@WiscWeeds

Enlist E3: What Applicators Should Know About this New Trait

Sarah Striegel

MS Student

Rodrigo Werle, PhD

Assistant Professor & Extension Weed Scientist

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN–MADISON

Extension
UNIVERSITY OF WISCONSIN–MADISON

Disclaimer

- Not to Endorse the Enlist E3 Technology
- Promote Effective Use of the Enlist E3 Technology

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN–MADISON

Waterhemp Resistance in WI: Preliminary Results

Treatment	Populations Screened	Resistant Populations	% Resistant Populations
1x Glyphosate	86	82	95%
3x Glyphosate	86	60	70%
1x Imazethapyr	82	79	96%
3x Imazethapyr	82	75	91%
1x Atrazine	80	8	10%
3x Atrazine	80	2	3%

MS Research: Felipe Faleco, UW-Madison WiscWeeds Program

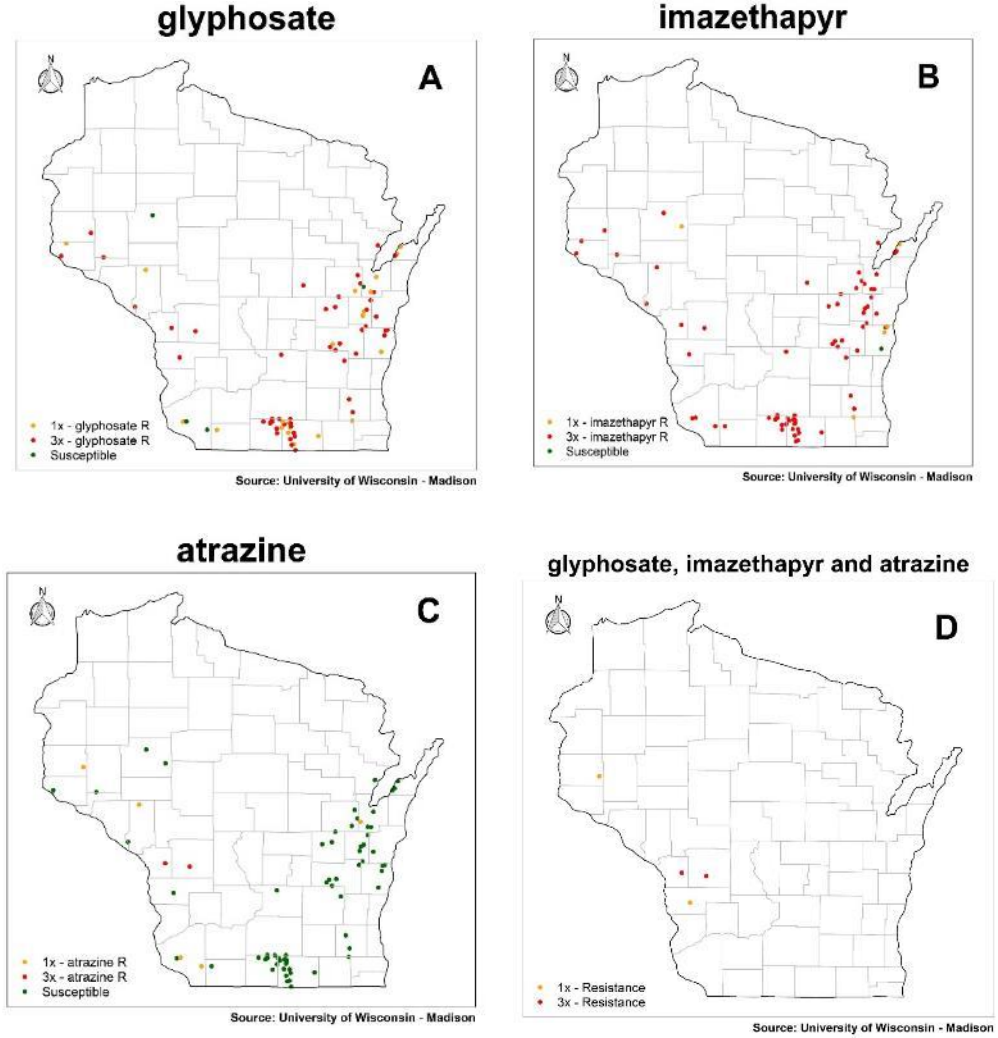
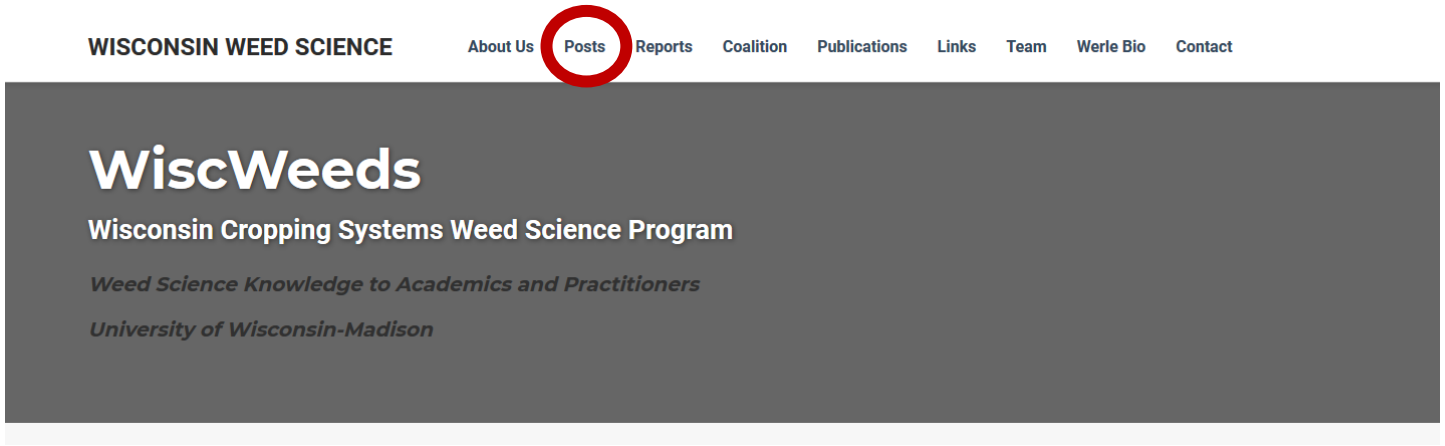
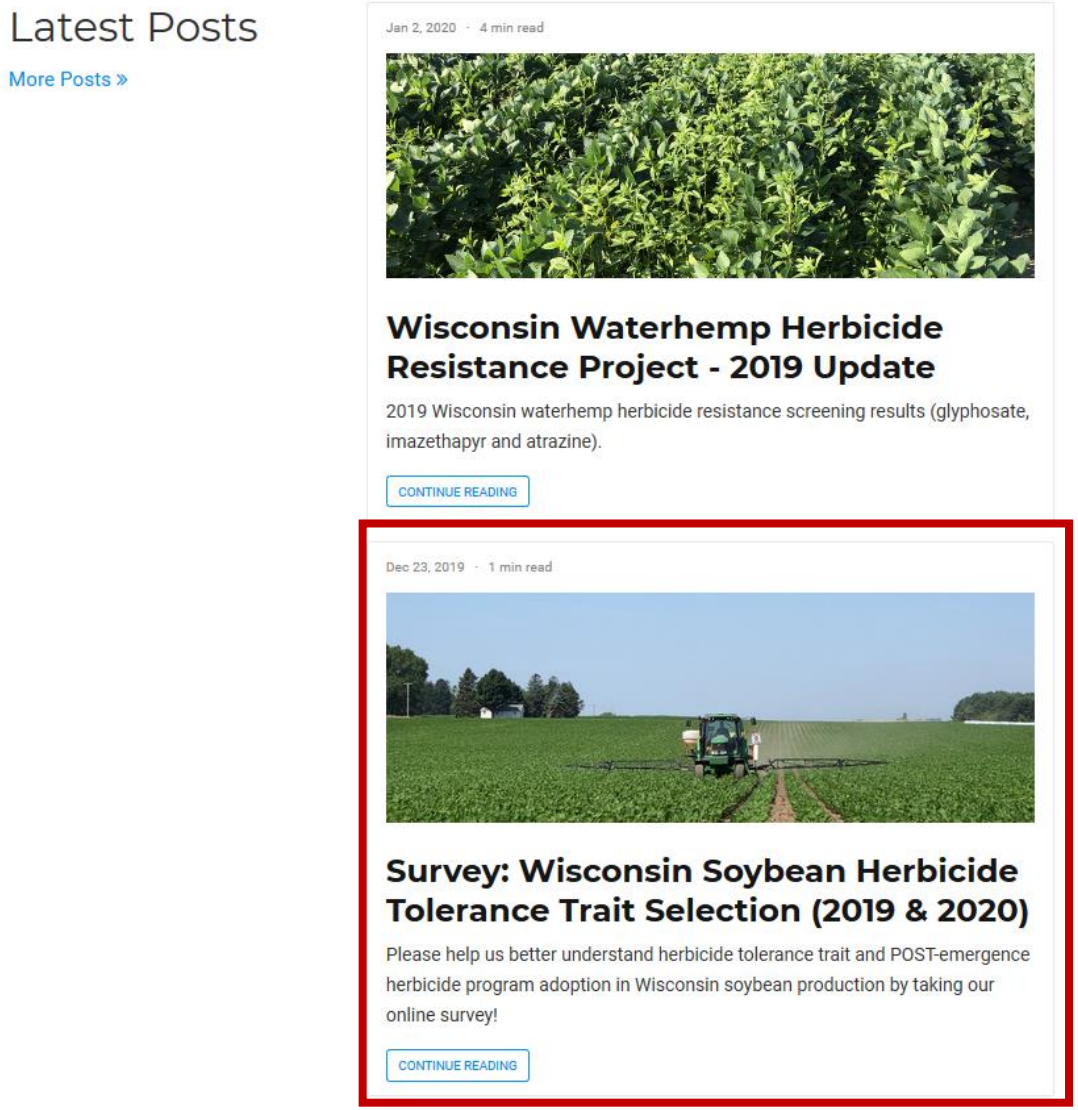


Figure 1: Distribution of waterhemp populations in Wisconsin according to their resistance level. Maps generated by Dr. Maxwel Oliveira.

Survey: Wisconsin Soybean Herbicide Tolerance Trait Selection (2019 & 2020)

