Drone Spraying in Various Crops

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LSU AgCenter Research & Extension

Summary:

- Types of drones
- Test in Soybeans
- Test in Sugarcane
- If we have time:
  - Drift
  - Rules
  - Operation S.A.F.E.

Sprayer Drones Currently Available:

DJI T40:

Hylio:

XAG P100 Pro:

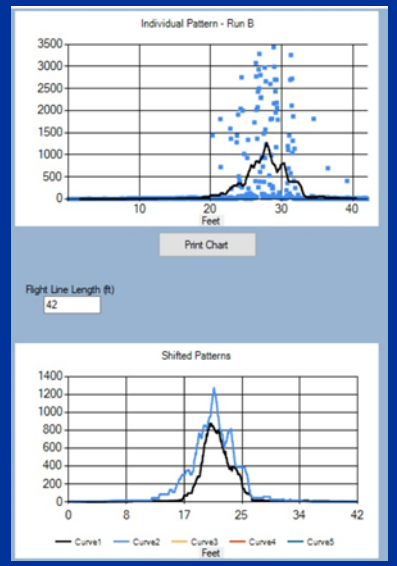
Soybean Tests:

For Testing to Two Large Spray Drones (10-15 L) were Constructed with Different Spray Systems

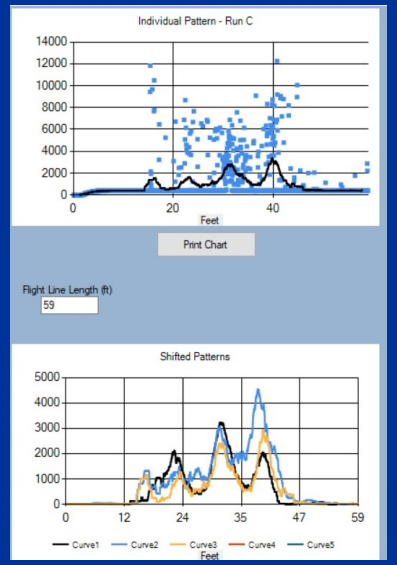
- Cover 2 acres per Battery in about 6 to 10 minutes @ 2 GPA
  - 13 to 20 ft. swath width
  - Operate 11 to 18 MPH
- Two different application systems:
  - Standard Fixed Orifice Hydraulic Nozzles:
    - AIXR11002 nozzles:
  - Centrifugal Nozzles:
    - Very hard to use and mount on a drone: need cutoffs and special systems to regulate flow

Other Spray Systems Tested:

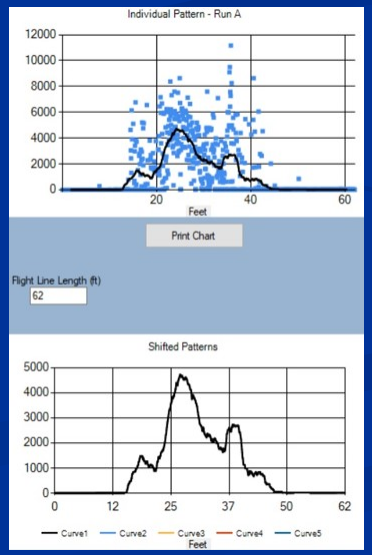
Herbi Nozzles:



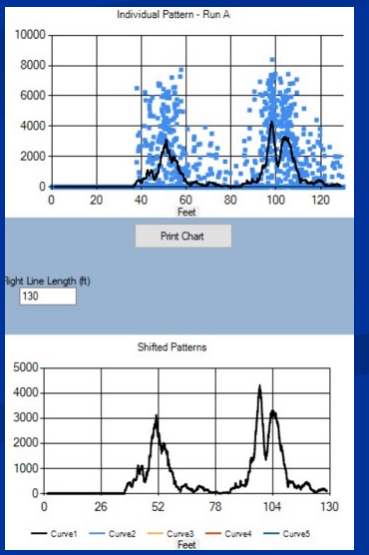
Boomless Pasture Nozzles:



Boomed Hydraulic Orifice Nozzles:

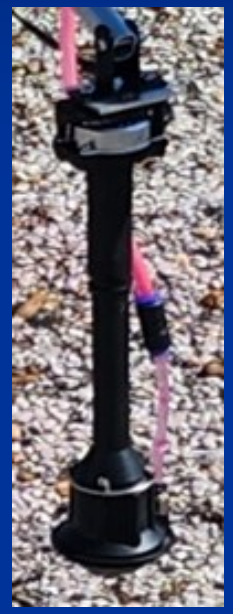


Boom Rotary Nozzles:

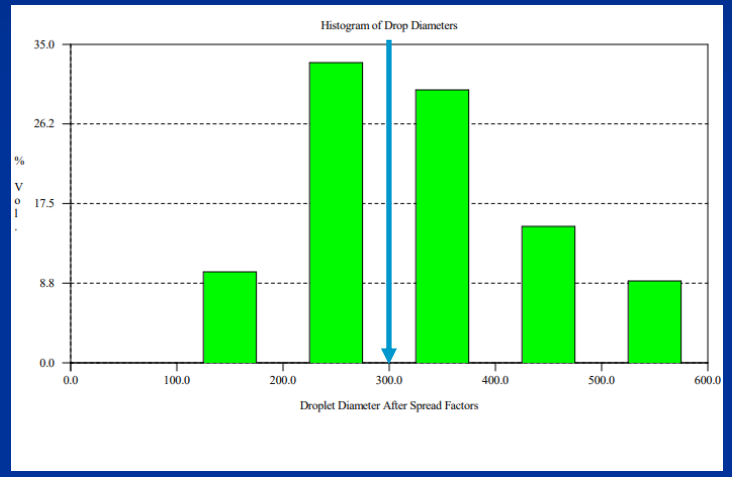


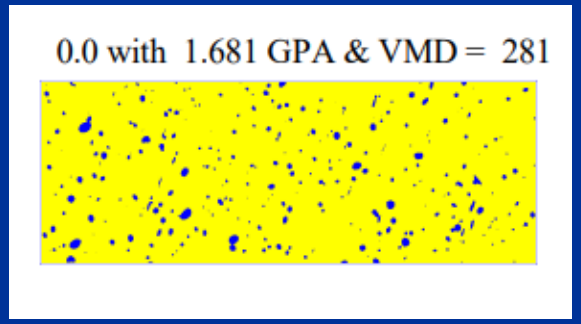
Example Flight:

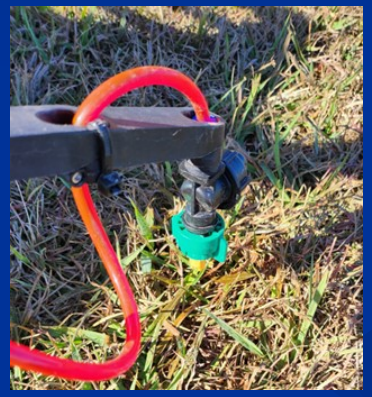
Spray Droplet Spectrum of Each Spray System:



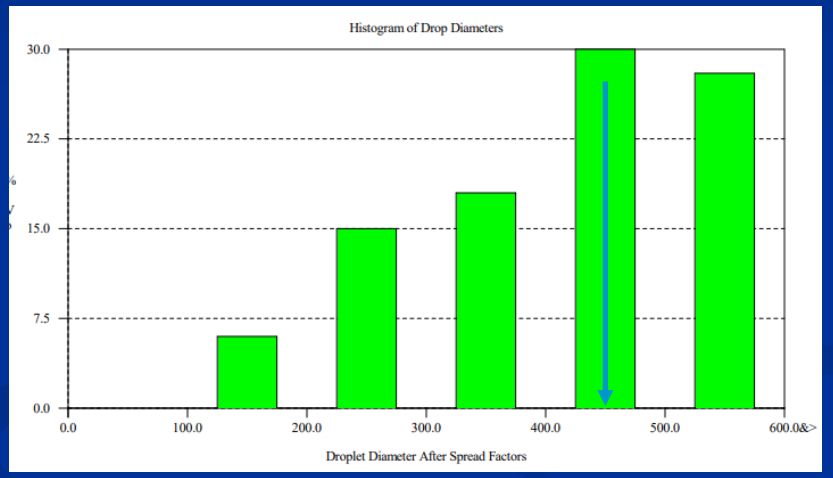
Centrifugal:

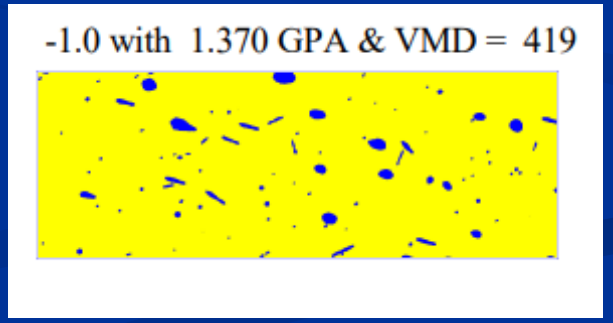




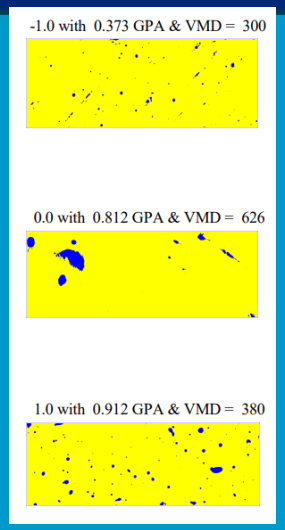
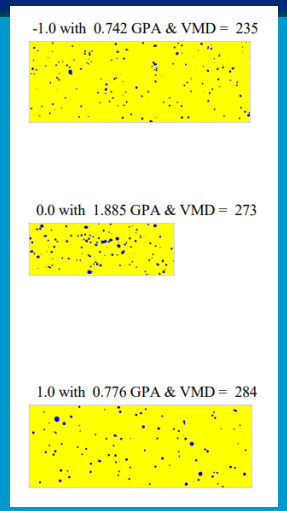
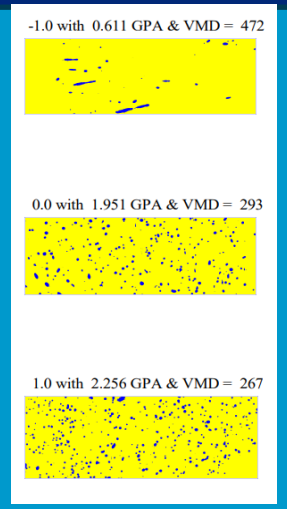
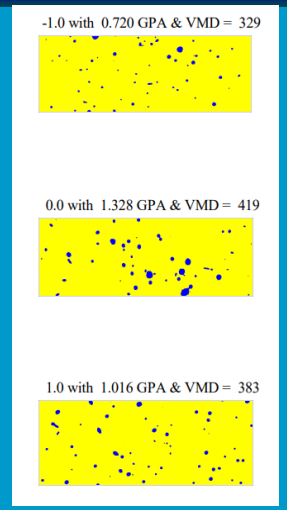
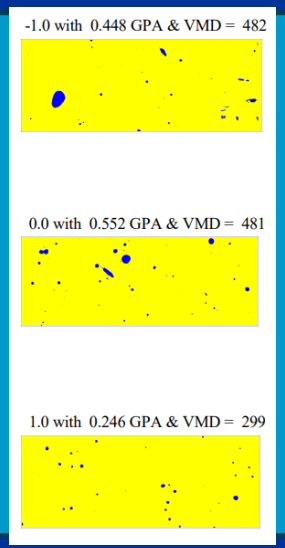
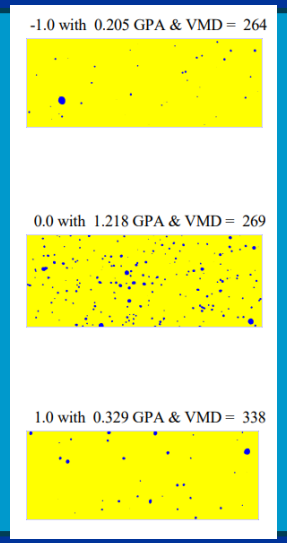
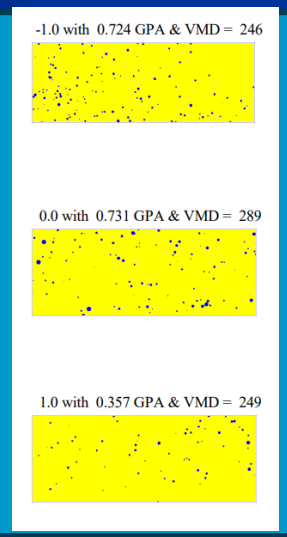
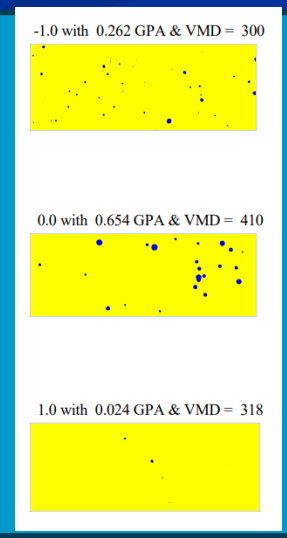


AIXR11002 Nozzles:





Canopy Infiltration Test in Soybeans:

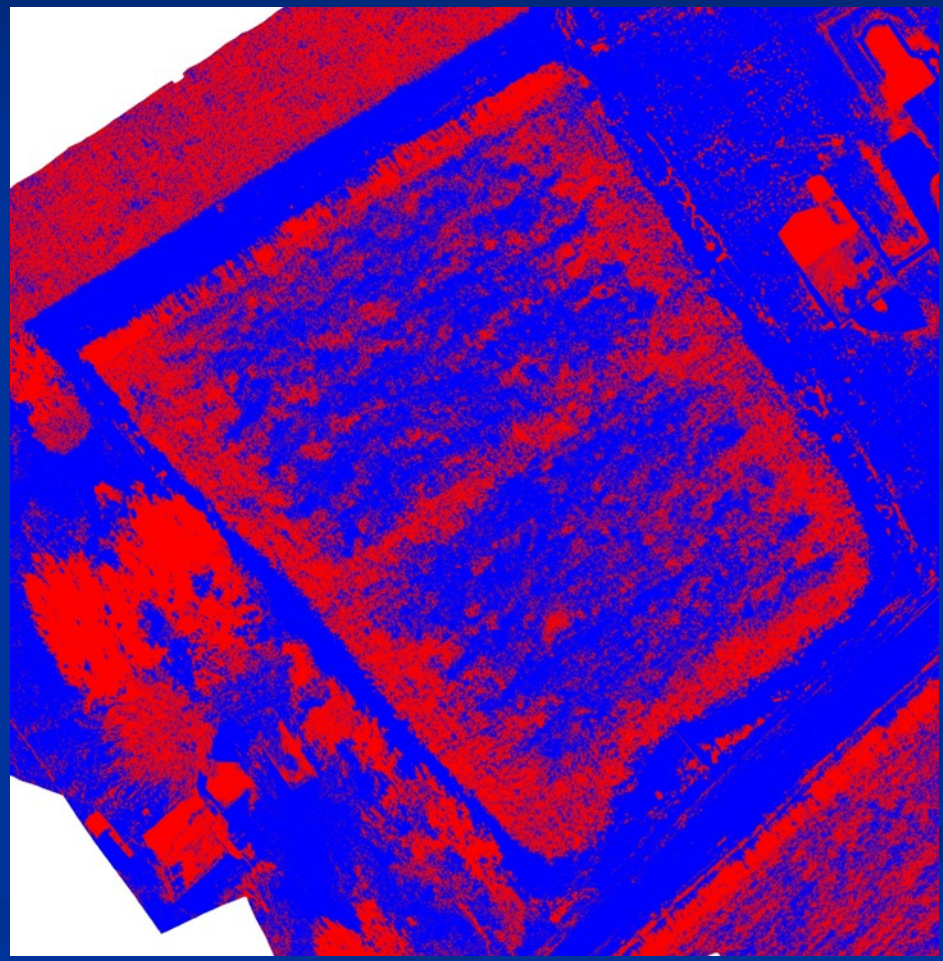
Centrifugal 4 ft. alt		Centrifugal 10 ft. alt		Centrifugal 15 ft. alt		AIXR11002 10 ft. alt.	
							
	0.643 GPA		1.13 GPA		1.61 GPA		1.02 GPA
	0.347 GPA		0.584 GPA		0.604 GPA		0.313 GPA

Testing in Sugarcane:

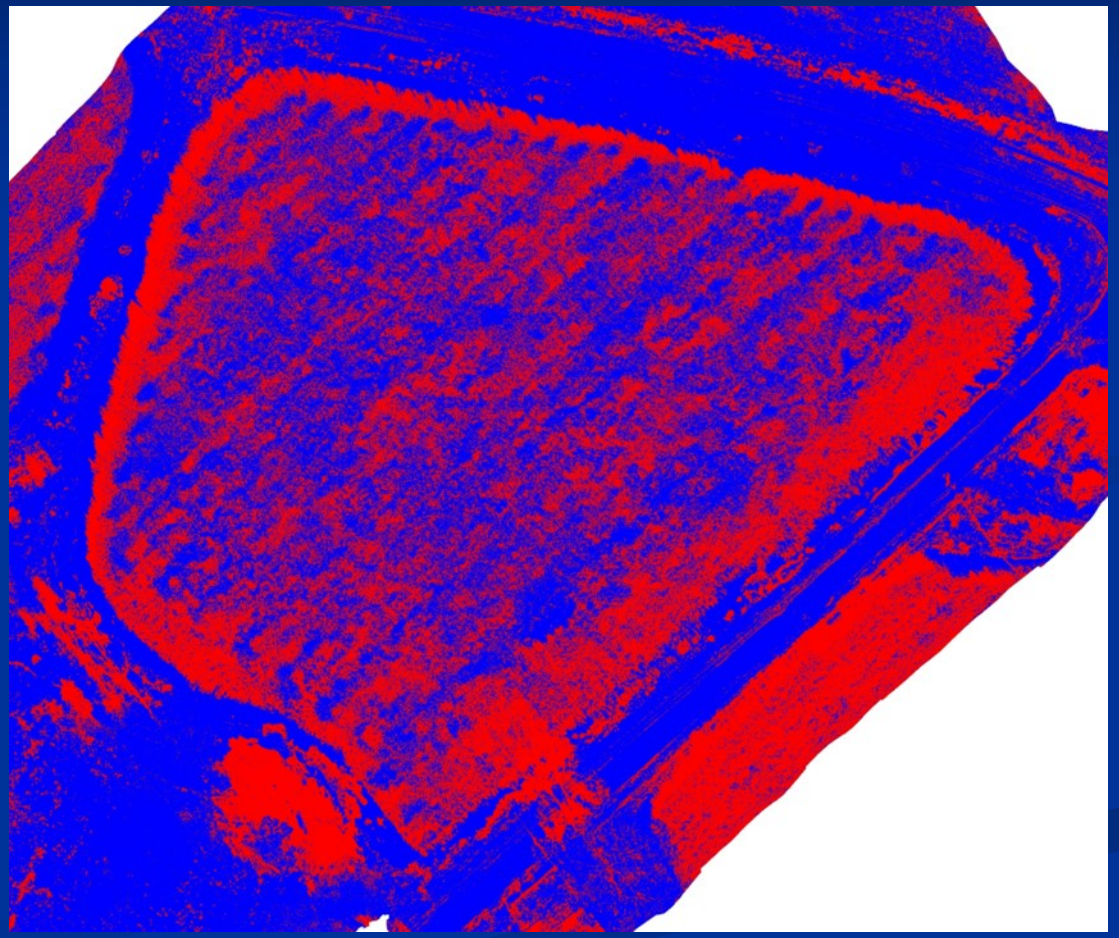
Ripener Coverage Tests:

- Three fields sprayed with both AIXR and Centrifugal nozzles to compare application efficiency:
- Looking for several things:
  - Coverage
  - Evenness
  - Border efficiency

Centrifugal Nozzles:

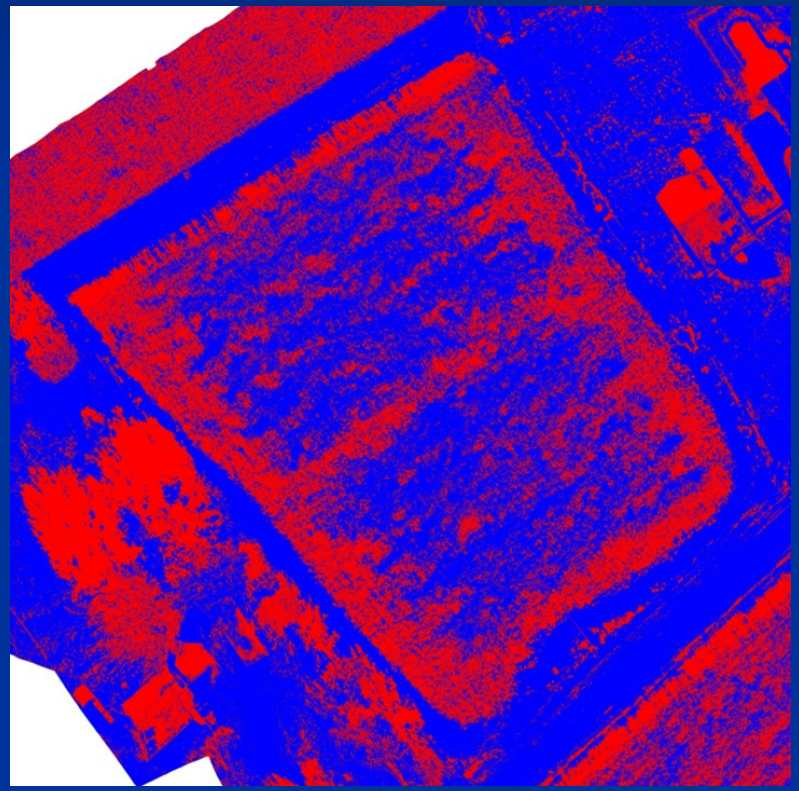


AIXR11002 Nozzles:



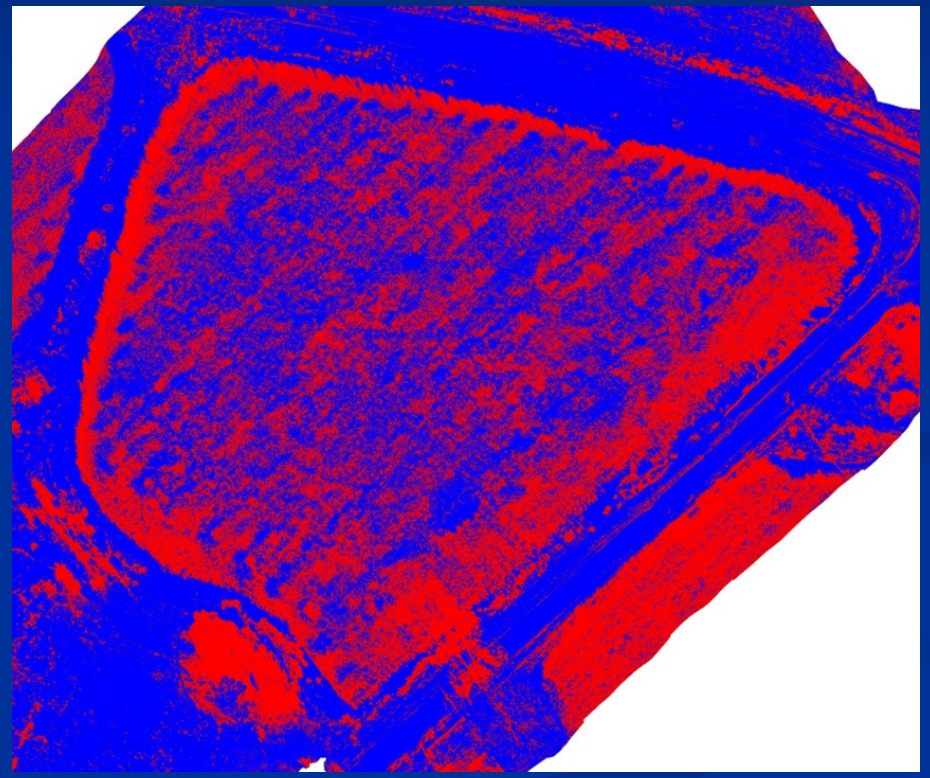
Comparison:

- Centrifugal:



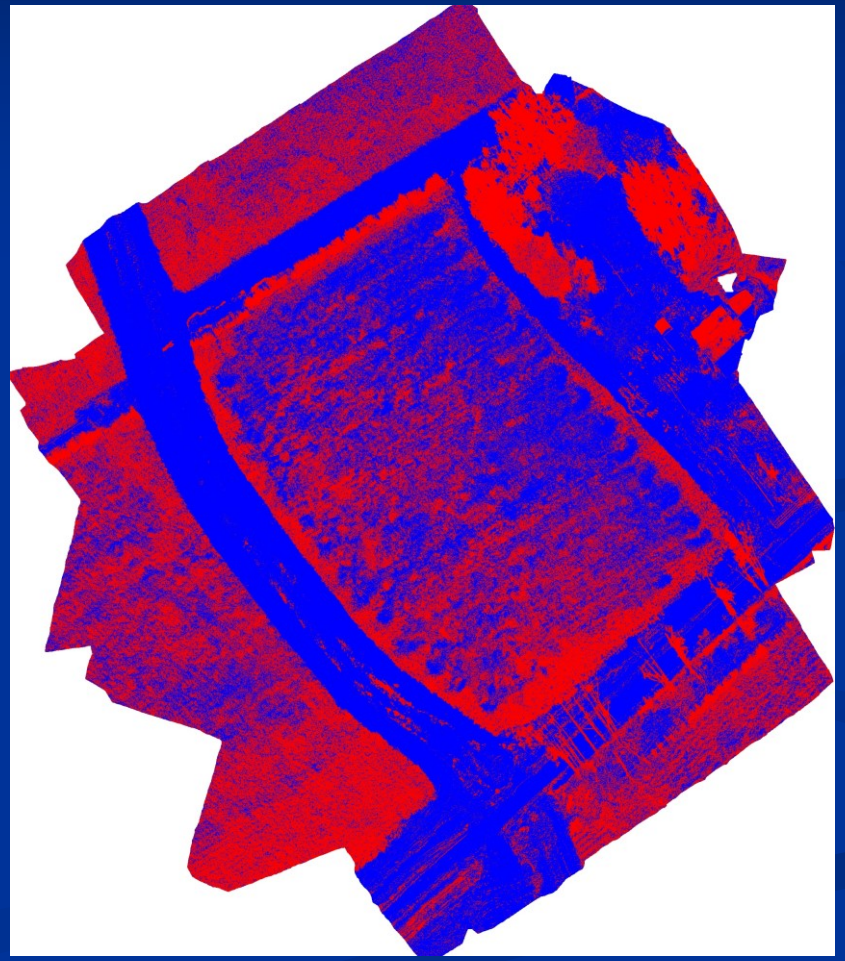
- C.V. = 16.1%
- GR Diff Value = 11.9

- AIXR11002:



- CV = 13.1%
- GR Diff Value = 12.6

Third Field Sprayed with AIXR11002 (faster speed / less Ripener):



Drift Test:

- Three Drift Poles placed downwind at 20, 50, and 250 ft. with droplet cards.
- 12 Passes Up Wind from Drift Poles in a Stiff 5 to 7 MPH cross-wind at 2 GPA:
- Pasture grass surface
- 2 GPA / 11 MPH

Drift Pole Test:

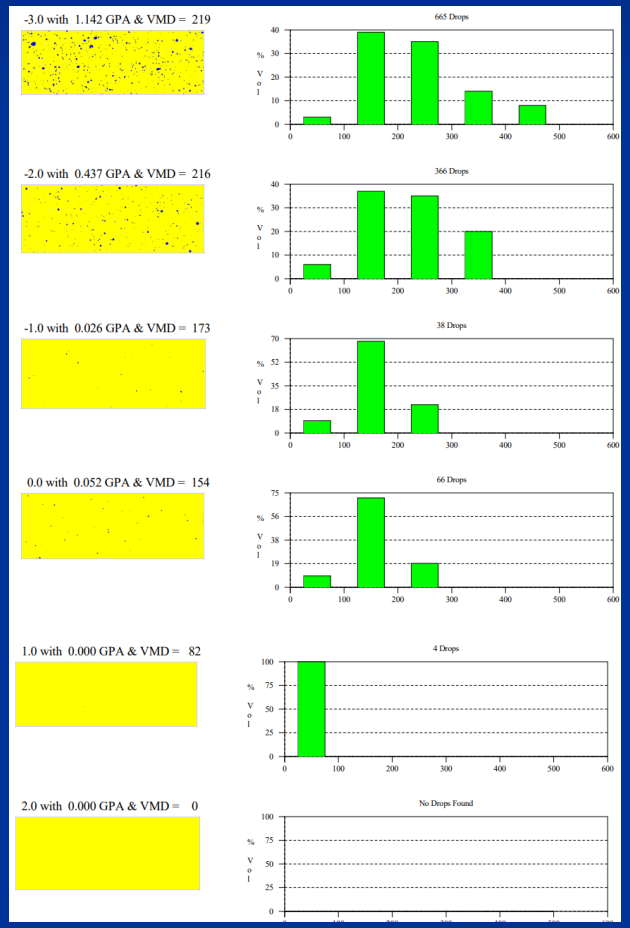
Pole Distances from Flight Line:

20 ft.

50 ft.

250 ft.

- Centrifugal Nozzles:

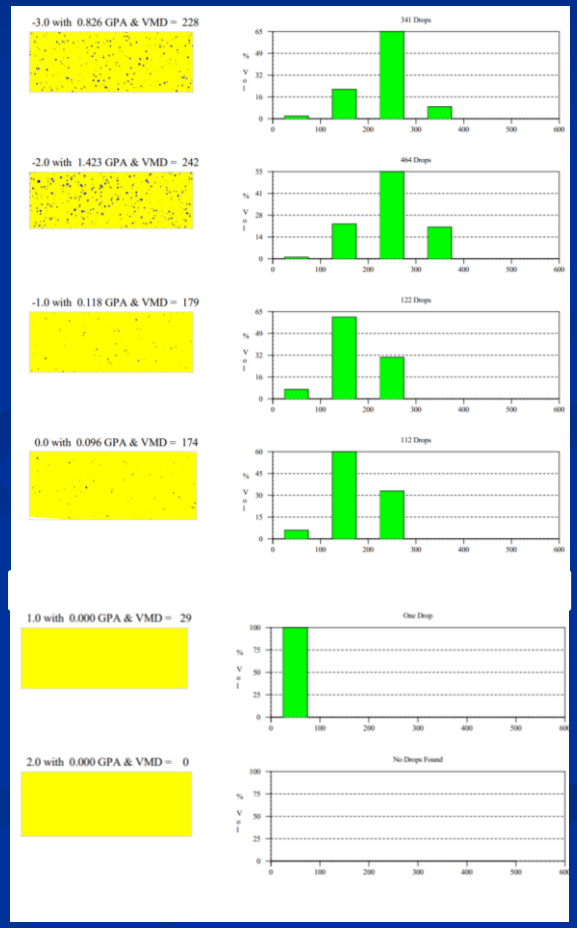


0.75 GPA

0.04 GPA

0.00 GPA

- AIXR11002 Nozzles:



1.1 GPA

0.11 GPA

0.00 GPA

Operation S.A.F.E. – Get Your Drone Tested!

