Midwest Soil Improvement Symposium: 2012

Research and Practical Insights into Using Gypsum

Is Sulfur Limiting Crops in Illinois and Surrounding States?

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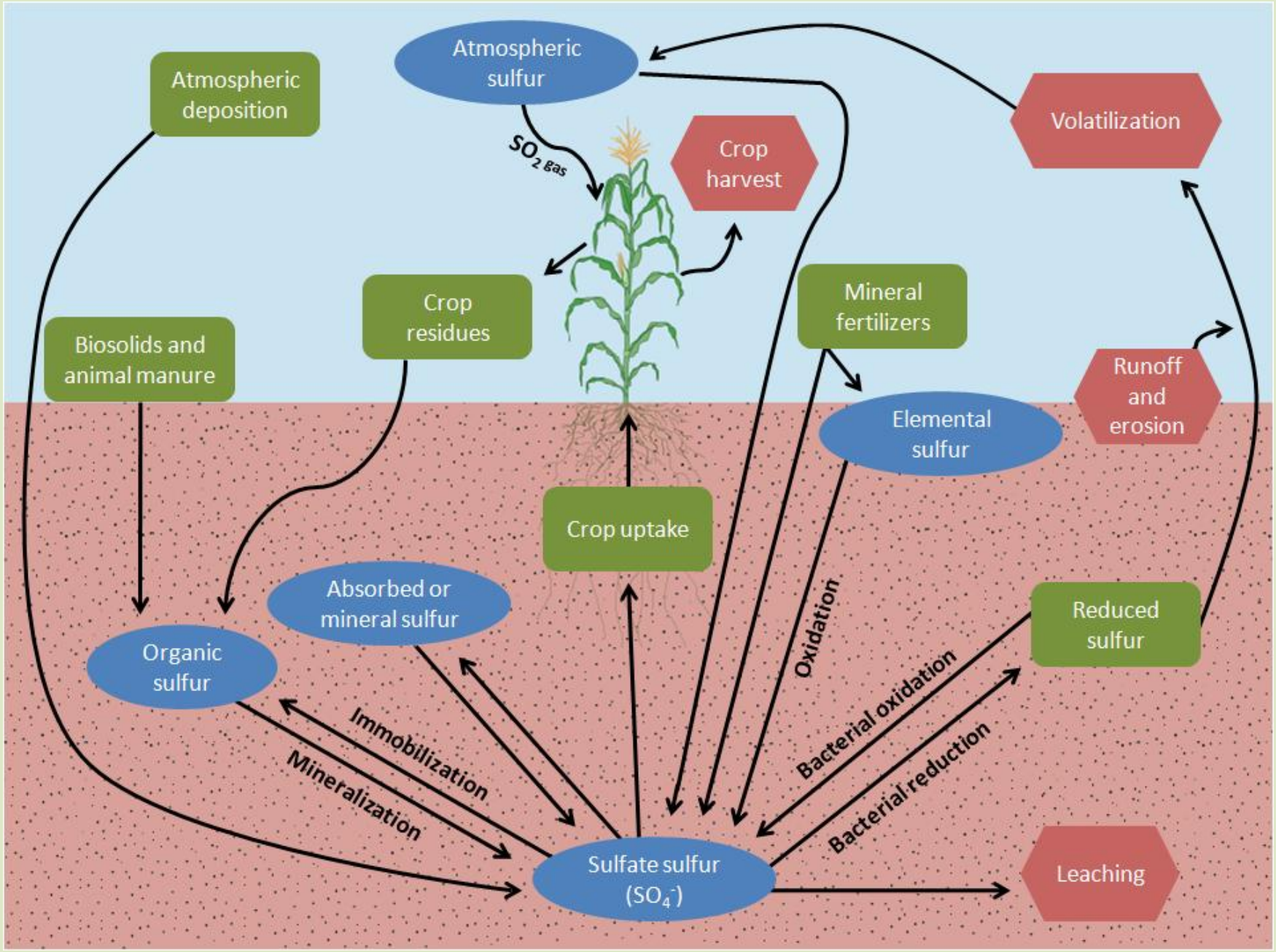
Sulfur Overview

- Classified as secondary, but it is required in amounts similar to those of phosphorus
  - 0.19 lb P vs. 0.07 lb S per bushel of corn
- Formation of amino acids, proteins and enzymes
- Becomes fixed in plant structures-- does not move
- Important in plant respiration, seed production and chlorophyll synthesis
- Required for nodulation and N fixation of legumes
- 13th most abundant element of the earth crust, most in mineral or organic forms unavailable to plants
- Undergoes transformations similar to N



13th Most abundant in soil, but in mineral and organic forms unavailable to plants

- Constituent of certain amino acids in proteins with function in cold and drought tolerance
- Plant respiration, seed production and chlorophyll synthesis
- Yellowing of young foliage (unlike for N)
- Interveinal chlorosis
- Stunting and delayed maturity

Fertilizer	% N	% P_2O_5	% K_2O	% S	% Mg	% Ca	% Zn
Ammonium sulfate $(NH_4)_2SO_4$	21	0	0	**24**	0	0	0
Ammonium thiosulfate $NH_4S_2O_3$	12	0	0	**26**	0	0	0
Elemental sulfur S	0	0	0	**>90**	0	0	0
Epson salt $MgSO_4 \cdot 7H_2O$	0	0	0	**12-14**	9	0	0
Gypsum $CaSO_4$	0	0	0	**17**	0	22	0
K-Mg sulfate (Sul-Po-Mag) $K_2SO_4 \cdot 2MgSO_4$	0	0	22	**23**	11	0	0
Potassium sulfate K_2SO_4	0	0	50	**18**	0	0	0
MES-10 $NH_4H_2PO_4 \cdot (NH_4)_2SO_4 \cdot S$	12	40	0	**10**	0	0	0
MESZ (NH4)H2PO4 + (NH4)2SO4 + S + ZnO	12	40	0	**10**	0	0	1
MES-15 $NH_4H_2PO_4 \cdot (NH_4)_2SO_4 \cdot S$	13	33	0	**15**	0	0	0
Sulf-N 26 $(NH_4)_2SO_4 \cdot NH_4NO_3$ (fused ammonium sulfate nitrate)	26	0	0	**14**	0	0	0

