Great glufosinate applications

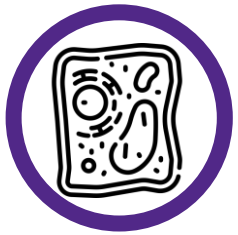
Sarah Lancaster

Assistant Professor and Extension Specialist
Department of Agronomy
Kansas State University

Information from Takano and Dayan. 2020. Glufosinate-ammonium: a review of the current state of knowledge

Outline

Glufosinate advances

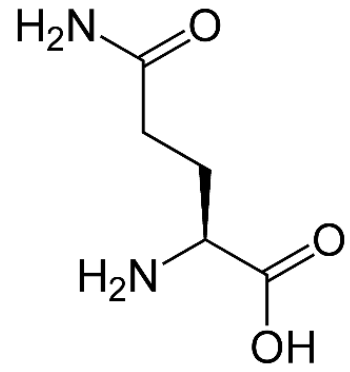


Glufosinate activity

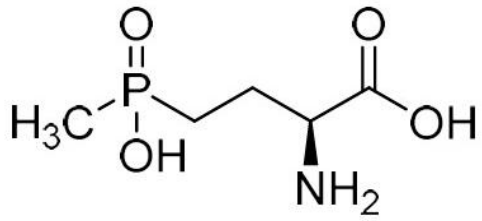
Glufosinate applications

Discovery

- Discovered by researchers studying bacteria Streptomyces
- Considered a ‘natural product’ because molecule is similar to amino acid glutamine



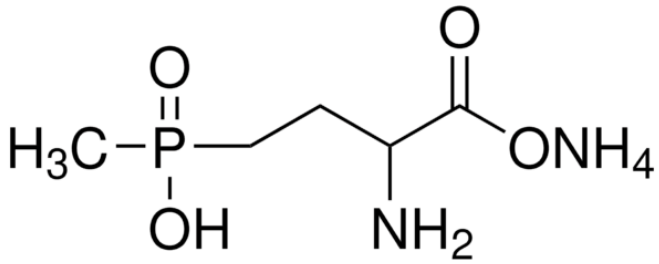
L-glutamine



L-glufosinate

Commercialization

- First commercialized in 1993 (Ignite)
- Liberty Herbicide registered in 1997
- Usually formulated as ammonium salt

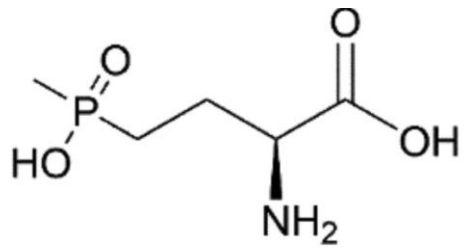


Glufosinate ammonium

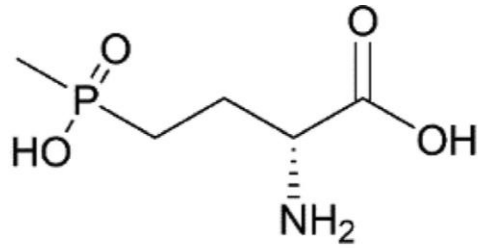
Commercialization

- First commercialized as a mixture of L-glufosinate (active form) and D-glufosinate

- Some current glufosinate formulations include:
  - Cheetah
  - Fever
  - Forfeit
  - Inflame
  - Interline
  - Liberty Ultra
  - Scout
  - Surmise
  - Total



L-glufosinate



D-glufosinate

Liberty Ultra

- Purified formulation
  - Commercialized in 2025
    - Interline Mega expected in 2026
- Liberty Ultra label first released with EPA's Herbicide Strategy
  - More detailed drift and runoff mitigation requirements
- Label change for 2026:
  - Application rate:
    - 19 fl oz – ~~29 fl oz~~ 34 fl oz
    - ~~58 fl oz/yr~~ 69 fl oz/yr maximum

The Herbicide Strategy

Finalized August 2024

Only affects agricultural uses of conventional herbicides

Intended to increase the efficiency of consultations with FWS required for EPA ‘actions’

Not self-implementing

Two big areas:
- Drift mitigation and Runoff mitigation

Drift mitigation

Percentage reduction in buffer distance

Combine reductions from multiple measures

Coarser droplet size
Drift reducing adjuvant
Hooded sprayers
Downwind windbreaks
Treating a reduced proportion of the field
Reducing the application rate
Relative humidity greater than 60% at time of application

Runoff reduction requirements

May require 0 to 9 points on label

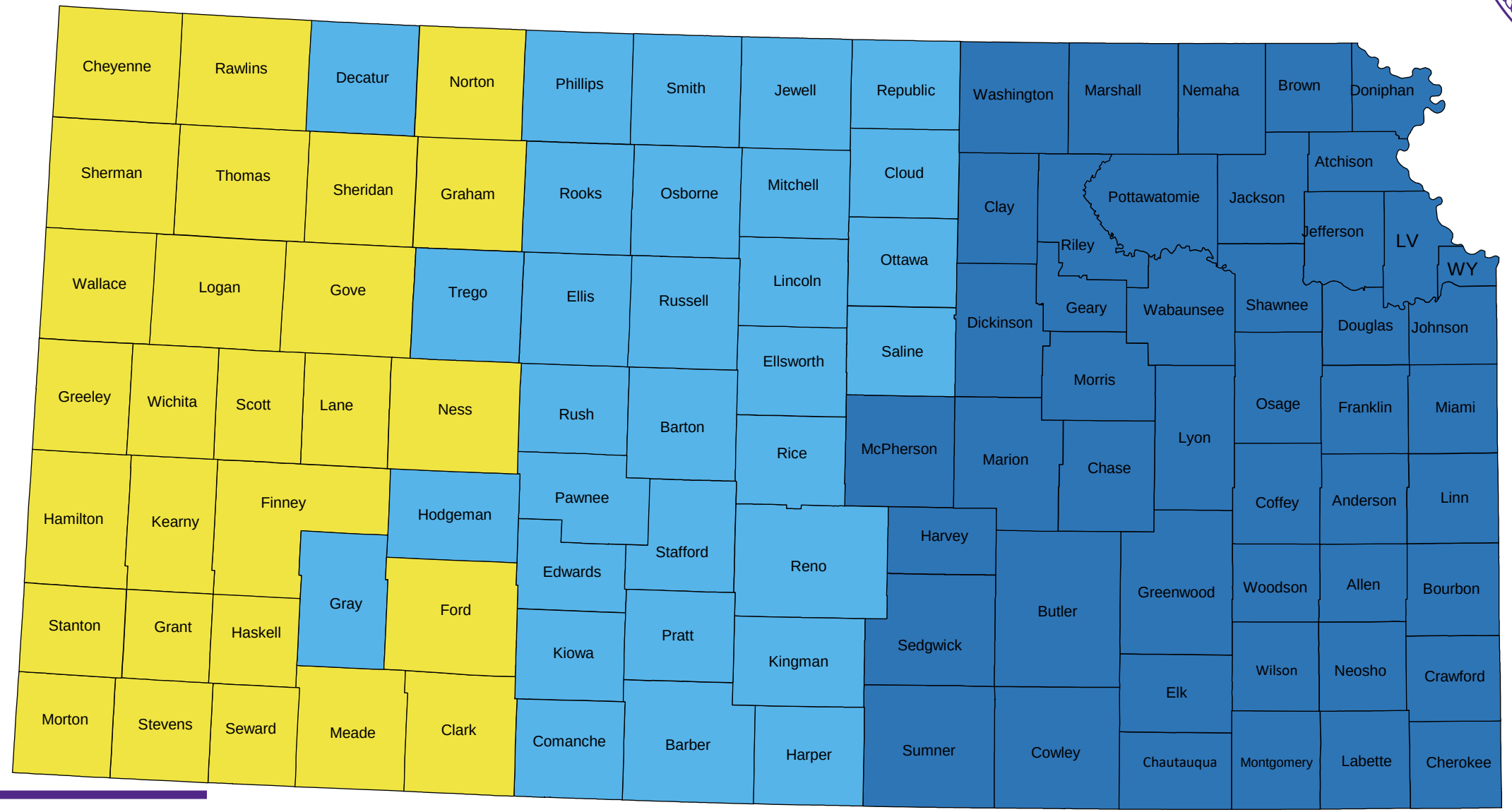
Mitigation Menu Website:
https://www.epa.gov/pesticides/mitigation-menu

Not required IF:

- Permanent berms
- Irrigation tailwater return
- Subsurface or tile drains with a water control structure and controlled outlet
- Areas with 1,000 ft down-gradient are entirely ‘managed’

Runoff mitigation relief

Low vulnerability: 3 points Medium vulnerability: 2 points High vulnerability: 0 points



Runoff mitigation

Field characteristics	Points
Slope ≤ 3%	2
Sandy soils	2
Farm management practices	
Tracking mitigation practices	1
Follow recommendation from a runoff/erosion specialist[1] or Participate in a qualifying conservation program	1 or 2
Application parameters	
Use an annual application lower than the maximum (but at least the minimum labeled rate)	1 – 10 to 29% reduction 2 – 30 to 59% reduction 3 – ≥60% reduction
Reduce the portion of the field treated	2 – 10 to 29% reduction 3 – 30 to 59% reduction 4 – ≥60% reduction
Soil incorporation (if not recommended on the label)	1

[1]Includes NRCS staff, Certified TSPs CCAs, CPAg, NAICC members, and Extension agents