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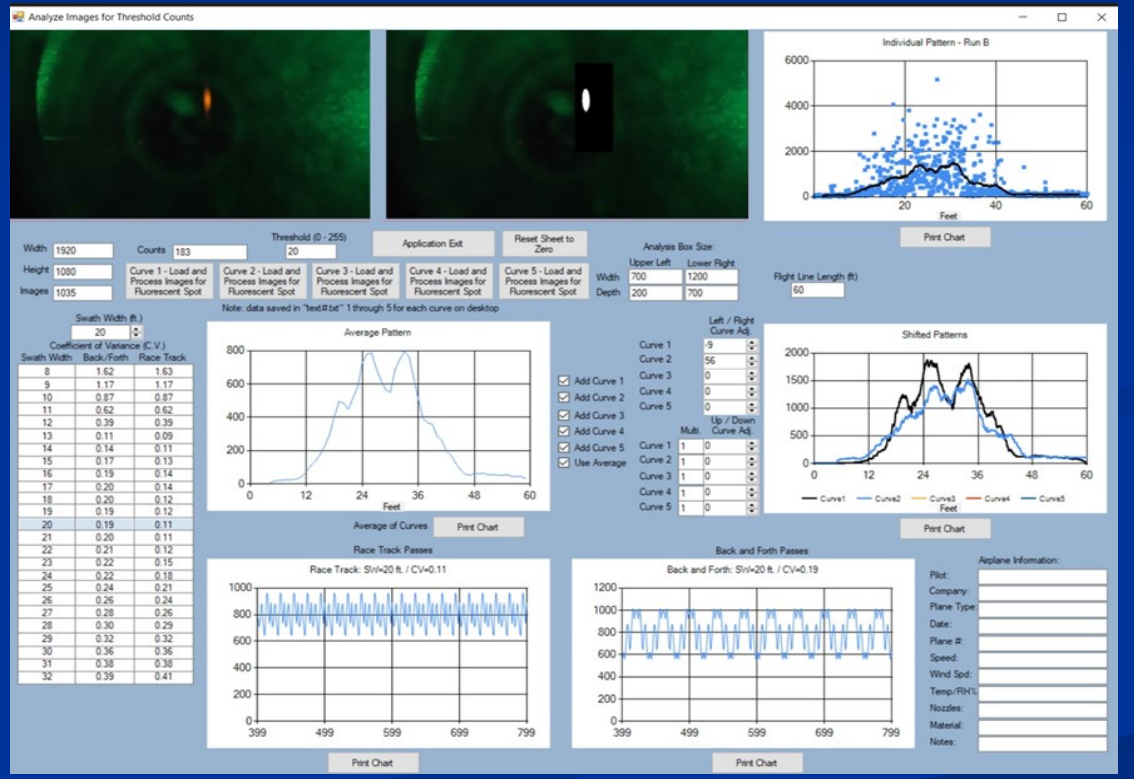
Pattern Testing:

- Test for two properties:
  - Swath width
  - Droplet spectrum (size, distribution, etc.)
- Additional properties:
  - Multiple pass C.V.
  - Field C.V.



Products Changing Very Quickly in Size and Type:

- XAG V40:
- Only 2 motors:

The End

Questions?

Thanks for Your Support!!!

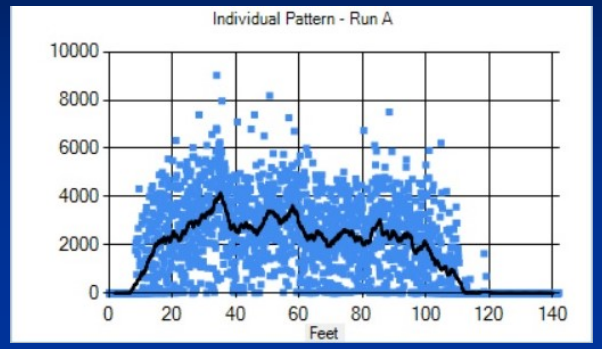
THE LOUISIANA
Soybean & Grain
RESEARCH & PROMOTION BOARD

American Sugar Cane League

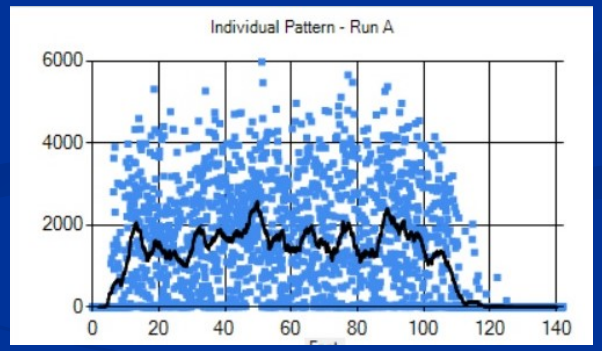
Multi-Pass Tests Example on AIXR11002 Nozzles:

- Tested at 13 ft., 20 ft., and 26 ft. swath widths
- No (low) wind conditions
  - < 3 MPH
- 11 MPH travel speed
  - 2/3 max speed for that drone
- 10 ft. flying height

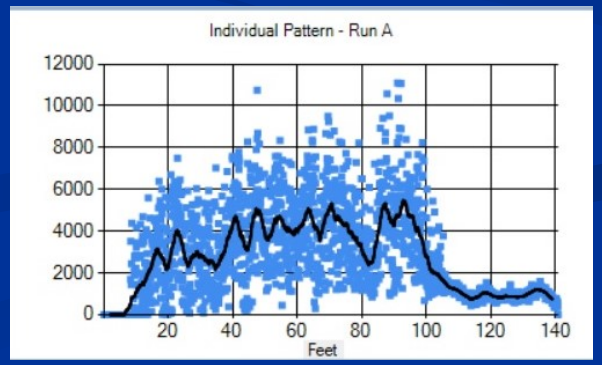
13 ft S.W.
C.V. – 0.17
to 0.22



20 ft S.W.
C.V. – 0.19
to 0.22



26 ft S.W.
C.V. – 0.26
to 0.28

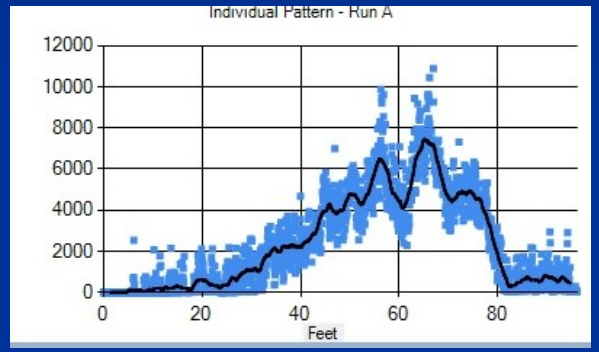


Licenses Needed to Use Sprayer Drones:

- FAA (Federal):
  - Part 107
  - Part 137
- LDAF (State):
  - Commercial pesticide applicators license
  - Aerial application license
  - drone license
- Business Insurance:
  - In case of drift claim or accident

Operation Differences - Wind Direction Effect - 6 MPH:

2 GPA Extra Coarse - Into the Wind (6 MPH)



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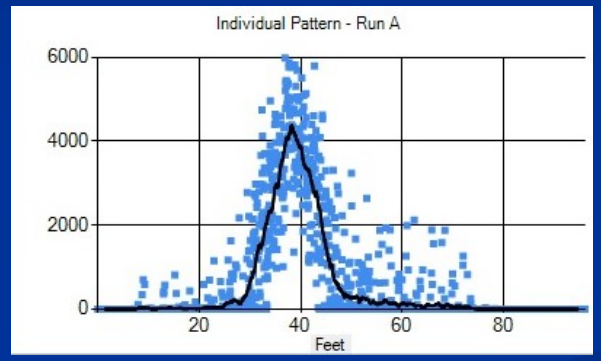
Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
13	0.68	0.68
14	0.51	0.50
15	0.32	0.29
16	0.14	0.05
17	0.15	0.05
18	0.16	0.10
19	0.16	0.12
20	0.17	0.13
21	0.17	0.14
22	0.18	0.15
23	0.19	0.13
24	0.20	0.12
25	0.22	0.11
26	0.24	0.12
27	0.25	0.14
28	0.26	0.16
29	0.26	0.17
30	0.25	0.17
31	0.23	0.16
32	0.21	0.16
33	0.20	0.16
34	0.20	0.16
35	0.20	0.17
36	0.21	0.18
37	0.21	0.19

2 GPA Extra Coarse - With the Wind (6 MPH)



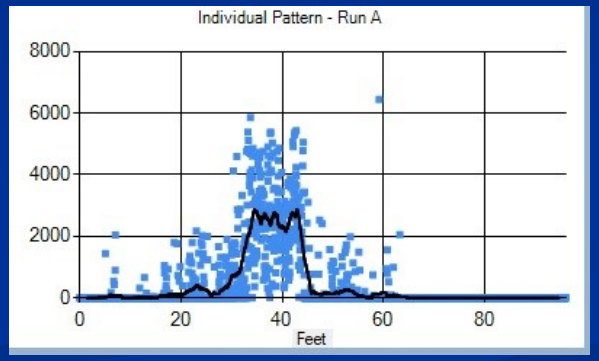
Swath Width (ft.)

14

Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
2	NaN	NaN
3	NaN	NaN
4	5.26	5.24
5	2.01	2.08
6	1.20	1.23
7	0.78	0.80
8	0.44	0.47
9	0.08	0.02
10	0.08	0.03
11	0.09	0.05
12	0.11	0.09
13	0.15	0.14
14	0.21	0.19
15	0.26	0.25
16	0.31	0.30
17	0.35	0.35
18	0.40	0.40
19	0.45	0.45
20	0.49	0.49
21	0.54	0.54
22	0.58	0.58
23	0.64	0.64
24	0.66	0.66
25	0.71	0.71
26	0.75	0.74

2 GPA Extra Coarse - With the Wind (6 MPH)



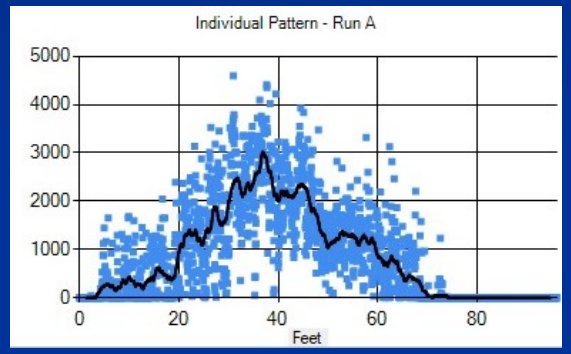
14

Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
2	NaN	NaN
3	NaN	NaN
4	5.79	7.03
5	2.02	2.11
6	1.20	1.24
7	0.78	0.82
8	0.47	0.50
9	0.23	0.22
10	0.21	0.20
11	0.13	0.12
12	0.10	0.09
13	0.12	0.13
14	0.19	0.19
15	0.27	0.27
16	0.35	0.34
17	0.40	0.40
18	0.47	0.47
19	0.51	0.50
20	0.54	0.53
21	0.56	0.56
22	0.58	0.58
23	0.62	0.62
24	0.63	0.63
25	0.67	0.67
26	0.71	0.71

