Current Remote Sensing and Sprayer Drone Technologies in Agriculture

by
Dr. Randy R. Price
LSU AgCenter, Alexandria, Louisiana

LSU AgCenter Research & Extension

Summary:

- Current drone systems
- Examples of what you can do with drones
- Research at the LSU AgCenter
- Sprayer Drones

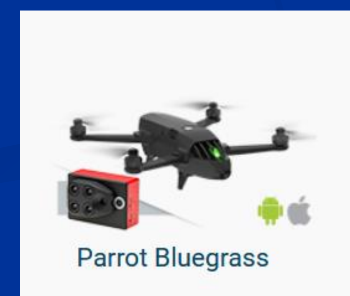
Types of Drones in Agriculture:

Retail Store Drones:

- DJI Phantom; Mavic, etc.
- Low Cost ($400 - $1200)
- RGB Visual Cameras
- Uses: Visual Observation and Mapping

Commercial Mapping Drone Systems:

- - Sentara, Ag Eagle, Parrot Bluegrass, Etc.
- Cost ($8000 - $15,000)
- NIR Camera / No Live View
- Uses: Mapping Only



Sprayer Drones:

- T10, T20, T30, etc.
- $10,000 to $25,000
- For spraying fields

Uses In Agriculture:

- 3 Main Uses:
  - Live Aerial Views:
    - Crop Scouting
    - Checking cattle / Fences
    - Etc.
  - Mapping:
    - Visual / Numerical Analysis
    - Prescription Maps
  - Crop Spraying
    - Small area: 10 to 40 acres

Drones I Recommend (Others Available):

DJI Mavic Mini 2 - $499

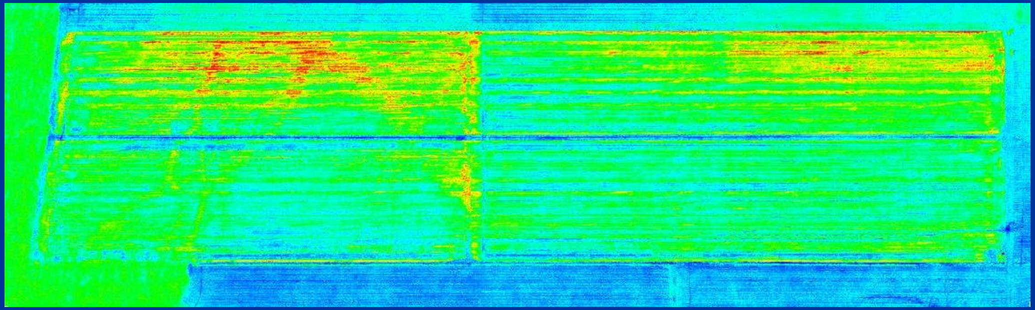
- Feels more like a toy, but powerful drone
- Disadvantages for use in Agriculture
  - License still required for commercial work in U.S. (not in many other countries)
- Not supported yet by agricultural flight software (drone deploy, Pix4D fields, etc., but close!)
- Advantages:
  - Low cost
  - Timed imagery capture function

DJI Mavic Air 2 ($599 to $958)

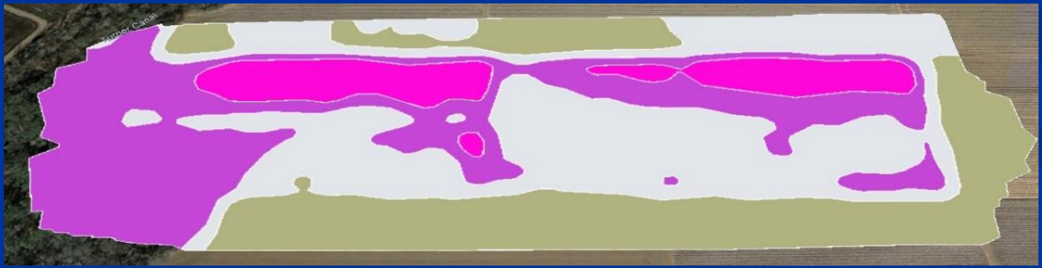
- Higher quality drone - heavier, more metal, etc.
- Longer flight times (30+ minutes)
- Operates in most winds (i.e. < 30 MPH)
- 48 Meg pixel camera
- Capable of very low crop scouting

Production of a Precision Farming Map for Sprayer:

RGB/NIR Image - Value for each wavelength



Plant Index Map - Single Value Map



Shape File - File for Sprayers 2 to 6 levels

Different Plant Indices:

Table. Available indices in *FIELDimageR*. Any other index can be implemented using the option *myIndex* and the new formula (*FIELDimageR::fieldIndex*).

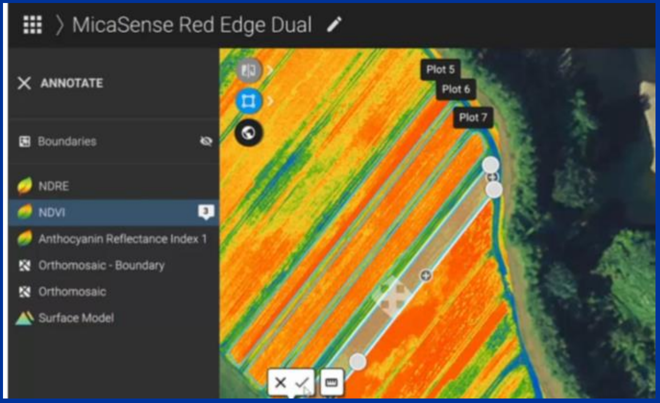
Description	Index	Formula	Related traits	References
Brightness Index	BI	sqrt((R^2+G^2+B^2)/3)	Vegetation coverage, water content	Richardson and Wiegand (1977)
Soil Color Index	SCI	(R-G)/(R+G)	Soil color	Mathieu et al. (1998)
Green Leaf Index	GLI	(2*G-R-B)/(2*G+R+B)	Chlorophyll	Louhaichi et al. (2001)
Primary Colors Hue Index	HI	(2*R-G-B)/(G-B)	Soil color	Escadafal et al. (1994)
Normalized Green Red Difference Index	NGRDI	(G-R)/(G+R)	Chlorophyll, biomass, water content	Tucker (1979)
Spectral Slope Saturation Index	SI	(R-B)/(R+B)	Soil color	Escadafal et al. (1994)
Visible Atmospherically Resistant Index	VARI	(G-R)/(G+R-B)	Canopy, biomass, chlorophyll	Gitelson et al. (2002)
Overall Hue Index[#]	HUE	atan(2*(B-G-R)/30.5*(G-R))	Soil color	Escadafal et al. (1994)
Blue Green Pigment Index	BGI	B/G	Chlorophyll, LAI	Zarco-Tejada et al. (2005)
Plant Senescence Reflectance Index	PSRI	(R-G)/(RE)	Chlorophyll, nitrogen, maturity	Merzlyak et al. (1999)
Normalized Difference Vegetation Index	NDVI	(NIR-R)/(NIR+R)	Chlorophyll, LAI, biomass, yield	Rouse et al. (1974)
Green Normalized Difference Vegetation Index	GNDVI	(NIR-G)/(NIR+G)	Chlorophyll, LAI, nitrogen, protein content, water content	Gitelson et al. (1996)
Ratio Vegetation Index	RVI	NIR/R	Biomass, water content, nitrogen	Pearson and Miller (1972)
Normalized Difference Red Edge Index	NDRE	(NIR-RE)/(NIR+RE)	Chlorophyll	Gitelson and Merzlyak (1994)
Triangular vegetation index	TVI	0.5*(120*(NIR −G)−200*(R −G))	Green LAI, chlorophyll, canopy	Broge and Leblanc (2000)
Chlorophyll vegetation index	CVI	(NIR*R)/(G^2)	Chlorophyll	Vincini et al. (2008)
Enhanced vegetation index	EVI	2.5*(NIR −R)/(NIR + 6*R −7.5*B + 1)	Chlorophyll, biomass, nitrogen	Huete et al. (2002)
Chlorophyll index – green	CIG	(NIR/G) −1	Chlorophyll	Gitelson et al. (2003)
Chlorophyll index – red edge	CIRE	(NIR/RE) −1	Chlorophyll	Gitelson et al. (2003)
Difference Vegetation Index	DVI	NIR-RE	Nitrogen, chlorophyll	Jordan (1969)

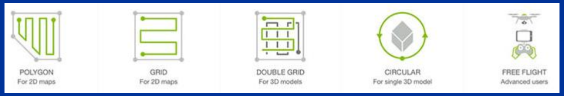
[#] Index HUE was modified to capture better the soil color. Original equation: "atan(2*(R-G-B)/30.5*(G-B))" (Escadafal et al., 1994)