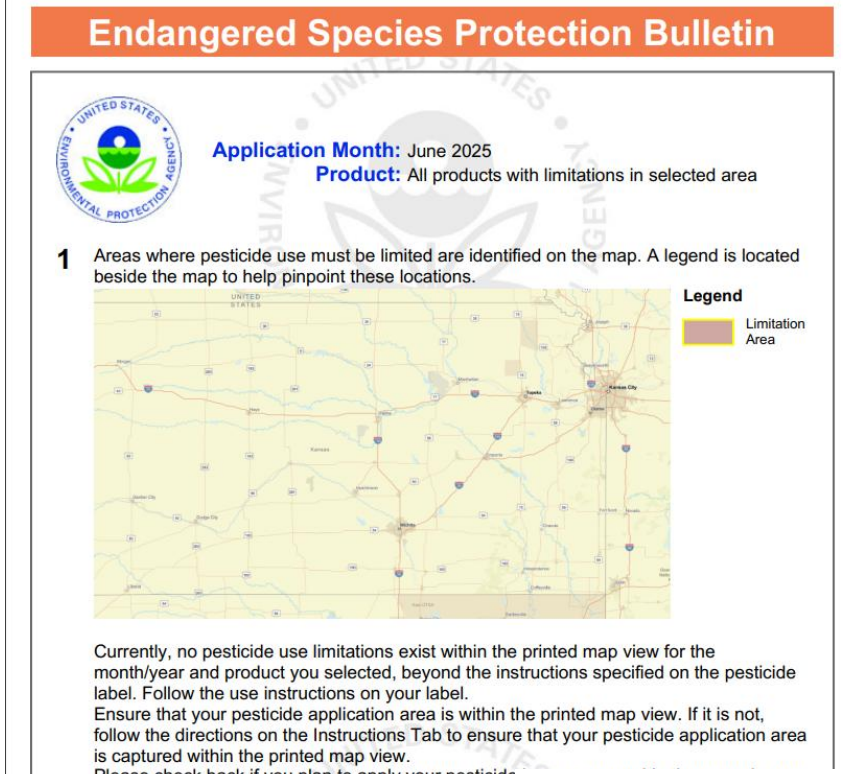
Runoff mitigation

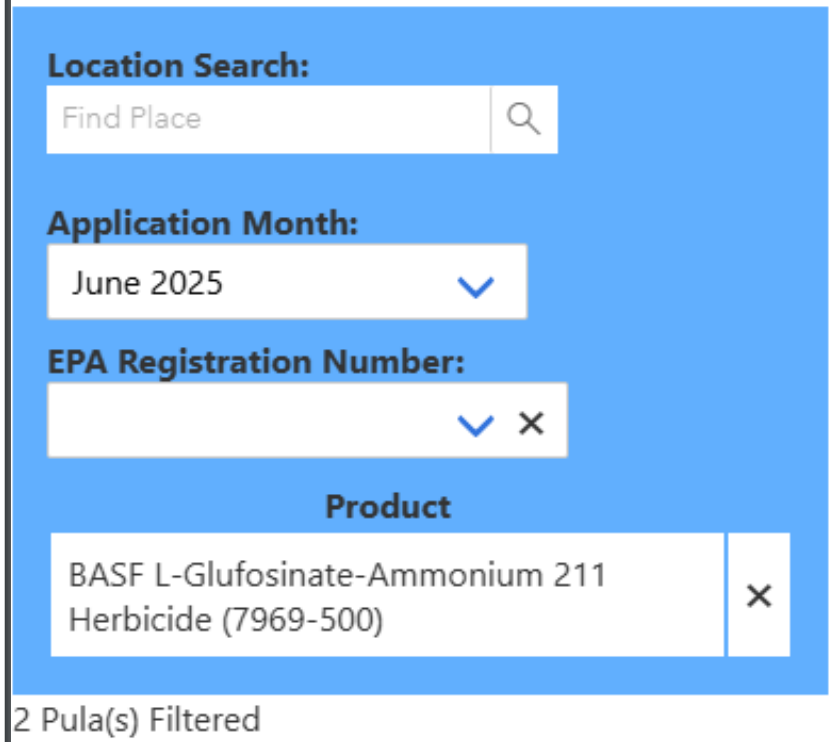
Measures applied in-field	Points
Conservation tillage	2 – Reduced till 3 – No till
Contour farming	2
Vegetative strips	2
Terraces	2
Cover crops/ground cover	1 – with tillage 2 – short term, no tillage 3 – long term, no tillage
Erosion barriers	2
Irrigation management	2 to 3
Measures applied adjacent to the field	
Grass waterway	2
Vegetative filter strips	1 to 3
Vegetated ditch	1
Riparian area	1 to 3
Wetlands	3
Habitat improvement area	1 to 3
Filtering devices	1 or 3
Water retention systems	2
Subsurface drainage	1

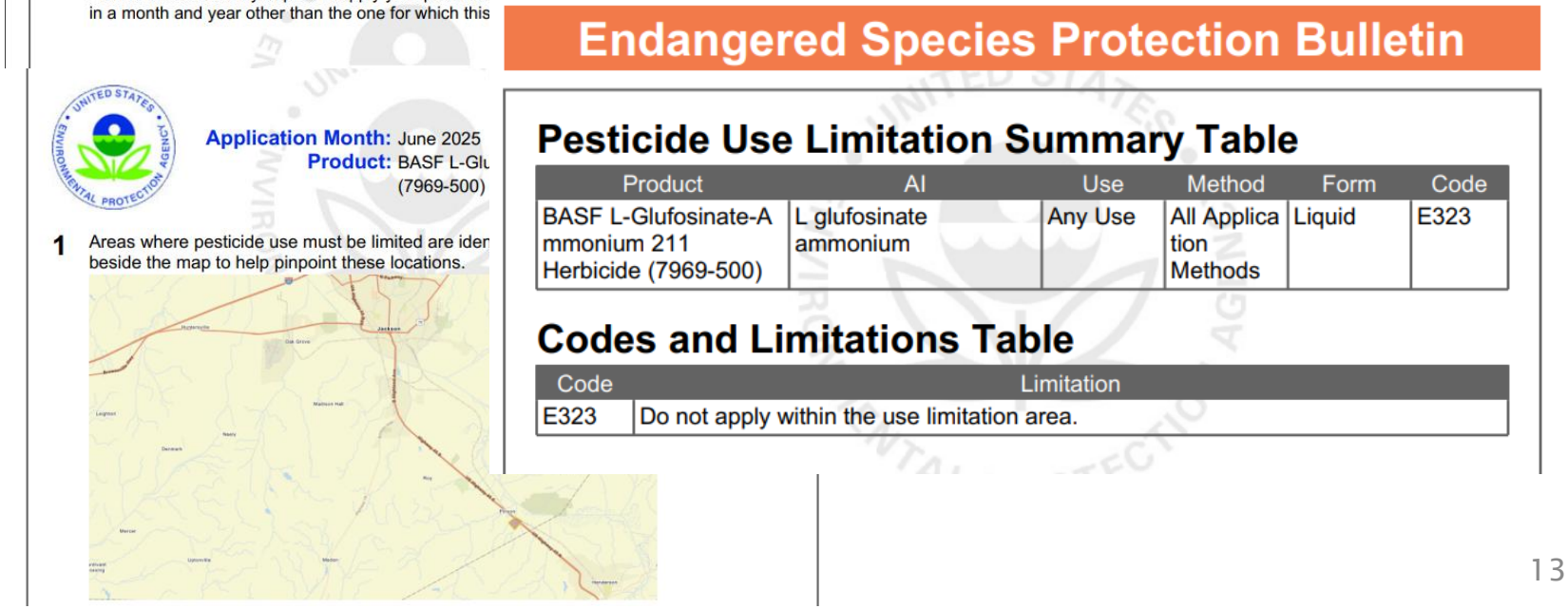
One point is earned for using measures from more than one of: in-field measures, field-adjacent measures, water retention measures

Bulletins Live! Two

https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins





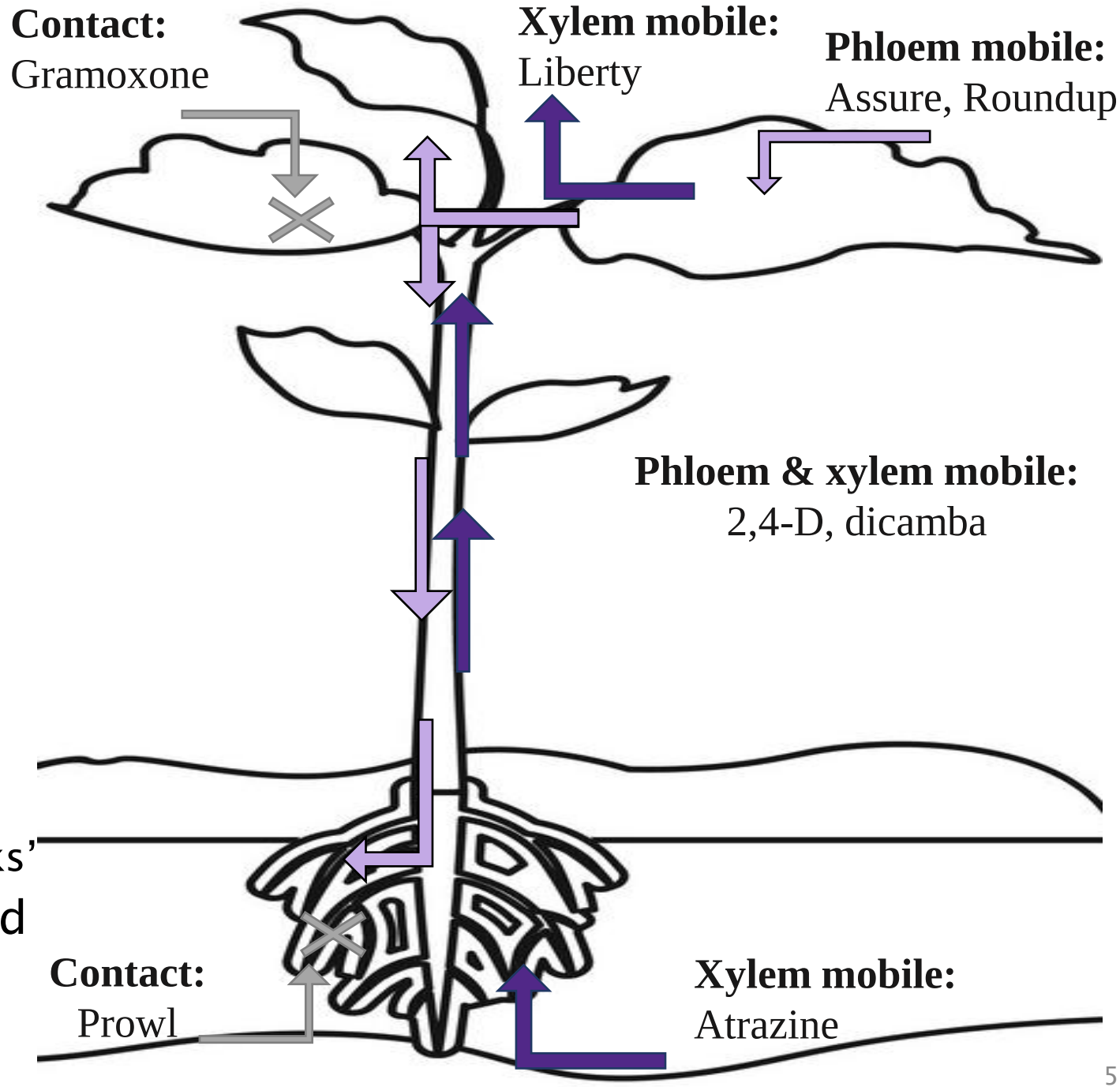


Herbicide comparisons

Glyphosate	Glufosinate	Paraquat
1. Non-selective	1. Non-selective	1. Non-selective
2. Tolerant crops available	2. Tolerant crops available	2. No tolerant crops
3. Translocated herbicide	3. Contact herbicide	3. Contact herbicide
4. Inhibits cellular metabolism	4. Initiates ROS production	4. Initiates ROS production
5. Only herbicide in SOA group	5. Two herbicides in SOA group	5. Two herbicides in SOA group
6. Excellent grass control	6. Good grass control	6. Good grass control
7. Resistant weed populations widespread	7. Resistant weed populations becoming more common	7. Resistant weed populations do occur

