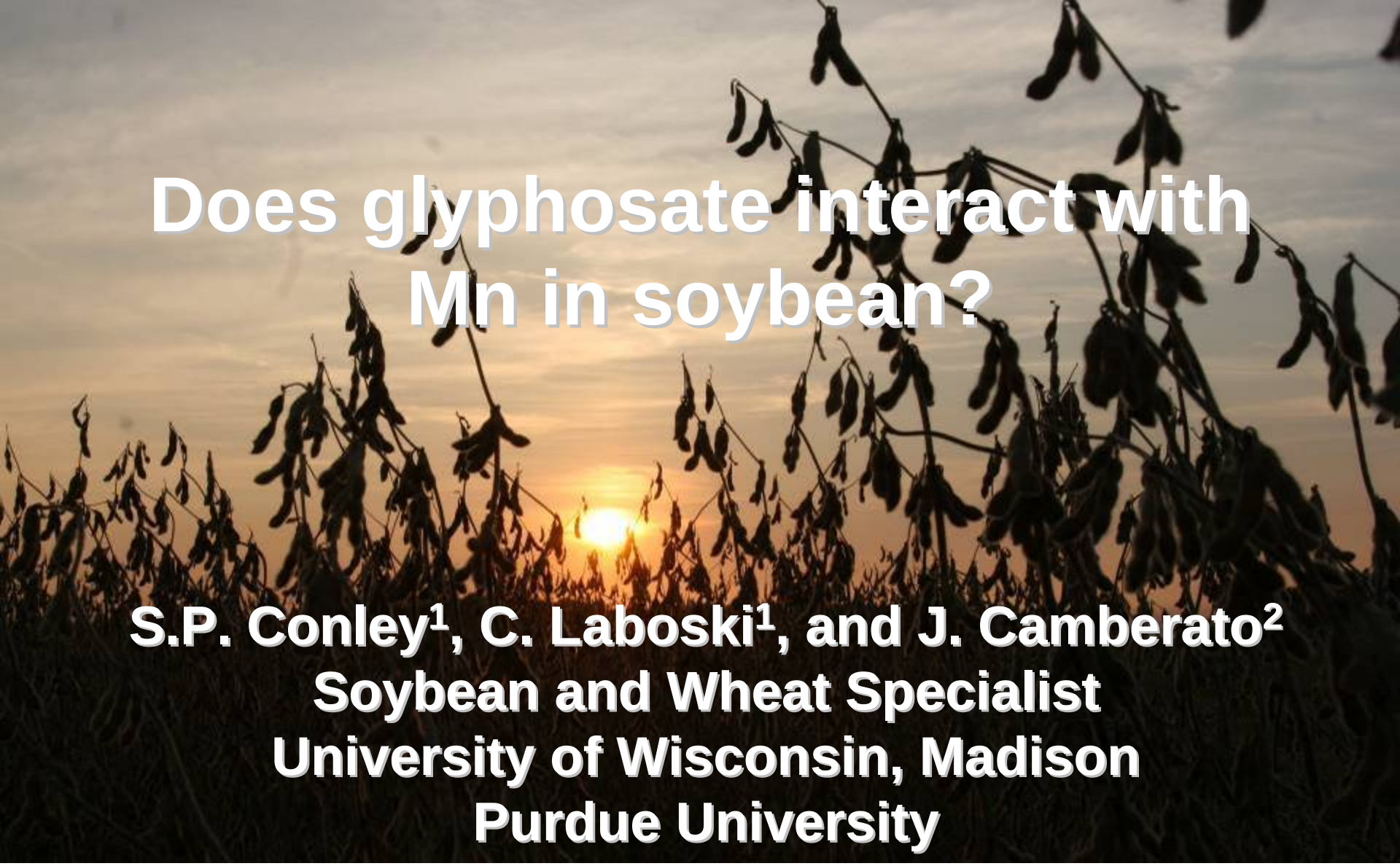

Does glyphosate interact with Mn in soybean?

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UW Extension

Current Wisconsin Mn Recommendations

- Current University of Wisconsin nutrient application guidelines for Mn are based on research conducted in the early 1970's (Randall et al., 1975)
  - Soils with OM ≤ 6.0% a soil test for Mn coupled with the relative crop need for Mn should be considered to determine fertilizer Mn needs
  - Crops with a high relative need for Mn, like soybean, grown on soils with OM > 6.0%, starter fertilizer containing Mn or foliar Mn application is recommended
- On soils with moderate to severe Mn deficiency, 4.5 to 10 lb Mn/a as MnSO4 in starter fertilizer was suggested
- If Mn deficiency appeared late, then a foliar Mn application could be made

Conditions resulting in Mn deficiency

- Low Mn availability
  - high pH (6.5 and above)
  - bacterial oxidation
  - OM (≥6%)
    - ↓ Exchangeable Mn

- Low Mn supply
  - poorly drained soils
    - $MnO \longrightarrow Mn^{++}$
  - sandy soils

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Soybean leaf Mn levels

Def.	Low	Suff.	High
----------tissue (ppm)----------			
<15	15-20	21-100	101-250

Most recently mature trifoliate at first flower. Shulte and Kelling, 1999.