Overview of Previous IL Study

- 82 site-years over a three-year period

  (27 sites in 1977, 26 in 1978, and 29 in 1979)

  - Low OM soils
  - Sand loam or coarser
  - S deficiency had been observed

  } 40% of sites

- Control and Gypsum at 50 lb S/a prior to planting
- Plant, soil, and grain yield data were collected
- Follow up greenhouse study

J. of Fert. Issues 2:95-104

Grain Yield

- S increased yield at 5 of the 82 locations (Average of 11.2 bu/a over the check)
  - 2 in NW IL (eroded silt loam and irrigated sand)
  - 1 in Central IL (silty clay loam)
  - 2 in Southern IL (silt loam and sandy loam)
- Average for all other sites was 0.5 bu/a higher than check plot

Other Findings

- Tissue samples were low or increased with S application in about 26 sites. Half of the locations were sandy soils with low OM
- Differences between field and greenhouse indicate S supply to the crop comes from atmospheric deposition and/or subsurface soil

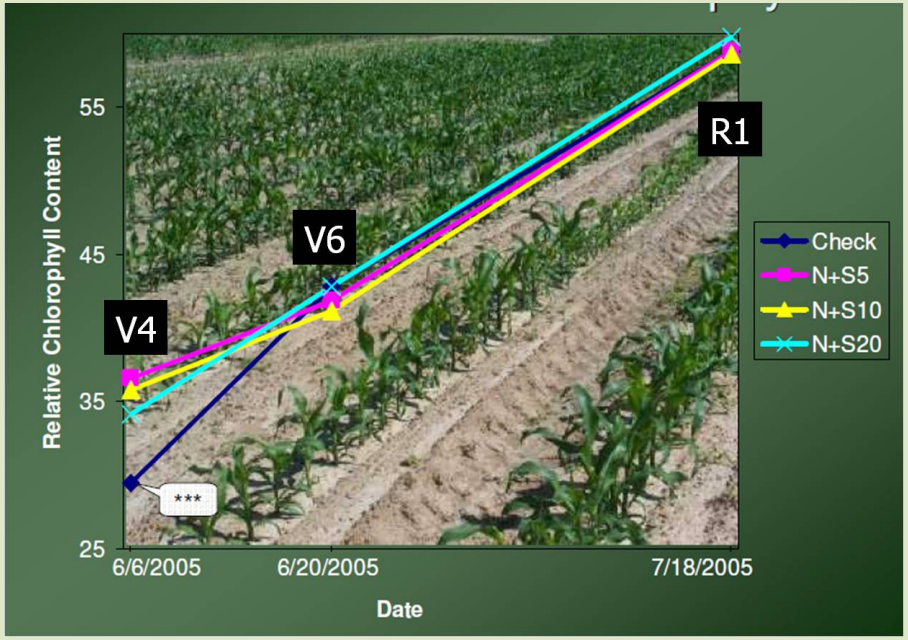
Michigan, Response to Starter

Treatment			2005		2006	
N	P	S	Ingham	Saginaw	Ingham	Montcalm
lb/a			bu/a			
25			178.2ab	190.7	160.4a	206.9ab
25	25		172.3ab	194.2	162.5a	207.2ab
25		5	174.7ab	193.1	158.2a	208.3ab
25		10	167.7ab	192.2	157.5a	210.5a
25		20	182.5a	189.0	157.8a	207.7ab
25	25	10	176.4ab	188.1	159.0a	208.4ab
		10	165.1ab	189.1	142.1b	199.6ab
Control			160.7b	188.9	139.9b	198.0b
LSD 0.05			20.55	NS	14.8	11.63
CV			5.03	2.74	4.03	2.38

Source: R. Gehl

Michigan, Deficiencies Only in Early Season

- More S in deeper layers
- More S available as soils warm up
- Early differences seldom cause yield reduction
- Yield reduction if deficiency continues beyond 20-30 DAE



Source: Gehl

Minnesota Research
Sulfur in Conservation Tillage

Soil	**S applied (lb/a)**	
	0	**6**
	bu/a	
Loamy fine sand	168.2	176.3*
Silty clay loam	187.1	187.0
Loamy fine sand	100.9	109.8*
Loam	152.5	163.1*
Silt loam	141.9	156.0**
Sandy loam	150.6	162.1*

Average yield increase 10.8%

Adapted from Rhem, SSSAJ 69: 709-717 (2005)

Iowa Research

- 1965-2004 approximately 200 site-years
  - Only 3 times statistically significant yield increase
- Sulfur deficiency in recent years is an issue in northeast Iowa
  - Especially on sandy soils, side-slope landscapes, low organic matter, eroded soils, sites with no manure
  - 15-25 lb S/acre needed

Sulfur Fertilizer Trials on Corn in Problem Field Areas, N.E. Iowa 2006

Location	Soil type	Sulfur	Yield	Moisture
			bu/acre	%
Lamont 1	Sparta lfs	No	123 a	24.6
		Yes	151 b	22.6
Lamont 2	Sparta lfs	No	154 a	22.6
		Yes	198 b	18.8
Thorpe 1	Chelsa lfs	No	88 a	14.8
		Yes	108 b	13.5
Thorpe 2	Kenyon l	No	196 a	19.8
		Yes	204 a	19.3
Waukon	Fayette sl	No	96 a	- -
		Yes	172 b	- -
Waterville	Fayette sl	No	118 a	33.0
		Yes	171 b	30.7

Sulfur applied as calcium sulfate at 40 lb S/acre.