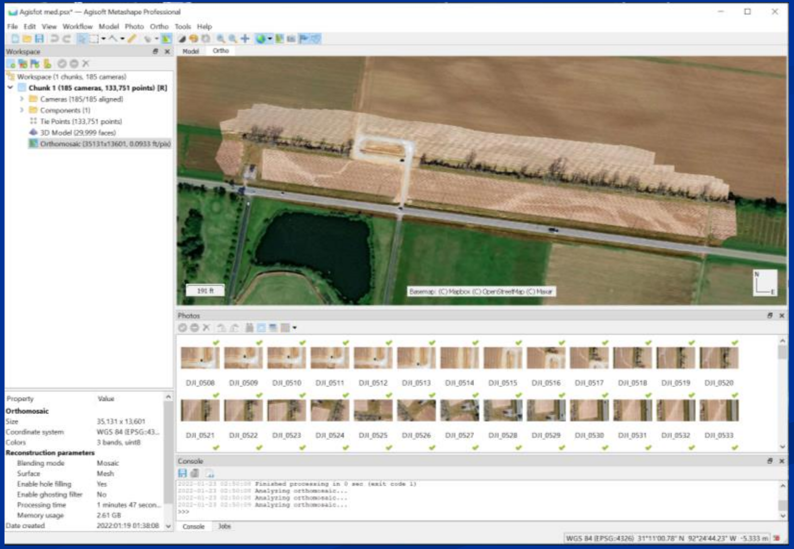
Mapping and Layering Software:

- Pix 4-D Suite:
  - Mapper - Puts images together
    - $5,000 / $291 per month
  - Fields - Ag. Functions in one package:
    - Automated flight guidance over field
    - Live mapping
    - Index calculations
    - Quick statistics (box area and see averages, etc.)
    - $166 per month or $3500 one time fee
  - Capture – Flight Guidance
    - Free from App store

- Agisoft:
  - $3,499
  - Makes Orthomosaics
  - Calculate indexes in equation format
  - Can generate prescription maps (shape files)
  - Get the Professional Version



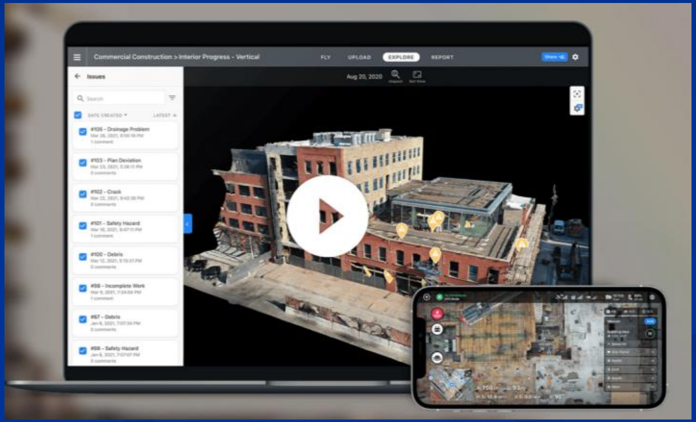




On-line and App Versions:

- Drone Deploy:
  - $1200 per year and up
  - Share maps across internet
  - Moving into other things such as robotic control
- Mapware:
  - 2 cents per megapixel, etc.
- Etc.

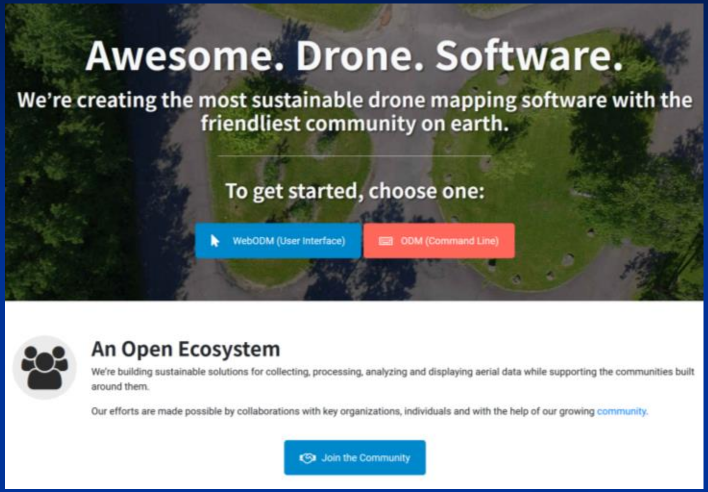
DroneDeploy

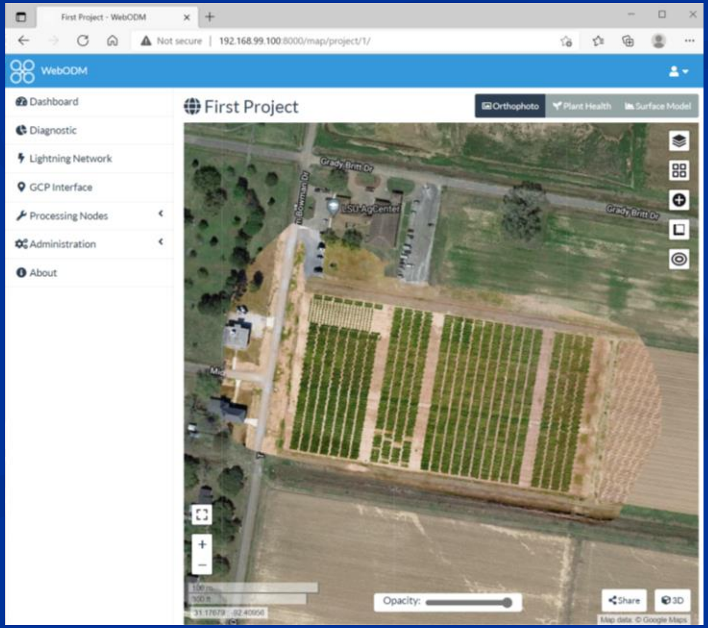


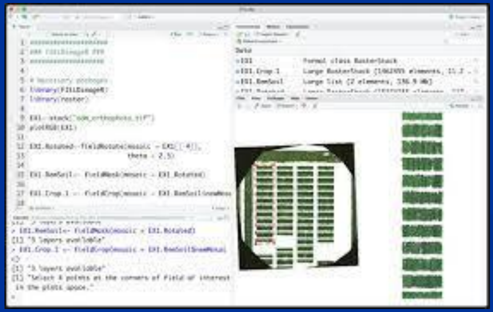
Mapware

Free Programs:

- Web ODM (OpenDroneMap)
  - 2-D Mapping / Orthomosaics
  - Free
    - Free command line / $57 for easy-to-use web version
    - Look as good as others
    - Took longer to process:
      - 45 minutes for field on left versus 10 minutes for Agisoft
- FieldImageR:
  - Analyzes plots for plant breeders







What Can You Do with Remote Sensing Drones:

Large Area Maps:

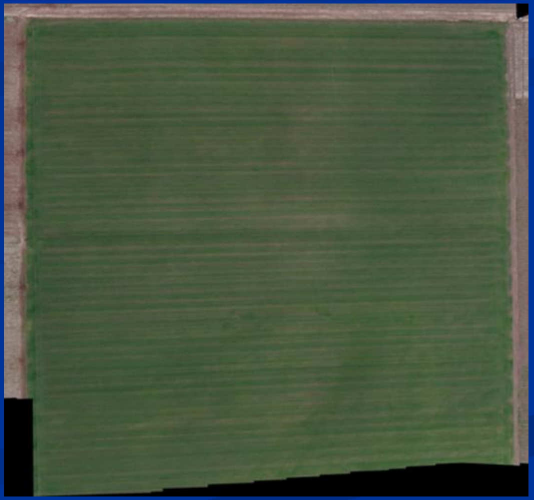
- DJI Mavic Air 2:
  - 30 to 35 minute flight time
  - 2 sec elapsed / 12M Images
  - Images taken slightly oblique
    - Fly down the rows (not across)
    - Good for getting rid for sunlight spots out of imagery
  - Used Average instead of Mesh Analysis in software
- Result: Mapped 250 to 300 acres with one battery.
- Airplanes: further
  - Probably 200 to 1200 acres per battery
  - A lot of photos – 1000 or more
  - Computer probably won't crunch that much data