Soil-test Mn needed for sufficiency in ***mineral*** soils

Soil pH	Soil-test Mn lb/acre
6.3	.9
6.6	.14
6.9	.19
7.2	.25
7.5	.30

Soil test Mn – 0.1 N HCl

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Soil-test Mn needed for sufficiency in ***organic*** soils

Soil pH	Soil-test Mn lb/acre
5.8	.8
6.1	.17
6.4	.25
6.7	.33
7.0	.41

Soil test Mn – 0.1 N HCl

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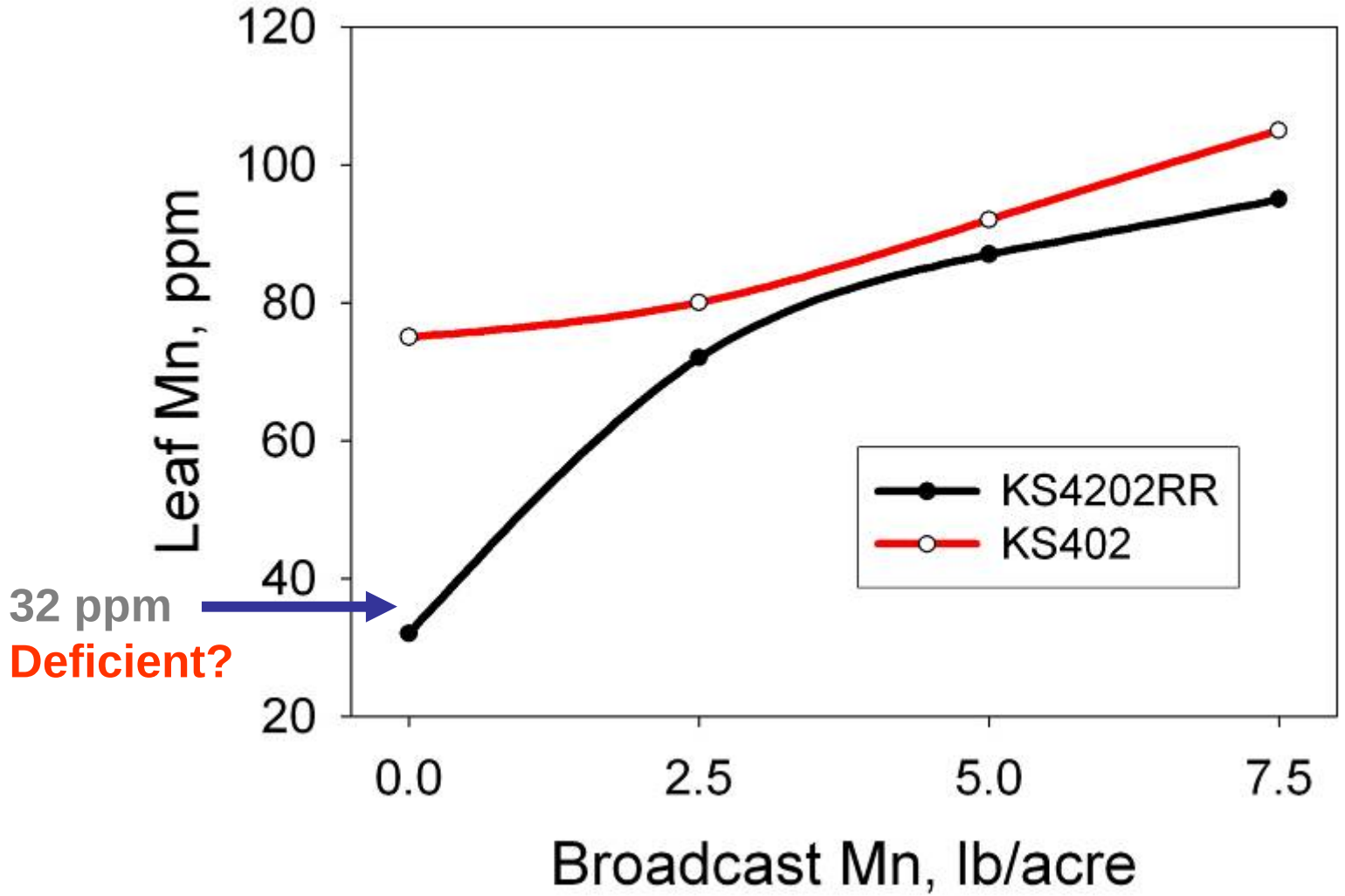
Do Mn tissue guidelines apply to glyph.-resistant soybeans



