A Potpourri of Glyphosate, Micronutrients, and Adjuvants

Mark Bernards
Extension Weed Specialist

University of Nebraska Lincoln

Outline

- All the fuss about micronutrients
- What is yellow flash?
- Soybean response to manganese
- Glyphosate application with micronutrients
- Water conditioners and AMS dose
- Comments on glyphosate side-effects

Micronutrients in the media

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GLYPHOSATE: THE MICRONUTRIENT MINIMIZER?

Lynn Grooms, Corn and Soybean Digest
Sep. 1, 2008 10:00am

Manganese deficiency in soybeans appears to be a growing issue in areas with high-pH soils (6.5 and up) and/or higher organic matter content and where glyphosate-resistant soybean varieties have been planted. Deficiencies have been reported in Indiana, Michigan, Kansas and Wisconsin.

One of the most limiting factors to high yield in glyphosate-resistant soybeans is a suspected micronutrient deficiency resulting from applications of glyphosate to soil, weeds and to glyphosate-resistant soybeans, report Shawn Conley and Carrie Laboski, soil specialists, University of Wisconsin (UW). They are conducting a study after numerous inquires about the issue last year.

"It's important to know that their research applies most

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2008
George Rehm
Univ of Minnesota
"This issue is not one we can paint with a broad brush."

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Micronutrient Deficiencies in Corn and Soybean Fields Can mean Big Losses

Karen Bernick, Corn and Soybean Digest
Mar. 25, 2010 10:00am

If you perform a Google search for "manganese deficiency in soybeans," a lengthy list of articles pops up, including several research papers examining the possible antagonistic relationship between manganese (Mn) and glyphosate.

Yet despite the many scientific efforts to understand micronutrient deficiencies, university soybean researchers and soil fertility experts find it difficult to provide simple guidelines on when and how soybean growers should apply micronutrient supplements.

"We don't really have a good recommendation system for micronutrients," says Fabian Fernandez, an assistant professor of soil fertility and plant nutrition at the University of Illinois. Fernandez says Mn deficiency is the most common concern among soybean growers, but

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2010
Fabian Fernandez
Univ of Illinois
"We don't really have a good recommendation system for micronutrients."

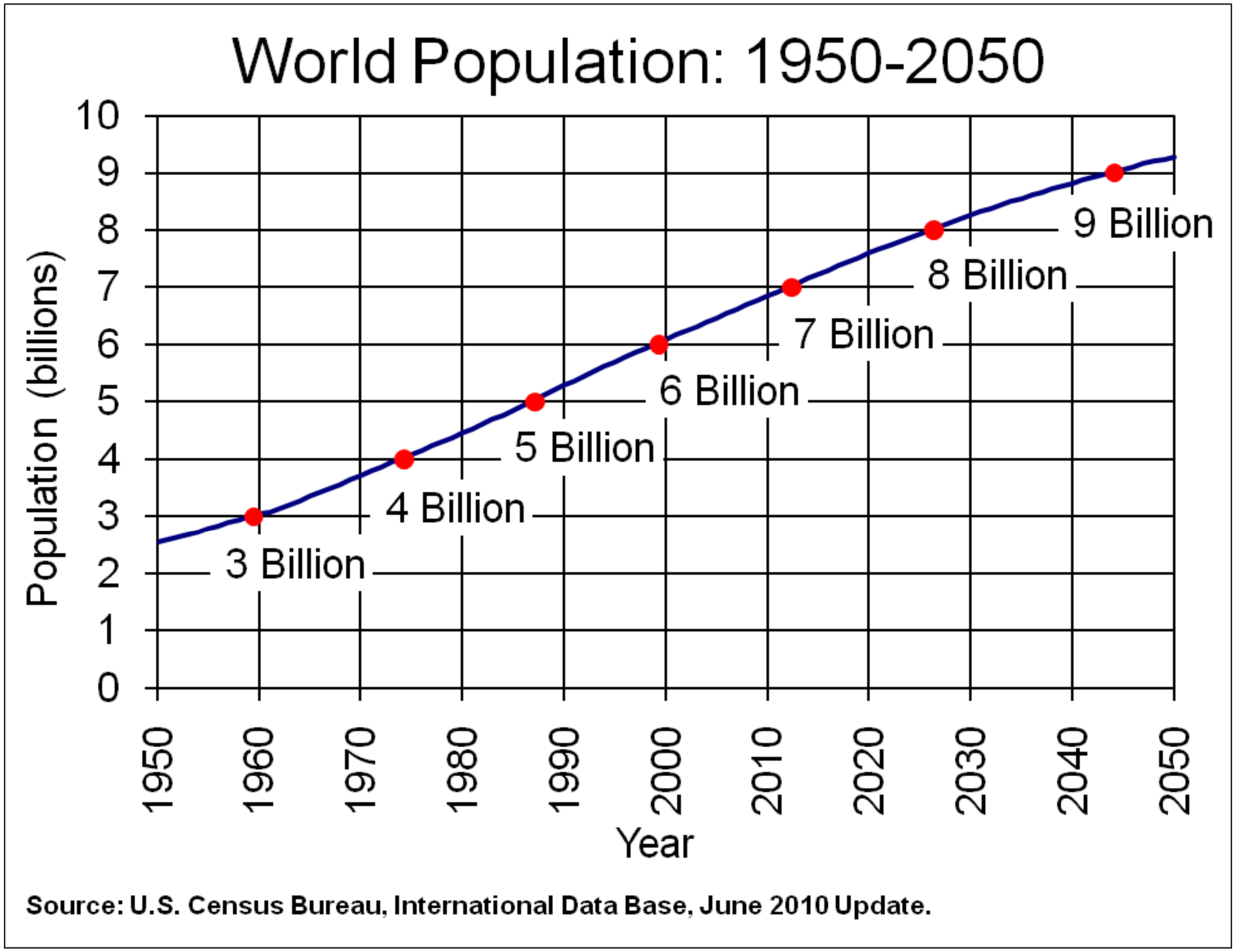
Don Huber's Arguments

- Glyphosate:
  - Changes soil microflora
  - Chelates micronutrients in the soil
  - Inhibits plant enzymes that regulate micronutrient uptake
  - Immobilizes Mn in plant tissues treated with glyphosate
- The glyphosate resistant gene reduces Mn efficiency

- **Micronutrient application will address these effects.**

Micronutrients and Yield Maximization

- Projected need to double food supply by 2050.
- Industry targets to double corn and soybean yield in US from 2000 level.
- Will greater micronutrient use be necessary to reach yield potentials?



Yellow flash in soybean

- Chlorosis of newly emerging soybean leaves following application of glyphosate
- Conditions
  - Rapid soybean growth
    - Warm and moist
  - Sprayer overlaps
  - Areas prone to micronutrient deficiency

Mechanism of Glyphosate-Resistance

- Identified gene from microbial source with an EPSP synthase enzyme that was insensitive to glyphosate
- Inserted gene encoding insensitive EPSP synthase into soybean
- GMO soybean has two copies of the EPSP synthase gene
  - 1 native (susceptible to glyphosate)
  - 1 introduced (insensitive to glyphosate)

Yellow Flash in Soybean

- **Myth:** glyphosate temporarily chelates manganese and reduces chlorophyll production
- **Fact 1:** One application of glyphosate temporarily reduced chlorophyll content in newly emerging soybean leaves compared to untreated control (Abendroth et al. 2005).
- **Fact 2:** Chlorosis in soybean was caused by application of AMPA, a glyphosate degradation product (Reddy et al. 2004).

Glyphosate breakdown to AMPA

Table 2. Effect of Glyphosate-isopropylammonium (Glyphosate-Ipa) Treatment at 6.72 kg/ha on Glyphosate, Shikimate, and Aminomethylphosphonic Acid (AMPA) Concentration in Treated and New Leaves of Glyphosate-Resistant Soybean over Time[a]

		treated leaves[b]			new leaves[c]		
treatment[d]	time after treatment, days	glyphosate, μg/g of tissue	shikimate, ng/g of tissue	AMPA, μg/g of tissue	glyphosate, μg/g of tissue	shikimate, ng/g of tissue	AMPA, μg/g of tissue
Tween 20 only	1	0 f	139 a	0 e			
glyphosate-ipa	1	527 a	131 a	42 a			
glyphosate-ipa	3	336 b	146 a	19 b			
glyphosate-ipa	5	167 c	135 a	10 c			
glyphosate-ipa	7	149 c	141 a	8 cd	239 a	126 a	42 a
glyphosate-ipa	14	99 d	167 a	3 de	121 b	147 a	21 b
glyphosate-ipa	22	37 e	147 a	1 e	3 c	148 a	1 c
Tween 20 only	22				0 c	121 a	0 c

[b] Means within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's protected LSD test. [b] Treated leaves included first pair, and first, second, and third trifoliolate leaves. [c] New leaves included fourth trifoliolate leaf and above. [d] Tween 20 at 0.5% (v/v) was added to all treatment solutions.

Reddy et al. 2005

AMPA effect on chlorophyll content

Table 3. Effect of Aminomethylphosphonic Acid (AMPA) Treatment on Chlorophyll Content 4 Days after Treatment and Shoot Fresh Weight 14 Days after Treatment of Glyphosate-Resistant (GR) and Non-GR Soybean[a]

	chlorophyll, % of control		shoot fresh wt, % of control	
AMPA rate,[b] kg/ha	GR soybean	non-GR soybean	GR soybean	non-GR soybean
untreated control	100 a	100 a	100 a	100 a
Tween 20	86 b	83 ab	98 a	93 ab
0.12	72 c	84 ab	96 ab	93 ab
0.25	58 d	82 bc	91 bc	90 bc
0.50	59 d	66 c	90 cd	91 bc
1.00	50 de	41 d	88 cd	85 c
2.00	40 ef	36 d	86 d	84 c
4.00	40 ef	41 d	74 e	66 d
8.00	34 f	31 d	61 f	51 e

[a] Means within a column followed by the same letter are not significantly different at the 5% level as determined by Fisher's protected LSD test. [b] Tween 20 at 0.5% (v/v) was added to spray solutions in all treatments except untreated control.

Reddy et al. 2005

Mn deficiency in soybean

- Where common?
  - Eastern Soybean Belt
  - High pH and/or high O.M. soils
- Interveinal chlorosis
- Deficiency symptoms often appear near time of postemergence herbicide applications
- Foliar and banded applications of Mn fertilizers are effective at alleviating symptoms

Soybean response to Mn in Nebraska

Hypotheses

On Mn-sufficient silt-loam or silty-clay loam soils in NE:

- GR and non-GR soybean varieties will respond similarly to foliar application of Mn
- Application of glyphosate will not affect GR soybean response to Mn

Methods

- Field studies in 2007 and 2008
  - South Central Agricultural Laboratory (Clay Center, NE)
    - Irrigated
    - Hastings silt loam, 2.5% O.M. and pH 6.5
      - Soil Mn, 7.3-11.2 ppm
  - Lincoln Agronomy Farm (Lincoln, NE)
    - Rainfed
    - Sharpsburg silty clay loam, 3.1% O.M. and pH 6.7

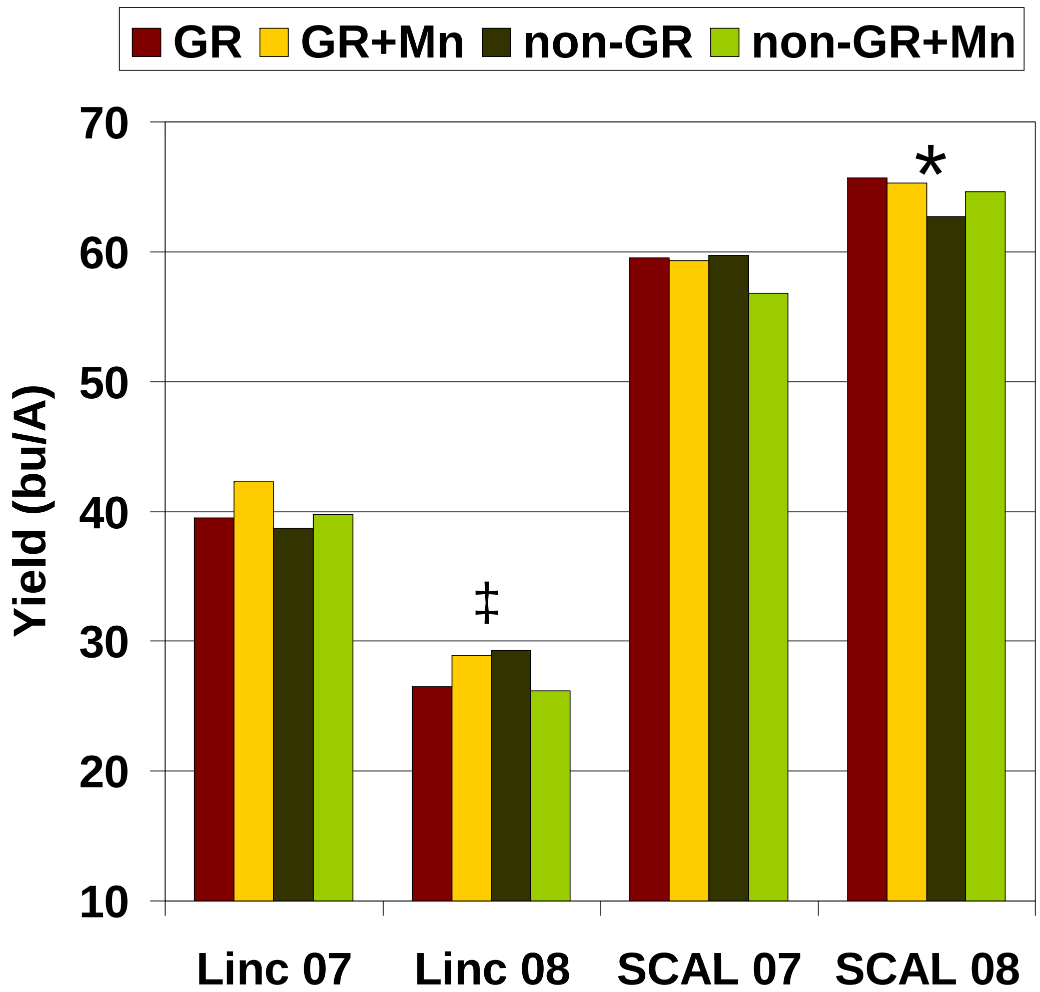
Variety response

- Mainplot - varieties
  - 4 GR
  - 4 non-GR
- Subplot – Mn
  - 0 lbs Mn
  - 1 lb Mn (0.33 lb Mn/A applied at V4, V8, and R2)
- 4 replications
- Soybeans were planted mid-May
- 150,000 seeds/A
- 30 in row spacing

Glyphosate-resistant gene and yield

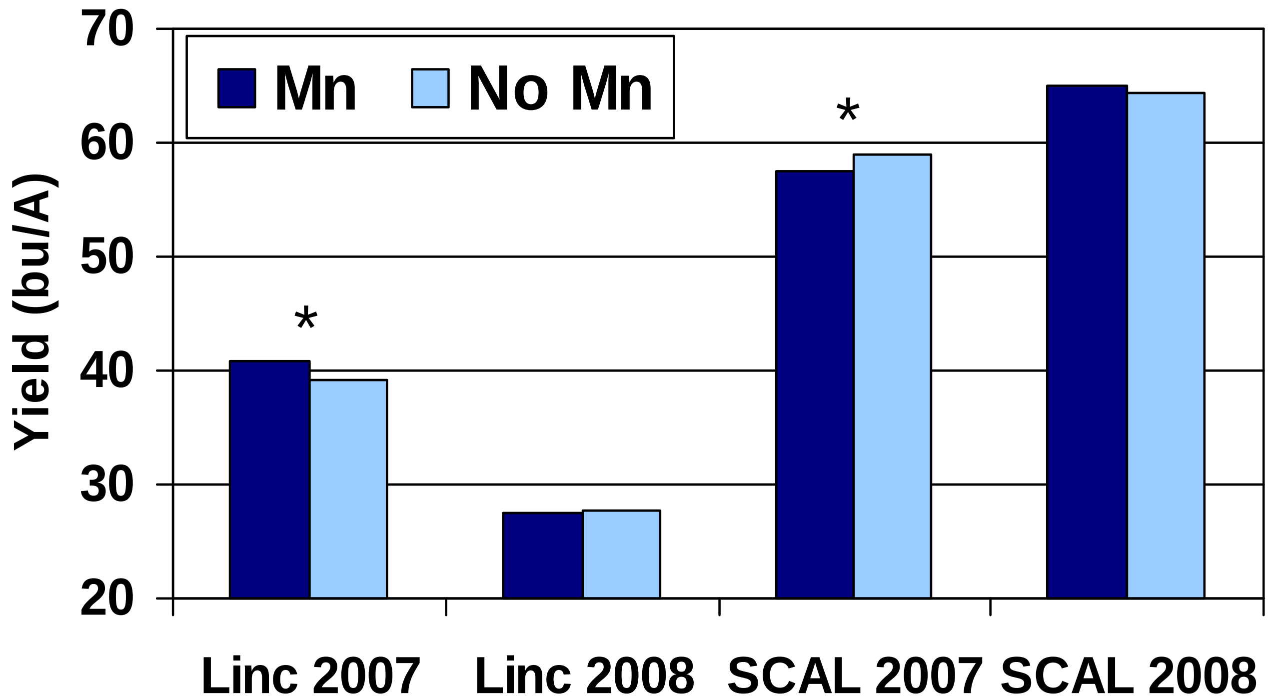
- Average of 4 GR and 4 non-GR varieties