Oblique Shot of Field - Good Way to See Different Areas of Field

- 2-D maps may allow you to see proportional differences better

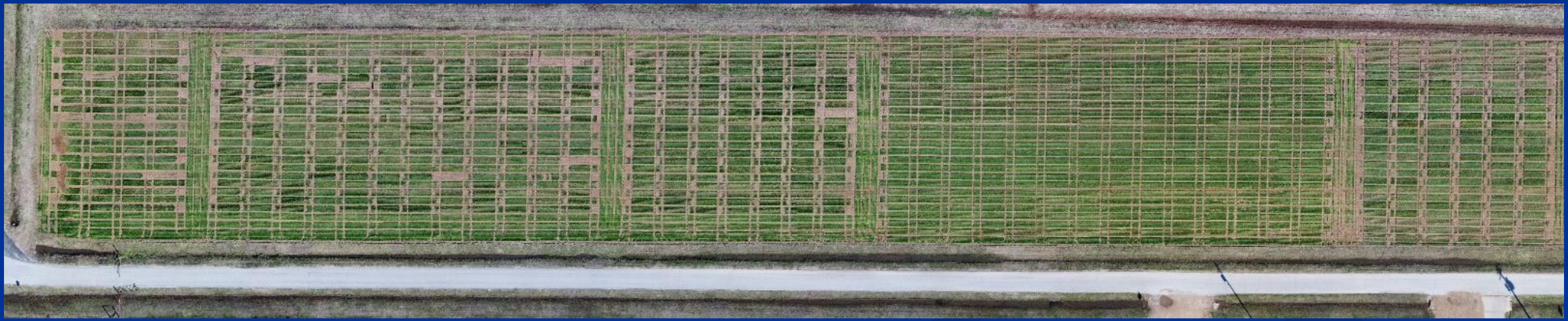
Oblique Image

2-D Image

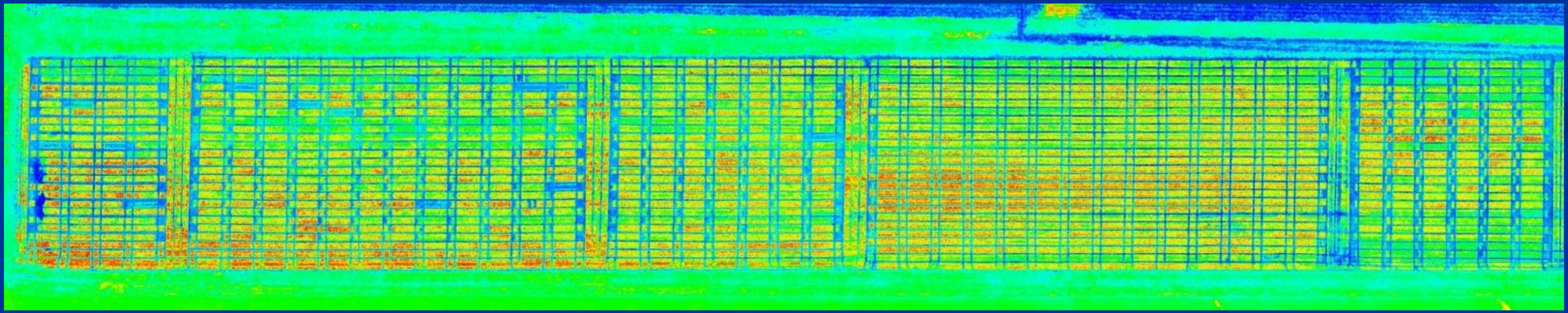


Maps to Indicate Different Growing Areas:

RGB Image



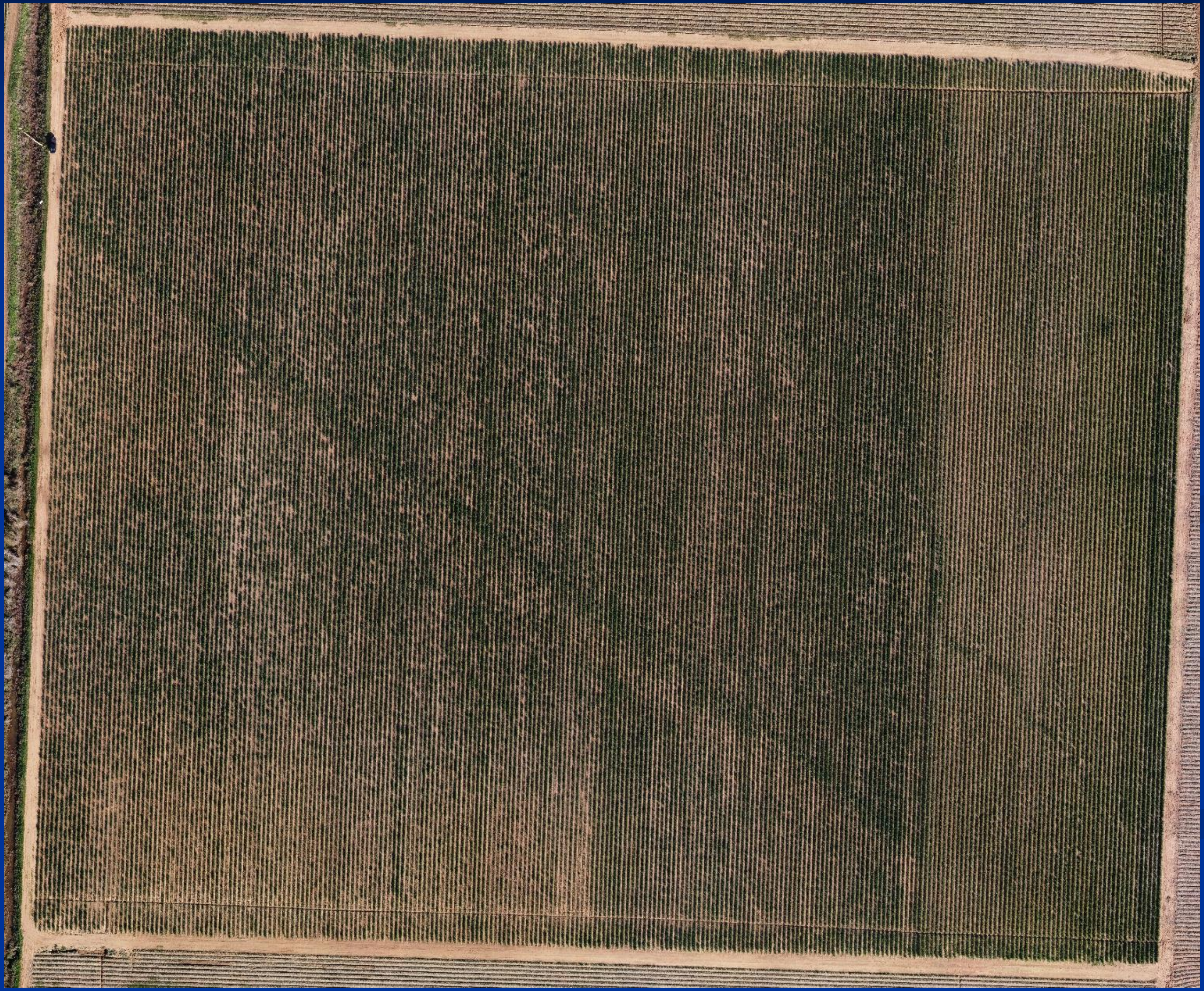
Indices Image (Green - Red) – Note: Red Color Denotes Best Foliage