Dr. Barney Gordon, KSU-2005 – uppermost expanded trifoliate at full bloom

Non-target effects of glyphosate

- Soil microflora change - Root exudates
  - Glyph. and/or decomposition products toxic to manganese releasing bacteria, enhance fixers
- Lower Mn uptake efficiency of glyp.-tolerant crops
  - Root & foliage

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Adapted from: Don M. Huber, Purdue University

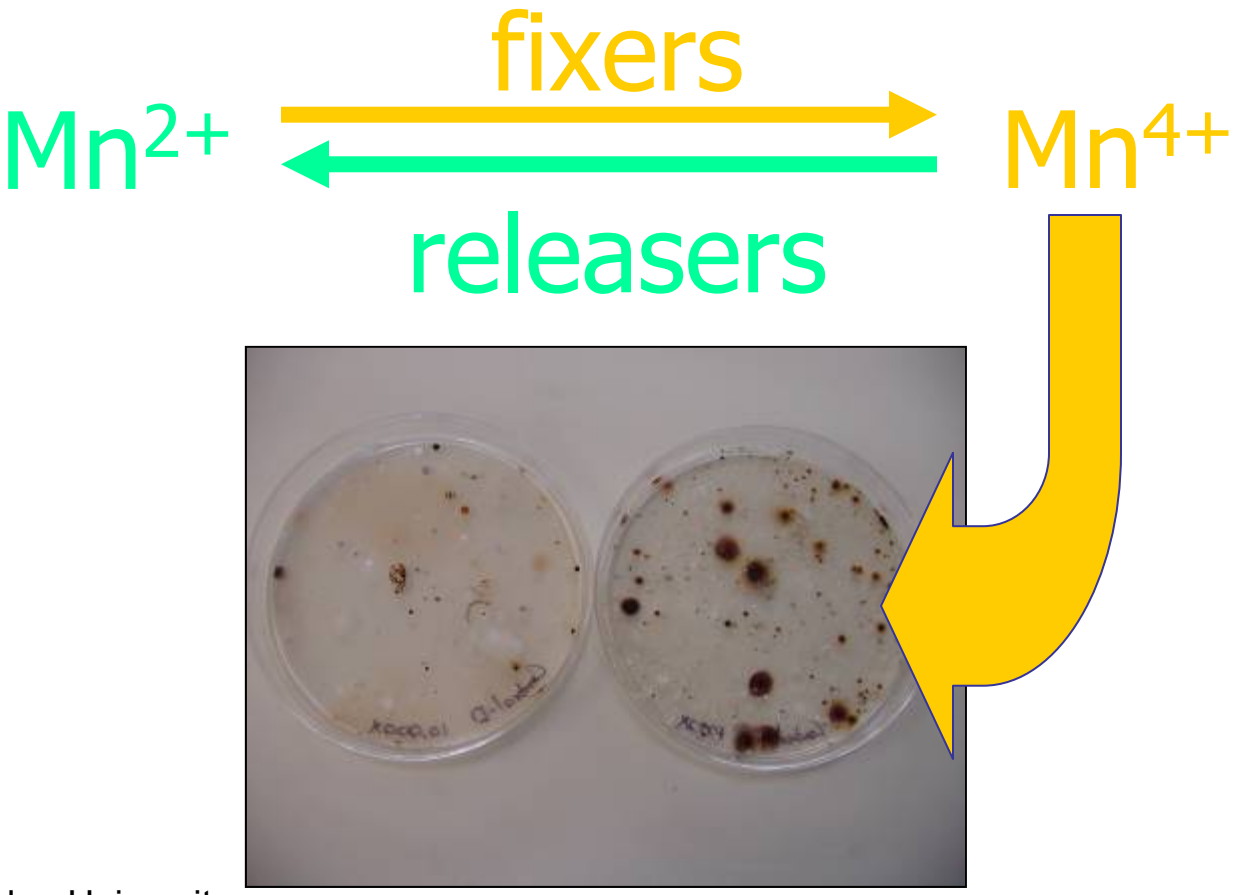
Mn releasing/fixing bacteria in the soybean rhizosphere soil 3 wk after glyphosate

Glyphosate	Mn releasing organisms	Mn fixing organisms
	------ Colonies per gram of soil -----	
NO	7,250	750
YES	740	13,250

Adapted from: Don M. Huber, Purdue University

Bacteria affect Mn availability

- Bacteria convert available Mn^{2+} to unavailable Mn^{4+}



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Mn-glyphosate interactions

- Immobilization of Mn by glyphosate
  - Translocation
  - Physiological efficiency
- Tissue nutrient conc. do not necessarily reflect severity of deficiency
- Efficacy of the glyphosate as herbicide reduced

Effects of Mn Applied with Starter Fertilizer and Foliar Mn on Soybean

- Soybean 'Beck's 321NRR' was planted on May 10th
- Row spacing 30" @ 145,000 seeds/acre

#	Starter fertilizer	Starter Mn	Foliar
1	None	None	None
2	10-34-0 at 10 gal/acre	None	None
3	10-34-0 at 10 gal/acre	DDP at 8 oz/acre	None
4	10-34-0 at 10 gal/acre	DDP at 8 oz/acre	DDP at 3 oz/acre with glyphosate
5	None	None	DDP at 3 oz/acre 10 d after glyphosate

- Individual treatment plots were 4 rows wide and 91 feet long.
- Each treatment was replicated six times in a RCBD

Data Collected

- Visual ratings of canopy greenness and growth on a scale of 1-5 were made June 15 and 22 and July 5
  - Greenness was rated 1=totally chlorotic and 5=dark green
  - Growth was rated on a relative basis with 1=least and 5=greatest canopy growth

- Two indices proportional to plant biomass were calculated from the reflectance data:
  - Simple ratio (SR = NIR/VIS)
  - Normalized difference vegetative index [NDVI = (NIR - VIS)/(NIR + VIS)].
    - (Crop Circle ACS-210 Plant Canopy Reflectance Sensor)

O.M.†	----------Mehlich-3 extractable nutrients ----------										pH	bpH§	CEC¶
	Bray-P‡	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B			
%	---------- ppm ----------												meq/100g
5.1	30	192	765	2600	9	5.7	12	83	1.6	0.7	6.5	6.8	22.3
Rating	H	H	VH	M	M	H	L	VH	H	M			

† Soil organic matter.
‡ Soil P is converted to Bray-P1 equivalence.
§ Buffer pH.
¶ Cation exchange capacity.

Effect of starter fertilizer and starter Mn on the nutrient concentration of the most recently fully expanded trifoliate

- Leaf tissue samples were taken 21 days after application (R1) of glyphosate to all treatments and application of foliar Mn (3 oz/a of Mn-DDP with glyphosate) to treatment 4 and 11 days after application of foliar Mn (3 oz/a of Mn-DDP) to treatment 5.

Treatment	N	P	K	Ca	Mg	S	Mn	Zn	Cu	Fe	B
	----------%----------						----------Mg kg^{-1} ----------				
(1) no starter or Mn	4.31	0.39	3.14	0.91	0.36	0.25	14	34	9	115	34
(2) starter only	4.32	0.39	3.09	0.92	0.36	0.25	14	35	9	115	35
(3) starter +Mn	4.12	0.38	2.99	0.87	0.36	0.23	15	33	8	106	33
(4) starter +Mn +foliar Mn	4.10	0.40	3.08	0.85	0.35	0.23	15	33	8	101	34
(5) foliar Mn	4.07	0.33	2.98	0.87	0.37	0.23	16	33	9	116	32

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Results: Soybean Growth and Canopy Response

Treatment	June 15		June 22		July 5
	Color	Growth	Color	Growth	Color
(1) no starter or Mn	2.8	2.8	3.5	4.0	3.5
(2) starter only	3.1	3.8	3.5	4.3	3.5
(3) starter +Mn	4.0	4.1	4.5	4.7	4.3
(4) starter +Mn +foliar Mn	4.0	4.3	4.7	5.0	4.7
(5) foliar Mn	2.8	3.3	3.0	3.8	4.5
Source of variation	Level of significance				
Treatment	0.006	0.0001	0.0007	0.002	0.05

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Results: Simple Ratio and NDVI

Treatment	June 15		June 22		July 5	
	SR	NDVI	SR	NDVI	SR	NDVI
1 no starter or Mn	3.6	0.56	5.0	0.66	7.2	0.75
2 starter only	3.9	0.58	5.1	0.66	6.9	0.74
3 starter +Mn	4.2	0.61	5.6	0.69	7.6	0.77
4 starter +Mn +foliar Mn	4.4	0.62	5.8	0.70	7.7	0.77
5 foliar Mn	3.7	0.56	4.7	0.64	7.7	0.77
Source of variation	Level of significance					
Treatment	<0.0001	<0.0001	<0.0001	<0.0001	0.10	0.06

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Results: Simple Ratio and NDVI

Treatment	Grain yield Bu/acre	Harvest moisture %
(1) no starter or Mn	52.2	14.9
(2) starter only	52.7	15.2
(3) starter +Mn	58.0	15.0
(4) starter +Mn +foliar Mn	61.5	17.0
(5) foliar Mn	56.4	17.0
Source of variation	Level of significance	
Treatment	0.003	0.92