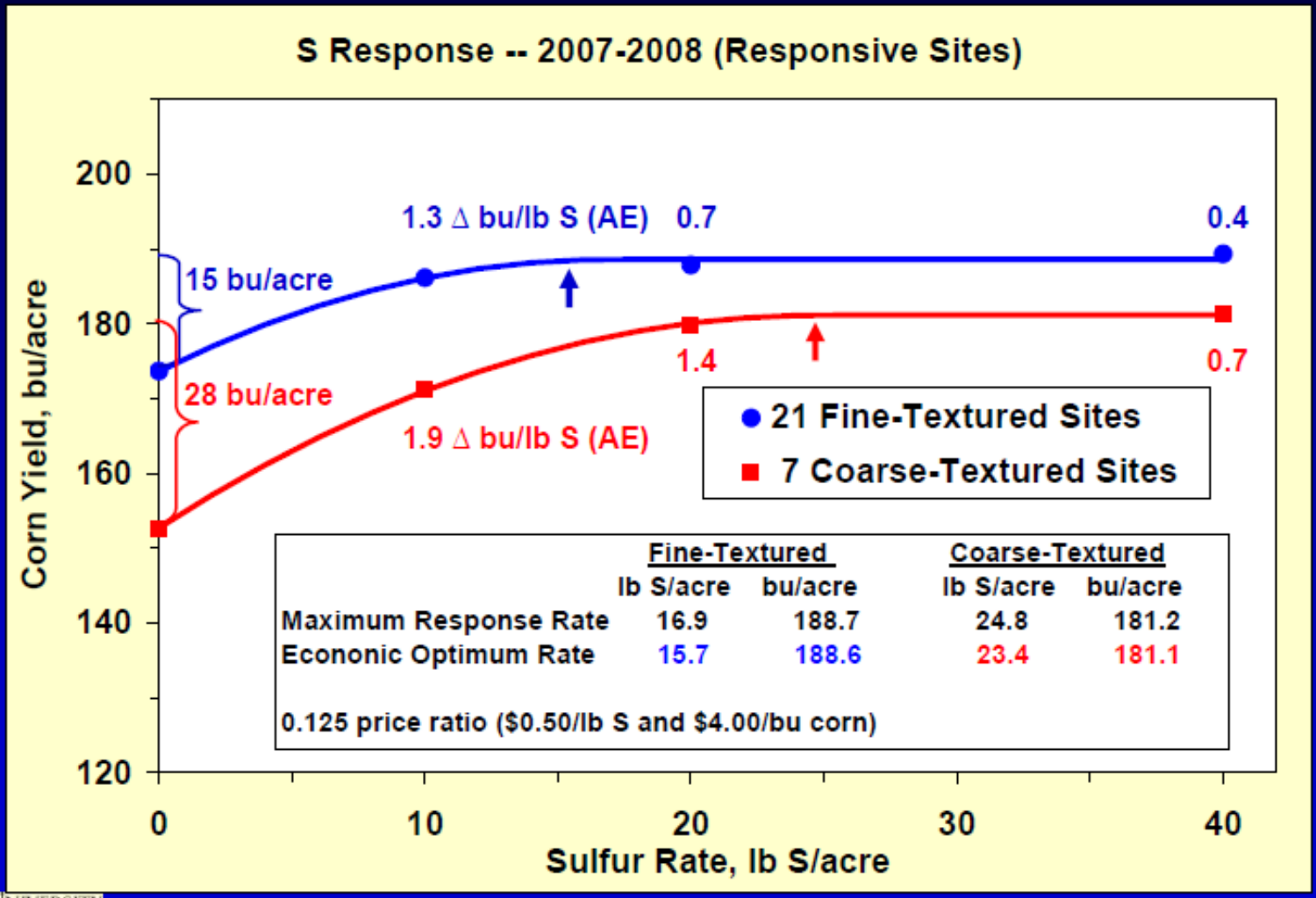
IOWA STATE UNIVERSITY
University Extension

Source: J. Sawyer

Twenty-Eight Responsive S Rate Sites, 2007-2008

Northeast Iowa

Soils: 21 fine texture (cl, sicl, sil, l); 7 coarse texture (fsl, lfs, sl)



IOWA STATE UNIVERSITY
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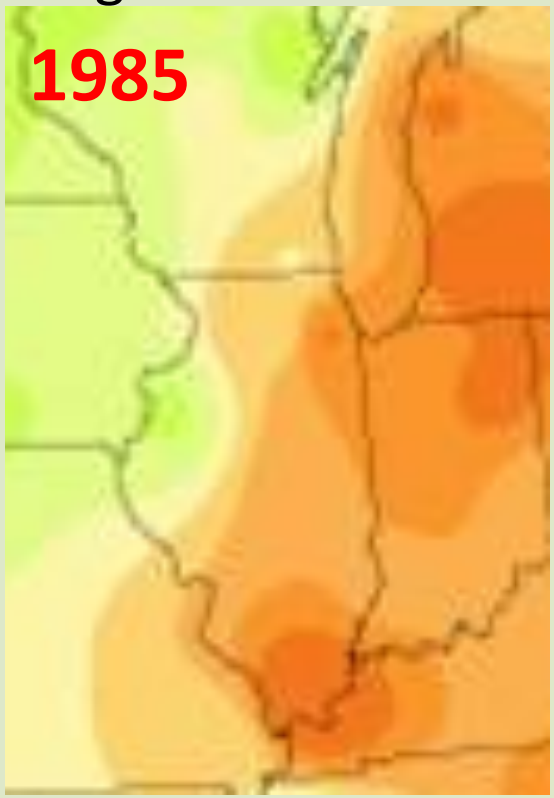
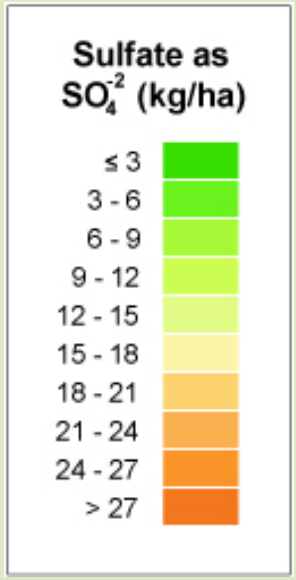
Source: J. Sawyer

