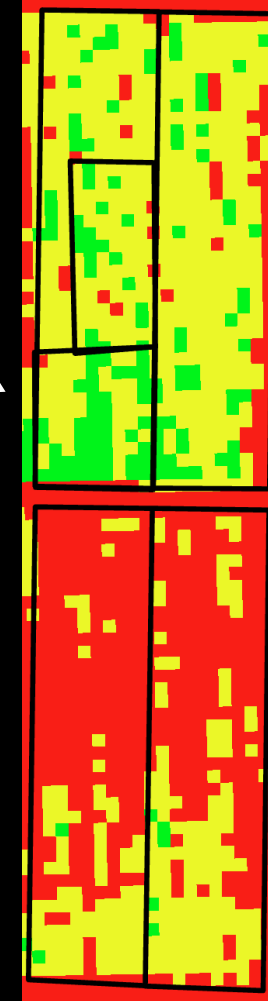
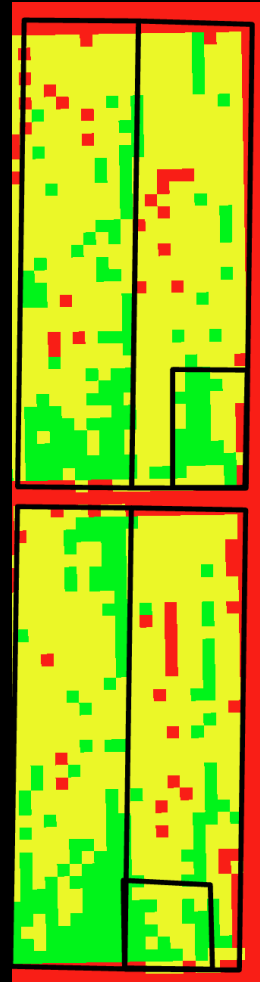
July 2022 - 2022-2023 Treatments

RGB

NDVI

NDVI

RGB






Block 1

Block 2

Block 3

Block 4

- 3 fumigation rates of Pic, lbs/A
 - 250 (low)
 - 300 (medium)
 - 350 (high - standard)

Color	Upper value	Label
	≤ 0.45	0.042 - 0.45
	≤ 0.6	0.451 - 0.6
	≤ 0.860611	0.601 - 0.861

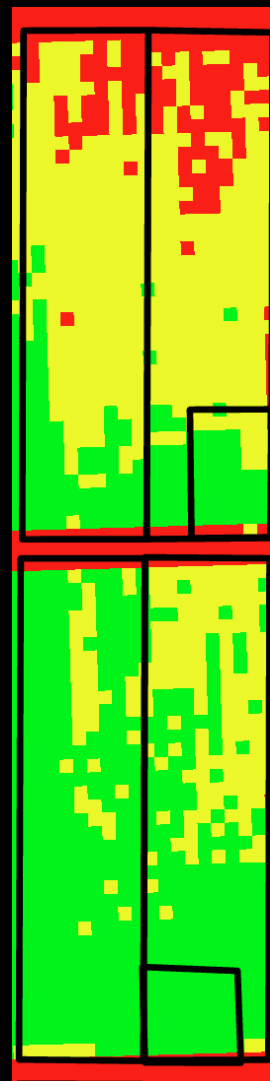
July 2023 - Mortality map at the end of season

RGB

NDVI

NDVI

RGB



- 3 fumigation rates of Pic, lbs/A
 - 250 (low)
 - 300 (medium)
 - 350 (high - standard)

Color	Upper value	Label
Red	≤ 0.65	0.089 - 0.65
Yellow	≤ 0.75	0.651 - 0.75
Green	≤ 0.967537	0.751 - 0.968



