

# **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<sup>-1</sup>
- **Three Nozzles (droplet sizes):**  
XR (M), AIXR (VC) and TTI (UC)
- All tests were performed using a spray volume of 18.7 L ha<sup>-1</sup> (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)



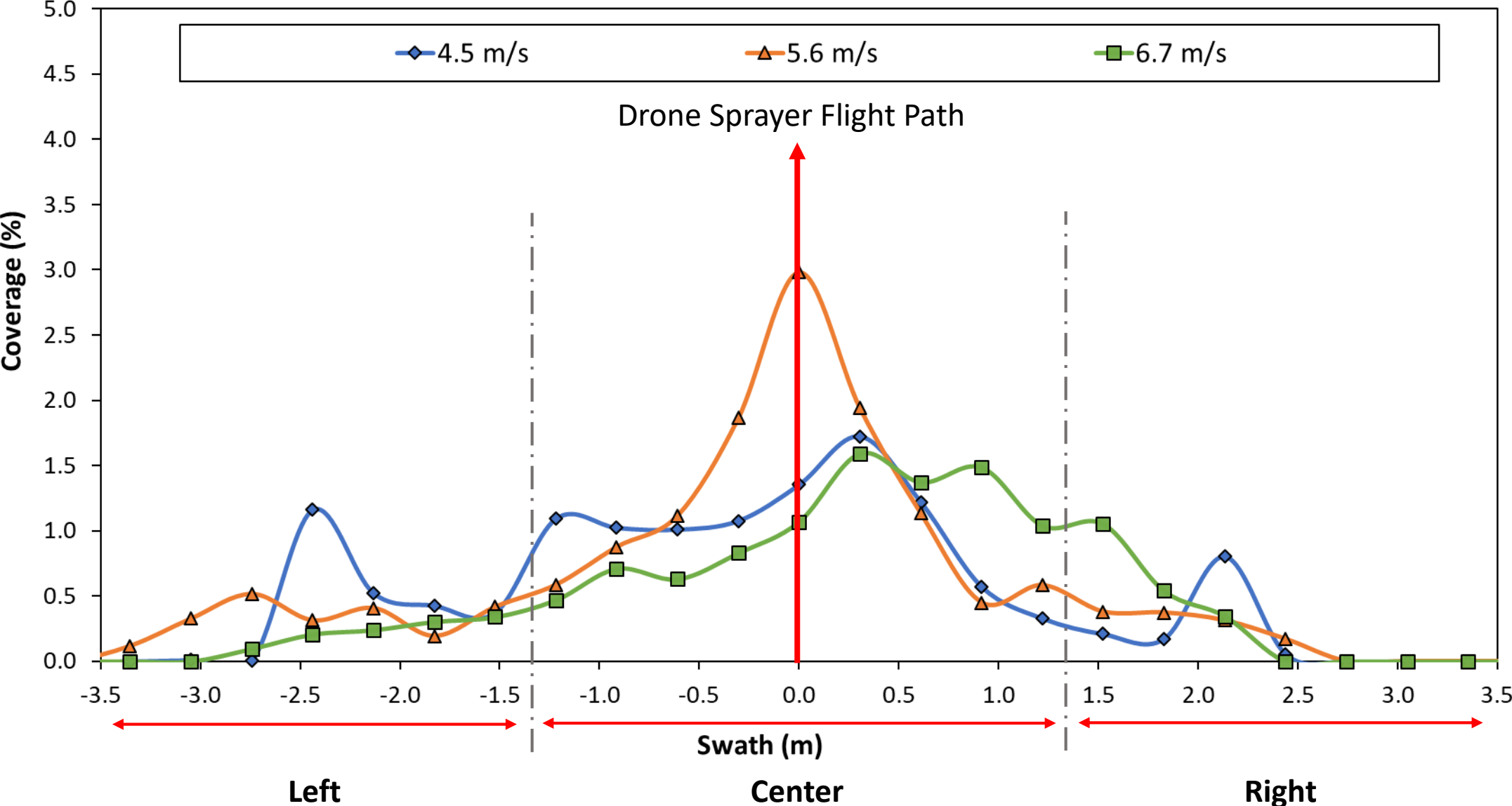
# Data Analysis



- 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.