Things Change

- **The frequency of S deficiency in corn has increased. Why?....**
- **Less atmospheric S deposition (Clean Air Act, 1970)**
- **Greater removal rates by increasing grain yields**
- **Less incidental S in fertilizers, insecticides, and fungicides**
  - **MAP DAP replaced superphosphates**
  - **Organic fungicides replaced copper sulfate**
- **Increased use of conservation tillage**
- **Fewer livestock operations less manure application**

Guesstimate 19-21 lb/a range





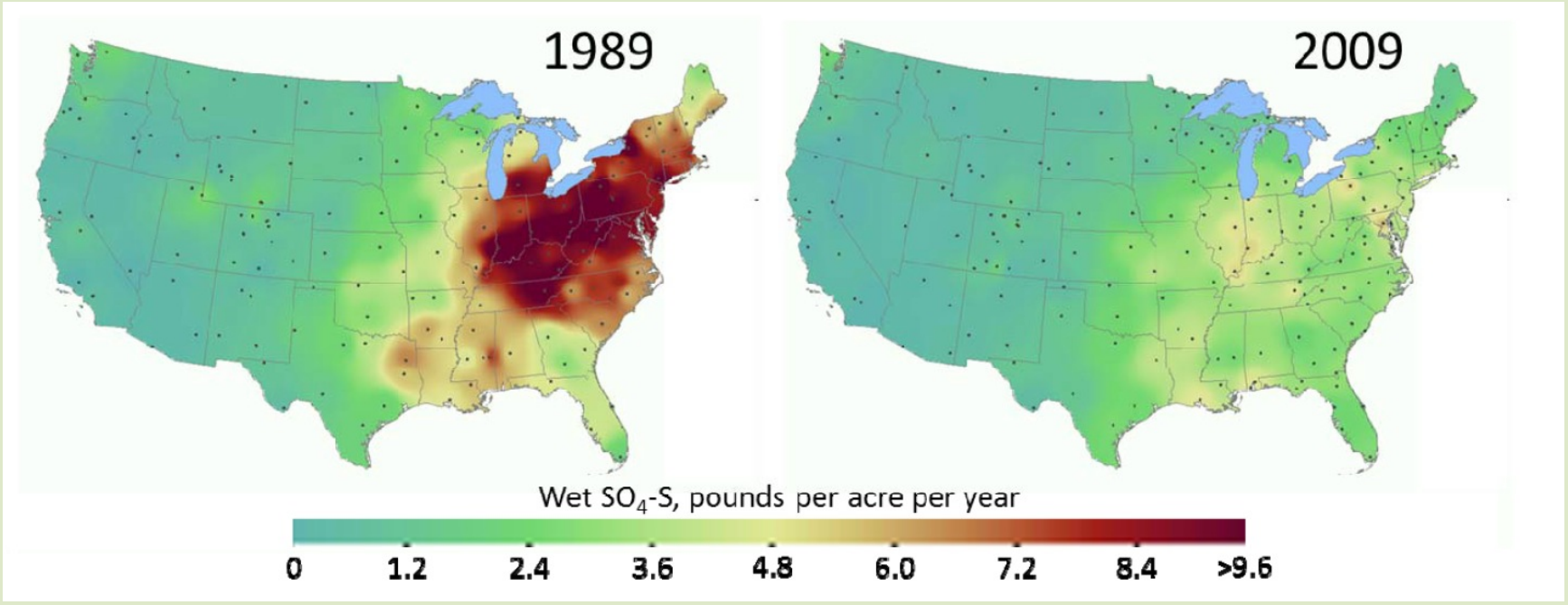
10 kg SO_4/ha = 3 lb S/acre

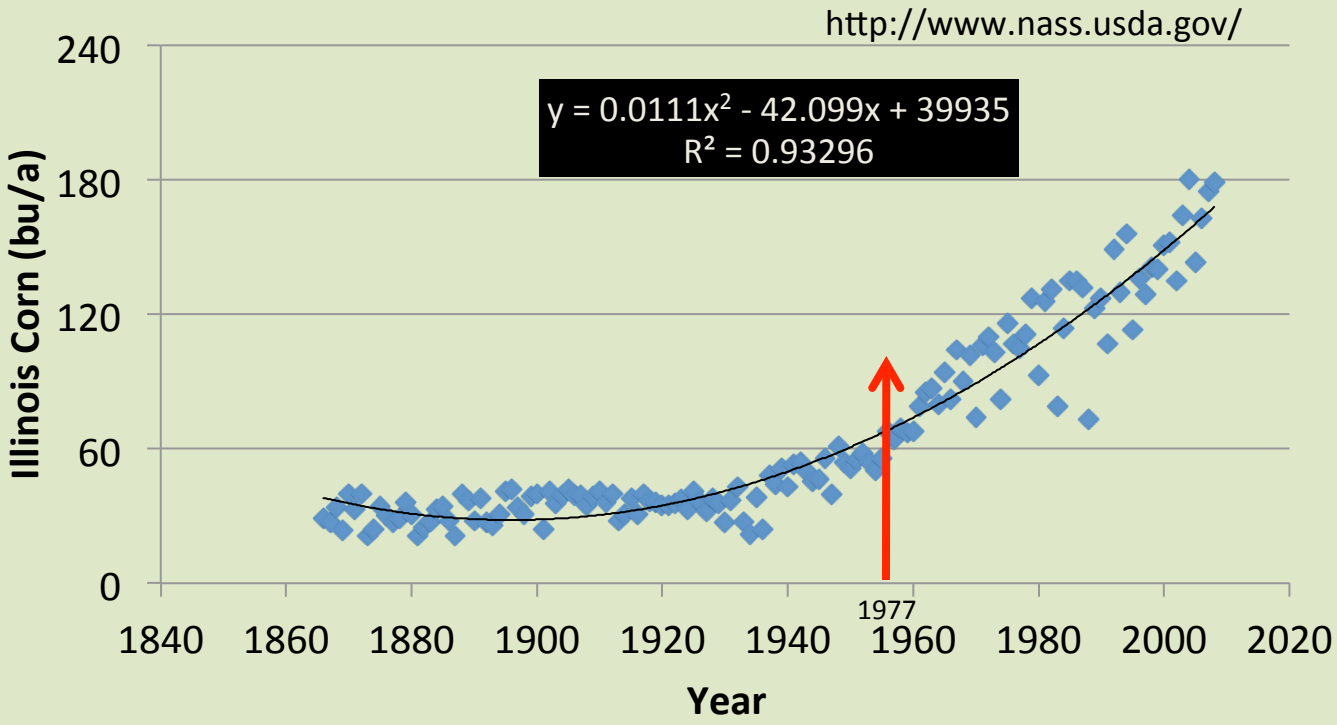
Estimate from early IL sulfur study: as much as 35 lb S/a

Guesstimate 13 lb/a

Strict air pollution standards have cleaned the air of gaseous sulfur compounds

Maps from the National Atmospheric Deposition Program
http://nadp.sws.uiuc.edu


1989
2009
Wet SO_4-S, pounds per acre per year
0
1.2
2.4
3.6
4.8
6.0
7.2
8.4
>9.6



Since the last study in Illinois

Yield increase 1.96 bu/a/yr Sulfur content 0.07 lb S/bu

S-use increase 0.14 lb S/a/yr

1980 (110 bu/a)= 7.7 lb S/a

2008 (165 bu/a) =11.6 lb S/a

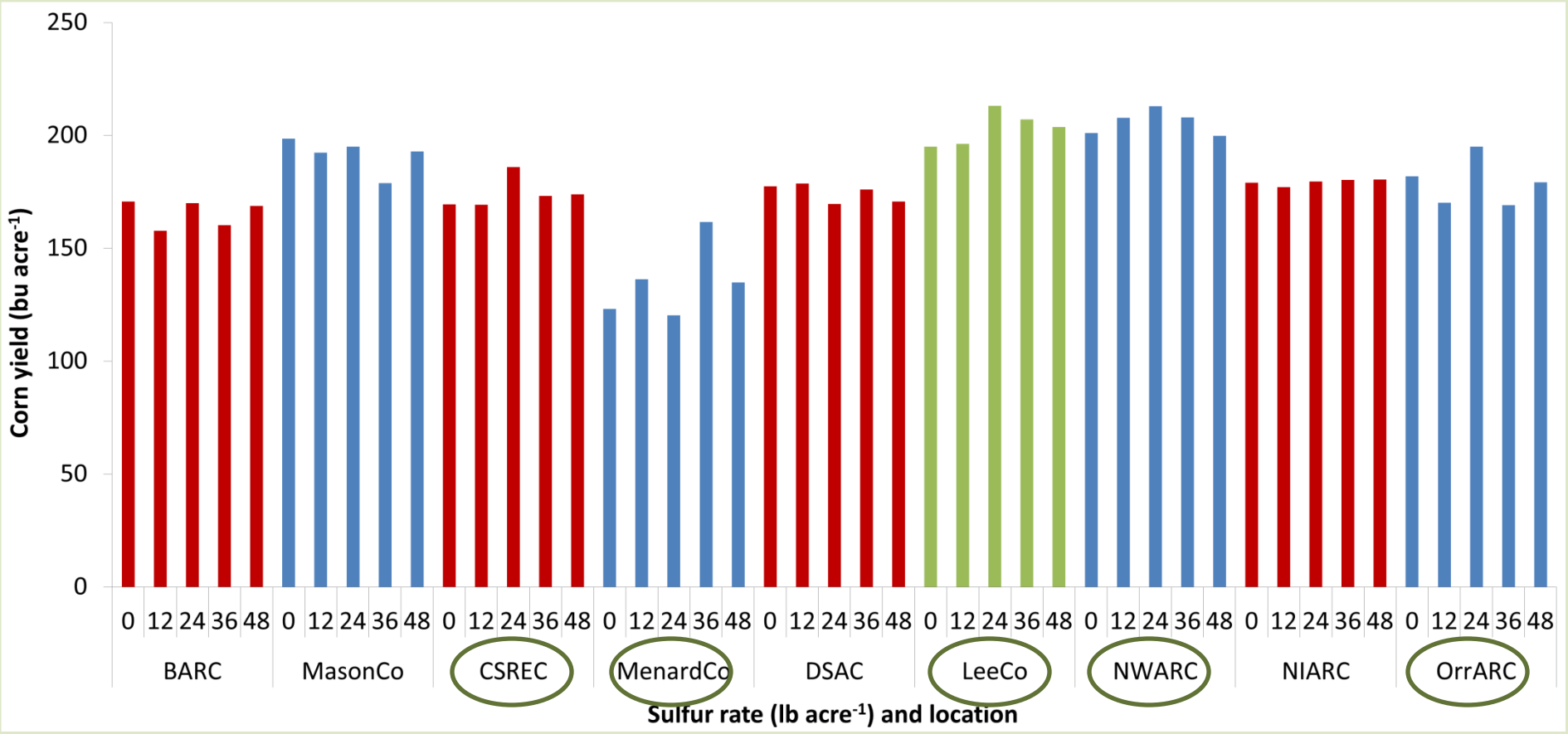
} 3.9 lb S/a more than in 1980!

220 bu/a not uncommon = 15.4 lb S/a

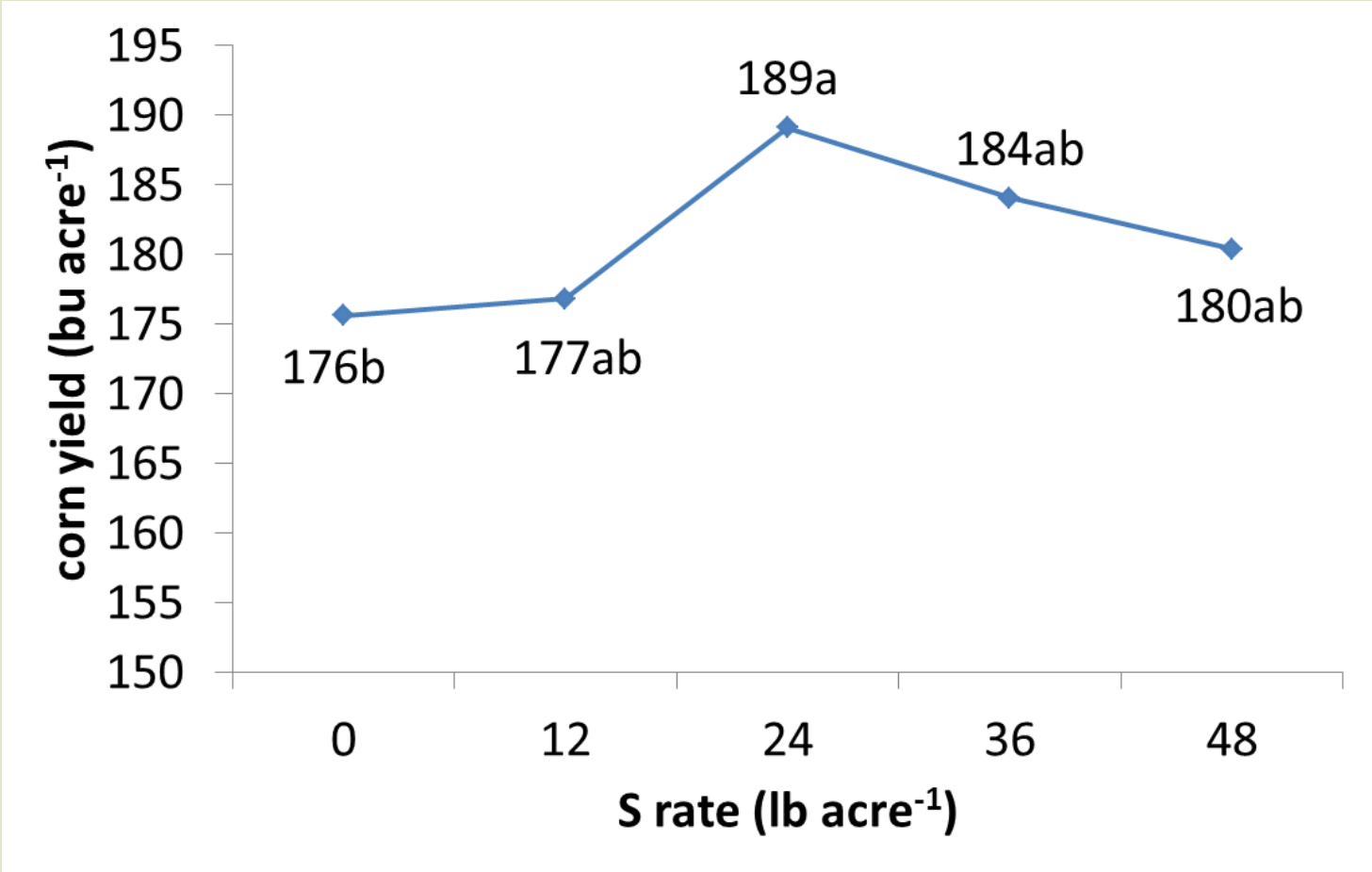
Small-Plot Trials

Year	Location	County	Soil Type
2009	BARC	Fayette	Cisne silt loam (low)
2010-2011	BARC	Fayette	Bluford silt loam 0-2% (low)
2009-2011	CSRC	Champaign	Wyanet silt loam 5-10% (low)
2009-2011	DSAC	Pope	Belknap silt loam 0-2% (low-moderate)
2011	Havana	Mason	Plainfield sand 1-7% (low)
2010	Mendota	Lee	Wyanet fine sandy loam 2-5% (low)
2011	Mendota	Lee	Ayr sandy loam 2-5% (low)
2010	Middletown	Menard	Broadwell silt loam 2-5% (low)
2009	NIARC	DeKalb	Flanagan silt loam 0-2% (high)
2010	NIARC	DeKalb	Drummer silty clay loam 0-2% (high)
2011	NIARC	DeKalb	Catlin silt loam 0-2% (low-moderate)
2009	NWARC	Warren	Sable silty clay loam (moderate-high)
2009	OrrARC	Pike	Downs silt loam (2-5%) (low-moderate)

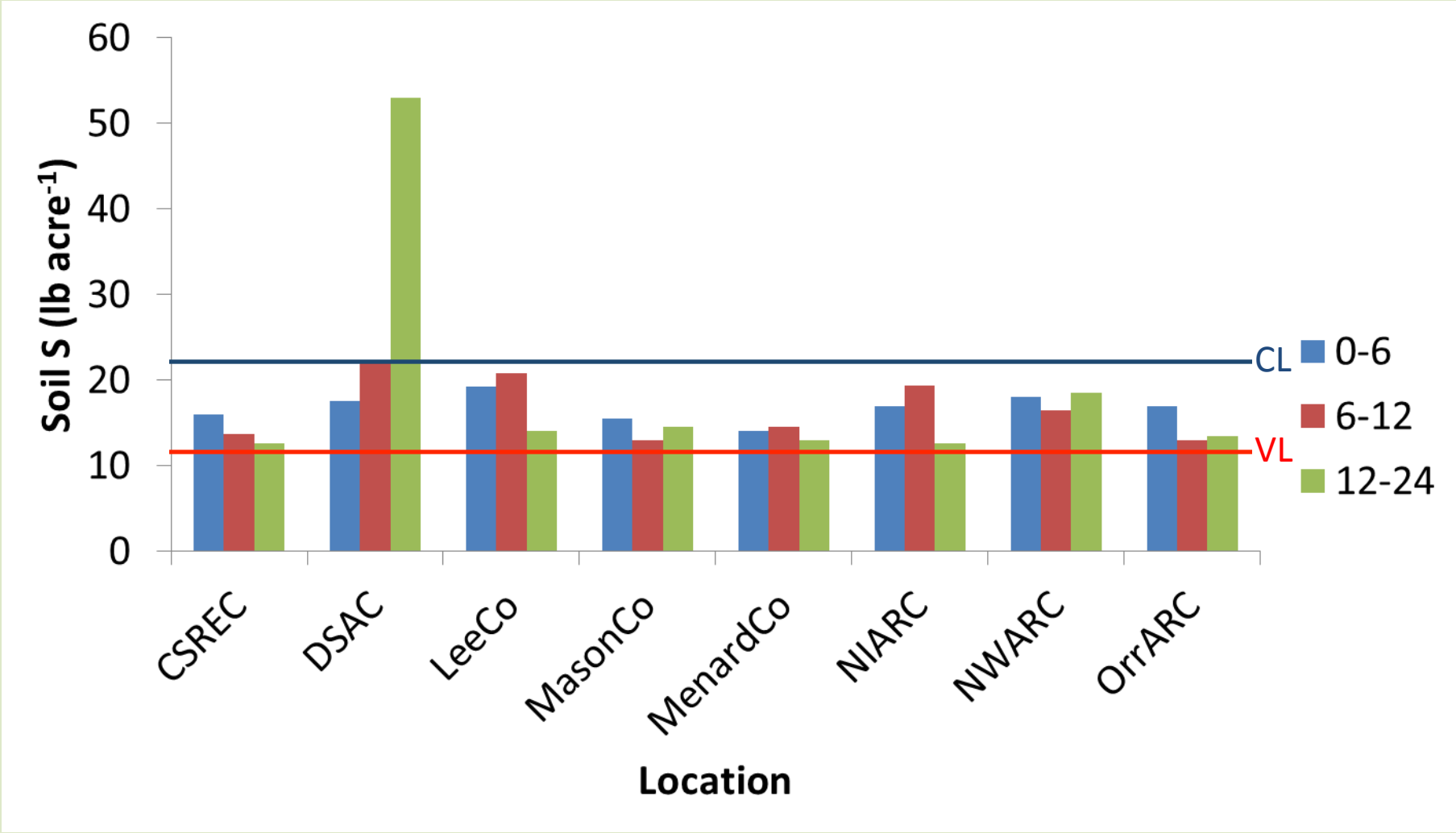
Corn Response to Sulfur Rate with MES-15 (18 site-years, 2009-2011)



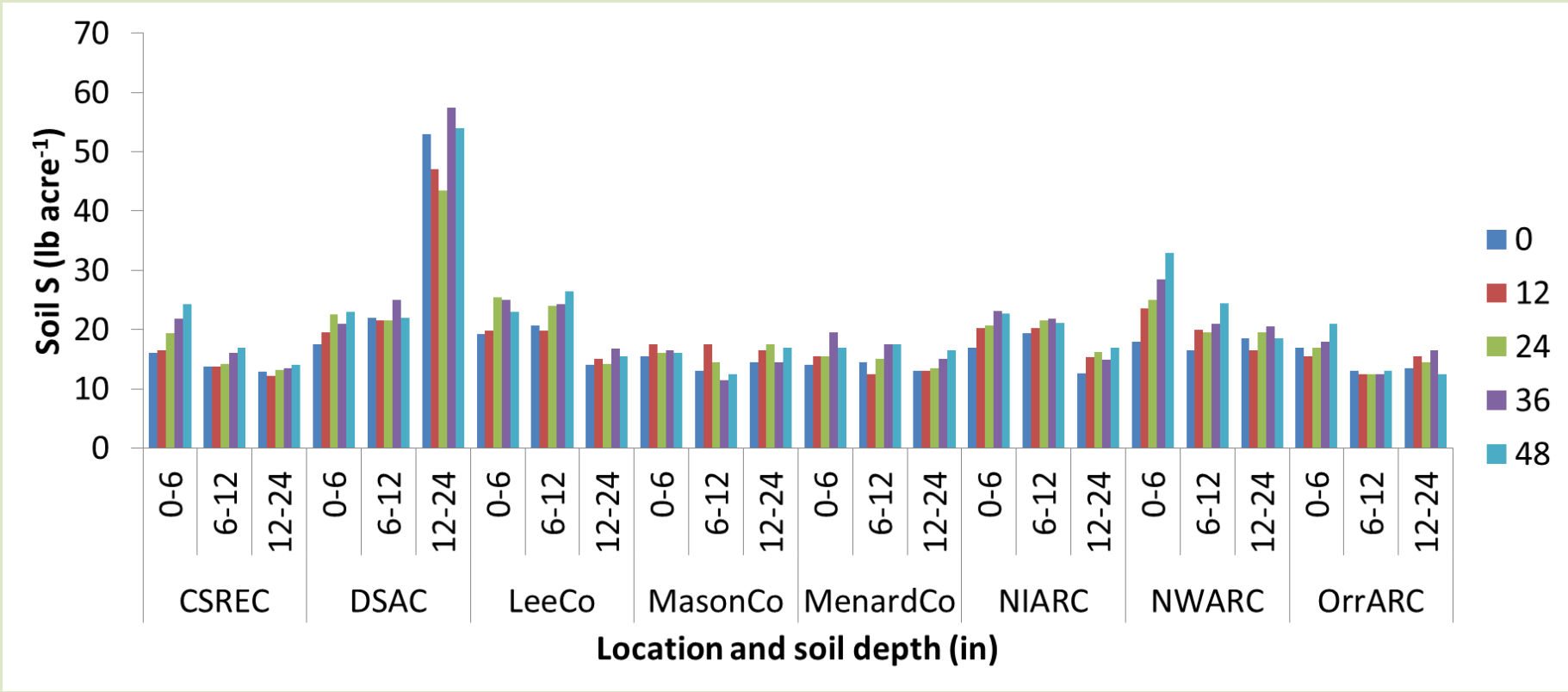
Champaign, Menard, Lee, Warren, Pike Counties (8 site-years)