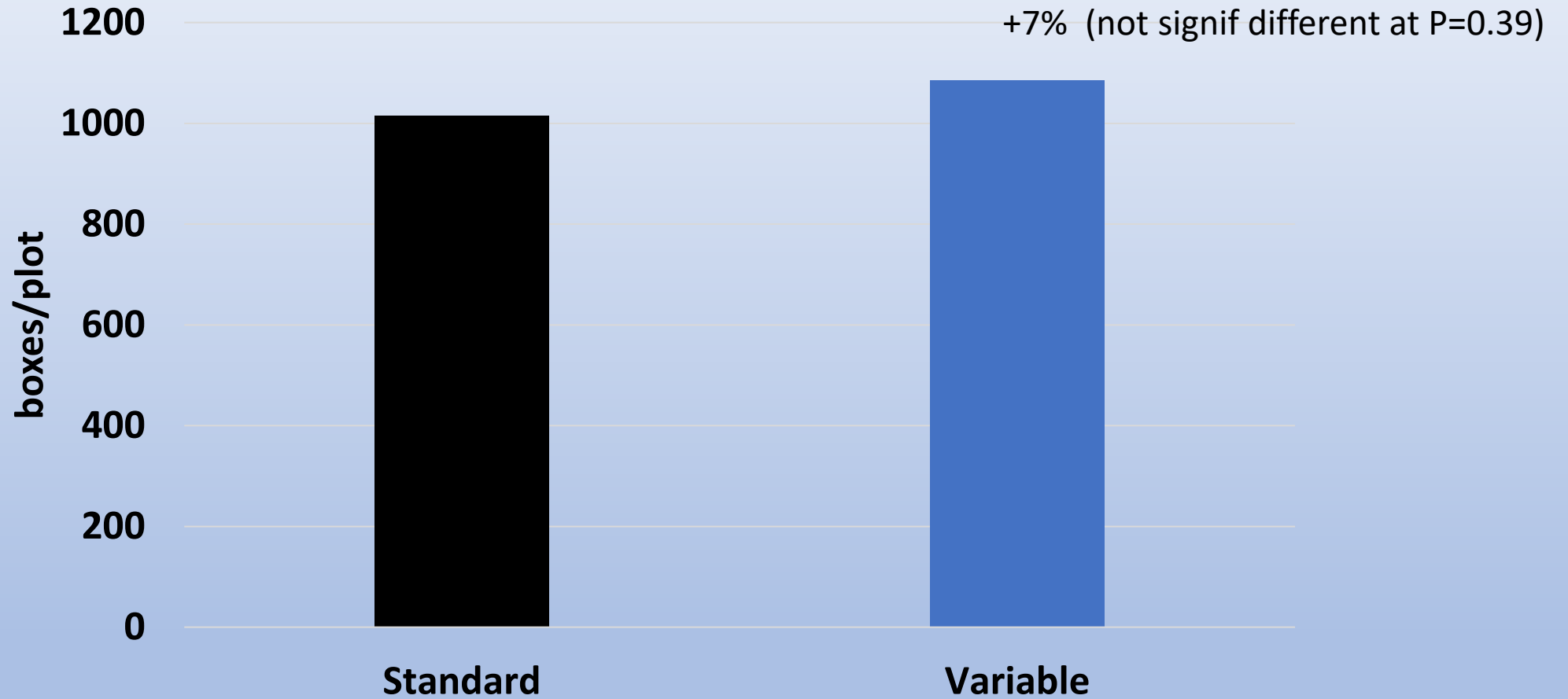
Block 1

Block 2

Block 3

Block 4

2023 yields (Feb-April)