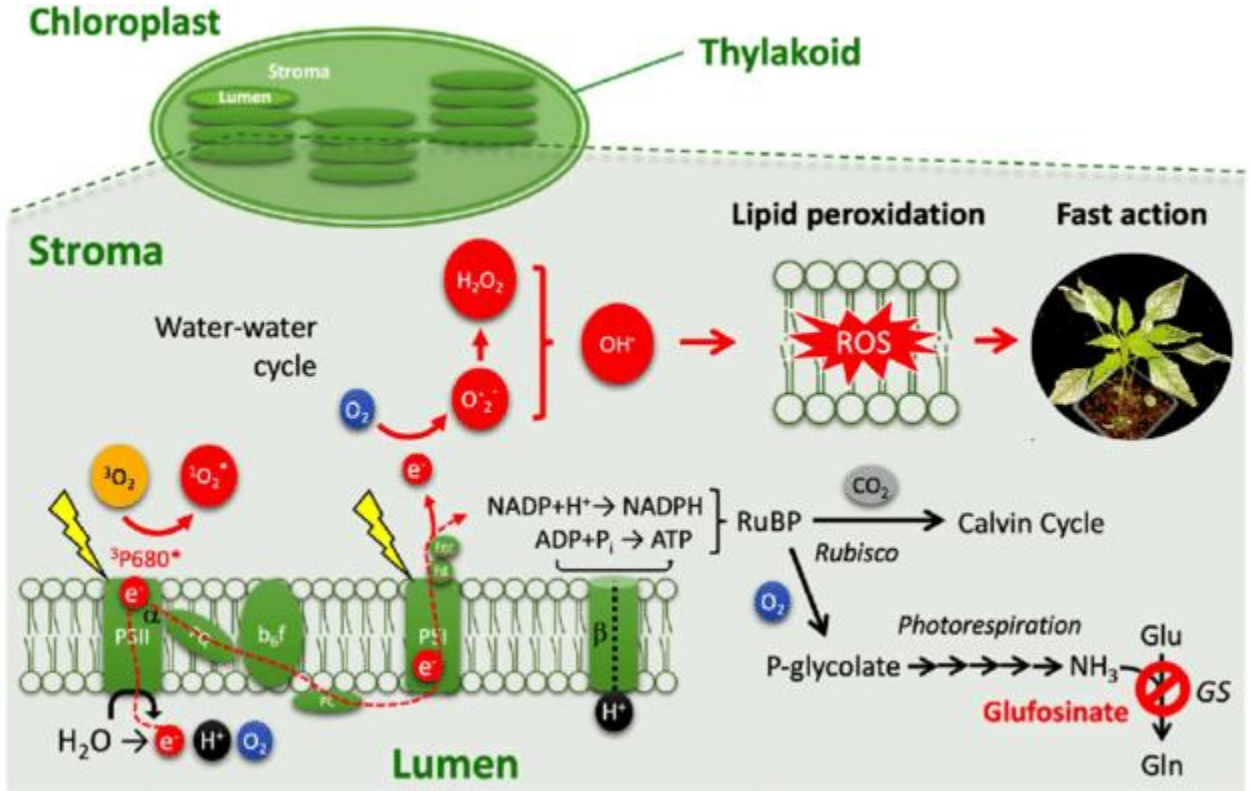
Glufosinate activity

- Most hydrophilic herbicide used
  - Very water soluble)
- Uptake by diffusion
  - Based on concentration gradient
- Translocated in xylem,
  - Accumulates in older leaves
    - Does not translocate to 'sinks'
  - Translocation rate influenced by transpiration rate



Glufosinate activity

- Target enzyme, glutamine synthetase helps convert nitrogen to amino acids
  - 2nd most abundant protein in leaves (after Rubisco)
- Ammonia accumulation in treated leaves contributes to rapid cell death
  - Main driver is the development of reactive oxygen species
    - Probably formed when glutamine synthetase inhibition prevents transfer of energy to the 'dark reactions' of photosynthesis

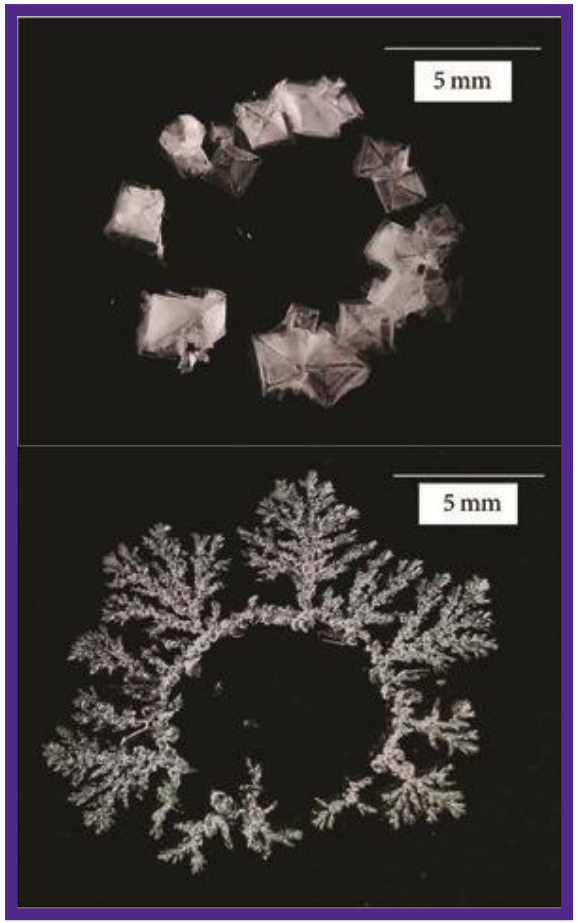


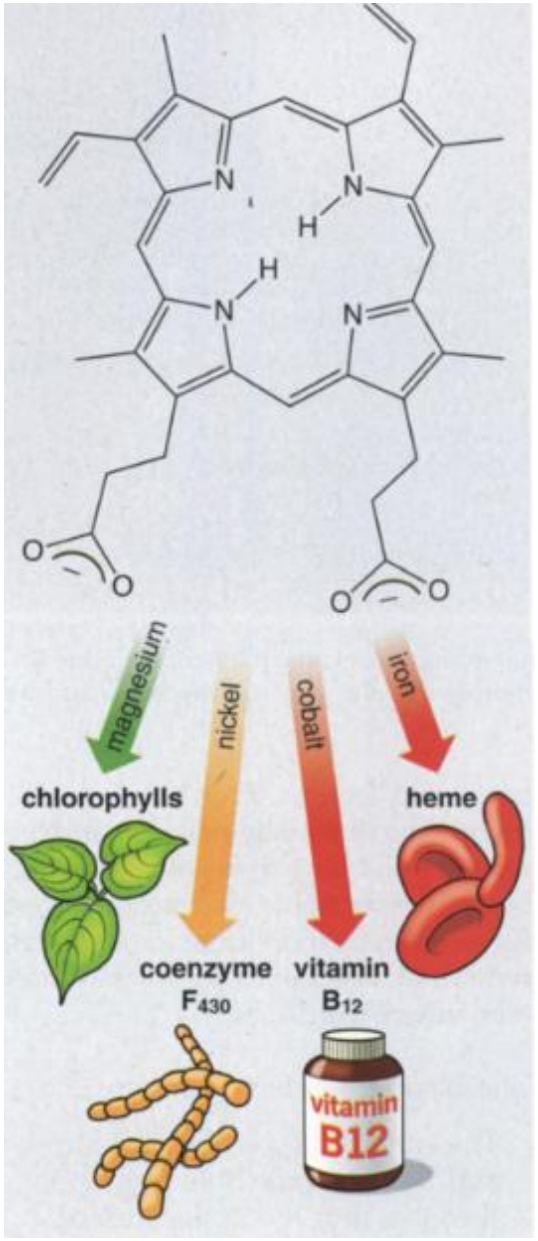
Takano et al. 2020. A novel insight into the mode of action of glufosinate: how reactive oxygen species are formed

Glufosinate activity

- Control differences among species is the result of:
  - Amount of herbicide that enters the leaf
    - leaf orientation
  - Number and location of meristem
  - Rate of herbicide metabolism

- Weather influences efficacy by affecting translocation
  - Differences in leaf cuticle may also be important
  - Higher humidity needed to keep herbicide in solution





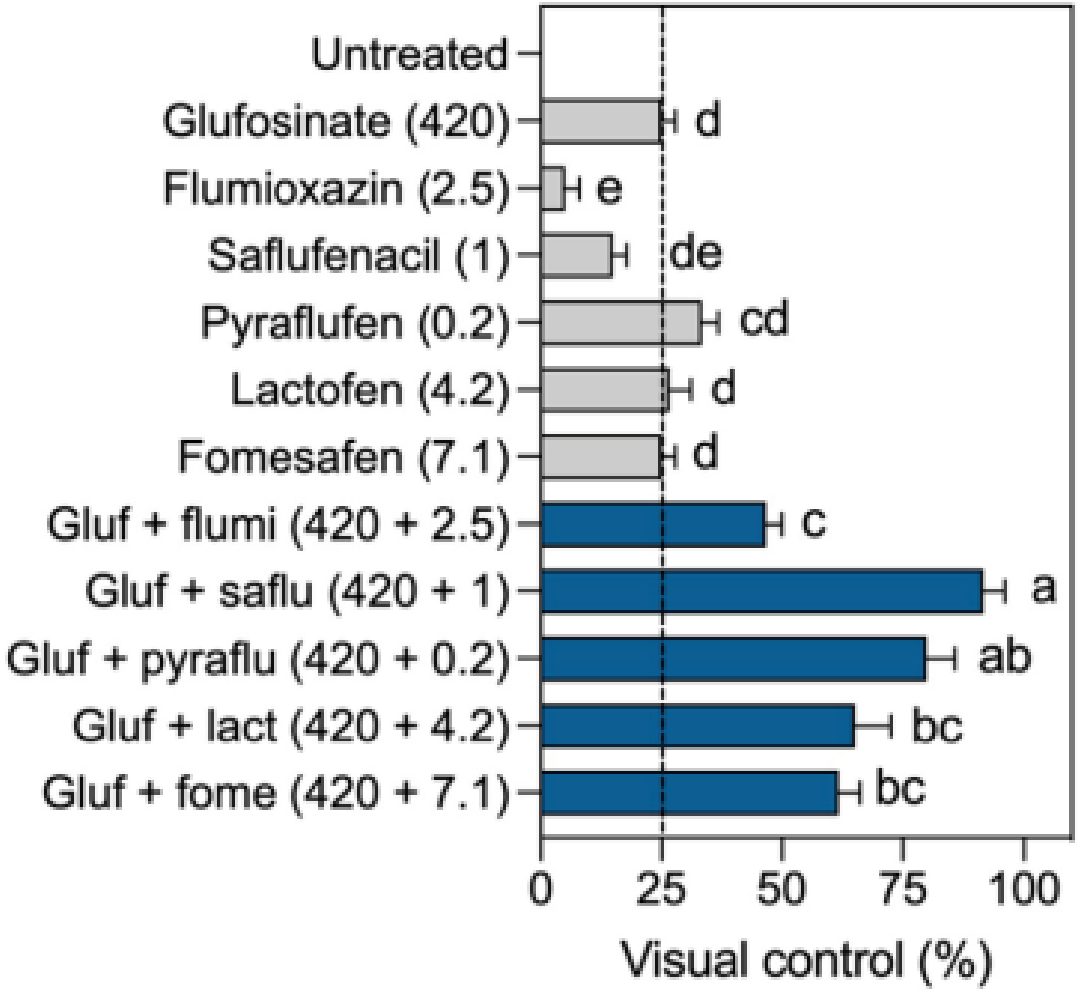
Glufosinate activity

- Mid-day applications more effective
  - Light needed to generate reactive oxygen molecules

Dayan and Dayan. 2011. Porphyrins: one ring in the colors of life: a class of pigment molecules binds King George III, vampires and herbicides

Glufosinate activity

- Synergy observed when applied with PPO inhibitors (Group 14 herbicides)
  - Both herbicides cause reactive oxygen molecules



Takano et al. 2020. Glufosinate enhances the activity of protoporphyrinogen oxidase inhibitors

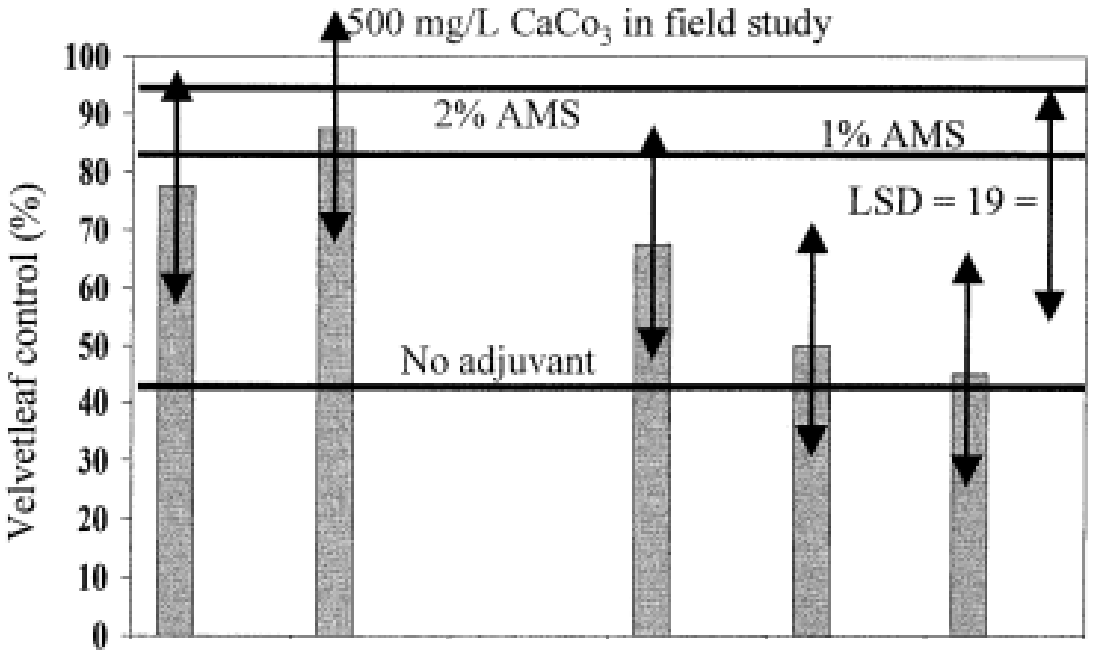
Glufosinate applications

Liberty ULTRA is only foliar-active with little or no activity in soil. Only weeds that are emerged at the time of application will be controlled by **Liberty ULTRA**.

- Apply to actively growing small weeds as specified in the **Weeds Controlled** section.
- **Liberty ULTRA** is a contact herbicide and requires uniform, thorough spray coverage.
- Warm temperatures, high humidity, and bright sunlight improve the performance of **Liberty ULTRA**.
- Necrosis of leaves and young shoots occurs within 2 to 4 days after application under good growing conditions.
- **Liberty ULTRA** is rainfast four (4) hours after application to most weed species; therefore, rainfall within four (4) hours may necessitate retreatment or may result in reduced weed control. Refer to specific use sections of this label for minimum intervals required before re-application of this product and use rates.
- **Liberty ULTRA** requires sunlight for activity. Applications near dawn and dusk may result in reduced weed control. For best results, make applications between sunrise and 2 hours before sunset.
- Weed control may be reduced if application is made when heavy dew, fog, and mist/rain are present; or when weeds are under stress due to environmental conditions including drought, cool temperatures, or extended periods of cloudiness.

Ammonium sulfate

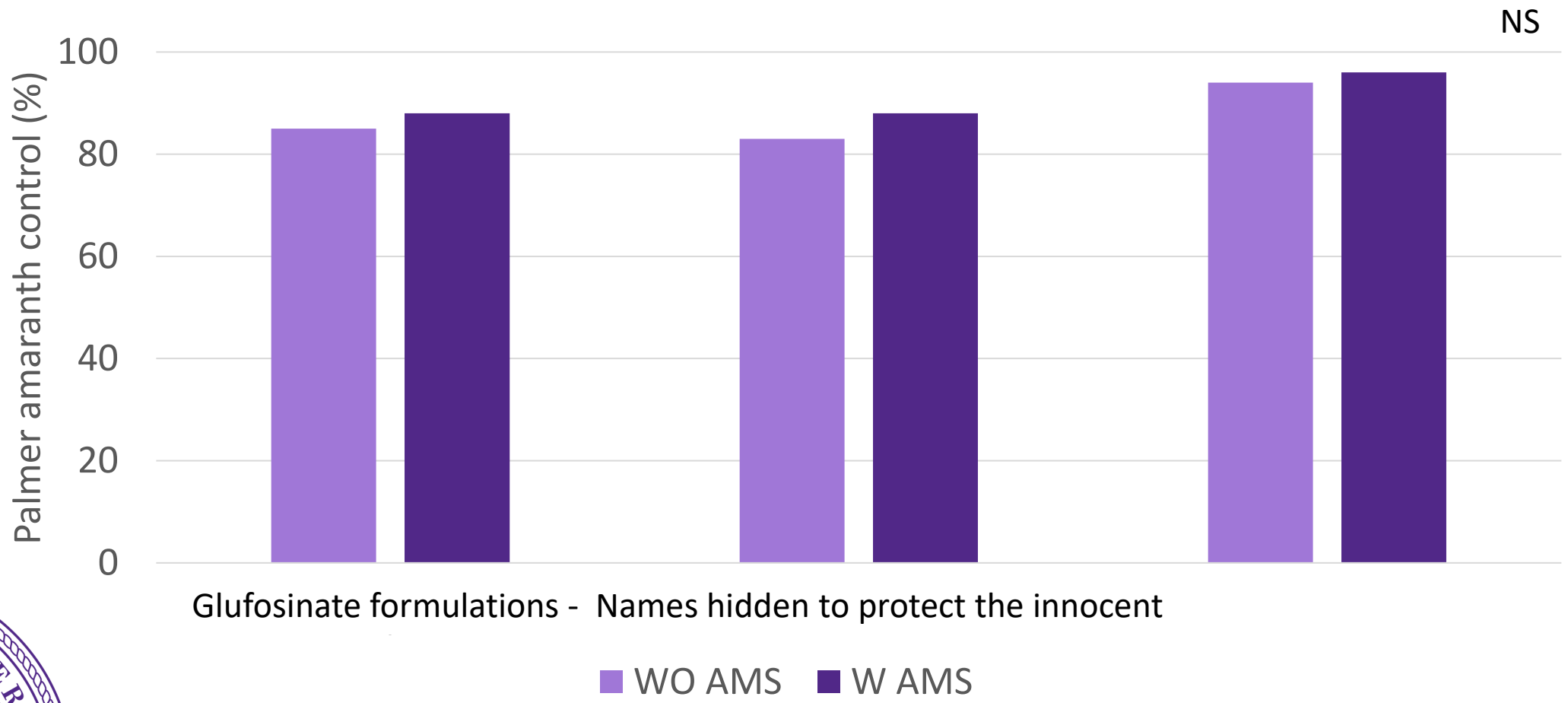
- 1.5 to 3 lbs/A AMS label recommendation
  - Many commercial applications using 5 lbs/A
- AMS replacements are not AMS
  - Prevents hard water antagonism
  - Increases absorption
  - Acts as a humectant



AMS 'substitutes' - Names hidden to protect the innocent

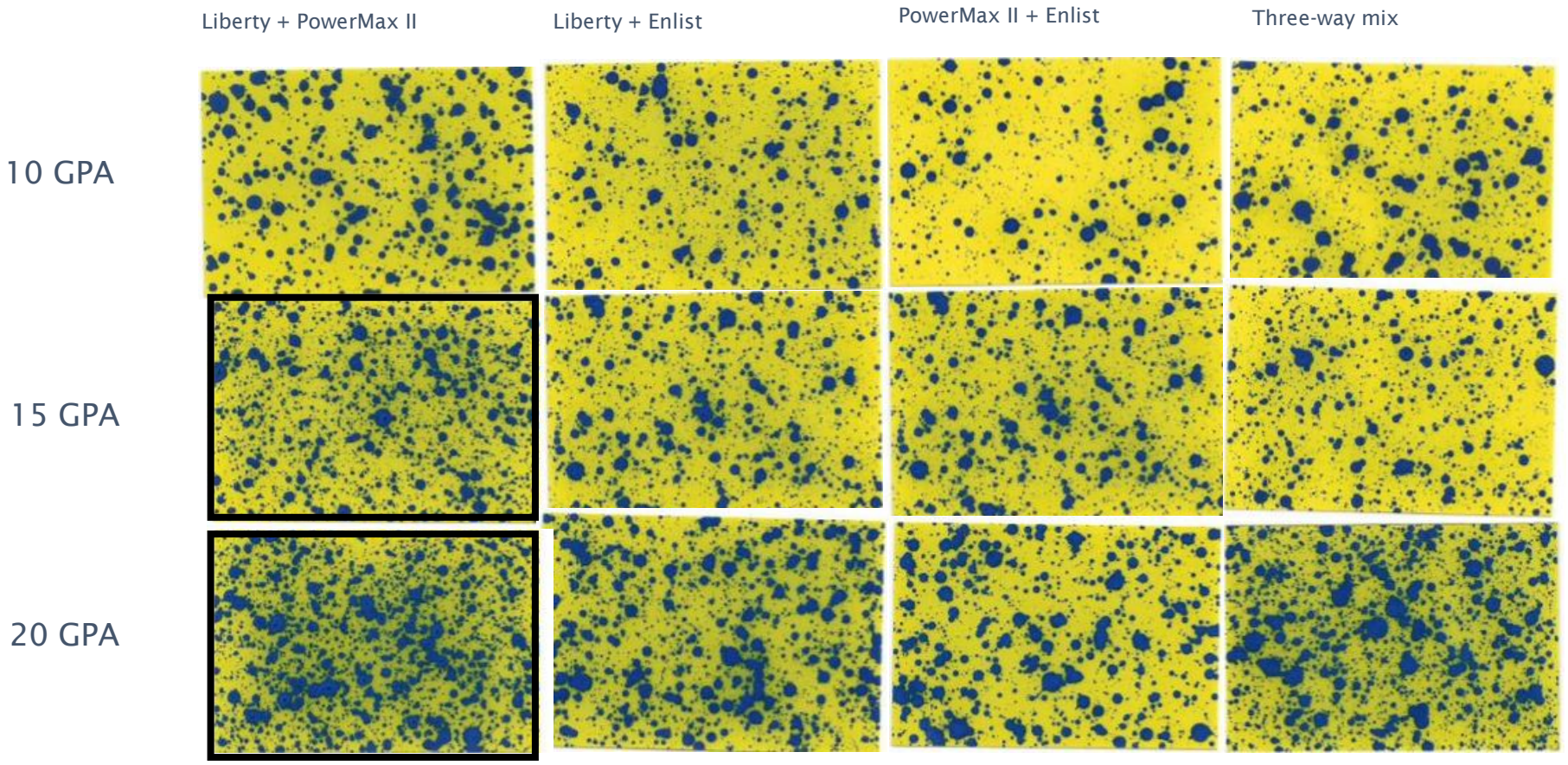
Pratt et al. 2003. Substitutes for Ammonium Sulfate as Additives with Glyphosate and Glufosinate.