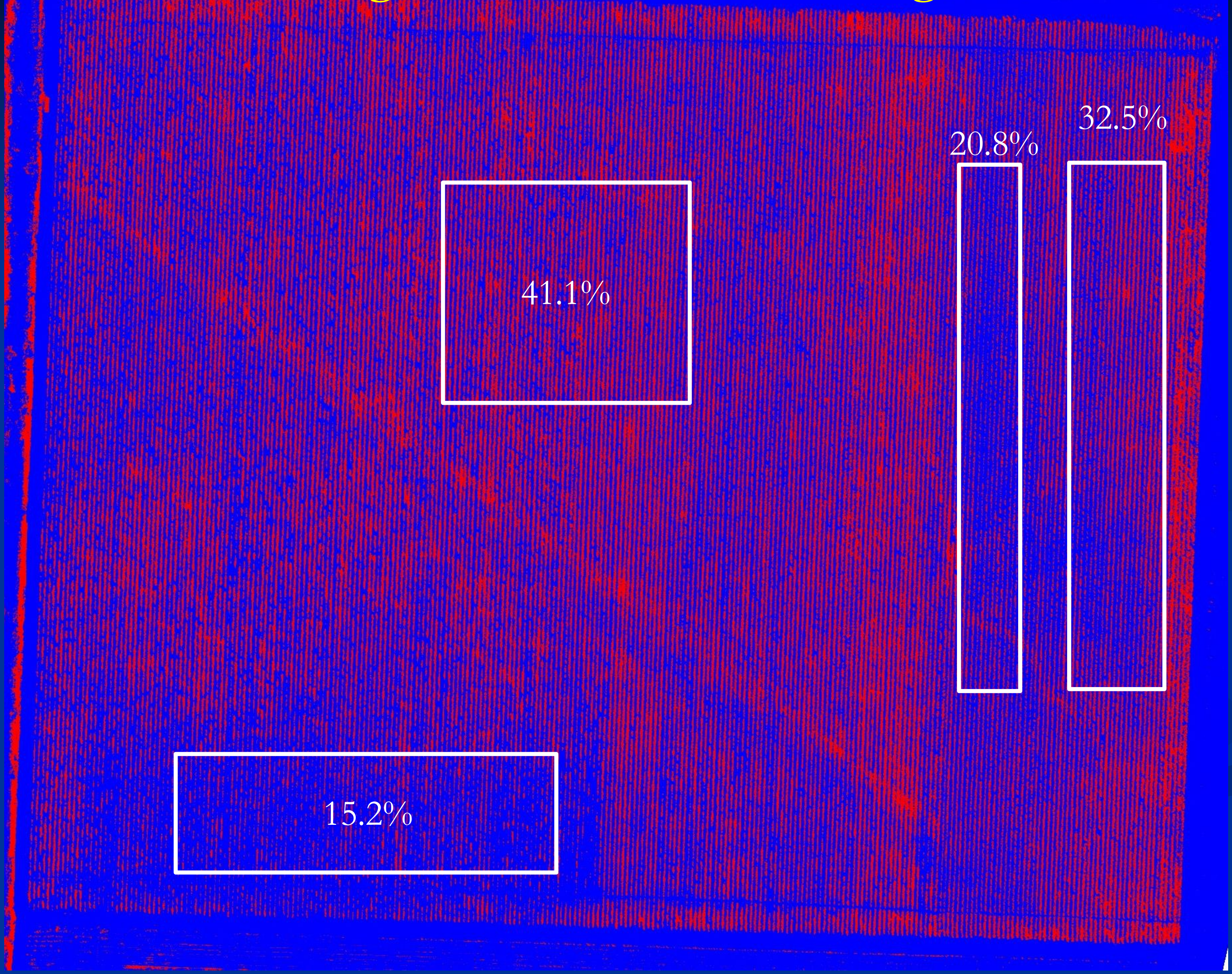
Close Ups - Spot Checking: Wheat Field

Mavic Mini - ($399) 20 Megapixel Camera

Sugarcane Plant Growth - 2021:



RGB Image of Field - Percent Foliage/Plants:



Wire Worm Damage in Soybean Plots:

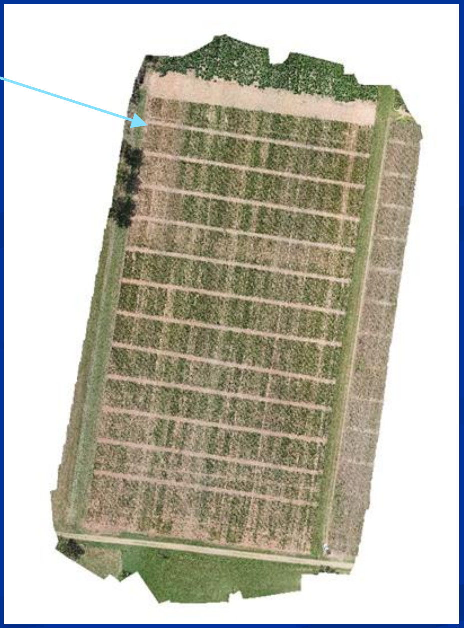
Visual Wire Worms in Soybean Field:

- Wire Worm Progression in Field with Time:

9/9/20

9/11/20

9/15/20



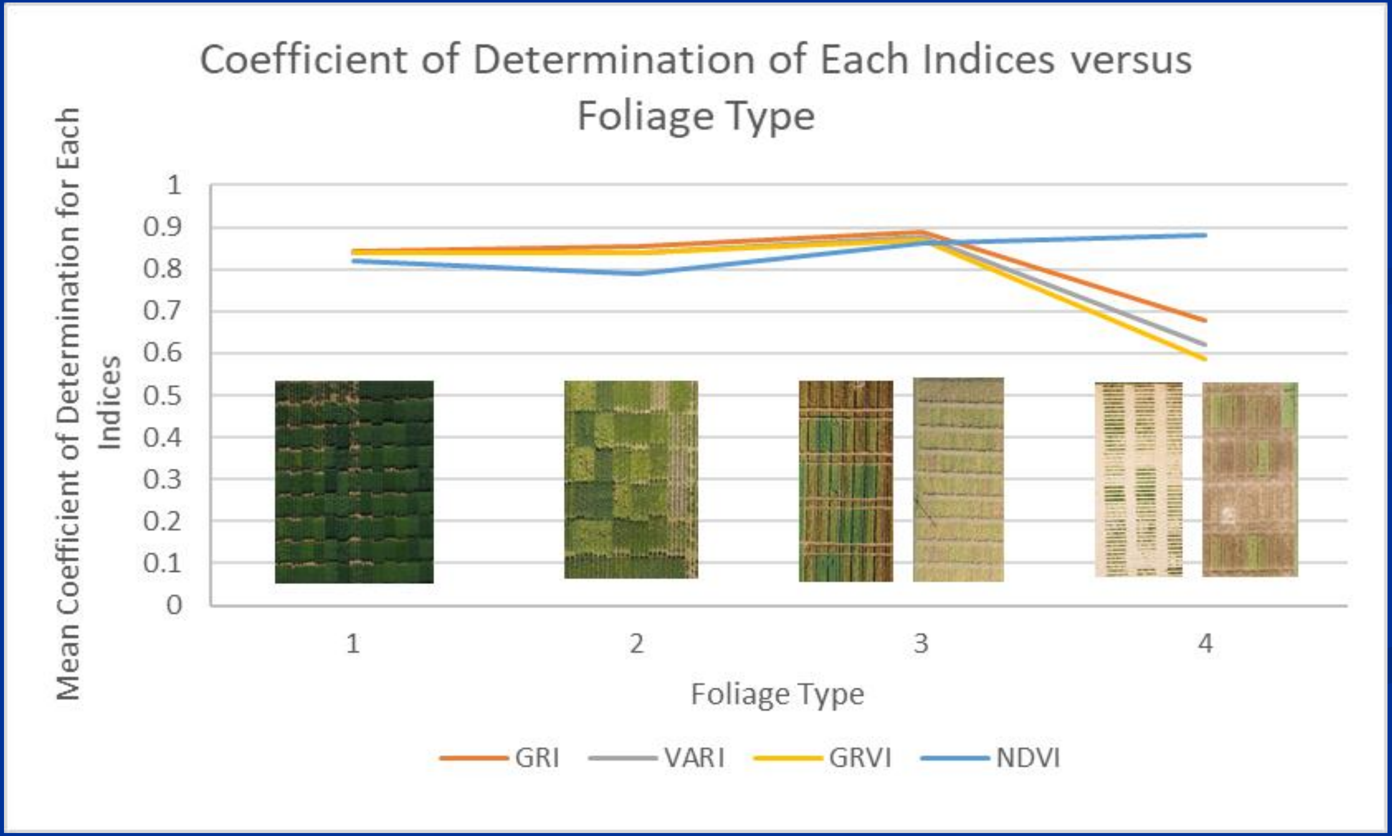
Oblique Shot of Sugarcane Field:

- Mosaic Leaf Strip

LSU AgCenter Research:

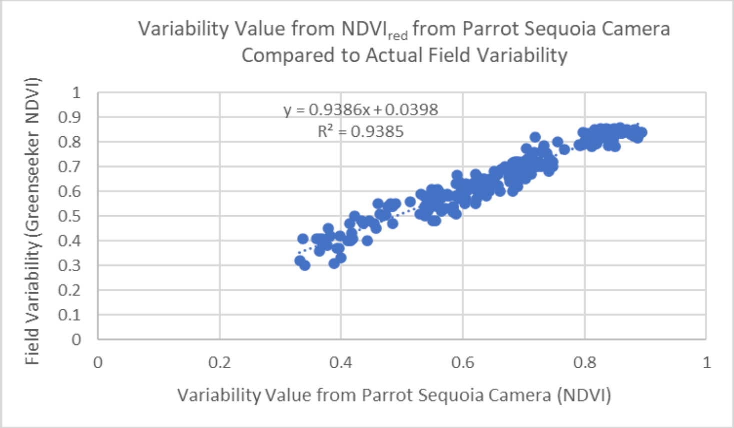
RGB Camera compared to NIR for Detecting General Field Variability:

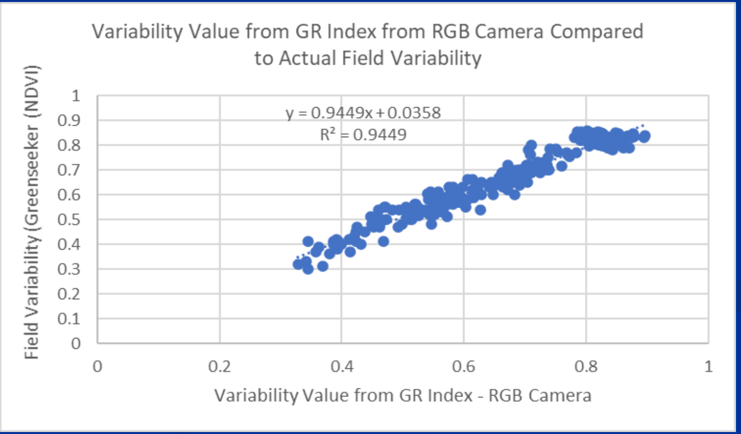
- In most situations, the RGB camera did better or as well as the NIR camera (NDVI) at indicating field variability.
- The NIR camera did perform better in fields with less foliage or higher amounts of soil background:

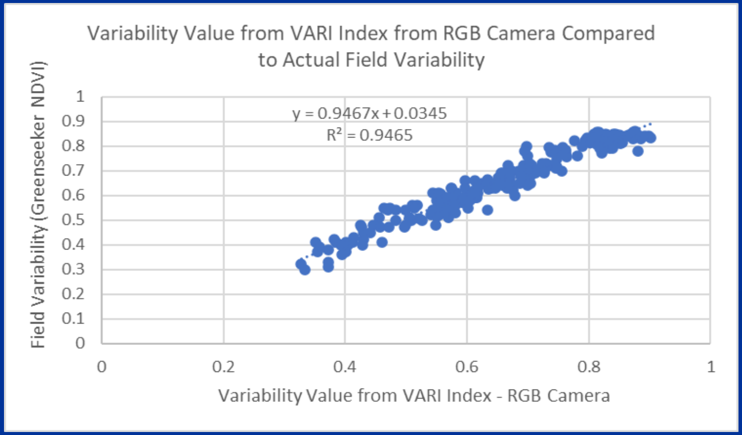


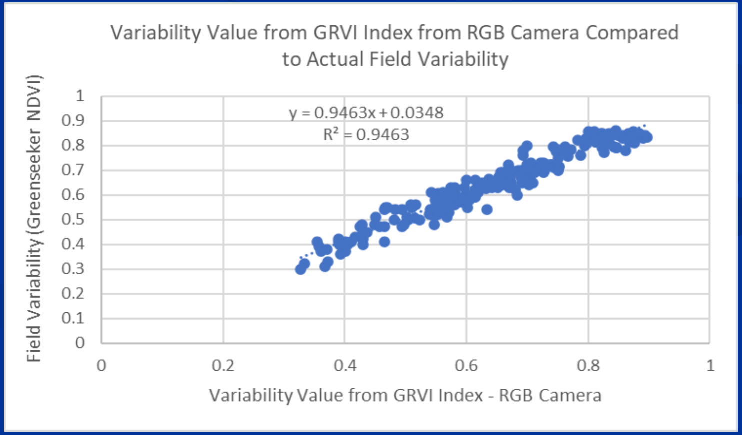
Comparison of RGB Camera Indices to NDVI indices and the Greenseeker:

- RGB camera and indexes did slightly better than NDVI when only foliage fields included







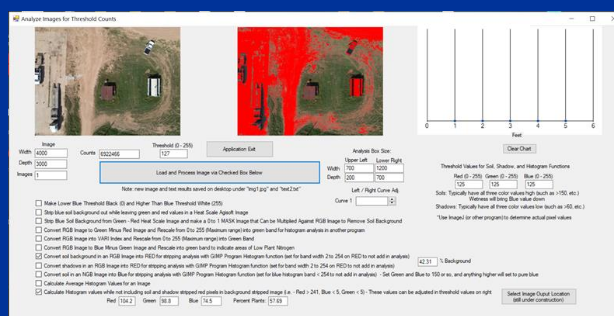


Program for Multi-Plot Analysis and Background Stripping:

- Software Makes it Easy to Perform Multiple Field or Plot Analysis:

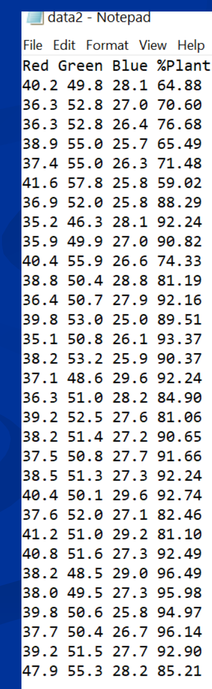
Original Images taken with Drone:

Software Can Analyze Multiple Images and Steps at Once:



Intermediate Images Stored in Separate Folder:

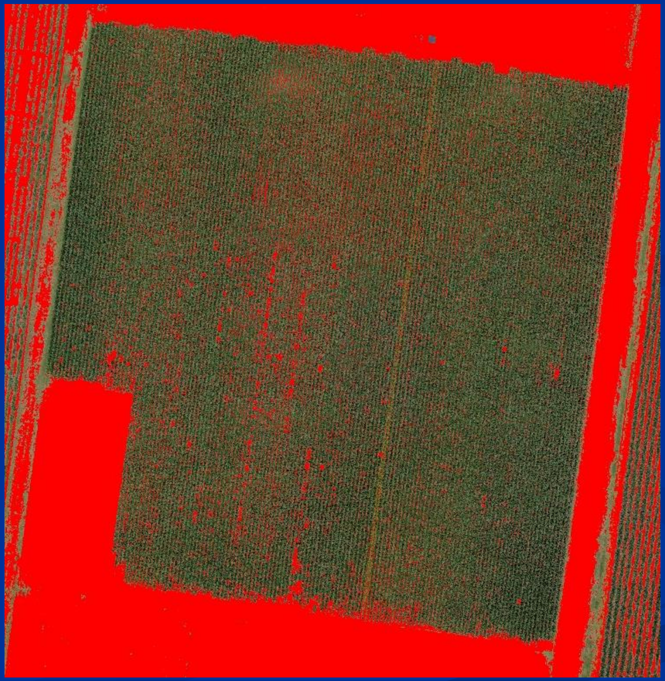
Text File Written with Results for Calculations in Excel



Red	Green	Blue	%Plants
40.2	49.8	28.1	64.88
36.3	52.8	27.0	70.60
36.3	52.8	26.4	76.68
38.9	55.0	25.7	65.49
37.4	55.0	26.3	71.48
41.6	57.8	25.8	59.02
36.9	52.0	25.8	88.29
35.2	46.3	28.1	92.24
35.9	49.9	27.0	90.82
40.4	55.9	26.6	74.33
38.8	50.4	28.8	81.19
36.4	50.7	27.9	92.16
39.8	53.0	25.0	89.51
35.1	50.8	26.1	93.37
38.2	53.2	25.9	90.37
37.1	48.6	29.6	92.24
36.3	51.0	28.2	84.90
39.2	52.5	27.6	81.06
38.2	51.4	27.2	90.65
37.5	50.8	27.7	91.66
38.5	51.3	27.3	92.24
40.4	50.1	29.6	92.74
37.6	52.0	27.1	82.46
41.2	51.0	29.2	81.10
40.8	51.6	27.3	92.49
38.2	48.5	29.0	96.49
38.0	49.5	27.3	95.98
39.8	50.6	25.8	94.97
37.7	50.4	26.7	96.14
39.2	51.5	27.7	92.90
47.9	55.3	28.2	85.21

Background Stripping Corn Test:

- Strip out unwanted background effects such as soil, water, or shadows in RGB imagery:
- Allows analysis to be applied to plants only without soil included
- Results:
  - Works well in some cases, but not in others:
    - Visual differences enhanced optical differences in fields
    - Plus: only evaluate foliage effects
    - Minus: Far away images tended to have "blended pixels" that contain both soil and plant colors combined

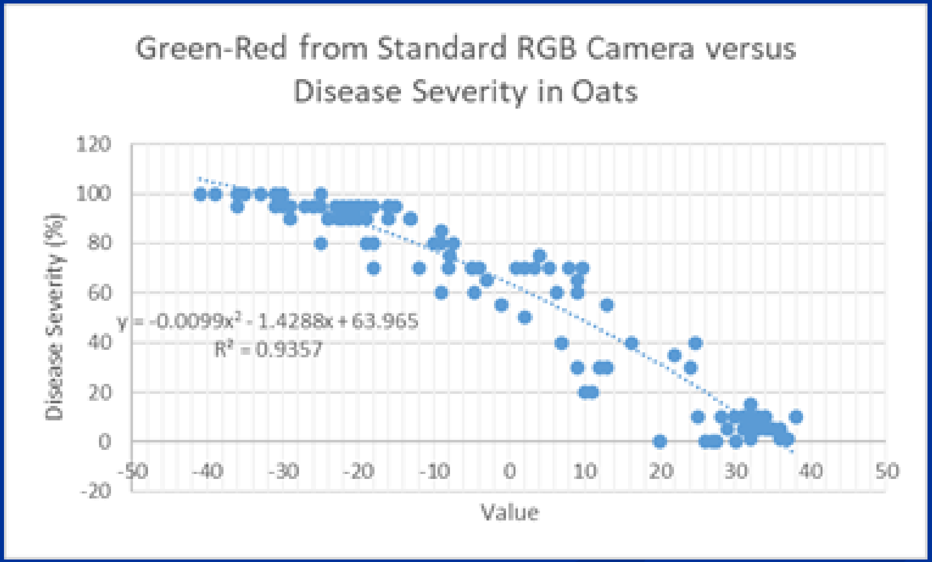


Corn field with soil background stripped to red

Background Stripping in Rice:

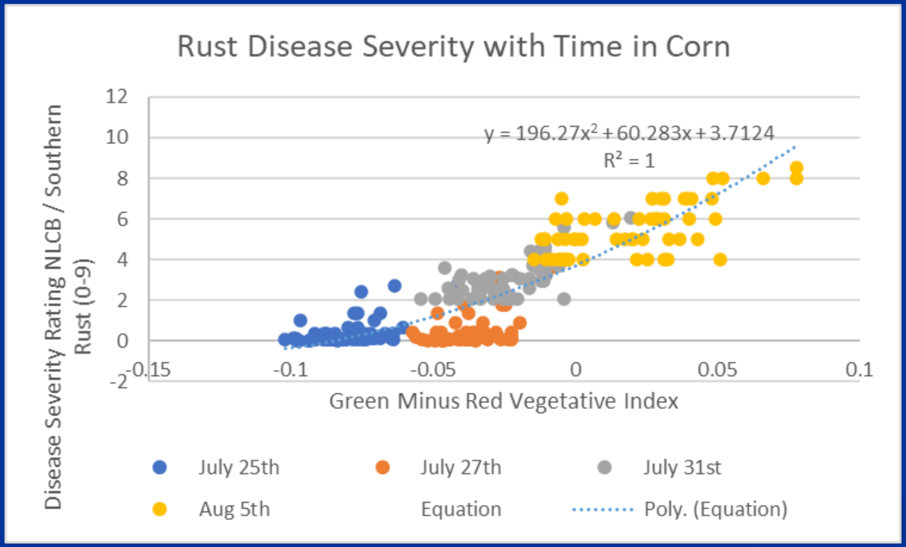
Disease Severity in Oats and Wheat:

- Fungicide on Plots versus No Fungicide:



Rust Severity in Corn:

- (NLCB) Northern Leaf Corn Blight and Rust: Damage areas very evident in maps and photos
  - Damage areas progressed very quickly through field - 3 to 5 days



Sprayer “Agricultural” Drones:

Sprayer Drones:

- Branded as “Agricultural” Drones
- Available from 10 to 30 Liter Sizes
  - 10 liter to stay under FAA weight limit
  - Rules not friendly to drones over 55 lbs. which includes most sprayer drones over 10 L
- Have radar and obstacle avoidance
- Select area to be sprayed on map or set AB line (built into controller)
- Most have:
  - Automatic return to work location
  - Automatic flowrate control
  - Radar height control
- 10 ft. to 20 ft. swath widths
- Flight 10 minutes
- Batteries- new Super LiPo
  - Higher voltages, faster charge times:
    - Old ones – 100 cycle charges / charge in approx. 45 minutes
    - New ones 300 cycles to 1000 cycle charges / charge in 15 minutes

DJI T10:

- Professional Spray Drone
- Folds up compact
- PWM nozzle and anti-drip siphons
- Fly's 10 minutes
- 15-minute quick charge batteries
    - Supposedly rated to 1000 charging cycles

Other Drones We Have:

Equipment Needed for Sprayer Drone Operation:

- Agricultural Drone
- Batteries (6 to 10)
- Charger
- Generator
- Trailer and possibly upright floor section (sugarcane)
- Chemical containers
- Wash area

$12,000 – $25,000

Trailer with Stand

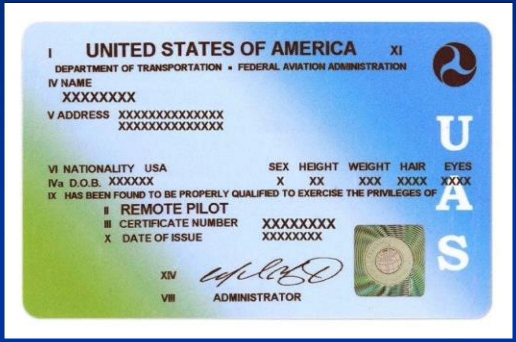
DIY Sprayer Drones:

- Most parts come "plug and play":
- Dedicated flight controller
  - Already has programmed for pump operation, tank empty trigger, return to last spray point, etc.
- Motors, ESC, Prop in one unit

Ripener in Sugarcane Field Applied with Sprayer Drone:

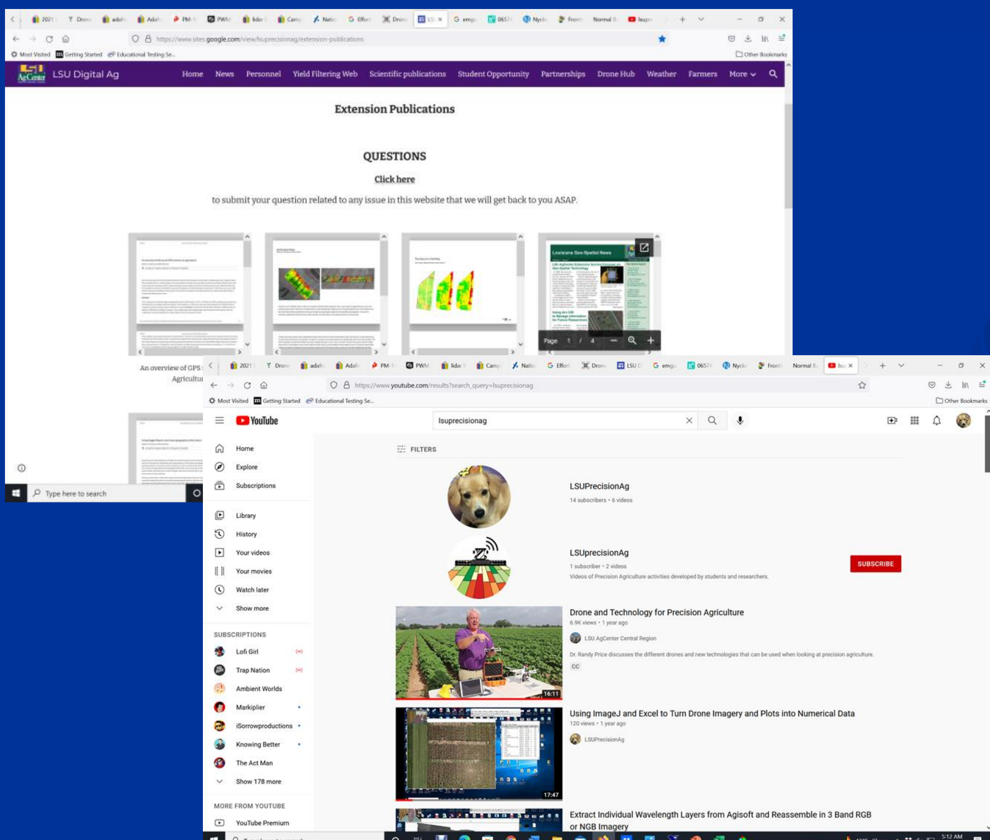
Licensing:

- Any drone operator performing commercial operations needs a license:
  - Part 107
    - Commercial drone pilots license
- Sprayer drones under 55 lbs.:
  - Above requirement plus:
  - Part 137 (agricultural aviation commercial license)
  - Several small waivers
- Sprayer drones over 55 lbs.:
  - Above plus:
  - Experimental aircraft licensing
    - See a lawyer for this aspect
  - Other requirements:
    - Notice to everyone within 500 ft. of field and 48 hours before flight that you will be flying



LSU Precision Ag Websites:

- Additional information on Main LSU AgCenter Page, Google, and YouTube under : LSUPrecisionAg and other keywords:



The End

Questions?