July 2023 – 2023-2024 Treatments

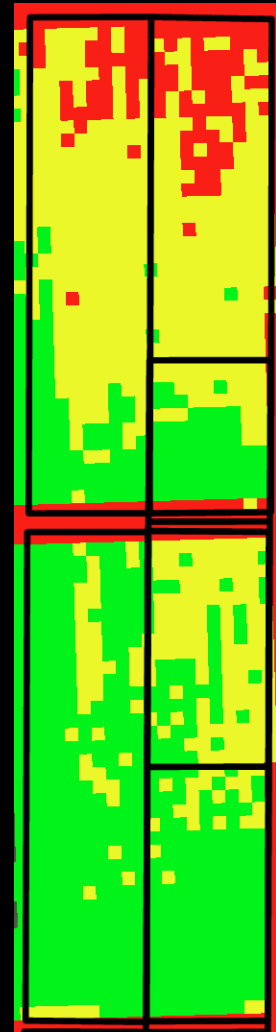
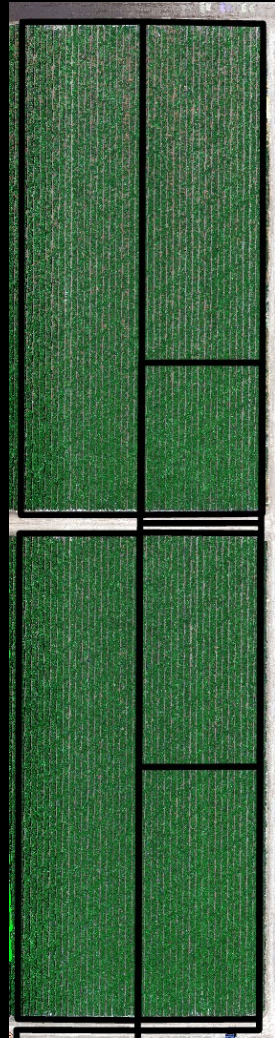
RGB

NDVI

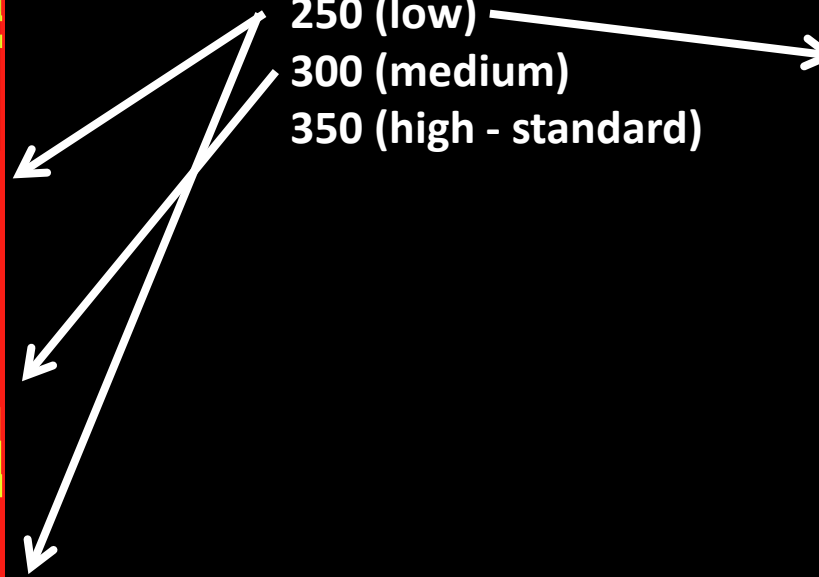
NDVI

RGB

Block 1

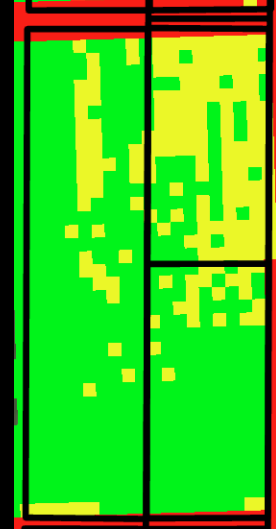
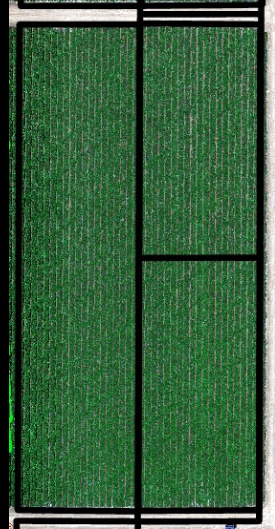


- 2023-2024 Season Treatments
- 3 fumigation rates of Pic, lbs/A
 - 250 (low)
 - 300 (medium)
 - 350 (high - standard)






Block 3

Block 2

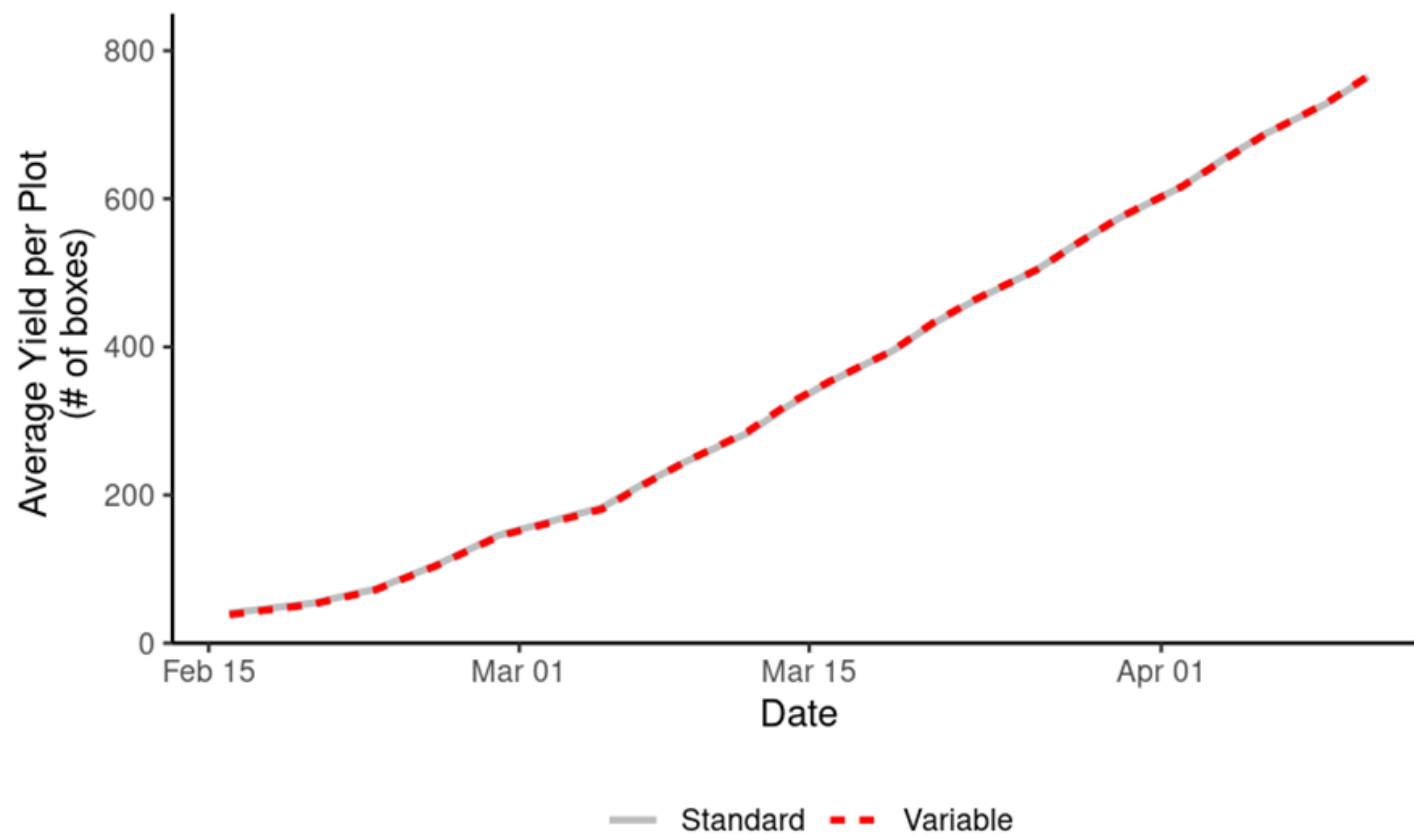


Block 4



Color	Upper value	Label
	≤ 0.65	0.089 - 0.65
	≤ 0.75	0.651 - 0.75
	≤ 0.967537	0.751 - 0.968

2024 Average Yield/Plot Over Time



2024 Average Cumulative Yield/Plot