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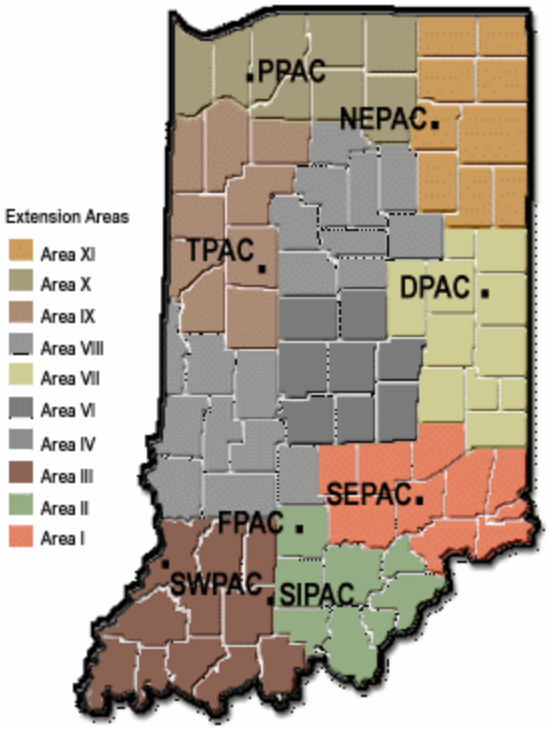
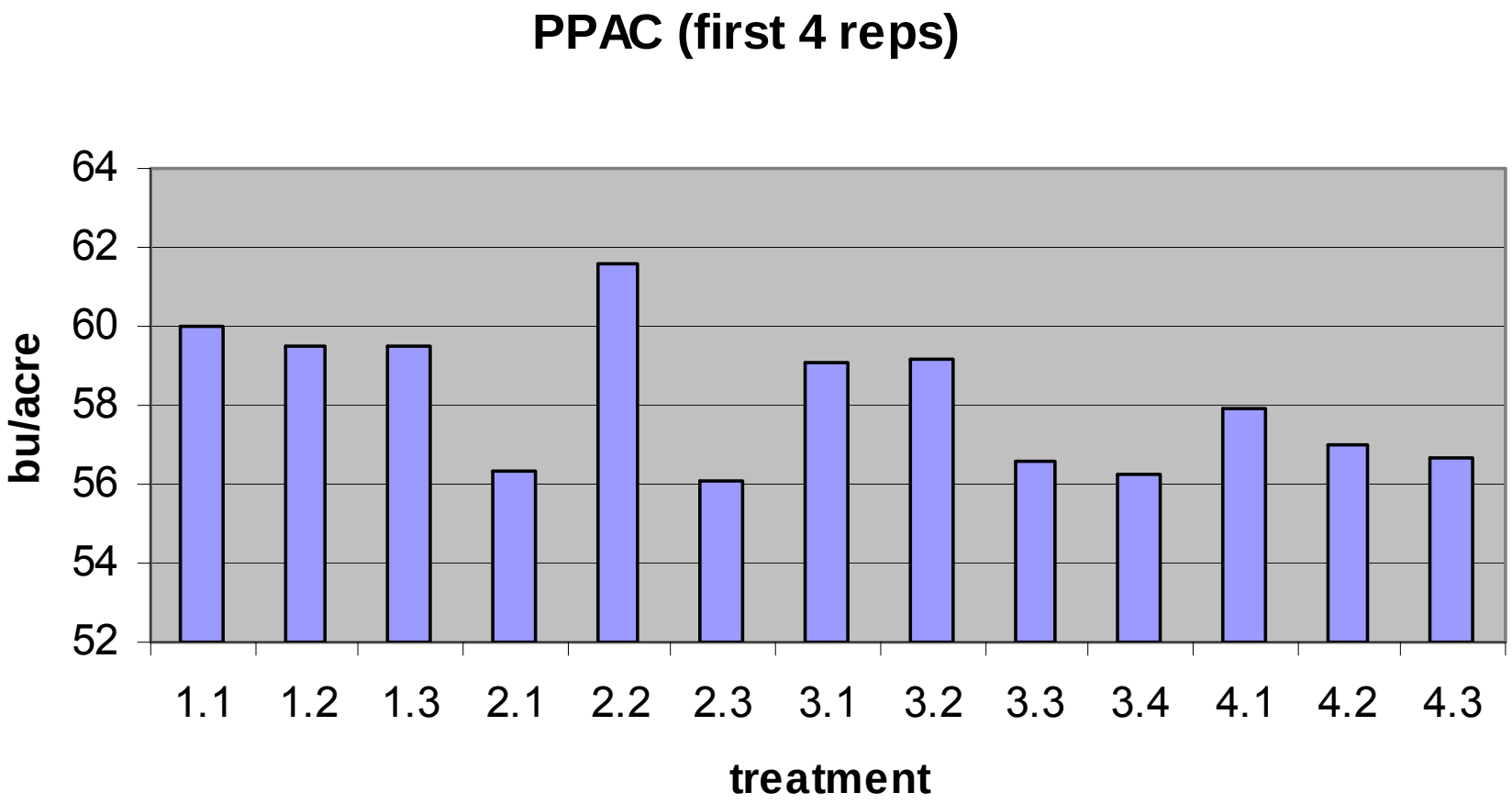
Effects of Glyphosate and Mn Timing on Soybean Yield

- RCB split-plot design with six replications
- Three locations across northern IN
- Row spacing 30” @ 145,000 seeds/acre
- Individual treatment plots were 20 by 70 feet
- Main affect
  - No glyphosate control
  - Glyphosate burndown only
  - Burndown + single post
  - Burndown + double post
- Sub-plot affect
  - Control
  - Mn @ 2.5 lbs/acre
  - Mn @ 5.0 lbs/acre
  - Foliar Mn for Main Trmt 3 only. Mn chelate @ 0.5 lb/acre



Vyn et al. 2007

Effects of Glyphosate and Mn Timing on Soybean Yield



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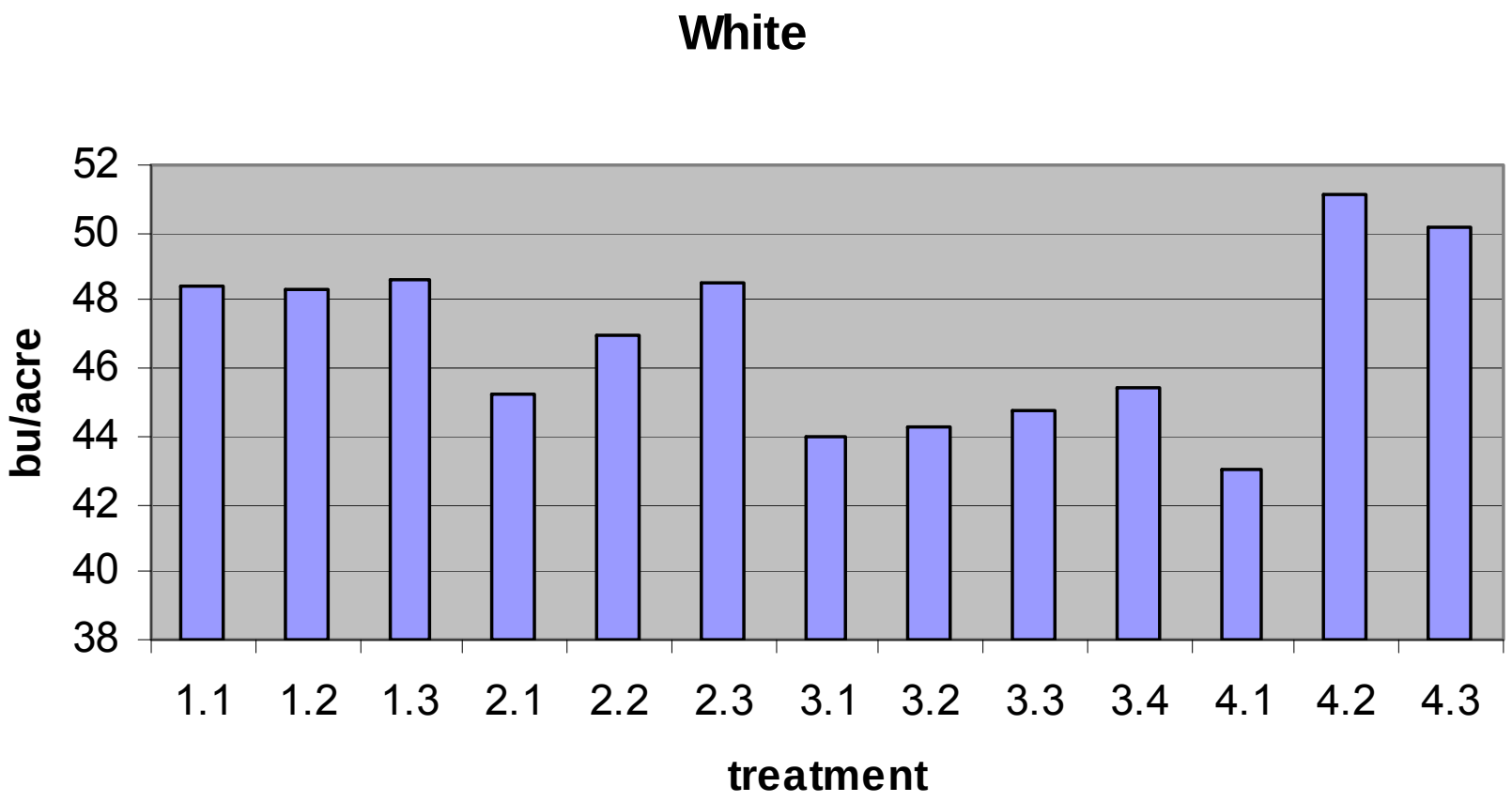
Effects of Glyphosate and Mn Timing on Soybean Yield



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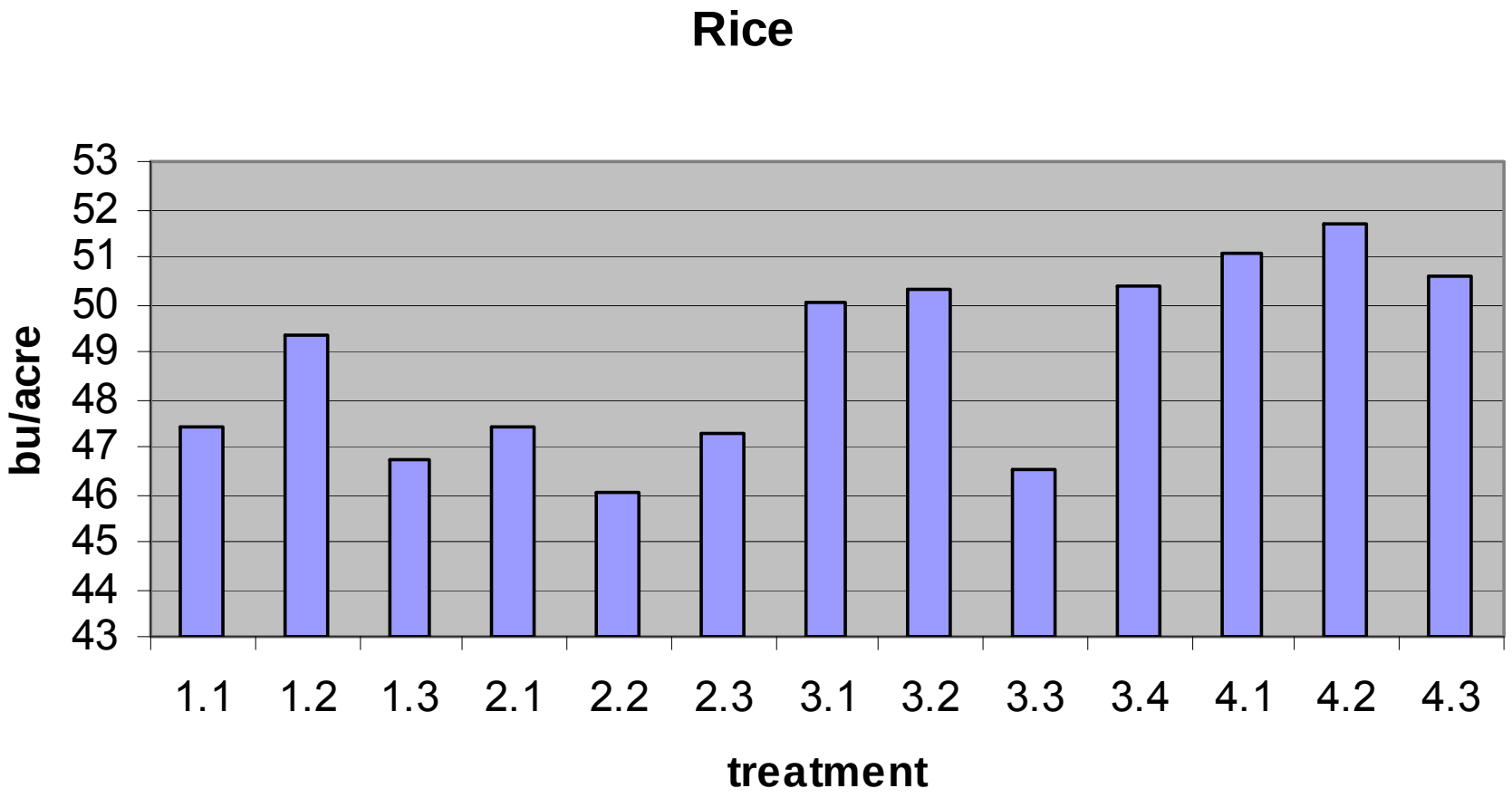
Effects of Glyphosate and Mn Timing on Soybean Yield



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Mn antagonism of glyphosate efficacy

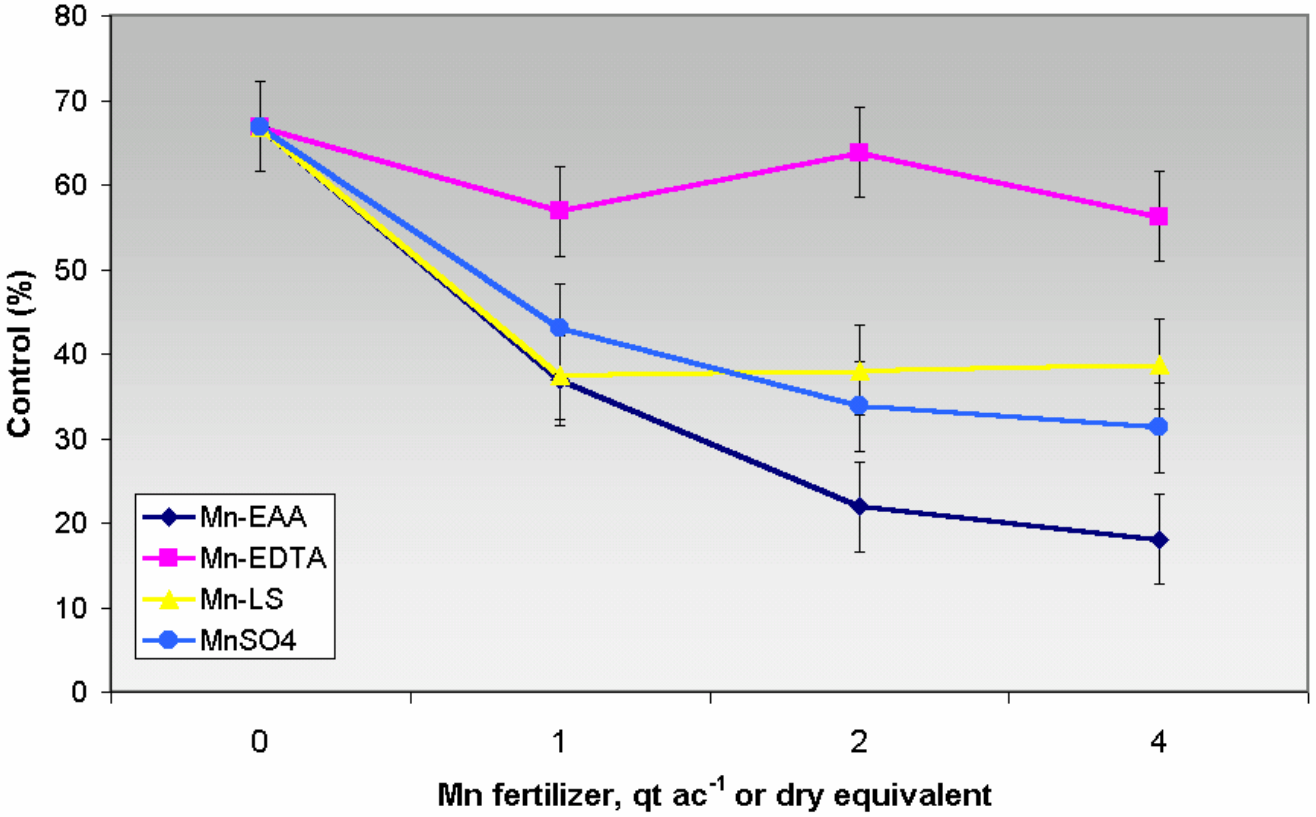

Figure 4. Velvetleaf control 14 days after treatment with glyphosate-Mn fertilizer tankmixes at three Mn fertilizer concentrations. "0" is efficacy of glyphosate without Mn. Data represent the averages of +/- AMS treatments. Error bars represent the standard error, p=0.05.

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Bernards et al., 2003

Slide courtesy of Ron Gehl, MSU

Mn/glyphosate antagonism

- Sulfate, ethylaminoacetate, lignosulfonate, but not EDTA, antagonized Roundup Ultra/Ultramax (Bernards, Thelen & Penner, MI, 2002)
- Mn-EDTA antagonized Roundup WeatherMAX
- AMS overcomes antagonism in LS but not totally in EAA or sulfate

Mn/glyphosate antagonism

- Lignosulfonate and glucoheptonate antagonized Roundup Ultra or Touchdown (Bailey, Poston, Wilson & Hines, VA, 2002)

- Mn-ethylaminoacetate but not Mn-EDTA antagonized Roundup WeatherMAX (Li, Wait & Bradley, MO, 2004)

Glyphosate-resistant corn may impact soybeans in rotation?

- Tissue Mn of RR corn 45 ppm lower than isoline (Beck's 5727)
- Application of glyphosate to soybean affects take-all in next wheat crop (Mn deficiency associated with take-all)
- More total applications of glyphosate – likely to have cumulative effects on soil bacteria

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(Dodds, Hickman & Huber, 2002)

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