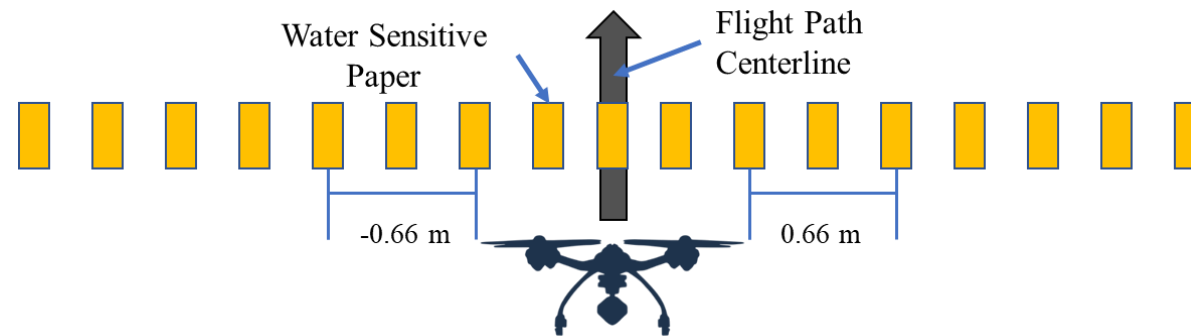
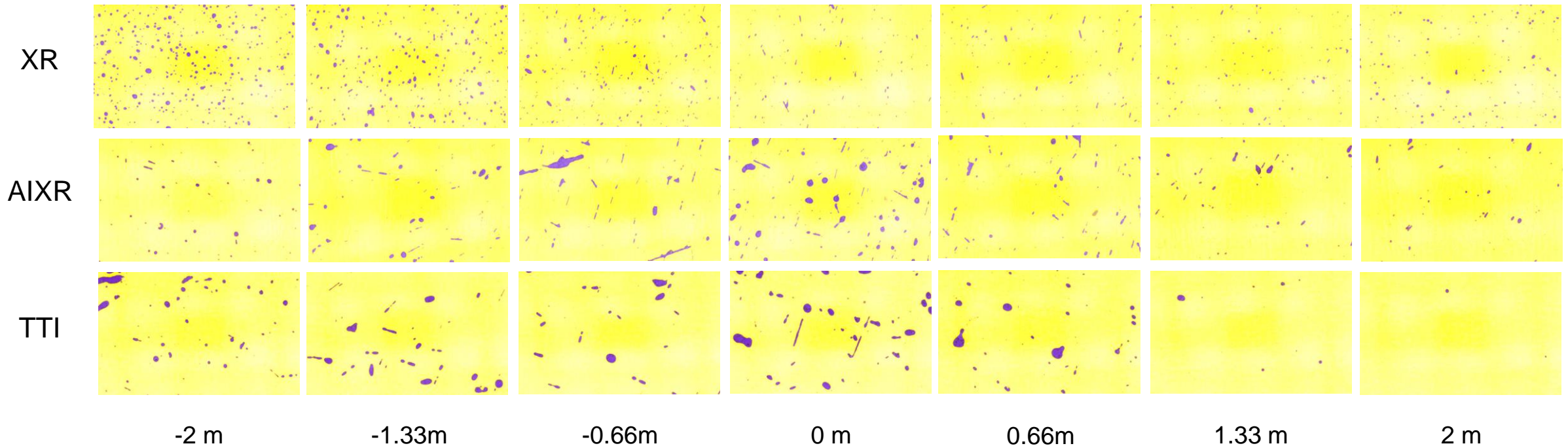


# Spray Deposition from Single-Pass Application

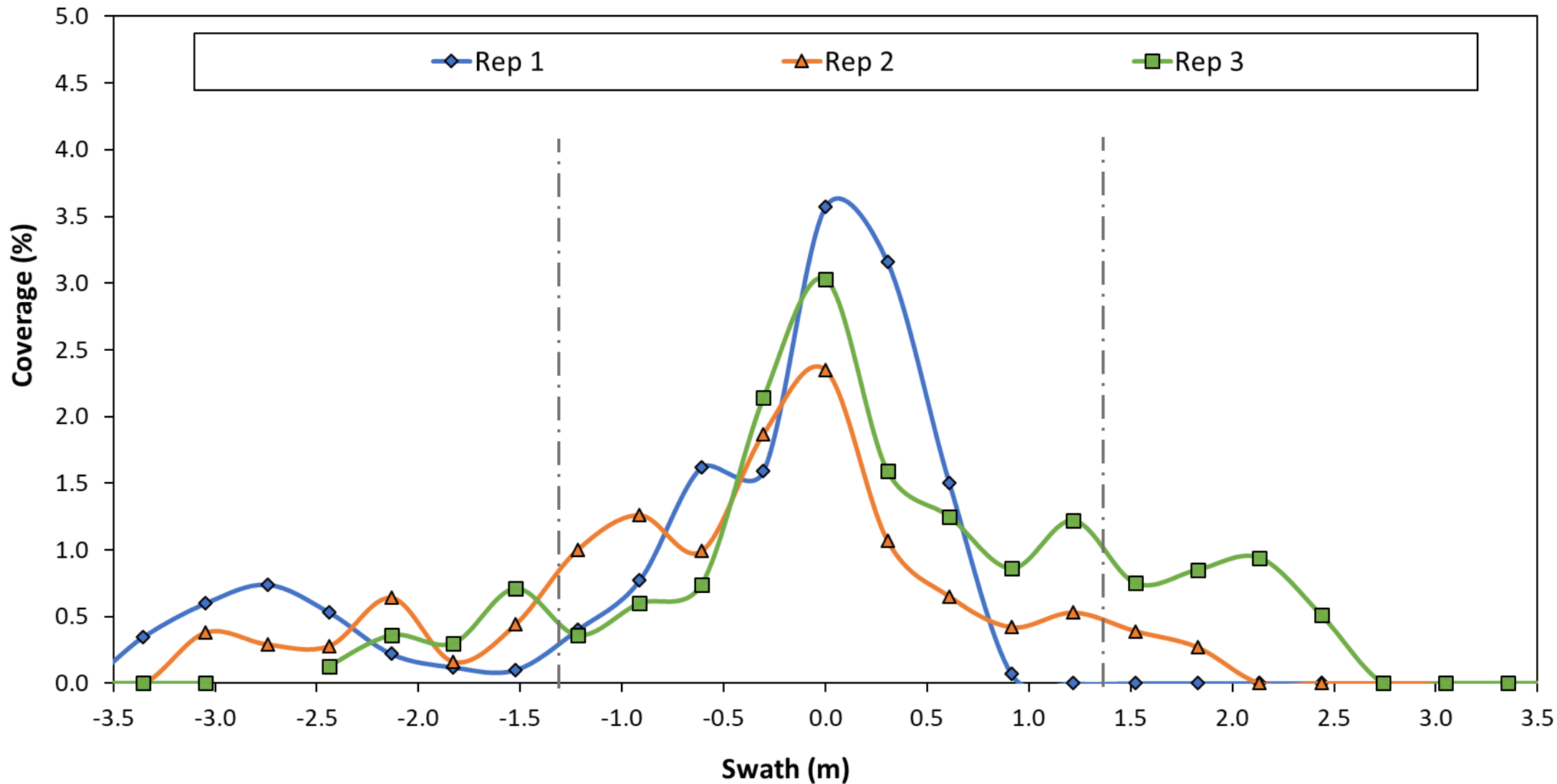


# Results

Spray Height = 2.3 m



# Variability within the Replications

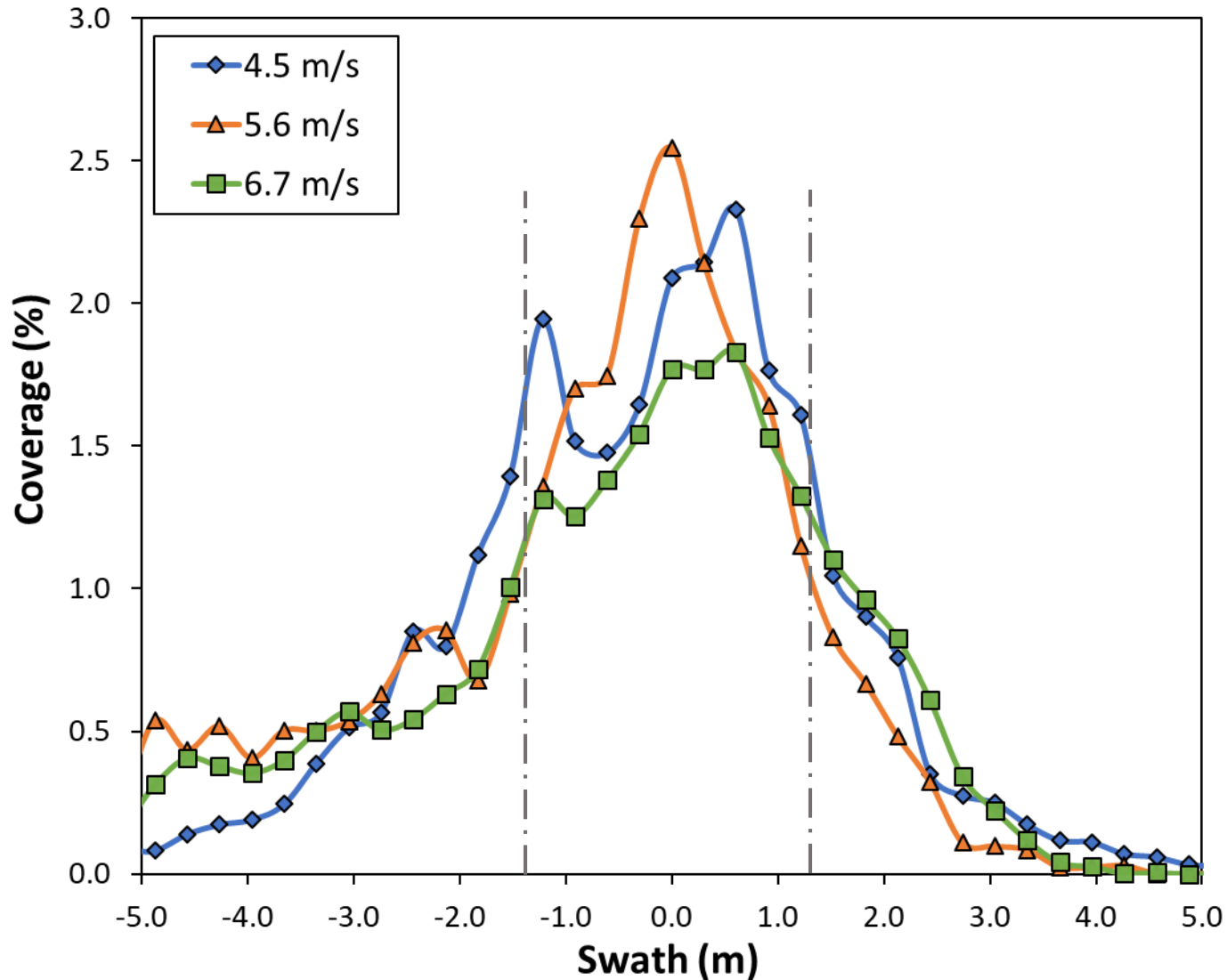


# ANOVA Results

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 <sup>-1</sup> )	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 <sup>-1</sup> )	Coverage (%)	CV (%)
4.5	0.66 a	160.29
5.6	0.64 a	153.06
6.7	0.57 a	142.40

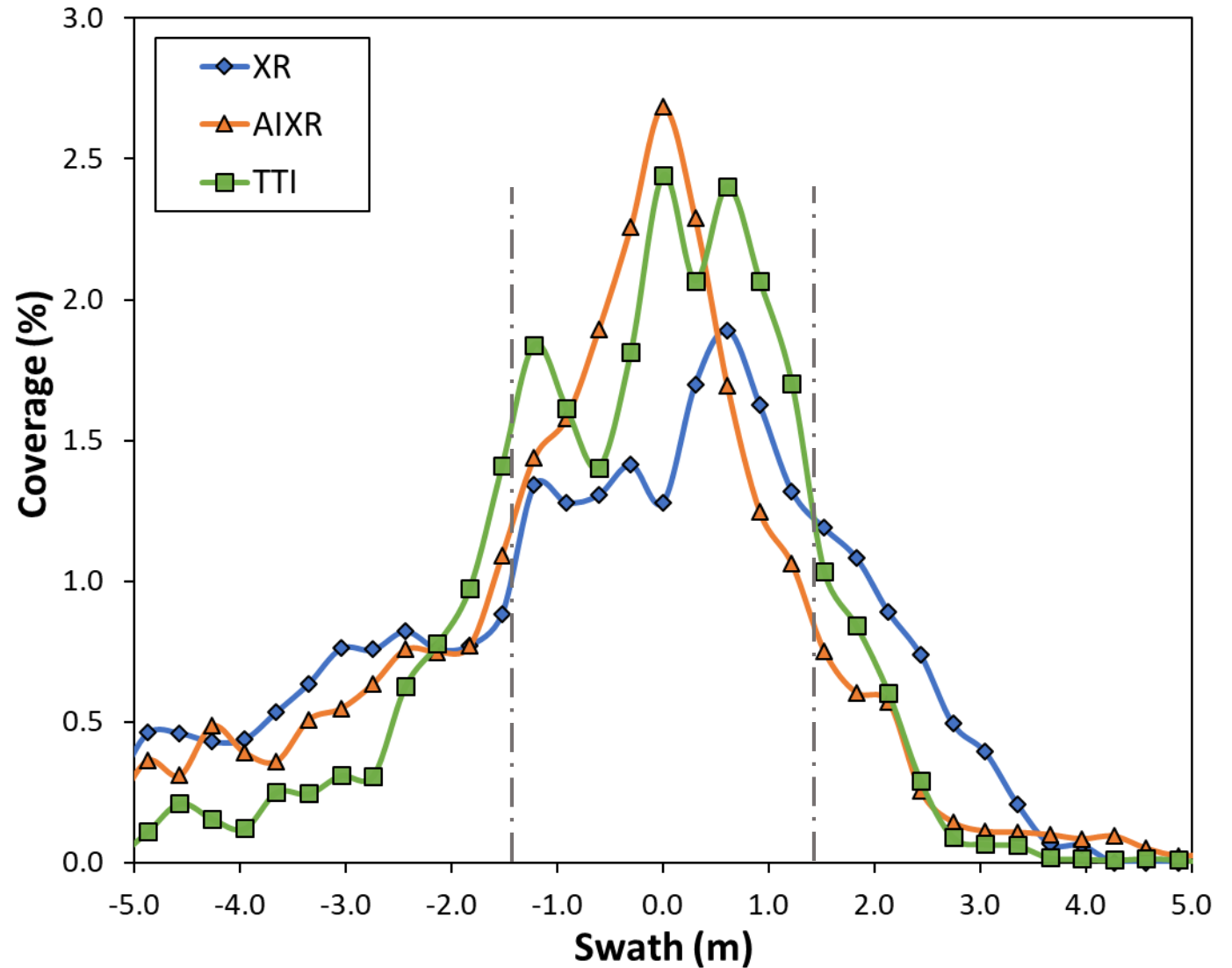
# Effect of Nozzle Selection on Coverage Uniformity

## Center Swath

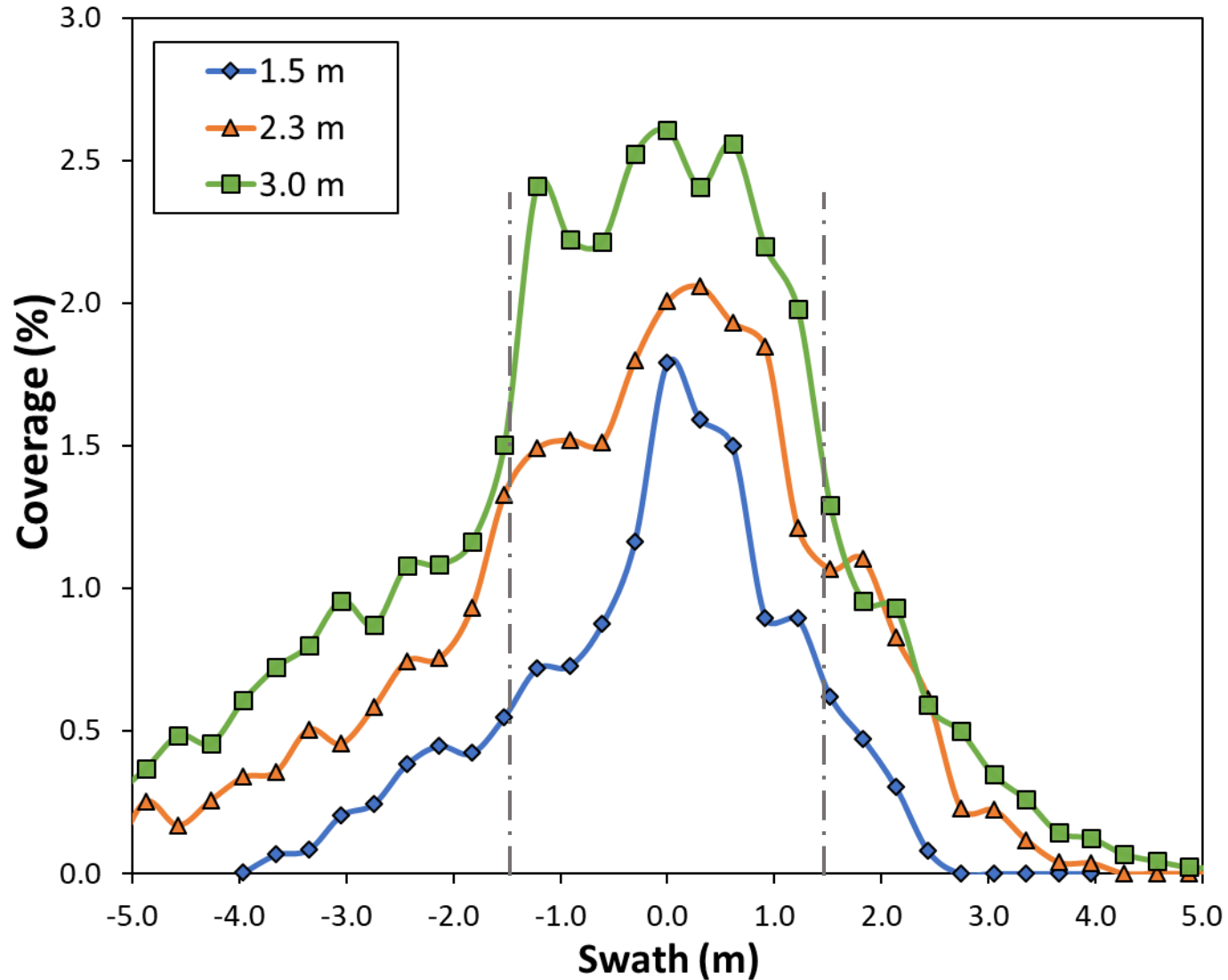
Nozzle	Coverage (%)	CV (%)
XR	1.46 a	72.89
AIXR	1.79 b	67.41
TTI	1.93 b	74.77

## 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 <sup>-1</sup> )	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 <sup>-1</sup> )	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<sup>-1</sup>

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<sup>-1</sup>

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<sup>-1</sup>), but coverage was reduced at the highest speed of 6.7 m s<sup>-1</sup> (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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**Spray Deposition and Efficiency of Fungicide Applications in Corn with a Spray Drone**  
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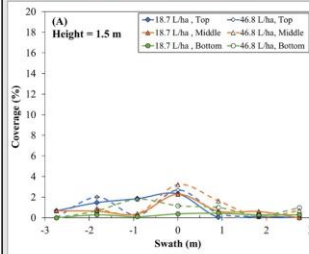
### Introduction

- The application of pesticides using unmanned aerial application systems (aka spray drones) is gaining interest rapidly in the United States.
- Timely application of fungicides is critical to protect corn yield from diseases such as southern corn rust and northern corn leaf blight (Paul et al., 2011).
- Fungicide applications in corn are among the top uses of spray drones currently in the Midwest and Southeast United States.
- Understanding the effect of different parameters on spray deposition and efficiency of fungicides applied with spray drones is important to inform best management practices and for effective technology utilization among growers and drone applicators.

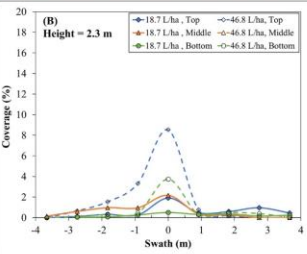


### Results

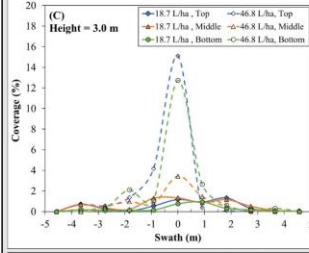
**(A) Height = 1.5 m**



**(B) Height = 2.3 m**



**(C) Height = 3.0 m**



**(D) Height = 3.8 m**

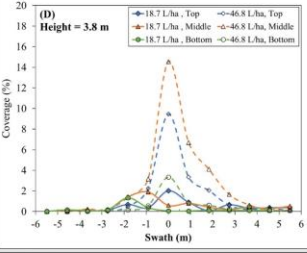


Figure 1: Spray coverage (%) at the top, middle and bottom positions within the corn canopy across the swath. Each graph represents spray deposition at different canopy positions for two spray volumes (18.7 and 46.8 L ha<sup>-1</sup>) grouped by height (1.5, 2.3, 3.0 and 3.8 m).

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### Hypothesis

Application parameters such as spray volume and height will significantly influence spray deposition and efficacy of fungicides applied with a spray drone.

### Objective

To assess spray deposition and efficacy of fungicide applications in corn with a spray drone at different spray volumes and heights from the crop canopy.

### Methods

**Spray Drone System:**




- DJI Agras T30 agricultural spray drone (30L tank, 16 nozzle configuration, Hexacopter)
- DJI D-RTK 2 high-precision GNSS mobile base station

**Study Treatments:**

- Two target spray volumes: 18.7 and 46.8 L ha<sup>-1</sup>
- Four heights to target different spray swaths: 1.5, 2.3, 3.0 and 3.8 m

**Data Collection:**

- Spray deposition was assessed using water-sensitive paper (WSP) placed at three different positions within the canopy: top (2 leaves above the ear leaf), middle (ear leaf), and bottom (2 leaves below the ear leaf).
- Spray deposition was measured using water only as a spray solution and across the whole spray swath for each treatment. To assess efficacy, fungicide products were applied in plots that measured 7.3 m (8 rows) × 24.3 m.
- Each treatment was replicated three times and randomized within the field. An untreated check was also left in the field to aid with disease ratings.
- Disease ratings were collected at three weeks after application to assess southern corn rust (SCR), tar spot (TS) and northern leaf blight (NLB). Yield was collected by harvesting center four rows (3.7 m) in each plot.

**Data Analysis:**

- WSP was analyzed using a DropScope instrument (SprayX, São Paulo, Brazil), which provided the area covered by spray droplets as coverage (%).
- Mean coverage was computed from replicated data and plotted to analyze trends across the swath.
- Data was subjected to an analysis of variance (ANOVA) and means were separated using the Student's t-test ( $\alpha=0.05$ ) in JMP Pro 16.0.

### Table 1: 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 $p \leq 0.05$ .

Effects	Top	Middle	Bottom
Spray Volume	0.0327*	0.0243*	0.0016*
Height	0.9136	0.2197	0.0970
Volume × Height	0.5929	0.1199	0.1435

### Table 2: Disease severity ratings and corn yield for spray volume treatments and untreated control. Values with the same letter within a column are not significantly different from each other ( $p > 0.05$ ).

Effects	Treatment	TS (%)	NLB (%)	SCR (%)	Yield (kg ha <sup>-1</sup> )
18.7 L ha <sup>-1</sup>	18.7 L ha <sup>-1</sup>	0.0685	1.97 b	0.0351 b	13,585
46.8 L ha <sup>-1</sup>	46.8 L ha <sup>-1</sup>	0.0000	0.03 b	0.0067 b	12,711
Control	Control	0.0074	6.70 a	0.4345 a	12,482

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### Conclusions

- Spray volume had a significant effect on spray deposition across all three canopy positions while application height showed no influence on deposition at any position within the canopy.
- The higher spray volume of 46.8 L ha<sup>-1</sup> showed consistently higher coverage especially towards the center of the swath than the lower rate of 18.7 L ha<sup>-1</sup>.
- Spray deposition was greatest at the top of the canopy and reduced thereafter towards the middle and bottom positions in the corn canopy.
- Both spray volumes exhibited similar efficacy on southern corn rust and northern leaf blight. No significant difference was observed for tar spot and corn yield between the study treatments and untreated control.

### Future Research

To evaluate and compare the spray deposition and efficacy of fungicides applied with a manned aerial applicator (crop-duster) and spray drones in corn.

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### References

Paul, P. A., Madden, L. V., Bradley,....., Esker, P. (2011). Meta-Analysis of Yield Response of Hybrid Field Corn to Foliar Fungicides in the U.S. *Corn Belt. Phytopathology*, 101(9), 1122–1132.

### Acknowledgements

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