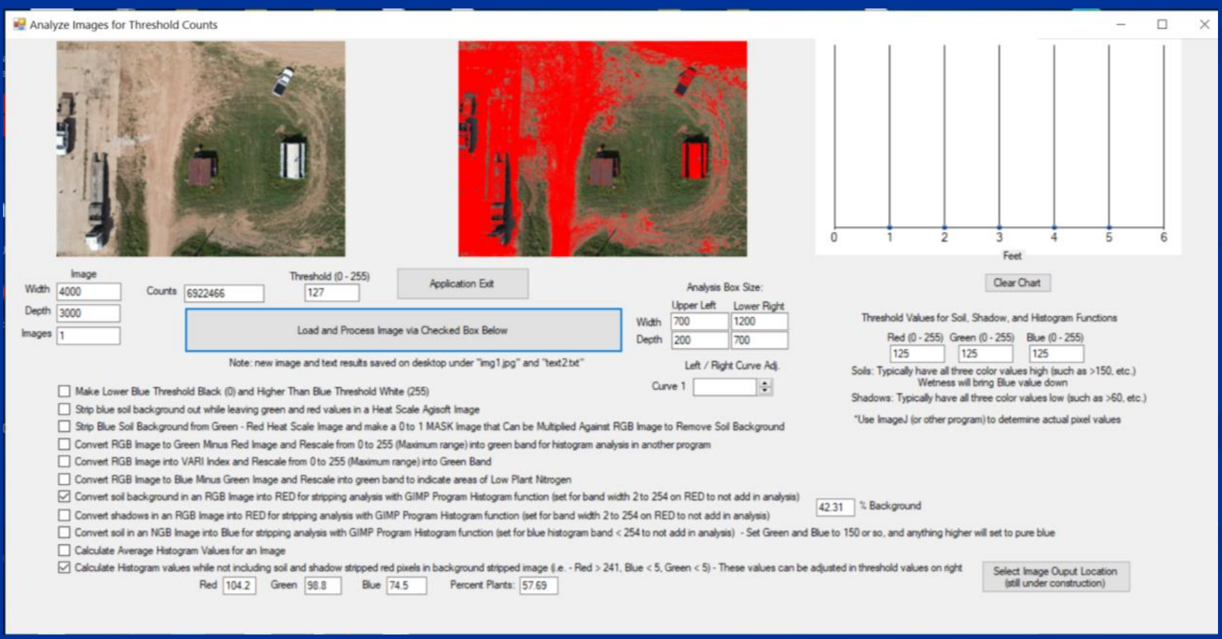
Special thanks to the Soybean & Grains Research and Promotion Board and the American Sugarcane League for provided funding and support for these projects

THE LOUISIANA
Soybean & Grain
RESEARCH & PROMOTION BOARD

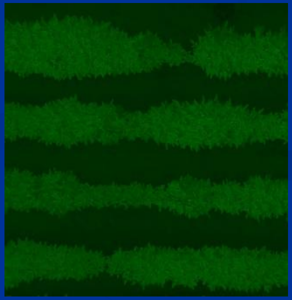
American
Sugar Cane
League

Drone Imagery Toolbox:

- Software will allow you to perform functions on RGB software:
  - Indices: GR, VARI, etc.
  - Background soil or shadow stripping:
  - Subtracting maps (images)
  - Histogram values on plots:
    - Soil background subtracting from histogram values

