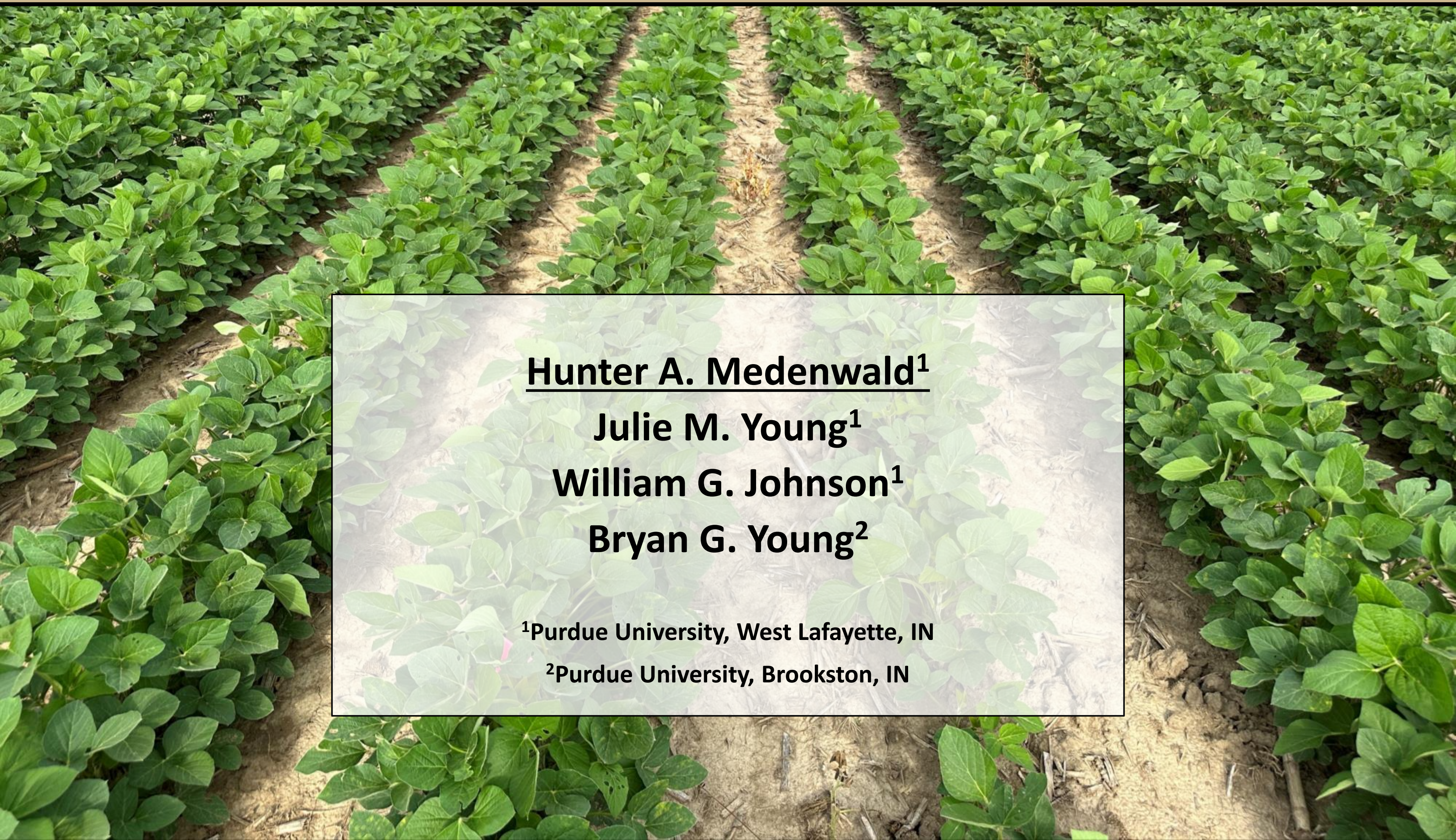
# Herbicide Active, Carrier Volume, and Spray Deposition for Optimizing Drone Herbicide Applications



Hunter A. Medenwald[1]
Julie M. Young[1]
William G. Johnson[1]
Bryan G. Young[2]

[1]Purdue University, West Lafayette, IN
[2]Purdue University, Brookston, IN

# Introduction

- Spray drones have recently gained popularity in the United States as a new application method to apply pesticides
- Fungicide applications in corn have been the primary driver for increased spray drone usage in the Midwest
- Spray drone applications occur at ultra-low carrier volumes to maximize operational efficiency with limited tank size and battery life

# Aerial Application Equipment

Photo credit: General Aviation News

Photo credit: Botse Aviation

Photo credit: Made-In-China

## Fixed-wing

- Capacity:
  340 to 3000 liters
- Speed:
  200 to 230 km $hr^{-1}$
- Boom Orientation:
  No greater than 70% of wingspan
- Ferrying Distance:
  Often long

## Single-rotor

- Capacity:
  75 to 230 liters
- Speed:
  80 to 100 km $hr^{-1}$
- Boom Orientation:
  No greater than 70% of rotor length
- Ferrying Distance:
  Long or short

## Multi-rotor

- Capacity:
  10 to 70 liters
- Speed:
  10 to 50 km $hr^{-1}$
- Boom Orientation:
  Varies between models
- Ferrying Distance:
  Short

PURDUE UNIVERSITY

# Carrier Volume

- Increasing carrier volumes may increase efficacy with contact herbicides, such as glufosinate[1,2]
- Systemic herbicides may be applied at lower carrier volumes due to translocation capabilities[3]
- Many herbicides with an aerial application label recommend minimum spray volumes of 47 L $ha^{-1}$

[1]Creech et al. (2015)
[2]Butts et al. (2018)
[3]Knoche (1994)

# Drone Pesticide Applications

- Previous research with spray drones has evaluated fungicides and insecticides in specialty crops and orchards[1,2,3,4,5]
- Limited research is available on herbicide applications in row crops with spray drones[6,7,8,9]


Photo credit: DJI Agriculture


Photo credit: DJI Agriculture


Photo credit: No-Till Farmer

[1]Chen et al. (2020)
[2]Jeeven (2023)
[3]Lou et al. (2018)
[4]Qin et al. (2018)
[5]Ribeiro et al. (2023)
[6]Caputti et al. (2023)
[7]Martin et al. (2020)
[8]Martin et al. (2022)
[9]Takekawa et al. (2023)

PURDUE UNIVERSITY

# Hypotheses

- The systemic activity of glyphosate will result in greater efficacy than the non-systemic activity of glufosinate at low carrier volumes
- Increasing the carrier volume will provide greater coverage resulting in increased efficacy of glufosinate and glyphosate

# Objectives

- Evaluate weed efficacy of glyphosate and glufosinate at several low carrier volumes
- Quantify the spray coverage of glyphosate and glufosinate at different carrier volumes in spray drone applications

PURDUE UNIVERSITY.

# Drone Parameters

- DJI Agras T30 equipped with 12 TeeJet XR11001 nozzles
- Assumed swath: 9 m
- Height above vegetation: 3 m
- Speeds
  - 9.4 L $ha^{-1}$ = 24 km $hr^{-1}$
  - 18.7 L $ha^{-1}$ = 16 km $hr^{-1}$
  - 28.1 L $ha^{-1}$ = 10.7 km $hr^{-1}$

# Two Field Sites

- Agronomy Center for Research and Education (ACRE)
  - West Lafayette, IN
  - XtendFlex soybeans: 346,000 seeds $ha^{-1}$ in 76 cm rows

- Davis Purdue Agricultural Center (DPAC)
  - Farmland, IN
  - Enlist soybeans: 376,000 seeds $ha^{-1}$ in 38 cm rows

ACRE

DPAC

PURDUE UNIVERSITY

# Experimental Design

- Factorial: herbicide (2) and carrier volume (3) in a RCBD with four replications
  - Herbicides
    - 717 g ai $ha^{-1}$ glufosinate
    - 925 g ae $ha^{-1}$ glyphosate
  - Carrier Volumes
    - 9.4 L $ha^{-1}$
    - 18.7 L $ha^{-1}$
    - 28.1 L $ha^{-1}$
- Benchmark Comparison
  - Hand boom application
  - 140 L $ha^{-1}$ treatment

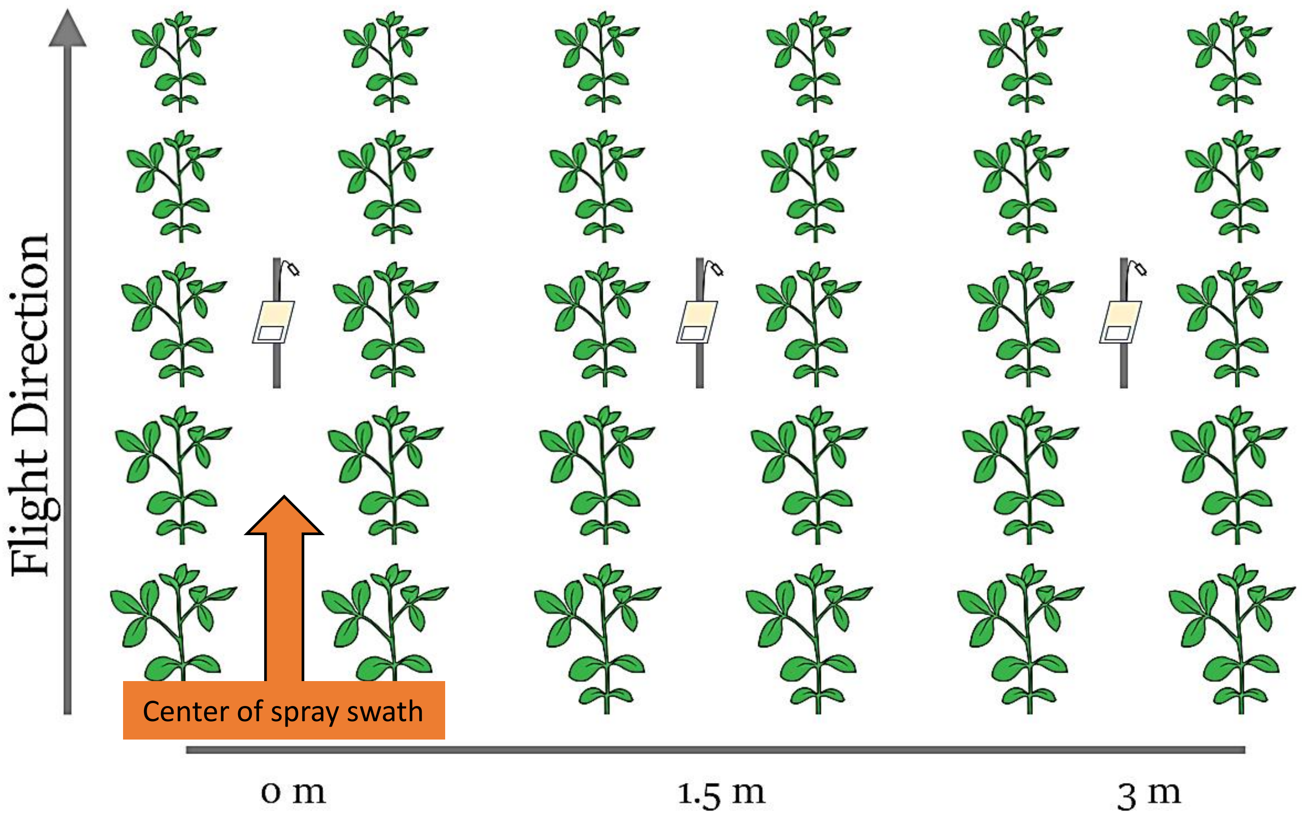
# Data Collection and Analysis

- Visual Estimates of Weed Control
  - Four individual plants/plot
  - 7 and 14 days after application (DAA)

- Spray-Solution Coverage
  - Kromekote cards placed 0, 1.5, and 3.0 m from the center of spray drone toward the outside of the spray swath
  - Cards fixed on top and bottom of board at each location
  - Pink foam marker dye included in spray solution

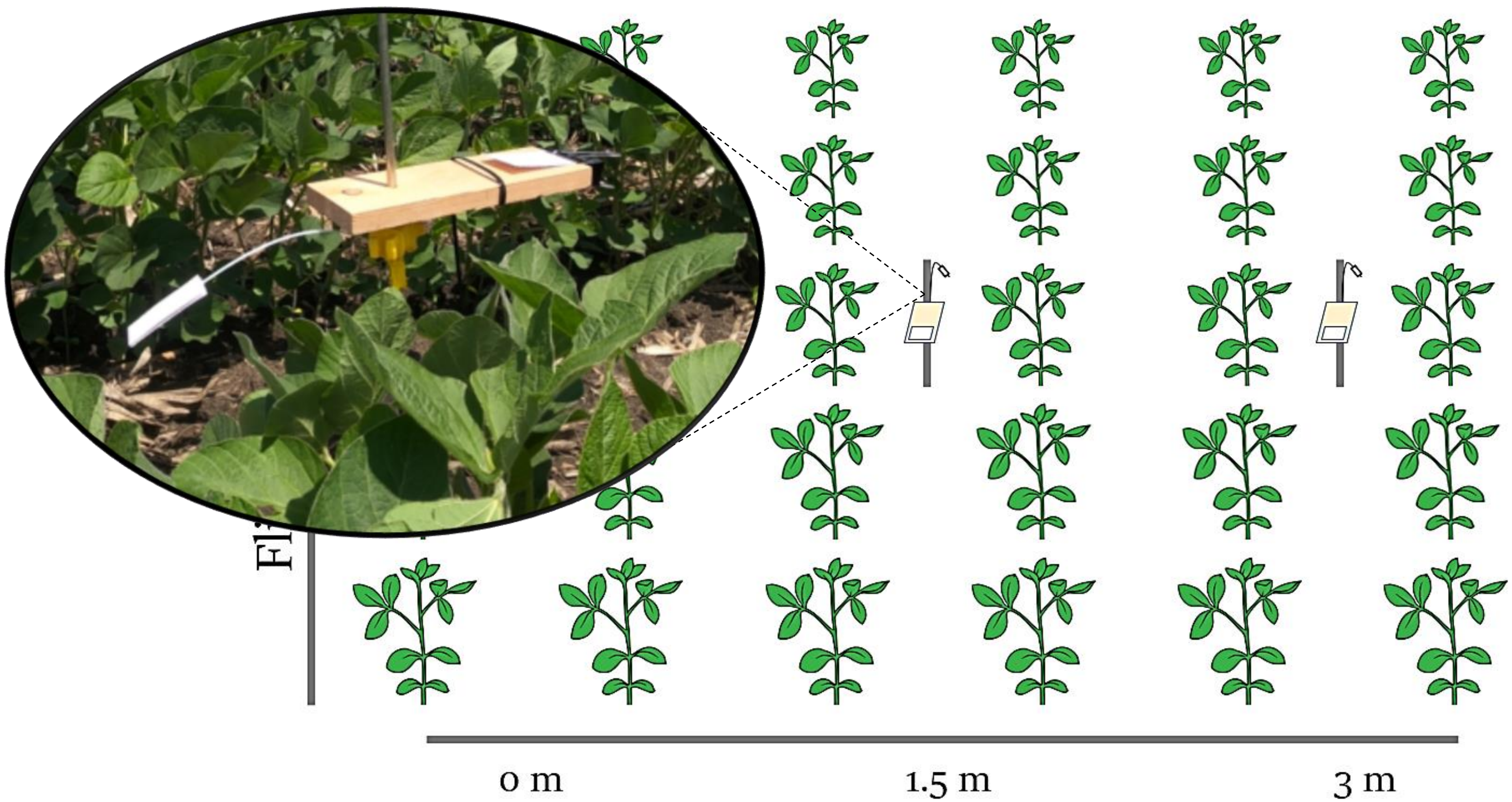
- Means separated at ($\alpha$ = 0.05) adjusted for Tukey's HSD using ANOVA in R software (ver. 4.3.1)

# Card Locations




PURDUE
UNIVERSITY.

# Card Locations

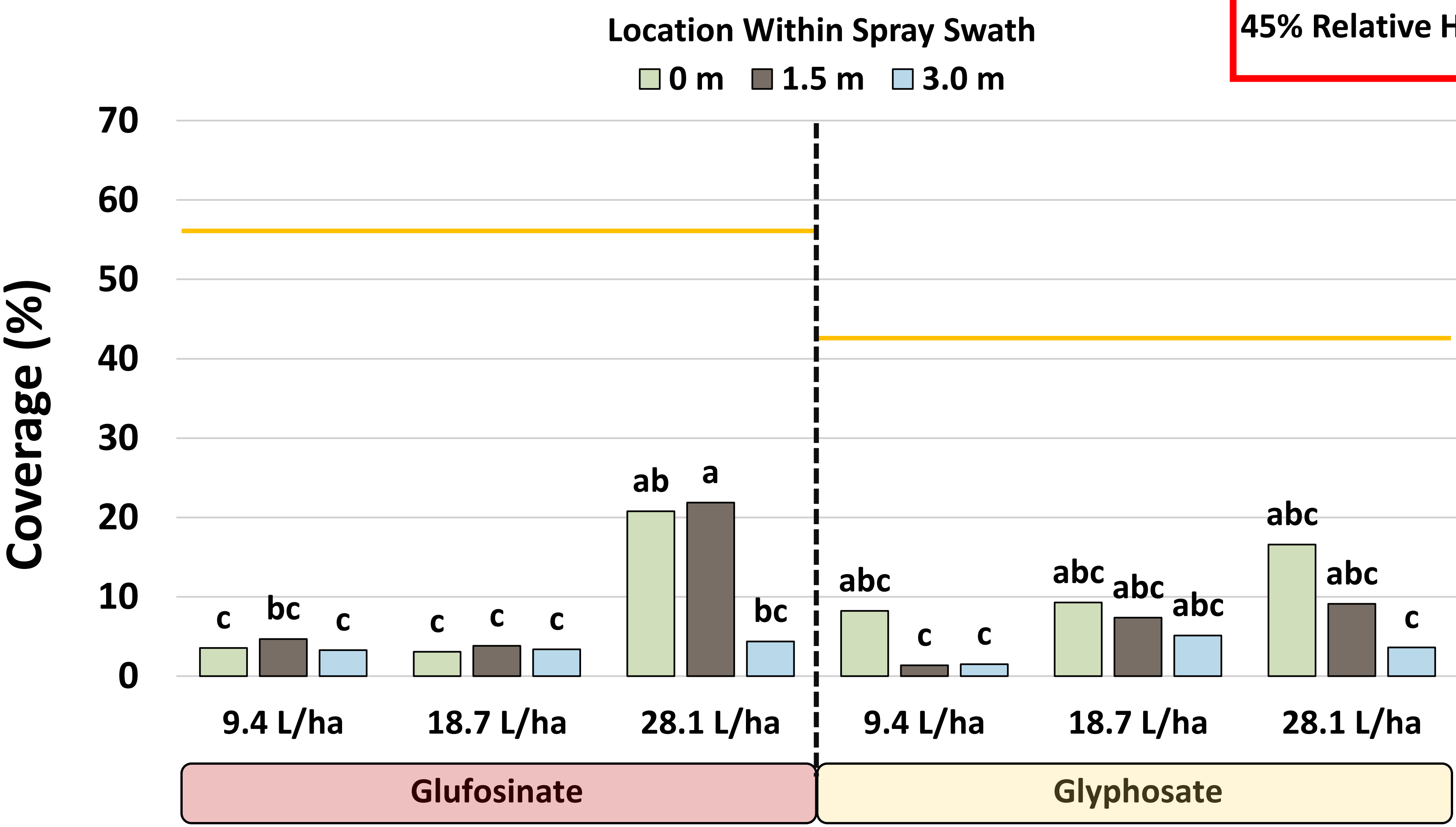


# Card Locations

# Results

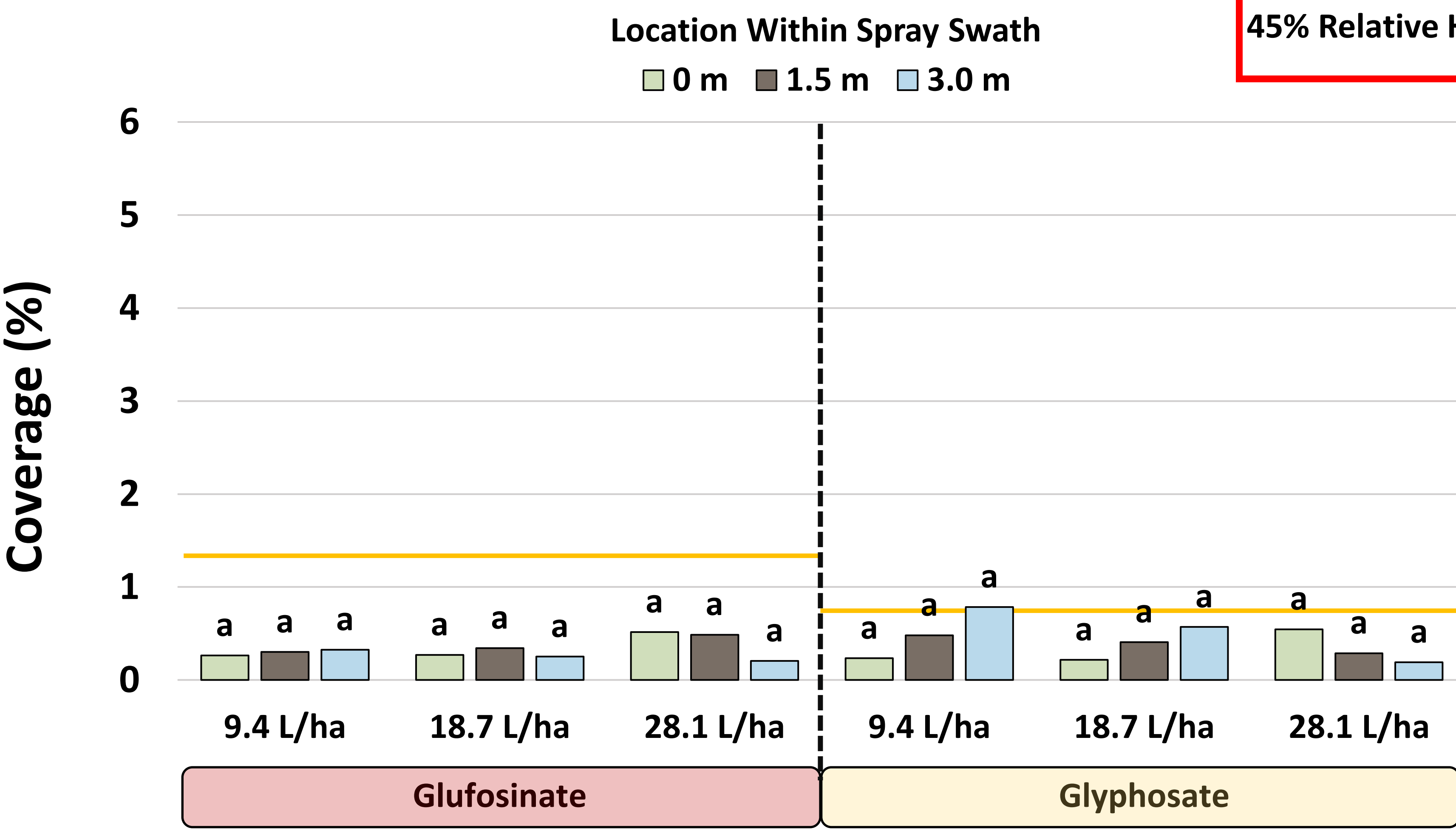
# Top of Board-ACRE

32ºC
45% Relative Humidity



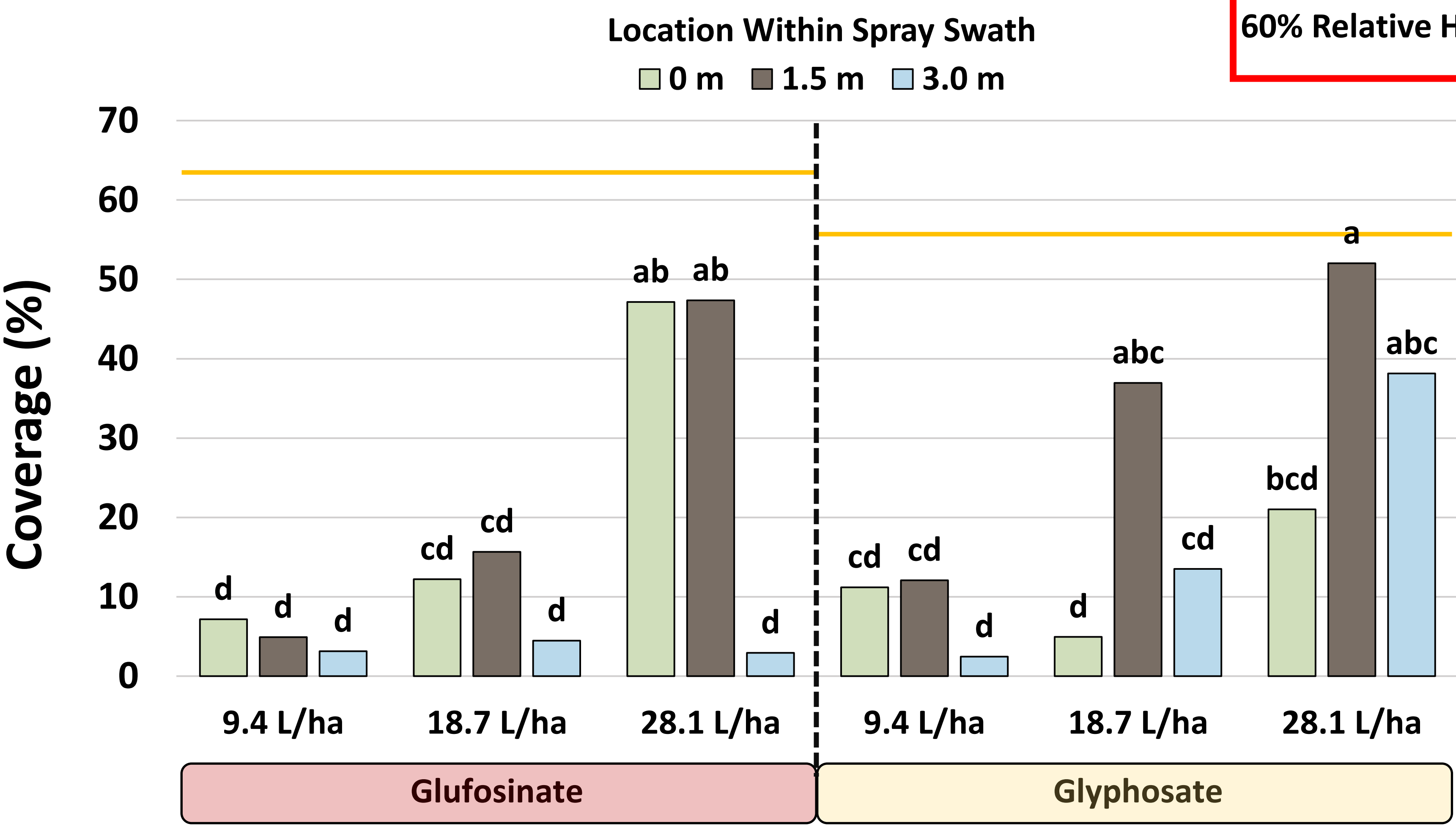
# Bottom of Board-ACRE

32°C
45% Relative Humidity



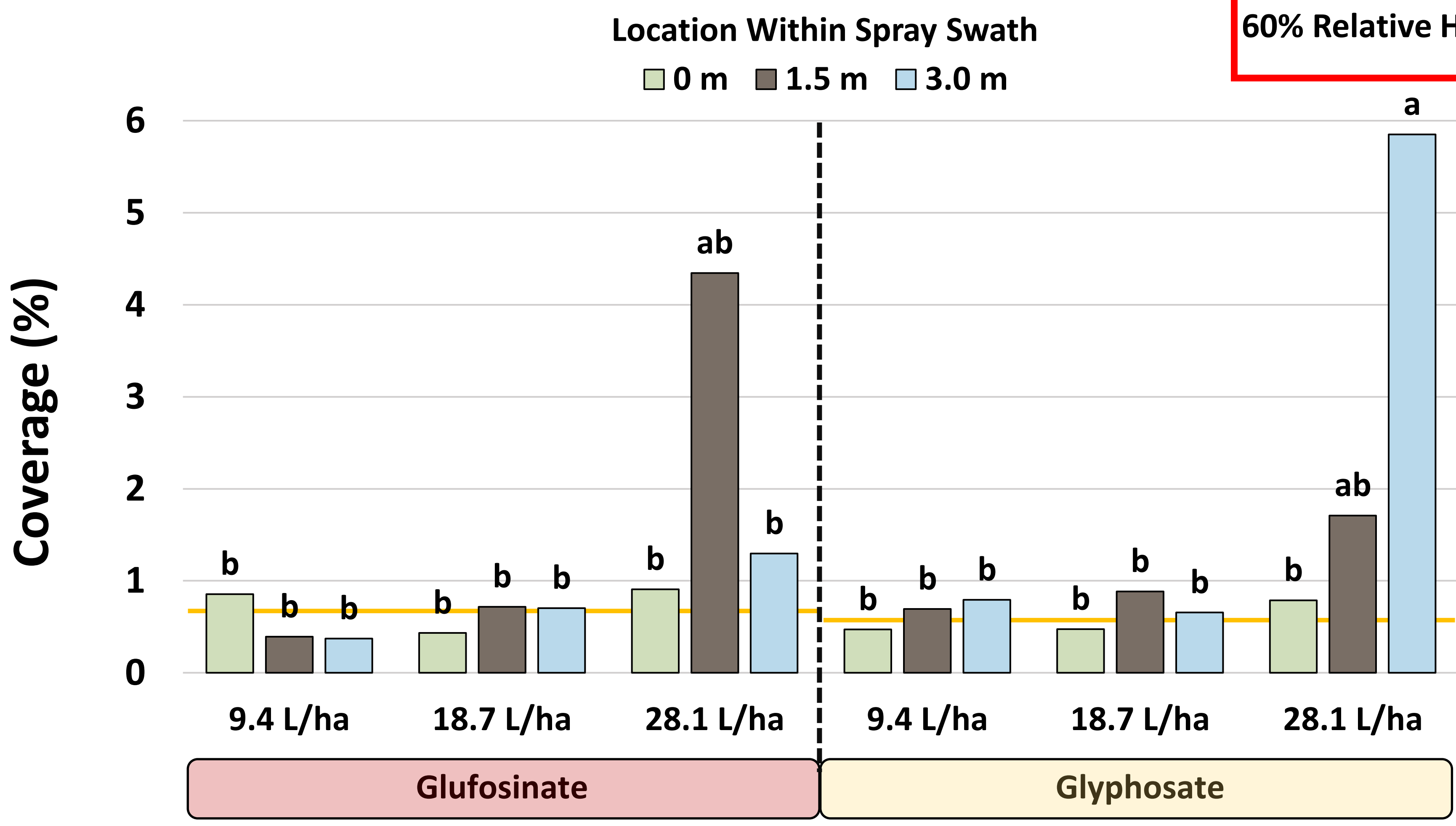
# Top of Board–DPAC

25°C
60% Relative Humidity

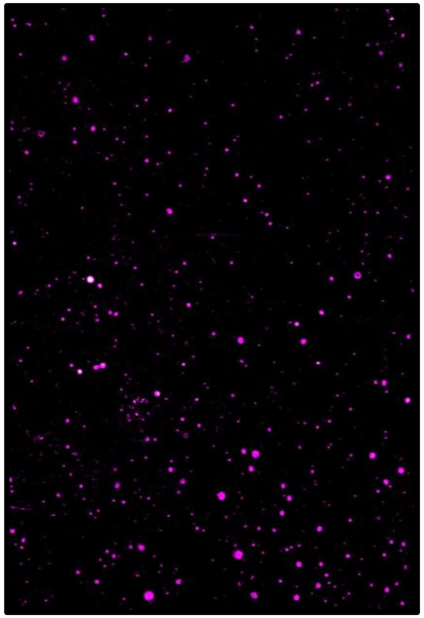


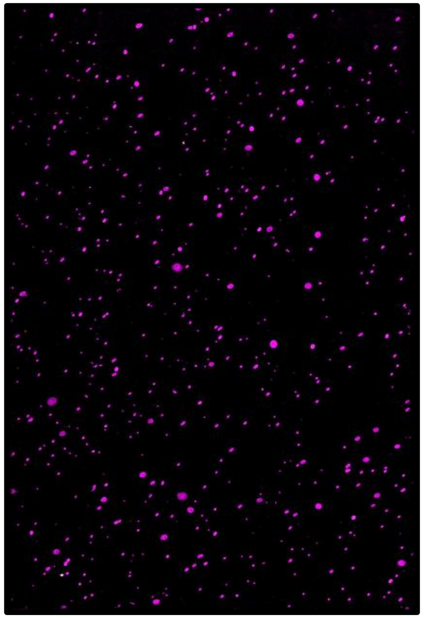
# Bottom of Board-DPAC

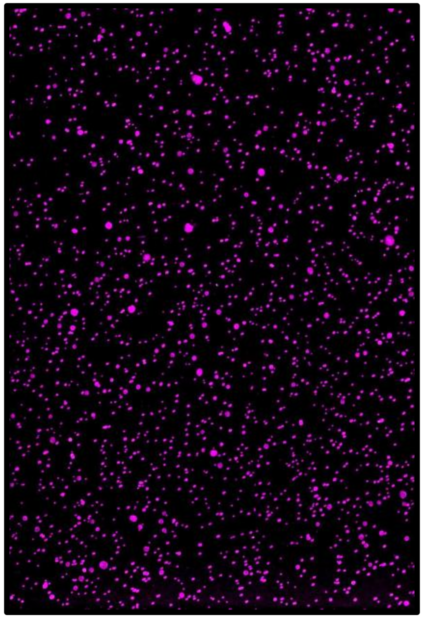
25°C
60% Relative Humidity

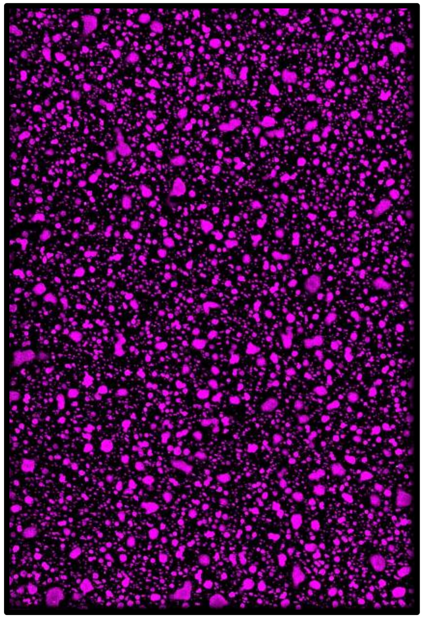


# Top Card 0 m Location



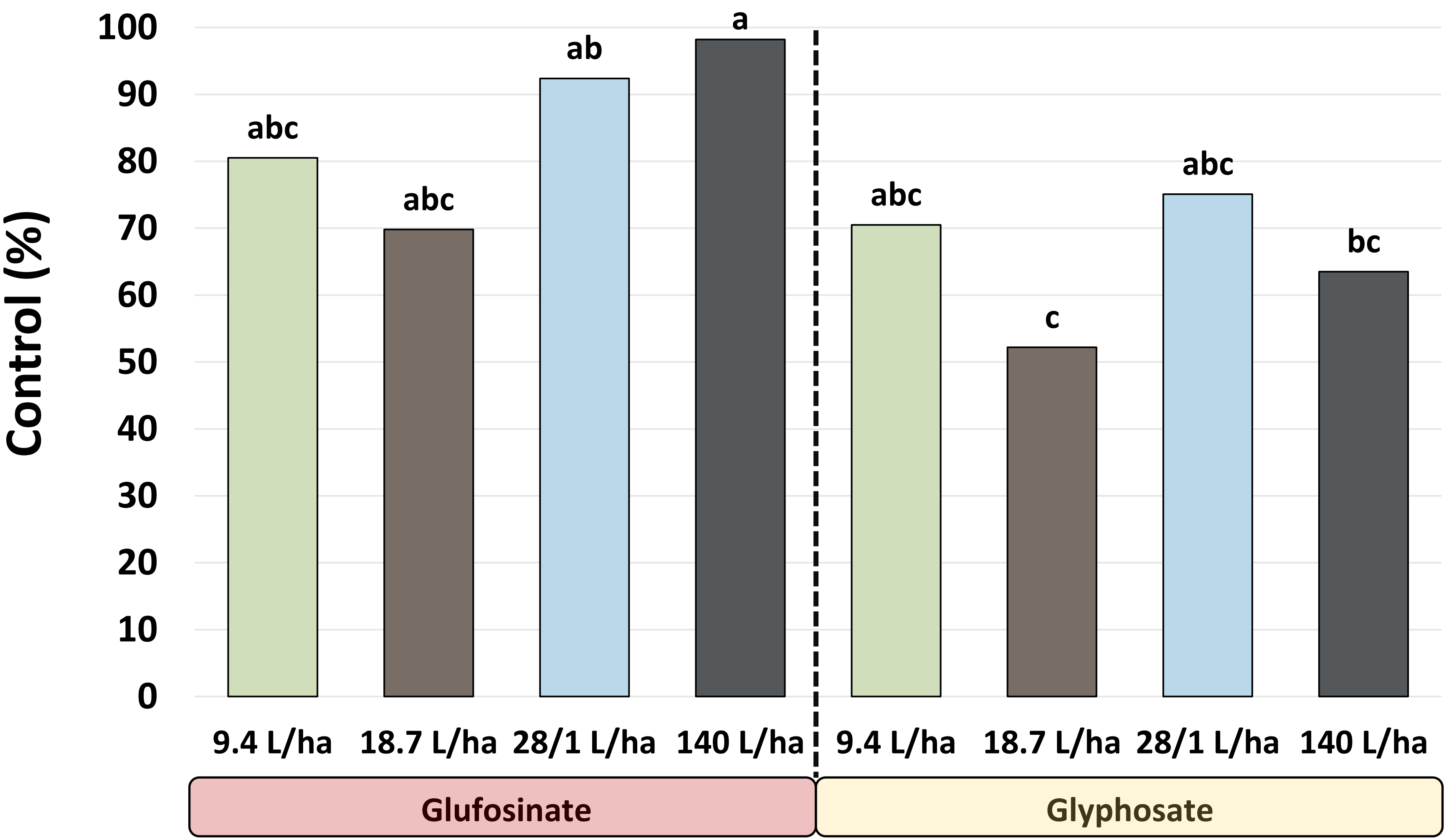




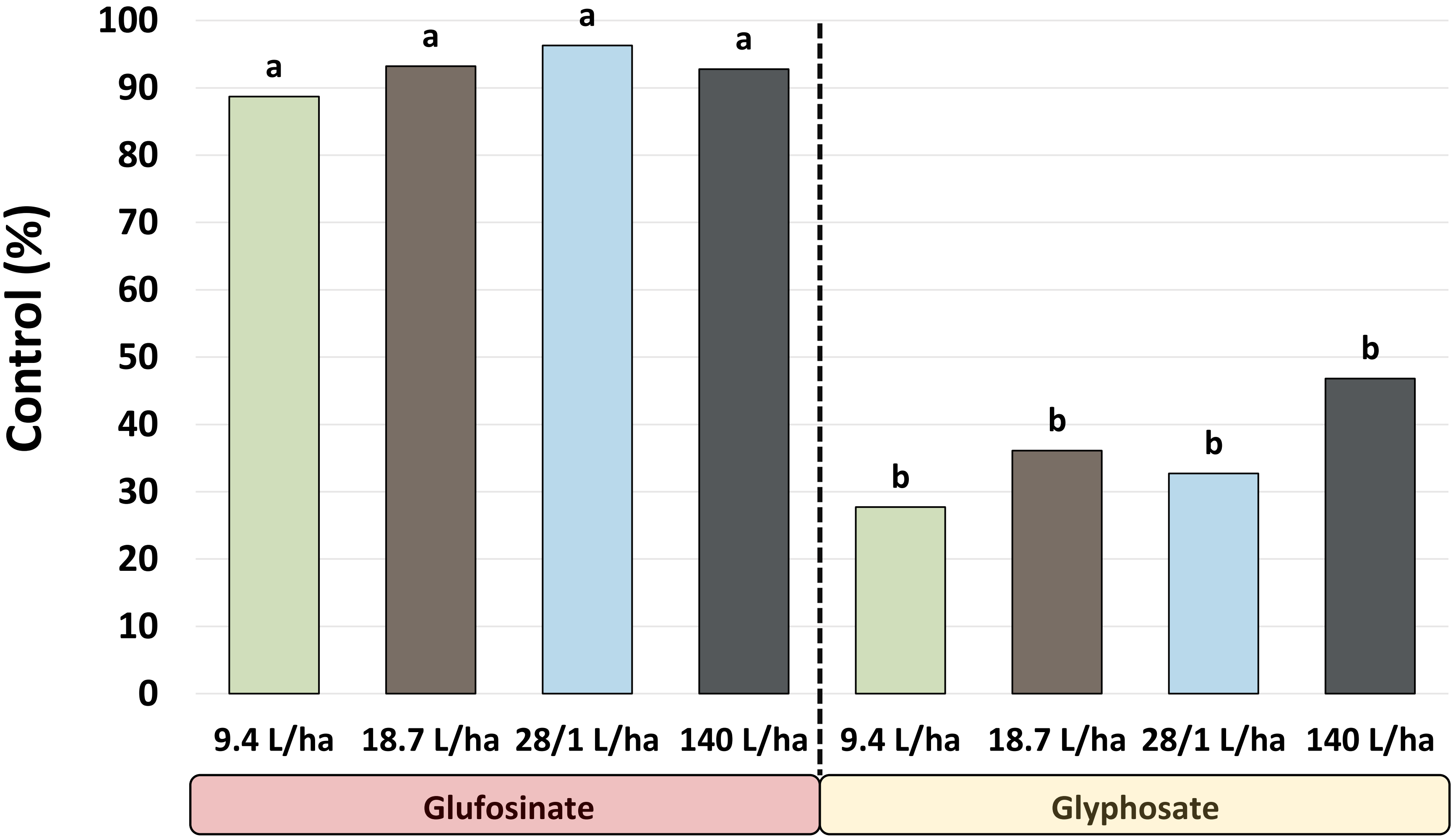


| | | | |
|---|---|---|---|
| 9.4 L/ha | 18.7 L/ha | 28.1 L/ha | 140 L/ha |
| 7.2% | 12.2% | 47.1% | 62.3% |
| Drone | | | Hand Boom |

# Ivyleaf Morningglory 14 DAA



# Common Ragweed 14 DAA



# Conclusions

- Overall, spray coverage was greater at DPAC than at ACRE, which was likely associated with differences in temperature and humidity at the time of application
  - ACRE: 32$^{o}$C, 45% relative humidity
  - DPAC: 25$^{o}$C, 60% relative humidity
- Coverage decreased towards the outside of the spray swath at ACRE, while the greatest coverage at DPAC occurred at 1.5 m
- Increasing the carrier volume generally increased spray coverage at all collection points with the exception of glufosinate on top and both herbicides on the bottom of the board at ACRE

# Conclusions

- Contrary to our hypothesis, weed control was greater with the contact herbicide glufosinate across carrier volumes at each site compared to the systemic herbicide glyphosate.
- No significant differences were observed when increasing the carrier volume for weed control of ivyleaf morningglory.
- Glufosinate resulted in greater efficacy on common ragweed than glyphosate, but no differences in efficacy were observed across carrier volumes within each herbicide.

# Implications

- Increasing the carrier volume in drone applications may not always translate to greater weed control
- Spray coverage across the spray swath is variable and may fluctuate under different environmental conditions
- Adequate weed control was achieved at low carrier volumes with glufosinate

# Future Research

- Further investigate contact and systemic herbicides in spray drone applications by repeating trials
- Explore influence of droplet size and carrier volume on weed efficacy
- Quantify herbicide deposition in addition to spray coverage
- Investigate the impact of adjuvant and herbicide formulation on spray pattern uniformity and deposition
- Consider other management sites for utility of herbicide drone applications

PURDUE UNIVERSITY

# Acknowledgements

# Questions?