www.WiscWeeds.info

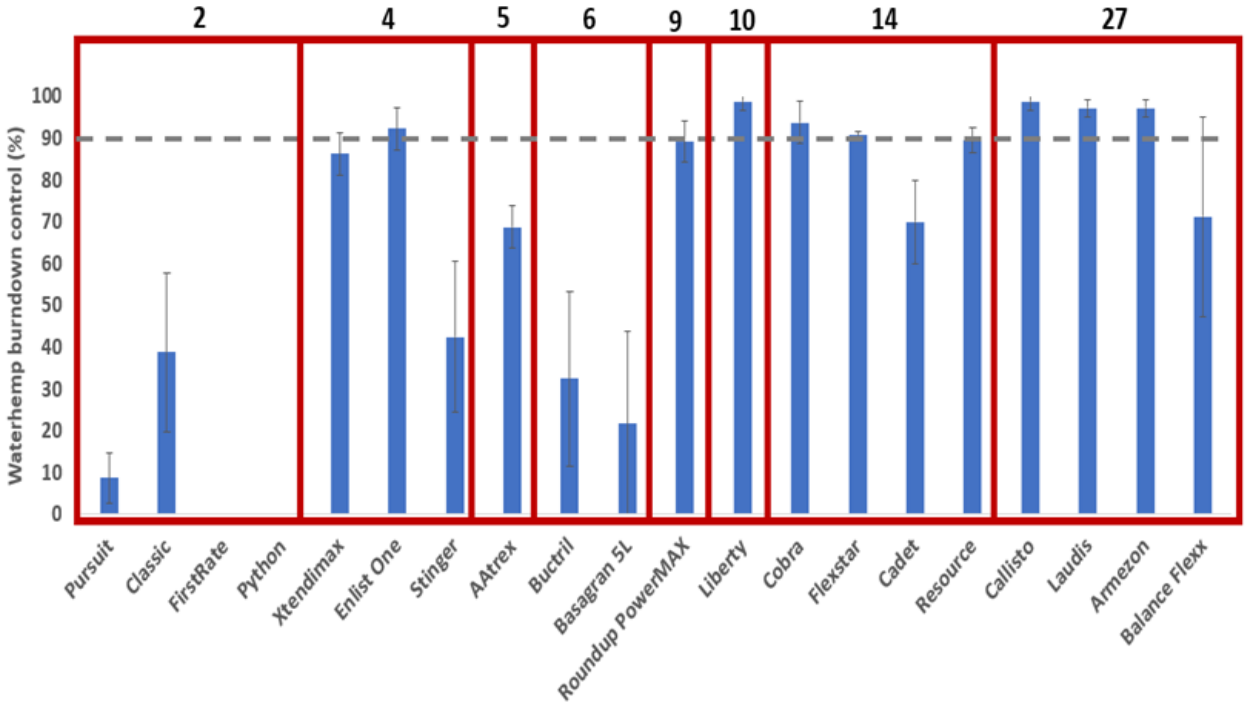




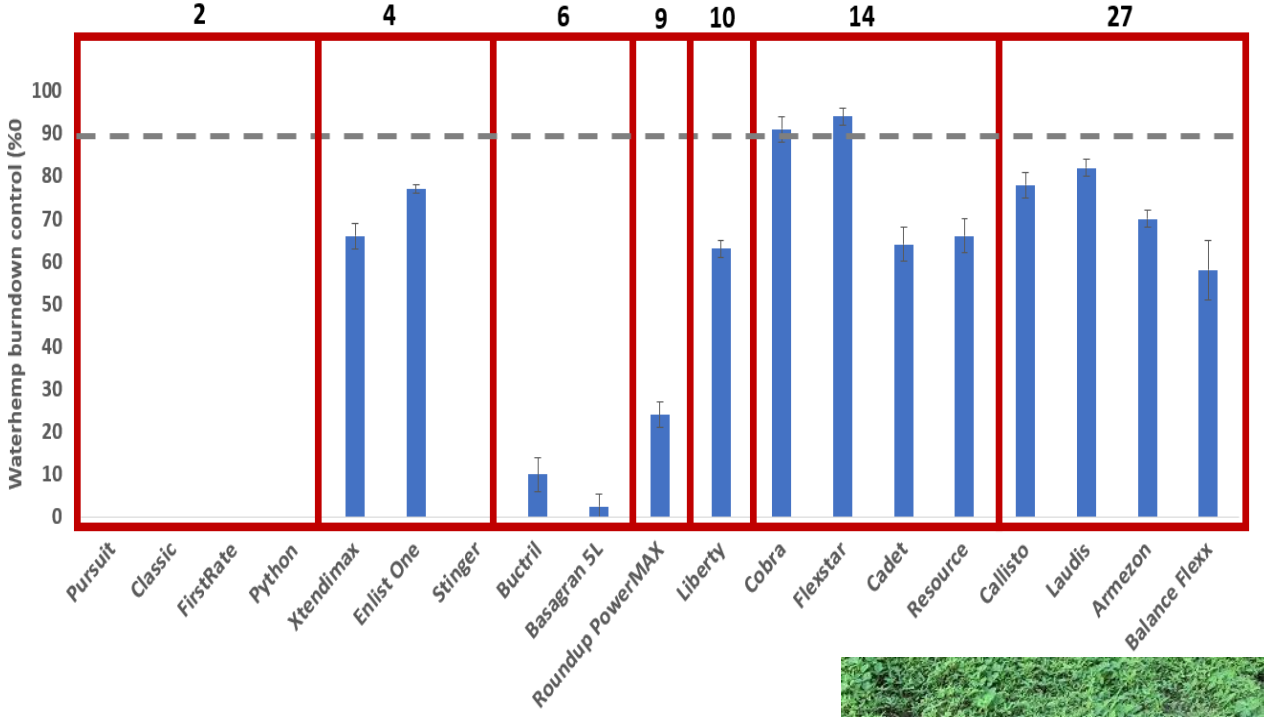
Objective: better understand herbicide tolerance trait and POST-emergence herbicide adoption in Wisconsin soybean production during 2019 and plans for 2020.

Waterhemp Burndown Control 14 DAT

Lancaster, WI 2019



Brooklyn, WI 2019



Large-Scale Dicamba Drift Studies

07/11/2018
Soybeans at V6
Wind speed = 3-6 mph
Air Temp = 81 F

07/14/2019
Soybeans at V5-V6
Wind speed = 3-5 mph
Air Temp = 82 F

Treatment (2018 and 2019)	Rate
Roundup PowerMax	32 fl oz/A
Xtendimax	22 fl oz/A
Intact	0.5% v/v
TTI11004; 15 GPA; Boom height = 32-inches; Nozzle spacing = 20-inches; Boom = 45 ft	

Treatment (2019)	Rate
+ MON51817	1% v/v

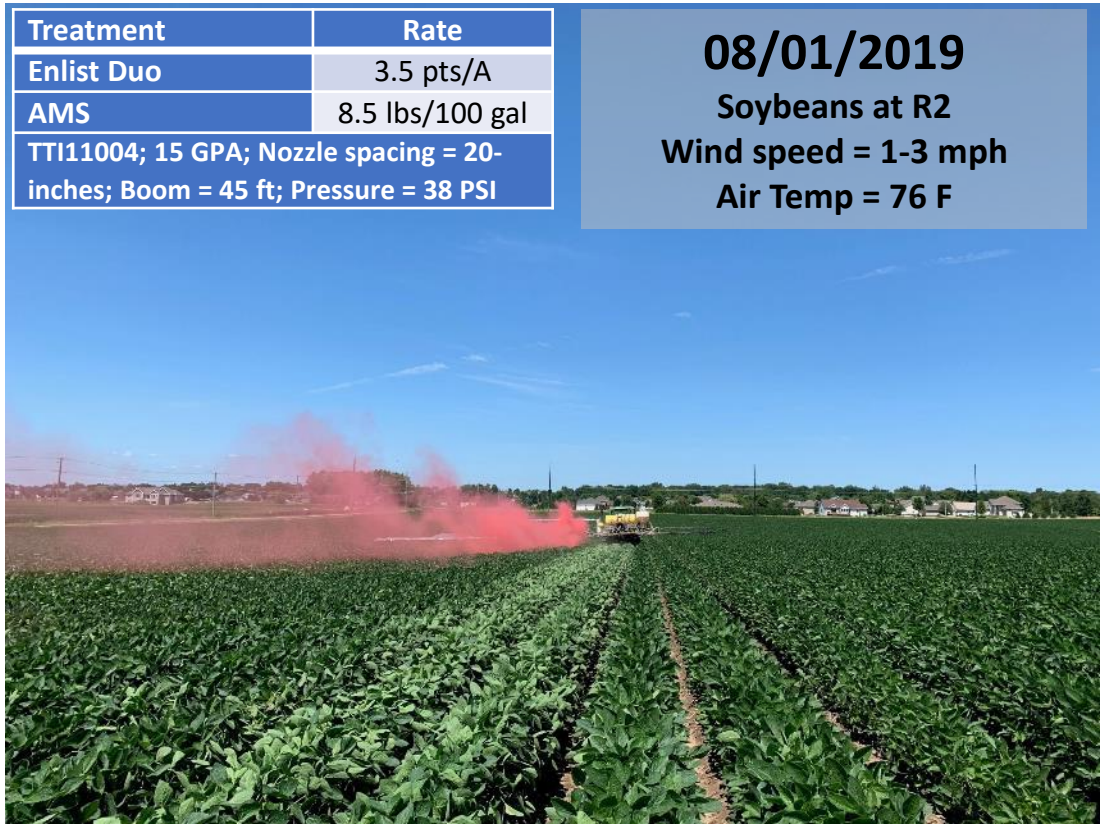

22 DAT
Non-Xtend block
Xtend block
Upwind
(South side)
→ N


22 DAT
Xtend block
Non-Xtend block
Downwind
(North side)
→ N

Large-Scale 2,4-D Drift Study (2019)

Treatment	Rate
Enlist Duo	3.5 pts/A
AMS	8.5 lbs/100 gal
TTI11004; 15 GPA; Nozzle spacing = 20-inches; Boom = 45 ft; Pressure = 38 PSI	

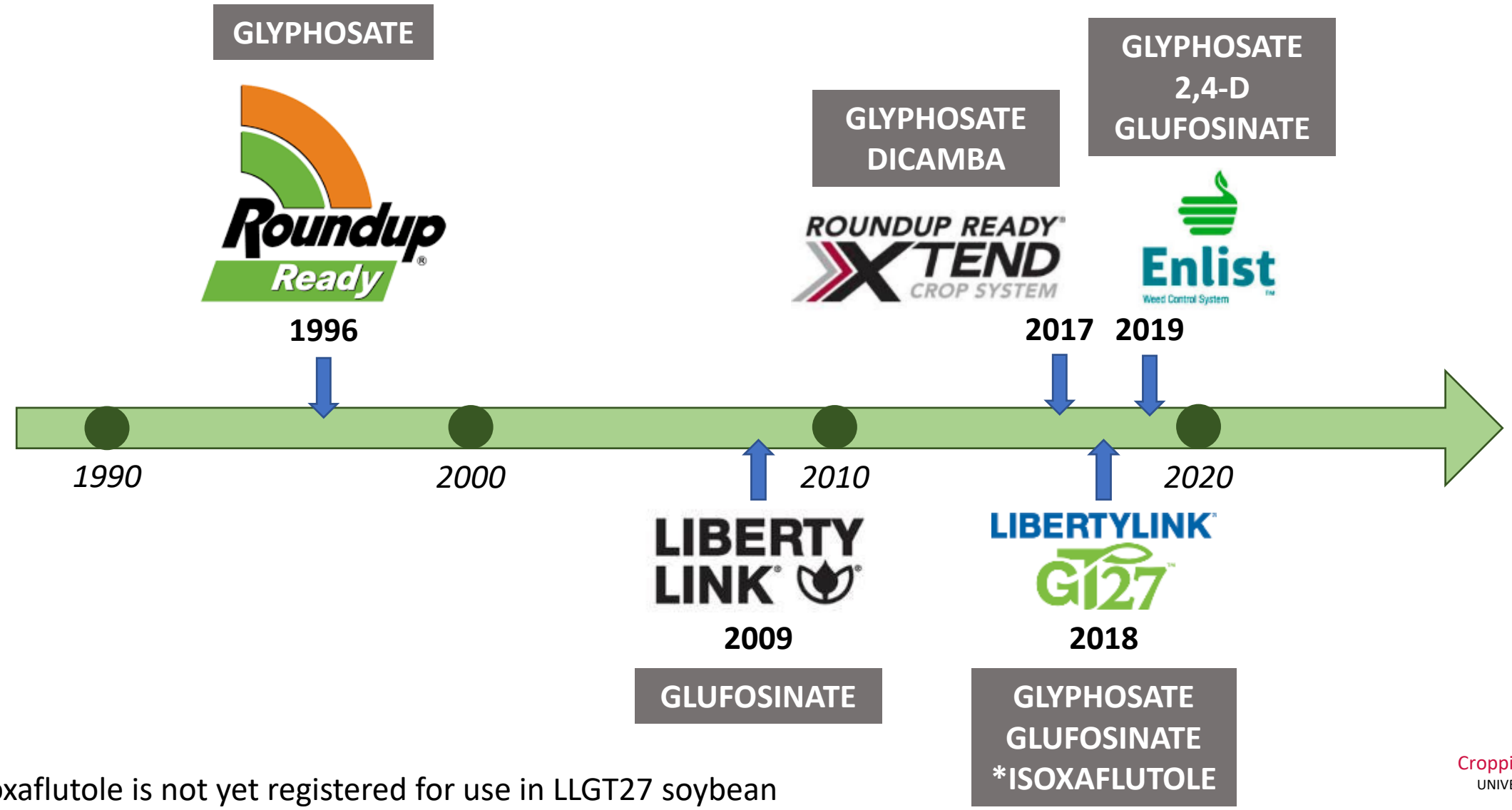
08/01/2019
Soybeans at R2
Wind speed = 1-3 mph
Air Temp = 76 F



Outline

- So many trait options… why Enlist E3?
- Application Requirements
  - Sensitive area buffers
  - Susceptible crops
  - Carrier volume, tank mixing guidelines, tank cleanout
  - Drift – particle and secondary movement
  - Weather considerations
- Performance in 2019 low tunnel volatility trial

Soybean Herbicide-Tolerant Traits

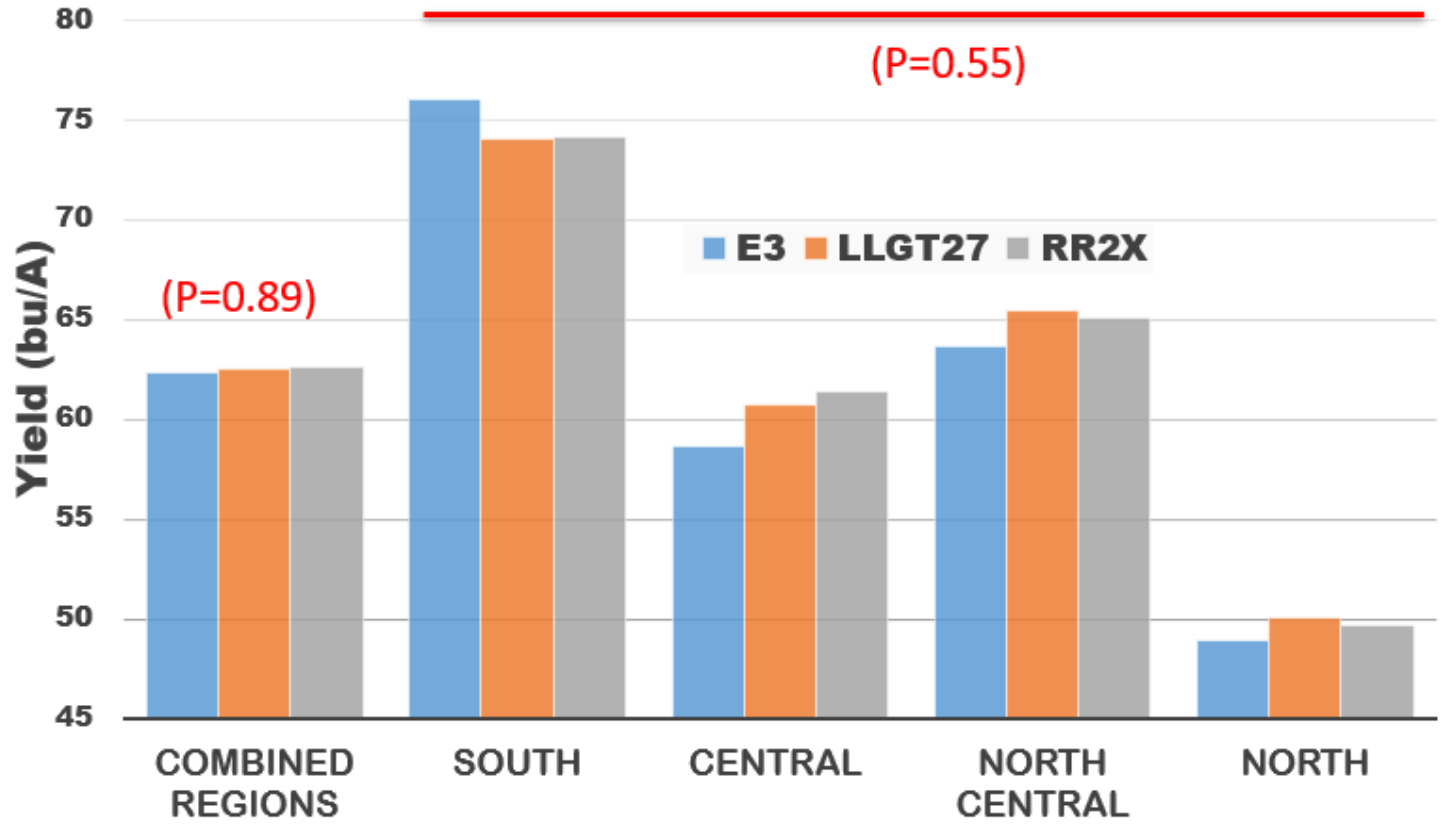


*isoxaflutole is not yet registered for use in LLGT27 soybean

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN-MADISON

Herbicide Trait Options In WI

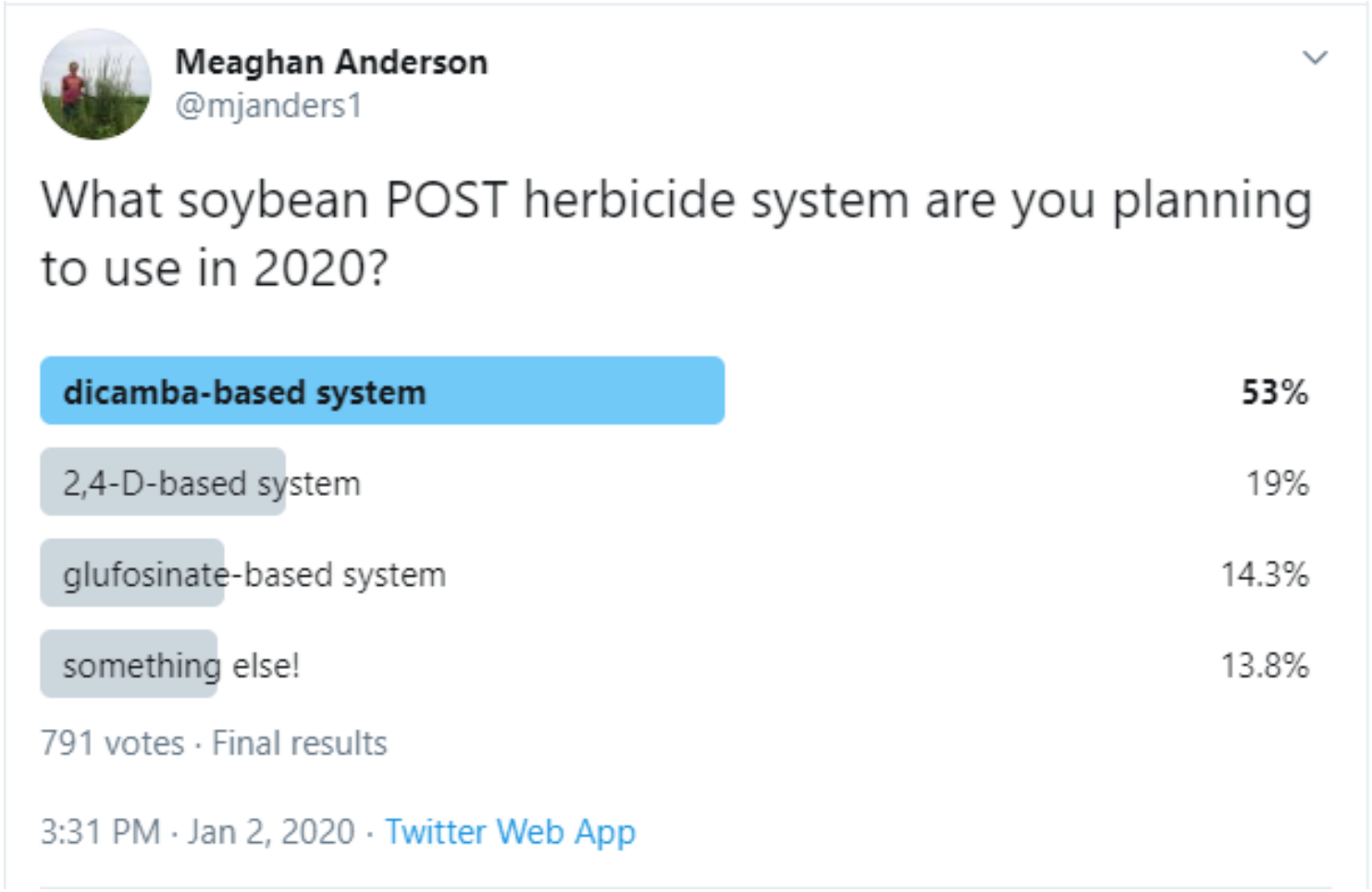
E3 vs LLGT27 vs RR2X



E3 N=26; LLGT27 N=41; RR2X N=97

*We did not have enough RR or RR2Y entries to test against

Herbicide selection



*survey results from Meaghan Anderson, ISU Extension & Outreach Agronomist

For use on Enlist corn, soybean, and cotton

Enlist Weed Control System™

Enlist Duo™ HERBICIDE with COLEX-D TECHNOLOGY

Convenient proprietary blend of 2,4-D choline and glyphosate

- Multiple modes of action in a convenient blend
- Fit for acres where grass control is needed; works well for burndown
- Improved tank stability for a blend that stays mixed

Enlist One™ HERBICIDE with COLEX-D TECHNOLOGY

Straight-goods 2,4-D choline with additional tank-mix flexibility

- 2,4-D choline as the basis for exceptional control
- Compatibility to tank-mix with qualified glufosinate, residual herbicides, insecticides and more
- Customize the ratio of herbicides to match each farm's needs

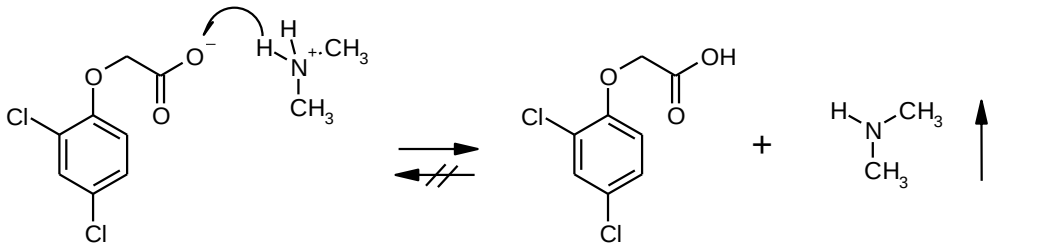
Both with the on-target benefits of 2,4-D choline with Colex-D® technology

APPLICATION RATE	
HERBICIDE	Glyphosate-resistant or hard-to-control weeds
Enlist Duo	4.75 pt./A
Enlist One	2.0 pt./A

Slide courtesy of Corteva

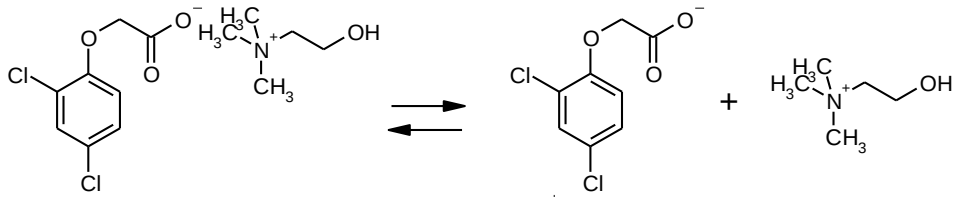
2,4-D choline: Inherently less volatile

2,4-D amine (DMA) breaks apart, leaving behind volatile 2,4-D acid

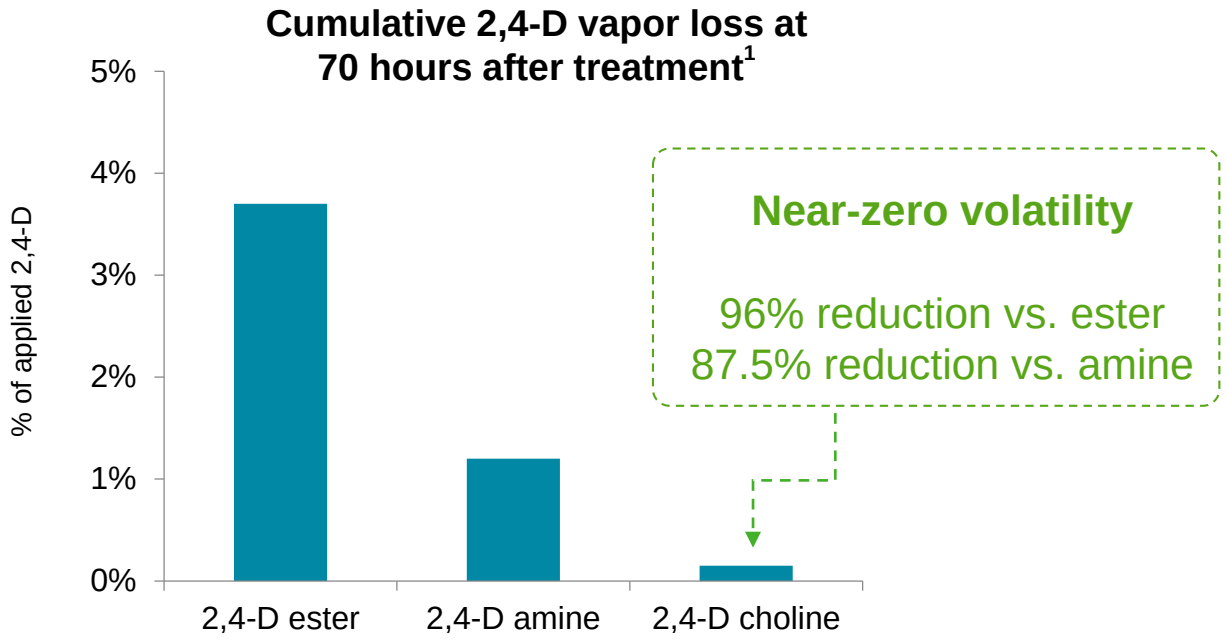


2,4-D amine | **2,4-D acid** | **Amine (vaporizes, leaving acid)**

2,4-D choline is more stable – stays associated



2,4-D choline | **Charged 2,4-D acid** | **Choline salt**



2,4-D choline is inherently less volatile than traditional forms of 2,4-D

Slide courtesy of Corteva

Enlist system

- Start clean with good PRE program
- Weed size still important
- Offers flexibility in POST program and timing

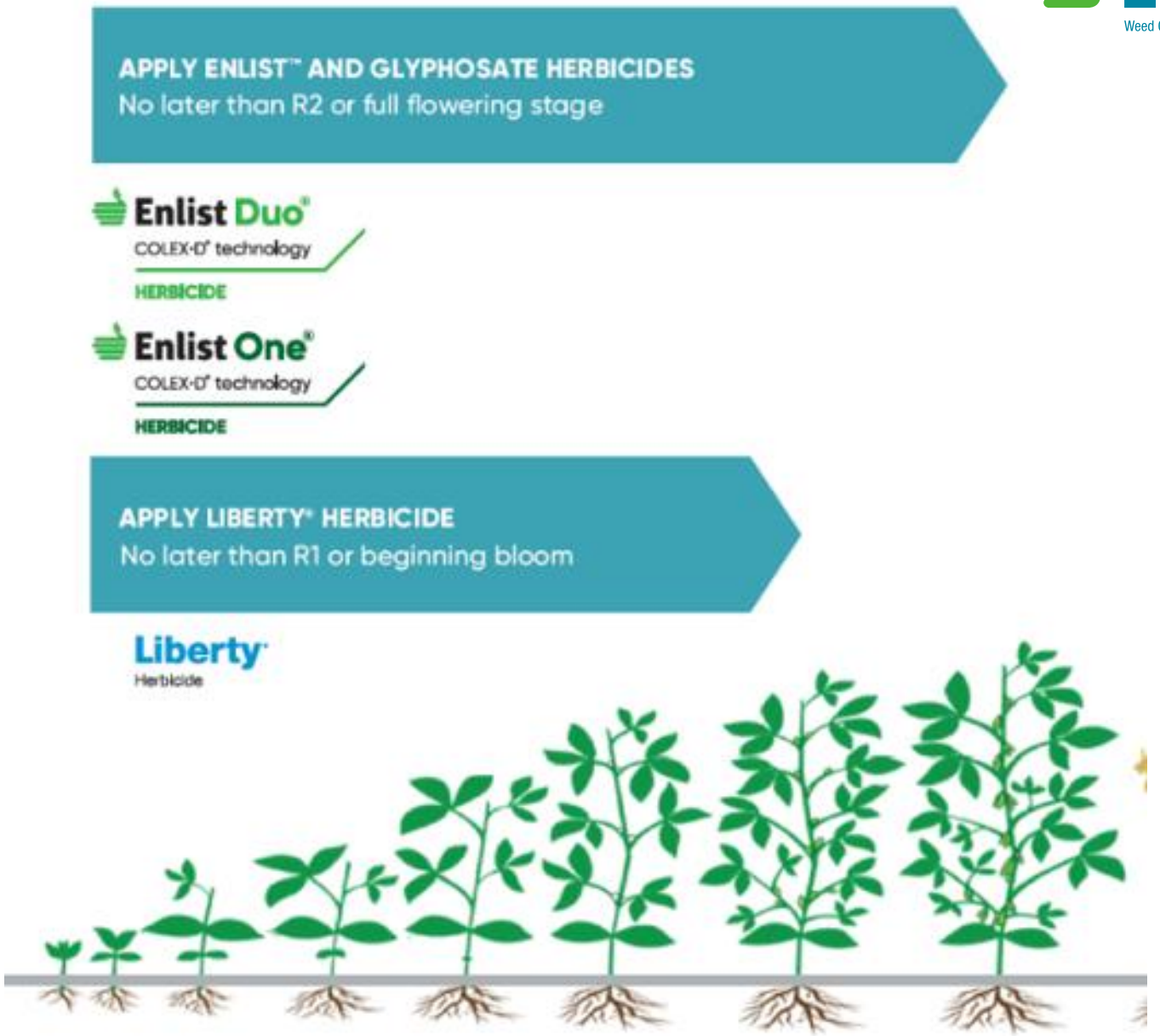


Image courtesy of Corteva

Sensitive area buffers

Sensitive area buffers ARE:

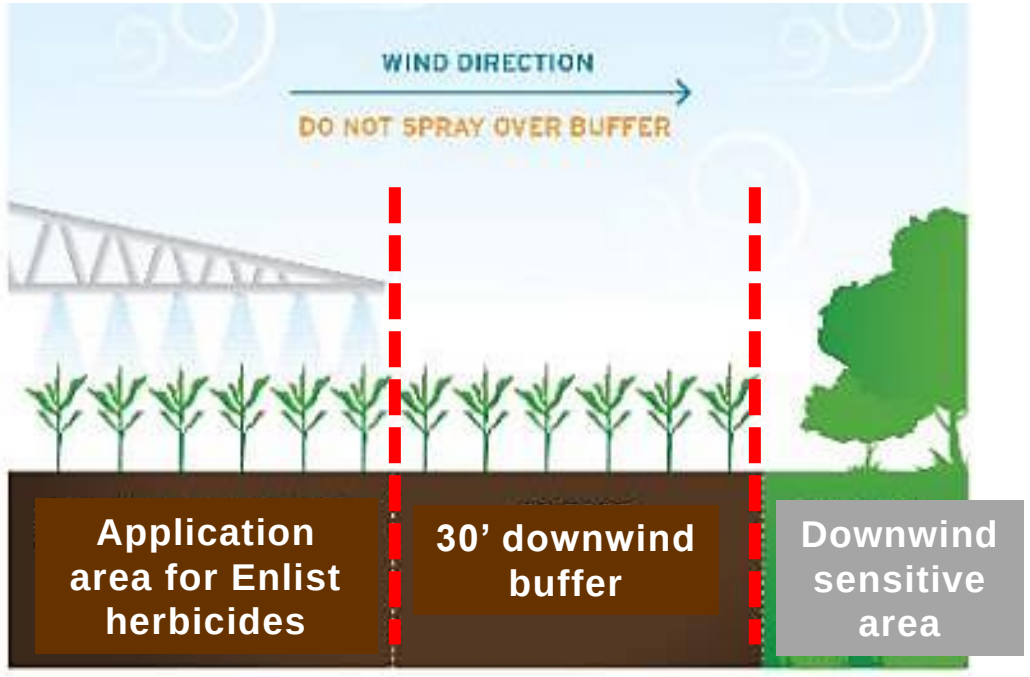
A requirement from EPA to protect potential endangered species habitat areas

Sensitive area examples

- Wooded area
- Pasture
- Roadside ditch
- Lawns

Sensitive area buffers ARE NOT:

Meant to protect downwind adjacent susceptible crops – including non-Enlist cotton

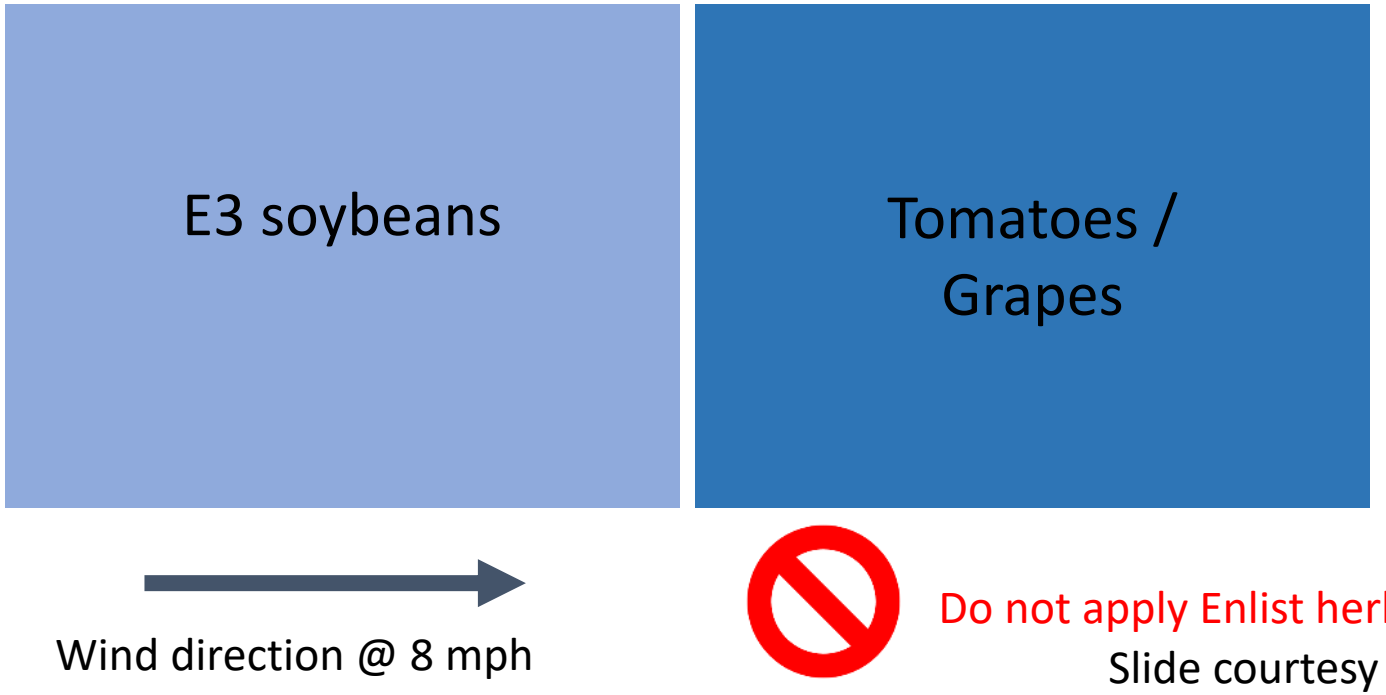


Slide courtesy of Corteva

Watch out for susceptible crops

- **Non-Enlist cotton**
- **Cucurbits** (ex. Watermelons, pumpkins)
- **Tobacco**
- **Grapes**
- **Tomatoes**
- **Fruiting vegetables**

DO NOT SPRAY Enlist herbicides when adjacent susceptible crops are downwind.

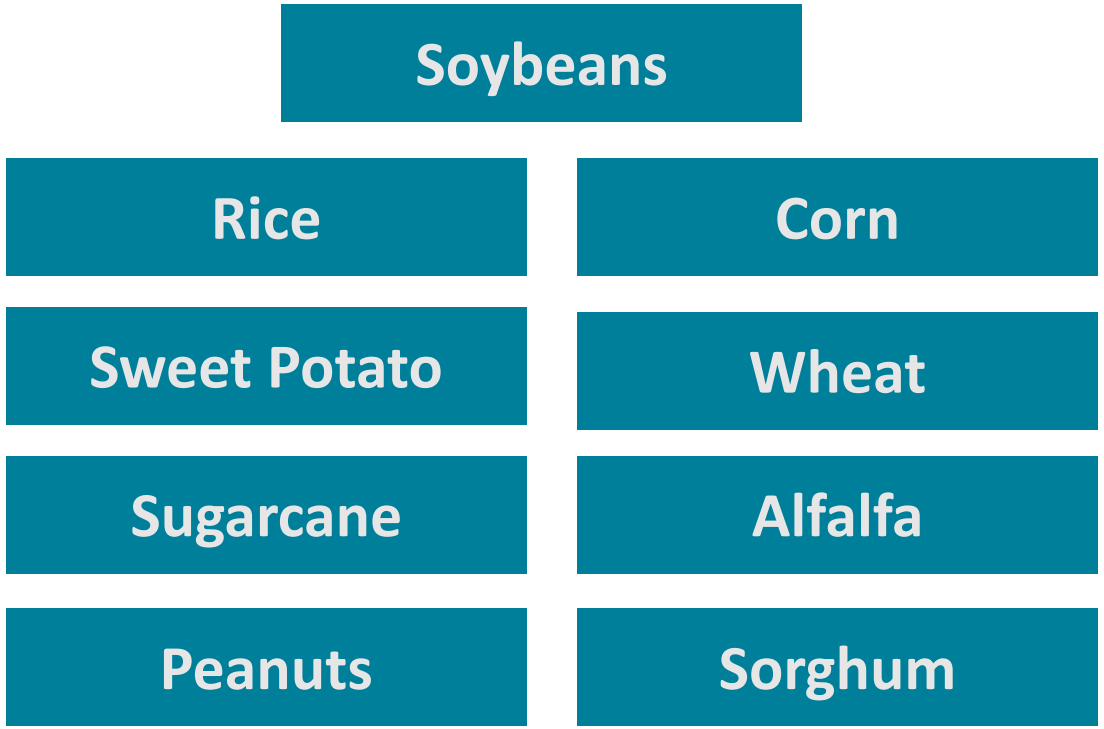


Slide courtesy of Corteva

Key differentiation:

Know the compatible crops

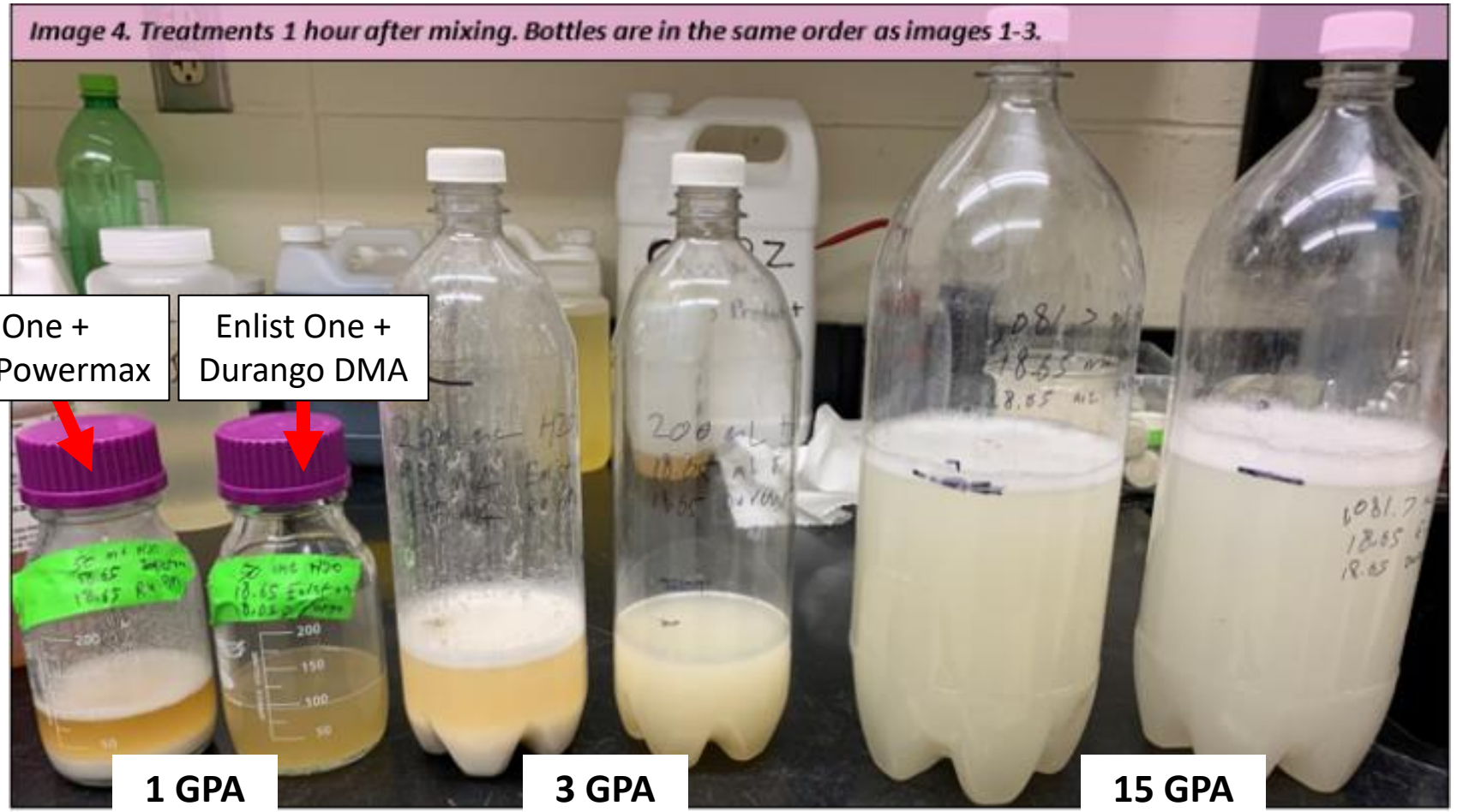
- Key crops that are **not** listed as susceptible on the Enlist labels:



Slide courtesy of Corteva

Carrier Volume Impacts Physical Compatibility

When some potassium salts of glyphosate are mixed with Enlist One in inductor tanks, then the products quickly separate, and a white chalky residue is left behind.



*Courtesy of Joe Ikley, North Dakota State University

Be sure to start with a clean sprayer before mixing a load with Enlist herbicides. Remember the required water carrier volume with Enlist herbicides is 10-15 gallons per acre. For more tips on sprayer setup, see the Enlist herbicides application guide.

LIQUID CARRIER

- Begin with half-full tank of water
- Begin agitation and continue throughout mixing process
- Add products in order:

1. AMS / water conditioning agents
2. Pre-slurry water-soluble packets
3. Wettable powders/dry flowables
4. Compatibility agents
5. Liquid flowables
6. Capsule suspension (CS) or suspension emulsion (SE)
7. Emulsifiable concentrate (EC)
   - Soluble liquids (SL)
   - Enlist Duo® herbicide at 4.75 pt/A
   - Enlist One™ herbicide at 2.0 pt/A – **When mixing with Enlist One, do not pour glufosinate ammonium products or glyphosate potassium into the tank at the same time as Enlist One. Add products one at a time, allowing enough time for recirculation between additions of each separate product.**
   - Glyphosate products
8. Crop Oil Concentrate (COC), NIS, other adjuvants
9. Top off with water carrier

Find the list of qualified tank mix partners at EnlistTankMix.com

- Use a high level of gallonage when mixing
- If mixing with other glyphosate formulations, check compatibility
- Plenty of water in between additions for induction tanks

Last updated 11/7/19

Products listed on EnlistTankMix.com have not been tested for crop response. Listing is not an endorsement of use.

PRINT

The products listed below were tested as required by the conditions of registration for Enlist One and found not to adversely affect the spray drift properties of Enlist One herbicide.

Corteva Agriscience makes no warranties regarding crop tolerance or physical compatibility of tank mixes of these products with Enlist One. Listing is not an endorsement, an agronomic recommendation or an indicator of efficacy.

Corteva partners with the University of Nebraska – Lincoln to provide tank mix testing opportunities. Request information via the "contact us" form.

Products listed are name brand products.

Herbicides

Abundit Edge
Accent Q
ACELLUS ATZ
Afforia
Aim EC
Ankur
Antares Prime
Anthem Flex

Enlist One®
COLEX-D® technology
HERBICIDE
QUALIFIED NOZZLES

Enlist One may only by tank-mixed with products that have been tested and found not to adversely affect the spray drift properties of Enlist One.

DO NOT TANK-MIX ANY PRODUCT WITH Enlist One unless:

1. You check the list of tested products found not to adversely affect the spray drift properties of Enlist One no more than 7 days before applying Enlist One; and
2. The product you tank-mix with Enlist one is identified on that list of tested products.

enlisttankmix.com

Mixing note

Can you mix Enlist, Roundup Powermax, and Liberty together?

Enlist One
Roundup Powermax + Liberty **are listed** as approved tank mix partners

Enlist Duo
Liberty **is not listed** as an approved tank mix partner

Tank cleanout

RINSE 1

1. Completely drain system (including pump, lines and boom) for at least five minutes.
2. Fill tank with clean water to at least 10% of total tank volume.
3. Circulate through entire system at least 15 minutes.
4. Spray out solution through boom/nozzles.

RINSE 2

1. Completely drain system (including lines and spray boom) for at least five minutes.
2. Remove and clean filters and strainers.
3. Fill tank with clean water to at least 10% of total tank volume (including cleaning agents at recommended rates if desired).
4. Circulate through system at least 15 minutes.
5. Let solution stand for several hours, preferably overnight if time allows.
6. Spray out solution through boom/nozzles.

RINSE 3

1. Completely drain system (including lines and boom) for at least five minutes.
2. Fill tank with clean water to at least 10% total tank volume.
3. Circulate through entire system at least 15 minutes.
4. Spray out solution through boom/nozzles.
5. Completely drain spray system, remove and clean nozzle tips and strainers separately.

Enlist sprayer cleanout guide

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN-MADISON

Definition of Drift

"Movement of spray particles and vapors off-target causing less effective control and possible injury to susceptible vegetation, wildlife, and people."

Adapted from National Coalition on Drift Minimization 1997 as adopted from the AAPCO Pesticide Drift Enforcement Policy - March 1991

Types of Drift:

- **Particle drift:** movement of spray particles during or after the spray application

  → nozzle selection, wind speed and direction, boom height, *temperature inversions*

- **Vapor drift:** associated with volatilization (gas, fumes);

  → temperature, formulation, wind speed and direction, *temperature inversions*

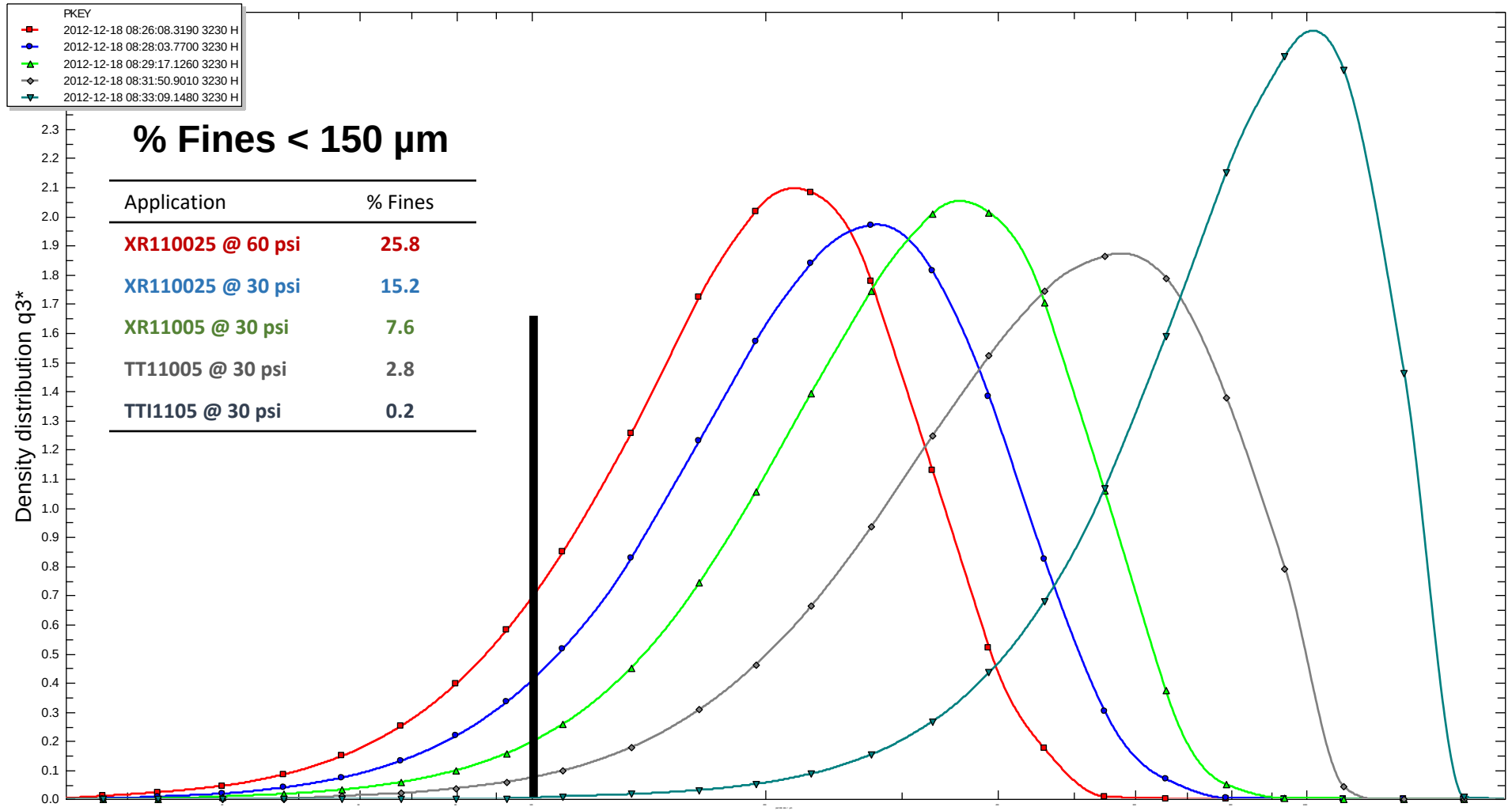
How far will particles go?

Droplet	Diameter (in μm)	Time to fall 10 ft	Travel distance in 3 mph wind
Fog	5	66 min	15,840 ft
Very fine	20	4.2 min	1,100 ft
Fine	100	10 sec	44 ft
Medium	240	6 sec	28 ft
Coarse	400	2 sec	8.5 ft
Fine rain	1,000	1 sec	< 5 ft

Source: *Herbicide Spray Drift,* NDSU Extension

*Slide courtesy of Dr. Greg Kruger, University of Nebraska-Lincoln

Particle Drift - Nozzle Selection

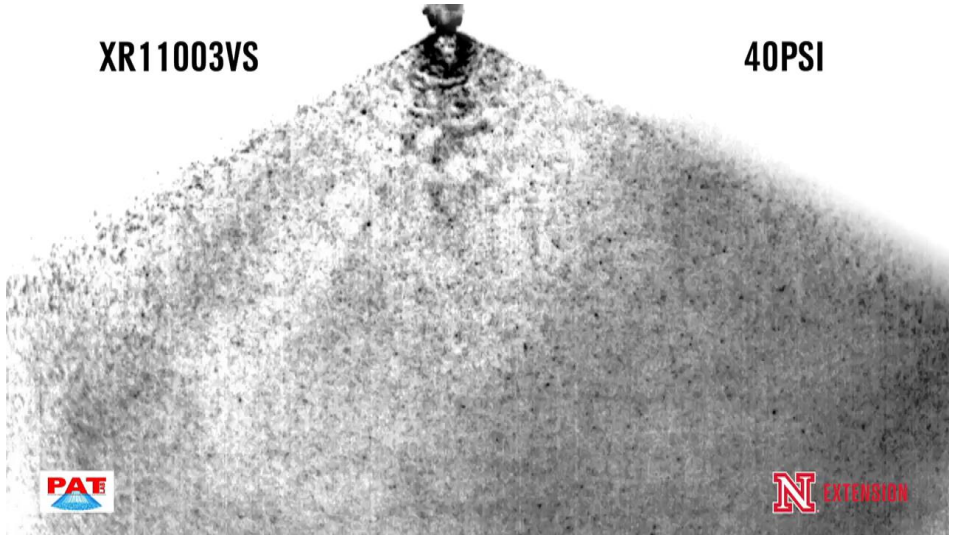


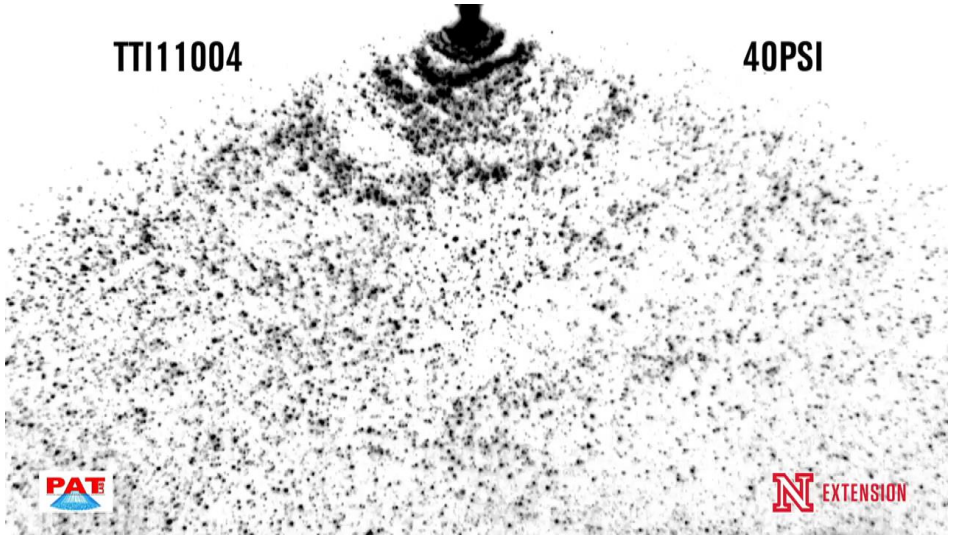
% Fines < 150 µm

Application	% Fines
XR110025 @ 60 psi	25.8
XR110025 @ 30 psi	15.2
XR11005 @ 30 psi	7.6
TT11005 @ 30 psi	2.8
TTI1105 @ 30 psi	0.2