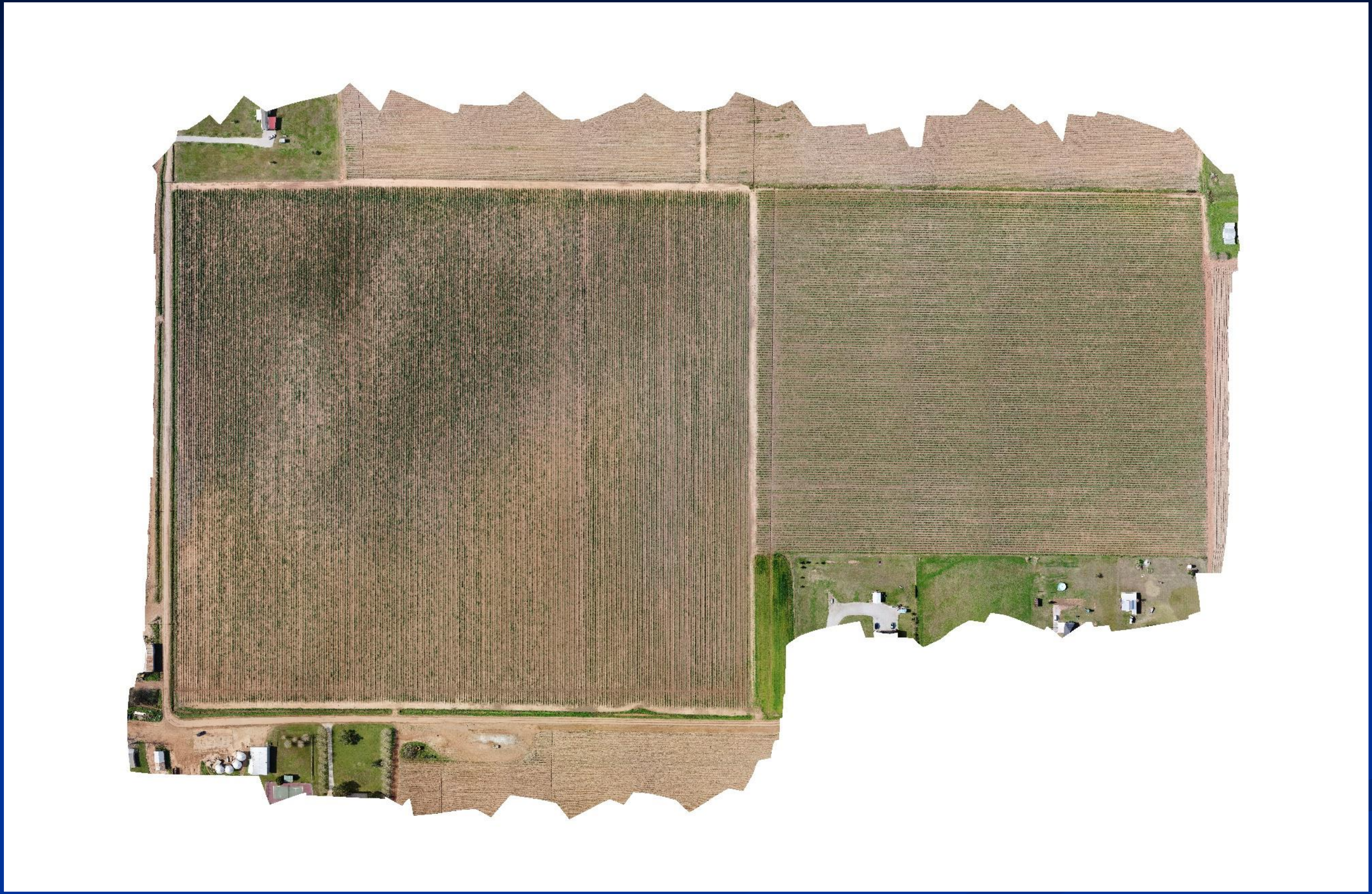


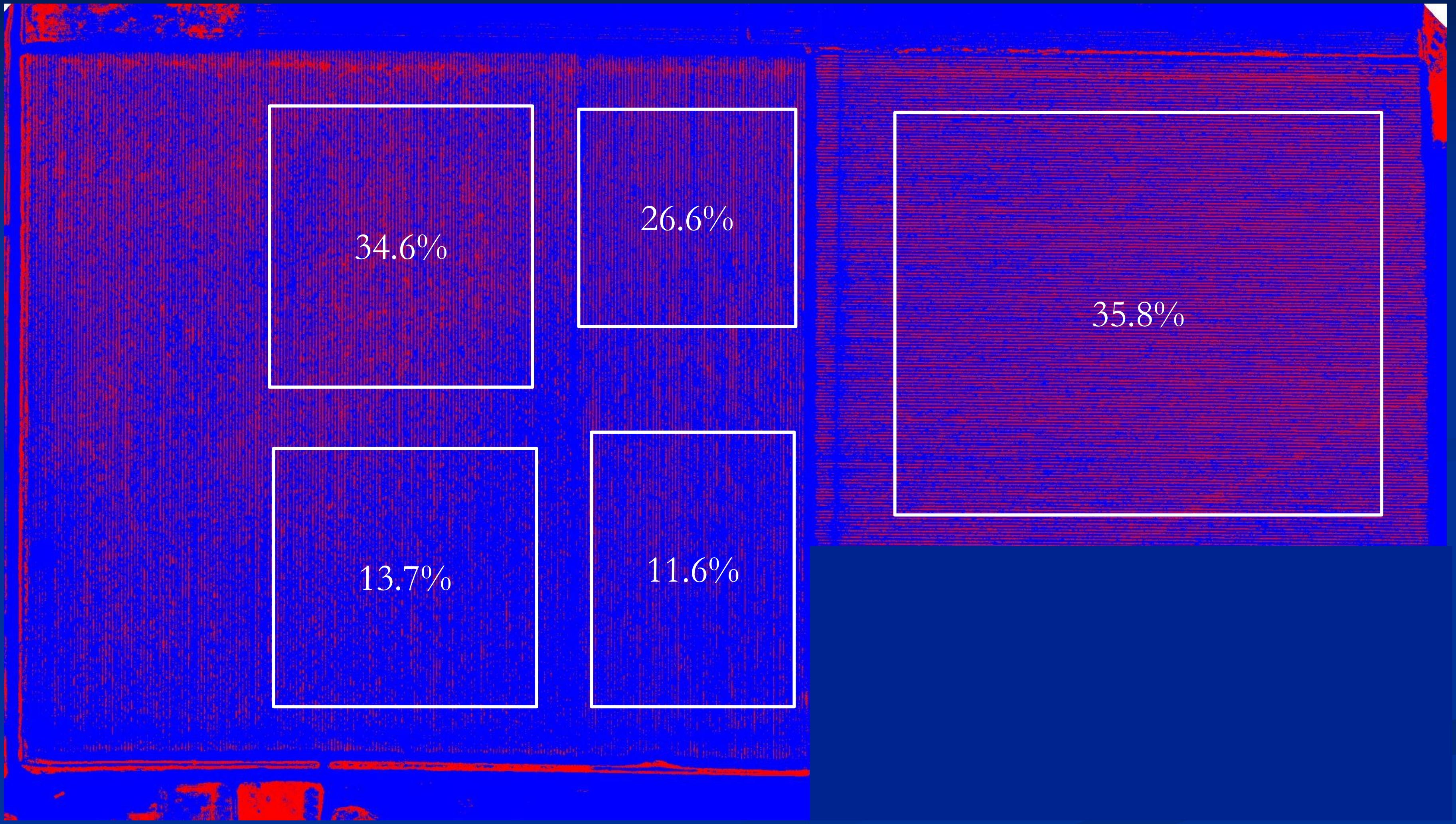
Background Stripping with Background Set to 0,0,0 (R,G,B)



VARI Ex.

Soil Stripping with Red Background Ex.




34.6%
26.6%
35.8%
13.7%
11.6%

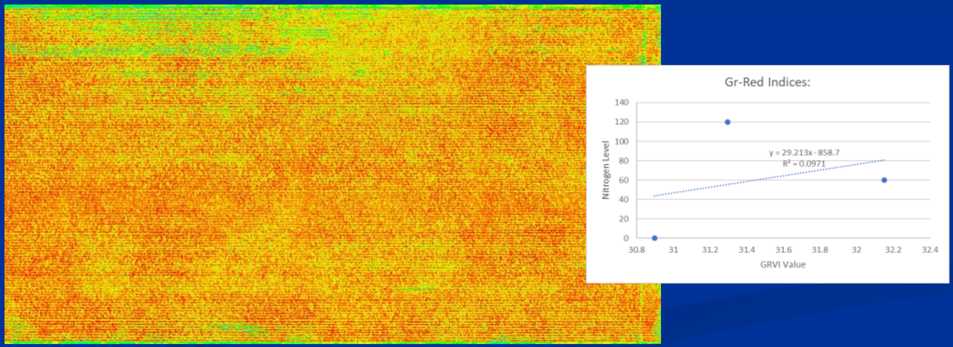
Other Indices - Nitrogen Detection in Cotton:

- BGVI and GRVI Indices maybe used to discriminate between nitrogen deficiency and crop variability:

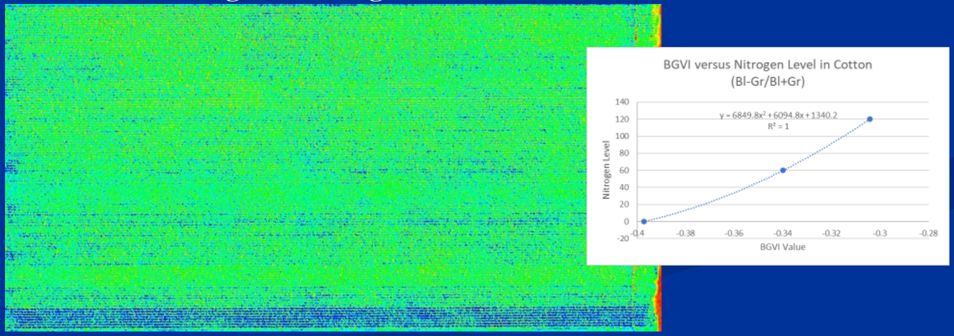
Raw RGB Image:

120 lbs./acre
60 lbs./acre
0 lbs./acre

GR Image – General Crop Variability



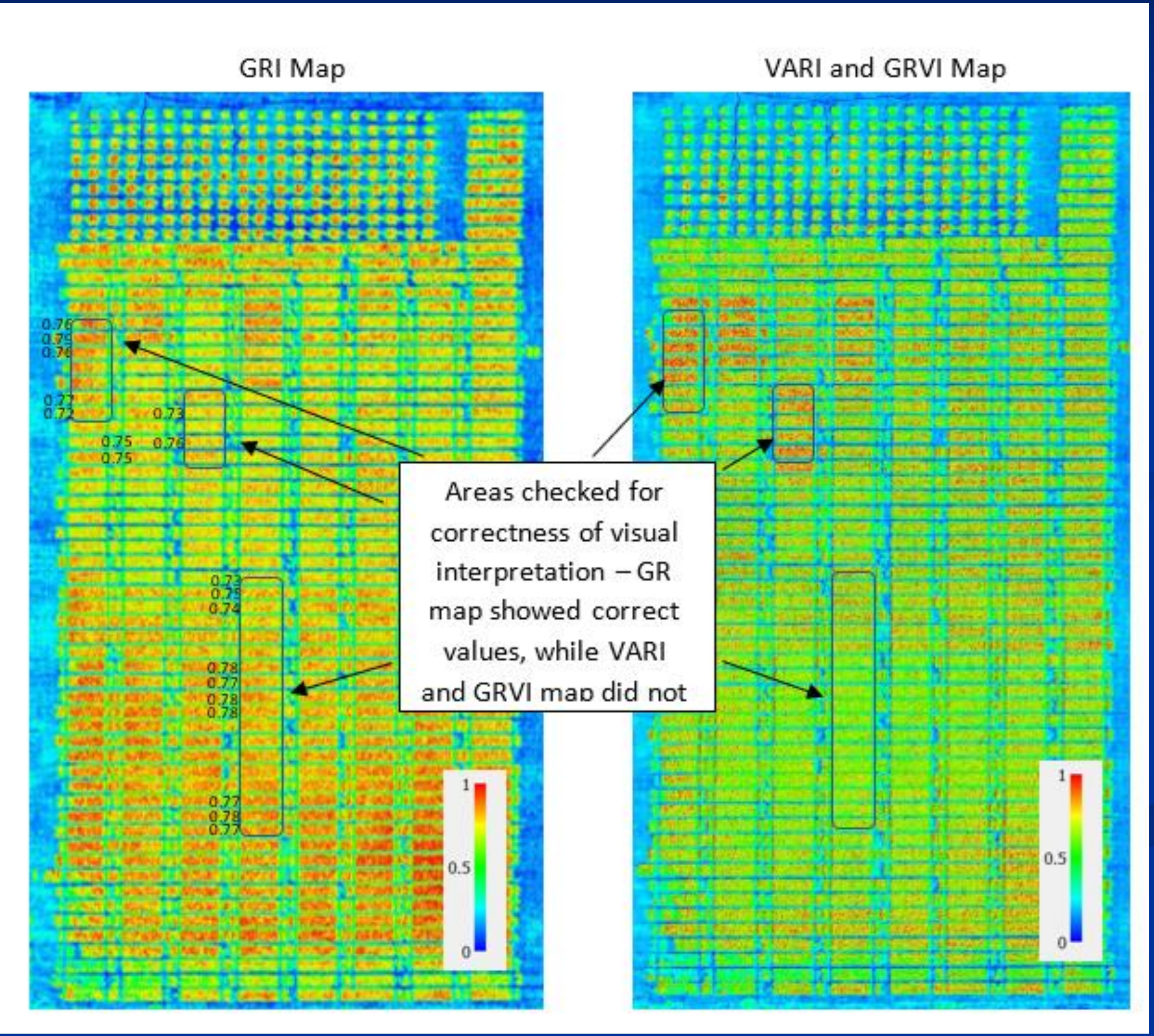
BGVI Image - Nitrogen Detection:



120 lbs./acre
60 lbs./acre
0 lbs./acre

Observational Checks:

- GR index performed better than other color indices (VARI or GRVI) for indicating general crop or field variance and health



Comparison of RGB to NDVI for Indicating General Field Variability: