Accuracy and Uniformity of Spray Drone Applications at Varying Operational Parameters

Coleman Byers
MS Student
College of Engineering
University of Georgia

UNIVERSITY OF GEORGIA
College of Engineering

UNIVERSITY OF GEORGIA
DIGITAL AG

Advancements in Drone Sprayers

- Improved capabilities in latest drone sprayers/models – swath, speed, droplet size etc.
- Unlike ground sprayers, limited information is available on the 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

Study 1 - 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

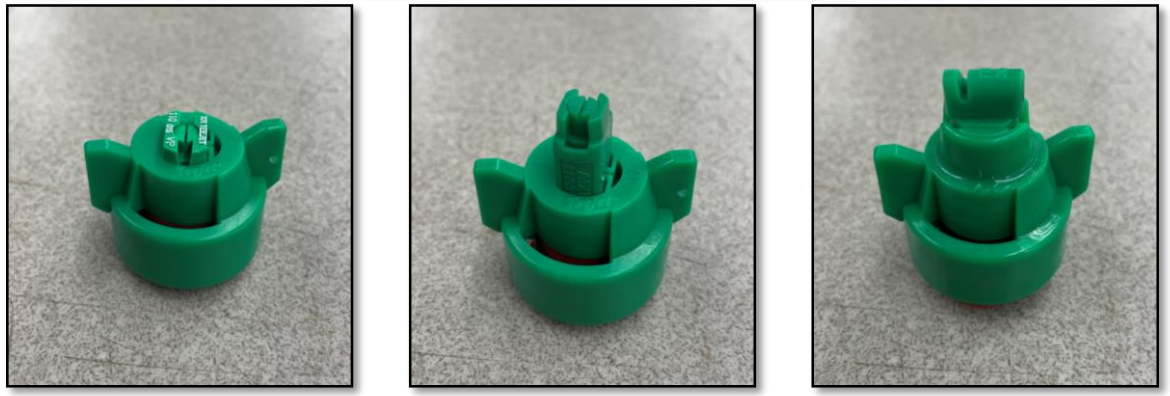
Three application speeds:

  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



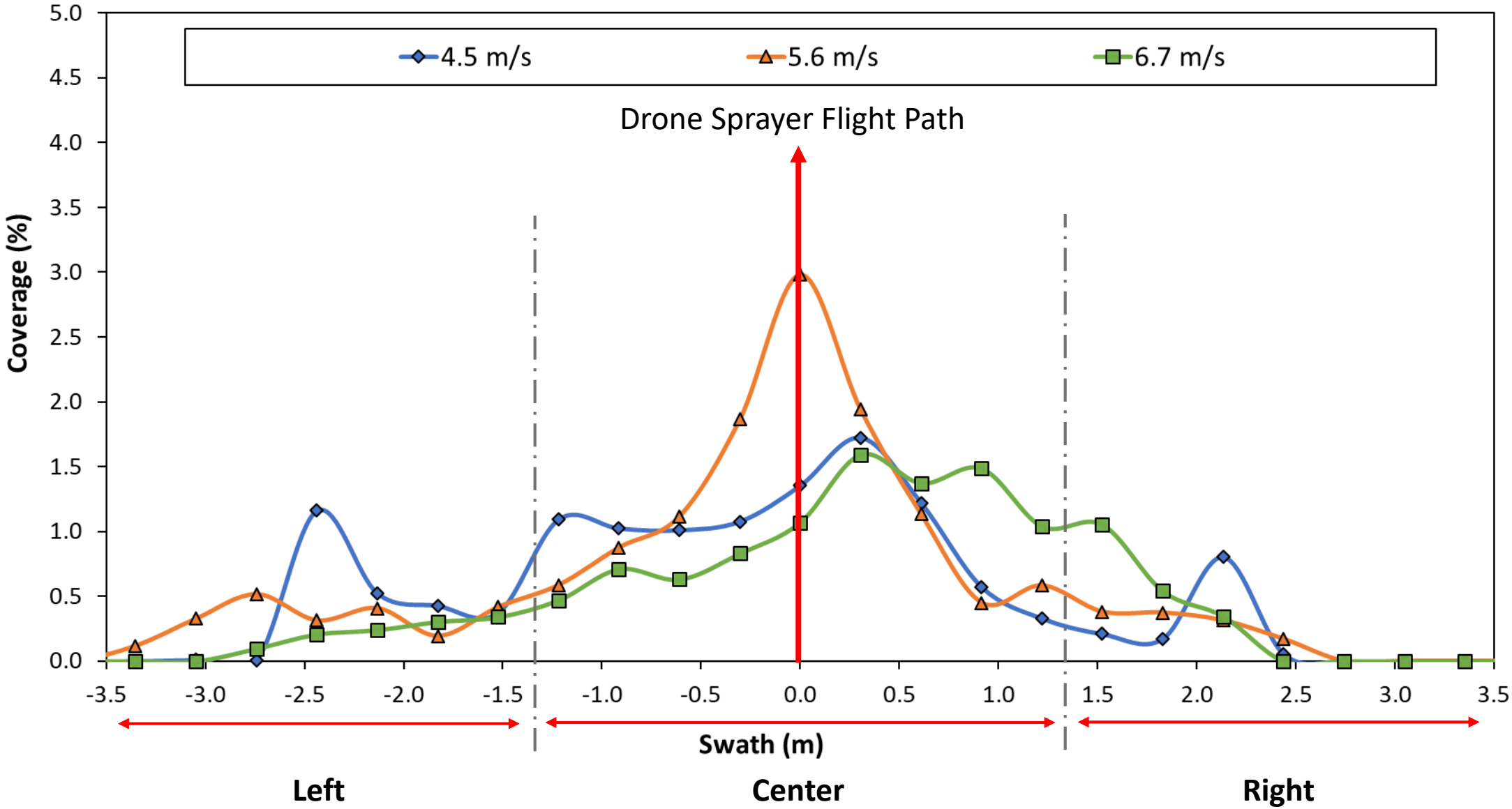
Data Collection

- 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

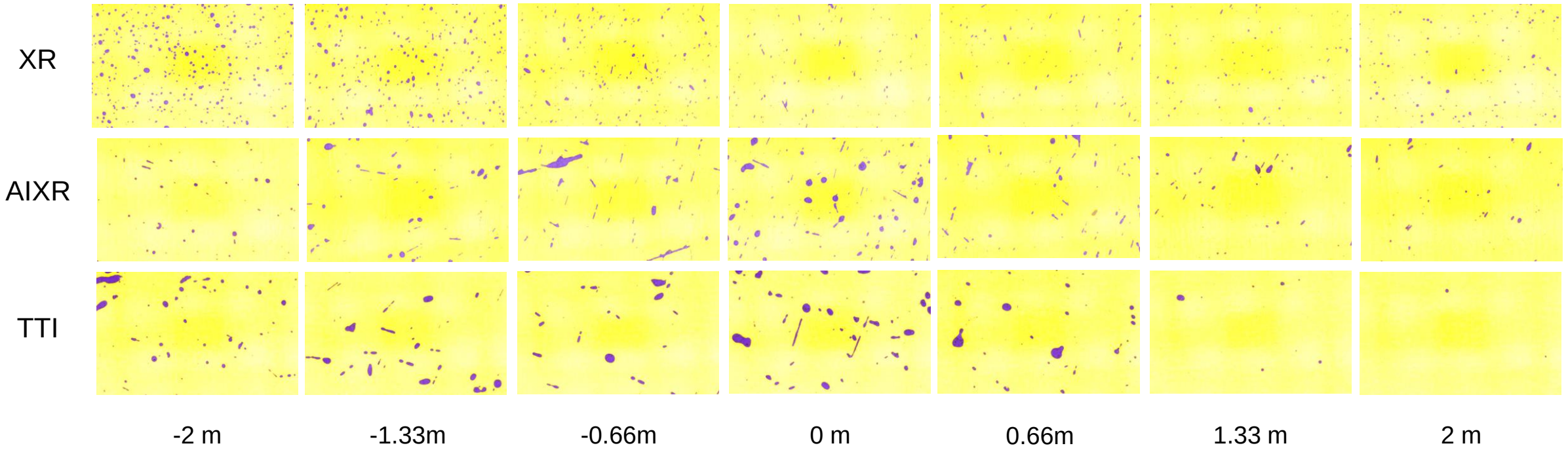
- WSP collected after each pass and analyzed using the SprayX Dropscope instrument
- Spray coverage (%) by each swath location was extracted from raw data for all tests
- Mean coverage was computed from replicated data and plotted to analyze for trends across the swath (left, center and right section)
- 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.

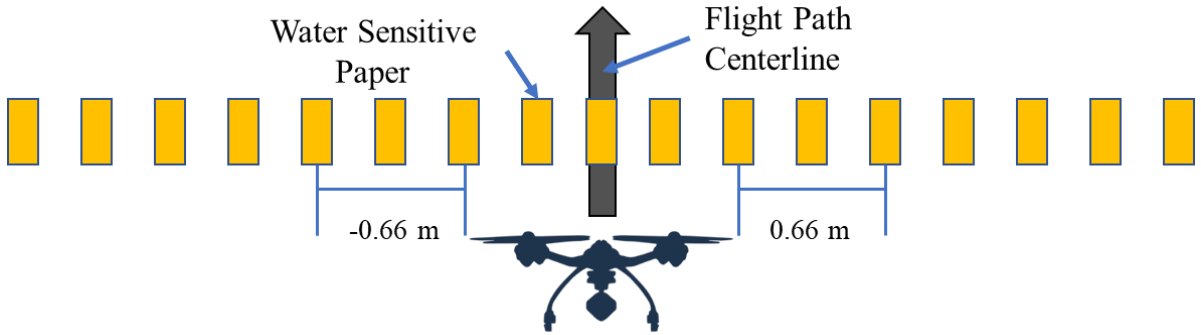
Spray Deposition from Single-Pass Application



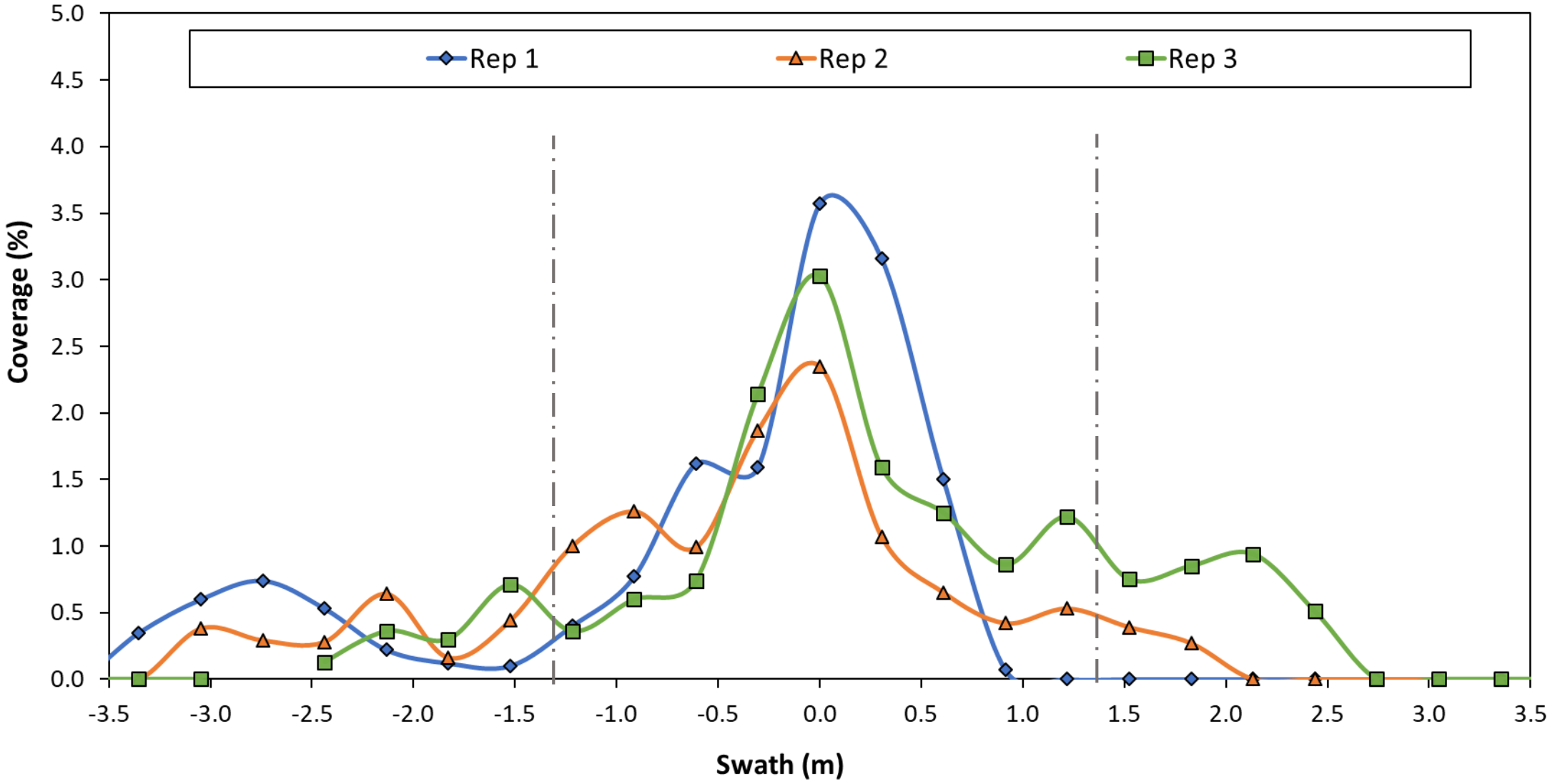
Results

Spray Height = 2.3 m

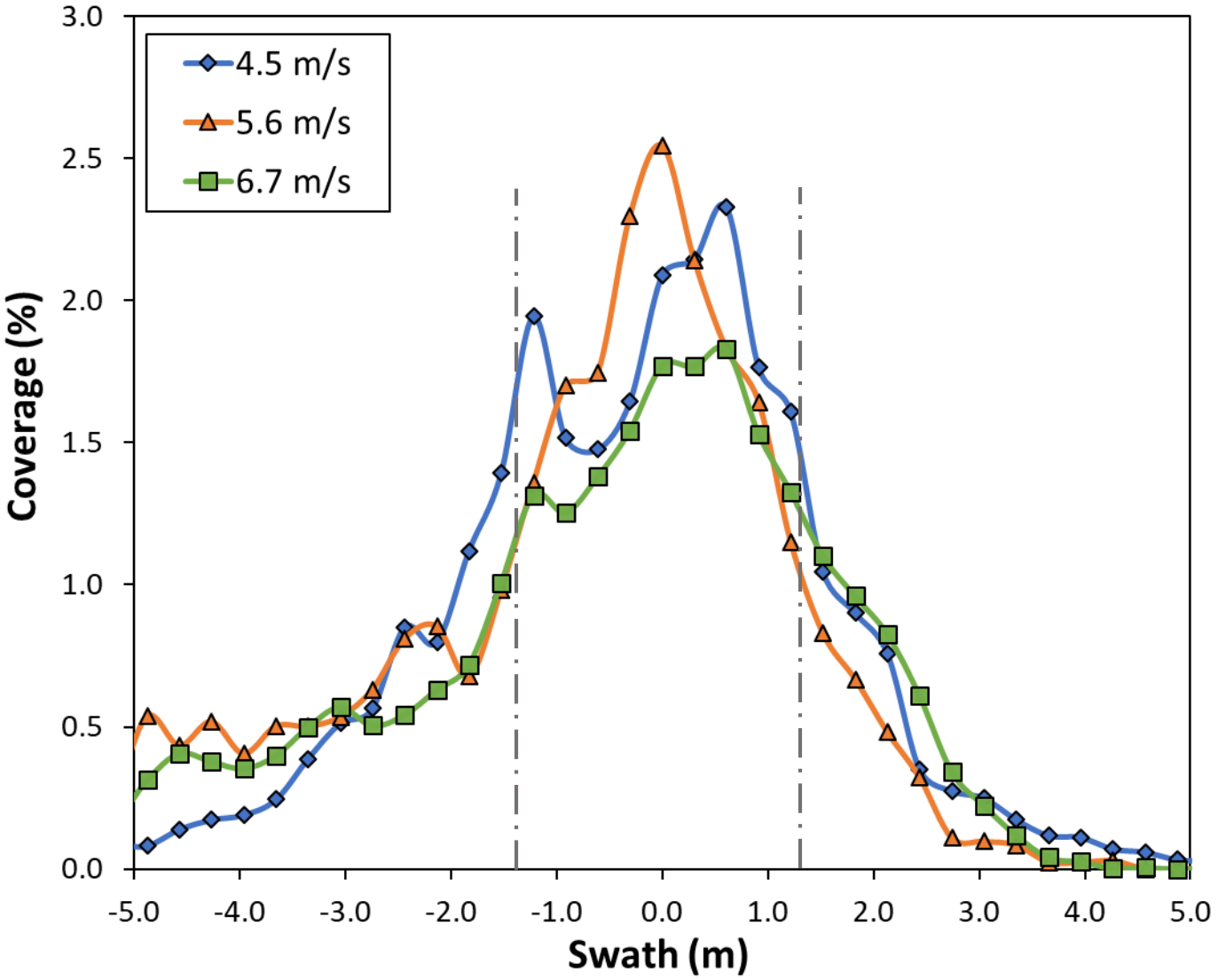




Variability within the Replications



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

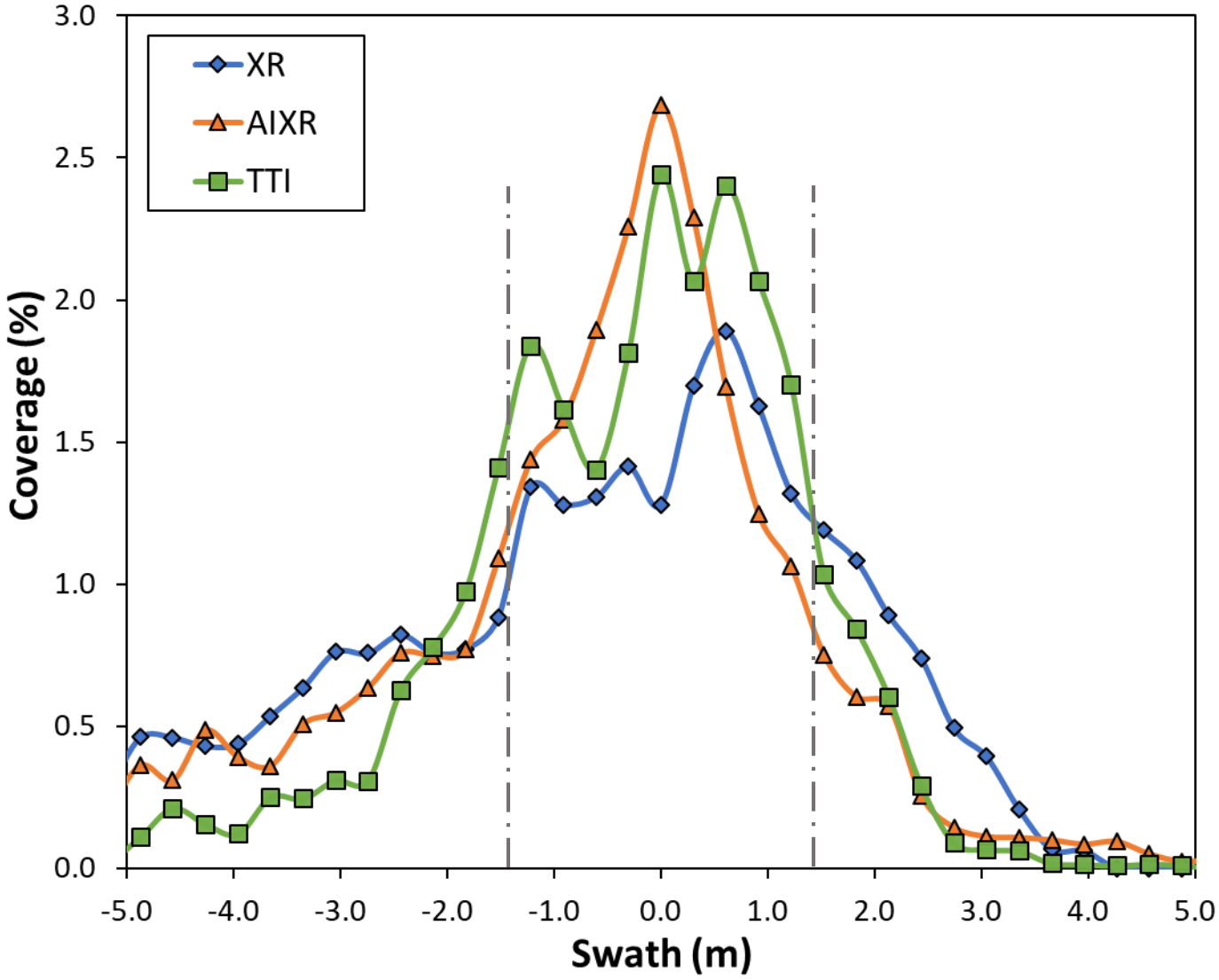
Effect of Nozzle Selection on Coverage Uniformity

Center Swath

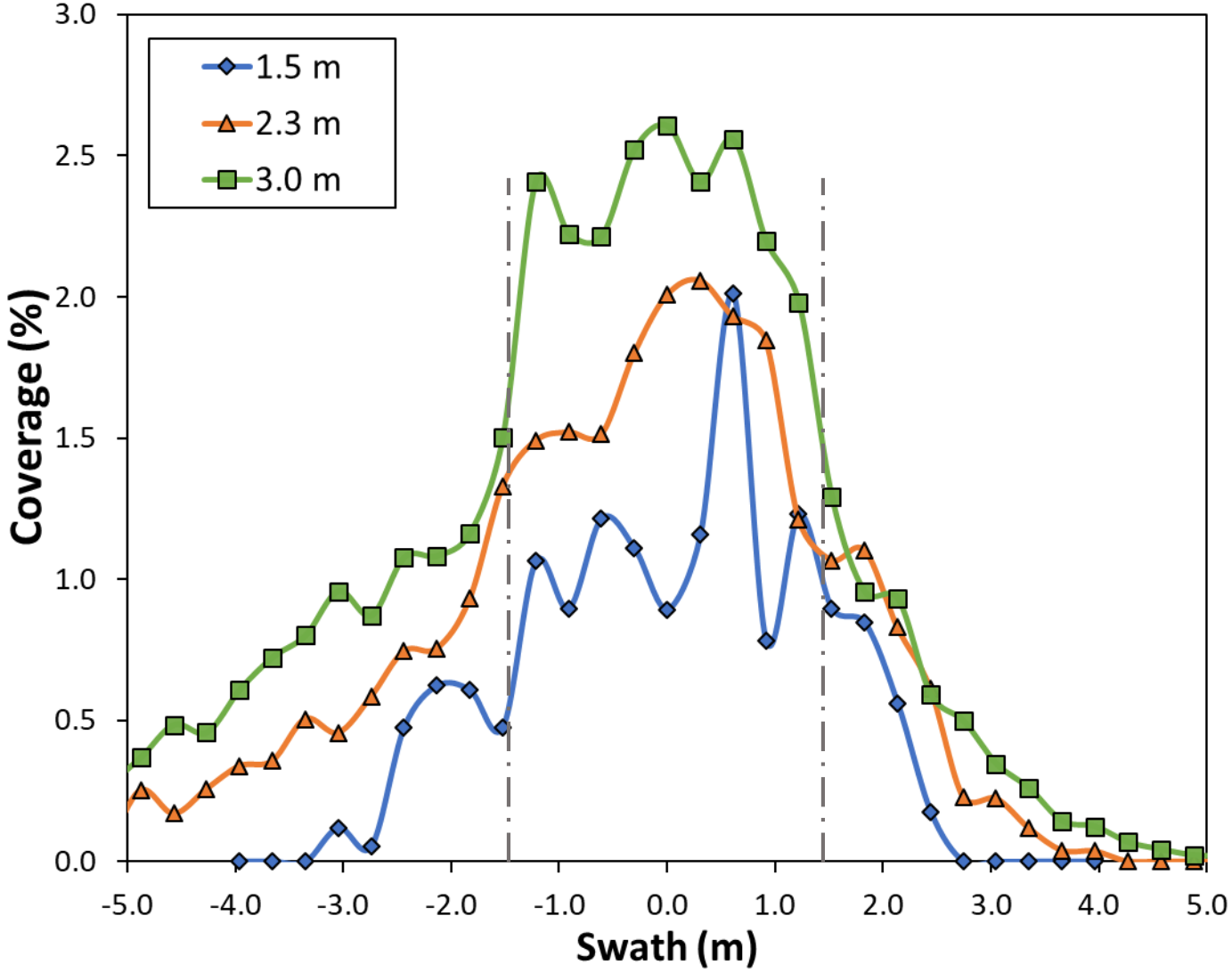
Nozzle	Coverage (%)	CV (%)
XR	1.46 a	72.89
AIXR	1.79 b	67.41
TTI	1.93 b	74.77

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



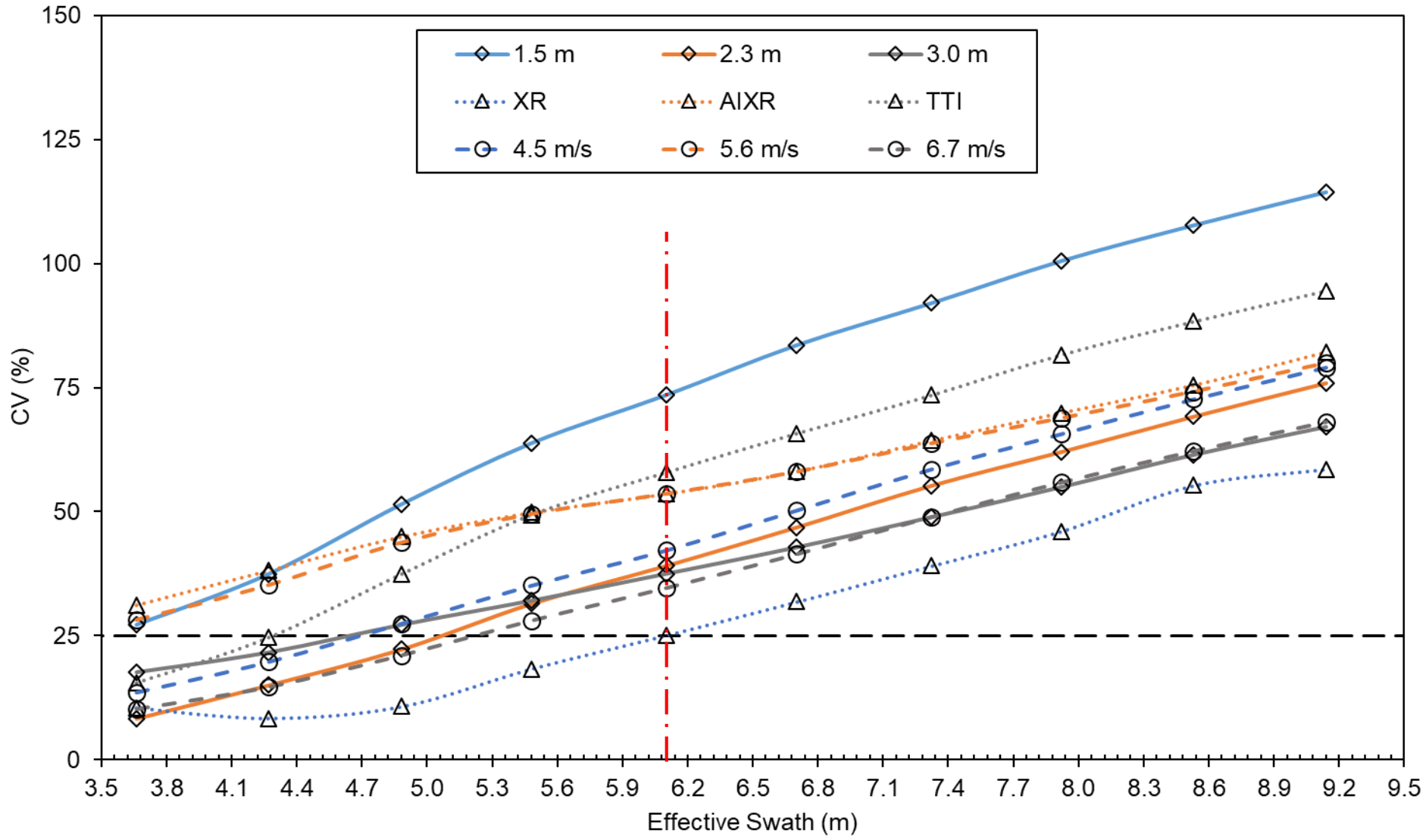
Center Swath

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

DJI T30 – Effective Swath



Study 1 - Conclusions

❑ **Application Height:**

- Coverage and coverage uniformity increased with height, with 3.0 m height providing 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)

❑ **Effective Swath:**

- Few application parameters allowed an acceptable variation (CV<25%) within a range of effective swaths, but does suggest that spray UAAS effective swath range may be significantly less than manufacturer-reported values.

Study 2 - Methods and Materials

- **<u>Drone Sprayers</u>**:
  - T40, SZ DJI Technology Co., (Shenzhen, China)
  - P100, XAG Co., Ltd., (Guangzhou, China)

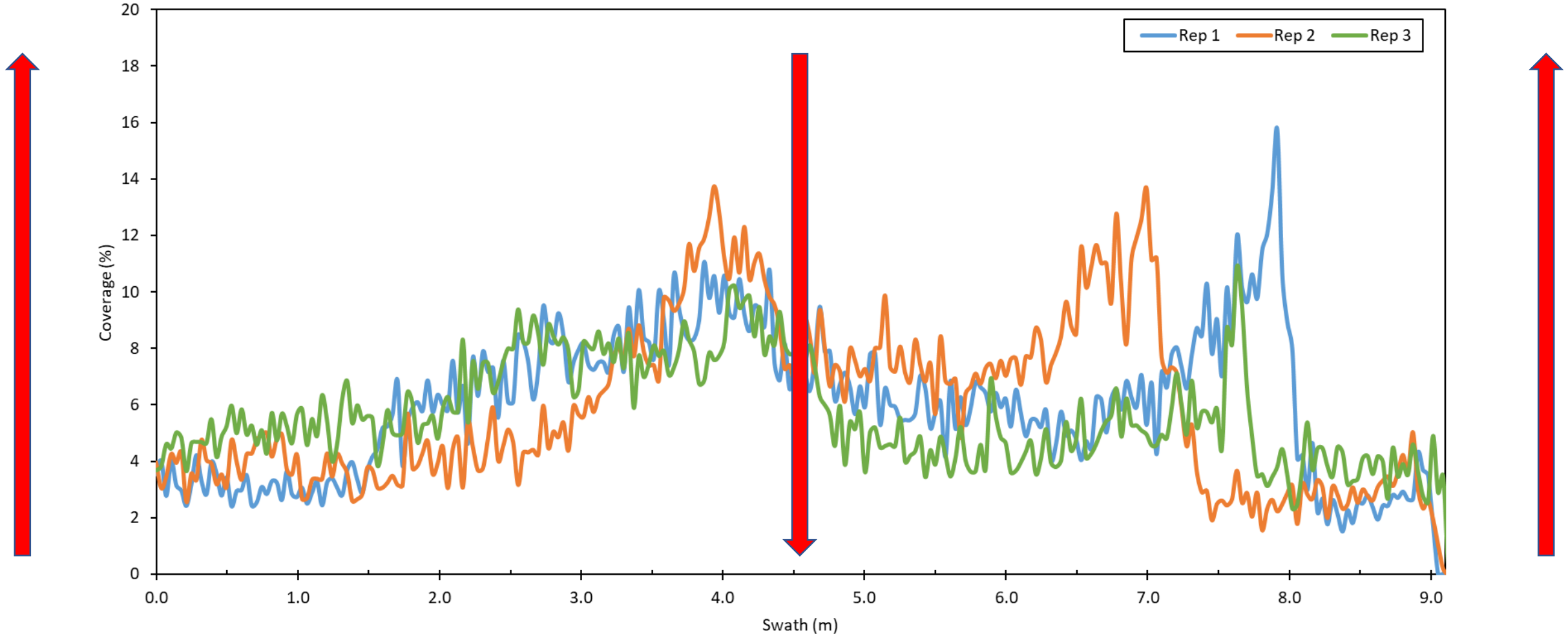
- **<u>RTK Base Stations</u>**:
  - D-RTK 2 High Precision GNSS Mobile Station, SZ DJI Technology Co.
  - XRTK Mobile Station, XAG Co., Ltd.

Treatments and Data Collection

- **Application Parameters:**
  - Target Swath: 9.1 m
  - Heights: 4.6, 6.1 m
  - Application Speeds: 4.6, 6.7 m/s (T40), 6.7, 9.1 m/s (P100)
  - Application Volume: 18.7, 28.1 L/ha (2, 3 GPA)
- **Data Collection:**
  - All testing was conducted with three passes from the sprayer to allow for deposition overlap
  - Continuous receipt paper placed across the swath (9.1 m)
  - Deposition data was processed utilizing the Swath Gobbler scanner (Application Insight, LLC)

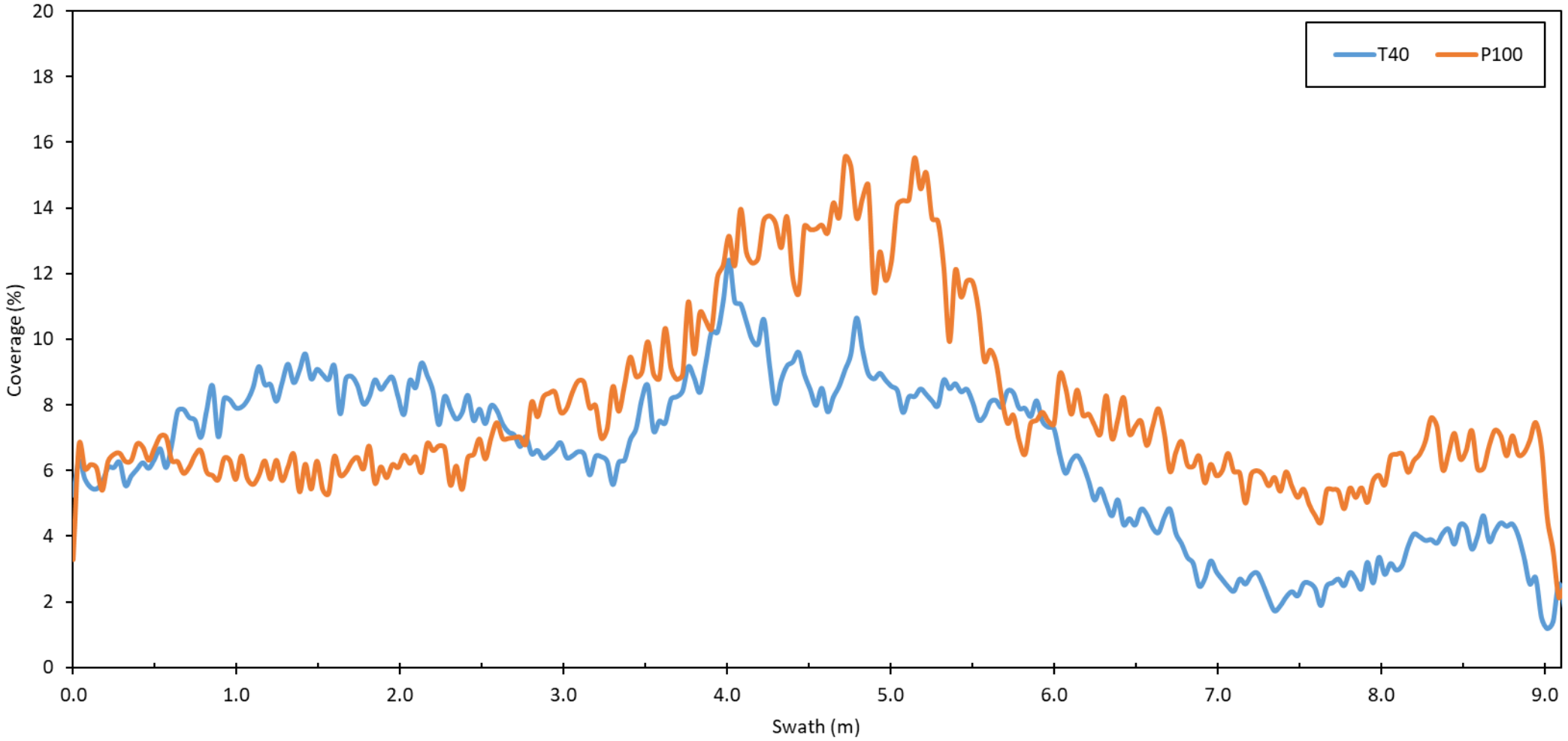
Results

Sprayer = P100, Volume = 18.7 L/ha, Speed = 9.1 m/s, Height = 6.1 m



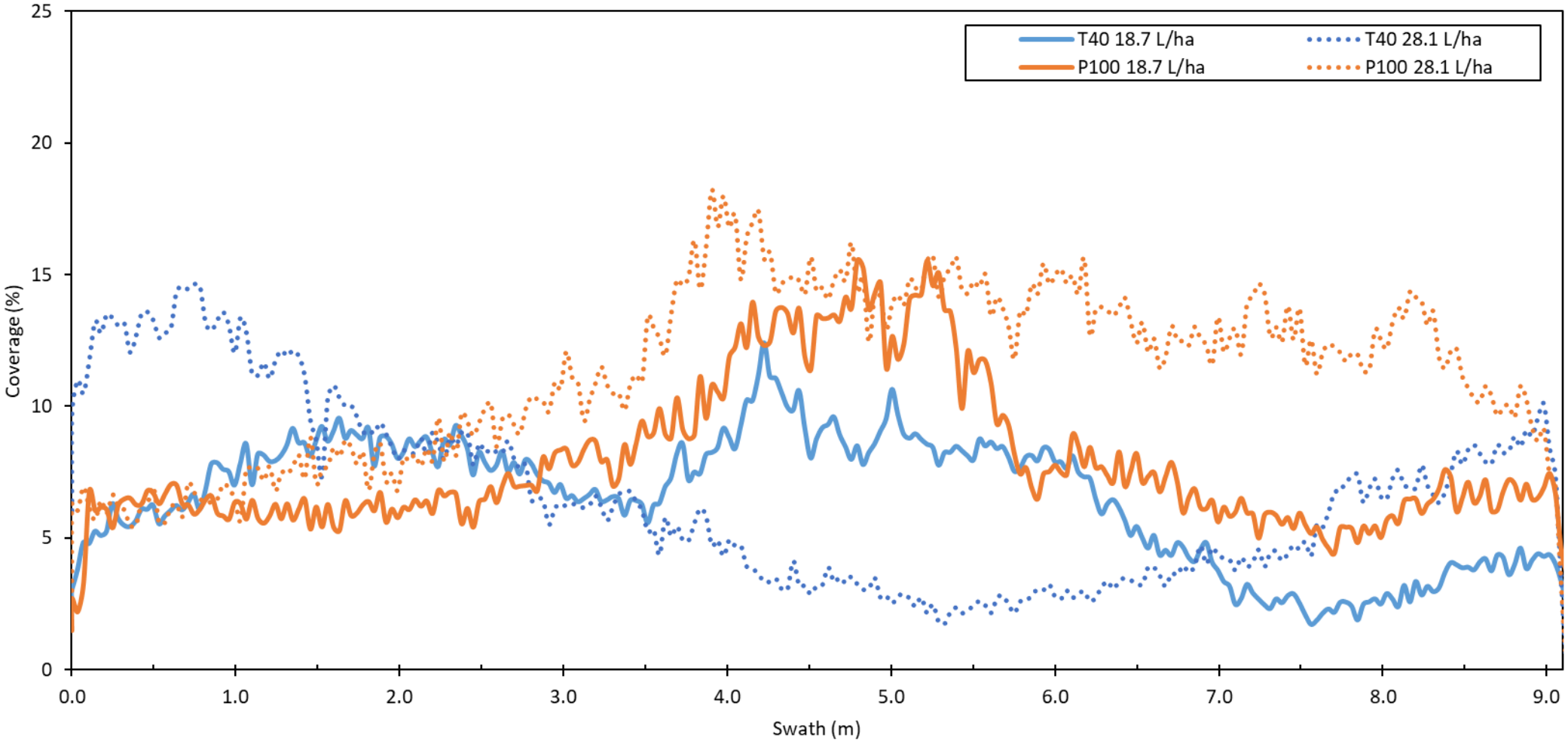
Results – Spray Drone

Volume = 18.7 L/ha, Speed = 6.7 m/s, Height = 4.6 m



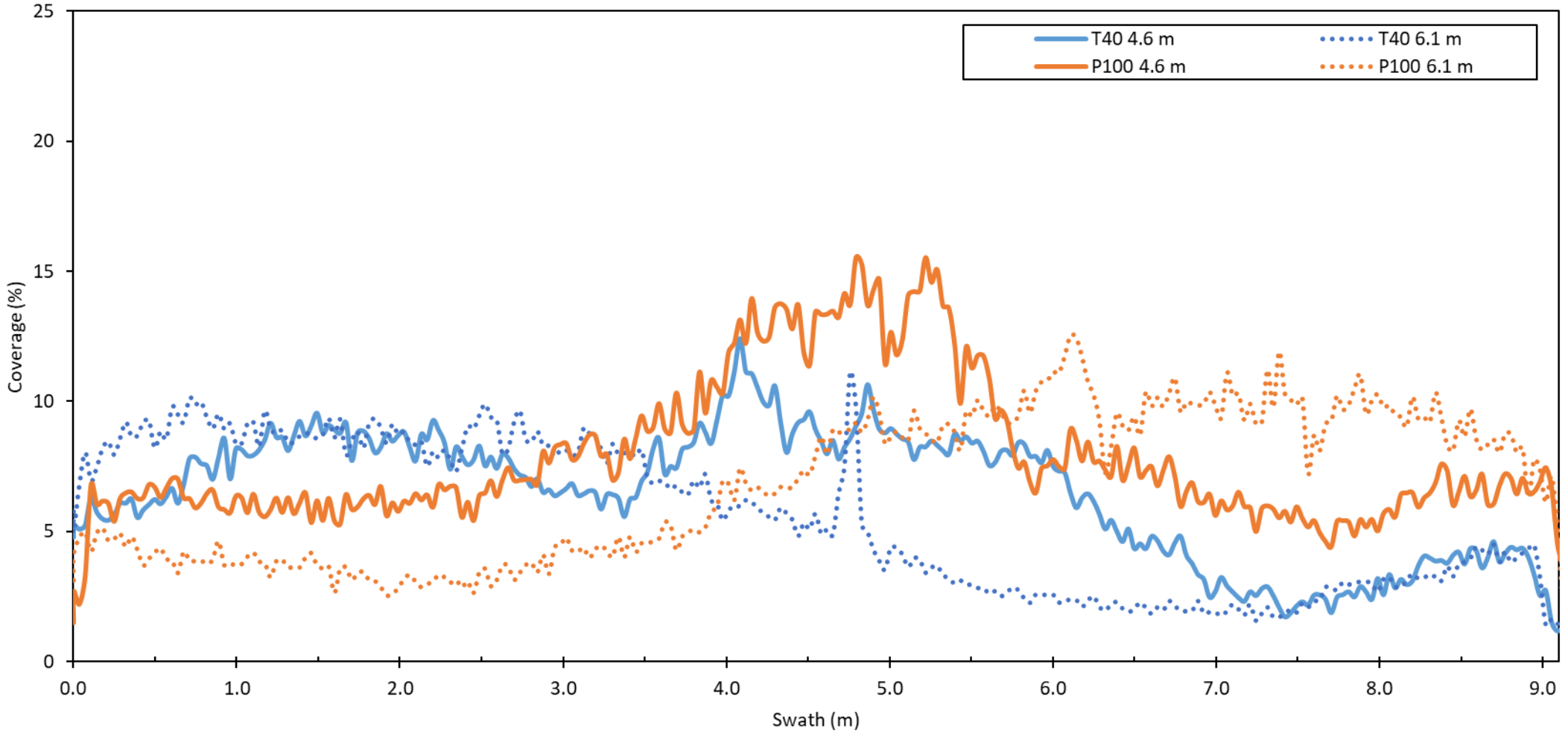
Results – Application Rate

Speed = 6.7 m/s, Height = 4.6 m



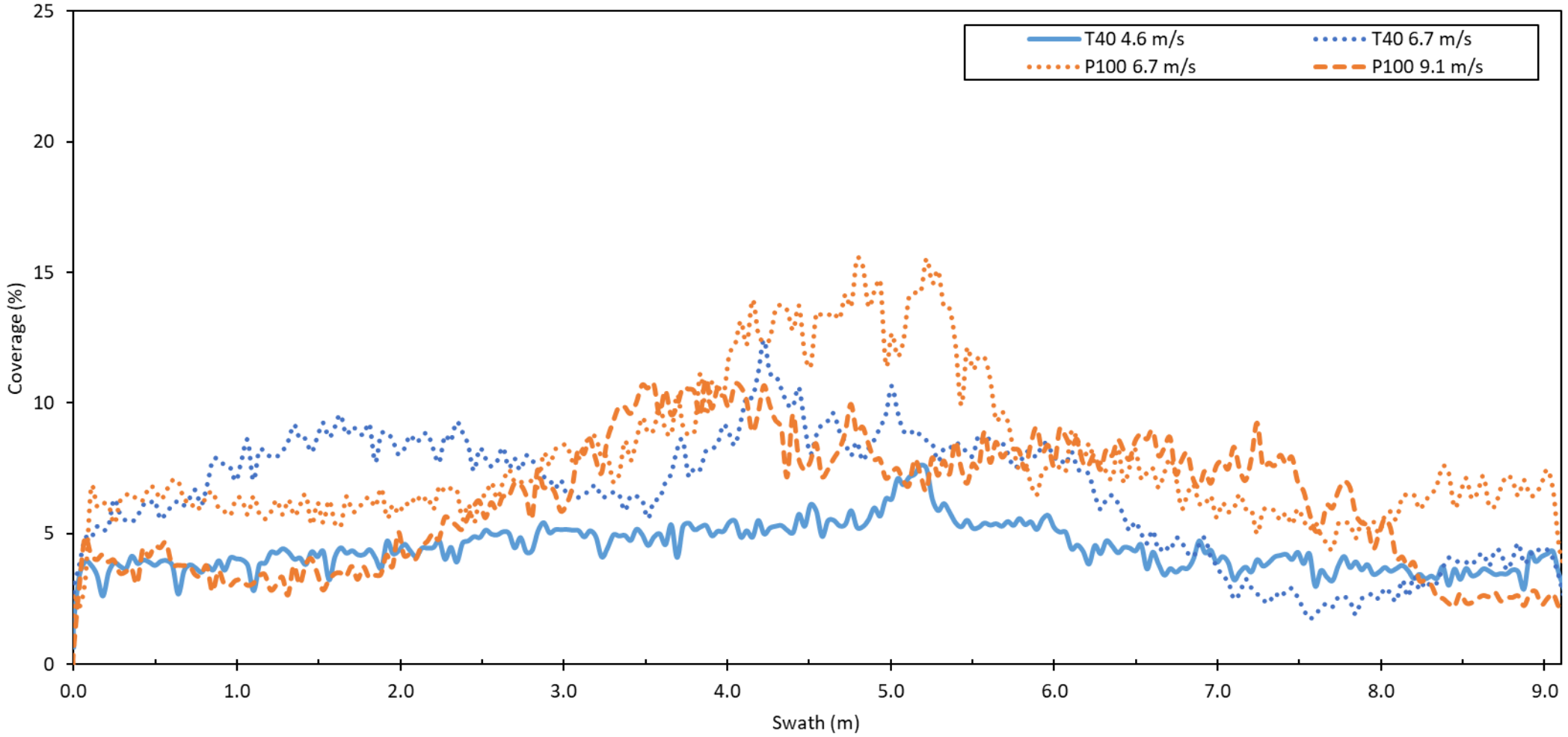
Results - Height

Volume = 18.7 L/ha, Speed = 6.7 m/s



Results - Speed

Volume = 18.7 L/ha, Height = 4.6 m



Study 2 - Conclusions

❑Spray Drone:

- Both tested platforms (the DJI T40 and XAG P100) appear to have similar mean spray deposition and uniformity trends across the tested parameters.

❑Application Rate:

- A higher application rate increased deposition for the P100, however, the mixed results found for the T40 highlight the effect of additional factors that influence deposition patterns.

❑ Application Speed:

- Increased speed resulted in a higher mean deposition for the T40 platform, however, it decreased deposition for the P100.

❑ Application Height:

- For both tested platforms, an increase in height decreased total deposition across the swath. However, increased height resulted in relatively higher uniformity.

Practical Considerations

- Commercial applicators need to perform swath testing to determine optimal parameters unique to each platform. For example, the T30's default nozzles and highest tested application speed consistently resulted in lower coverage.

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

- Increased application speed and height may result in an increase in spraying capacity, however, these can result in lower deposition and a higher risk for off-target movement reducing application efficacy.

Thanks!

Cole Byers

Coleman.Byers@uga.edu

Graduate Research Assistant
College of Engineering
University of Georgia
Tifton, GA

Twitter: @ENGRTechCole
https://agtechdata.uga.edu/