*Slide courtesy of Dr. Greg Kruger, University of Nebraska-Lincoln

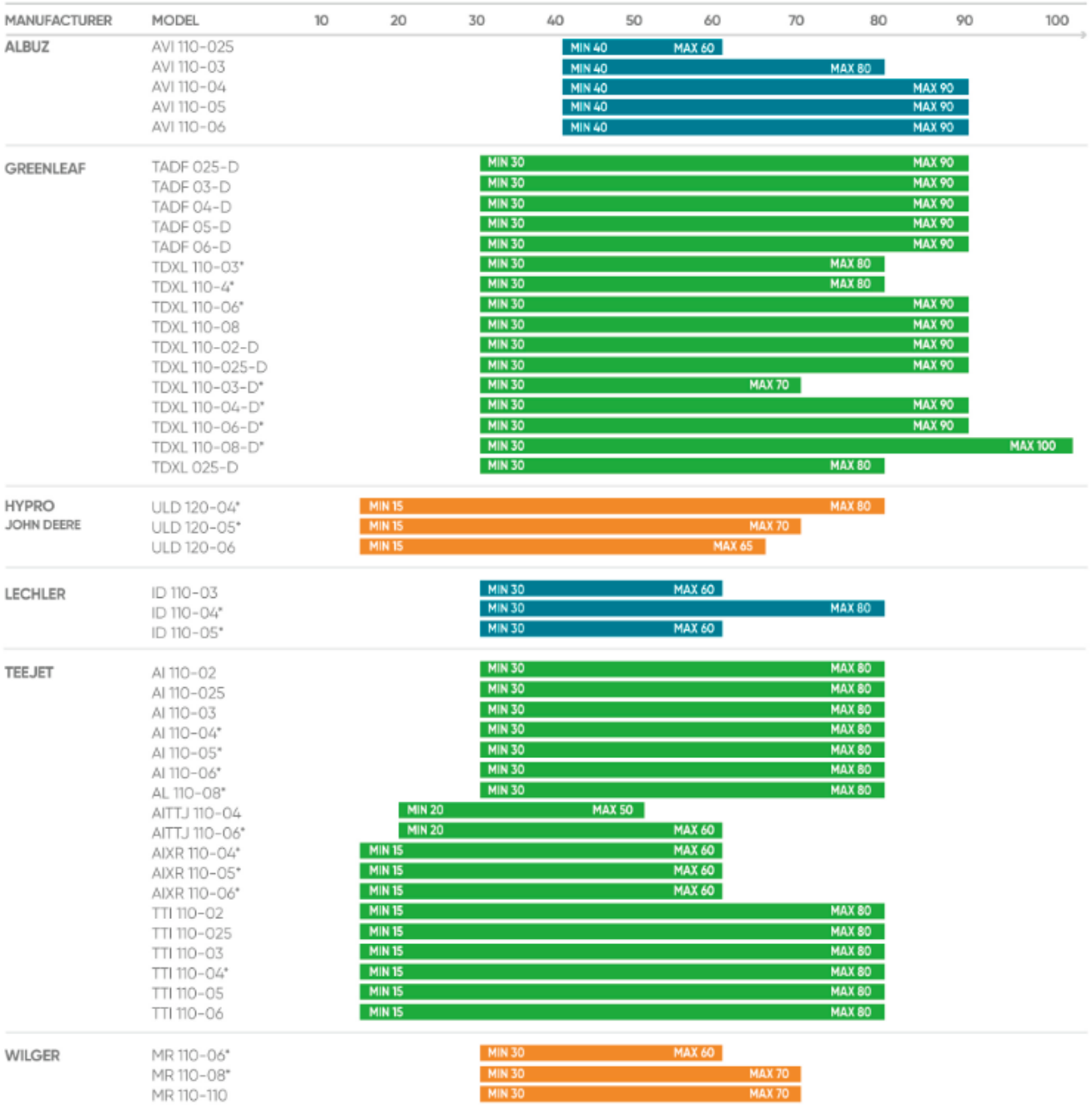
Particle Drift - Nozzle Selection





*Slide courtesy of Dr. Greg Kruger, University of Nebraska-Lincoln

Enlist One® herbicide *LABELED NOZZLES WITH PRESSURE RANGES (PSI)*

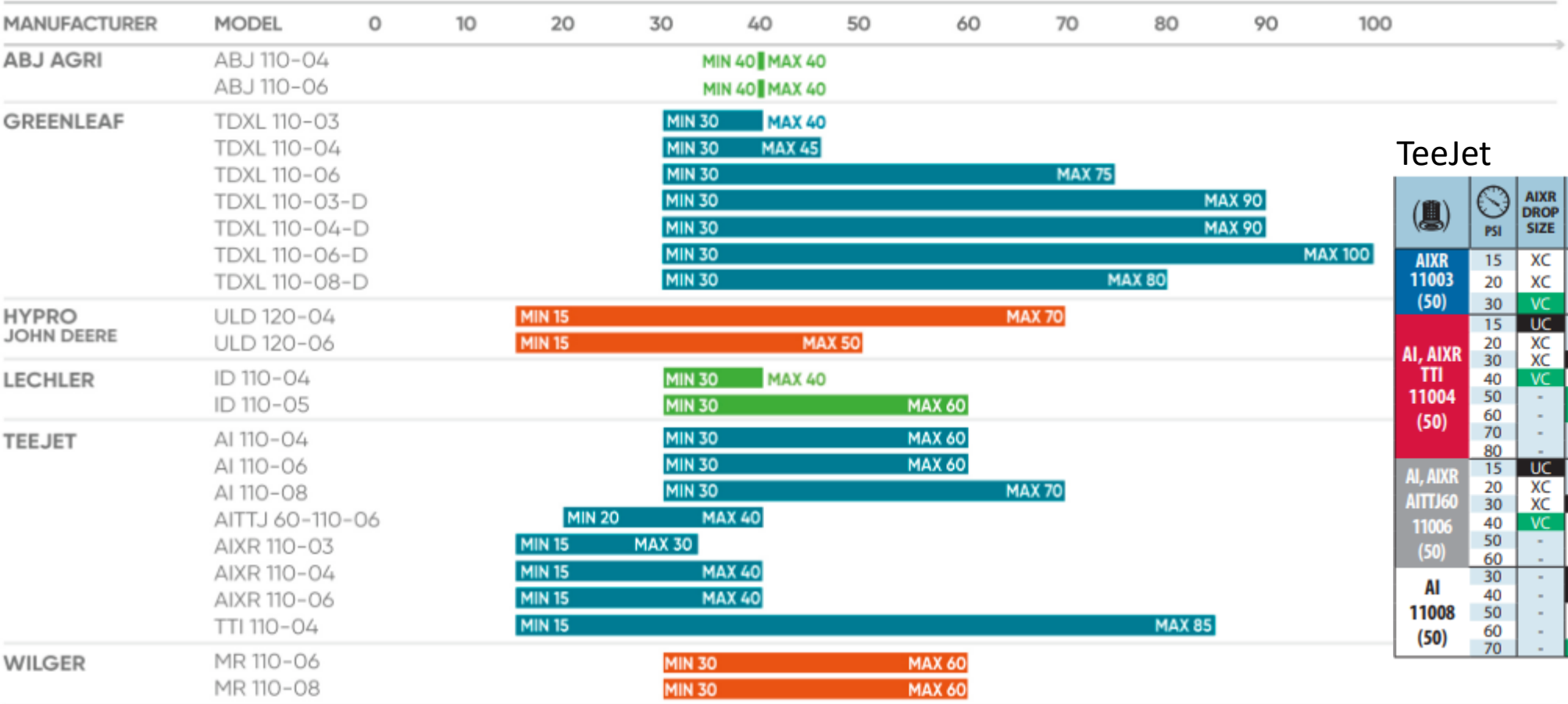


* Indicates nozzle also qualified with Enlist Duo herbicide.

https://www.enlist.com/en/approved-tank-mixes/enlist-one/enlist-one-allowable-nozzles.html

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN-MADISON

Enlist Duo® herbicide *LABELED NOZZLES WITH PRESSURE RANGES (PSI)*



TeeJet

	PSI	AIXR DROP SIZE	AI DROP SIZE	AITTJ60 DROP SIZE	TTI DROP SIZE	CAPACITY ONE NOZZLE IN GPM	CAPACITY ONE NOZZLE IN OZ/MIN
AIXR 11003 (50)	15	XC	-	-	-	0.18	23
	20	XC	-	-	-	0.21	27
	30	VC	-	-	-	0.26	33
AI, AIXR TTI 11004 (50)	15	UC	-	-	UC	0.24	31
	20	XC	-	-	UC	0.28	36
	30	XC	UC	-	UC	0.35	45
	40	VC	XC	-	UC	0.40	51
	50	-	VC	-	UC	0.45	58
	60	-	VC	-	UC	0.49	63
	70	-	-	-	XC	0.53	68
	80	-	-	-	XC	0.57	73
AI, AIXR AITTJ60 11006 (50)	15	UC	-	-	-	0.37	47
	20	XC	-	UC	-	0.42	54
	30	XC	UC	XC	-	0.52	67
	40	VC	XC	VC	-	0.60	77
	50	-	XC	-	-	0.67	86
	60	-	XC	-	-	0.73	93
AI 11008 (50)	30	-	UC	-	-	0.69	88
	40	-	UC	-	-	0.80	102
	50	-	XC	-	-	0.89	114
	60	-	XC	-	-	0.98	125
	70	-	VC	-	-	1.06	136

https://www.enlist.com/en/approved-tank-mixes/enlist-duo-allowable-nozzles.html

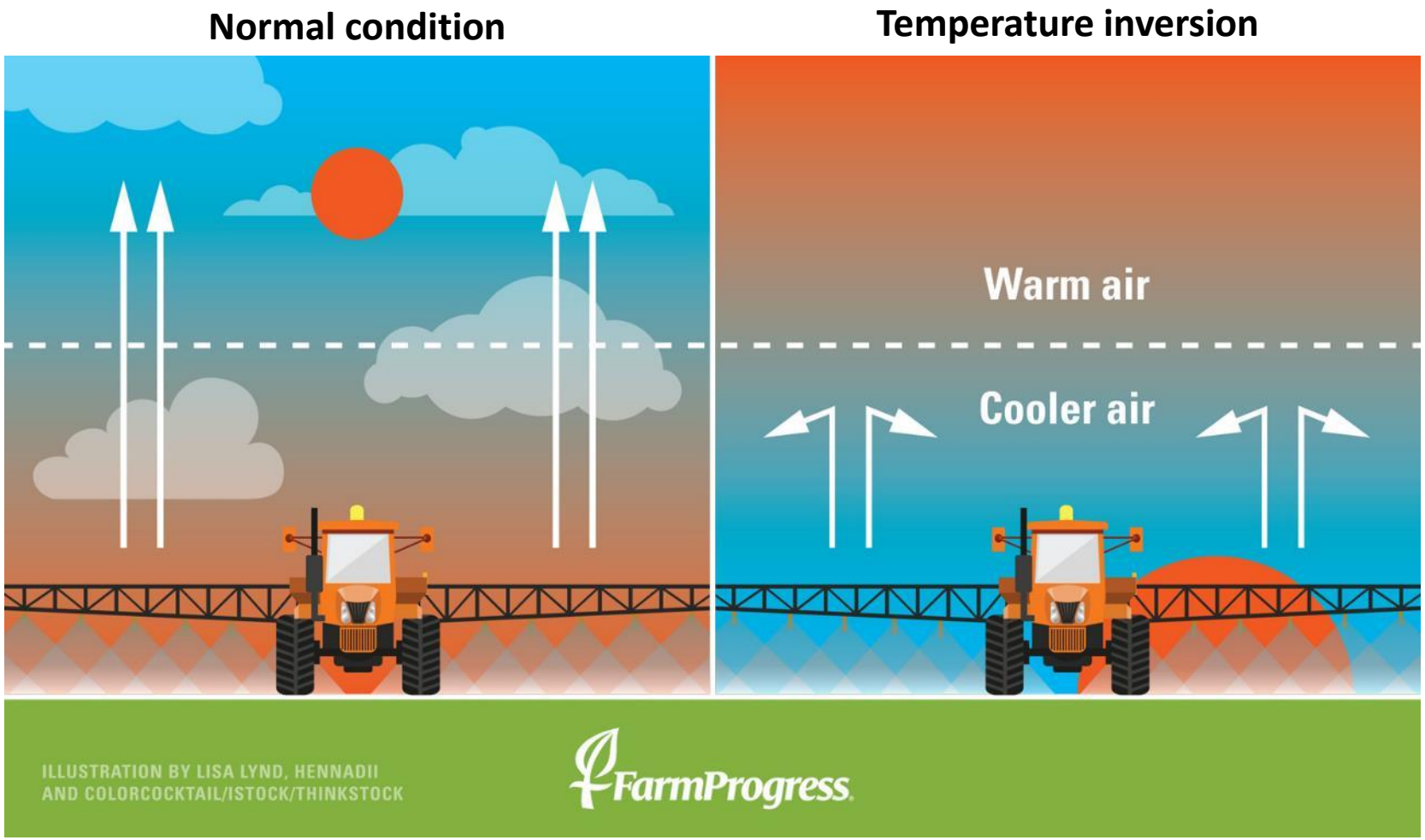
Weather considerations

- Wind speed restrictions – under 15 mph
- High temperature + low relative humidity = greater risk for vapor drift
- Temperature inversions

Temperature Inversions

Applications should not occur during a local, low level temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of the smoke from a ground source generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Temperature Inversion



http://www.missouriruralist.com/weather/8-things-about-temperature-inversion-you-should-know-now

How Common are Surface Temperature Inversions in Northwest Missouri?

Northwest Missouri

	Number of Inversions[a]		Typical Start Time[b]	
	2015	2016	2015	2016
March	24	15	5:00 to 6:00 p.m.	5:00 to 6:00 p.m.
April	23	13	6:00 to 7:00 p.m.	6:00 to 7:00 p.m.
May	15	24	6:00 to 7:00 p.m.	6:00 to 7:00 p.m.
June	13	29	6:00 to 7:00 p.m.	6:00 to 7:00 p.m.
July	12	14	6:00 to 8:00 p.m.	7:00 to 8:00 p.m.

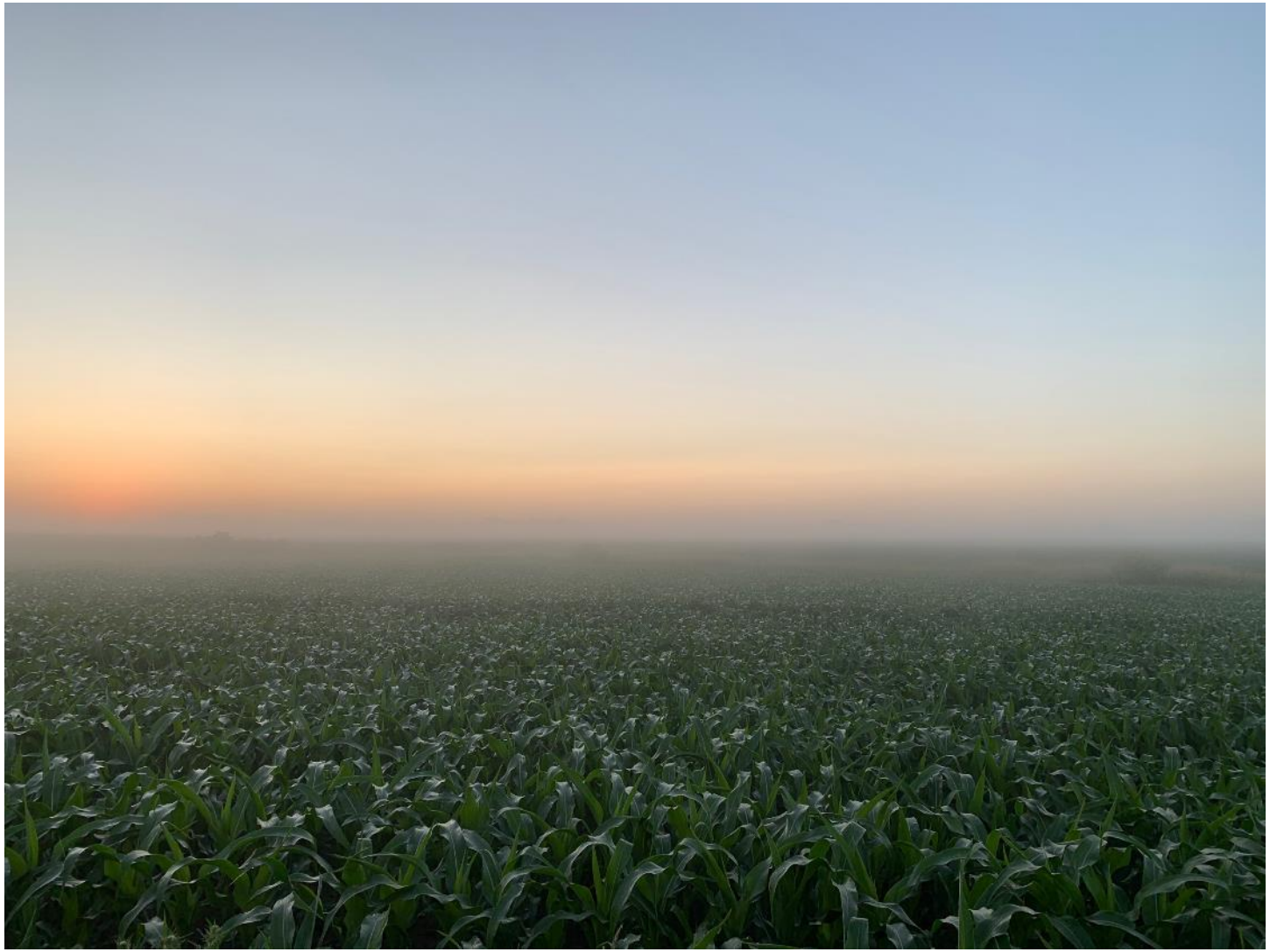
[a]Inversions were classified as air temp at 46 cm above surface < air temp at 168 cm < air temp at 305 cm; temperature differences had to occur for > 1 hour in duration and intensity had to be > 1.0°C between 305 and 46 cm air temperatures.

[b]Mode was used to determine typical start times

Bish and Bradley, unpublished

*Slide courtesy of Dr. Kevin Bradley, University of Missouri

Temp Inversion (07/12/2019, Dane County, WI at Sunrise)



Using Smoke Grenades to Validate our Inversion Modeling (June 8, 2017)

Released at 4:00, No Inversion Present

Released at 7:30, Inversion Present

*Slide courtesy of Dr. Kevin Bradley, University of Missouri

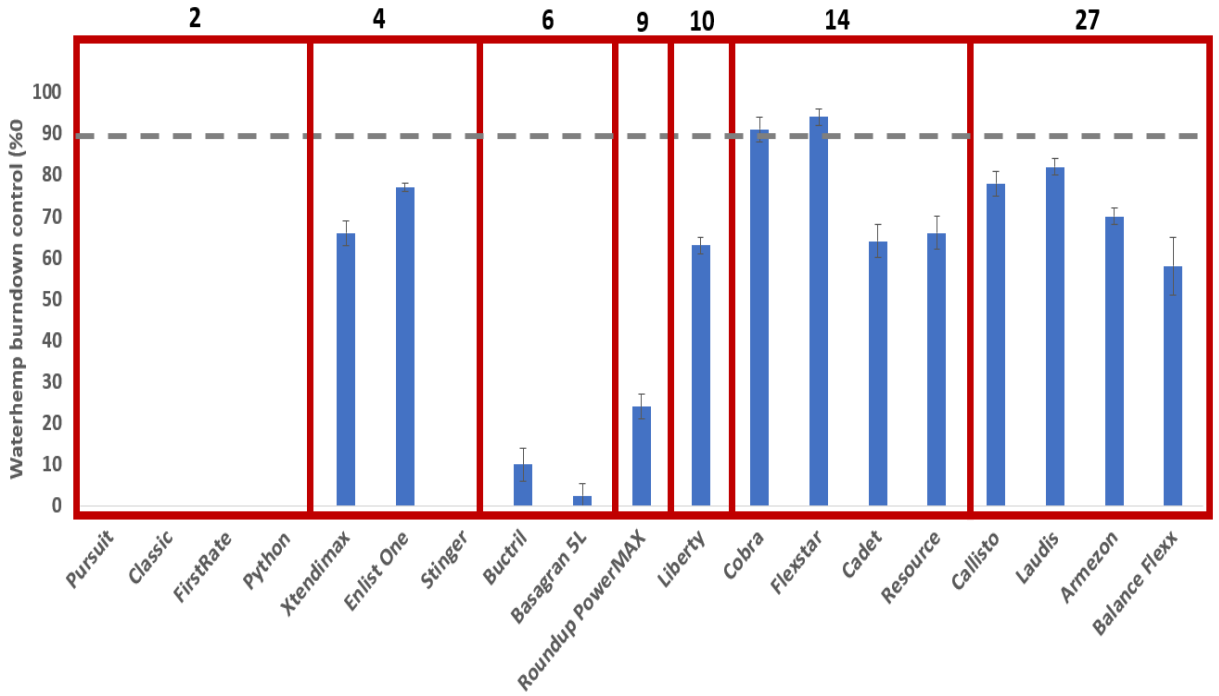
Getting the Most out of 2,4-D

1. Start clean & use an effective PRE-emergence herbicide
2. Spray small weeds & consider a layered-residual approach
3. Large droplet size
4. Understand the landscape (be aware of sensitive areas)
5. **Follow label requirements by the book!**
   - Tank-mix partners
   - Nozzle selection
   - Weather/Time of day restrictions

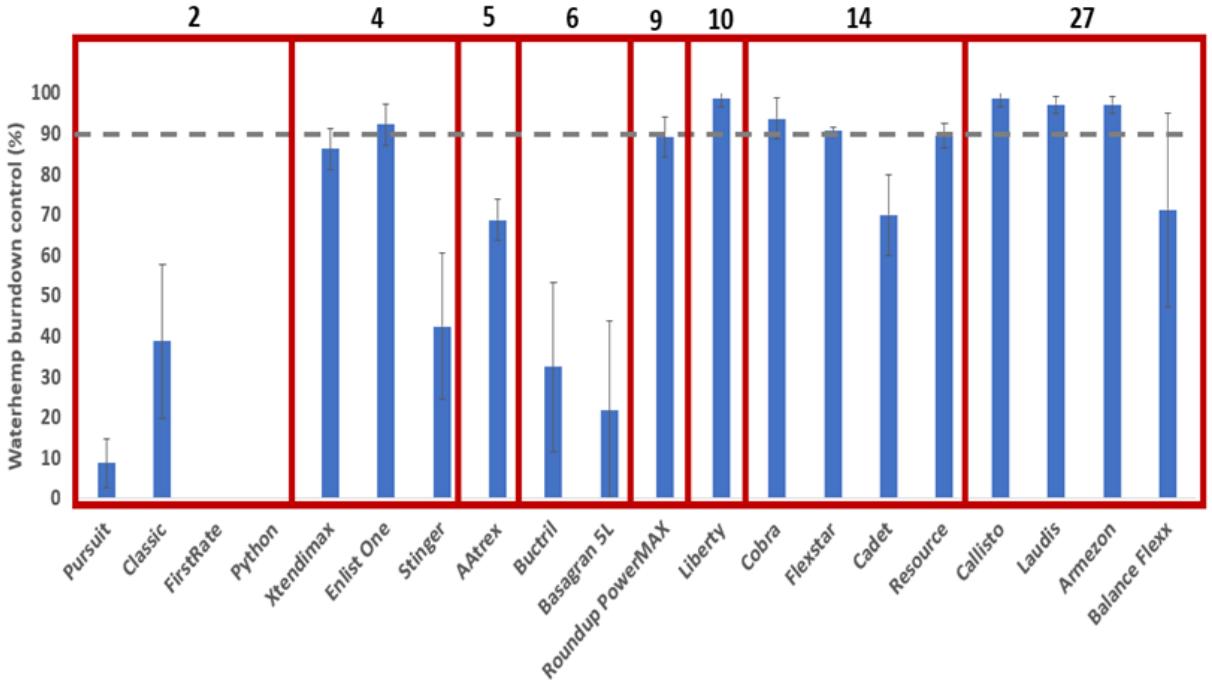
Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN-MADISON

Waterhemp Burndown Control 14 DAT

Brooklyn, WI 2019



Lancaster, WI 2019



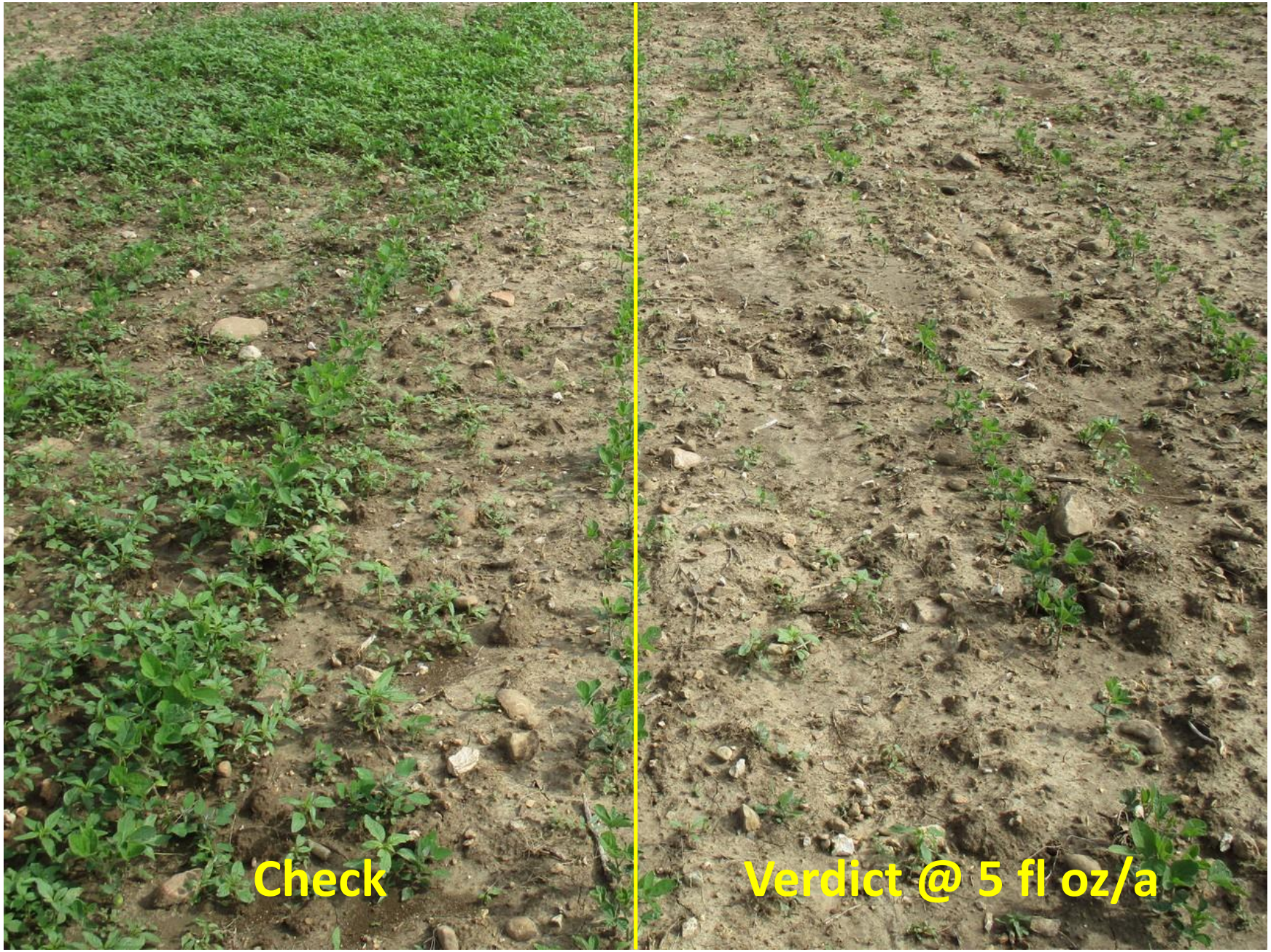
Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN-MADISON

19-BRO-SB17

- Sponsor: BASF
- Enlist E3 Soybean, dominant species: waterhemp
- **EPOST:** 7/1 - 1-3” weeds/V2 soybean
- **LPOST:** 7/18 - 1-4” weeds/R1 soybean
- Treatments
  - **Verdict @ 5 fl oz/a** was applied to all treatments PRE

Enlist Duo @ 56 fl oz/a	**2-pass** PRE *fb* EPOST
Liberty @ 32 fl oz/a + Roundup PM @ 32 fl oz/a + AMS @ 3 lb/a	
Liberty @ 32 fl oz/a + Enlist One @ 24 fl oz/a + AMS @ 3 lb/a	
Liberty @ 32 fl oz/a + Enlist One @ 24 fl oz/a + Roundup PM @ 32 fl oz/a + AMS @ 3 lb/a	
Liberty @ 32 fl oz/a + Roundup PM @ 32 fl oz/a + AMS @ 3 lb/a *followed by* Enlist Duo @ 56 fl oz/a	**3-pass** PRE *fb* EPOST *fb* LPOST
Enlist Duo @ 56 fl oz/a *followed by* Liberty @ 32 fl oz/a + Roundup PM @ 32 fl oz/a + AMS @ 3 lb/a	

Plots at E POST application: 7/1



0%

Check

43%

Verdict @ 5 fl oz ***fb***
Enlist Duo @ 56 fl oz

25%

Verdict @ 5 fl oz ***fb***
Liberty @ 32 fl oz +
Roundup @ 32 fl oz +
AMS: 3 lb/a

70%

Verdict @ 5 fl oz ***fb***
Liberty @ 32 fl oz +
Enlist One @ 24 fl oz +
AMS: 3 lb/a

0%

Check

43%

Verdict @ 5 fl oz ***fb***
Enlist Duo @ 56 fl oz

91%

Verdict @ 5 fl oz ***fb***
Enlist Duo @ 56 fl oz ***fb***
Liberty@ 32 fl oz + Roundup@ 32 fl oz
+ AMS: 3 lb/a

0%

Check

25%

Verdict @ 5 fl oz ***fb***
Liberty@ 32 fl oz + Roundup@ 32 fl oz
+ AMS: 3 lb/a

95%

Verdict @ 5 fl oz ***fb***
Liberty@ 32 fl oz + Roundup@ 32 fl oz
+ AMS: 3 lb/a ***fb***
Enlist Duo @ 56 fl oz

Performance in 2019 Low Tunnel Volatility Trial

- Growth regulator herbicides (such as dicamba and 2,4-D) commonly used post-emergence (POST) in corn, and recently, resistant varieties of soybeans and cotton
- Numerous cases of growth regulator injury in susceptible varieties and species
  - Due to misapplication, particle drift, and secondary movement

Objective: Investigate the impact inclusion of glyphosate in tank mix has on secondary movement of dicamba and 2,4-D.

Materials and Methods

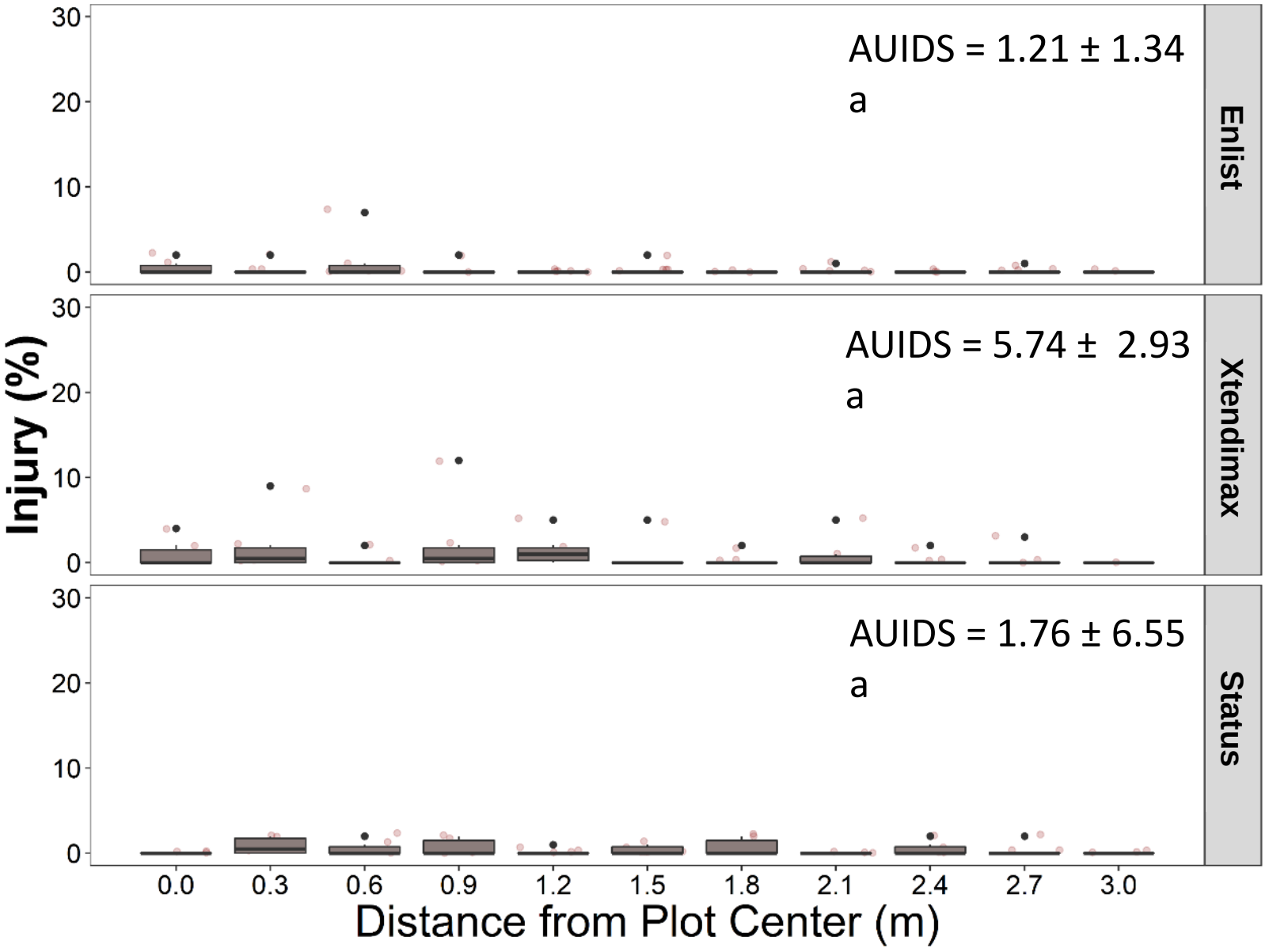
- Arlington, Wisconsin, 2019; replicated twice
- Simulated two application times in the season (early versus late), organized in a RCBD with three replications
- Seven treatments including one nontreated control (NTC)

1	Xtendimax with Vaporgrip® (88 fl oz./ac.)	**4**	+ Roundup Powermax (113 fl oz/ac.)
2	Status (20 oz./ac.)	**5**	
3	Enlist One (96 fl oz./ac.)	**6**	Enlist Duo (224 fl oz./ac.)

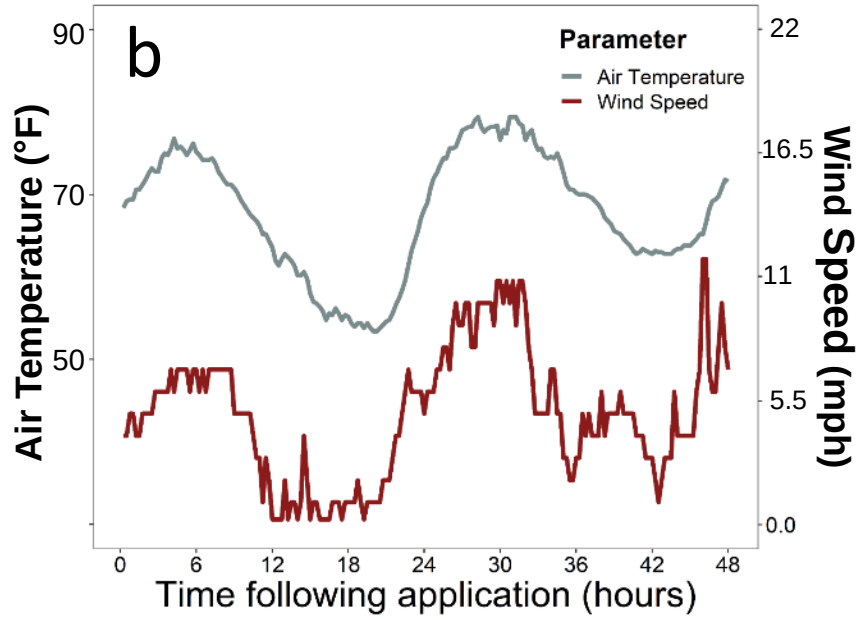
Materials and Methods

- Soils flats sprayed off-site and placed into center of low-tunnels constructed over susceptible soybeans at V3-V4 for 48 hours
- Visual injury 0-100% collected 28 days after flat placement
- Data analyzed in R version 3.5.2
  - Injury data used to estimate "Area under the Injury over Distance stairs"

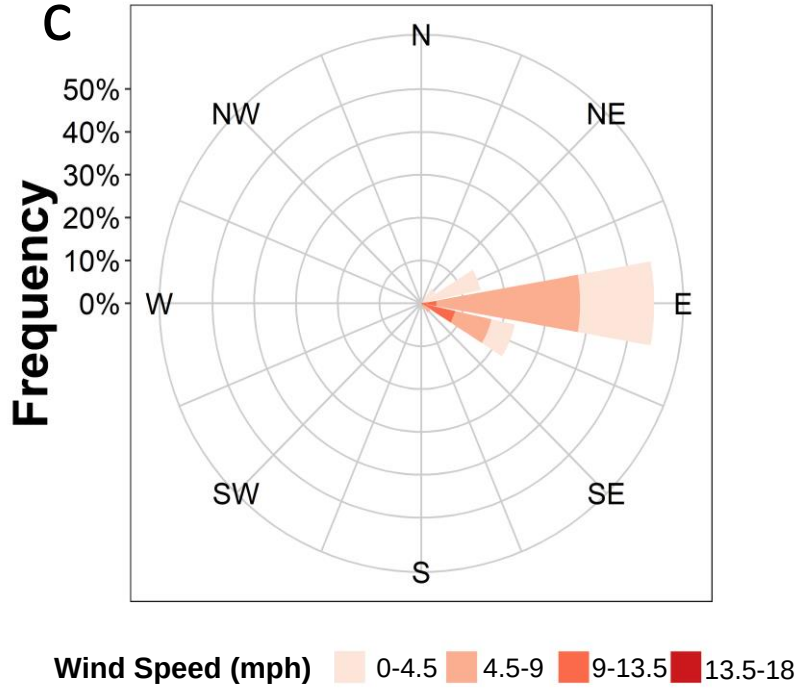
a **Early Application, Run 1** **Application: 6/21/2019**

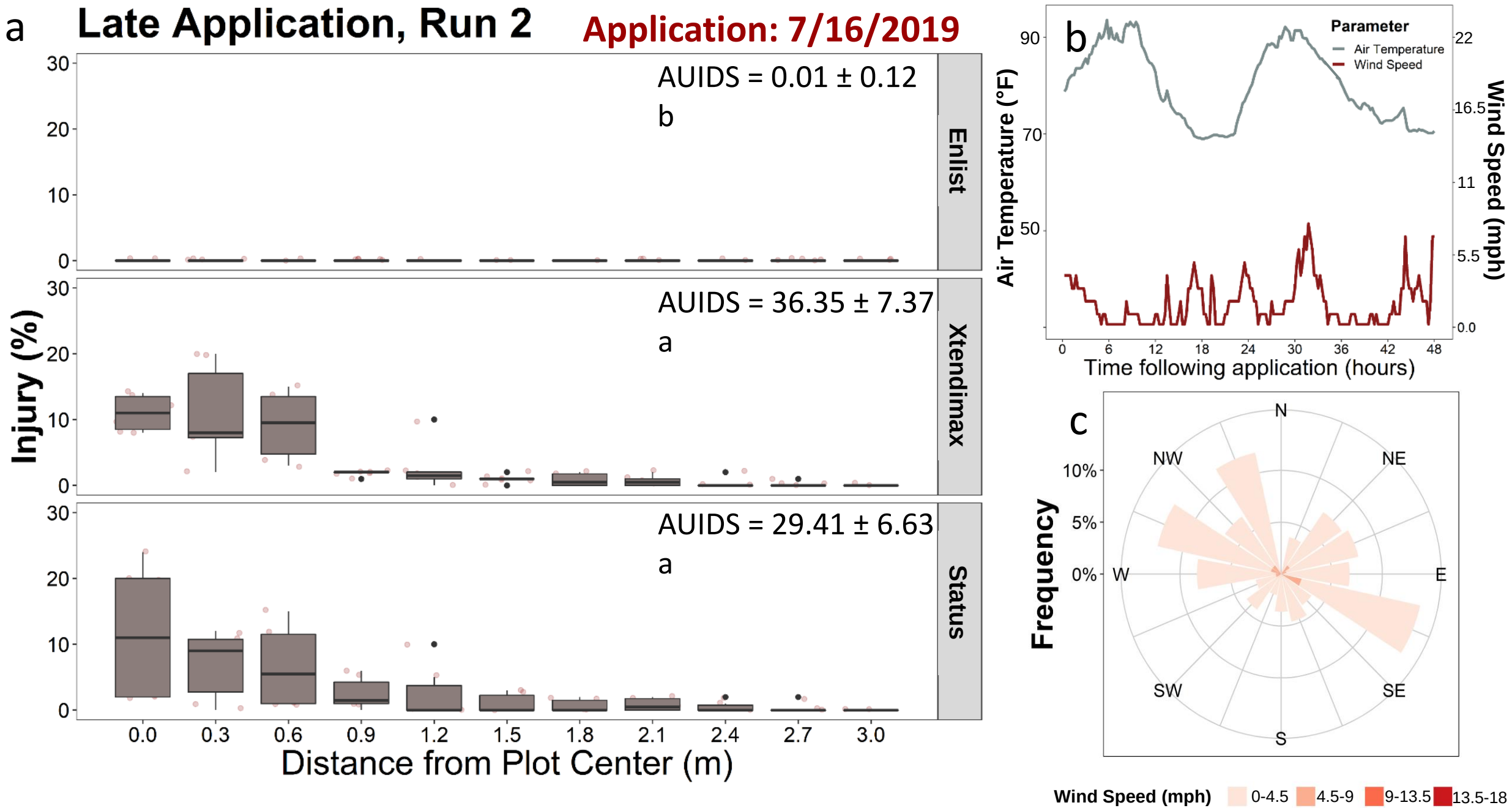


b



c




a
Late Application, Run 2
Application: 7/16/2019
AUIDS = 0.01 ± 0.12
b
Enlist
AUIDS = 36.35 ± 7.37
a
Xtendimax
AUIDS = 29.41 ± 6.63
a
Status
Injury (%)
0
10
20
30
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
Distance from Plot Center (m)
b
Parameter
Air Temperature
Wind Speed
Air Temperature (°F)
Wind Speed (mph)
90
70
50
22
16.5
11
5.5
0.0
0
6
12
18
24
30
36
42
48
Time following application (hours)
c
Frequency
10%
5%
0%
N
NE
E
SE
S
SW
W
NW
Wind Speed (mph)
0-4.5
4.5-9
9-13.5
13.5-18

Summary

- Presence/absence of glyphosate did not impact injury
- Xtendimax treatments typically showed the most injury, but Status showed comparable injury especially during adverse conditions
  - 2,4-D treatments showed minimal to no symptomology for all application times
- Weather conditions following application seem to be a driving factor

Take Home

- **Know the label & follow it**
- Practice good herbicide-resistant trait stewardship
- Prevent particle drift
- Be aware of nearby susceptible crops

Extension
UNIVERSITY OF WISCONSIN-MADISON

College of
Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON
Growing the future

NPM

WISCONSIN SOYBEAN MARKETING BOARD

Wisconsin CORN

USB UNITED SOYBEAN BOARD

CHEMICAL COMPANIES

BRIEN HYBRIDS

Thanks!

Rodrigo Werle, Ph.D.
Assistant Professor & Weed Specialist
UW-Madison|UW-Extension

Email: rwerle@wisc.edu
Phone: 608-262-7130
Twitter: @WiscWeeds
Blog: WiscWeeds.info

Questions?