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Spray Performance Characterization of DJI Agras T30 Drone Sprayer at Varying Heights, Speeds and Nozzle Types

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Introduction

- The application of Unmanned Aerial Systems (UAS) have been increasing rapidly in agriculture

- Multiple UAS platforms are available commercially today for aerial application of pesticides **(drone sprayers)**

- Drone sprayers are another potential application technology that allow for timely applications, especially in areas inaccessible to ground equipment

Advancements in Drone Sprayers

- Improved capabilities in latest drone sprayers/models – swath, speed, droplet size etc.

- Unlike ground sprayers, limited information is available on selection of parameters for effective pesticide applications (e.g. speed, height)

- Assessing application performance of these platforms is important to inform best management practices and effective technology utilization

DJI Agras T30

DJI Agras T40

Hypothesis

For pesticide applications with drone sprayers, application height, flight speed and nozzle type will have a significant impact on spray deposition and uniformity across the swath.

Objective

To evaluate the influence of **application height, speed and nozzle type** on spray deposition uniformity across the swath for a DJI T30 drone sprayer.

Methods and Materials

- **Location**:
  - Tifton, GA (UGA Research Farm)
- **Drone Sprayer**:
  - T30, SZ DJI Technology Co., (Shenzhen, China)
  - D-RTK 2 High Precision GNSS Mobile Station, SZ DJI Technology Co., (Shenzhen, China)

Study Treatments

- **Three Heights (target swaths):**

  1.5, 2.3 and 3.0 m

Three application speeds:

  4.5, 5.6, and 6.7 m s^{-1}

- **Three Nozzles (droplet sizes):**

  XR (M), AIXR (VC) and TTI (UC)

- All tests were performed using a spray volume of 18.7 L ha^{-1} (2 GPA), using water only and as a single pass applications



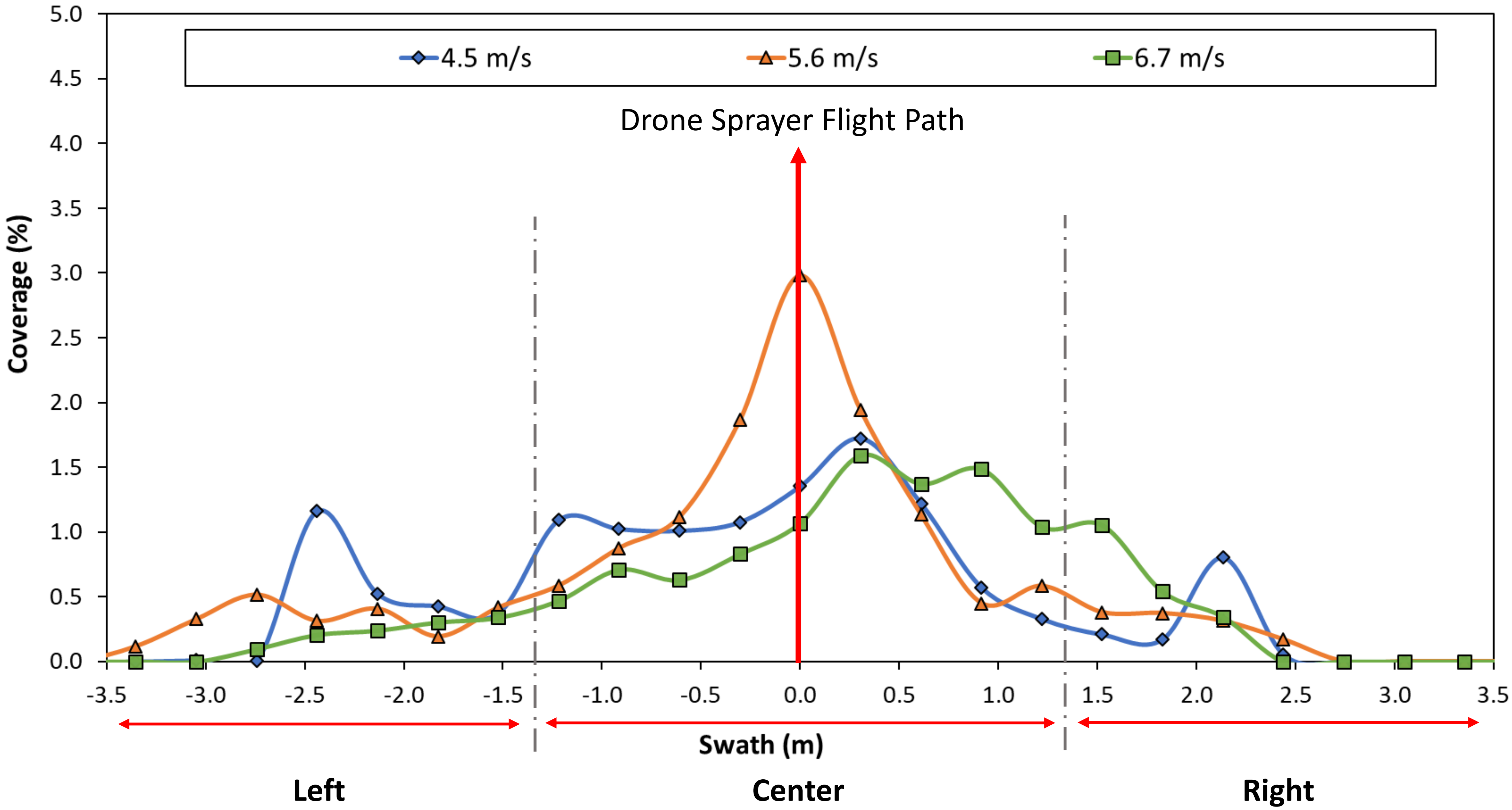
Data Collection

- Water-sensitive paper (WSP) placed at 0.3 m increments across the swath (varied with height - 5.4 to 9.1 m)
- Each pass represented a treatment combination of speed x height x nozzle type
- Each treatment was replicated three times
- Meteorological data collected using Davis Instruments 6250 (wind speed, temperature and humidity)

Data Analysis

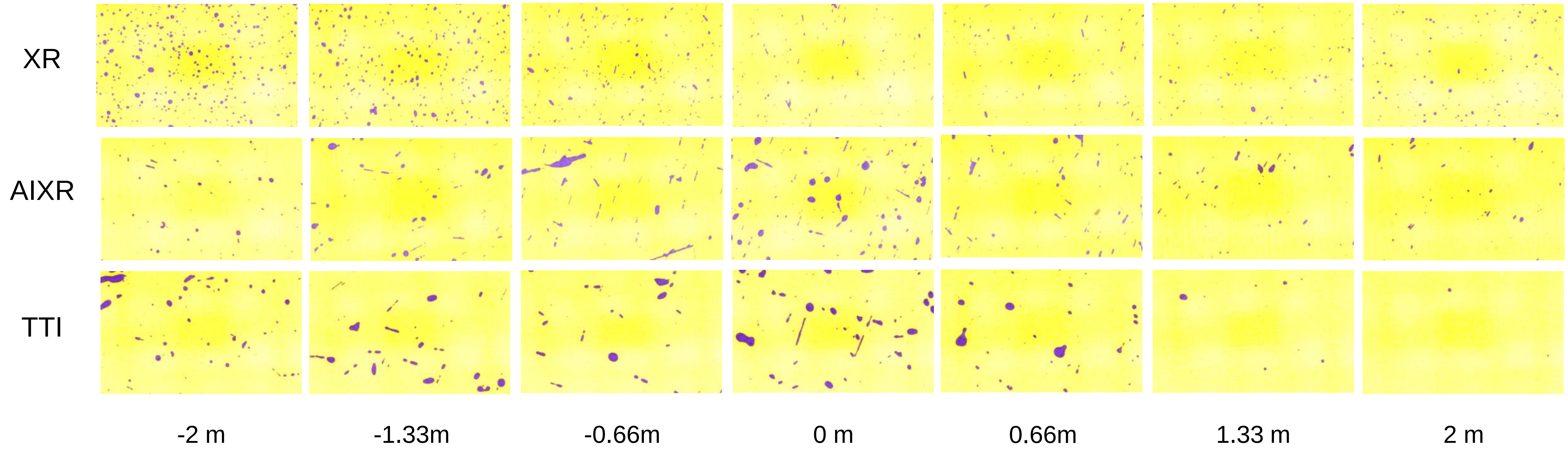
- WSP collected after each pass and analyzed using the SprayX Dropscope instrument
- Spray coverage (%) by each swath location was extracted from raw data for all tests
- Mean coverage was computed from replicated data and plotted to analyze for trends across the swath (left, center and right section)
- Data for each swath section was subjected to ANOVA (*$\alpha = 0.05$*) and means were separated using the Student's t-test ($p \leq 0.05$) in JMP Pro 16.0.

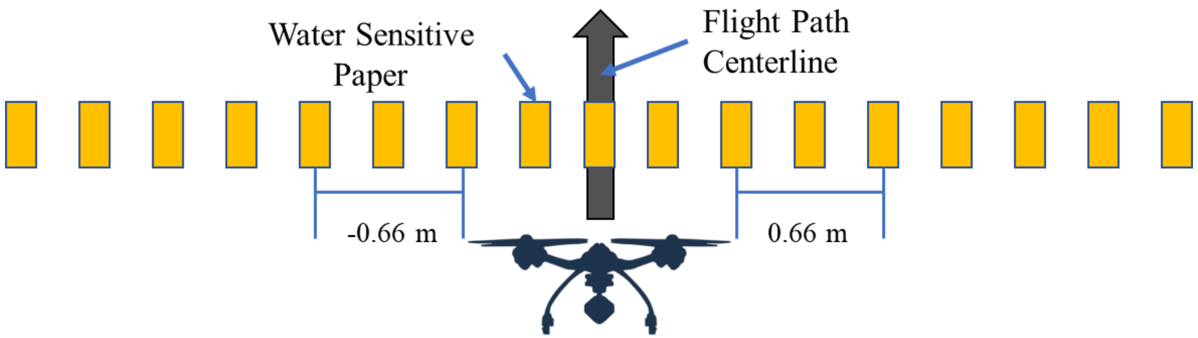
Spray Deposition from Single-Pass Application



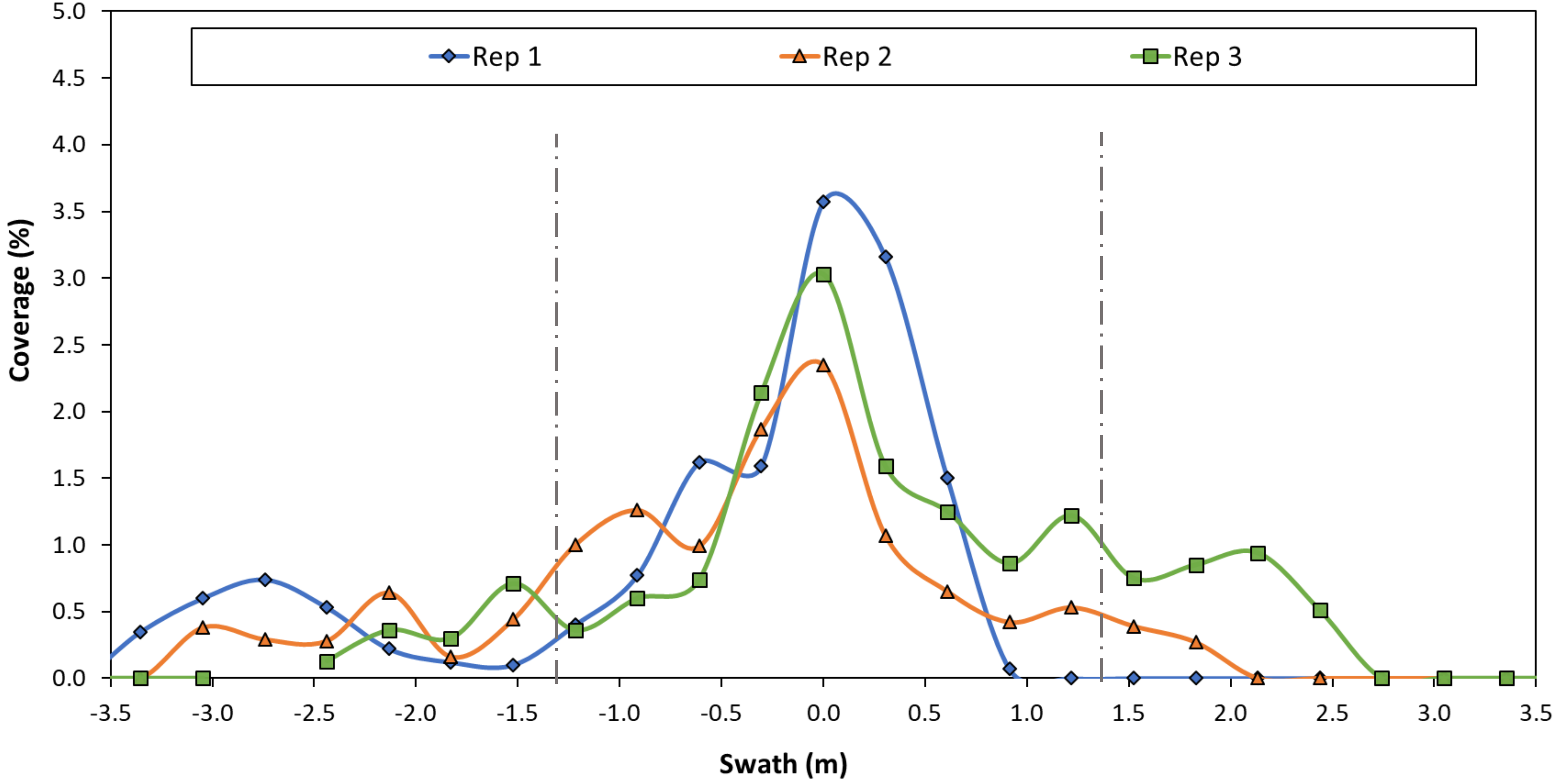
Results

Spray Height = 2.3 m





Variability within the Replications

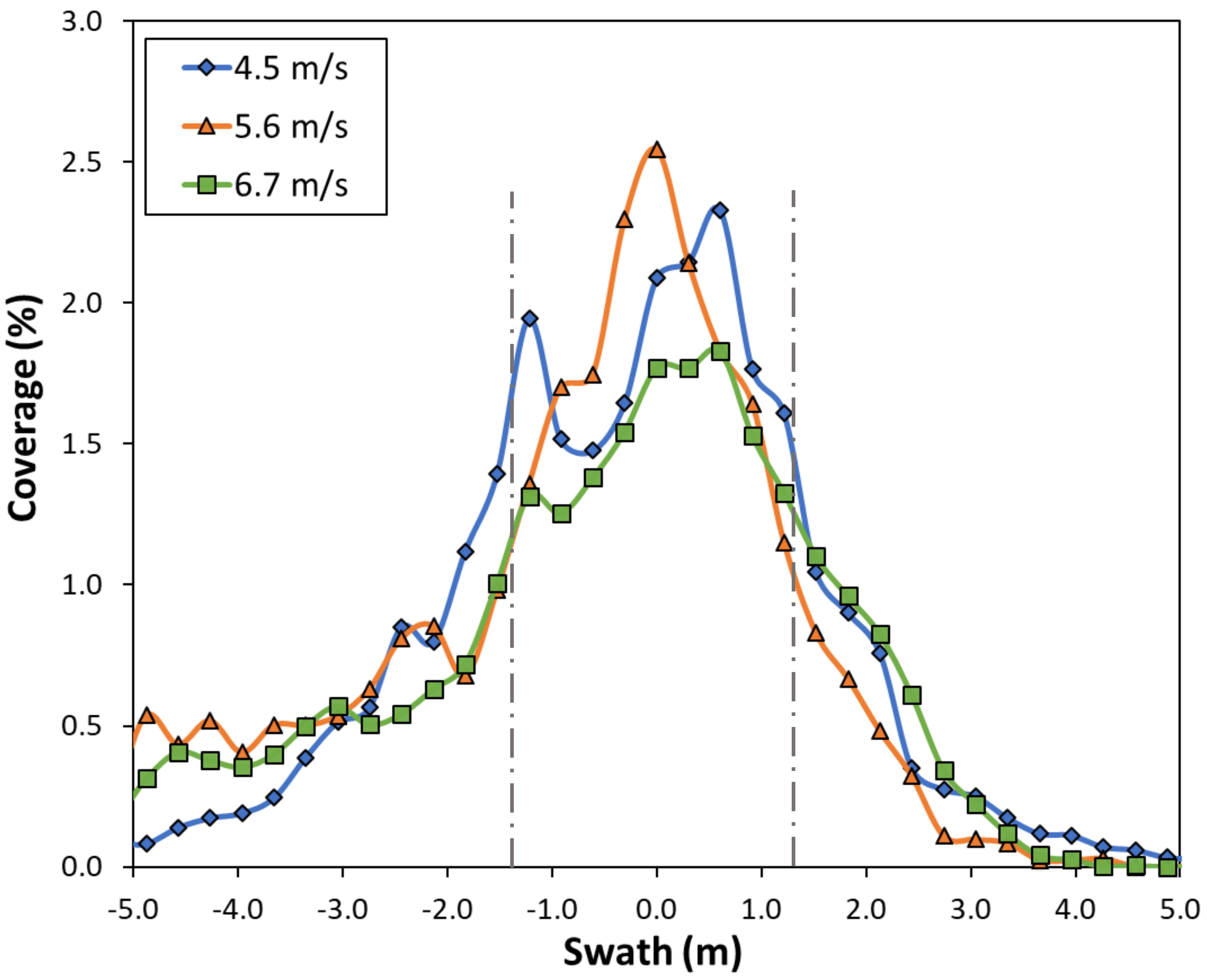


ANOVA Results

Factor	Left	Center	Right
Height	**<0.0001***	**<0.0001***	0.0952
Nozzle	**0.0060***	**<0.0001***	**0.0482***
Speed	0.1681	**0.0027***	0.0837
Height*Speed	0.1502	0.0675	0.1962
Height*Nozzle	0.2055	0.2198	**0.0008***
Speed*Nozzle	0.8081	0.2081	**0.0328***
Height*Speed*Nozzle	**<0.0001***	**0.0211***	**0.0458***

P-values from the ANOVA test illustrating the effect of spray volume, height, and their interaction on spray deposition at different canopy positions. * indicates significant effects at $p \leq 0.05$.

Effect of Flight Speed on Coverage Uniformity



Center Swath

Speed (m s^{-1})	Coverage (%)	CV (%)
4.5	1.84 a	76.02
5.6	1.82 a	73.39
6.7	1.52 b	65.28

Entire Swath

Speed (m s^{-1})	Coverage (%)	CV (%)
4.5	0.66 a	160.29
5.6	0.64 a	153.06
6.7	0.57 a	142.40

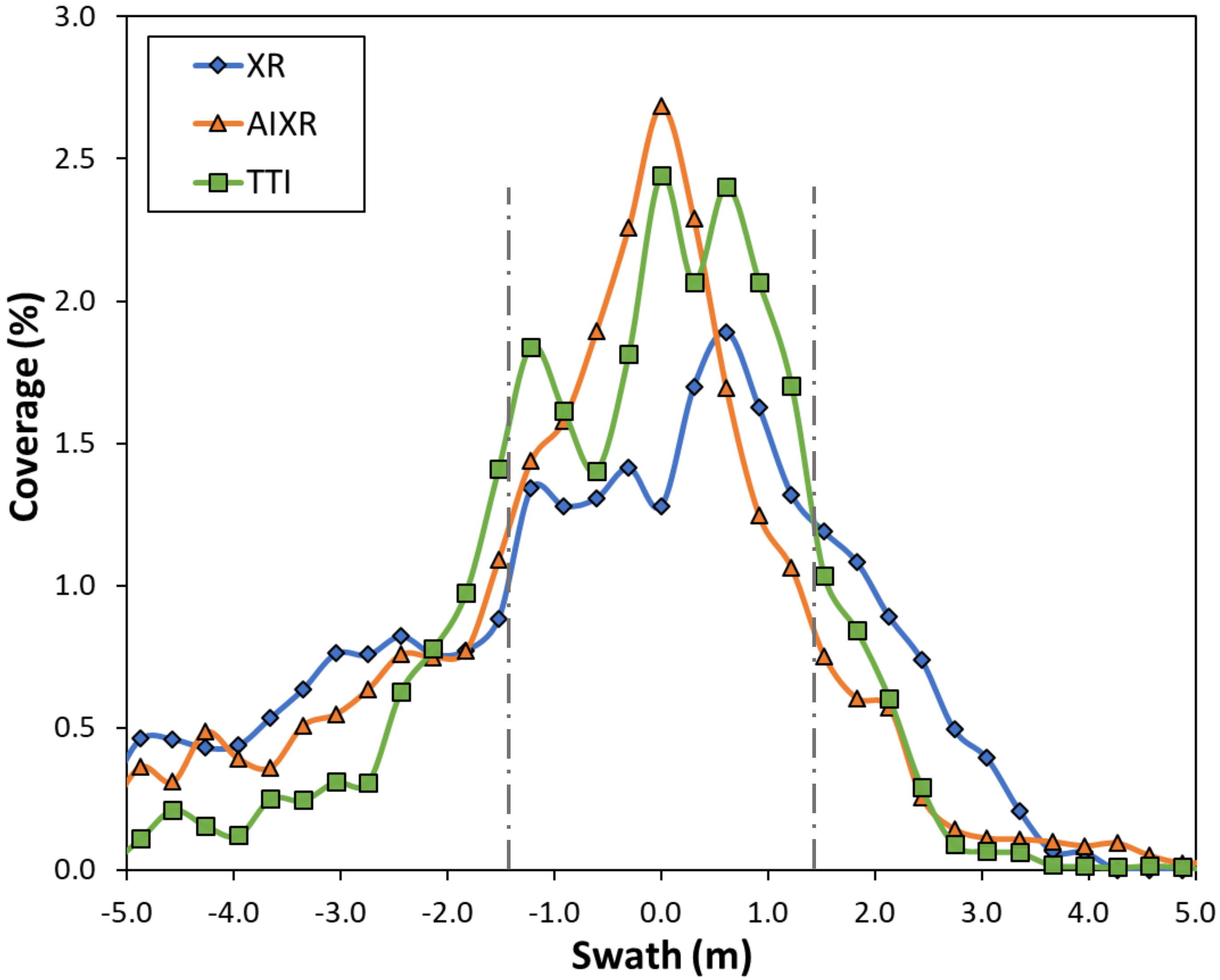
Effect of Nozzle Selection on Coverage Uniformity

Center Swath

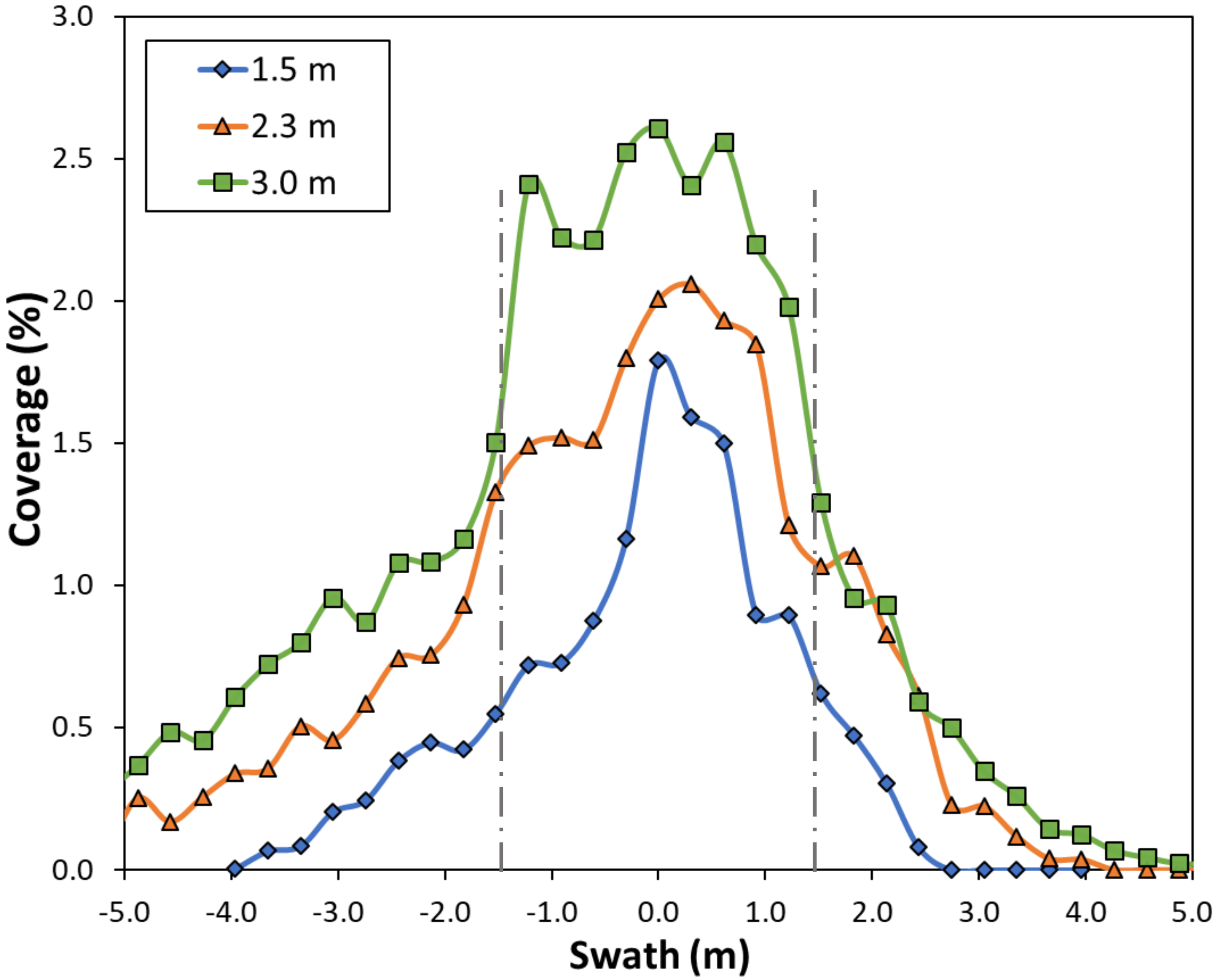
Nozzle	Coverage (%)	CV (%)
XR	1.46 a	72.89
AIXR	1.79 b	67.41
TTI	1.93 b	74.77

Entire Swath

Nozzle	Coverage (%)	CV (%)
XR	0.65 a	134.38
AIXR	0.64 a	150.97
TTI	0.64 a	172.11



Effect of Application Height on Coverage Uniformity



Center Swath

Height (m)	Coverage (%)	CV (%)
1.5	1.13 a	99.86
2.3	1.71 b	67.45
3.0	2.35 c	51.28

Entire Swath

Height (m)	Coverage (%)	CV (%)
1.5	0.52 a	163.89
2.3	0.62 b	156.29
3.0	0.73 c	144.46

Interaction : Height x Speed x Nozzle

Height (m)	Speed (m s^{-1})	Nozzle	Center	
			Mean (%)	CV (%)
1.5	4.5	AIXR	1.04 kl	94
		TTI	1.53 fghijk	137
		XR	1.22 hijk	64
	5.6	AIXR	1.28 ghijk	72
		TTI	1.50 fghijk	120
		XR	0.95 kl	50
	6.7	AIXR	1.02 kl	45
		TTI	1.15 ijk	46
		XR	0.46 l	80
2.3	4.5	AIXR	1.87 cdefg	56
		TTI	1.79 defgh	71
		XR	1.12 jk	81
	5.6	AIXR	1.67 efghij	57
		TTI	1.87 cdefg	80
		XR	2.15 bcde	61
	6.7	AIXR	2.08 cdef	49
		TTI	1.51 fghijk	56
		XR	1.32 ghijk	86
3.0	4.5	AIXR	2.36 bcd	47
		TTI	3.25 a	40
		XR	2.35 bcd	50
	5.6	AIXR	2.73 ab	66
		TTI	2.41 bc	45
		XR	1.84 cdefg	38
	6.7	AIXR	2.09 cdef	51
		TTI	2.35 bcd	31
		XR	1.74 efghi	53

Height = 3.0 m, Nozzle = XR

Speed (m s^{-1})	Coverage (%)	CV (%)
4.5	2.35 a	50
5.6	1.84 ab	38
6.7	1.74 b	53

Height = 2.3 m, Speed = 4.5 m s^{-1}

Nozzle	Coverage (%)	CV (%)
XR	1.12 a	81
AIXR	1.87 b	56
TTI	1.79 b	71

Nozzle = TTI, Speed = 5.6 m s^{-1}

Height (m)	Coverage (%)	CV (%)
1.5	1.50 a	119
2.3	1.87 ab	80
3.0	2.41 b	45

Conclusions

- **Application Height:**
  - Coverage and coverage uniformity increased with height, with 3.0 m height providing a significantly higher coverage.

- **Application Speed:**
  - Application speed had similar coverage at the two tested lower speeds (4.5 and 5.6 m s^{-1}), but coverage was reduced at the highest speed of 6.7 m s^{-1} (recommended application speed by spray drone manufacturers).

- **Nozzle Type:**
  - AIXR (Coarse) or TTI (Very-Coarse) nozzles provided improved coverage than the XR nozzle (medium droplet, default nozzle on most new drone sprayers)

Future Research & Practical Implications

- Future research – Need to investigate performance of other newer spray drone models (DJI T40, XAG P100) and determine optimal application parameters (height, speed and droplet size)

- Commercial applicators need to perform swath testing to determine optimal parameters. In this study, the T30's default nozzles and maximum application speed showed consistently lower coverage.

- Performance of drone sprayers will likely vary in the presence of a crop canopy from bare ground. Applicators need to test coverage in presence of crop canopies and adjust parameters accordingly.

Thanks!

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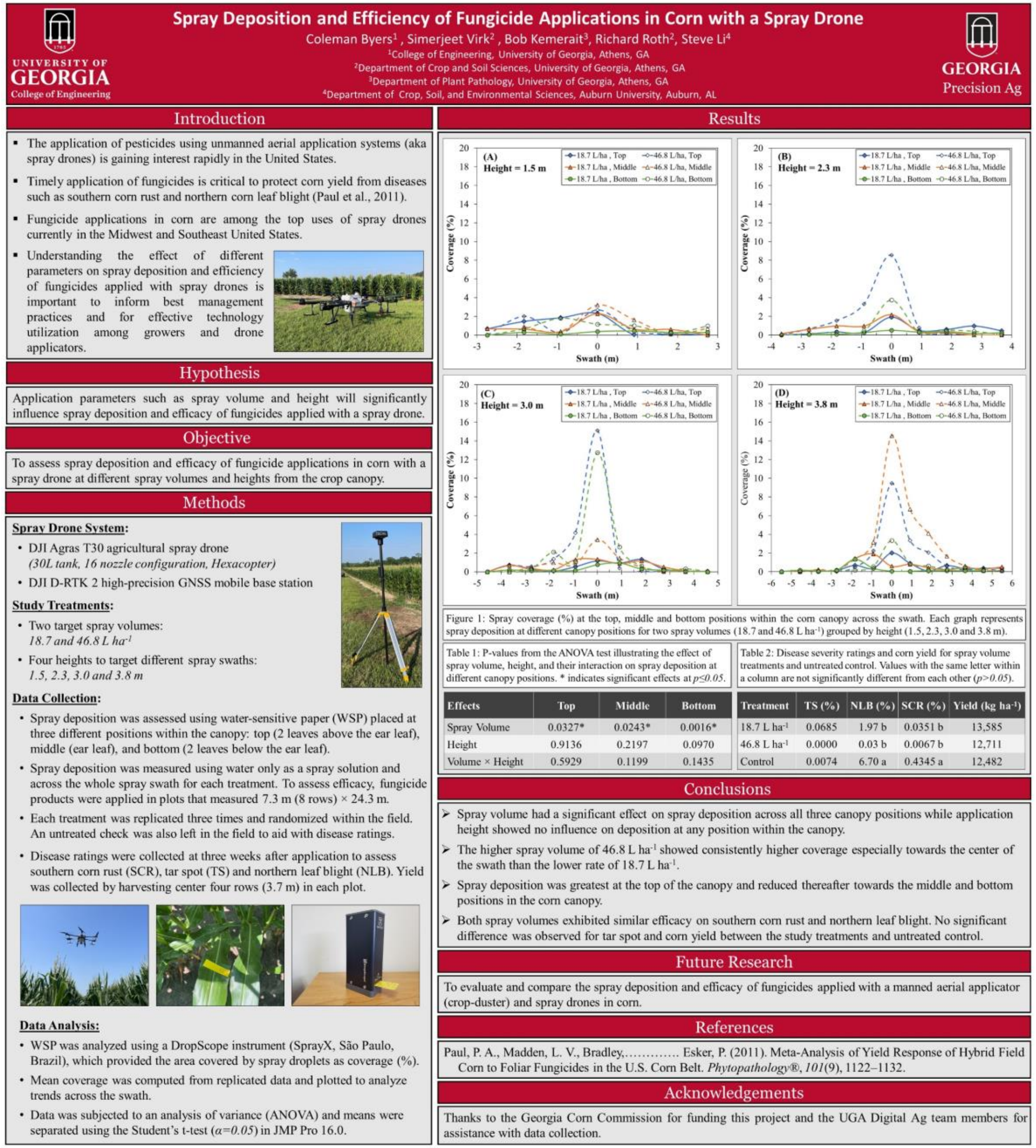

Poster# 1092, Precision Ag Session: Tuesday, 4:00 to 6:00 PM