Glufosinate comparisons – Manhattan KS
28 DAT (July 29, 2024)



Spray volume

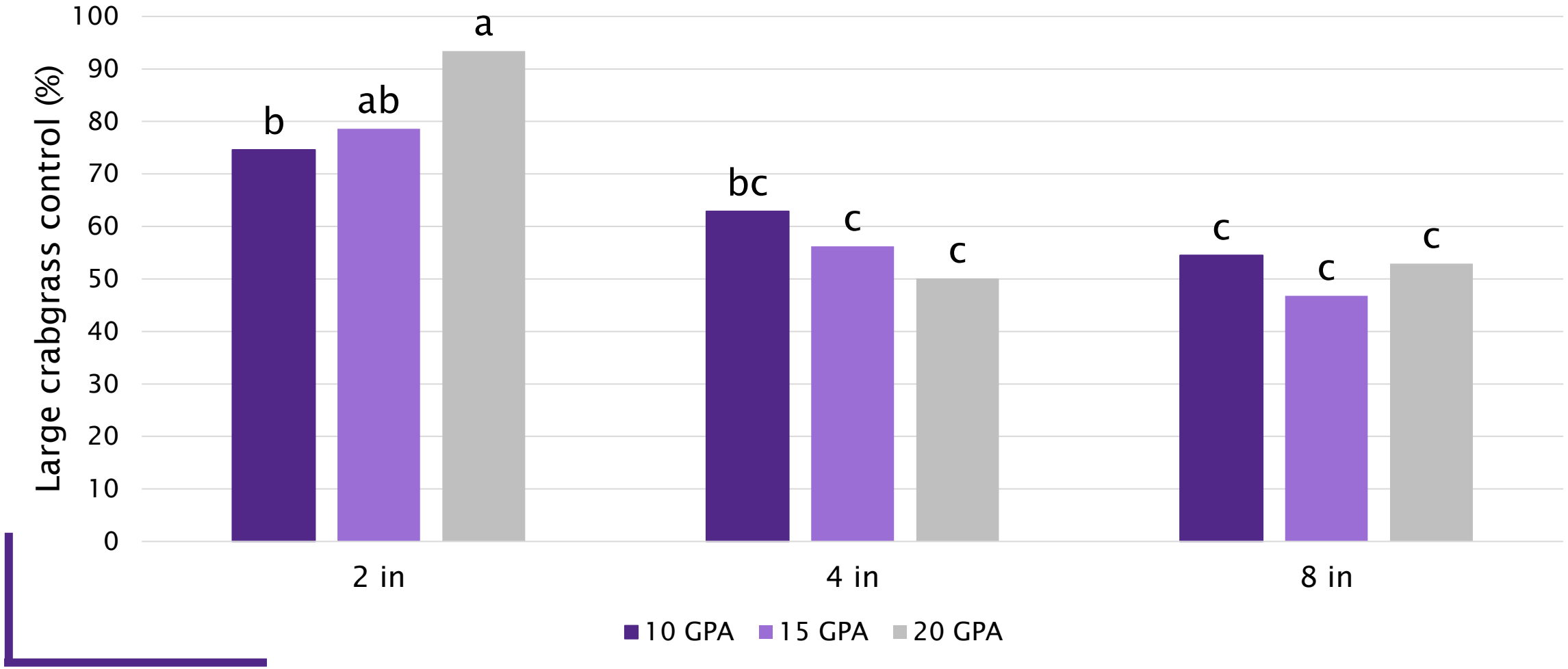
- Needed for adequate coverage



Lammers, 2021

Spray volume and weed size

2- and 3- way combinations of glyphosate, glufosinate, 2,4-D



Lammers, 2021

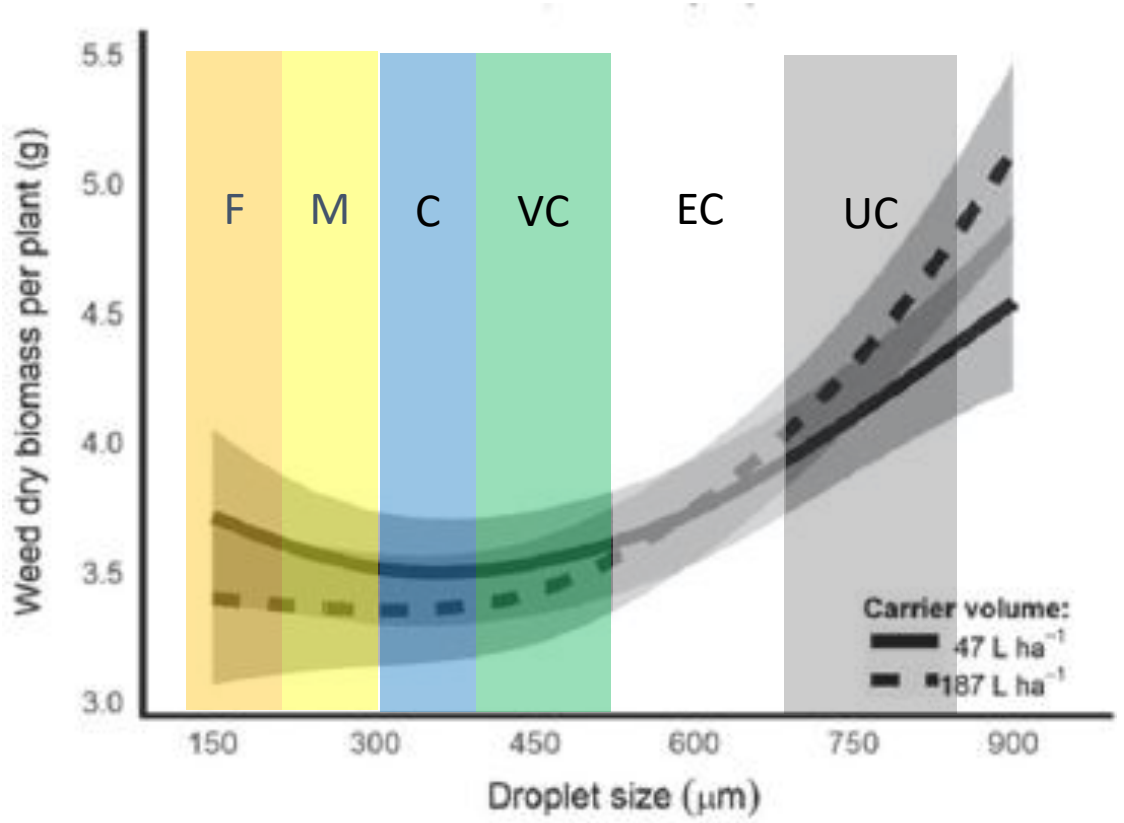
Droplet size

- Smaller droplets have greater surface area
  - Better coverage

Droplet size	V_{MD} (microns)	Degree of atomization	Relative size
Very fine	100	Fine mist	Human hair
Fine	150	Fine mist	Sewing thread
Medium	190	Fine drizzle	--
Coarse	275	Fine drizzle	Toothbrush bristle
Very coarse	350	Light rain	--
Extremely coarse	480	Light rain	Staple
Ultra coarse	660	Light rain	--

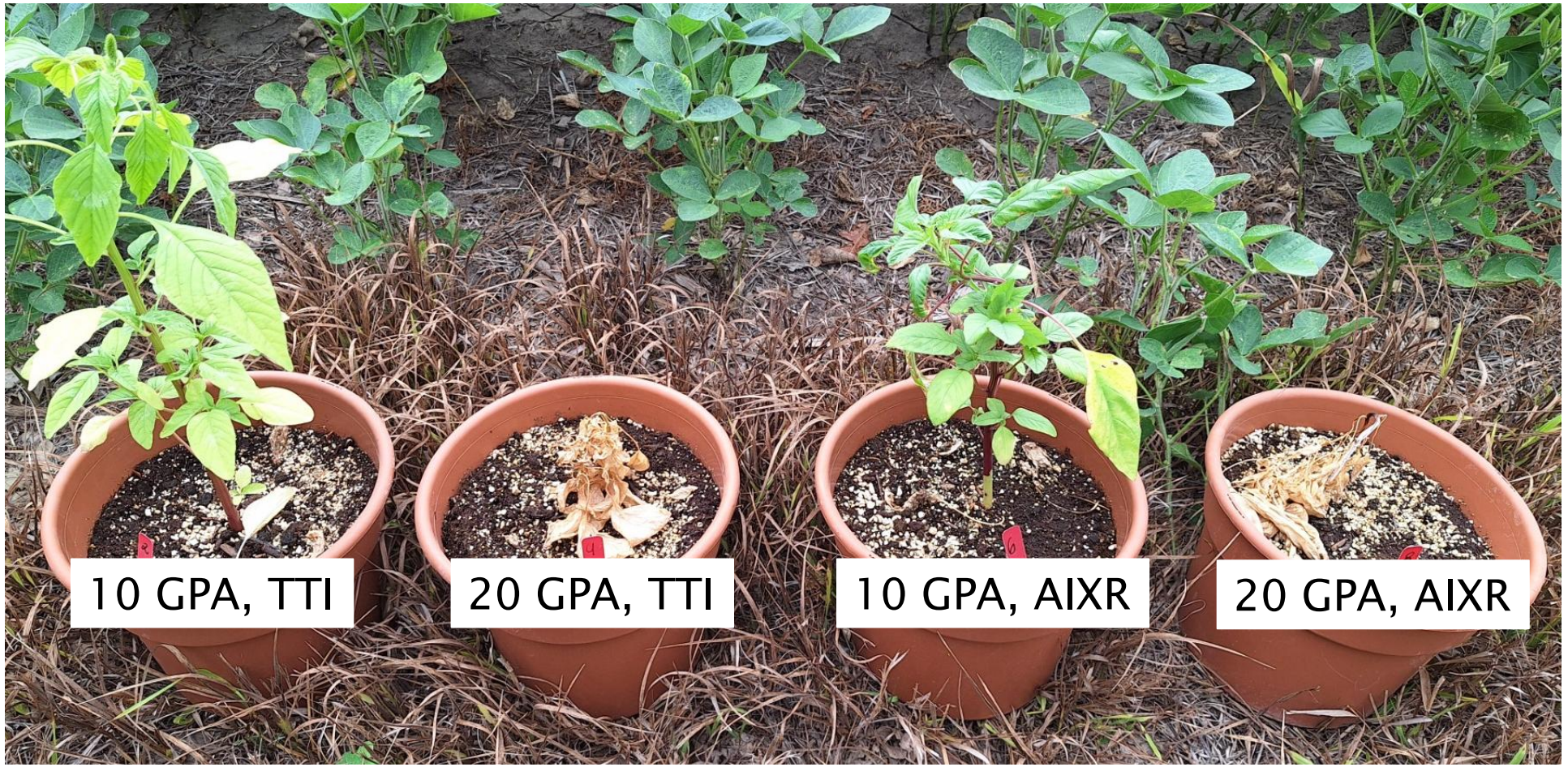
Spray volume and droplet size for glufosinate

- Liberty
  - Mississippi, Nebraska, North Dakota
- Smaller droplets = greater control
- Higher volume = more consistent control



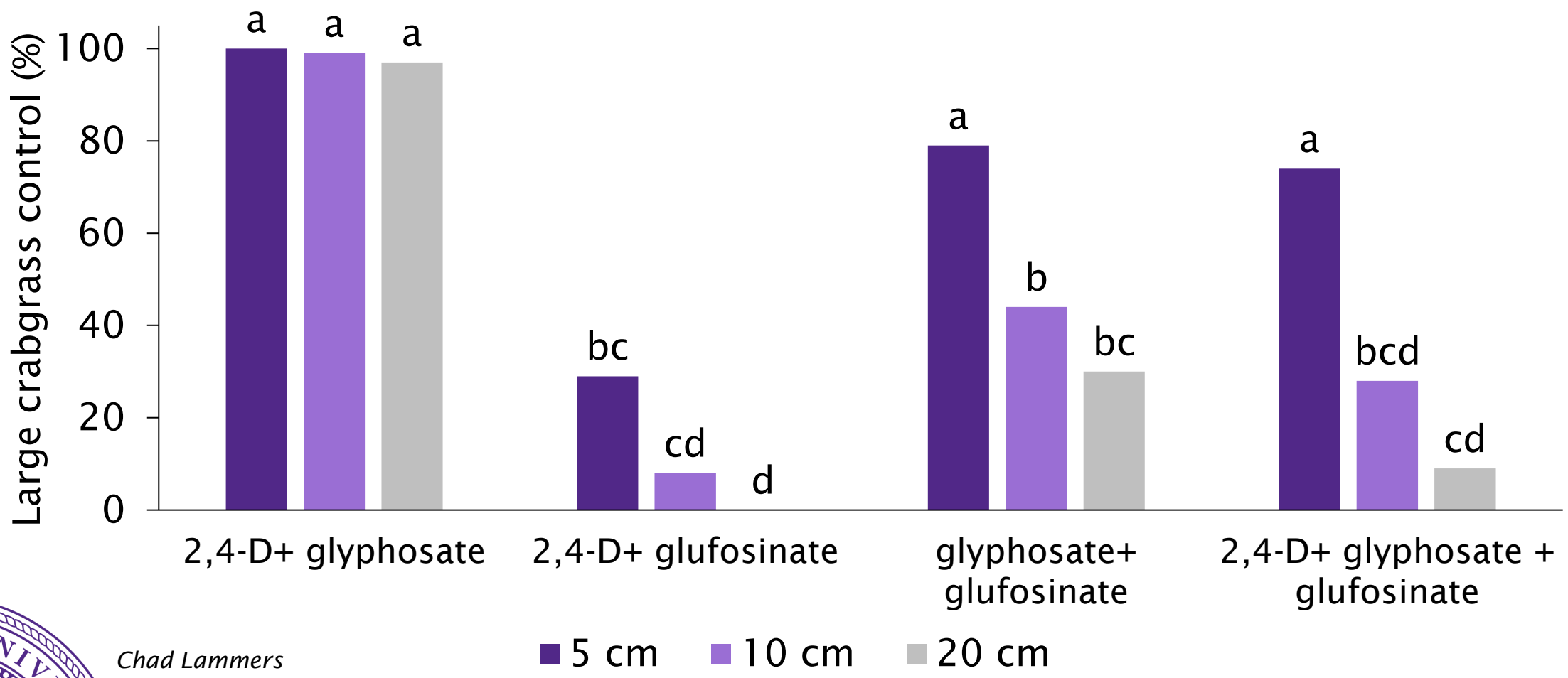
Butts et al., 2018

Spray volume and droplet size



Weed size

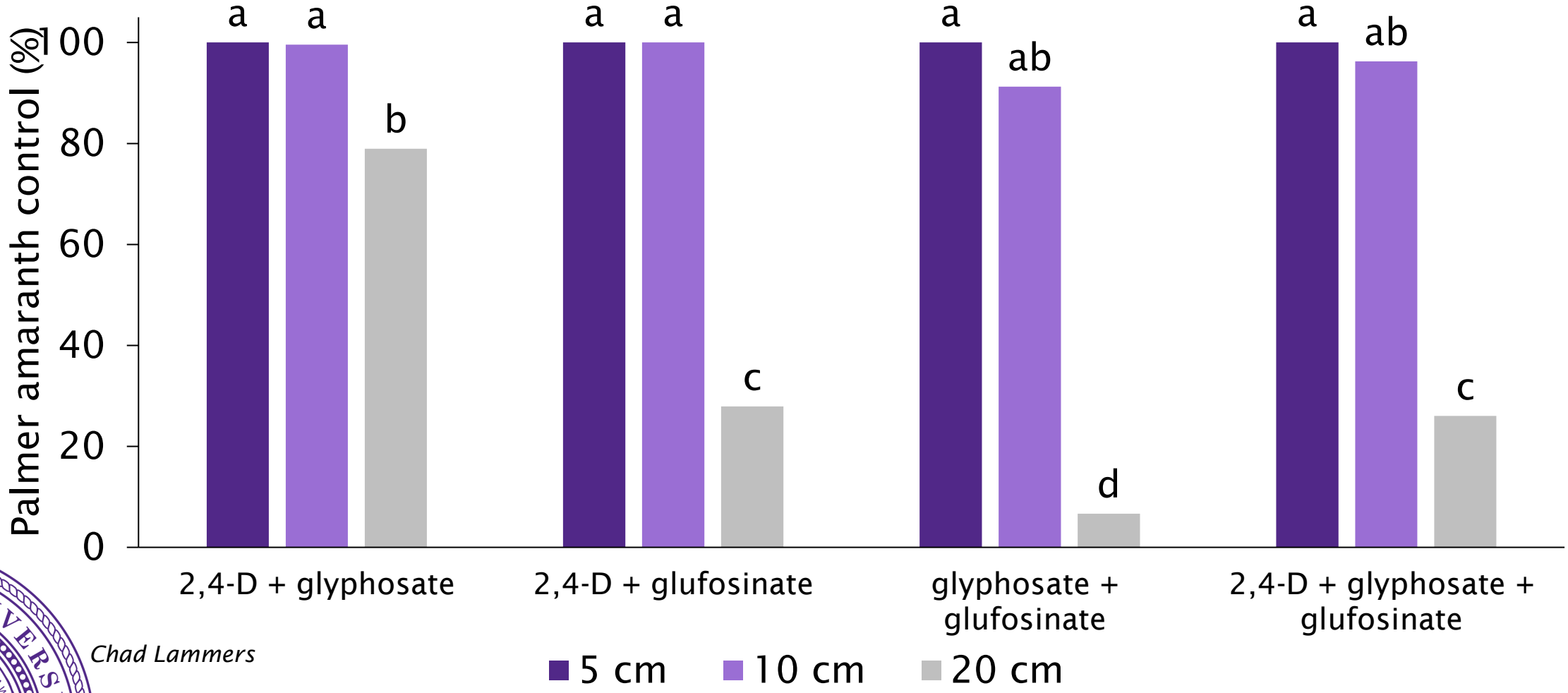
10, 15, and 20 GPA



Chad Lammers

Weed size

10, 15, and 20 GPA



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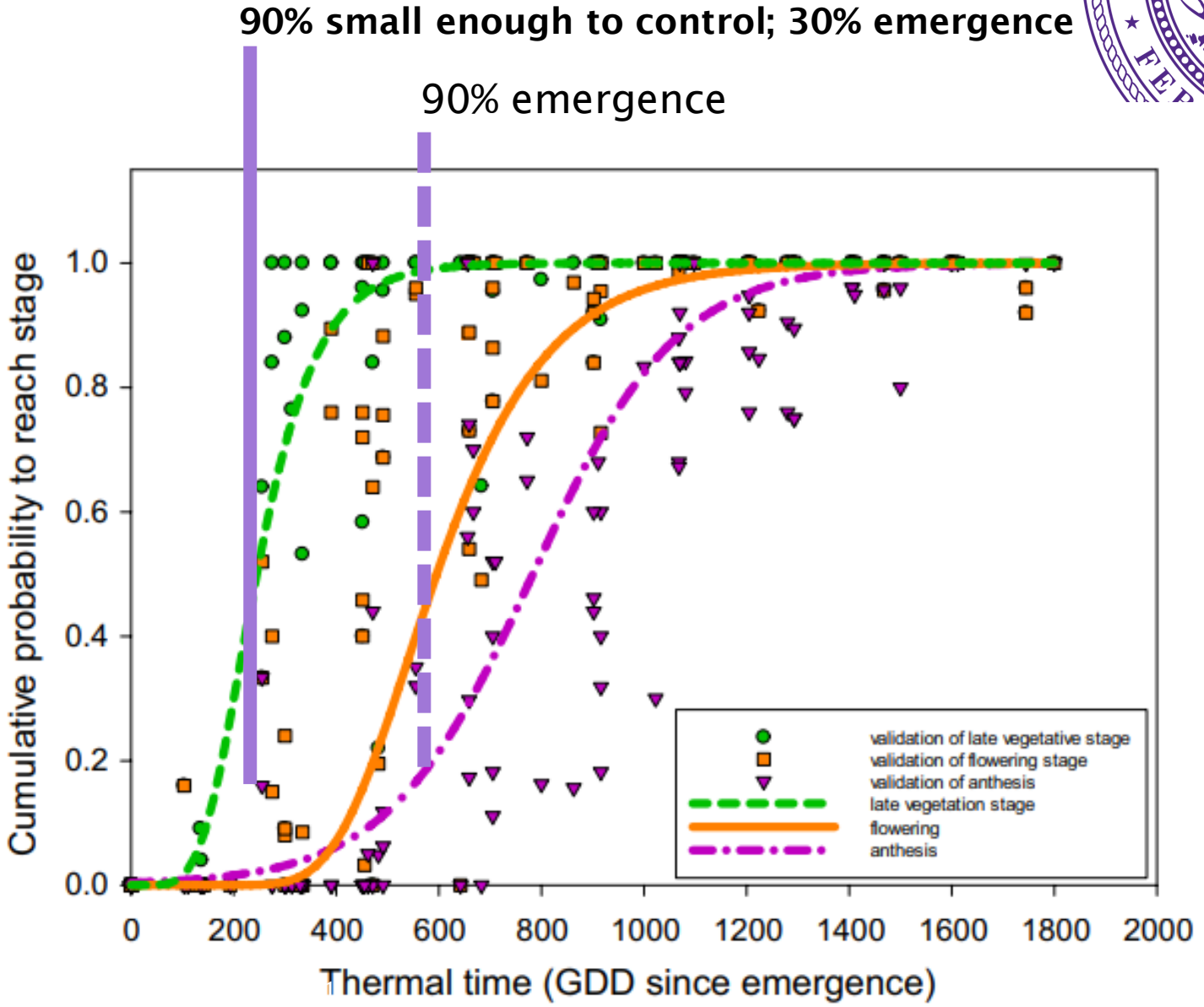
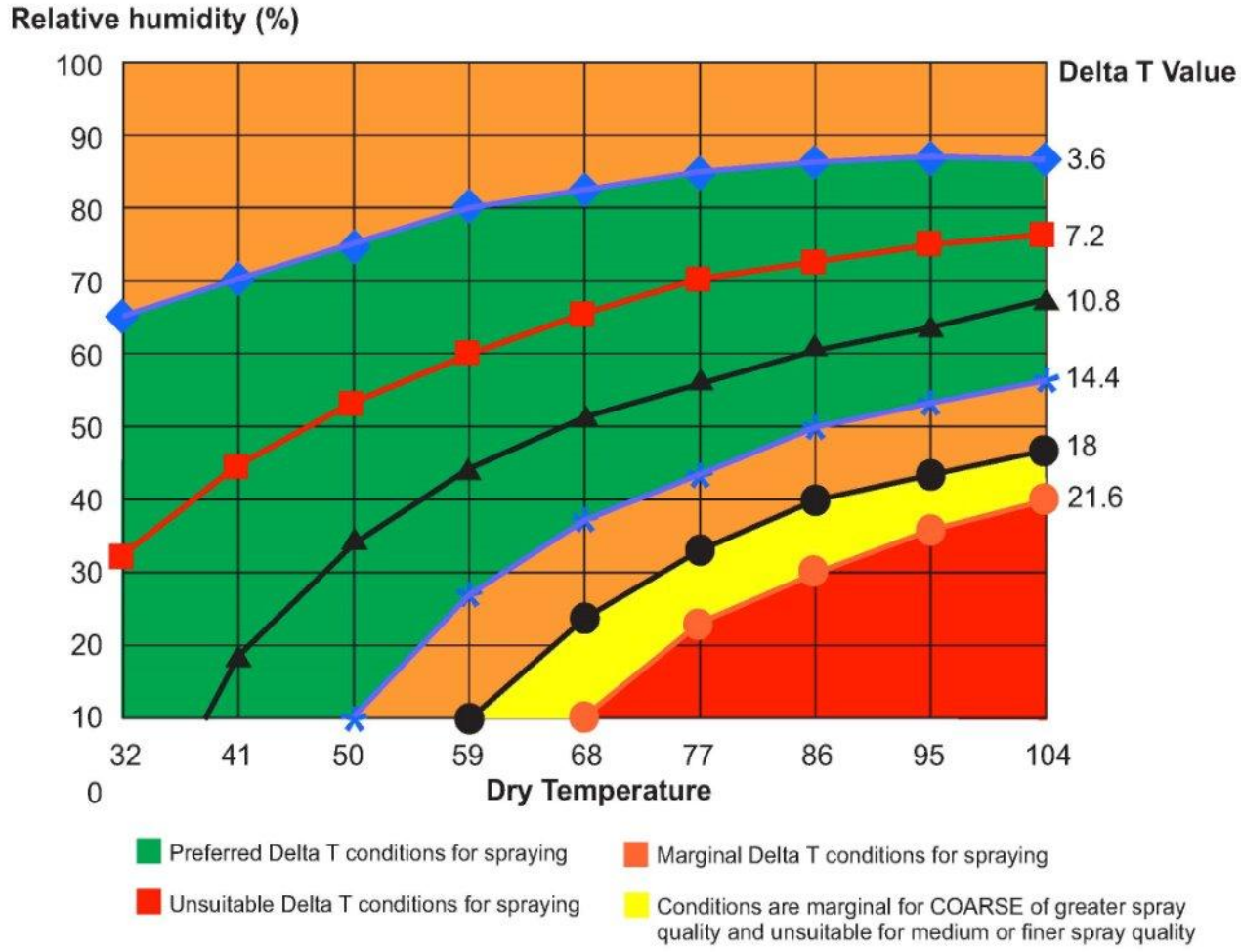
Weed size

"Well-timed control actions not only ensure adequate control of the largest individuals but also are effective means to eliminate a larger proportion of the expected population."

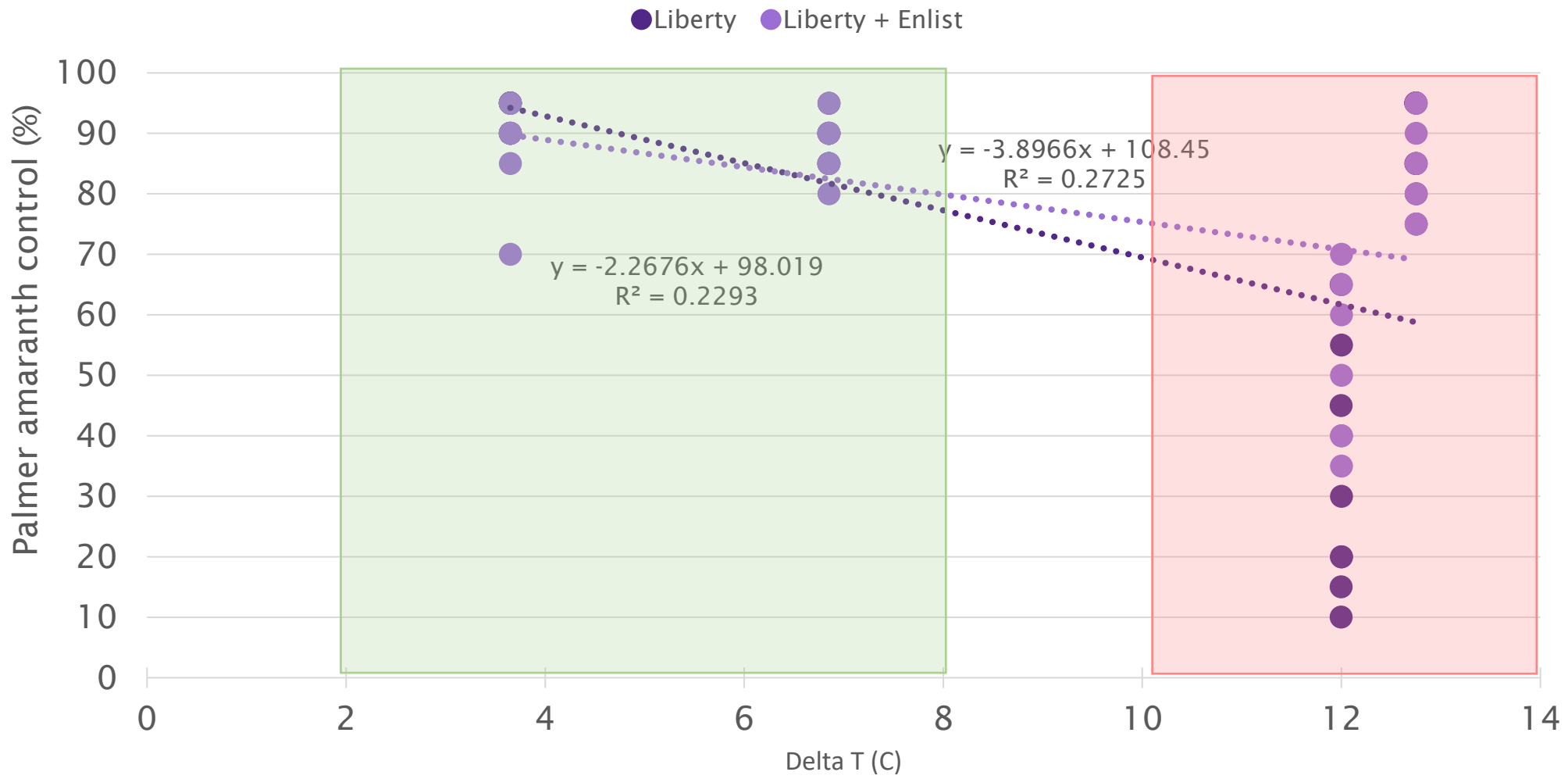


Humidity

- Indicator of droplet evaporation
- Function of temperature & humidity
- Ideal is 4 to 14
  - 2 to 8 in C

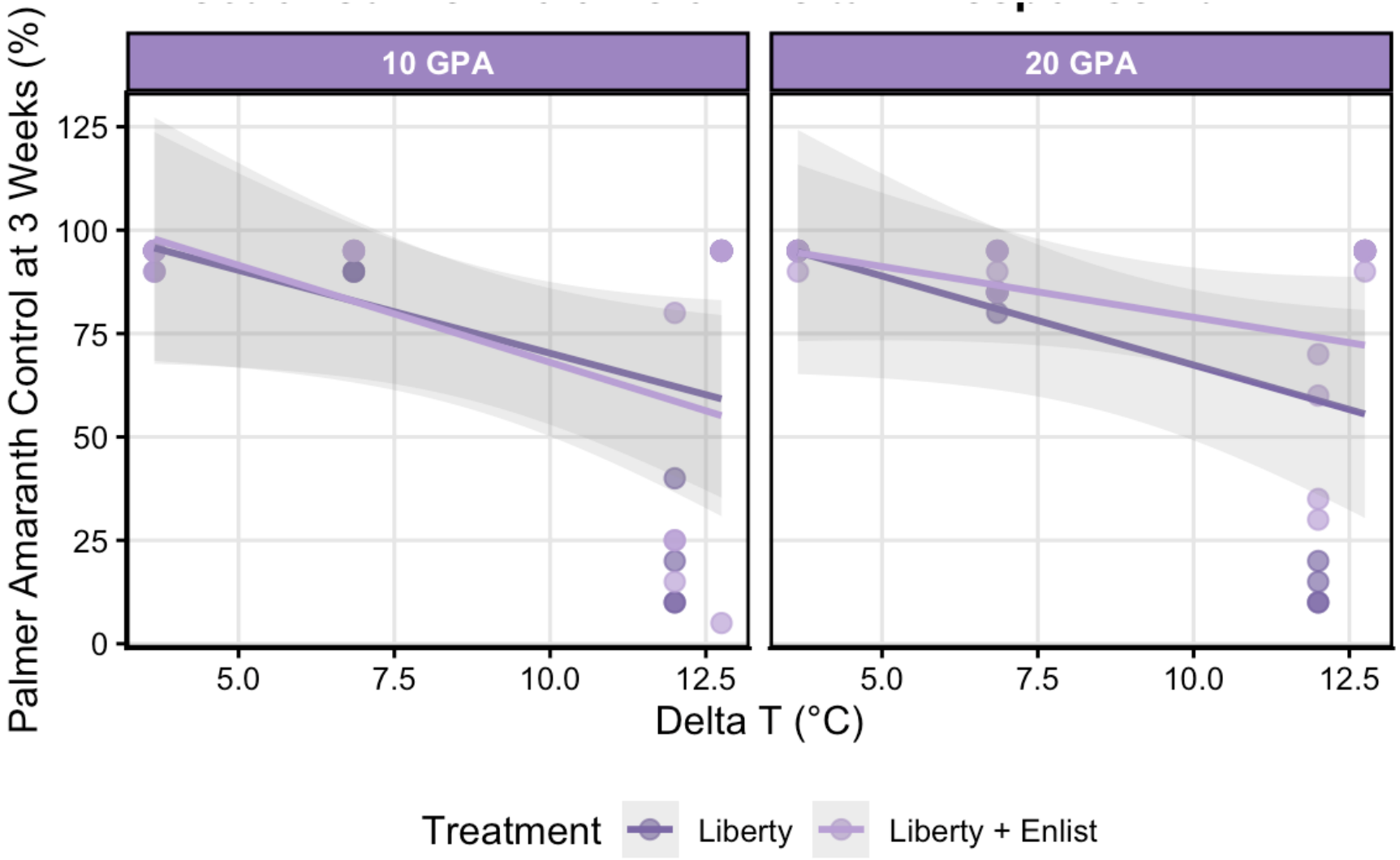


Effective Strategies for Glufosinate & 2,4-D Applications – Delta T

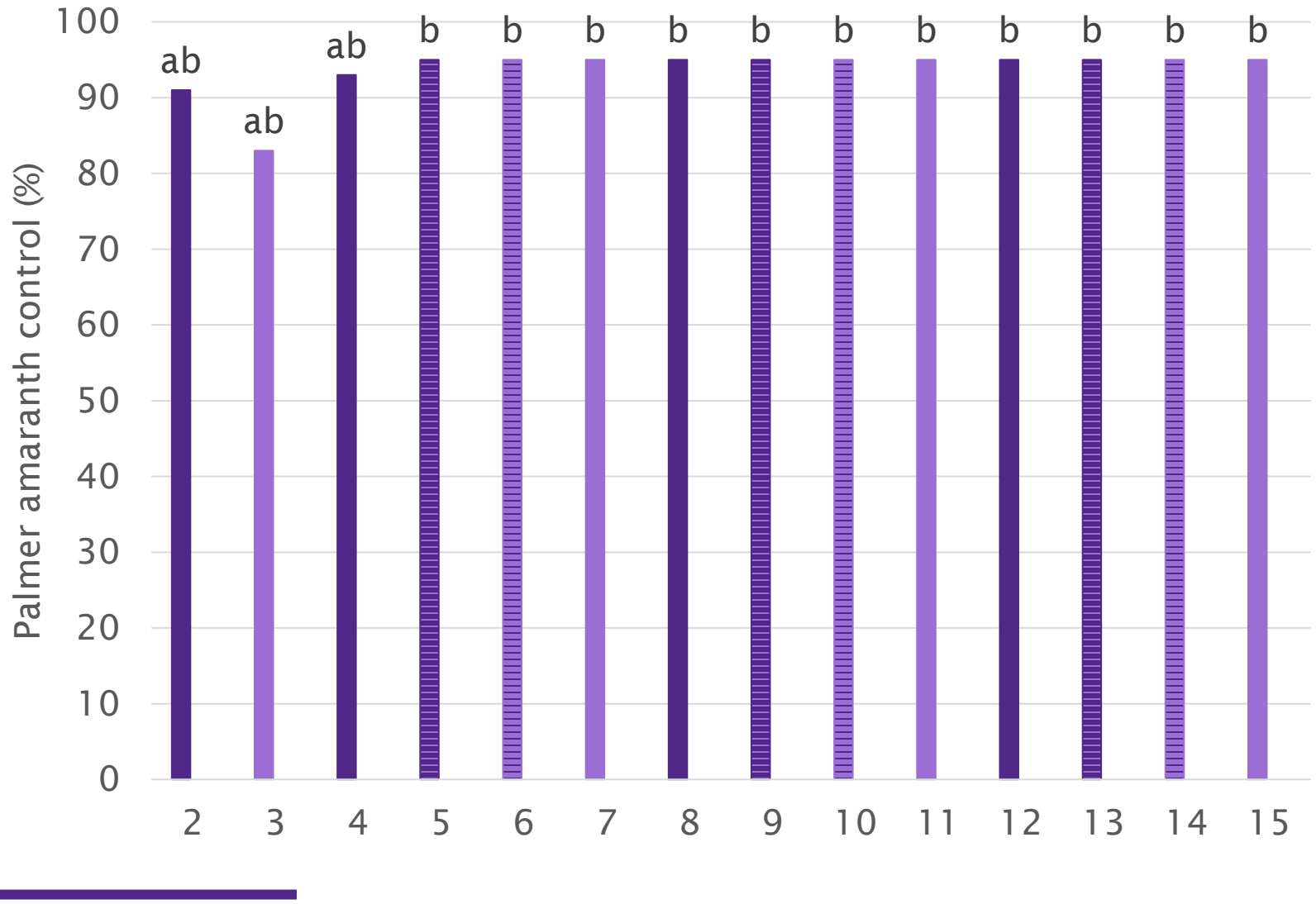


Lalit Mohan, 2024

Effective Strategies for Glufosinate & 2,4-D Applications – Delta T and spray volume



Sequential applications for control of larger Palmer amaranth in Enlist systems



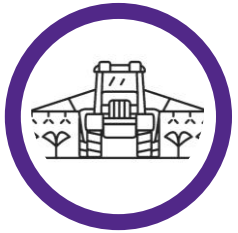
Treatments			
	Herb. 1	Herb. 2	Interval
2	Liberty		
3	Liberty + Enlist		
4	Liberty	Liberty	3 DAA
5		Liberty + Enlist	
6	Liberty + Enlist	Liberty	
7		Liberty + Enlist	
8	Liberty	Liberty	10 DAA
9		Liberty + Enlist	
10	Liberty + Enlist	Liberty	
11		Liberty + Enlist	
12	Liberty	Liberty	14 DAA
13		Liberty + Enlist	
14	Liberty + Enlist	Liberty	
15		Liberty + Enlist	

Mohan et al. 2024

Conclusions

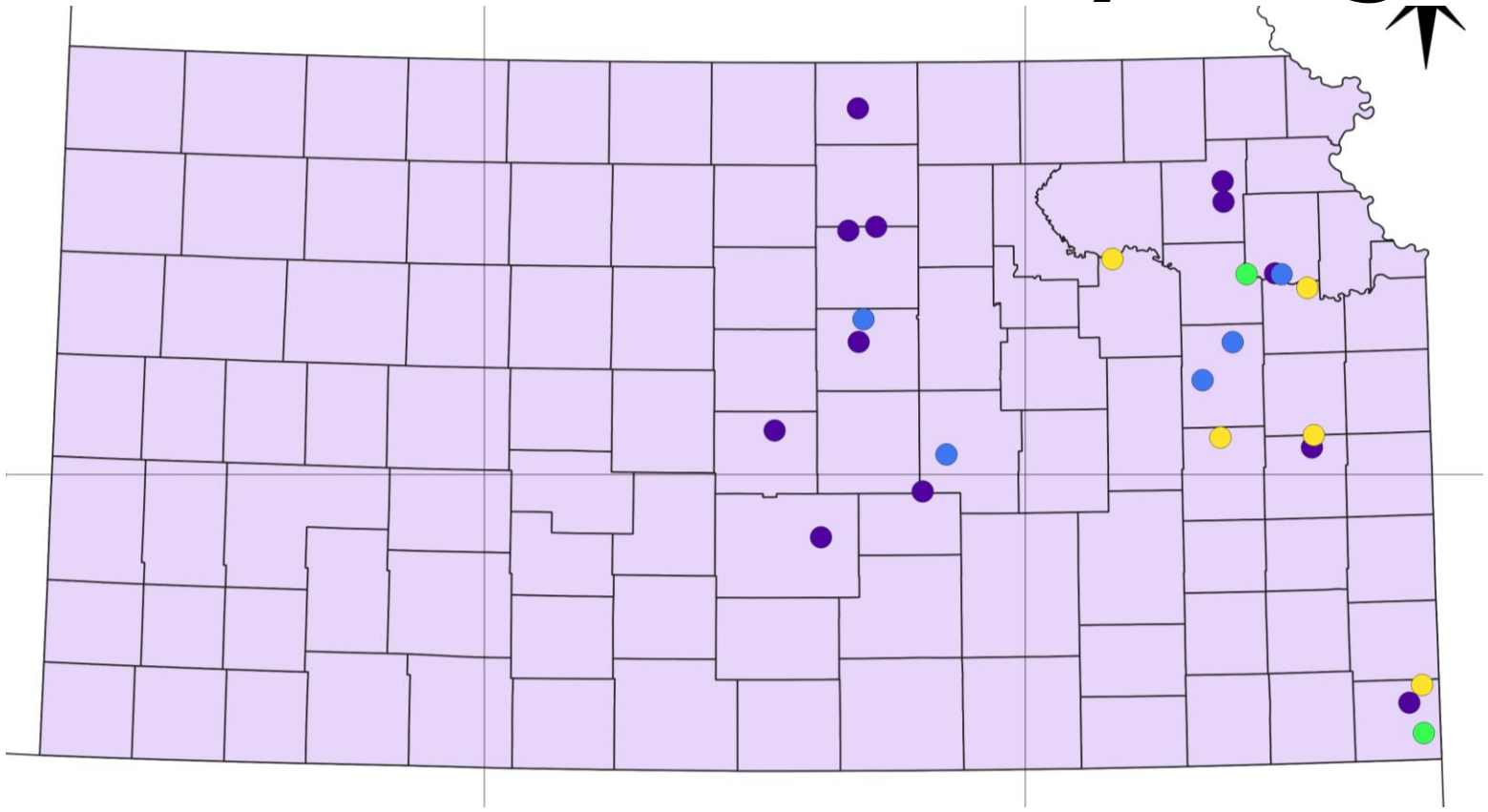
New glufosinate formulations

Herbicide uptake and photosynthesis are key to activity

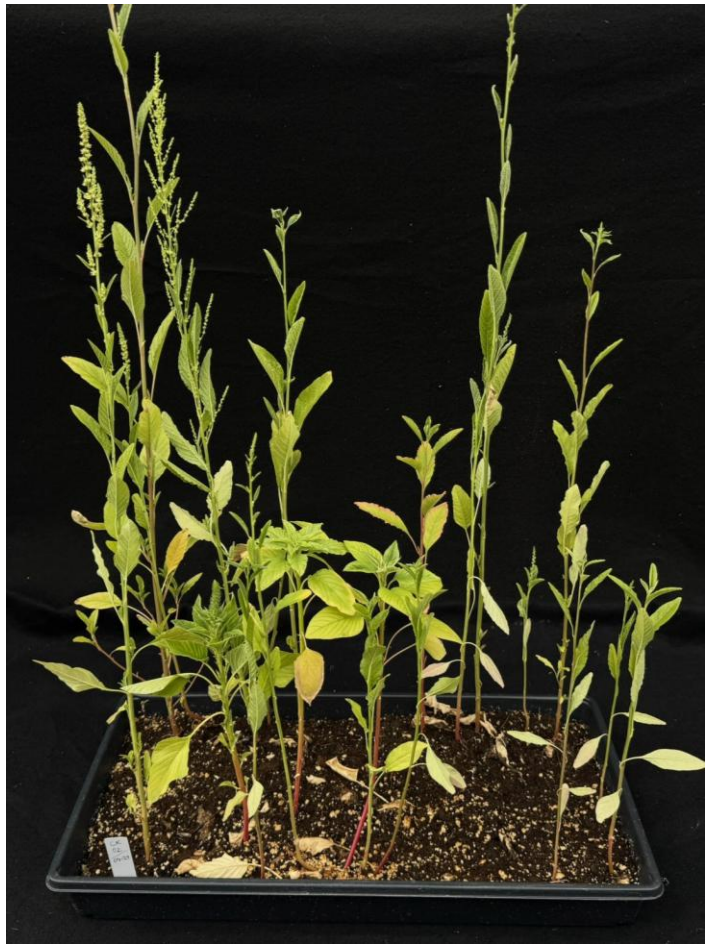


Slow droplet evaporation (spray volume, droplet size, AMS) is key to successful applications

Reduced sensitivity to glufosinate



48% acceptable (0-10% survivors)
20% fair (11-30% survivors)
24% poor (31-60% survivors)
8 % failure (>60% survivors)



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slancaster@ksu.edu

@KStateWeedSci

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War Against Weeds podcast

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