Effect	P value	Site Years
GR gene	<0.05	SCAL 08
Mn	n.s.	-
GR x Mn	<0.05	Linc 08

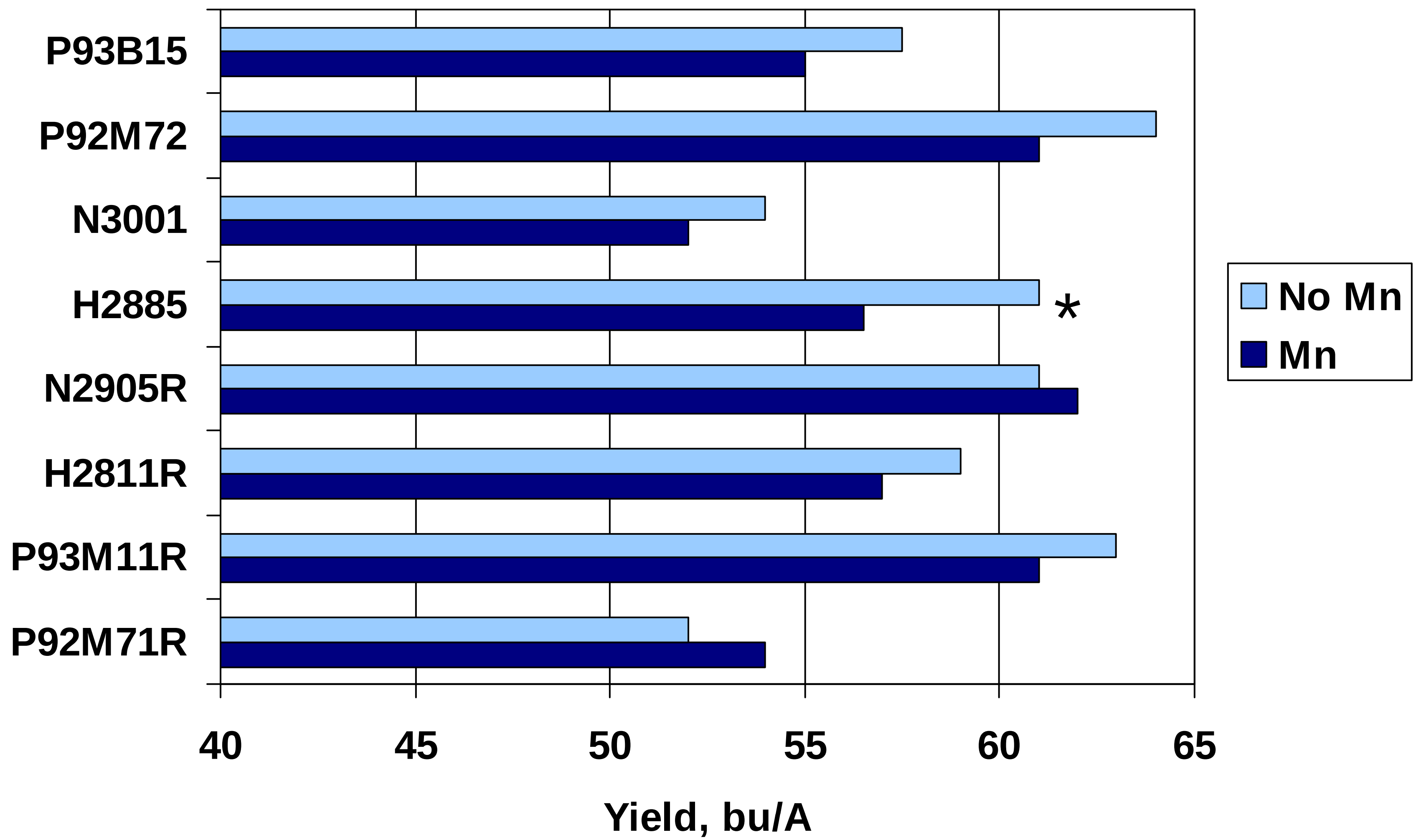


Variety and Mn effect - Yield

Effect	P value	Site Years
Variety	<0.01	4
Mn	<0.05	2
Variety x Mn	n.s.	-



Variety response – SCAL 2007



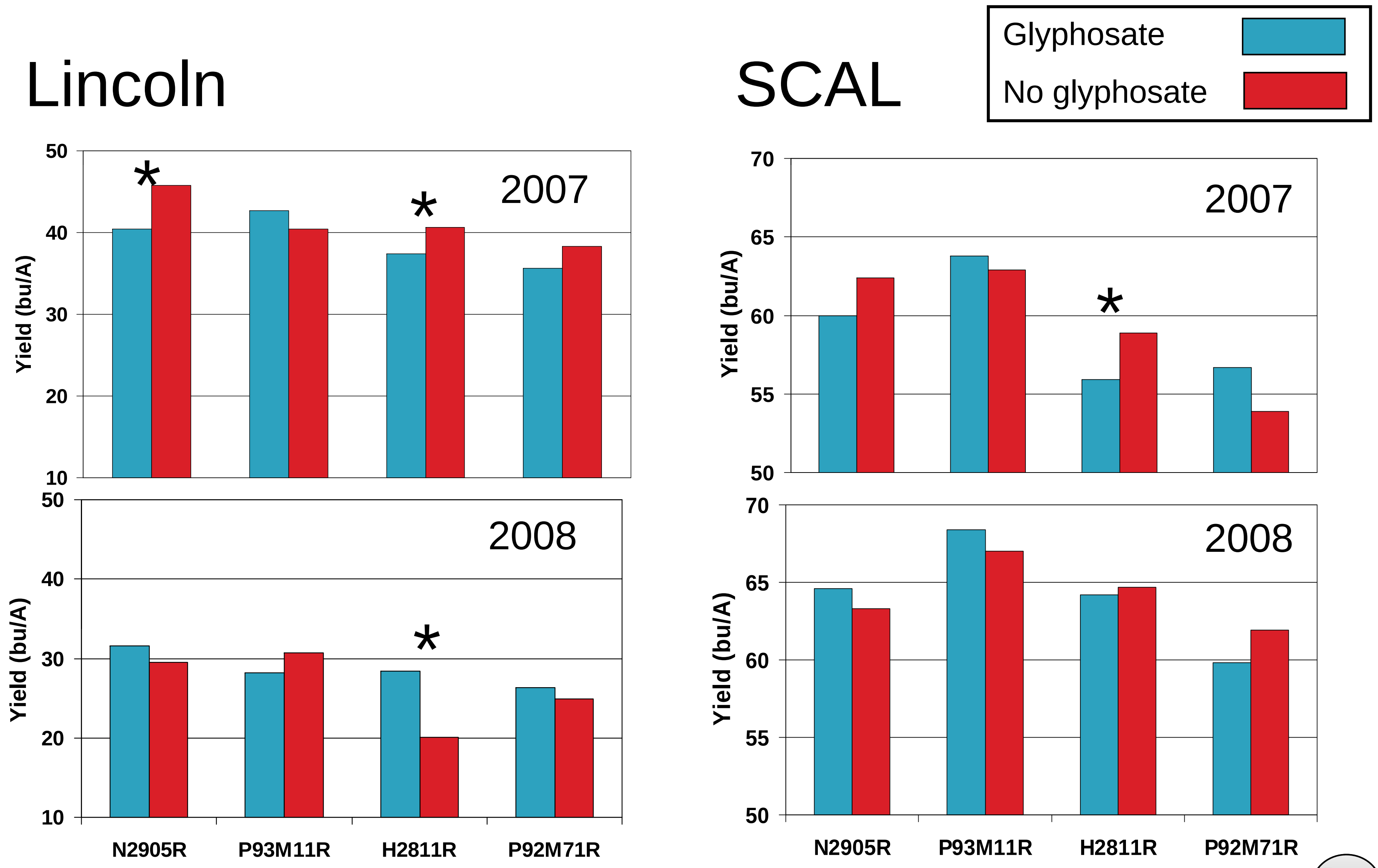
* $p<0.05$, within variety response to Mn only 2 times in 4 site years

Glyphosate application effect on yield

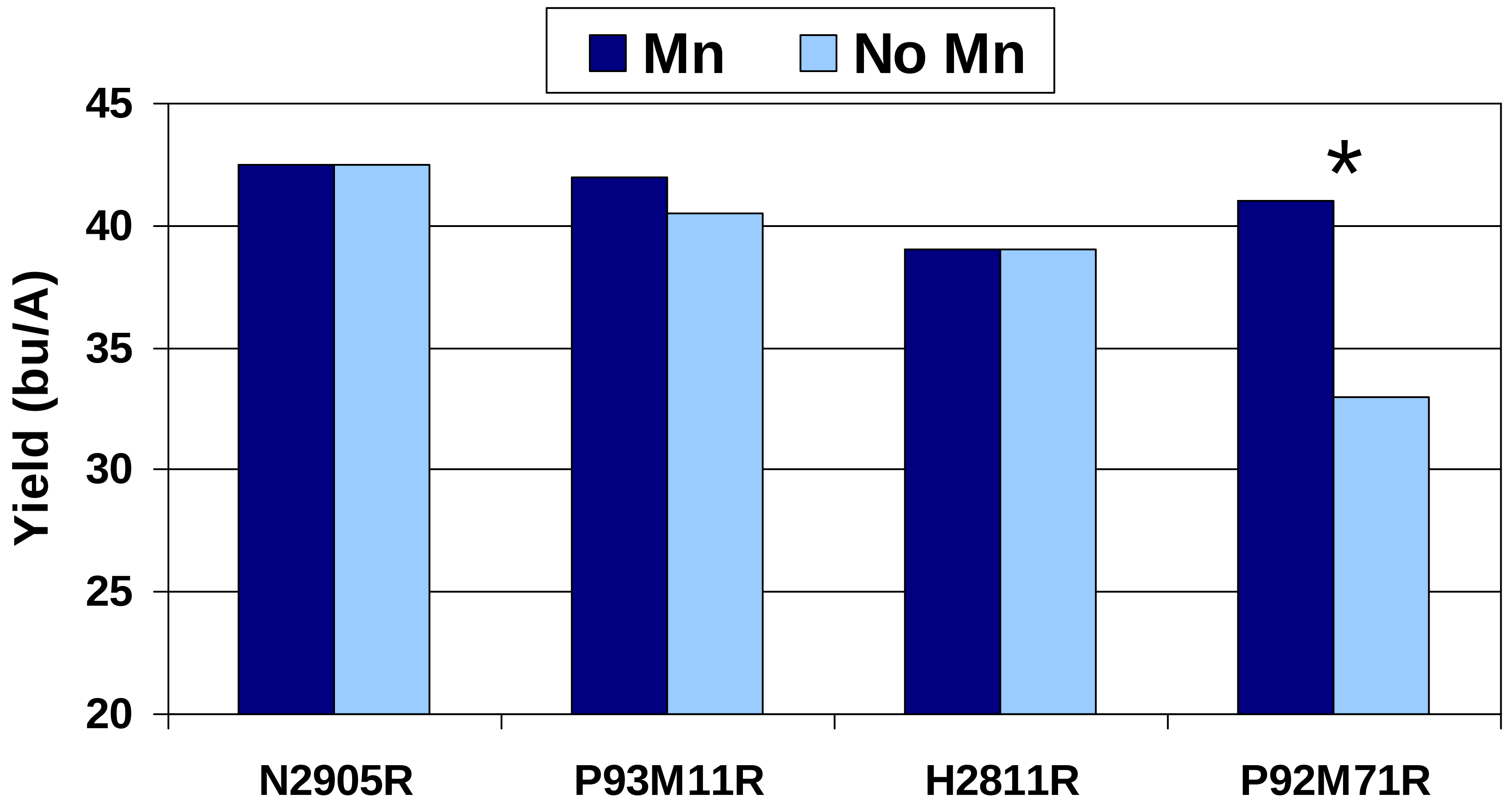
- 4 varieties
- Glyphosate
  - No glyphosate
  - Glyphosate at 0.75 lb ae/A applied at V6
- Mn
  - No Mn
  - Mn at 0.33 lb/A at V4, V8, and R2

Effect	P value	Site Years
Variety	<0.01	4
Mn	<0.01	1
Glyphosate	<0.05	2
Variety x Glyphosate	<0.05	3
Mn x Glyphosate	n.s.	-
Variety x Mn	<0.01	1
Var x Mn x Gly	n.s.	-

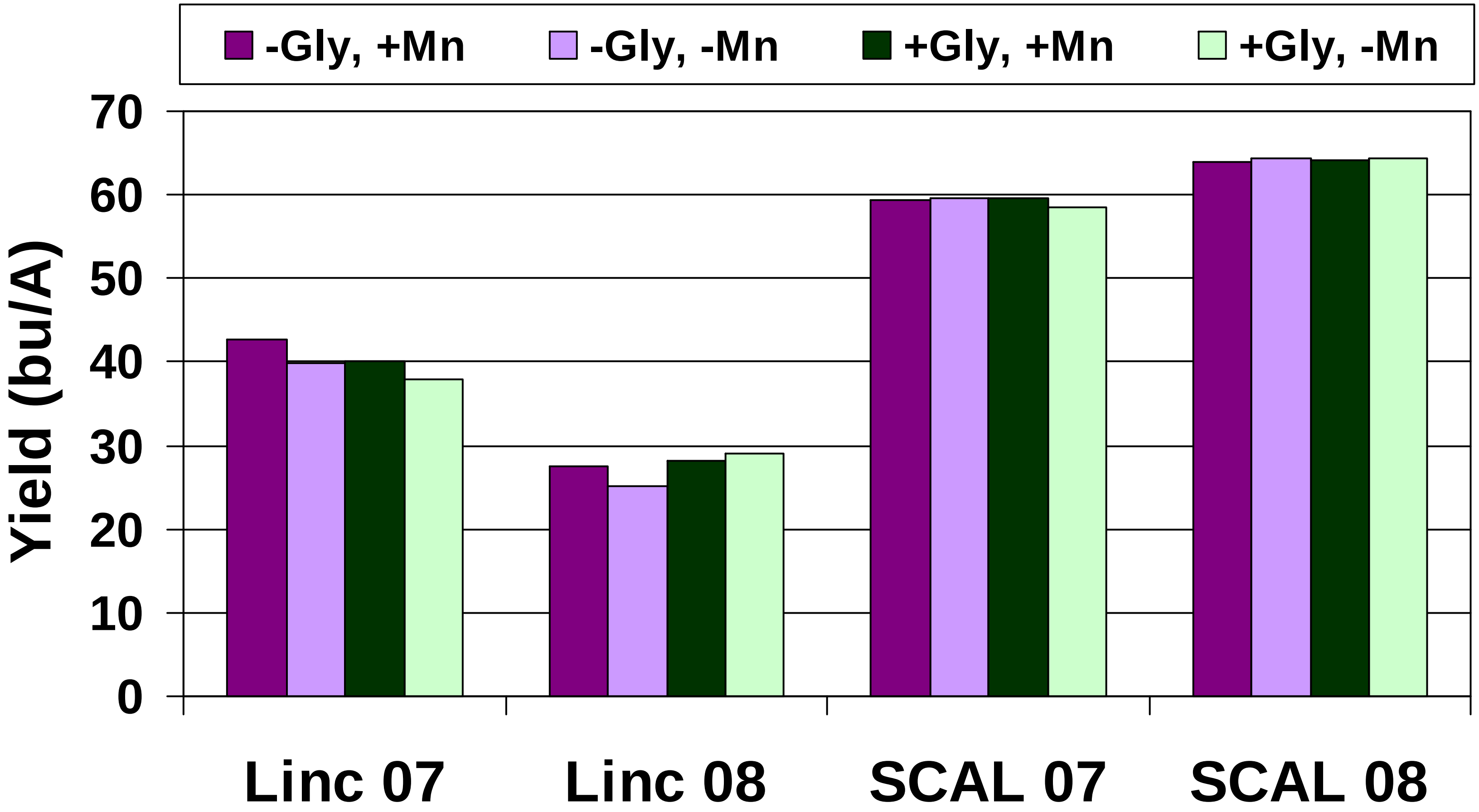
Variety x Glyphosate interaction



Mn x Variety – Lincoln 2007



Mn x Glyphosate interaction



Conclusions from NE study

- No consistent response to Mn fertilizer between glyphosate-resistant and non-glyphosate resistant soybean
- No consistent response to Mn application within varieties
- No consistent response to glyphosate application within varieties
- No interaction between glyphosate and Mn applications

Soybean response to Mn - Indiana

- Differential response between a GR and non-GR soybean on Mn-marginal soil in Indiana (Dodds et al. 2001)
  - Lower tissue Mn in GR soybean
- Chlorosis ratings and tissue Mn concentrations varied among several GR and non-GR soybean varieties (Dodds et al. 2002)
- Mn was not translocated when applied with or shortly after glyphosate (less than 7 days) (Huber et al. 2004)
- Neither IL nor IN reported problems with plants use of Mn after glyphosate appl. (Bernick 2010)

Soybean response to Mn - Kansas

- Yield of a GR-soybean increased with Mn application, but yield of non-GR isoline did not change in Northeast Kansas (Gordon 2007).
- Leaf tissue Mn concentration of GR-isoline was 60% less than of non-GR isoline in absence of Mn application (Gordon 2007)
- No difference in response to Mn application between GR and non-GR isolines in 3rd year of study (Gordon 2008)
- Yield response to Mn among GR and non-GR varieties was inconsistent at 5 locations and 2 years across Kansas (Nelson 2008)

Soybean response to Mn - Ontario

- No yield benefit with Mn application (tested across several Mn formulations)
- Some Mn treatments resulted in a 10-15% yield reduction
  - Some due to plant injury from micronutrient application
- All but 2 Mn formulations reduced glyphosate activity (Soltani et al. 2011)

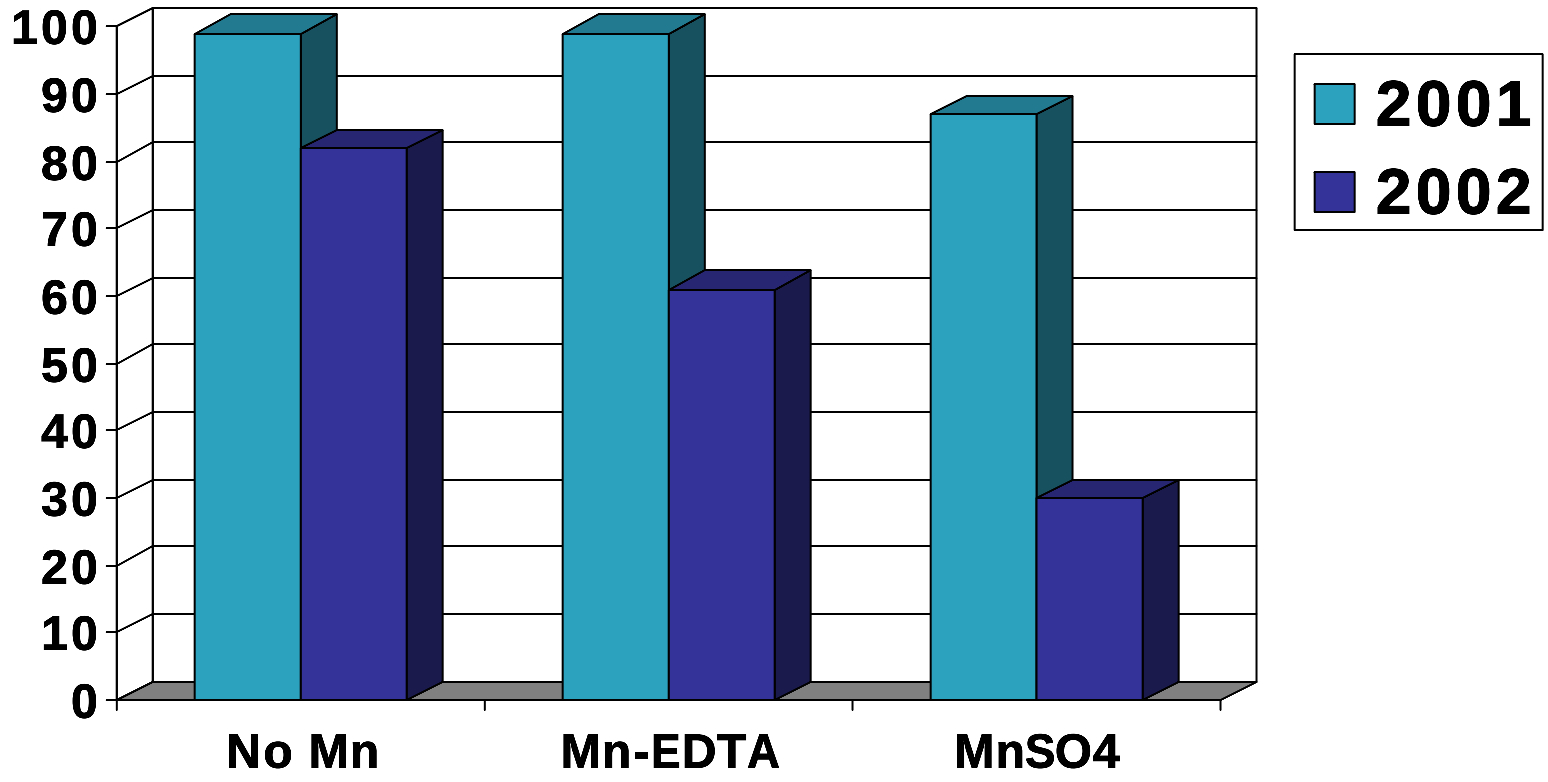
Response to Mn - Michigan

Table 1. Chlorophyll level and grain yield as affected by Mn fertilizer applied in glyphosate tank-mixtures to glyphosate-resistant soybean.

Mn treatment	Mn rate	SPAD-502 reading	Yield
	-lb/A-	11 DAT	-bu/A-
no Mn	0.0	25.9 b	33 b
$MnSO_4$	2.5	37.1 a	57 a
Untreated	0.0	23.9 b	24 b

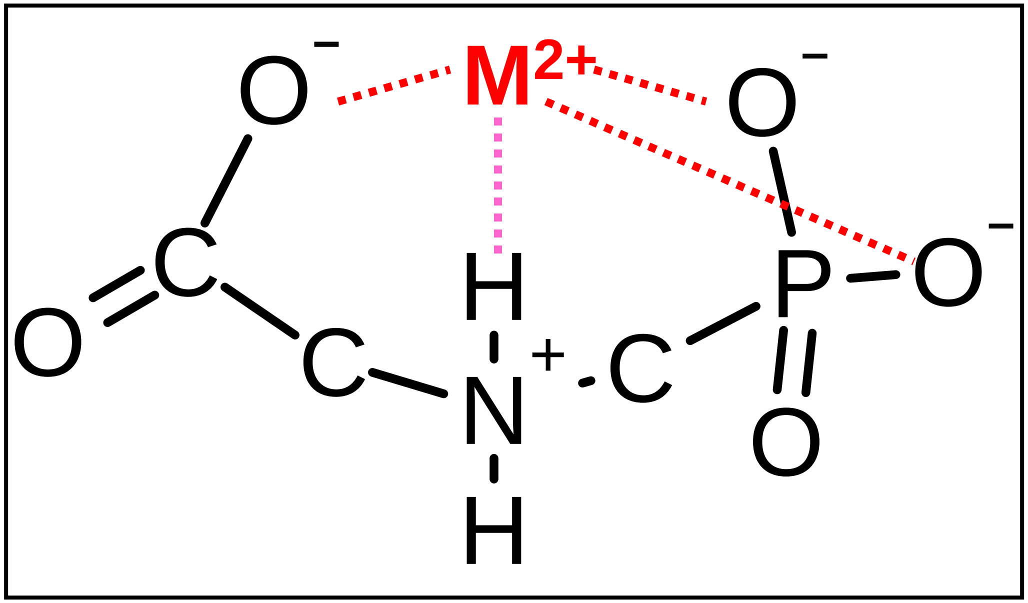
Mn antagonism in the field

Common lambsquarters control 28 DAT with glyphosate-AMS-Mn fertilizer tank-mixtures in soybean in 2001 and 2002. Glyphosate was applied at 0.5 lb ae/A.



Tank-mixing Micronutrient Fertilizers and Glyphosate

Glyphosate as chelate



- Glyphosate forms complexes with di- and tri-valent metal cations

Antagonism

Antagonism of herbicide efficacy occurs when adding a product to the spray solution causes a reduction in weed control.

glyphosate + $ZnSO_4$ | glyphosate | glyphosate + $ZnSO_4$ + NT | glyphosate + NT

Antagonistic Cations

Glyphosate

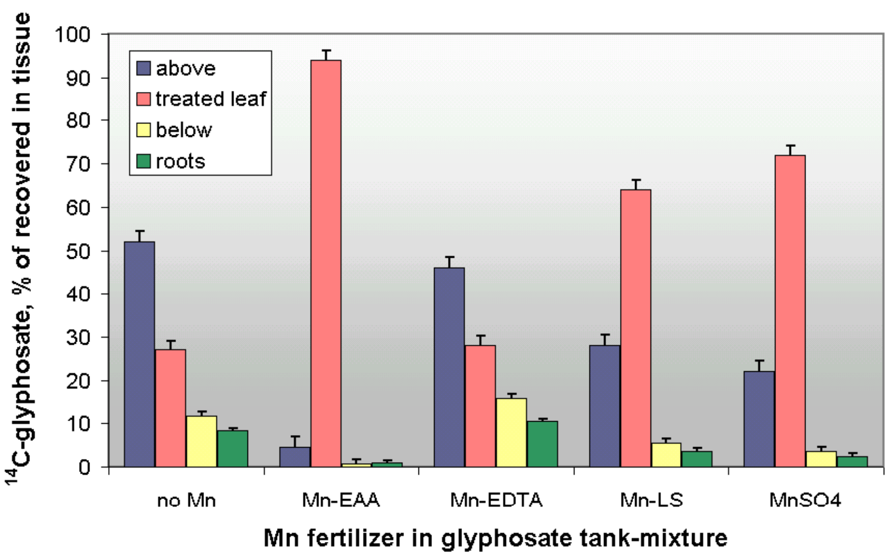
Glyphosate + $FeSO_4$

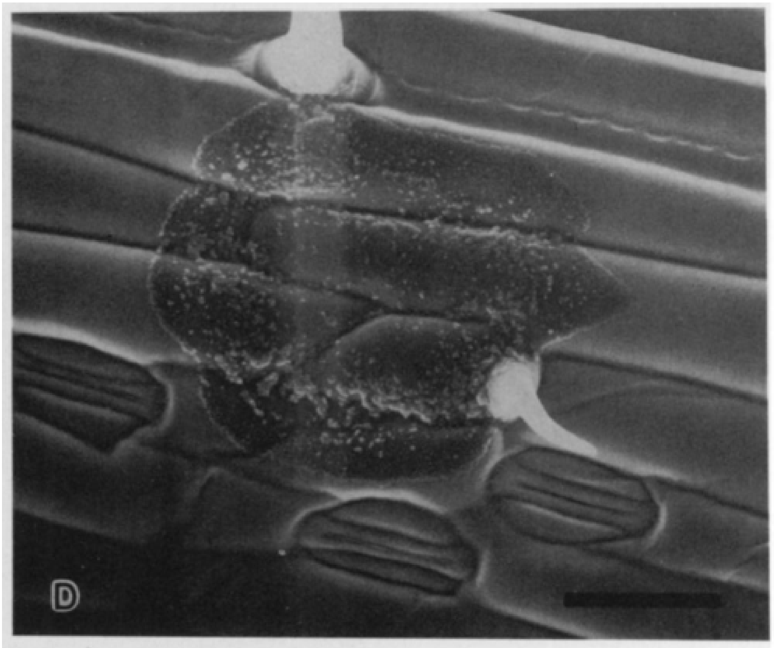
- Cations antagonistic to glyphosate activity:

Al^{3+}
Fe^{3+}
Ca^{2+}
Mn^{2+}
Zn^{2+}
Mg^{2+}
Cu^{2+}
Na^{+}
K^{+}

Glyphosate efficacy and di-/tri-valent cations

- Reduced absorption
- Reduced translocation
- Reduced control



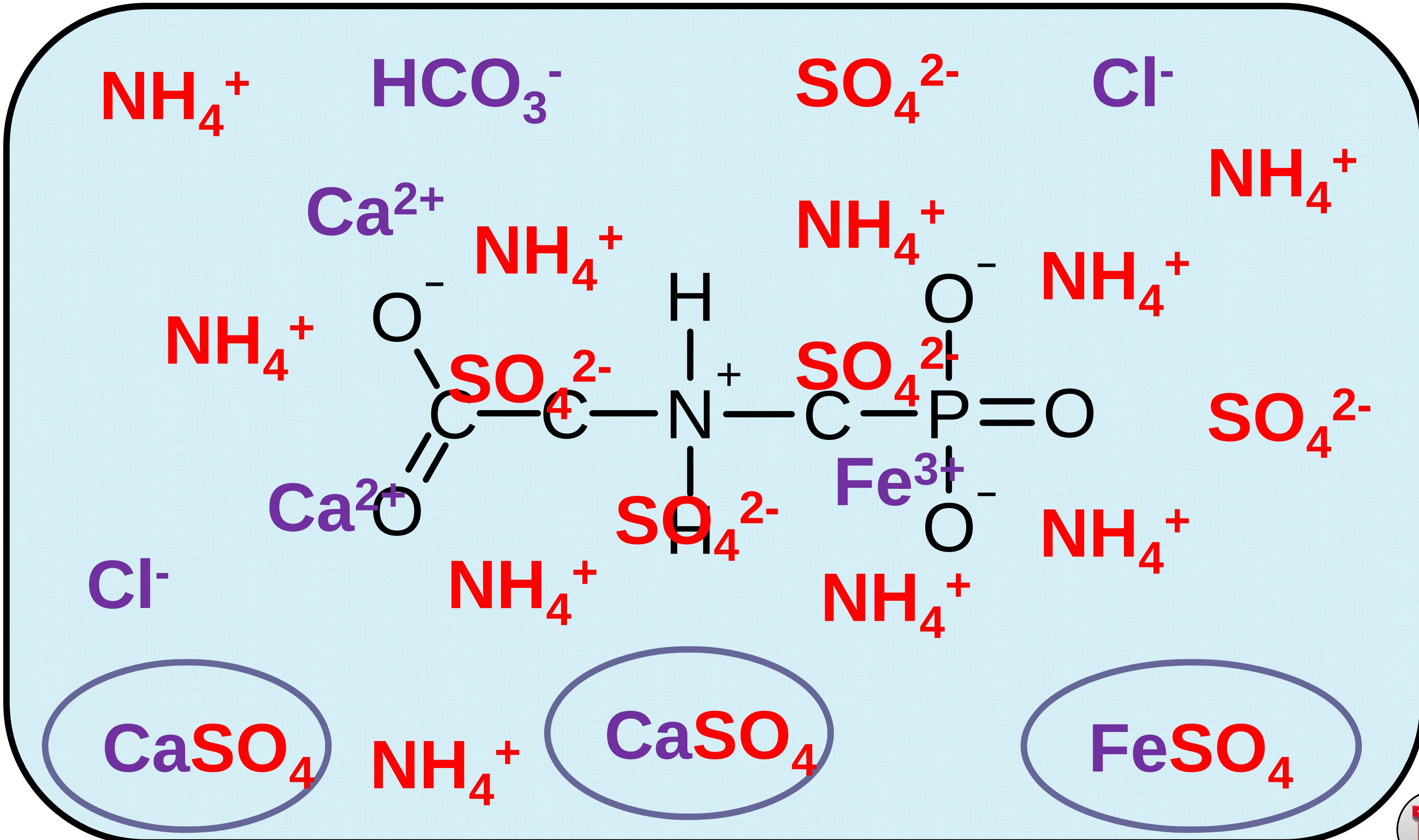


Nalewaja and Matysiak, 1992

Water conditioners and adjuvants

- Water conditioners
  - ammonium sulfate (AMS)
  - EDTA
  - Citric acid
  - NTANK (NT)
  - N-Tense
  - CLASS ACT Next Generation (CANG)
  - Surfate
  - ReQuest
  - Choice
  - Bronc Max, etc.
- Fertilizer adjuvants
  - EDTA
  - HEDTA
  - Citric acid
  - Lignin sulfonates
  - Flavonols
  - Mannitol
  - iminodisuccinic acid
  - glucoheptonate

AMS - Mode of Action



Objectives

1. Quantify the antagonism caused by various formulations of B, Cu, Fe, Mn, Zn, and micronutrient mixtures, on glyphosate efficacy.