Operation Differences (cont.) - Wind Direction Effect - 6 MPH:

2 GPA Extra Fine - Into the Wind (6 MPH)



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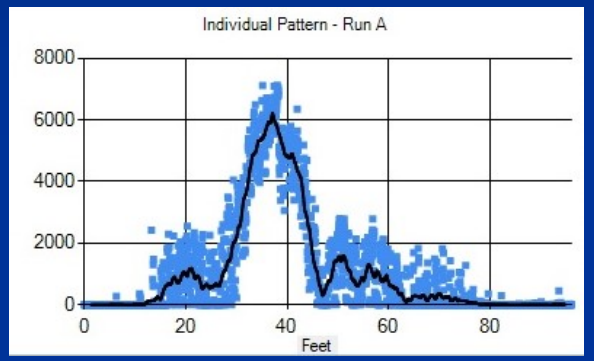
Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
8	1.43	1.42
9	1.05	1.04
10	0.77	0.77
11	0.54	0.54
12	0.30	0.29
13	0.12	0.05
14	0.11	0.06
15	0.12	0.07
16	0.12	0.09
17	0.10	0.07
18	0.11	0.08
19	0.11	0.06
20	0.09	0.08
21	0.09	0.11
22	0.09	0.12
23	0.12	0.12
24	0.13	0.13
25	0.13	0.14
26	0.13	0.15
27	0.12	0.15
28	0.11	0.15
29	0.12	0.15
30	0.12	0.16
31	0.12	0.17
32	0.12	0.17

5 GPA Extra Fine - With the Wind (6 MPH)



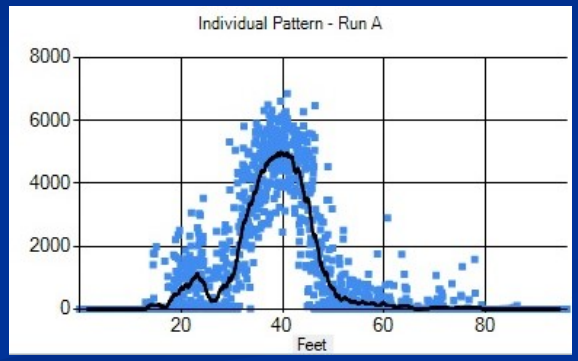
Swath Width (ft.)

14

Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
2	NaN	NaN
3	NaN	NaN
4	5.41	5.26
5	1.98	2.03
6	1.18	1.21
7	0.77	0.79
8	0.44	0.46
9	0.10	0.08
10	0.09	0.07
11	0.09	0.05
12	0.08	0.04
13	0.07	0.05
14	0.10	0.10
15	0.17	0.17
16	0.25	0.24
17	0.31	0.30
18	0.36	0.35
19	0.39	0.38
20	0.40	0.40
21	0.41	0.41
22	0.42	0.42
23	0.43	0.44
24	0.43	0.43
25	0.45	0.44
26	0.45	0.45

5 GPA Extra Coarse - With the Wind (6 MPH)



Swath Width (ft.)

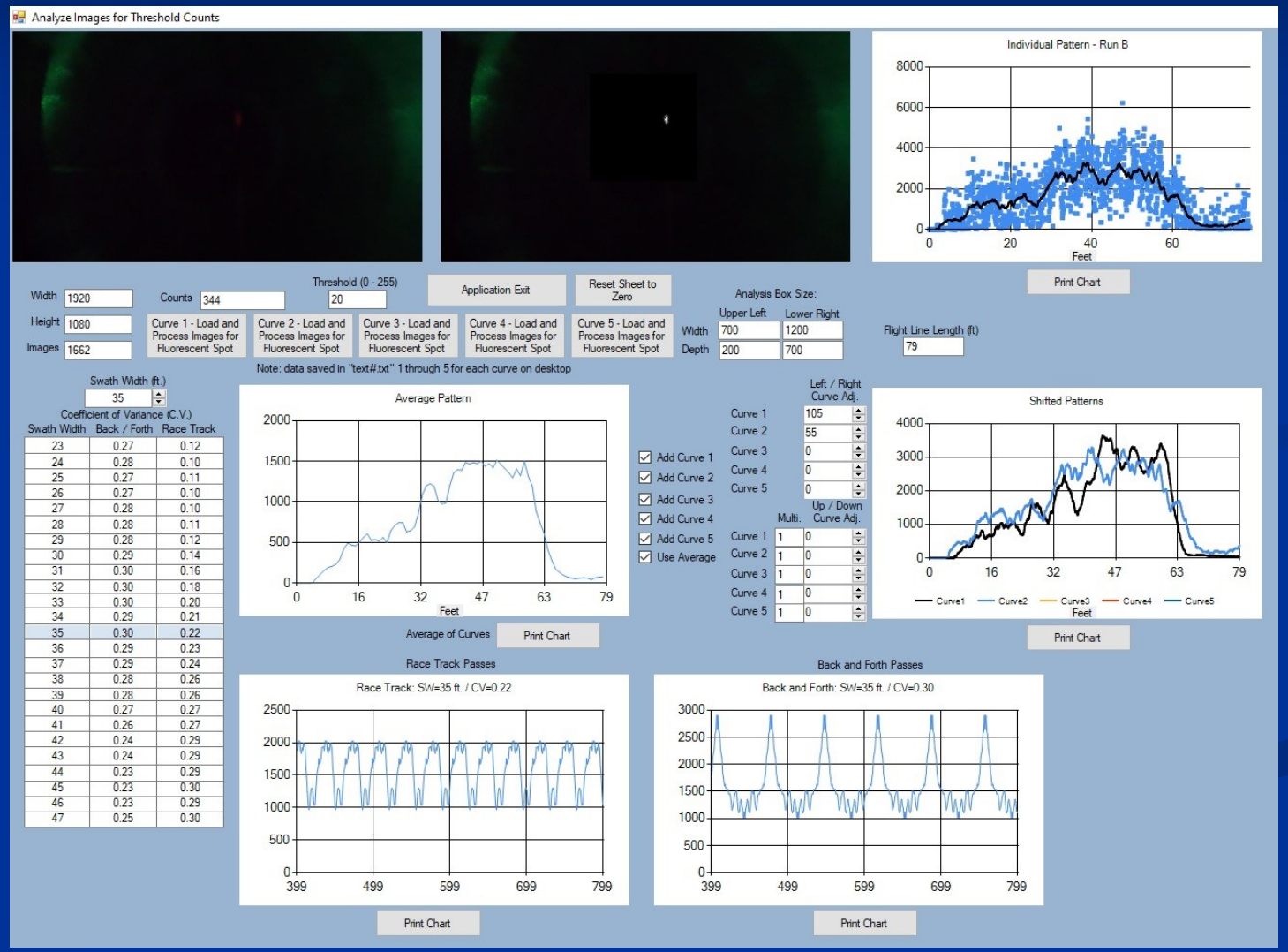
15

Coefficient of Variance (C.V.)

Swath Width	Back / Forth	Race Track
3	NaN	NaN
4	NaN	10.00
5	2.63	2.67
6	1.44	1.46
7	0.96	0.96
8	0.62	0.63
9	0.30	0.31
10	0.05	0.07
11	0.07	0.09
12	0.07	0.07
13	0.04	0.05
14	0.06	0.05
15	0.11	0.10
16	0.18	0.17
17	0.23	0.23
18	0.29	0.29
19	0.34	0.33
20	0.38	0.37
21	0.41	0.41
22	0.45	0.43
23	0.48	0.46
24	0.49	0.47
25	0.52	0.50
26	0.54	0.52
27	0.55	0.54

T40 Pattern and Swath Width:

- Very wide pattern
  - 40 ft. total pattern
  - 30 to 35 ft. swath width
- Using extra fine double cutter wheel using extra fine speed setting
- 15 ft. flying height
  - Lower altitude (5 – 6 ft.) was only 25 ft.

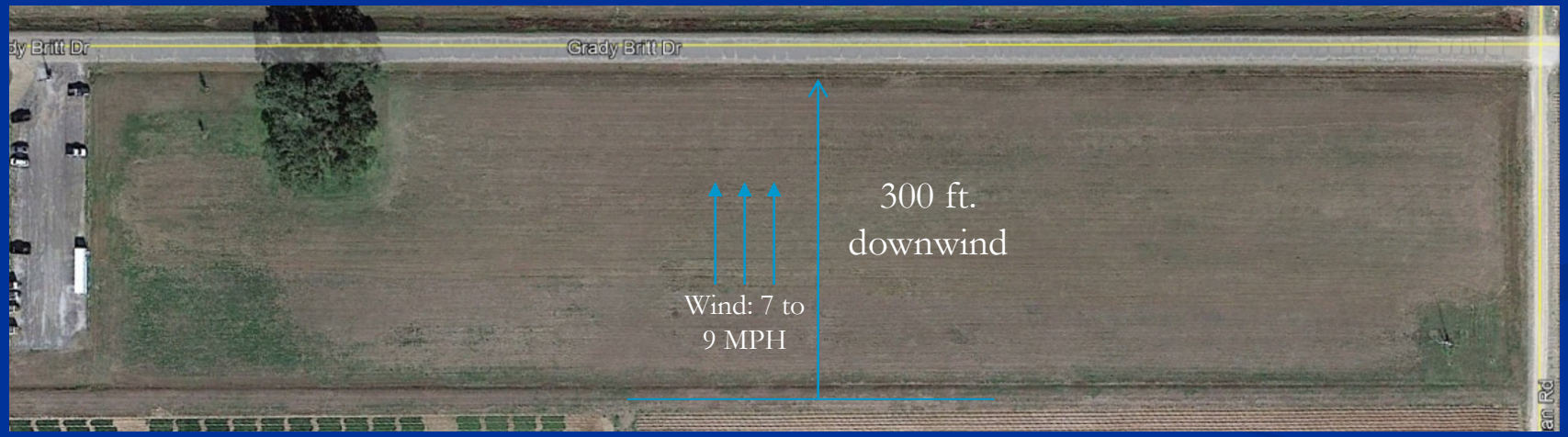


Characteristics of Centrifugal versus Standard Nozzle System:

- Centrifugal/Rotary Nozzles:
  - 300 - 350 um maximum droplet size (or smaller) based on rotation speed and disk type.
  - Higher flying height needed to increase canopy penetration and create a more uniform application.
  - Drift was not more then AIXR11002 nozzles (and may actually be less)
  - Slight less swath width than under-the-motor standard AIXR11002 tips.
- Standard AIXR11002 Nozzles:
  - Application height did not affect uniformity as much.
  - Slightly wider application width than centrifugal nozzles
    - 25% in this case.
  - Not as good for canopy infiltration
    - Larger droplets, less got to the bottom.
  - Better C.V. on multi-pass test across wider range of environmental conditions.

Long Distance Drift Pole Test:

- Crosswind drift pole placed 300 ft. downwind from flying path
- Cards Placed at 4, 8, 12, and 16 ft. heights
- Three Reps and one calibration (no spray for at least 10 minutes time)



<u>USDA Leading Edge Drone:</u>
<u>Spray Properties</u>:

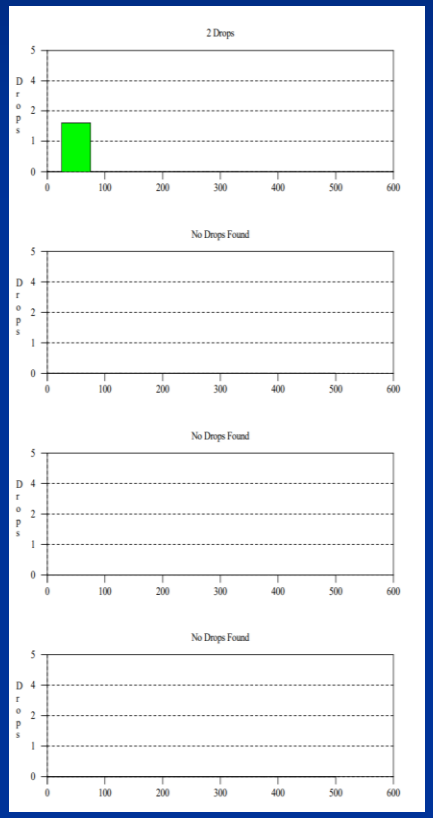
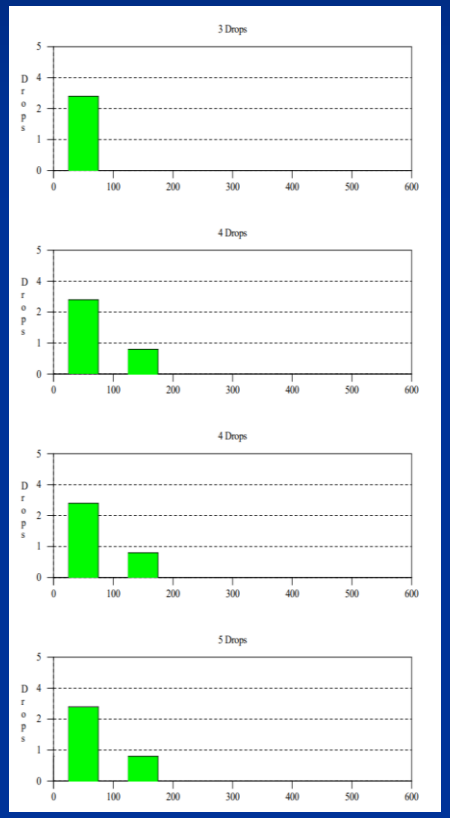
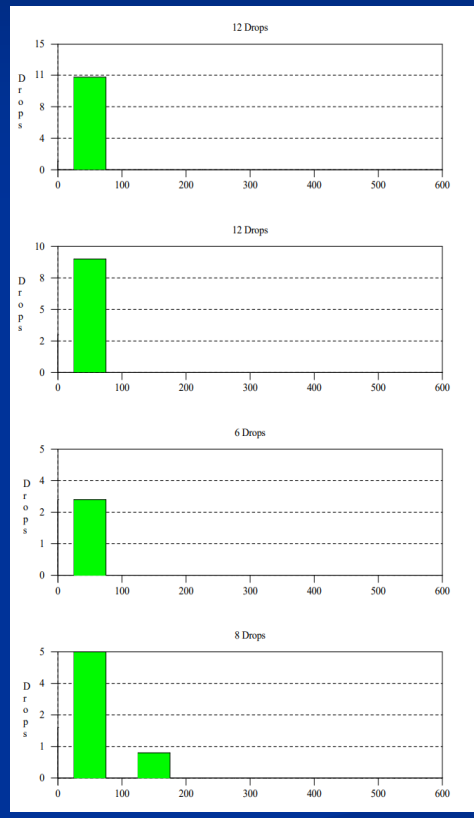
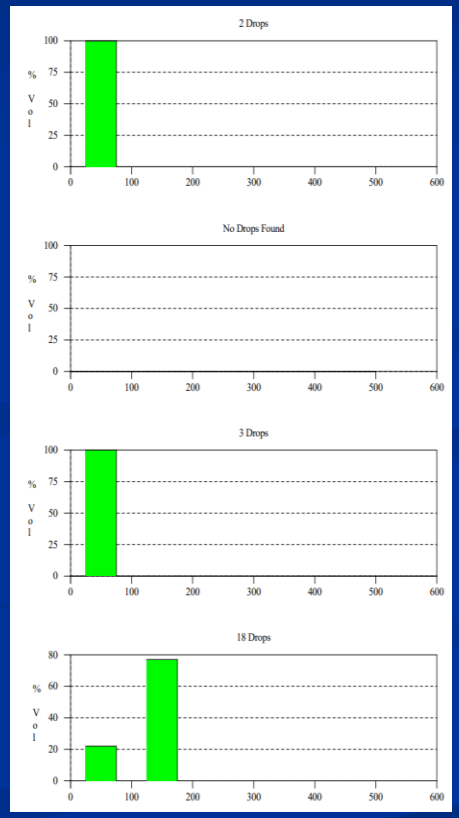
- 2 GPA / TT11001
- 20 ft. Swath
- 12 Passes
- 74F / 74%RH
- Water Only
- Analyze with Droplet Scan®

Long Distance Drift Results – Test Cards and GPA:

Calibration	Rep 1	Rep 2	Rep 3
-2.0 with 0.000 GPA & VMD = 29	-2.0 with 0.000 GPA & VMD = 97	-2.0 with 0.001 GPA & VMD = 56	-2.0 with 0.000 GPA & VMD = 62
-1.0 with 0.000 GPA & VMD = 0	-1.0 with 0.001 GPA & VMD = 115	-1.0 with 0.001 GPA & VMD = 86	-1.0 with 0.000 GPA & VMD = 0
0.0 with 0.000 GPA & VMD = 0	0.0 with 0.001 GPA & VMD = 123	0.0 with 0.000 GPA & VMD = 77	0.0 with 0.000 GPA & VMD = 62
1.0 with 0.000 GPA & VMD = 0	1.0 with 0.001 GPA & VMD = 115	1.0 with 0.001 GPA & VMD = 77	1.0 with 0.003 GPA & VMD = 141

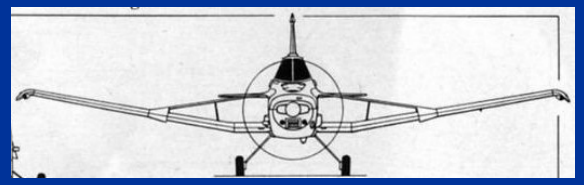
Average GPA Drift @ 300 ft.: 0.00075 GPA (< 0.001 GPA)

Test Cards Results – Number of Droplets:

Calibration	Rep 1	Rep 2	Rep 3
			
Total Droplets:			
2	16	38	23

Average: 2 droplets per card

- **Drift Pole**:
  - Airplane: Turbine Thrush
  - Release Height: 15 – 20 ft.
  - Winds: 7 to 9 MPH (max for spraying)
  - Drift Pole: 300 ft. downwind
  - Four passes back and forth
  - 2 GPA / 40 psi

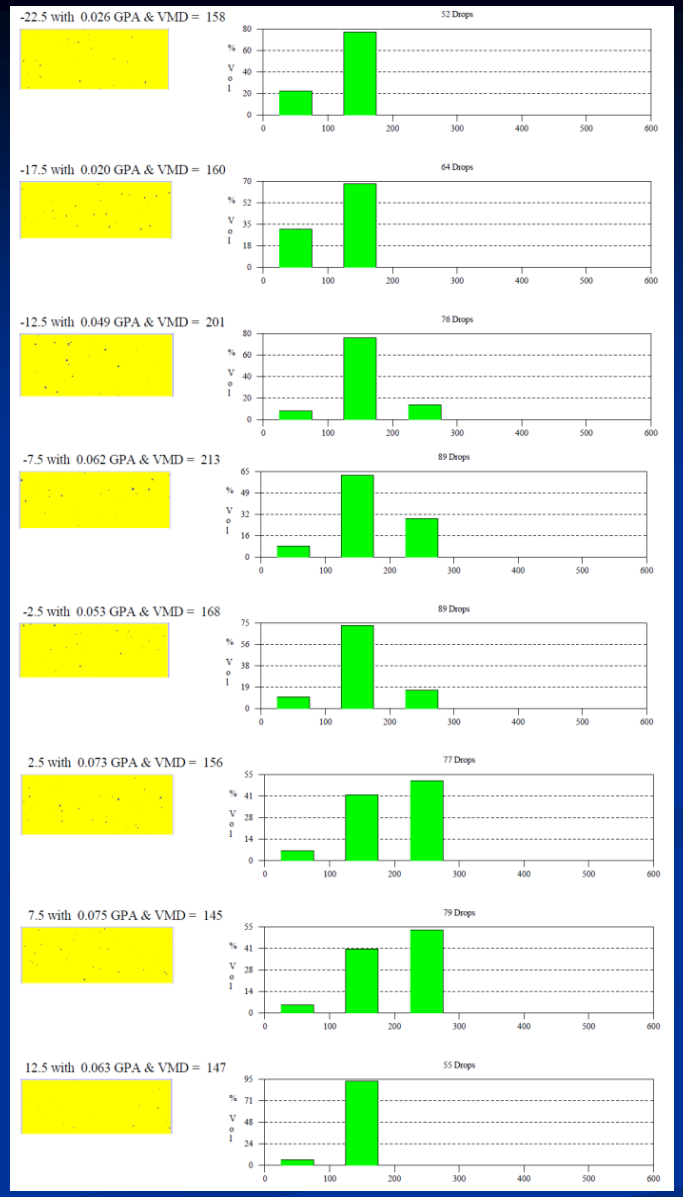


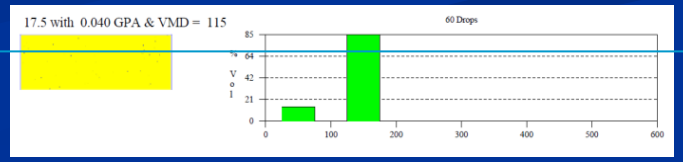
45 ft.

300 ft.

15 – 20 ft.

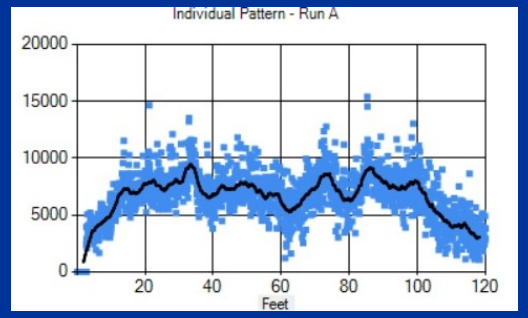
Ground Level – Card Every 5 ft.



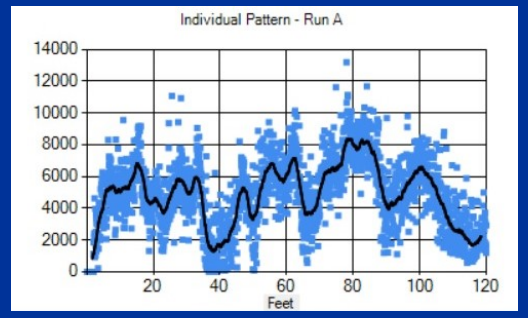


Effect of Flying Height on Centrifugal Nozzles for Multi-Pass Consistency:

- Centrifugal drone flown at two different heights in multi-pass test:
  - Swath width - 4 m
  - 2 Nozzles / 0.35 GPM per nozzle / 11 MPH / 2.25 GPA / Regular GPS
- Results:



Higher Altitude – 15 to 20 ft.



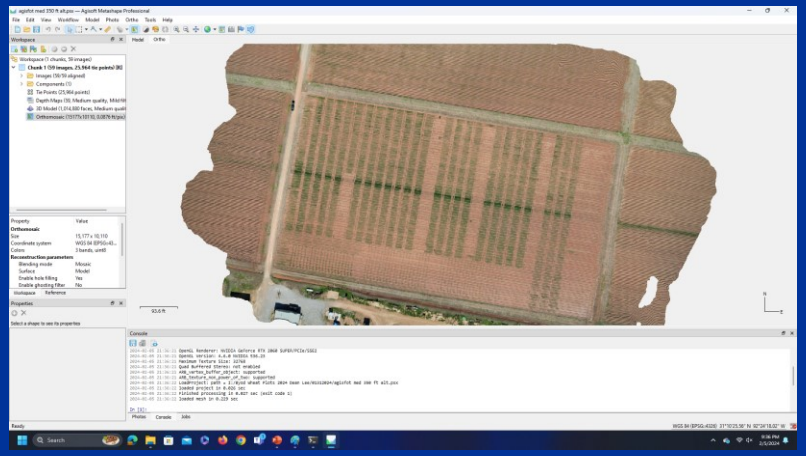
Lower Altitude – 4 to 6 ft.

High Altitude Passes

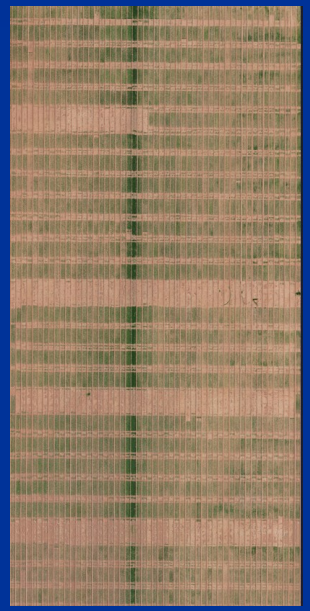
Low Altitude Passes

Getting Plot Data Out of Images:

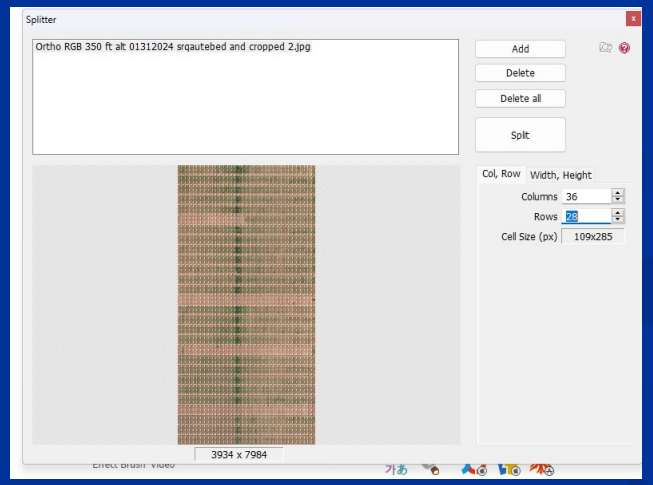
Georectification and Assembly Program - Agisoft



Straighten and Crop: Microsoft Image Comp.



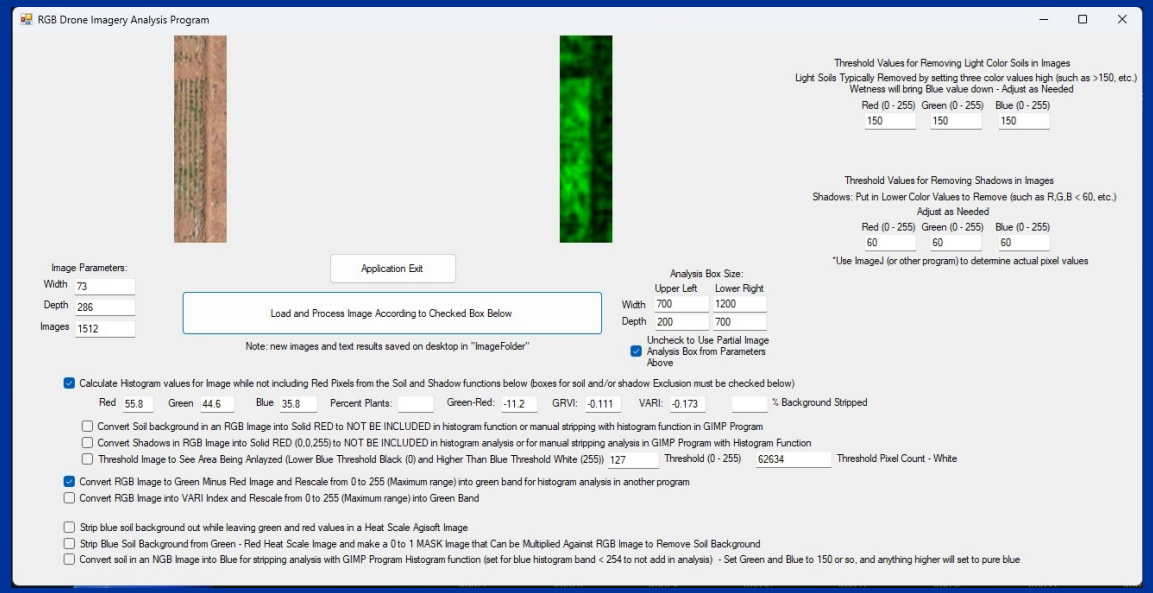
Splitter Program: PhotoScape



1512 Individual Plot Images

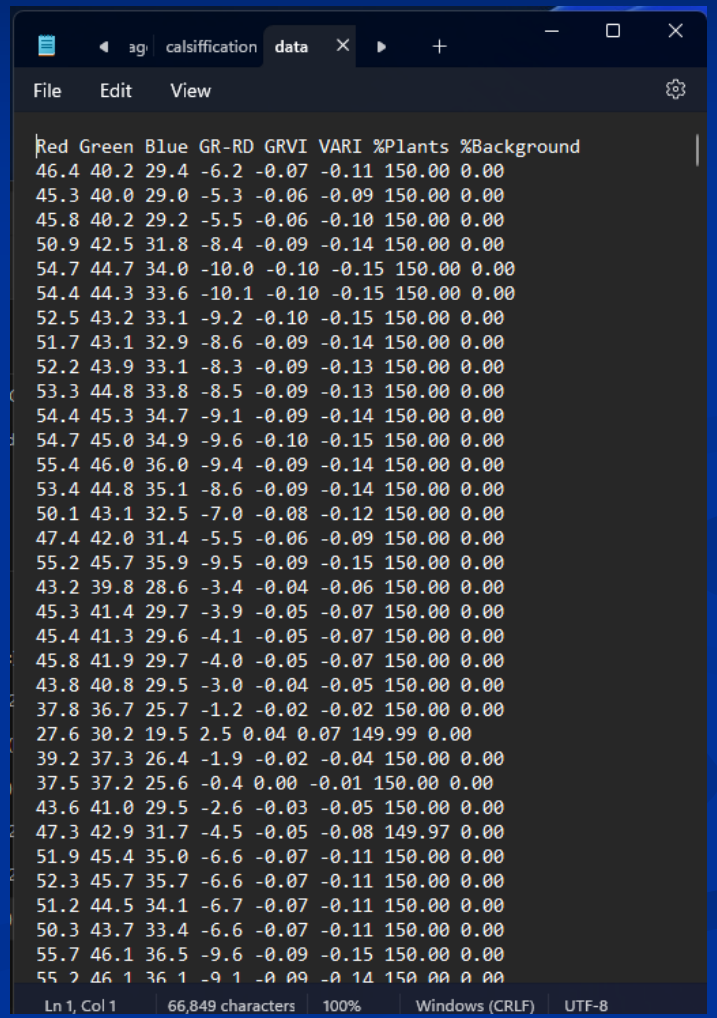
Page 2:

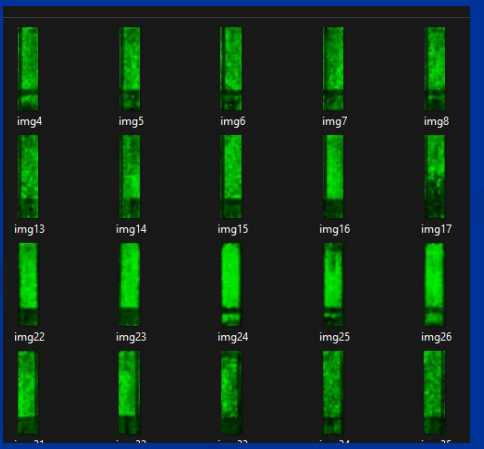
Drone Conversion Program:



- Process took about 60 minutes to perform (first time)

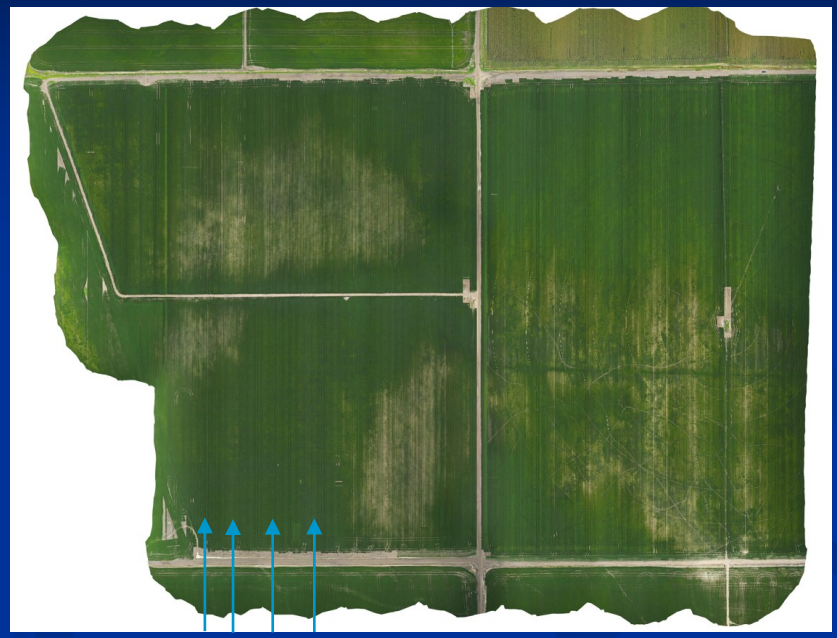
Output and Resultant Images:

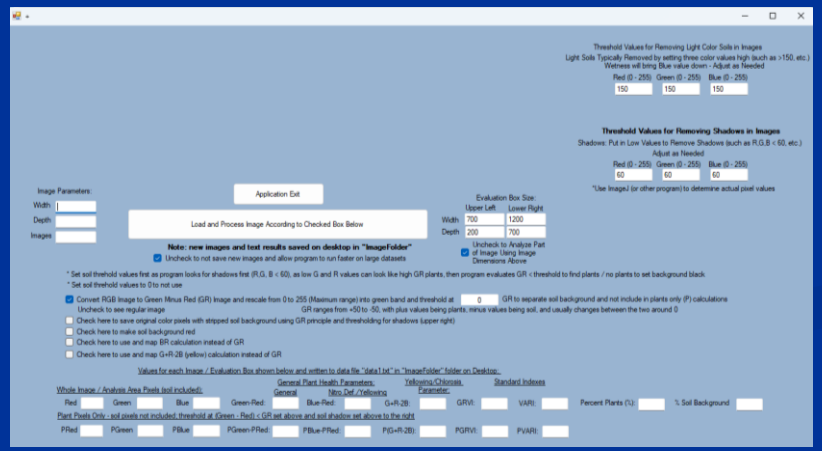


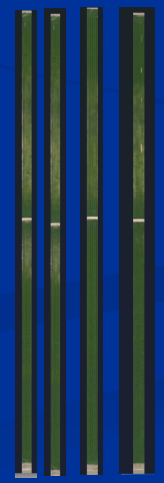


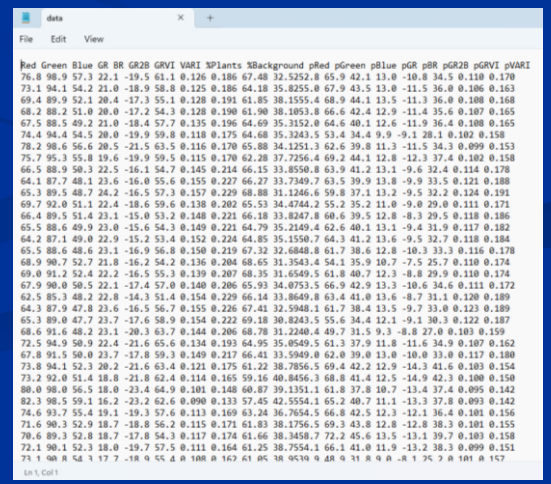
Remote Sensing Activities:

- Weekly Assessment of Soybean fields for Chlorosis effects using remote sensing drones:
  - Flew two large production fields every two weeks (9 dates) during the growing season to record high chlorosis effects from manganese
  - 200 acres
  - Evaluate for quantitative change



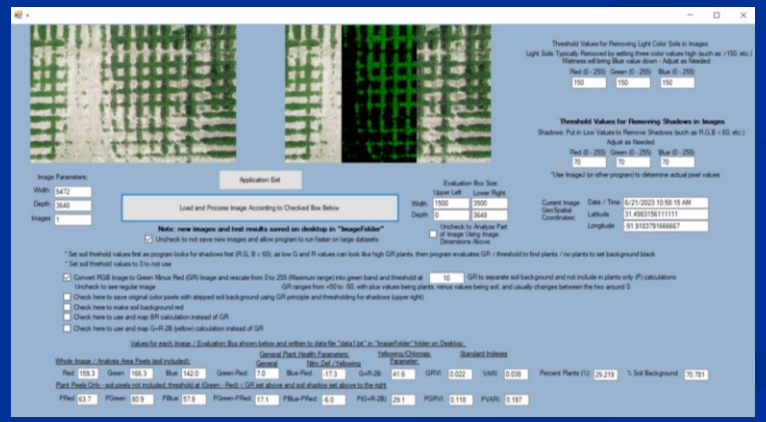


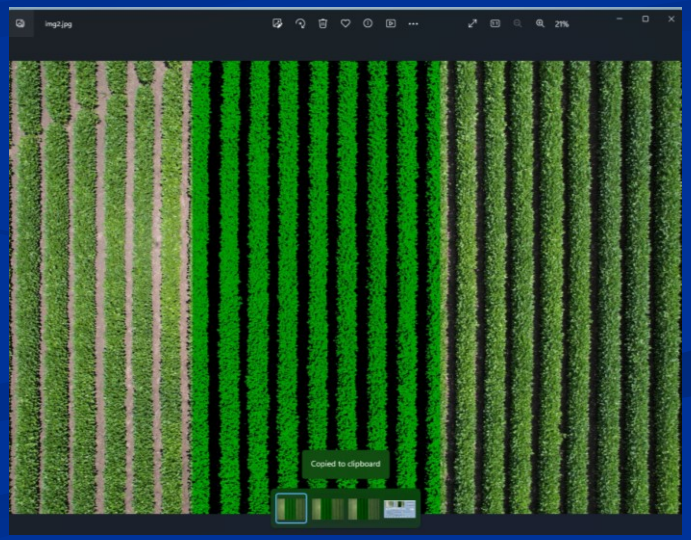




Low Altitude Remote Sensing Approach:

- Low altitude drone test:
  - Fly at low altitude and record imagery data (several hours)
  - Download to computer
  - Analysis with program – 30 minutes





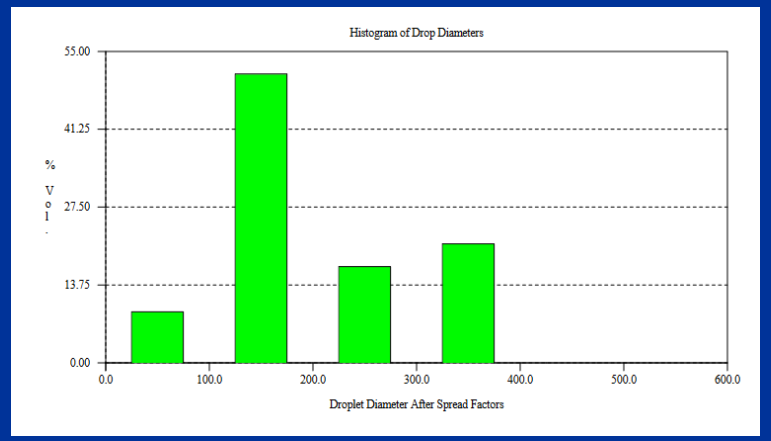
Drone Demonstration at Multiple Field and Youth Career Days:

- 4 4-H and FAA Career Days:
  - Students allowed to fly drones
- 1 Field Day:
  - Dean Lee: Sprayer drone presentation and flight of centrifugal nozzles
- Multiple Farm Visits:
  - Sprayer drone demonstration flights

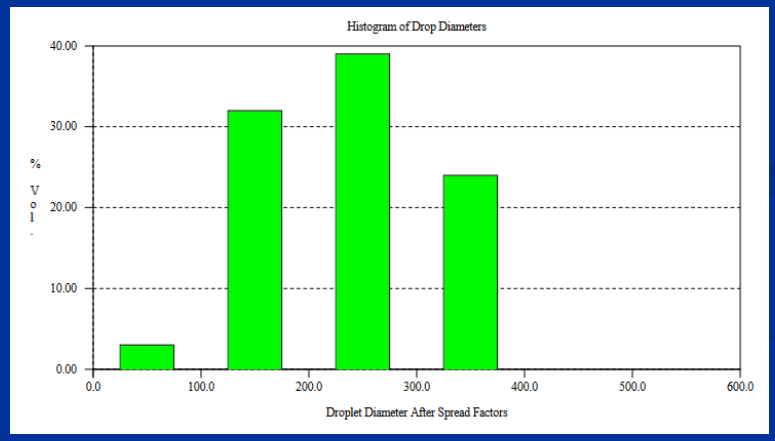
Droplet Spectrum of T40 @ 2 GPA:

- Largest mean droplet was 300 um:

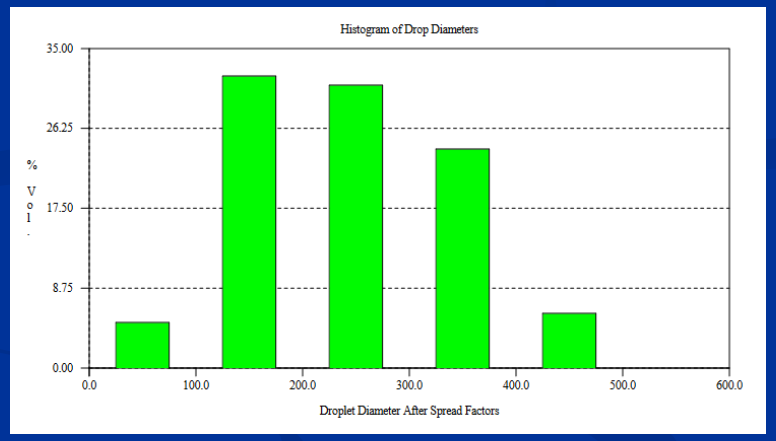
Extra fine wheel / Extra fine setting:



Extra fine wheel / Course setting:



Course wheel / Course setting:



DJI T40:

- T40 – rotary / centrifugal
  - Rotary / centrifugal nozzles:
    - Liquid disk spreaders that operate at different rotational speeds and have different disk; double cutter, coarse, etc.
- T30 – regular hydraulic orifice nozzles (XR, etc.)
  - AIXR11001 or TT11002 are best
  - Some cut off in the middle but depends upon flight speed

DJI T40:

DJI T30: