Evaluation of drone, airplane and ground sprayers in simulated corn fungicide application

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Untreated plants

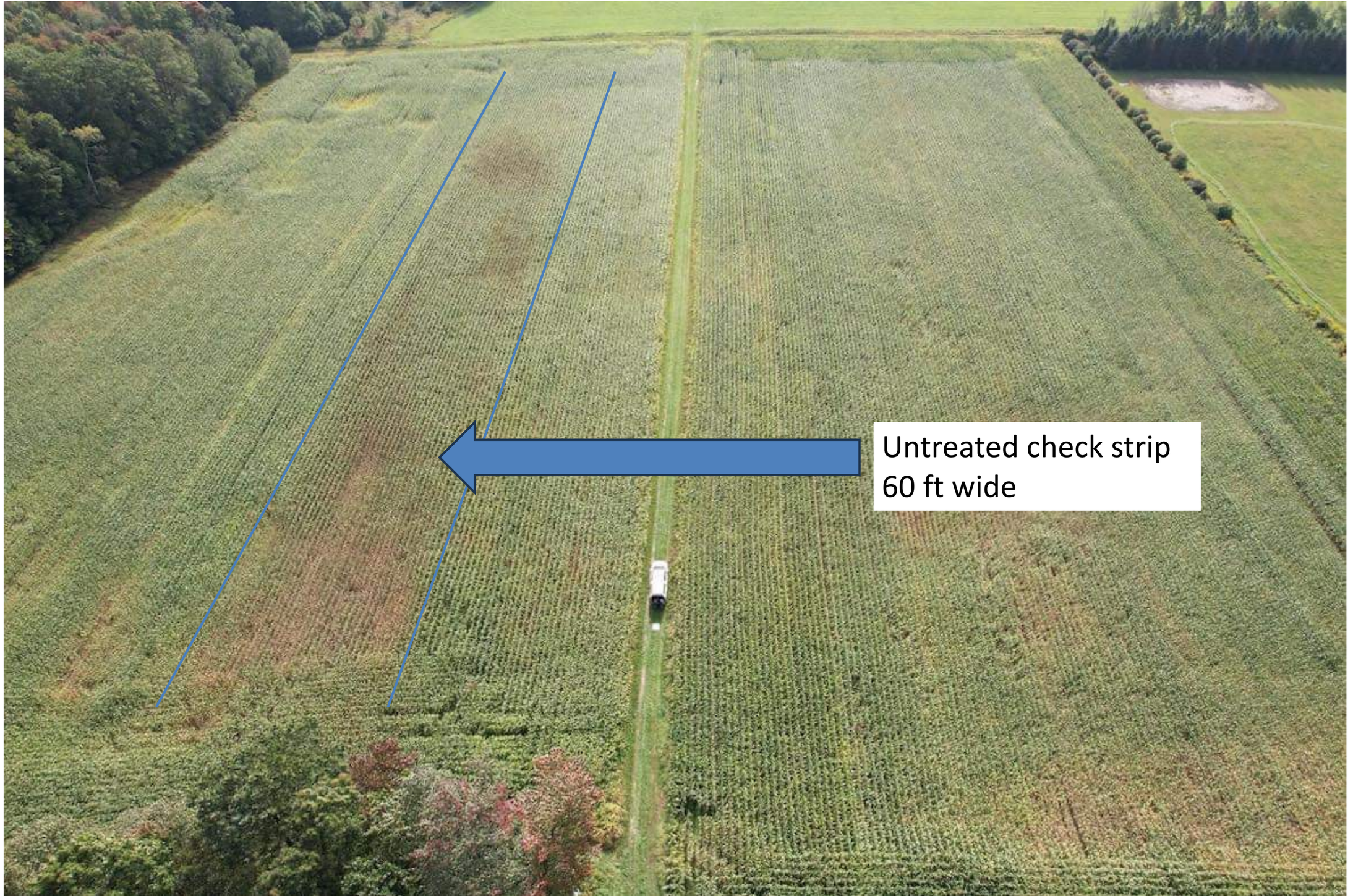
Bellefonte, Pennsylvania

Veltyma fungicide sprayed at 7 oz/A with 0.5 oz/A of Justified (drift reducing agent and deposition aid)

2 GPA with T40

13 ft height, 32 fps, 27-28 ft swath width

Photo credit to:
Tyler Fleck and Flecks Ag Services of Warriors Mark, Pennsylvania


Untreated check strip
60 ft wide

Objectives and Hypothesis

Objective

To compare spray deposition and canopy penetration of sprayer drones and airplane on tassel stage corn

Question???

Will propeller downwash, spray volume and addition of DRA enhance spray deposition and canopy penetration?

Questions???

Will spray direction according to crop row affect droplet deposition and canopy penetration?

Materials & Methods

- Two experiments were conducted at Columbia, AL and Blakely, GA during summer 2023.

1st App. : June

2nd App. : July

Materials & Methods

- Two experiments were conducted at Columbia, AL and Blakely, GA during summer 2023.

1st App. : June

2nd App. : July

Materials & Methods

1st: Experiment treatments

#	Treatment	Application method	Droplet size / Nozzle	Rate (% v/v)	GPA	Flight speed (mph)	Swath (ft)	Flight direction
1	No DRA	DJI Agras T30	TeeJet XR 110015	-	2	15	25	N-S
2	No DRA	DJI Agras T40	300 µm	-	3	20	29	
3	No DRA	DJI Agras T40	300 µm	-	2	22	33	
4	IntactPro	DJI Agras T40	300 µm	0.25		22	33	
5	Experimental DRA	DJI Agras T40	300 µm	1.0		22	33	
6	Ultralock	DJI Agras T40	300 µm	1.0		22	33	
7	Accudrop	DJI Agras T40	300 µm	1		22	33	
8	No DRA	DJI Agras T40	300 µm	-		22	33	W-E
9	No DRA	1996 Thrush S2R-turbo	Teejet XR 8010 and 8015s	-		160	83	N-S

*GPA= gallons per acre
*All spray application had Rhodamine WT dye
*Flight height was 10 ft for all treatments

- Rhodamine WT spray dye: 34 g/acre rate for all treatments, equipment and spray volume
- Each drone block approximately 2 acres
- Each airplane block 8 acres

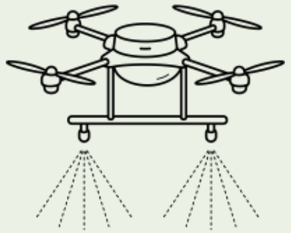
- Collection at 50, 100, and 150 ft from front of the block
- 25 samples per transect (rep), 3 reps
  - Total of 75 plants sampled per treatment (High, ear, and low leaf)

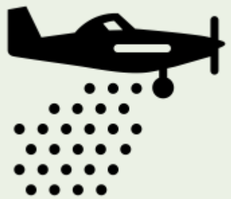
Columbia AL site

Thicker canopy 250 + bushel field irrigated

Blakely GA site

Thinner canopy
250+ bushel field
irrigated





Water Sensitive Paper (WSP's) + Mylar card

Materials and Methods

- Sample analysis:

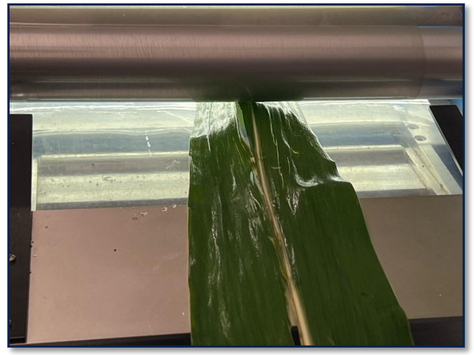
Wash mylar cards with distilled water

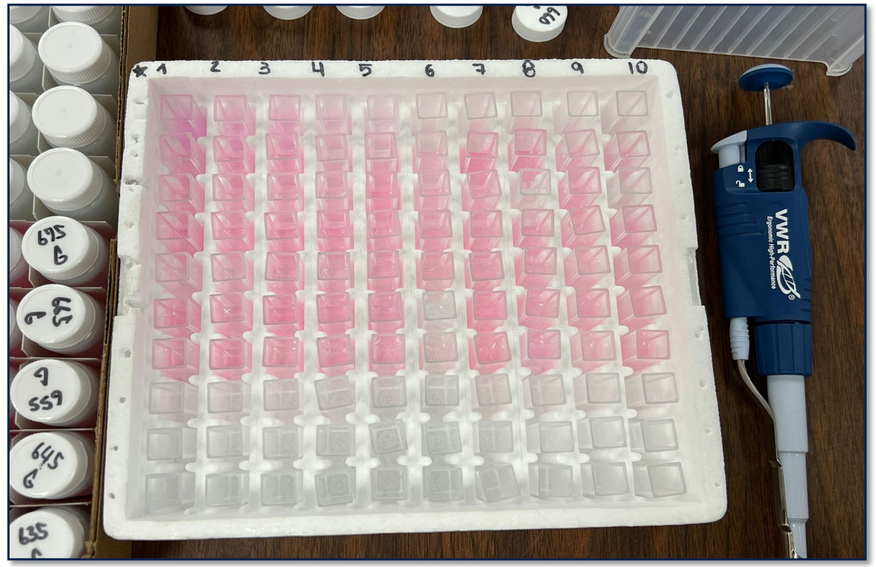
Transferred the liquid to vials

Leaf Area Index (LAI) machine

Trilogy®Laboratory Fluorimeter

Standardized by leaf area and initial dye conc.





All data analyzed in SAS 9.4 using Proc GLIMMIX, means comparisons generated with Tukey's HSD, $\alpha = 0.05$

Materials & Methods

Weather data at Columbia, AL:

#	Treatment	Application method	GPA	Wind speed (mph)	Wind direction	Temperature (F)
1	No DRA	DJI Agras T30	2	5	NNE	88
2	No DRA	DJI Agras T40	3	9	SW	87
3	No DRA	DJI Agras T40	2	0	N	83
4	IntactPro	DJI Agras T40	2	12	WSW	89
5	Experimental DRA	DJI Agras T40	2	14	WSW	89
6	Ultralock	DJI Agras T40	2	5	SSE	87
7	Accudrop	DJI Agras T40	2	5	SSW	93
8	No DRA (W-E)	DJI Agras T40	2	9	WSW	88
9	No DRA	Airplane	2	12	SW	79

Data collected with WatchDog 2000 Series (Spectrum Technologies, Aurora, IL)

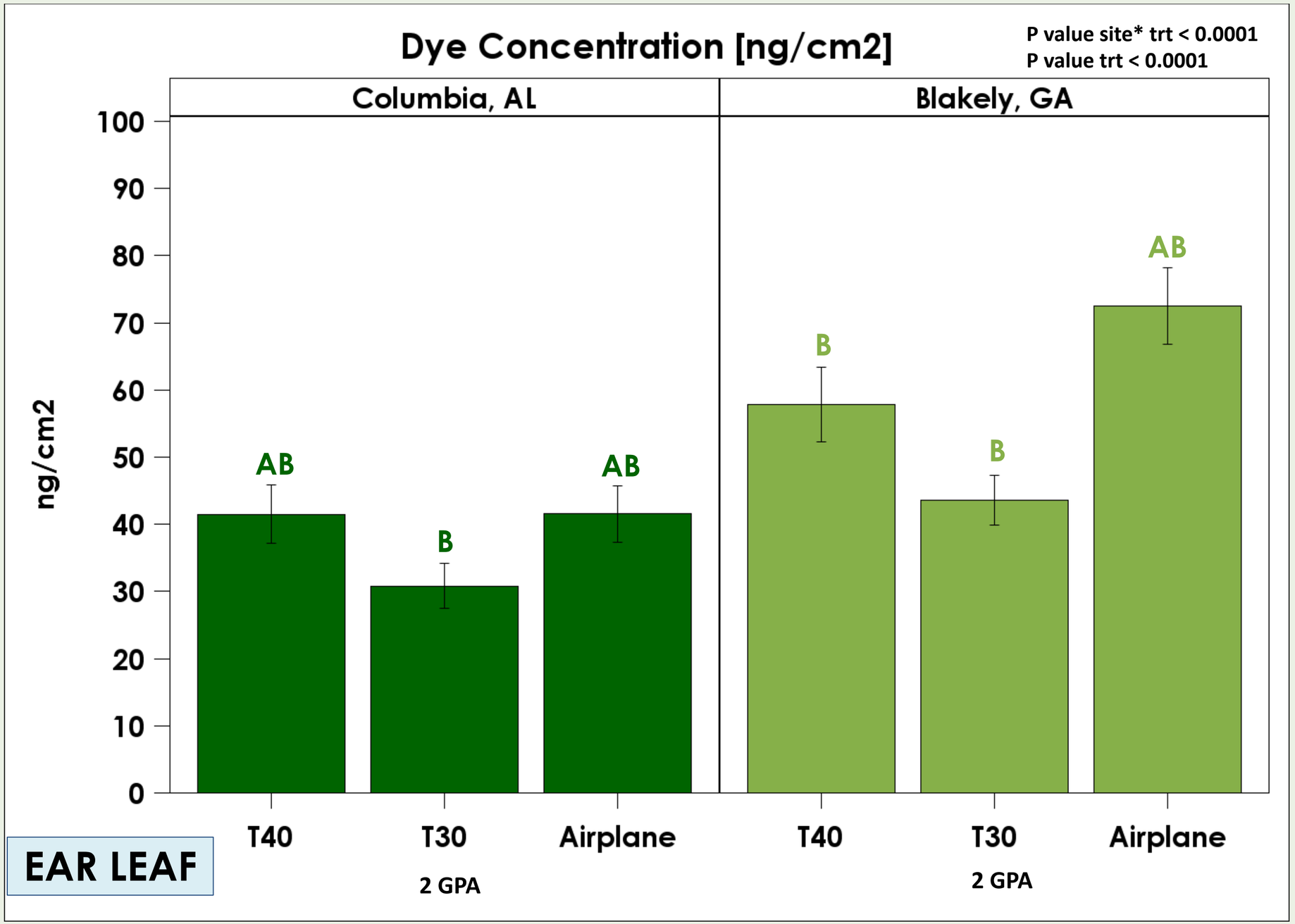
Materials & Methods

Weather data at Blakely, GA:

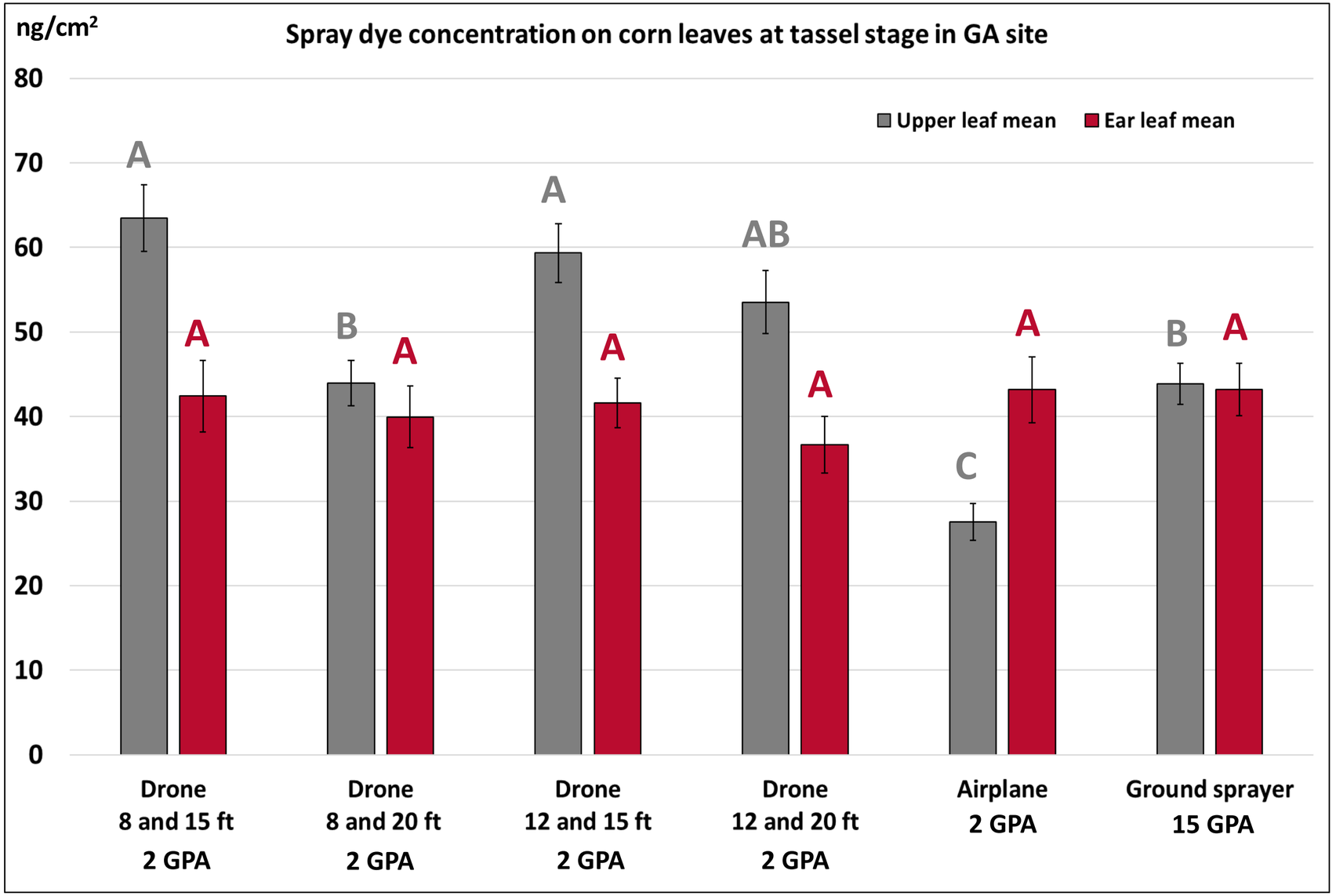
#	Treatment	Application method	GPA	Wind speed (mph)	Wind direction	Temperature (F)
1	No DRA	DJI Agras T30	2	12	NW	88
2	No DRA	DJI Agras T40	3	13	W	90
3	No DRA	DJI Agras T40	2	8	SW	83
4	IntactPro	DJI Agras T40	2	9	SSW	85
5	Experimental DRA	DJI Agras T40	2	7	NNW	87
6	Ultralock	DJI Agras T40	2	10	WNW	92
7	Accudrop	DJI Agras T40	2	13	WNW	93
8	No DRA (W-E)	DJI Agras T40	2	9	NW	86
9	No DRA	Airplane	2	12	SW	79

Data collected with WatchDog 2000 Series (Spectrum Technologies, Aurora, IL)

Results & Discussion


Dye Concentration [ng/cm2]
P value site* trt < 0.0001
P value trt < 0.0001
Columbia, AL
Blakely, GA
ng/cm2
100
90
80
70
60
50
40
30
20
10
0
AB
B
AB
B
B
AB
T40
T30
Airplane
T40
T30
Airplane
2 GPA
2 GPA
EAR LEAF

2022 Results - Dye concentration on ear leaves, Blakely GA

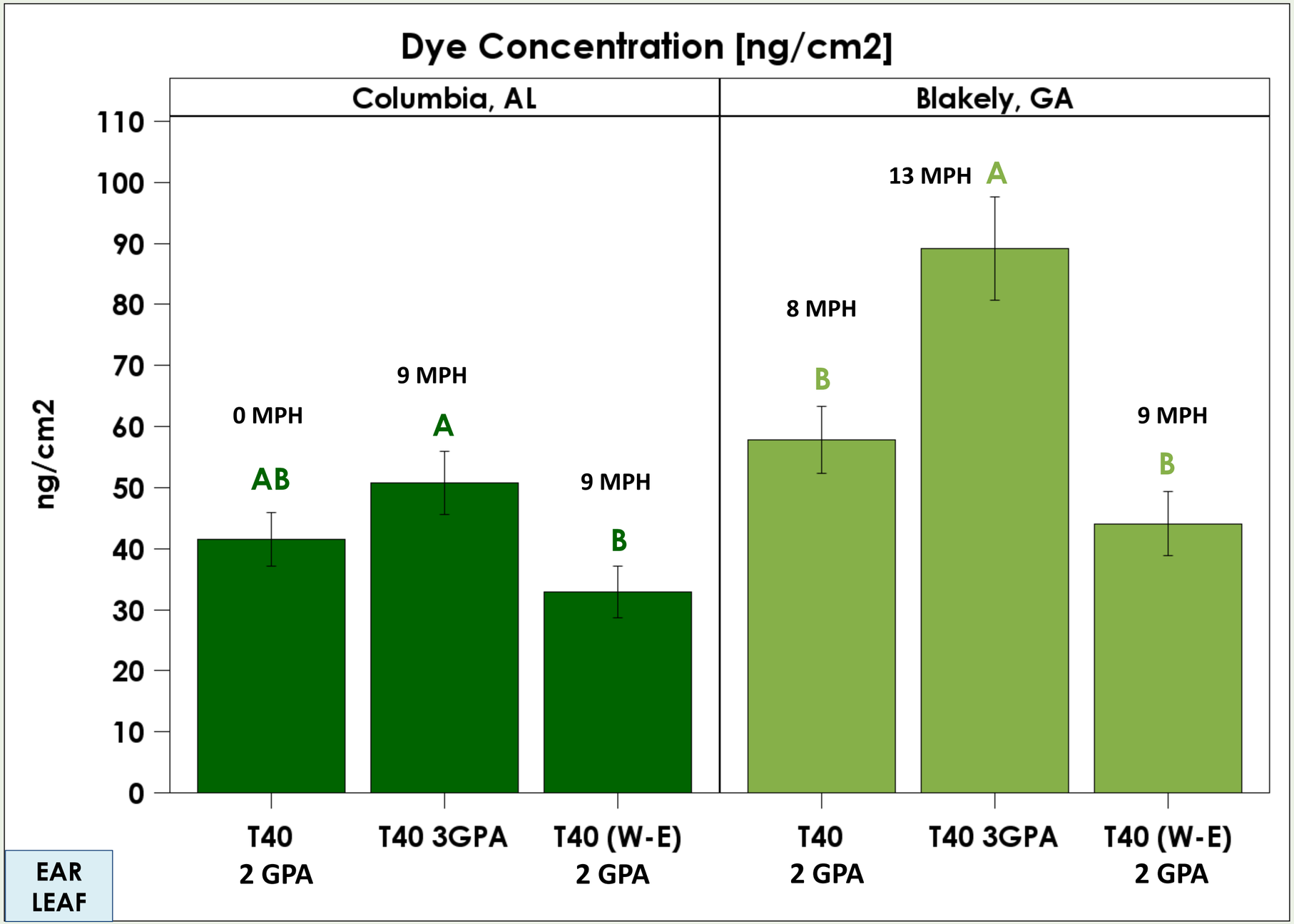


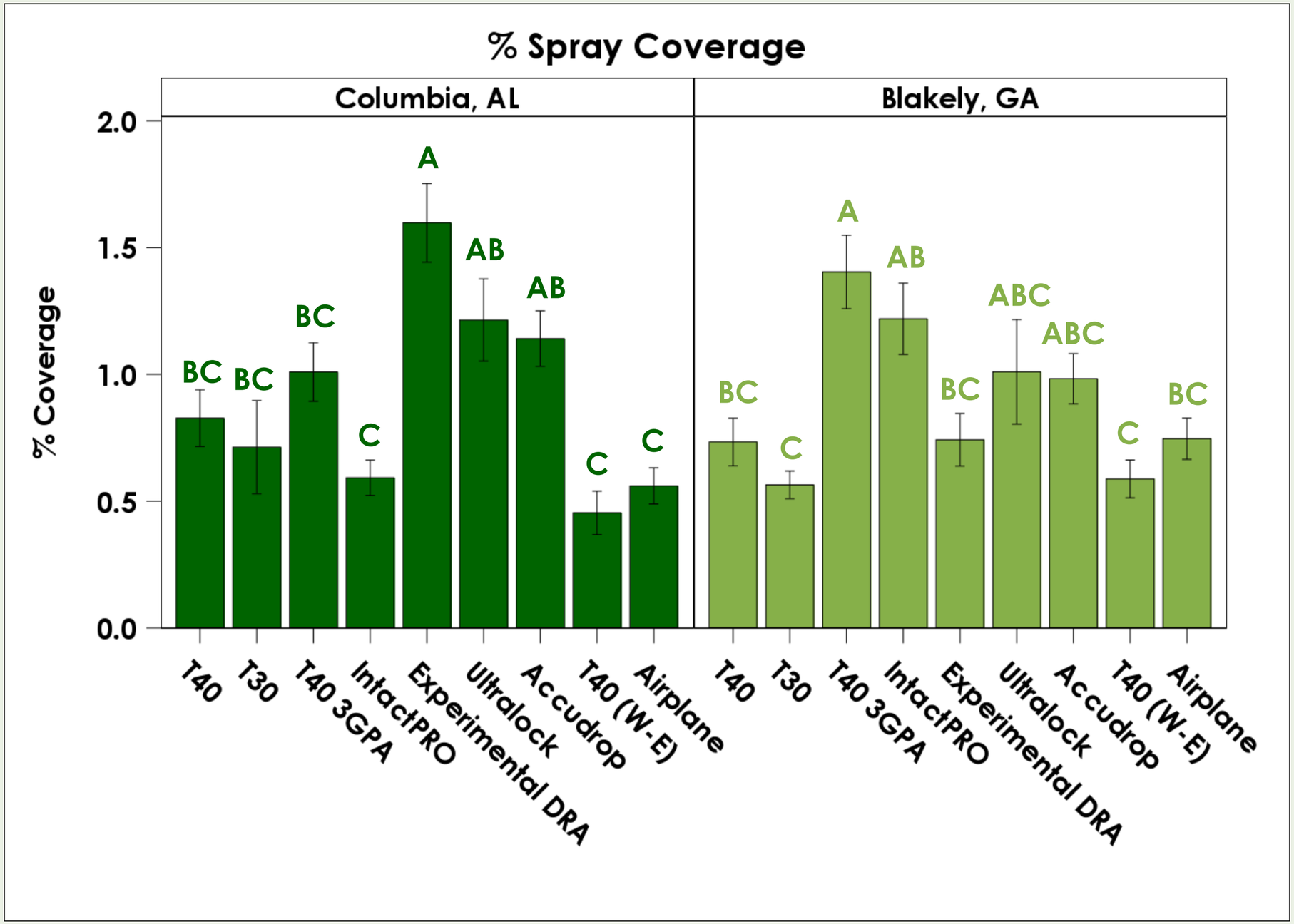
T30 and airplane
2 GPA

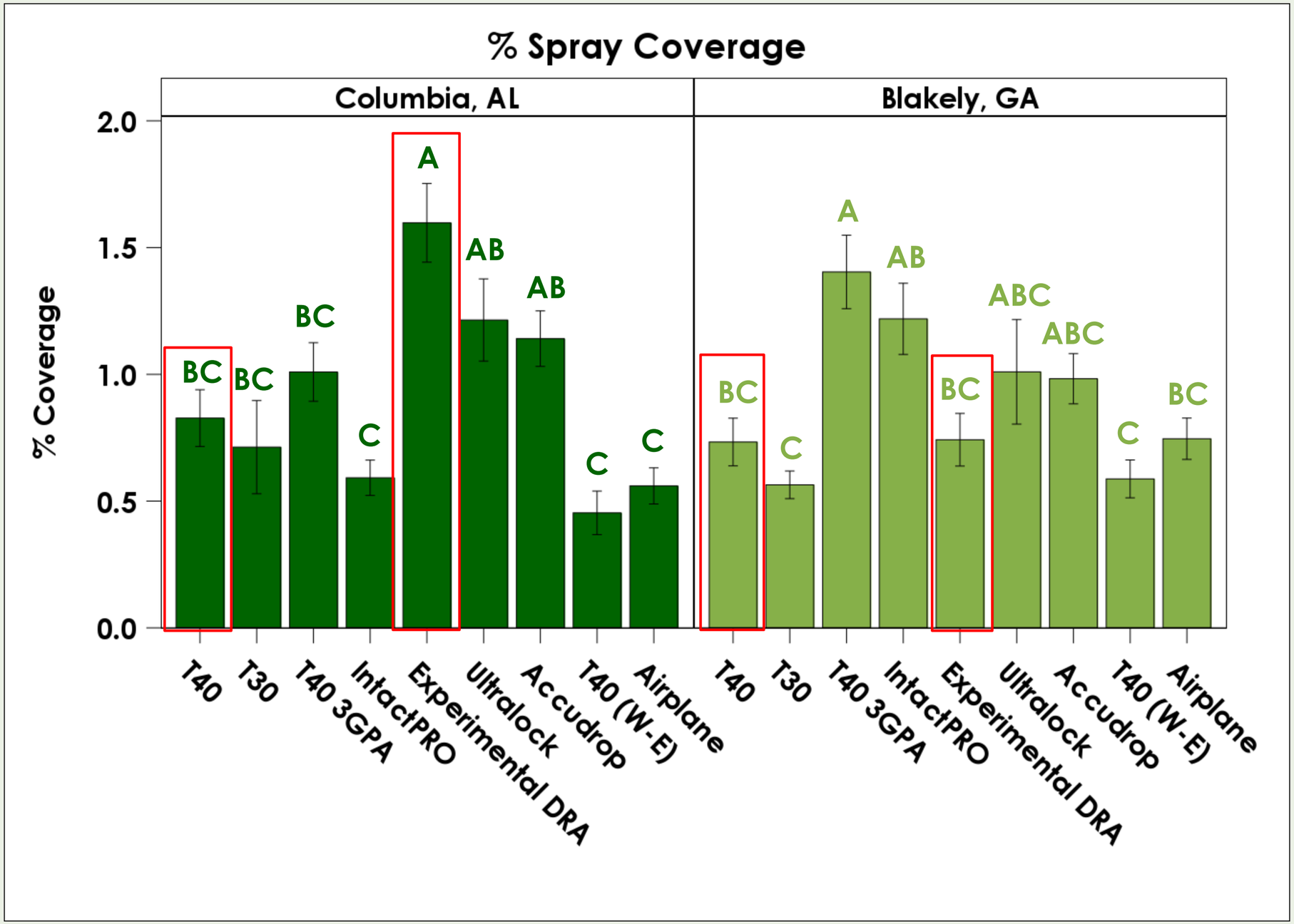
Ground sprayer
15 GPA

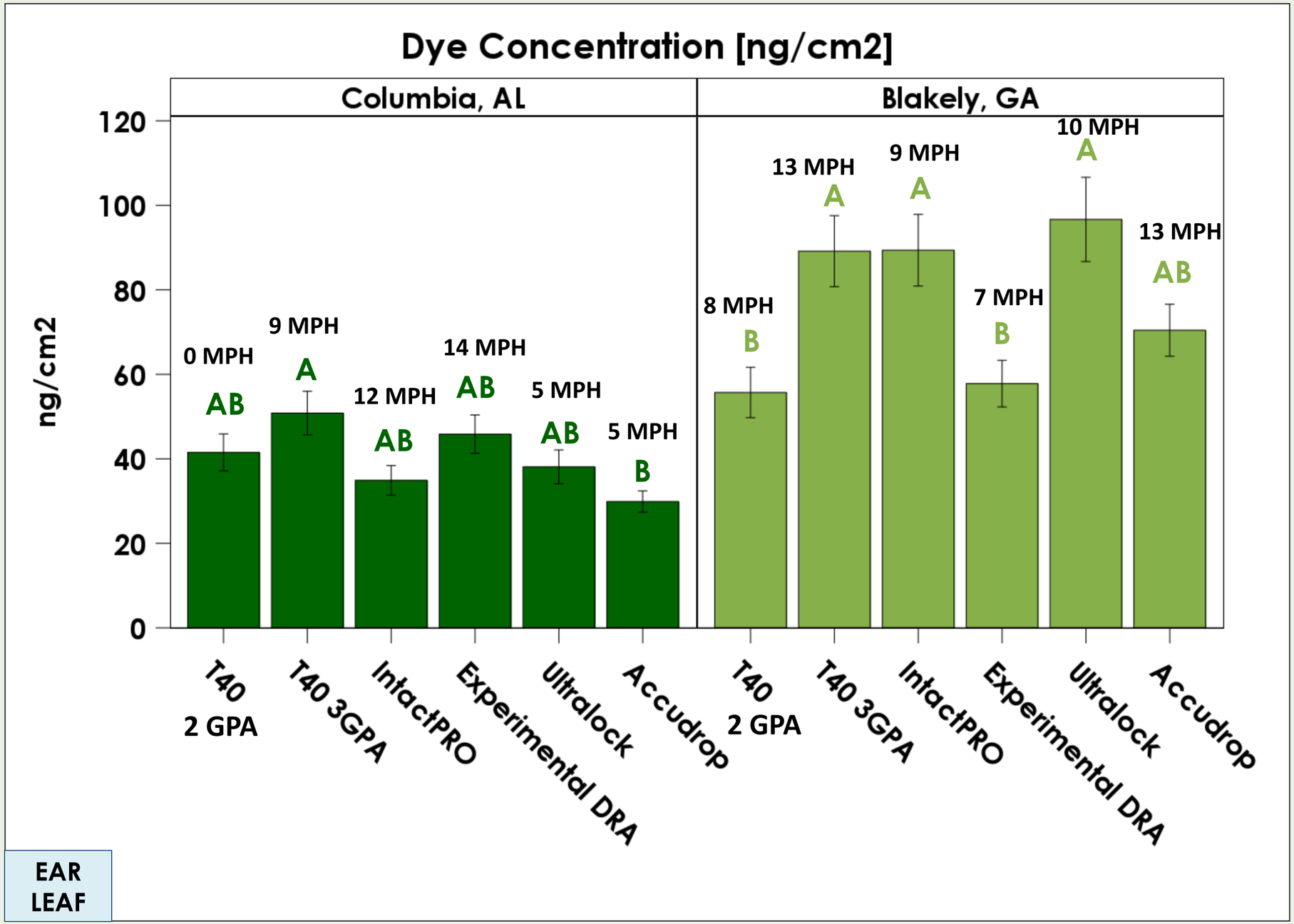
36 inch row corn

Means followed by the same letter in same color are not significantly different(α=0.05); Letters of different colors cannot be compared to each other.


Dye Concentration [ng/cm2]
Columbia, AL
Blakely, GA
ng/cm2
110
100
90
80
70
60
50
40
30
20
10
0
0 MPH
AB
9 MPH
A
9 MPH
B
8 MPH
B
13 MPH
A
9 MPH
B
T40
2 GPA
T40 3GPA
T40 (W-E)
2 GPA
T40
2 GPA
T40 3GPA
T40 (W-E)
2 GPA
EAR
LEAF

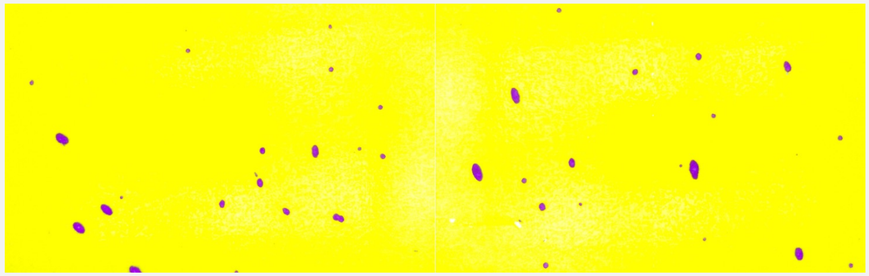

% Spray Coverage
Columbia, AL
Blakely, GA
% Coverage
2.0
1.5
1.0
0.5
0.0
BC
BC
BC
C
A
AB
AB
C
C
BC
C
A
AB
BC
ABC
ABC
C
BC
T40
T30
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
T40 (W-E)
Airplane
T40
T30
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
T40 (W-E)
Airplane


% Spray Coverage
Columbia, AL
Blakely, GA
% Coverage
2.0
1.5
1.0
0.5
0.0
BC
BC
BC
C
A
AB
AB
C
C
BC
C
A
AB
BC
ABC
ABC
C
BC
T40
T30
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
T40 (W-E)
Airplane
T40
T30
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
T40 (W-E)
Airplane

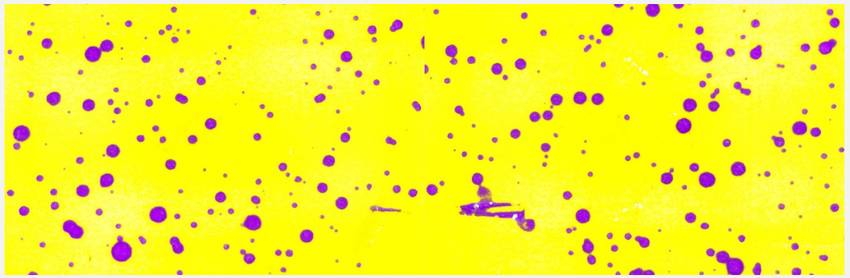

Dye Concentration [ng/cm2]
Columbia, AL
Blakely, GA
ng/cm2
120
100
80
60
40
20
0
0 MPH
AB
9 MPH
A
12 MPH
AB
14 MPH
AB
5 MPH
AB
5 MPH
B
8 MPH
B
13 MPH
A
9 MPH
A
7 MPH
B
10 MPH
A
13 MPH
AB
T40
2 GPA
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
T40
2 GPA
T40 3GPA
IntactPRO
Experimental DRA
Ultralock
Accudrop
EAR
LEAF

Columbia, AL

T40 NO DRA

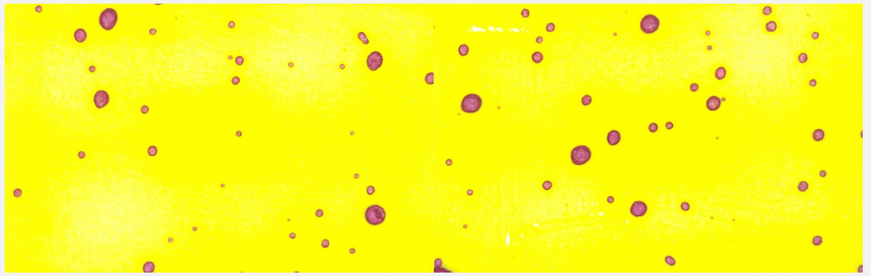


T40 Exp. DRA

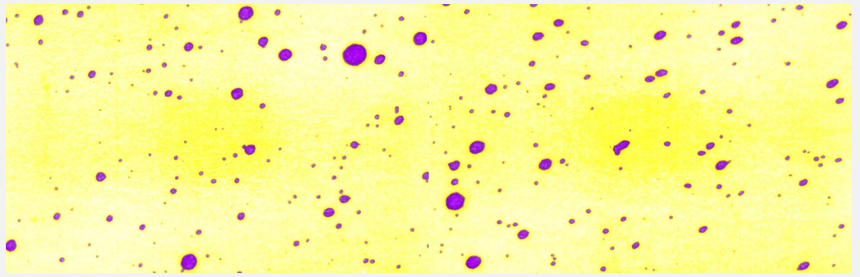


Blakely, GA

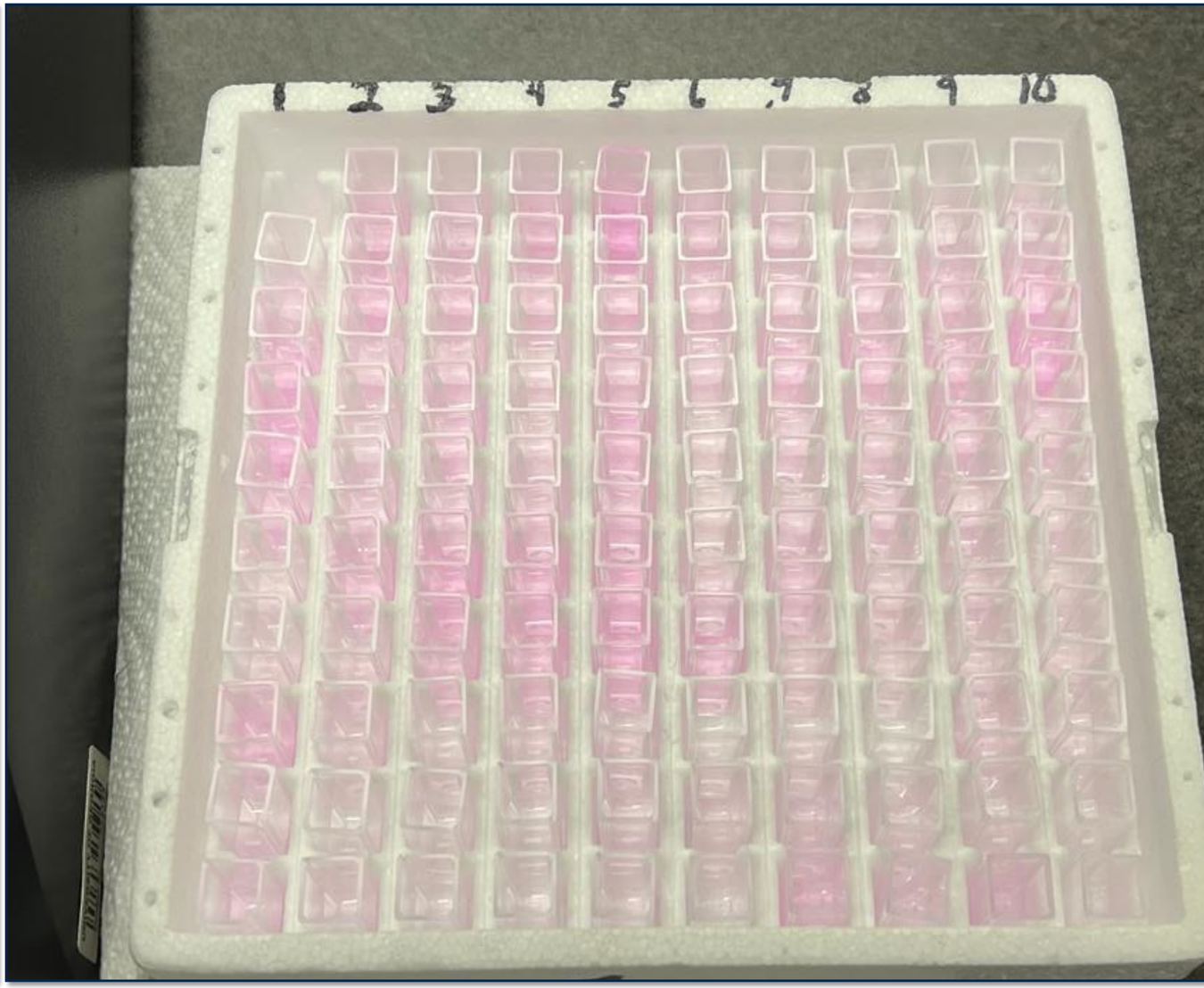
T40 NO DRA



T40 Exp. DRA



Drone No DRA



Drone with DRA

Summary (1st Exp.)

- Less canopy density resulted in higher deposition values (dye deposition GA > AL)
- Flight direction of the drone does not show a significant impact in dye concentration
- DRA increased dye deposition and % coverage, but performance of individual product was inconsistent across two locations
- Higher spray volume (3 GPA vs 2 GPA) increased deposition and demonstrated more resistance to wind

Materials & Methods

- Two experiments were conducted at Columbia, AL and Blakely, GA during summer 2023.

- Corn canopy is thinner and drier in the July application than June app.

1st App. : June

2nd App. : July

Materials & Methods

2nd: Experiment treatments

#	Treatment	Application method	Droplet size / Nozzle	Rate (% v/v)	GPA	Flight speed (mph)	Swath (ft)
1	No DRA	DJI Agras T40	300 µm	-	2	22	33
2	IntactPro	DJI Agras T40	300 µm	0.25	2	22	33
3 & 4	No DRA	Airplane	Various	-	2	160	83

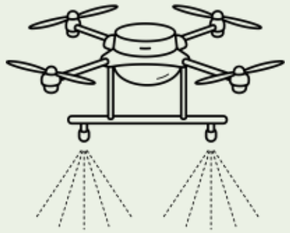
*GPA= gallons per acre
*All spray application had Rhodamine WT dye
*Flight height was 10 ft for all treatments

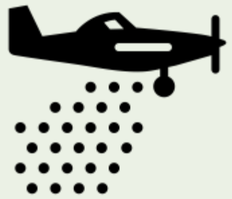
Spray plane information

2nd application (July 19th, 2023. 3-4:30 pm)

- **Plane 1: Air tractor 802 with 800-gal tank. Nozzle type CP 256, 40 degree flat fan nozzles, 0.06 orfices. Pressure 40 PSI. Speed 170 MPH. Swath 87 ft. Altitude 12 ft**

- **Plane 2: Air tractor 602 with 630-gal tank. Nozzle type CP-09-3P straight stream, 0.062 orfices. Pressure 60 PSI. Speed 160 MPH. Swath 83 ft. Altitude 12 ft.**





Water Sensitive Paper (WSP's) + Mylar card

Mylar card 2nd leaf above ear leaf

Mylar card 2nd leaf below ear leaf

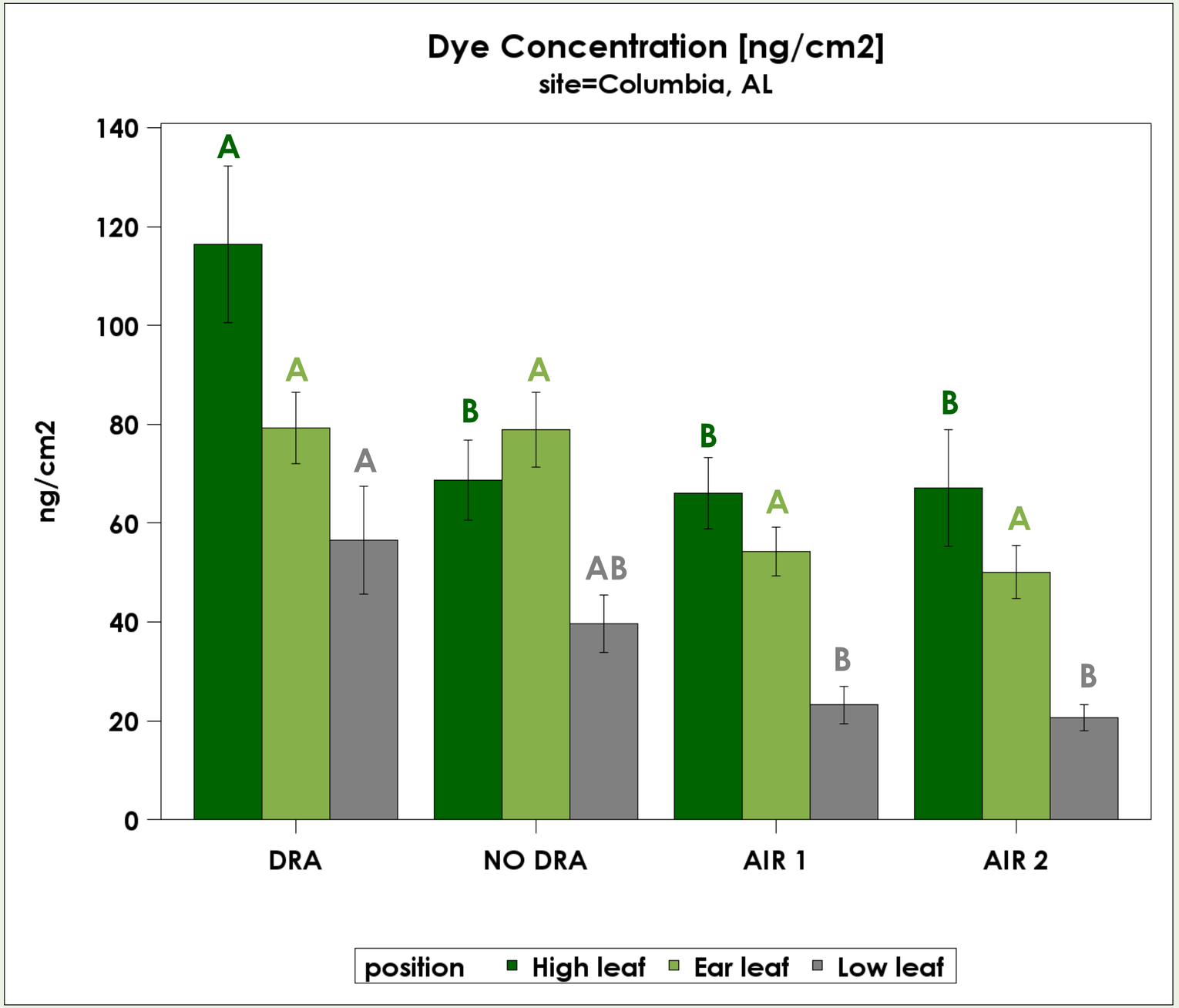
Materials & Methods

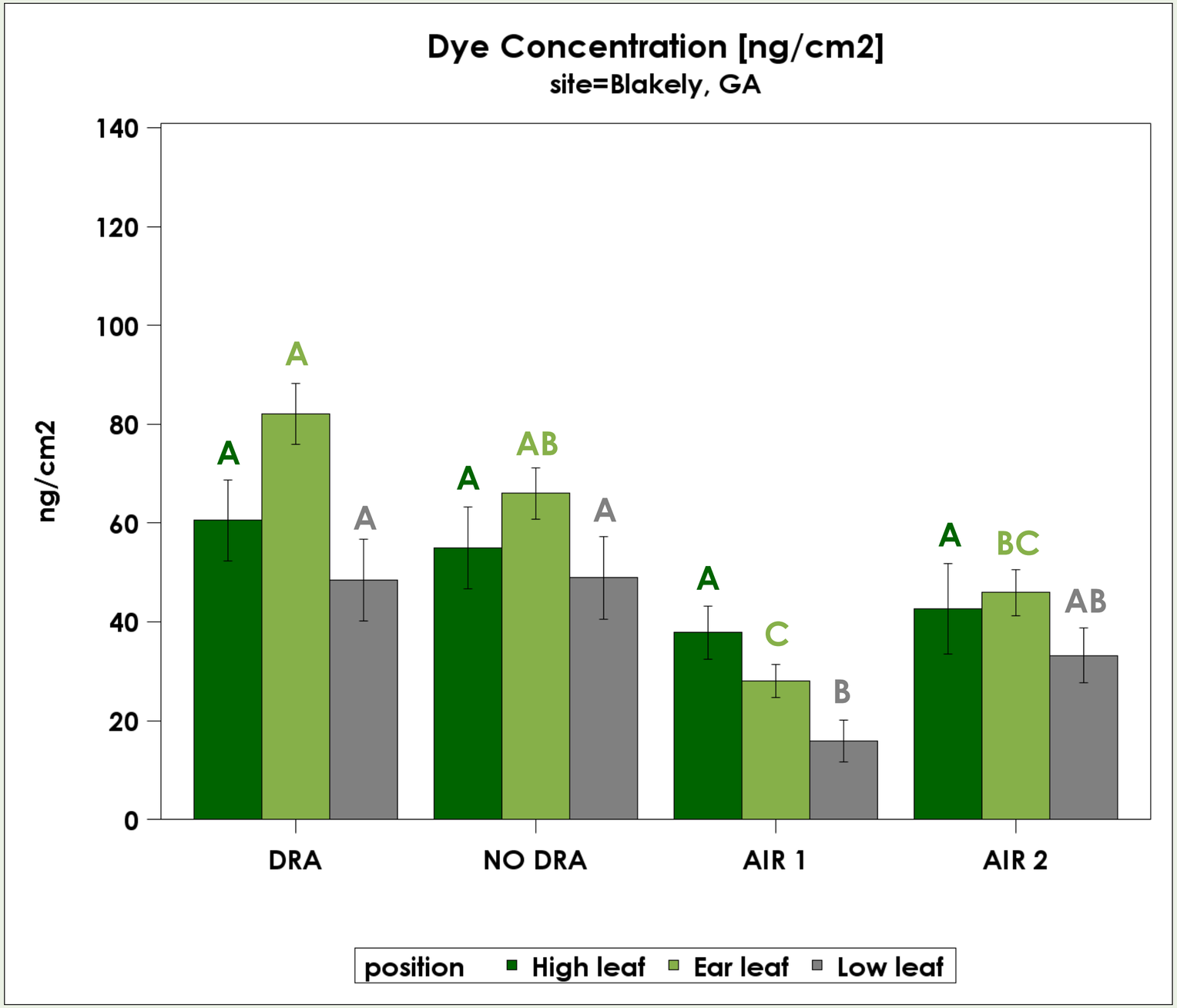
Weather data at both locations:

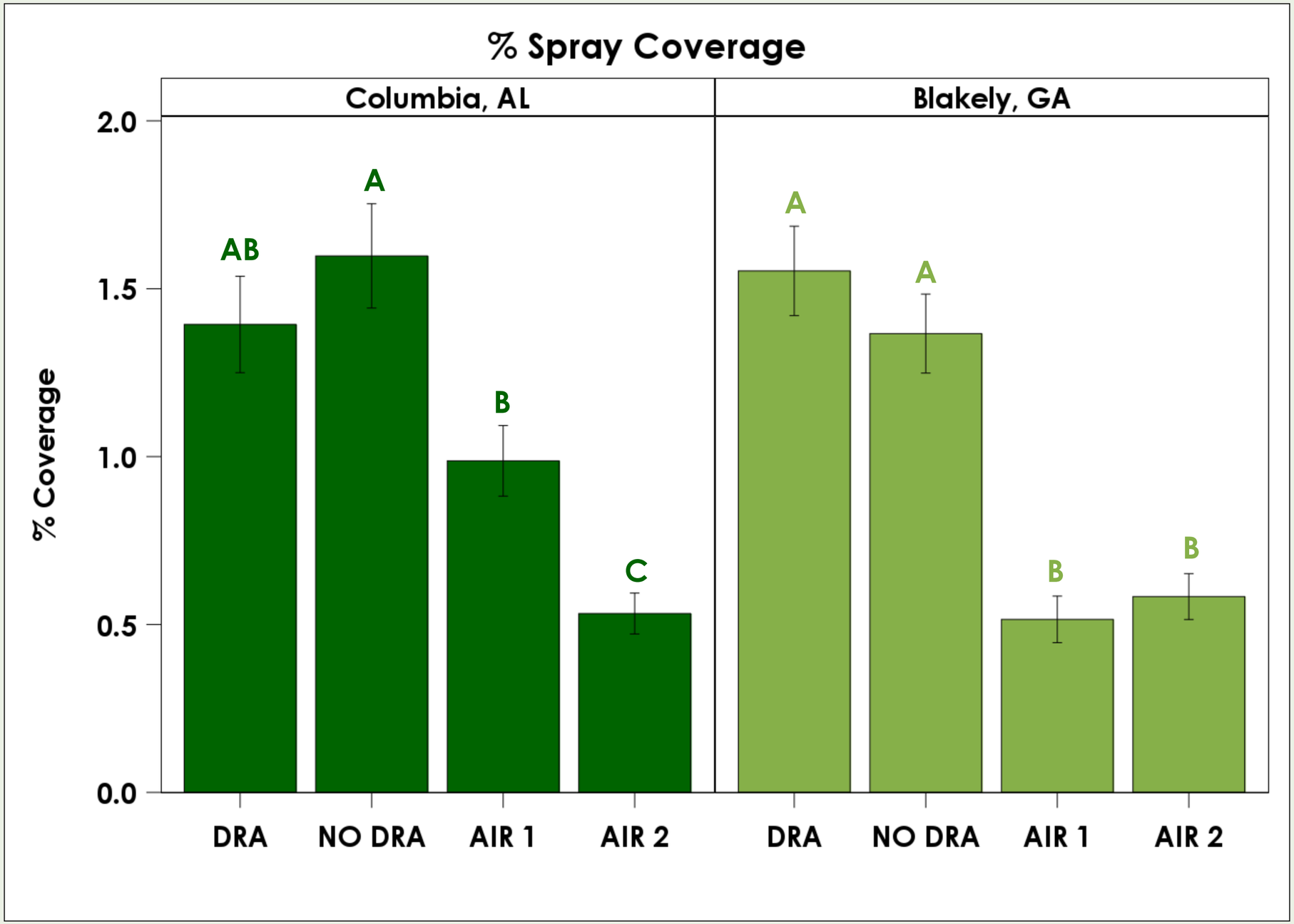
Site	#	Treatment	Application method	GPA	Wind speed (mph)	Wind direction	Temperature (F)
Columbia, AL	1	No DRA	DJI Agras T40	2	10	WNW	92
	2	IntactPro	DJI Agras T40	2	10	NWW	92
	3 & 4	No DRA	Airplane	2	8	W	91
Blakely, GA	1	No DRA	DJI Agras T40	2	9	SW	89
	2	IntactPro	DJI Agras T40	2	7	WNW	85
	3 & 4	No DRA	Airplane	2	8	W	91

Data collected with WatchDog 2000 Series (Spectrum Technologies, Aurora, IL)

Results & Discussion


Dye Concentration [ng/cm2]
site=Columbia, AL
ng/cm2
140
120
100
80
60
40
20
0
A
A
A
B
A
AB
B
A
B
B
A
B
DRA
NO DRA
AIR 1
AIR 2
position
High leaf
Ear leaf
Low leaf

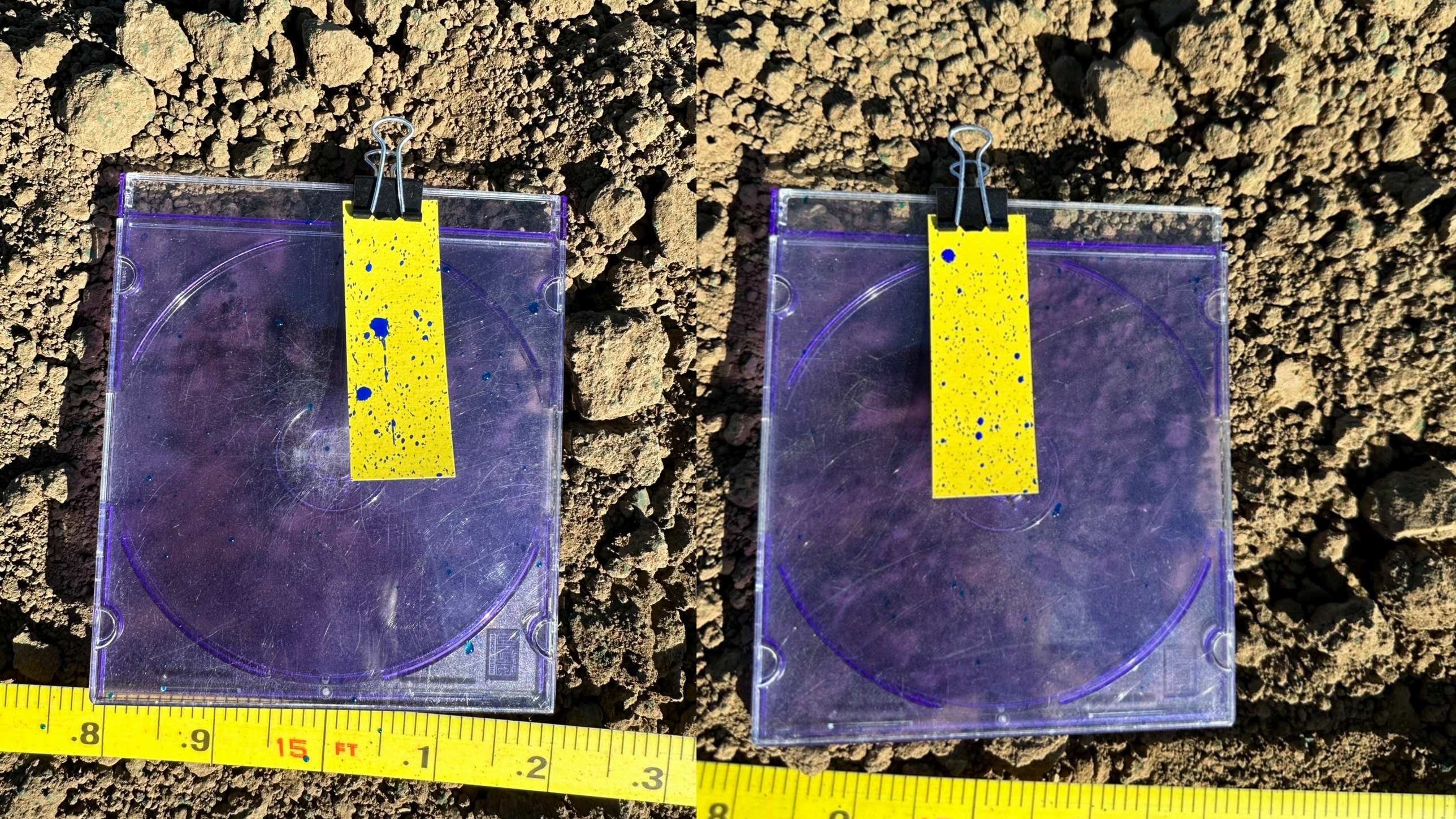

Dye Concentration [ng/cm2]
site=Blakely, GA
ng/cm2
140
120
100
80
60
40
20
0
A
A
A
A
AB
A
A
C
B
A
BC
AB
DRA
NO DRA
AIR 1
AIR 2
position
High leaf
Ear leaf
Low leaf

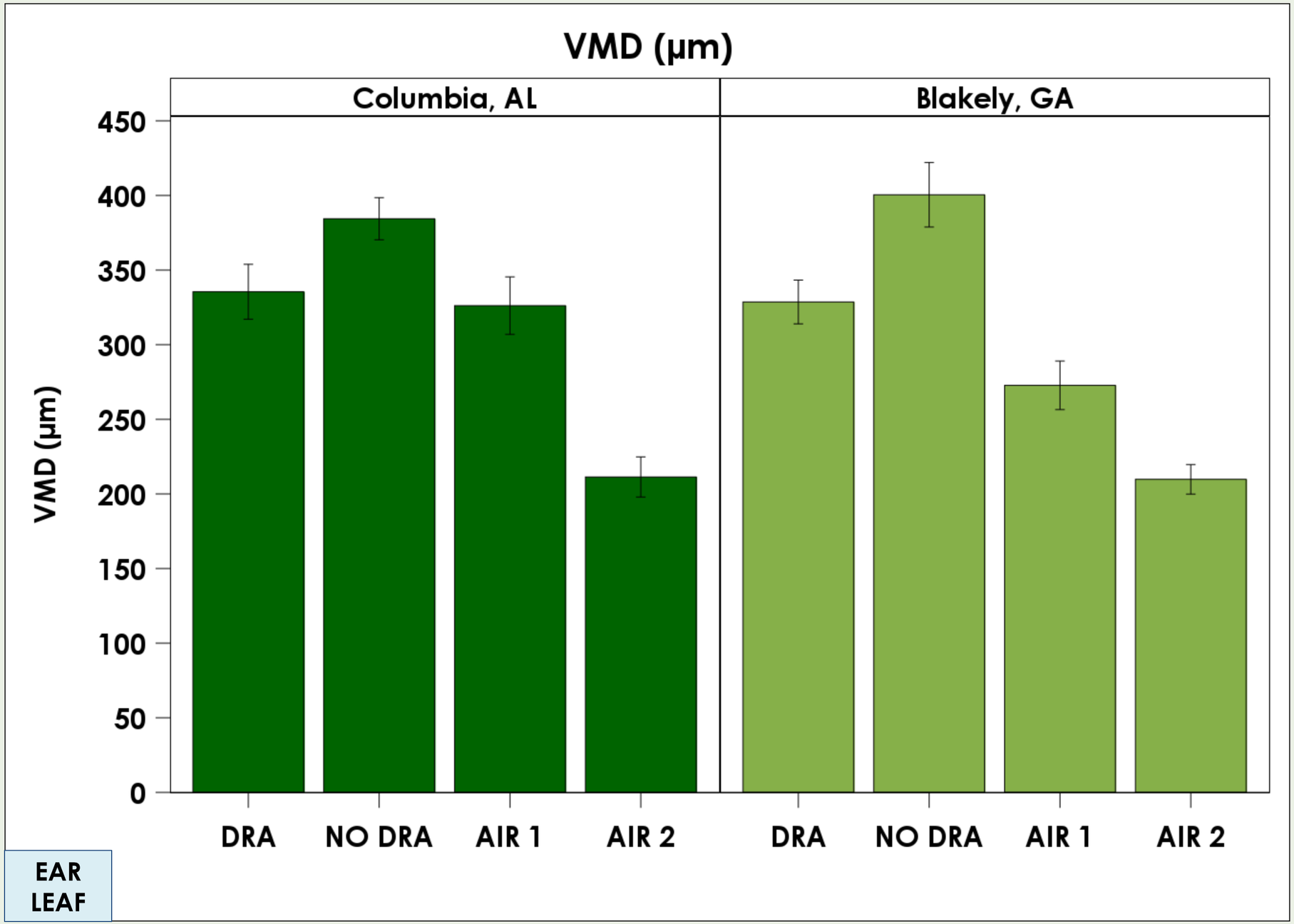

% Spray Coverage
Columbia, AL
Blakely, GA
% Coverage
2.0
1.5
1.0
0.5
0.0
AB
A
B
C
A
A
B
B
DRA
NO DRA
AIR 1
AIR 2
DRA
NO DRA
AIR 1
AIR 2

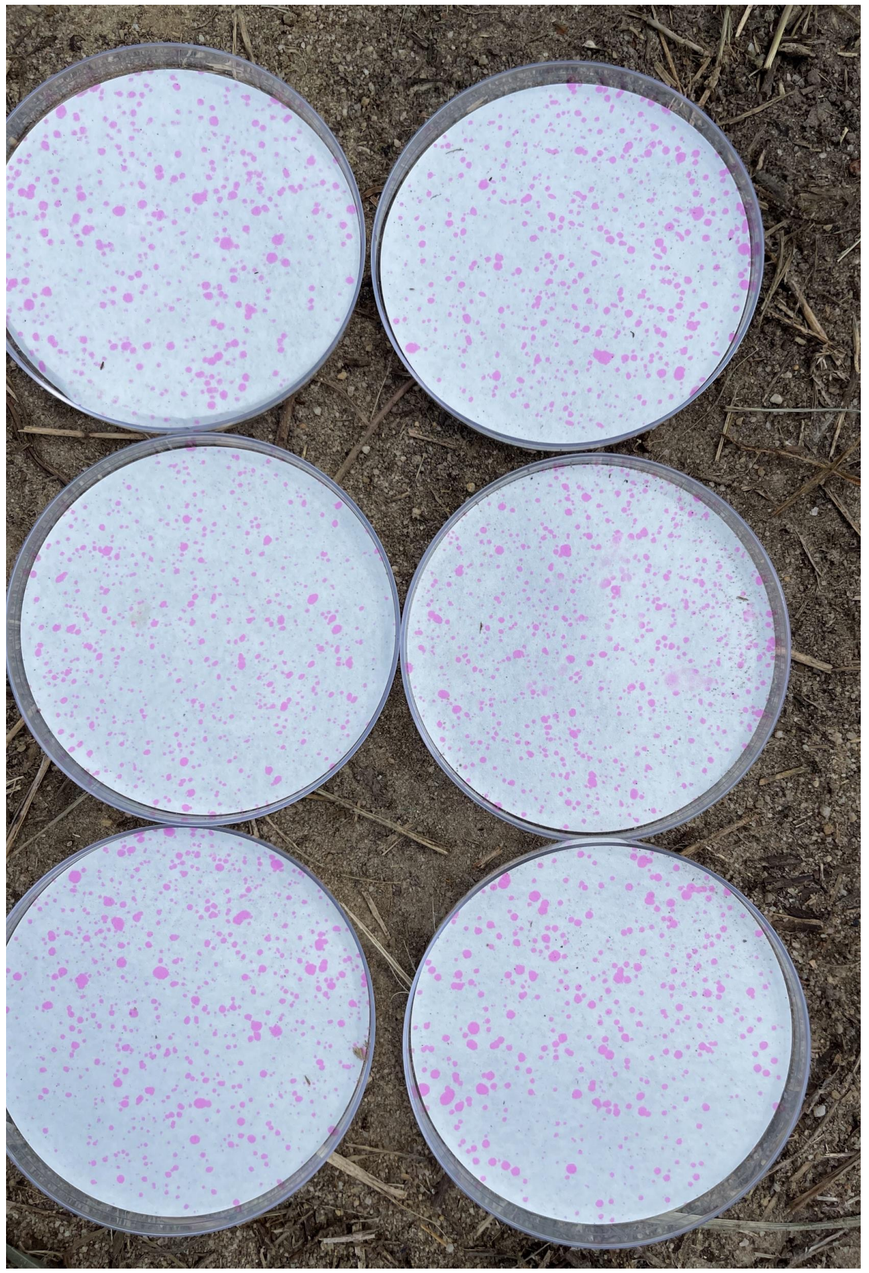
So why there are some significant deposition and coverage differences this time between airplane and drone???

My assumptions (further validation needed)

1. Thinner and drier canopy
2. Droplet size and spectrum differences
3. Propeller downdraft


.8
.9
15
FT
.1
.2
.3


VMD (µm)
Columbia, AL
Blakely, GA
VMD (µm)
450
400
350
300
250
200
150
100
50
0
DRA
NO DRA
AIR 1
AIR 2
DRA
NO DRA
AIR 1
AIR 2
EAR LEAF



Top

T20p Middle

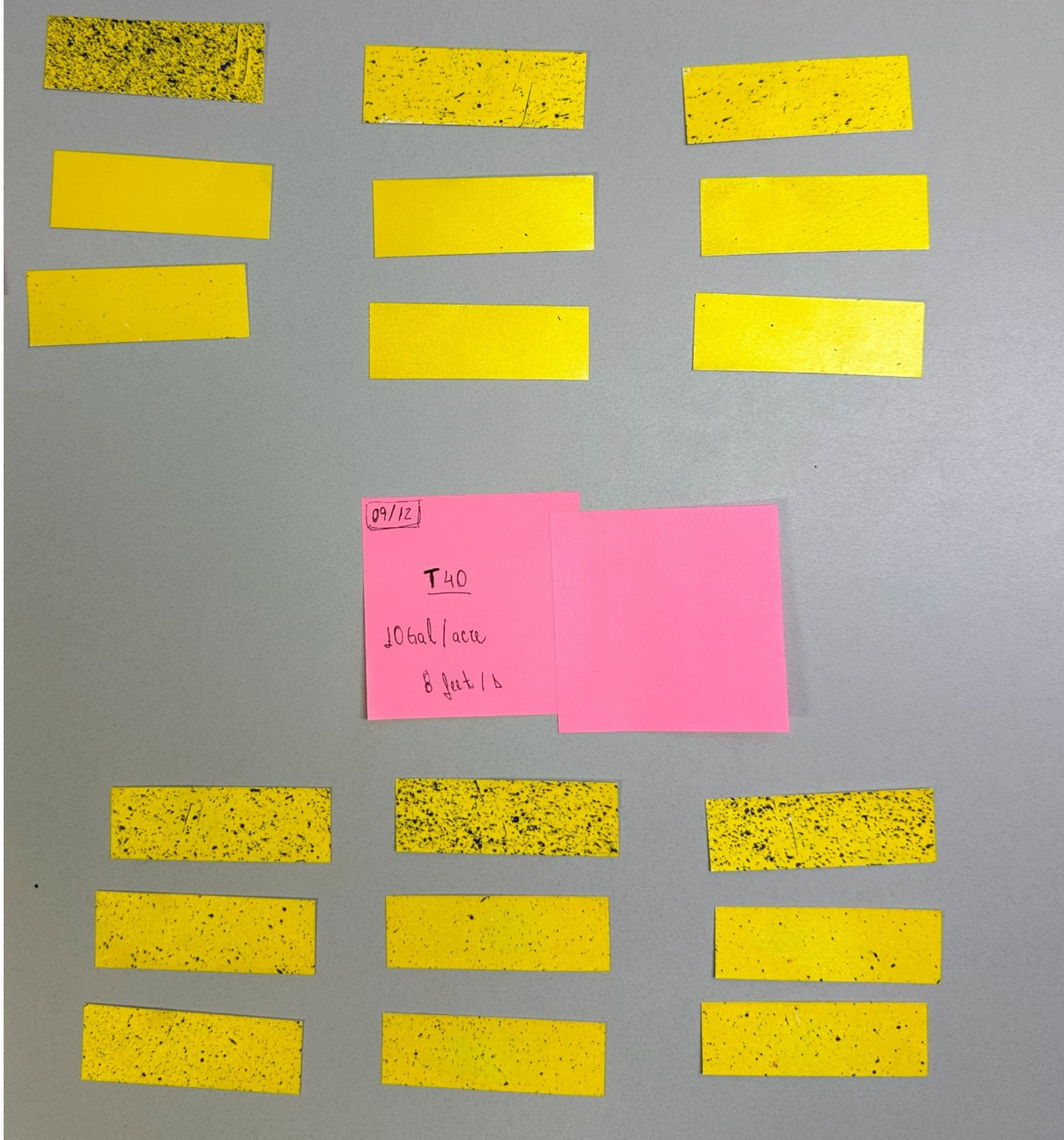
Low

Canopy position

Top

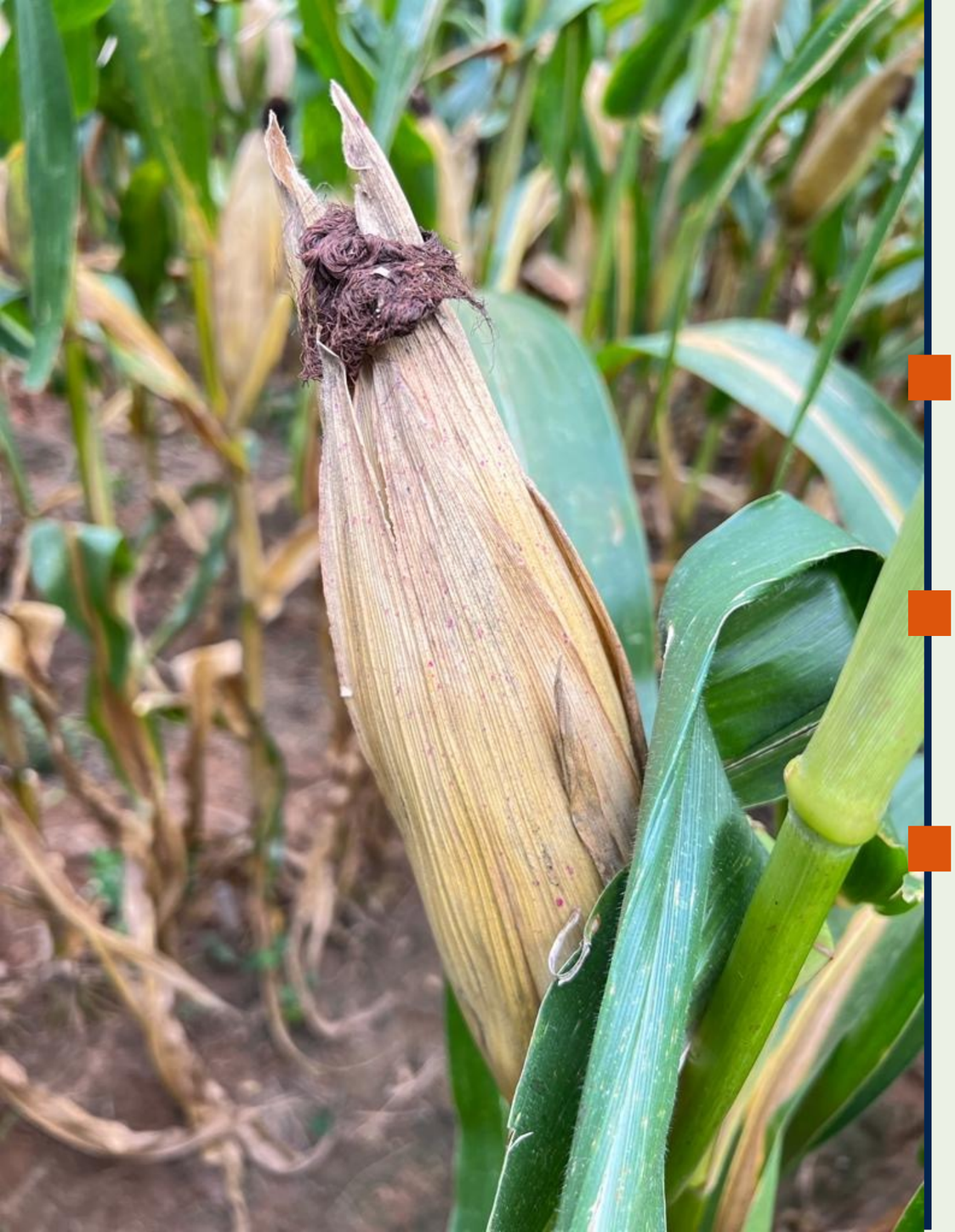
T40 Middle

Low



Summary (2nd Exp.)

- Dye deposition similar between drone and airplane, slightly favoring drone on ear leaves
- DRA effect diminished as canopy dried up, only trend of deposition increase was seen
- Drone showed the trend to blew more fluorescent dye deeper into corn canopy than airplanes, possibly to the downwash under the propellers (Dengeru et al. ,2022)



Conclusions

- Airplane and spray drone performed similarly in 2022 and 2023 June field trial. No statistical differences were observed
- DRA in general is very beneficial to increase deposition. However, identify the best one is difficult due to the inconsistence found in the results
- 3 GPA demonstrated better deposition and wind resistance than 2 GPA
- Flight direction did not affect dye deposition
- Thinner or more open canopy may favor spray drone slightly more than airplane due to the propeller downdraft. DRA effect starts to diminish in this type of canopy

Future Research

- Repeat, repeat, repeat!!! Multistate collaboration in 2024 corn application trials including Midwest locations

Acknowledgements

- Farmers collaborators: Andy Williams, Josh Creel and Caleb Traugh
- Alabama wheat and feed grain commission for providing funding
- My grad students Livia Pereira, Thiago Caputti, student interns and undergrad student workers

FB group: @ Agricultural drones for the US

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