2. Determine if the water conditioners AMS, CANG, and NT, can prevent antagonism from occurring.

Materials and Methods

- Greenhouse bioassays
  - Velvetleaf (*Abutilon theophrasti*)
  - Giant foxtail (*Setaria faberi*)
- Isopropylamine salt of glyphosate
  - 0.25 lb ae/A
- Single-tip track sprayer
- Spray volume: 10 gal/A
- Spray pressure: 25 psi
- All solutions were prepared in distilled water

Materials and Methods

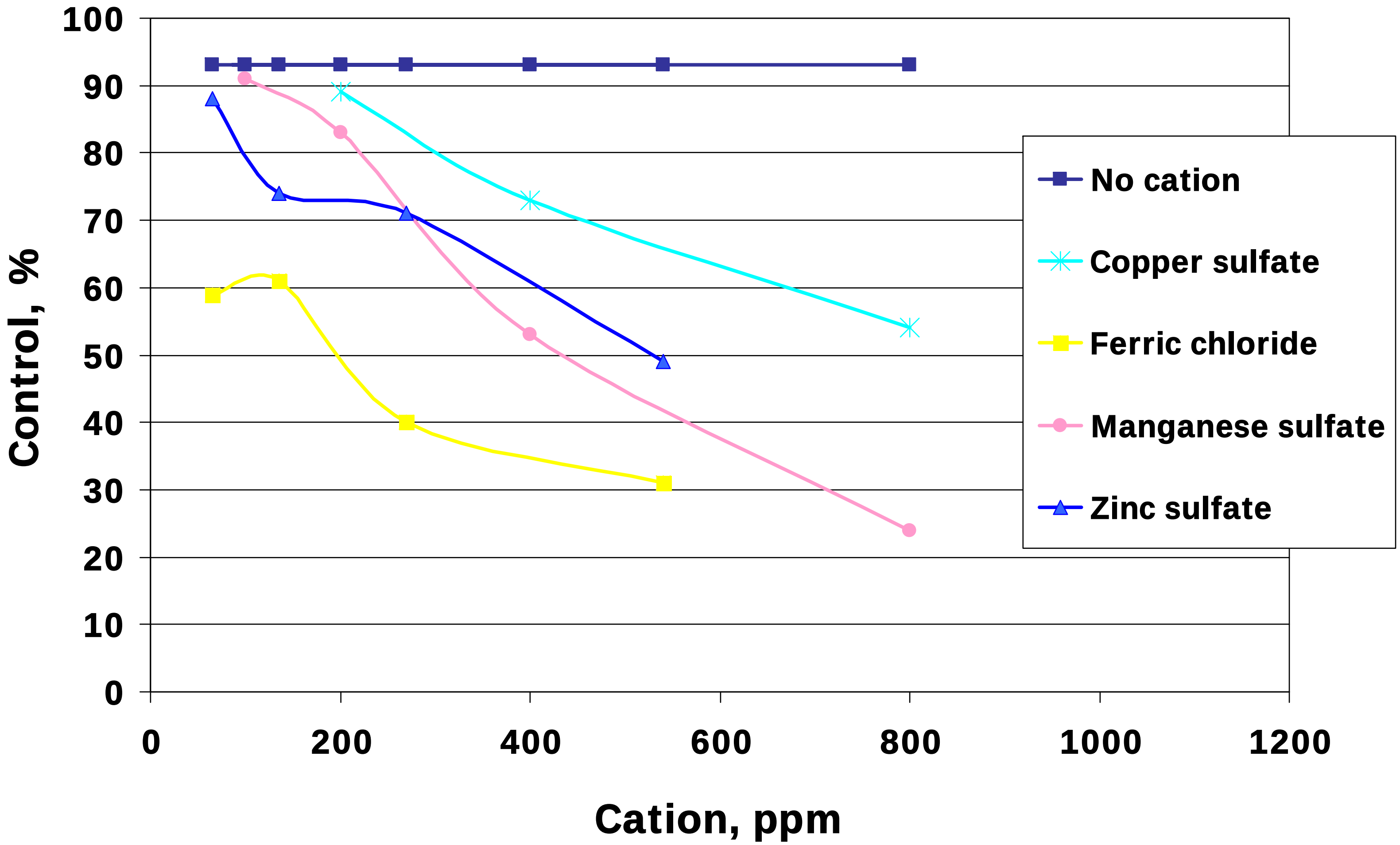
- Micronutrient formulations (except Boron)
  - sulfate salt
  - ammonium citrate salt
  - EDTA or HEDTA chelate
  - micronutrient charged catalyst flavonol
  - lignosulfonic acid chelate (LSA)

- Water conditioner adjuvants
  - 2% AMS (w/w)
  - 2.5% CANG (CLASS ACT® Next Generation) (v/v)
  - 1.0% NT (NTANK™) (v/v)

Materials and Methods

- Micronutrient application rates
  - Boron, 0.25 lb/A (Boric acid and sodium borate)
  - Copper, 0.45 lb/A
  - Iron, 0.4 lb/A
  - Manganese, 1.0 lb/A
  - Zn, 0.5 lb/A
- Micronutrient mixtures
  - Chelated by EDTA and citric acid (MC)
  - not chelated (MS)
  - in lb/A: N - 0.32, S – 0.16, B - 0.02, Fe – 0.05, Mn – 0.16, Zn – 0.11

Velvetleaf, 21 DAT, Bernards et al. 2004



Micronutrient concentration in the tank-mixture

Fertilizer rate	Analysis	Micronutrient rate	Spray volume 10 gal/A	Spray volume 20 gal/A
			---Nutrient, mg/L---	
4 gal/A	5% X	2 lb/A	24,000	12,000
2 gal/A	5% X	1 lb/A	12,000	6,000
1 gal/A	5% X	0.5 lb/A	6,000	3,000
0.5 gal/A	5% X	0.25 lb/A	3,000	1,500
0.25 gal/A	5% X	0.125 lb/A	1,500	750
0.25 gal/A	1% X	0.025 lb/A	300	150

Boron (0.25 lb/A)

Table 1. Control of giant foxtail with glyphosate (0.25 lb/A) + boron tank-mixtures, 14 DAT.

	Water conditioner adjuvant in tank-mixture[a]		
Boron salt	None	AMS	NT
	------------------ Control, % ----------------		
None	100 a	99 a	100 a
Boric acid (HB)	93 a	99 a	100 a
Sodium borate (NaB)	88 a	100 a	78 b

[a] Means within a column followed by the same letter are not statistically different, p = 0.05.

Boron (O.25 lb/A)

FIG. 1 - *Velvetleaf control, 14 DAT.*

'HB' - Boric acid

'NaB' - Sodium borate

glyphosate + HB	glyphosate + HB + AMS	glyphosate + HB + NT	glyphosate + NaB	glyphosate + NaB + AMS	glyphosate + NaB + NT	untreated	glyphosate

Copper (0.45 lb Cu/A)

Table 2. *Control of giant foxtail with glyphosate (0.25 lb/A) + copper (Cu) tank-mixtures.*

Cu formulation	Water conditioner adjuvant in tank-mixture[a]			
	None	AMS	CANG	NT
	------------------------ Control, %	------------------------		
None	96 a	99 a	94 a	99 a
Cu sulfate	56 de	67 bc	64 b	89 abc
Cu citrate	63 cd	68 bc	74 b	83 c
Cu EDTA	66 c	74 b	92 a	87 bc
Cu flavonol	80 b	91 a	94 a	94 ab
Cu LSA	46 e	61 c	64 b	94 ab

[a] Means within a column followed by the same letter are not statistically different, p = 0.05.

Copper (0.45 lb/A)

Cu sulfate: most antagonistic

Cu EDTA: least antagonistic

Tank-mixed with Cu fertilizer:	glyphosate	glypho. + AMS	glypho. + 0.5% NT	glypho. + 1% NT	glypho. + CANG	fertilizer only	No fertilizer (glyphosate)

weedscience.unl.edu

Copper (0.45 lb/A)

Table 3. *Control of velvetleaf with glyphosate (0.25 lb/A) + copper (Cu) tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Cu formulation	None	AMS	CANG	NT
	------------------------- Control, %	-------------------------		
None	78 a	90 a	71 a	91 a
Cu sulfate	19 d	53 c	29 e	68 cd
Cu citrate	41 c	56 c	49 d	61 d
Cu EDTA	57 b	67 b	66 ab	77 b
Cu flavonol	44 c	64 b	63 bc	71 bc
Cu LSA	41 c	56 c	58 c	69 c

[a] Means within a column followed by the same letter are not statistically different, p = 0.05.

Iron (0.4 lb Fe/A)

Table 4. *Control of giant foxtail with glyphosate + Fe tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Fe formulation	None	AMS	CANG	NT
	------------------------ Control, % ------------------------			
None	99 a	95 a	98 a	98 a
Fe sulfate	8 d	28 c	16 c	64 c
Fe citrate	21 c	28 c	16 c	53 d
Fe EDTA	**68 b**	**71 b**	**61 b**	**79 b**
Fe flavonol	**69 b**	**73 b**	**66 b**	**81 b**

[a] Means within a column followed by the same letter are not statistically different, p = 0.05.

Iron (O.4 lb/A)

FIG. 4 - *Velvetleaf control, 14 DAT.*

untreated	glypho.	glypho. + $FeSO_4$	glypho. + $FeCl_2$	glypho. + Fe flavonol	glypho. + Fe HEDTA	glypho. + Fe citrate

Iron + glyphosate + AMS.

FIG. 5 – *Control of velvetleaf, 14 DAT*

Fe sulfate Fe flavonol Fe HEDTA Fe citrate no Fe

Iron (0.4 lb Fe/A)

Table 5. *Control of velvetleaf with glyphosate + Fe tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Fe formulation	None	AMS	CANG	NT
	------------------------	Control, %	------------------------	
None	40 a	55 a	55 a	69 a
Fe sulfate	0 b	3 cd	0 c	4 bc
Fe citrate	0 b	0 d	3 c	0 c
Fe EDTA	5 b	11 bc	9 c	6 bc
Fe flavonol	1 b	**19 b**	**23 b**	11 b

[a] Means within a column followed by the same letter are not statistically different, $p = 0.05$.

Manganese (1 lb / A)

Table 6. *Control of giant foxtail with glyphosate (0.28 kg/ha) + manganese (Mn) tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Mn formulation	None	AMS	CANG	NT
	------------------------- Control, % -------------------------			
None	98 a	96 a	99 a	99 a
Mn sulfate	53 d	88 ab	70 c	91 a
Mn citrate	69 c	81 b	74 bc	95 a
Mn EDTA	83 b	93 a	82 b	94 a
Mn flavonol	91 ab	97 a	93 a	97 a
Mn LSA	44 d	71 c	58 d	74 b

[a] Means within a column followed by the same letter are not statistically different, p = 0.05.

Mn (1 lb/A)

No adjuvant

With NT

glypho. + $MnSO_4$	glypho. + Mn citrate	glypho. + Mn EDTA	glypho. + Mn LSA	glypho. + Mn flavonol	glypho.	untreated

Manganese (1 lb / A)

Table 7. *Control of velvetleaf with glyphosate (0.28 kg/ha) + manganese (Mn) tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Mn formulation	None	AMS	CANG	NT
	------------------------ Control, % ------------------------			
None	68 a	79 a	74 a	84 a
Mn sulfate	9 d	50 bc	22 c	74 ab
Mn citrate	40 c	70 a	53 b	81 a
Mn EDTA	64 ab	56 b	62 b	69 bc
Mn flavonol	57 b	55 b	61 b	61 c
Mn LSA	10 d	41 c	24 c	67 bc

[a] Means within a column followed by the same letter are not statistically different, $p = 0.05$.

Zinc (0.5 lb/A)

Table 8. *Control of giant foxtail with glyphosate (0.28 kg/ha) + zinc (Zn) tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Zn formulation	None	AMS	CANG	NT
	------------------------- Control, % -------------------------			
None	99 a	97 a	98 a	99 a
Zn sulfate	38 d	51 d	30 c	84 b
Zn citrate	53 c	86 ab	66 b	81 b
Zn EDTA	59 c	69 c	73 b	83 b
Zn flavonol	81 b	76 bc	88 a	91 ab
Zn LSA	14 e	46 d	23 c	81 b

[a] Means within a column followed by the same letter are not statistically different, $p = 0.05$.

Zinc

glypho. + $ZnSO_4$	glypho. + Zn citrate	glypho. + Zn EDTA	glypho. + Zn LSA	glypho. + Zn flavonol	glypho.

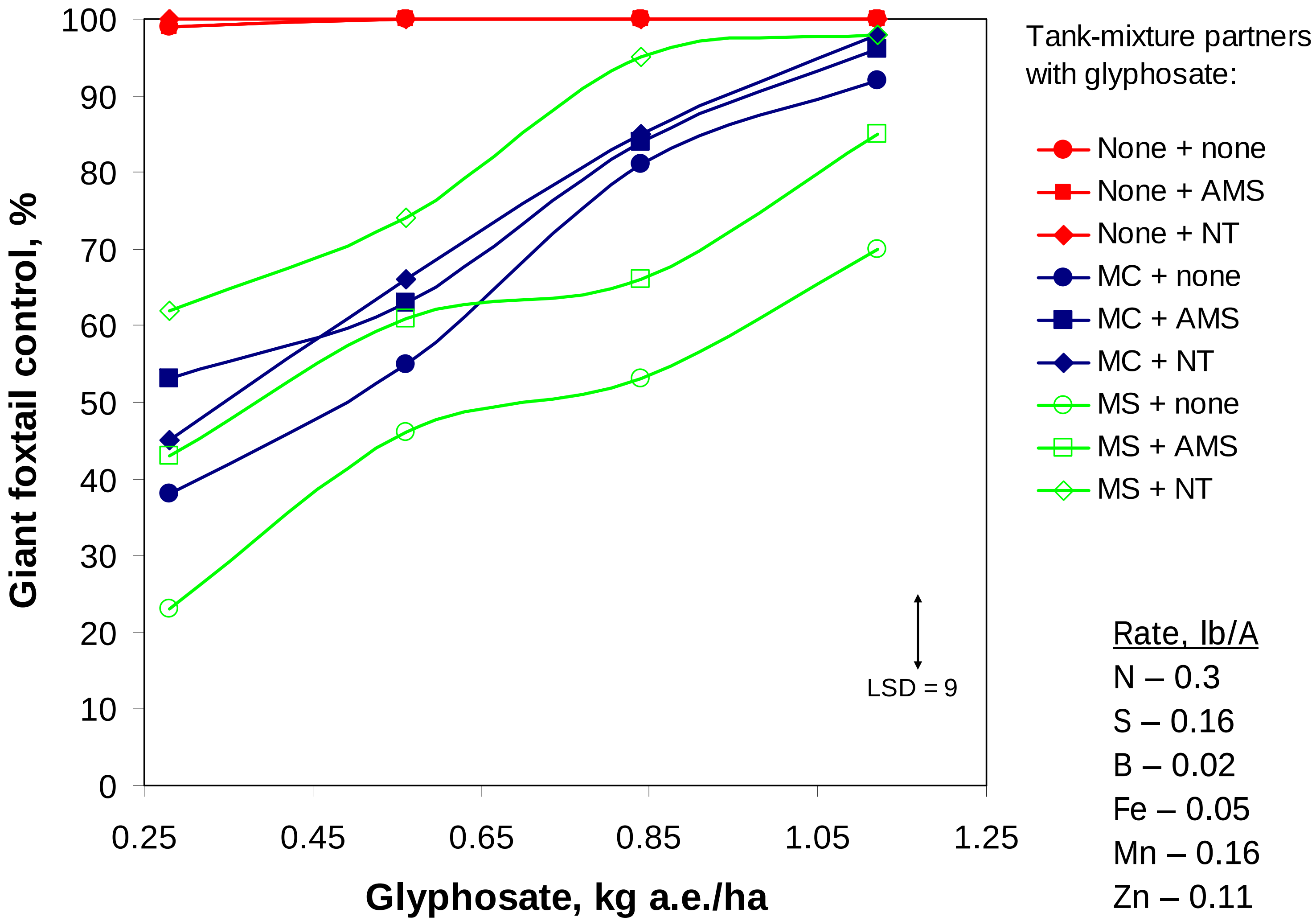
Zinc (0.5 lb/A)

Table 9. *Control of velvetleaf with glyphosate + Zn tank-mixtures.*

	Water conditioner adjuvant in tank-mixture[a]			
Zn formulation	None	AMS	CANG	NT
	------------------------ Control, %	------------------------		
None	66 a	78 a	70 a	76 a
Zn sulfate	20 c	40 c	1 d	54 b
Zn citrate	24 c	59 b	53 b	61 b
Zn EDTA	47 b	62 b	62 b	57 b
Zn flavonol	48 b	59 b	54 b	60 b
Zn LSA	5 d	54 b	13 c	58 b

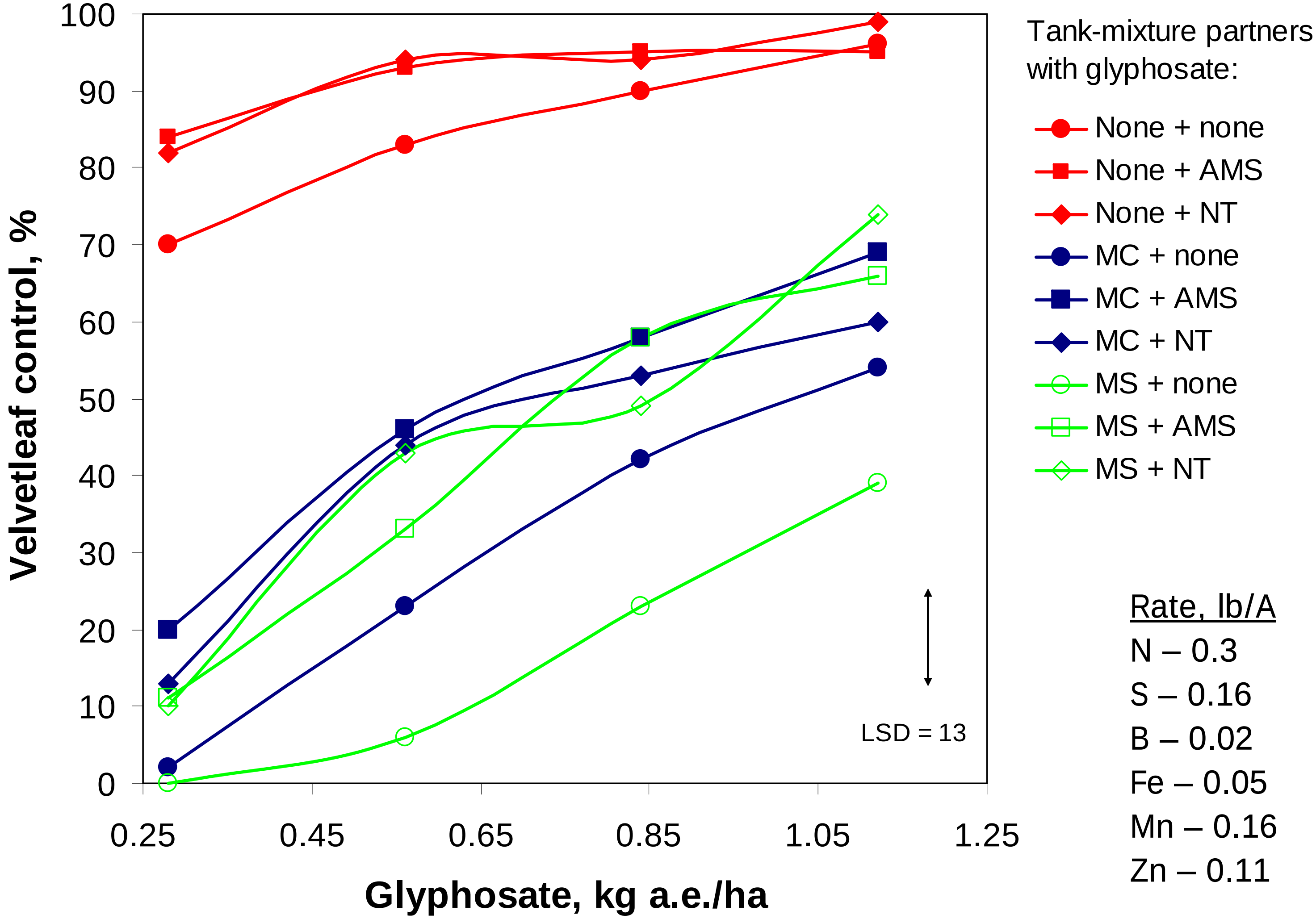
[a] Means within a column followed by the same letter are not statistically different, $p = 0.05$.

Giant foxtail control with micronutrient mixtures



Rate, lb/A
N – 0.3
S – 0.16
B – 0.02
Fe – 0.05
Mn – 0.16
Zn – 0.11

Velvetleaf control with micronutrient mixtures



Rate, lb/A
N – 0.3
S – 0.16
B – 0.02
Fe – 0.05
Mn – 0.16
Zn – 0.11

Summary - Micronutrient formulations

- Most Cu, Fe, Mn, and Zn formulations antagonized glyphosate on giant foxtail and velvetleaf
  - The EDTA, HEDTA, or flavonol formulations were the least antagonistic
  - The sulfate salt or lignosulfonic acid formulations were the most antagonistic
- Tank-mixtures containing NT overcame the antagonism more often than those containing AMS or CANG.
- Boron salts can also antagonize glyphosate efficacy

Summary - Micronutrient mixtures

- Antagonistic effect of multiple micronutrients in tank-mixture is at least additive
- Increasing the glyphosate rate may overcome antagonism, but may also be cost-prohibitive on some species
- Adding AMS or NT increased velvetleaf control for MC and MS tank-mixtures, but neither overcame the antagonism

Tank-mixing glyphosate and micros

Efficient Solution

- Nutrient deficiency
- Non-antagonistic fertilizer formulation
- Highest labeled rate of glyphosate
- Effective water conditioner
- Warm and humid

Potential Problem

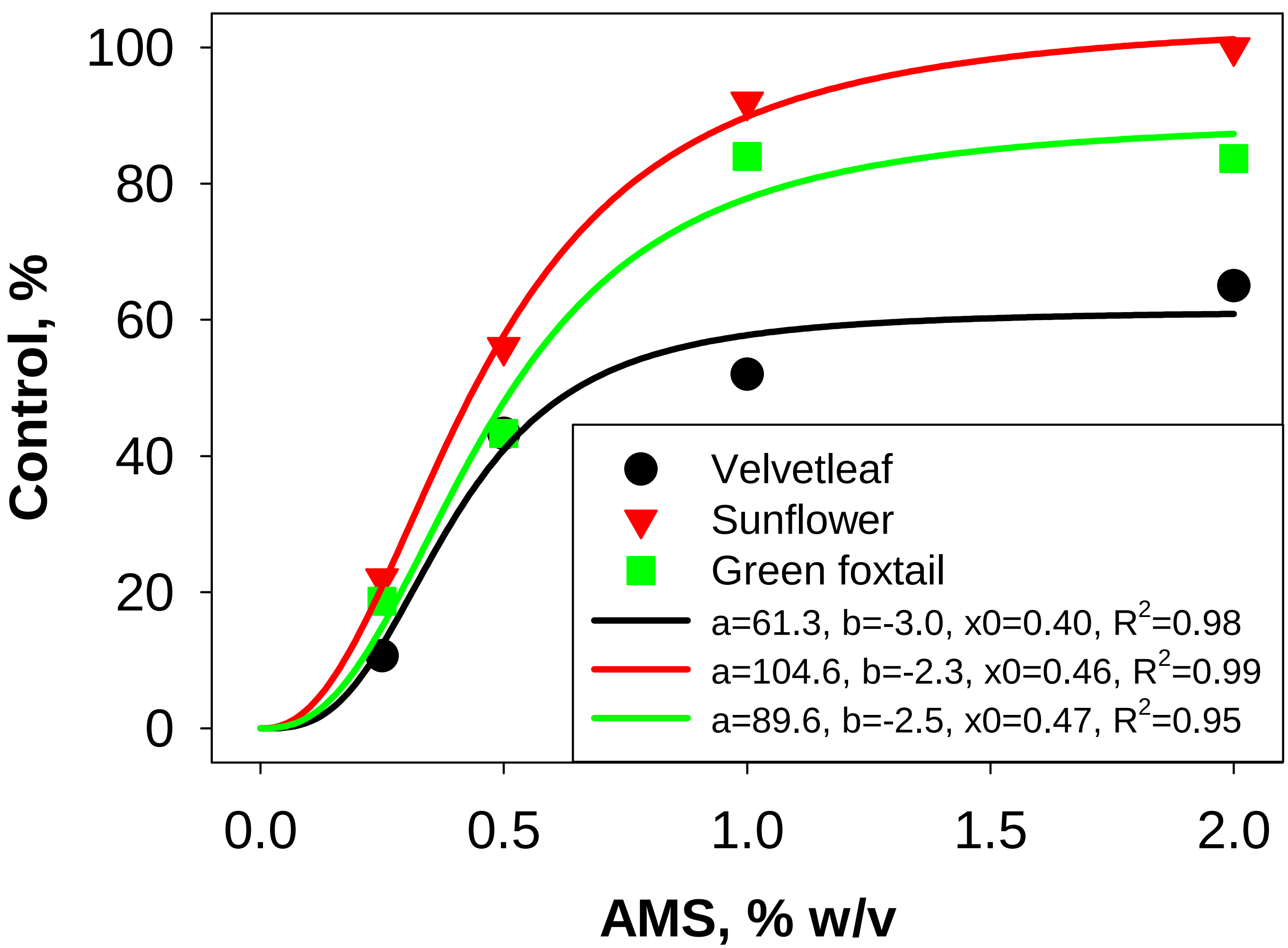
- No nutrient deficiency
- Antagonistic fertilizer formulation
- Reduced glyphosate rate
- No water conditioner
- Large weeds, droughty conditions

More recent work on micronutrients

- Penner et al. (2010, NCWSS)
  - All micronutrient fertilizers antagonized glyphosate
  - Some minor differences in water conditioners – but do not completely overcome the antagonism

Water conditioner variability

AMS Rate Matters



Objective

Evaluate commercial "water conditioners" in proposed test method to define water conditioners

Methods and Materials

- Glyphosate (0.28 lb ae/A)
  - ipa salt, 3 lb ae/gallon, 41% w/w, low load
- GPA 10
- Nozzles TT Jet 11001
- Pressure 40 psi
- Water Distilled
  1000 ppm hard water

Methods and Materials

Species:

- NE = **Vele**, wahe, fxtl.
- KS = **Vele**, ilmg, sorg, bygr, and corn.
- IL = **Vele**, ilmg, wahe, fxtl.
- MN = **Vele**, soy, cocb, bygr, and fxtl.
- ND = Flax, amar, tabw, and corn.

- Size at appl: 4 to 24 inches
- Replications: 4
- Evaluated: 14 and 28 DAT

Treatments

- Glyphosate - distilled water (DW)
- Glyphosate - hard water (HW)
- Glyphosate + AMS (DW)
- Glyphosate + AMS (HW)
- Glyphosate + 10 water conditioners at rec. rates (HW)
- All treatments applied:

  (-)

  (+) MON 0818 surfactant @ 0.25% v/v

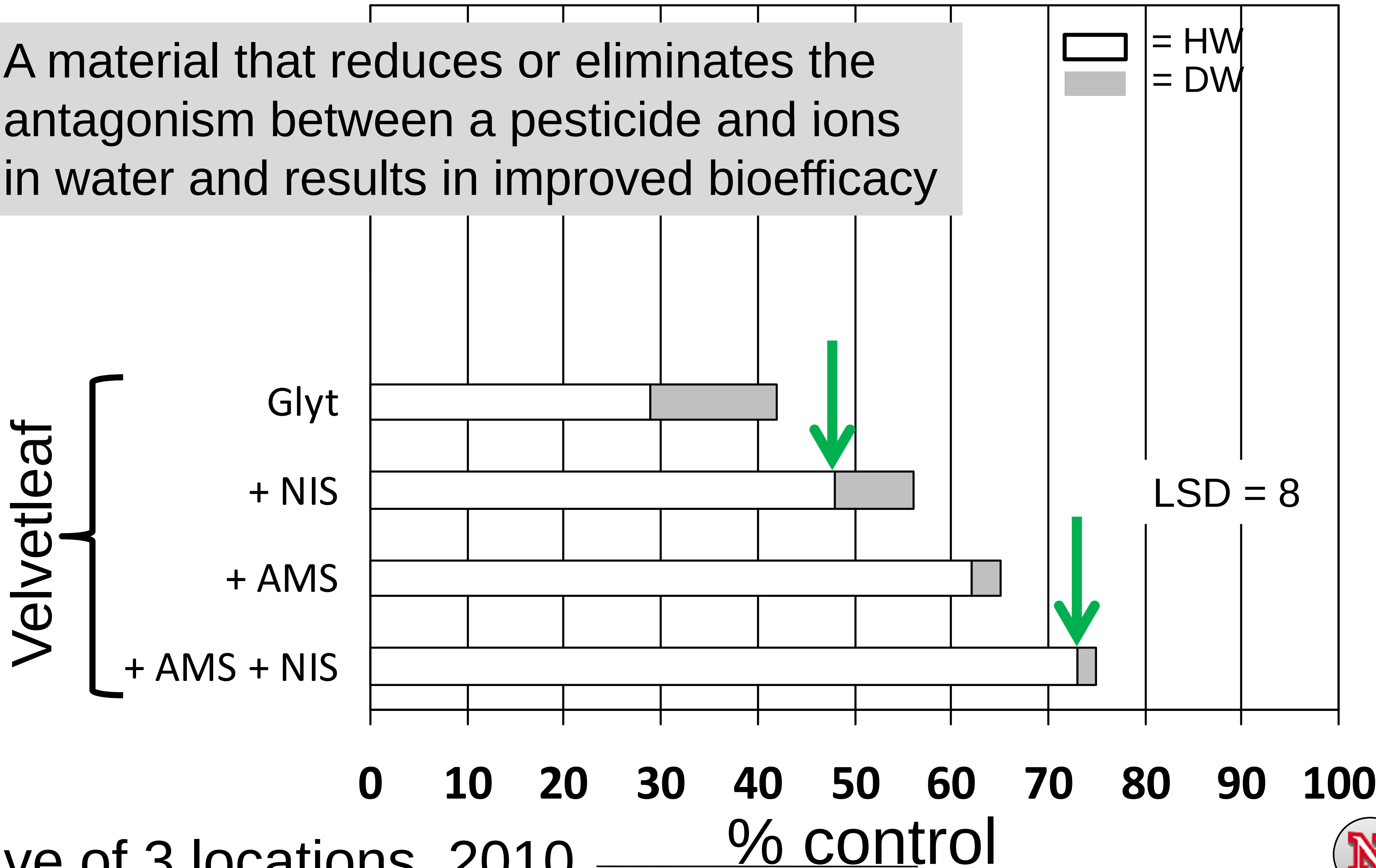
Water Conditioner adjuvants

- Request = Water conditioner (WC) (0.5% v/v)
- Helfire = Acidic WC (0.5% v/v)
- N-Tense = WC + NIS (0.5% v/v)
- Array = AMS + Deposition + Defoamer (9 lb/100 gal)
- Bronc Max = AMS + WC (0.5% v/v)
- Choice Weather Master = AMS + WC (0.5% v/v)
- Cayuse Plus = AMS + NIS (0.5% v/v)
- Class Act NG = AMS + NIS (2.5% v/v)
- Bronc Plus Dry EDT = AMS + NIS (10 lb/100 gal)
- Flame = AMS + NIS (0.5% v/v)

Adjuvant Identity Protection Program

Water conditioner

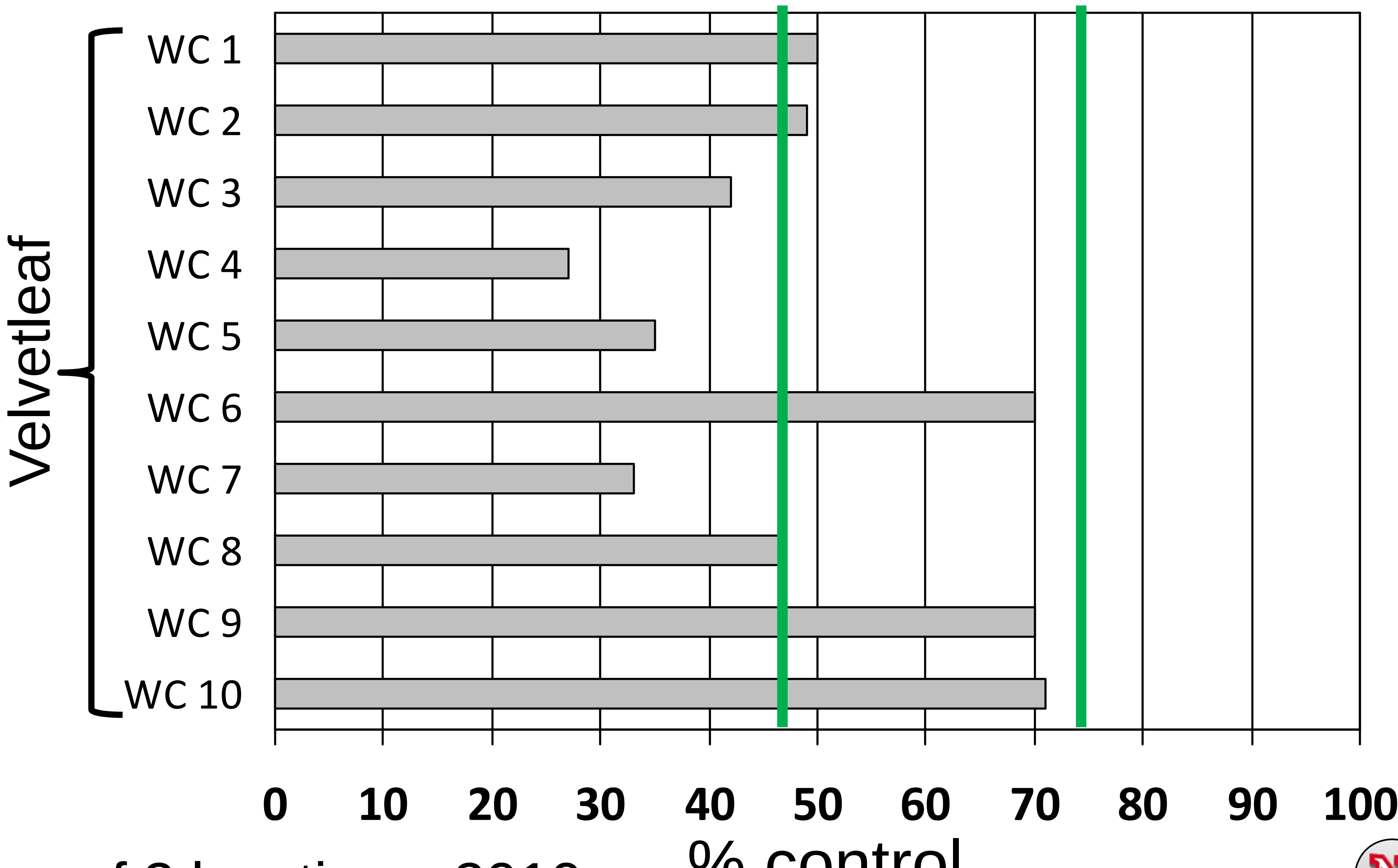
A material that reduces or eliminates the antagonism between a pesticide and ions in water and results in improved bioefficacy



Ave of 3 locations, 2010

weedscience.unl.edu

Water conditioner effectiveness



Ave of 3 locations, 2010

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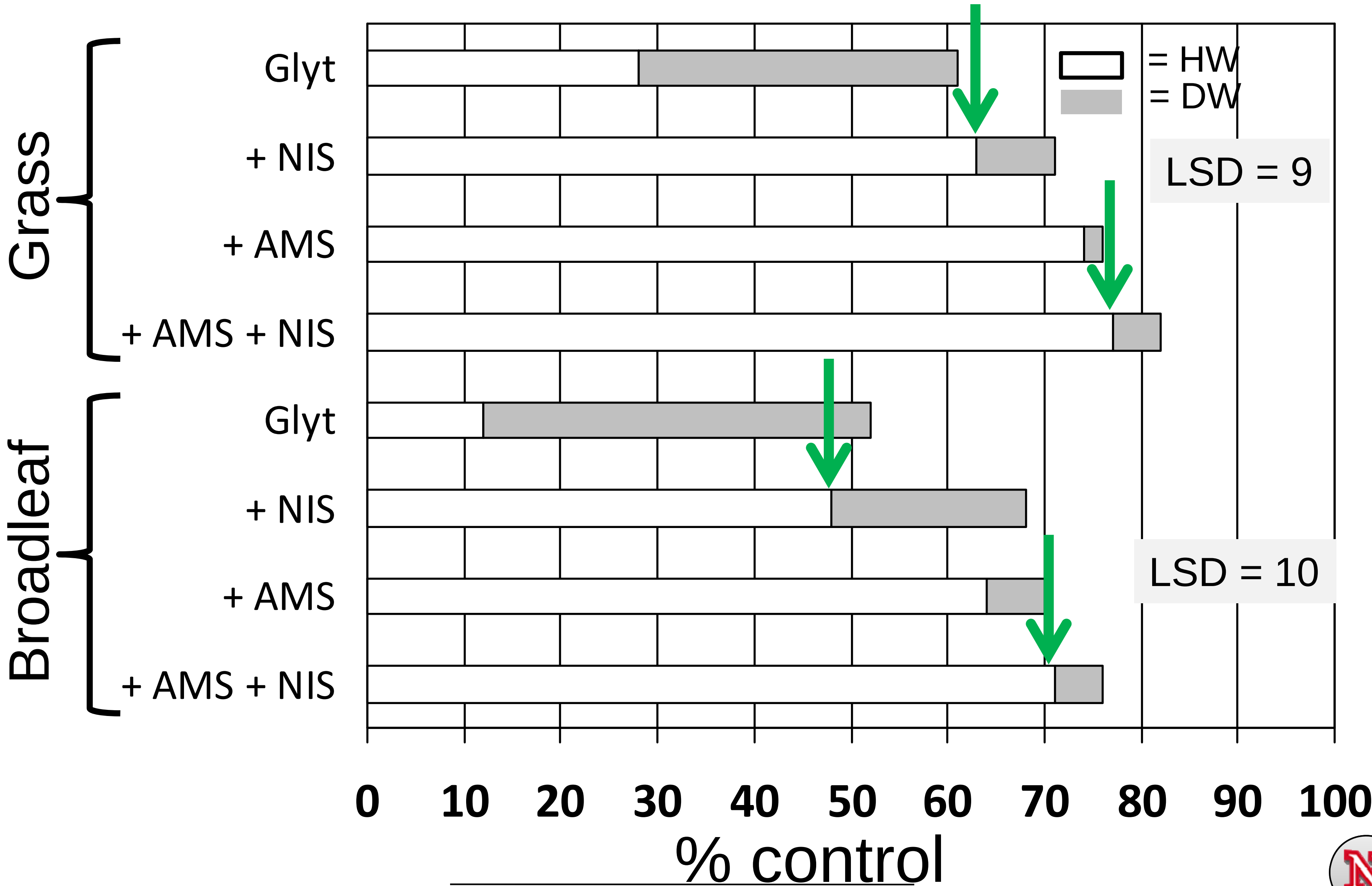
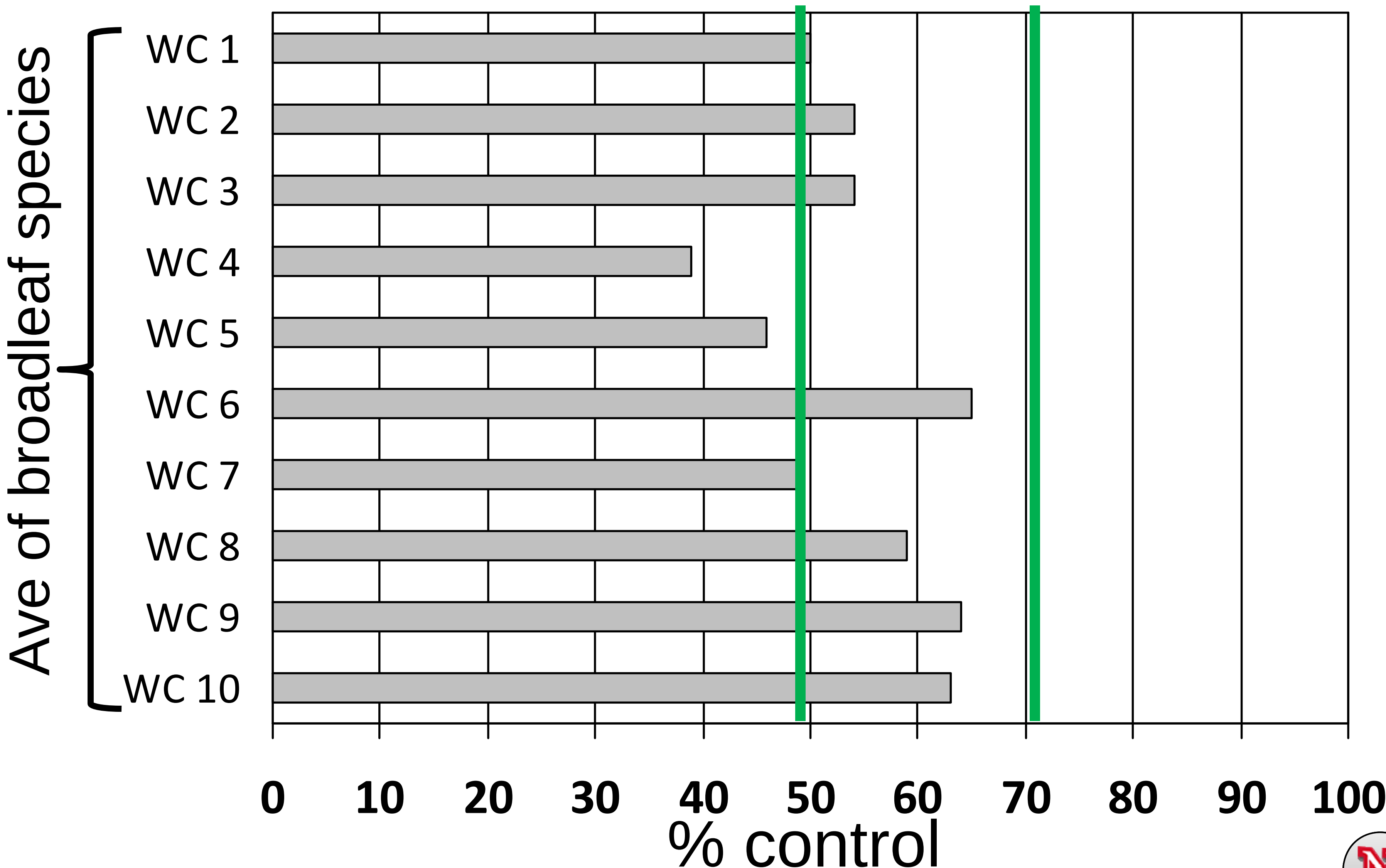
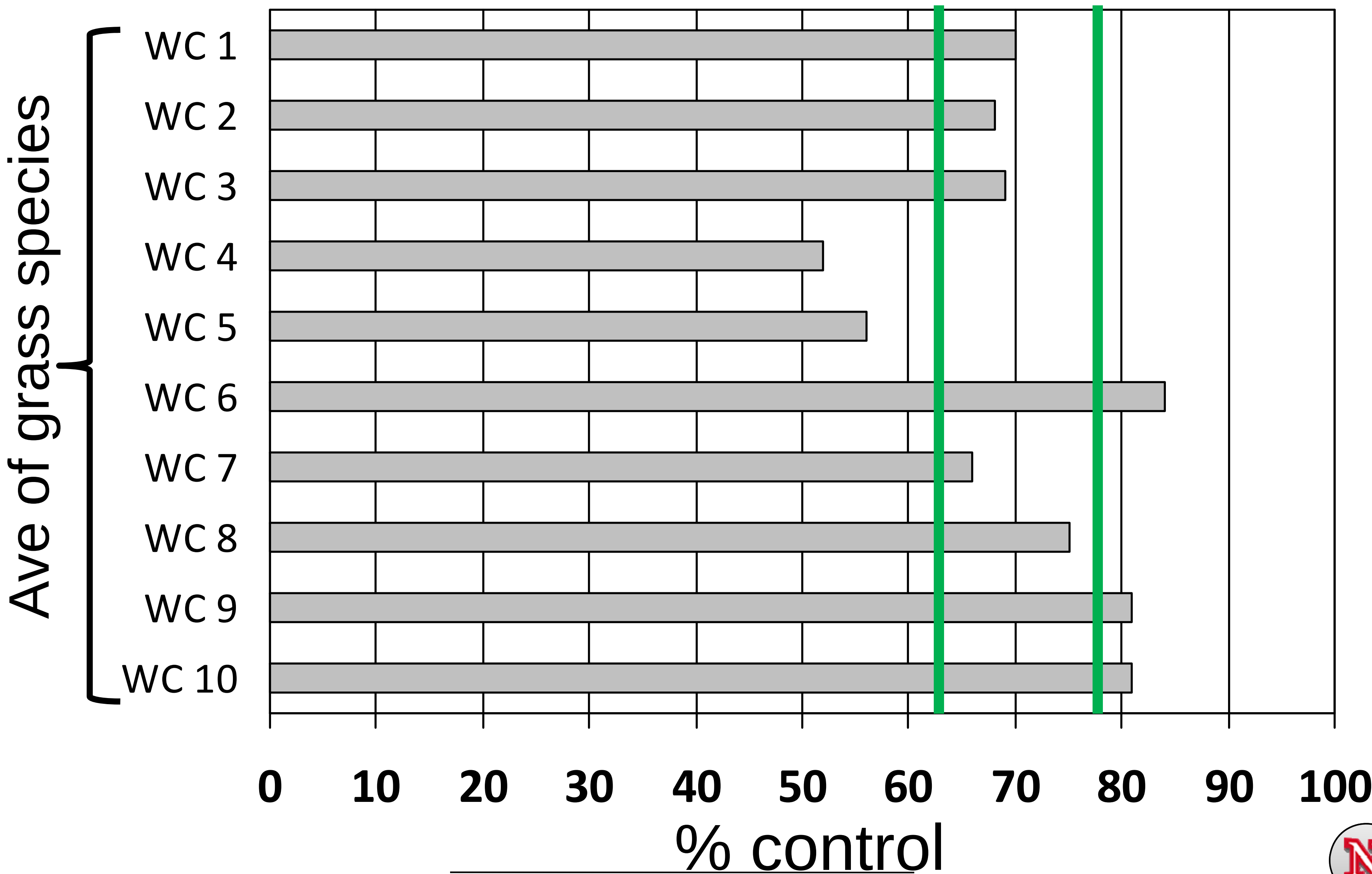
Average of 5 locations, 2010



Broadleaf species, 5 locations, 1000 ppm



Grass species, 5 locations, 1000 ppm



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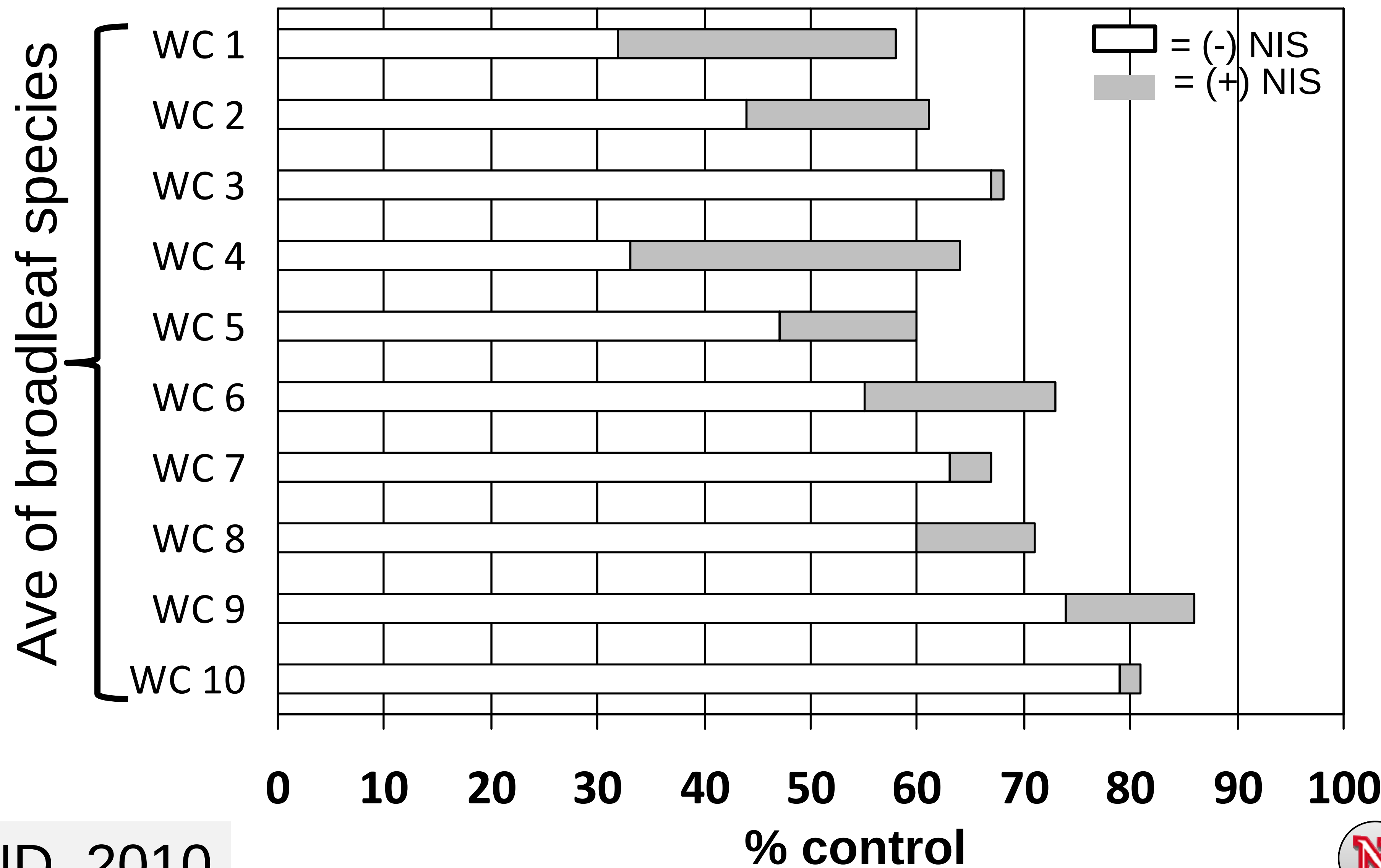
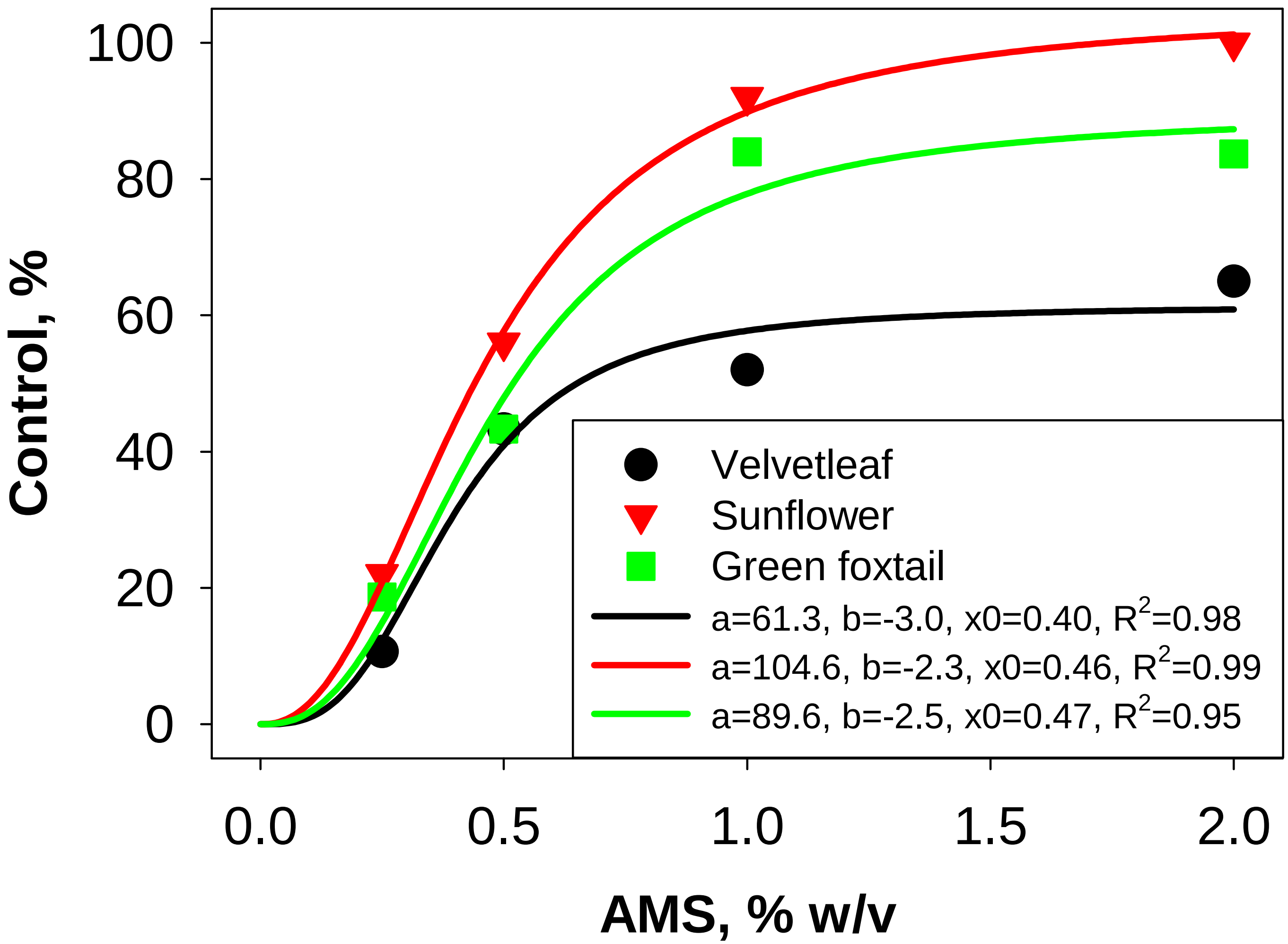
Response to NIS



ND, 2010

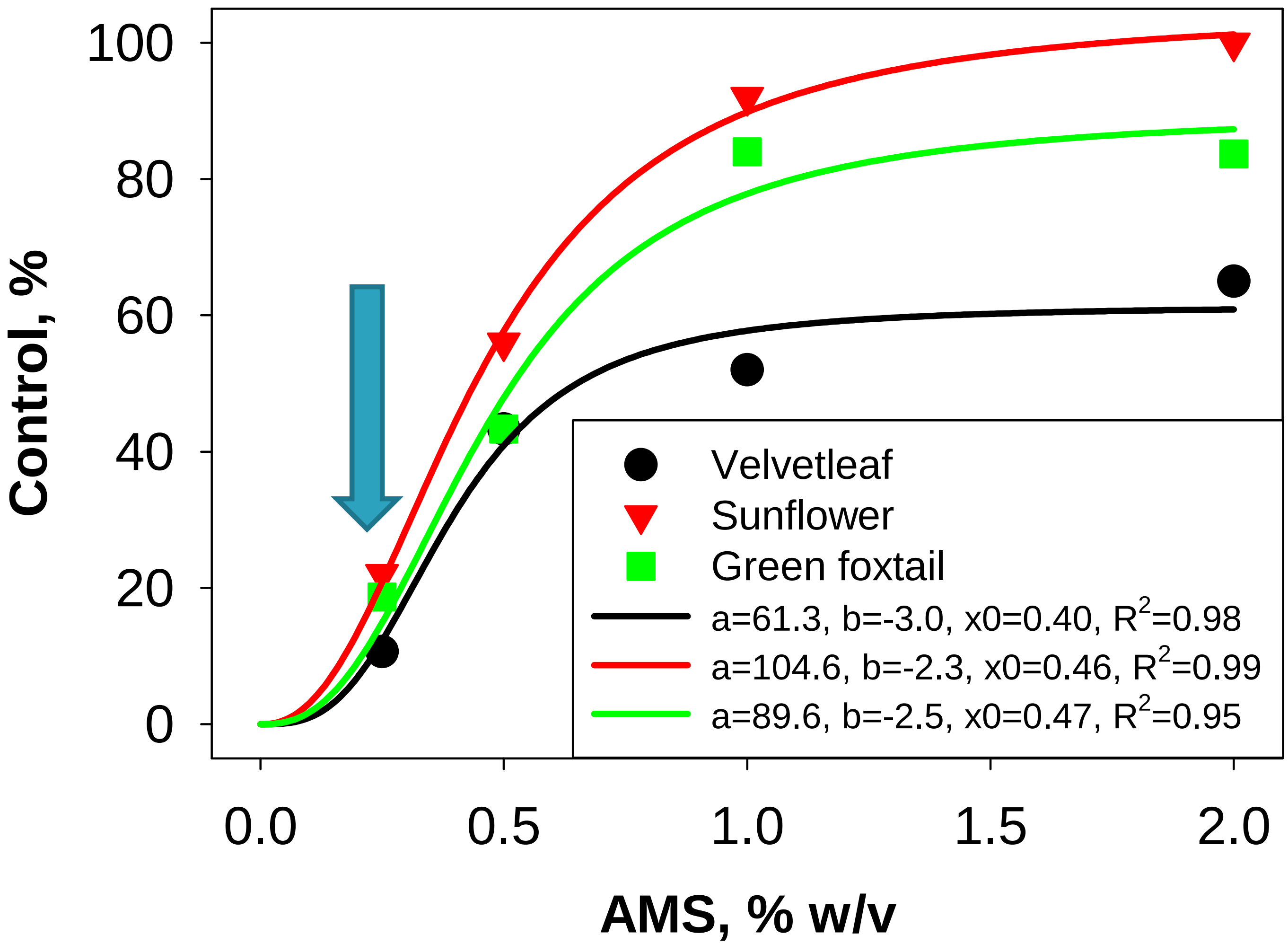
AMS Rate Matters



AMS rate in water conditioners

- Approximate load
  - 3.75 lb AMS/gal
- Typical use rate
  - 0.5% v/v
- AMS in tank
  - (0.5 gal/100 gal)*(3.75 lb/gal) =
- 1.88 lb AMS/100 gal = 0.2% (w/v)

AMS Rate Matters



Observations

- Water conditioner products vary widely in their effectiveness
- Rates are often too low for extremely hard water scenarios
  - 1000 ppm
    - Dry rates, minimum 8.5 lb/100 gal
    - Liquid rates, minimum 2.5% v/v
- Rates may be adequate if water quality is good

Precipitation delayed herbicide applications

http://images.publicradio.org/content/2008/06/18/20080618_flooded_field_33.jpg


06/07/2010

Why growth stage restrictions?

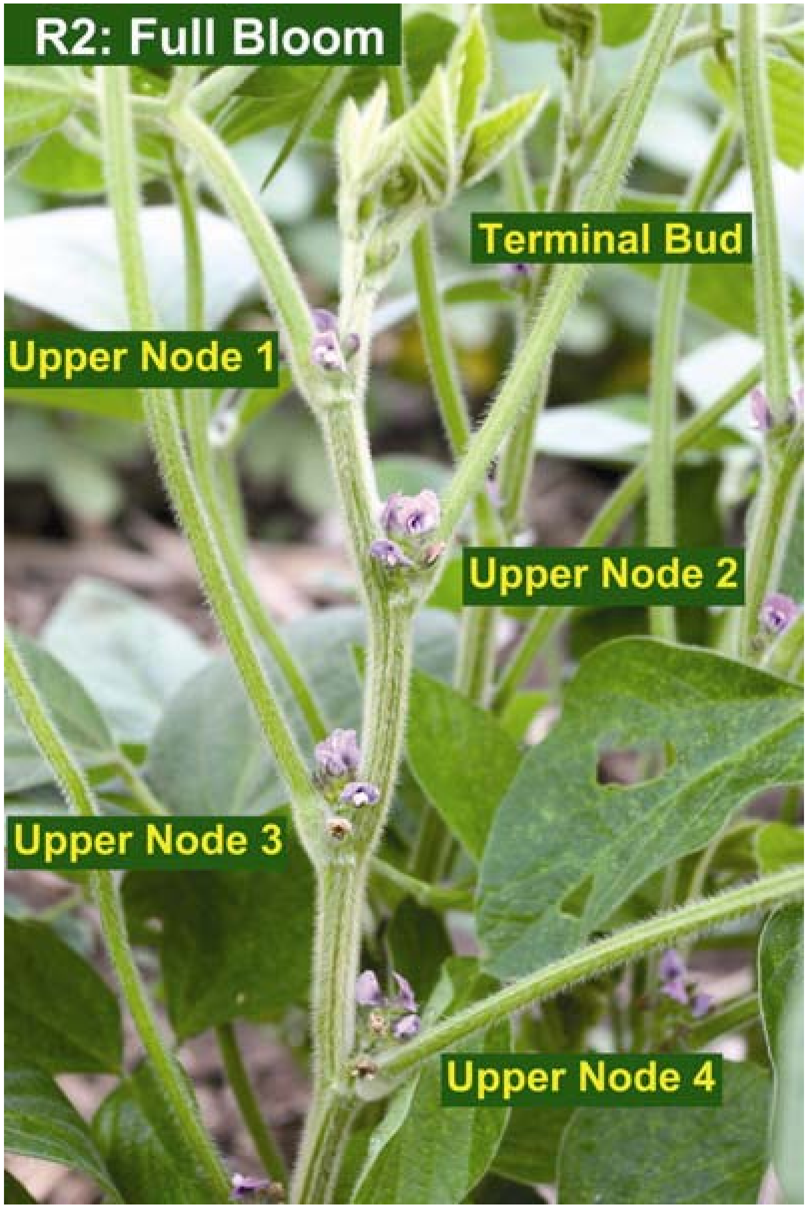
1. To not exceed allowable pesticide residues
2. To avoid crop injury
3. To guarantee good weed control
   a. Weeds too large
   b. Canopy too dense

http://hoegys.ca/cms/files/image/1195.jpg

What is the maximum height for a broadcast application of glyphosate in RR2 corn?

Gyphosate use in corn

- Restrictions differ among glyphosate labels
- Drop nozzles recommended above 24”
- No applications allowed beyond 30” in RR corn
- Drop nozzles required above 30” (V8) in RR2
- No applications allowed beyond 48” in RR2
- Maximum in-crop applications totaled less than 64 fl oz K-salt or 96 fl oz IPA-salt

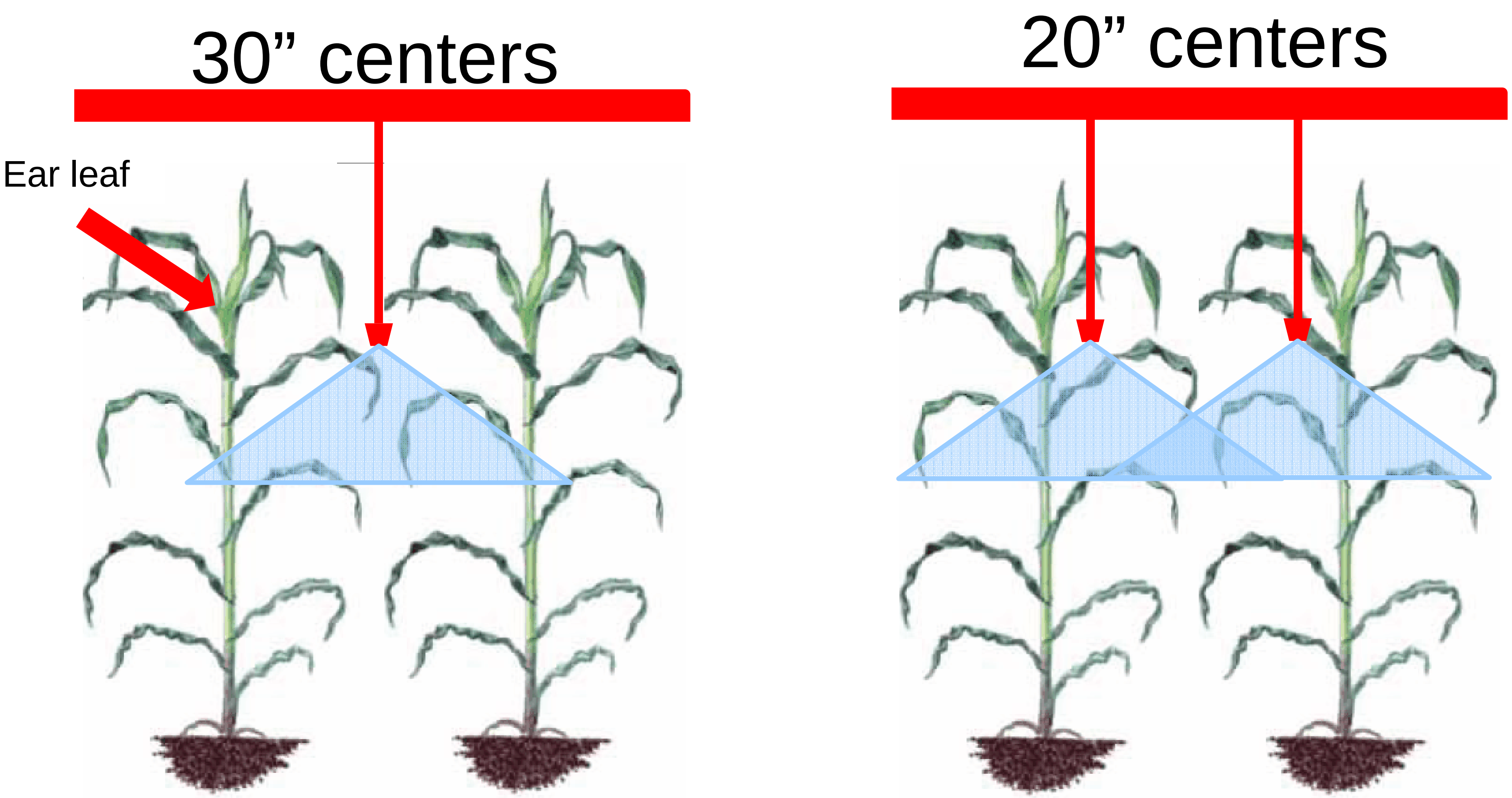


http://t3.gstatic.com/images?q=tbn:ANd9GcQ45rvbLNBG0VEcwYBTs5gF-nkGhxl3jFs9xmgh8M01yJc59rd1sw

Glyphosate use in soybean

- Emergence through flowering (R2) stage
- Maximum weed height of 8 inches with a 22 fl oz/A application rate
- Maximum single use rate in crop:
  - 44 fl oz/A
- Maximum season-long in-crop use:
  - 64 fl oz/A

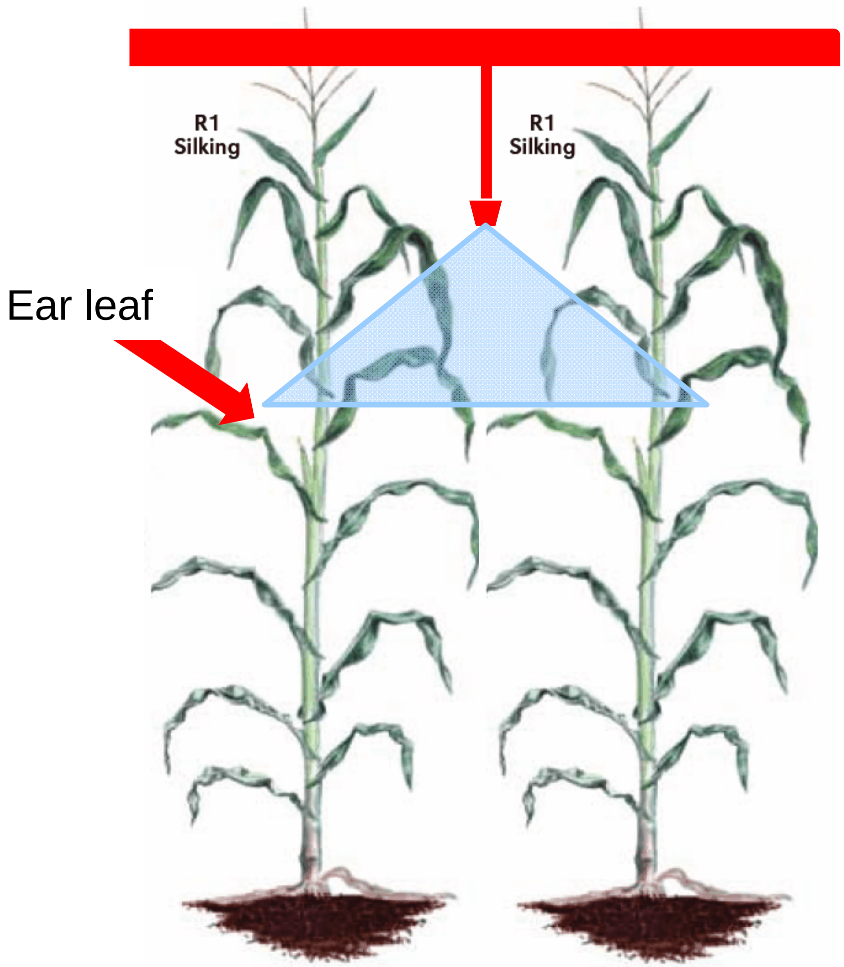
Drop nozzle spacing matters!



V12 corn

Where does the pesticide go?

- Translocated herbicides
  - Moves to the sink
    - Ear
    - Tassel
- Contact herbicide
  - Most stays in treated leaf

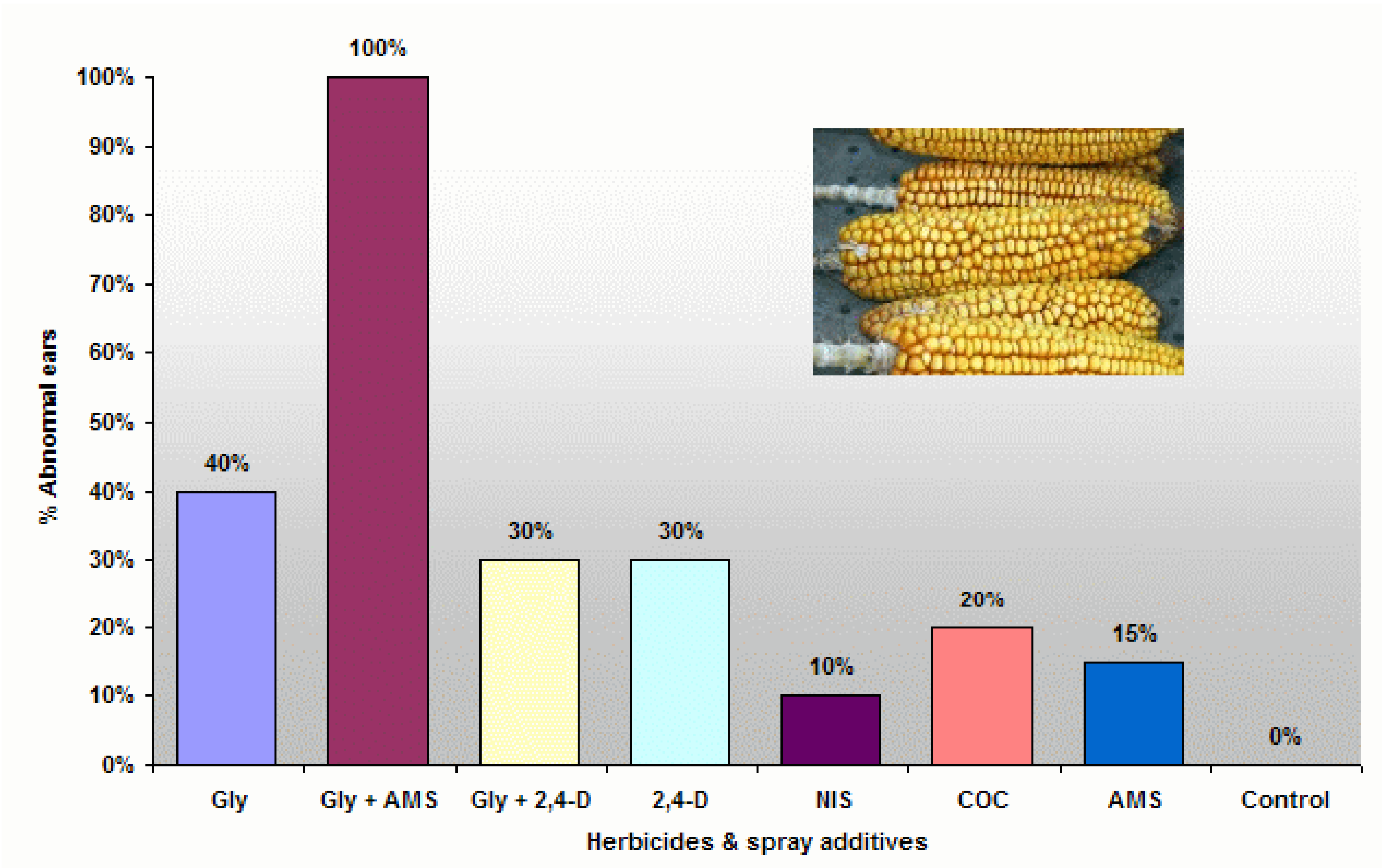


Arrested ears - NIS

Irregular rows - glyphosate

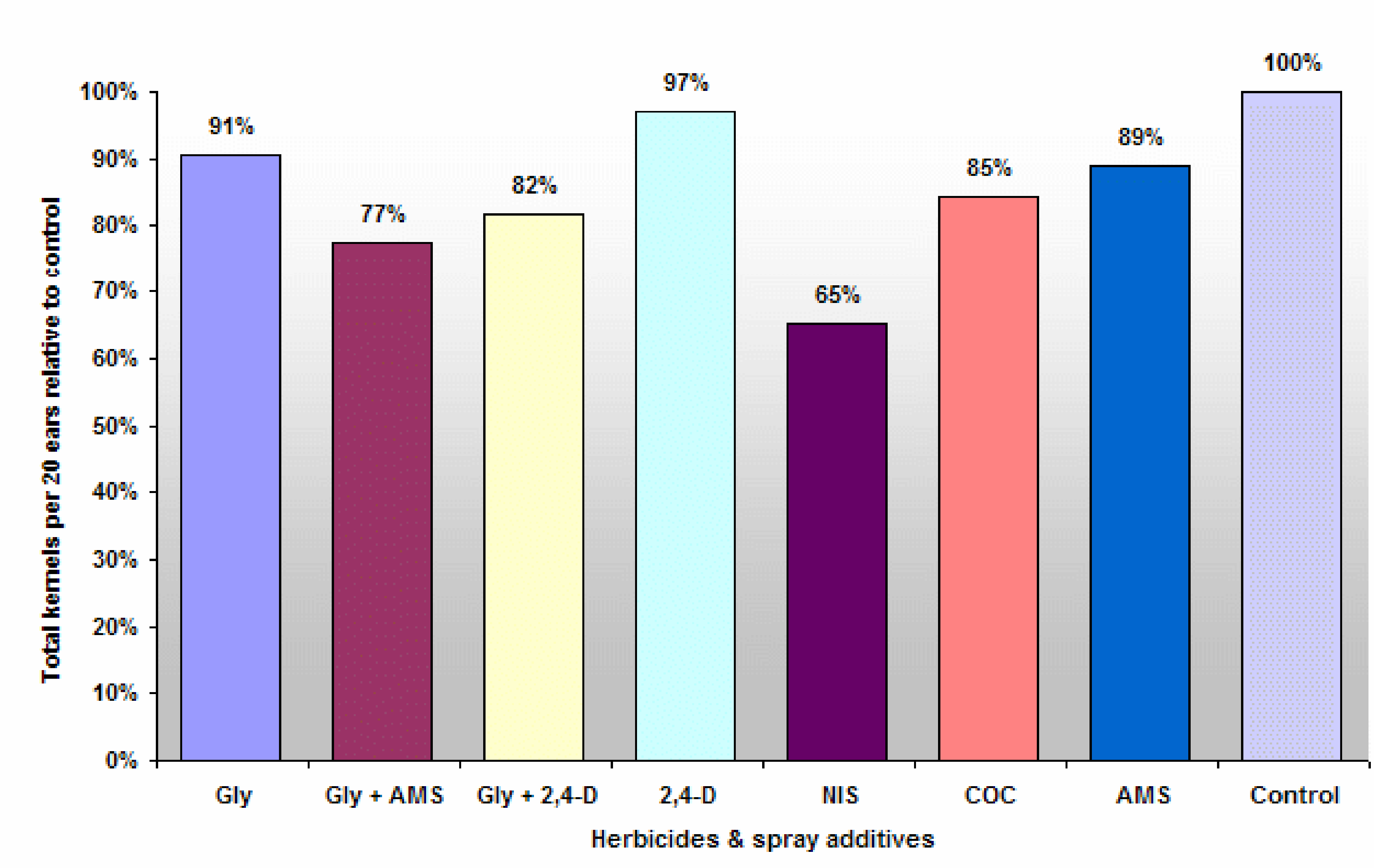
http://www.kingcorn.org/news/articles.08/ArrestedEars-1209.html

% abnormal ears caused by late appl.



http://www.kingcorn.org/news/articles.08/ArrestedEars-1209.html

% Kernel number as affected by late application



http://www.kingcorn.org/news/articles.08/ArrestedEars-1209.html

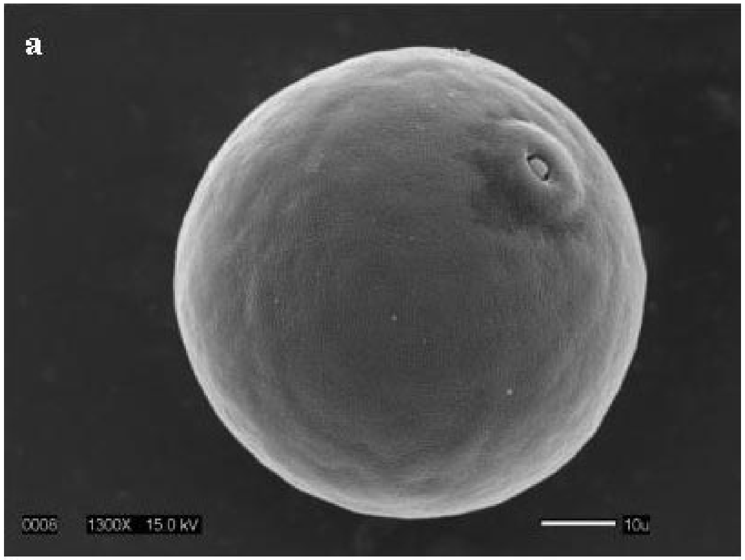
Late herbicide application – glyphosate + Cadet

Late herbicide application - Ignite

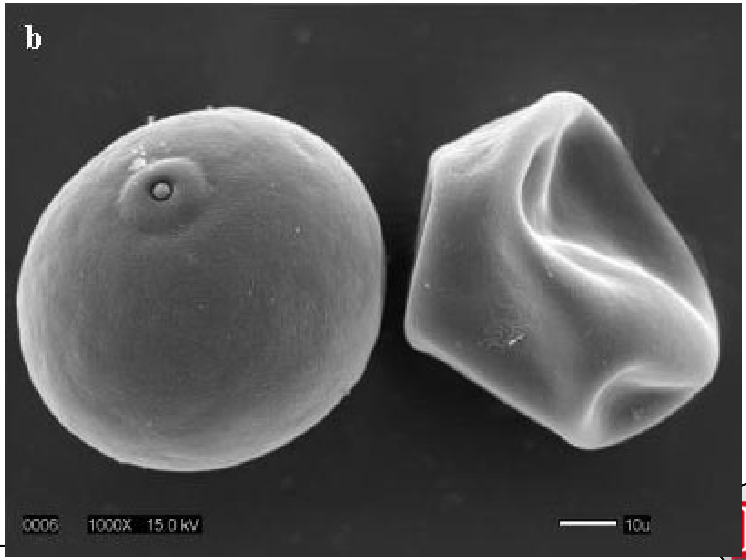
Glyphosate effects on corn pollen

Glyphosate applications at V8 or later reduced pollen viability 40%

Non-treated



Glyphosate applied at V10



Thomas et al. 2004. Weed Sci 52:275

At what corn growth stage do newly emerging weeds no longer reduce yield:

1. V2
2. V5
3. V8
4. V11
5. Tasseling

When do newly emerging weeds no longer reduce yield in corn?

- It depends!
  - Weed species
    - Sunflower vs. foxtail
  - Density
    - High vs low
  - Fertility
  - Moisture
- Range of growth stages from research
  - Earliest: V2
  - Latest: R1 – Silking
  - Average: V10

Summary

- Yellow flash is temporary toxicity caused by glyphosate degradation product
- Mn applied to soybean should be targeted to locations with measurable deficiency
- Tank-mixing glyphosate and micronutrients compromises glyphosate activity
- AMS products vary, but most important factor is AMS rate in tank
- Late applications of glyphosate can impact corn ear development

Questions?

Thank you!