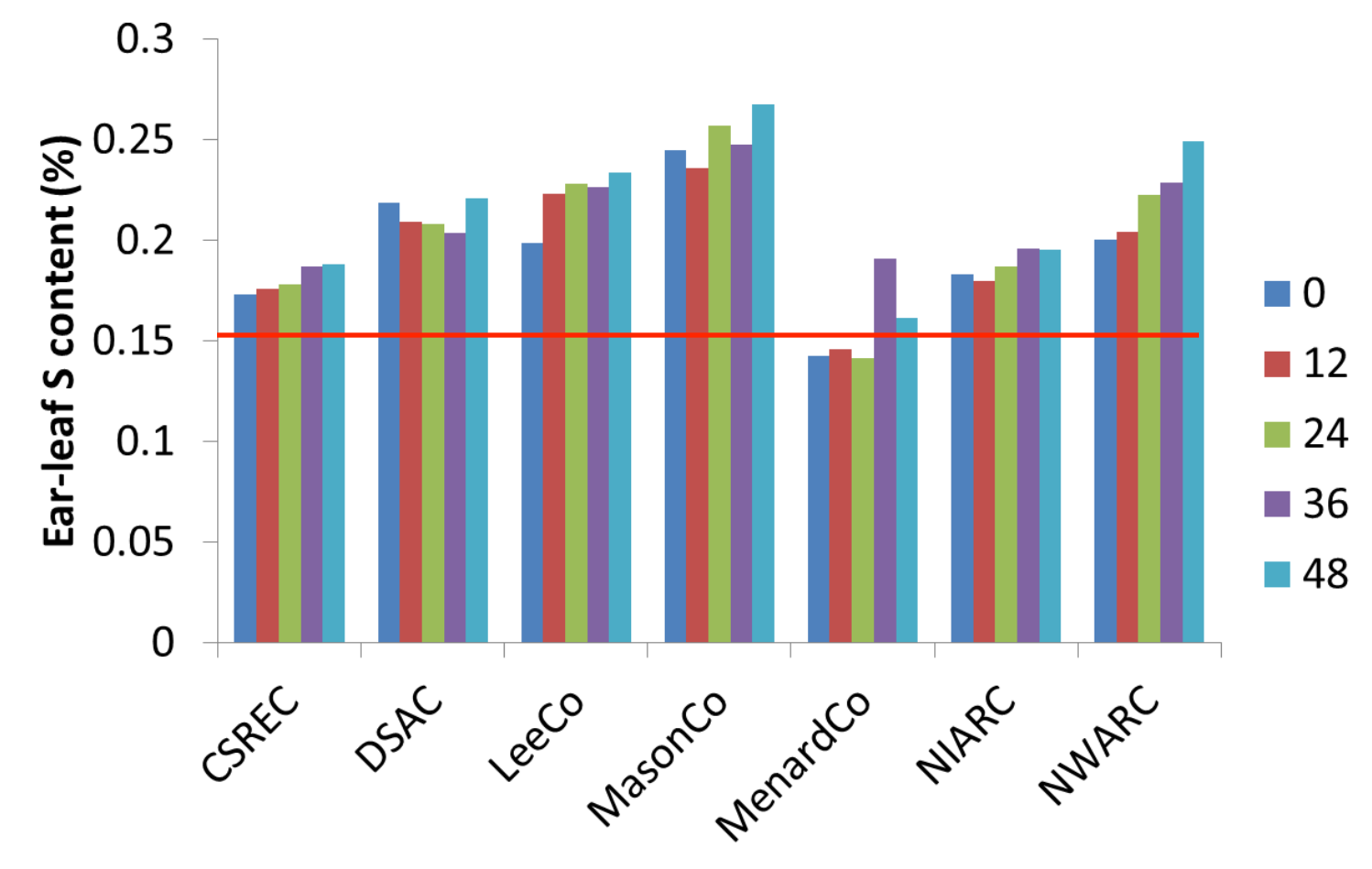
Soil S for Check Plots at V6 by Depth
(Averaged across years)



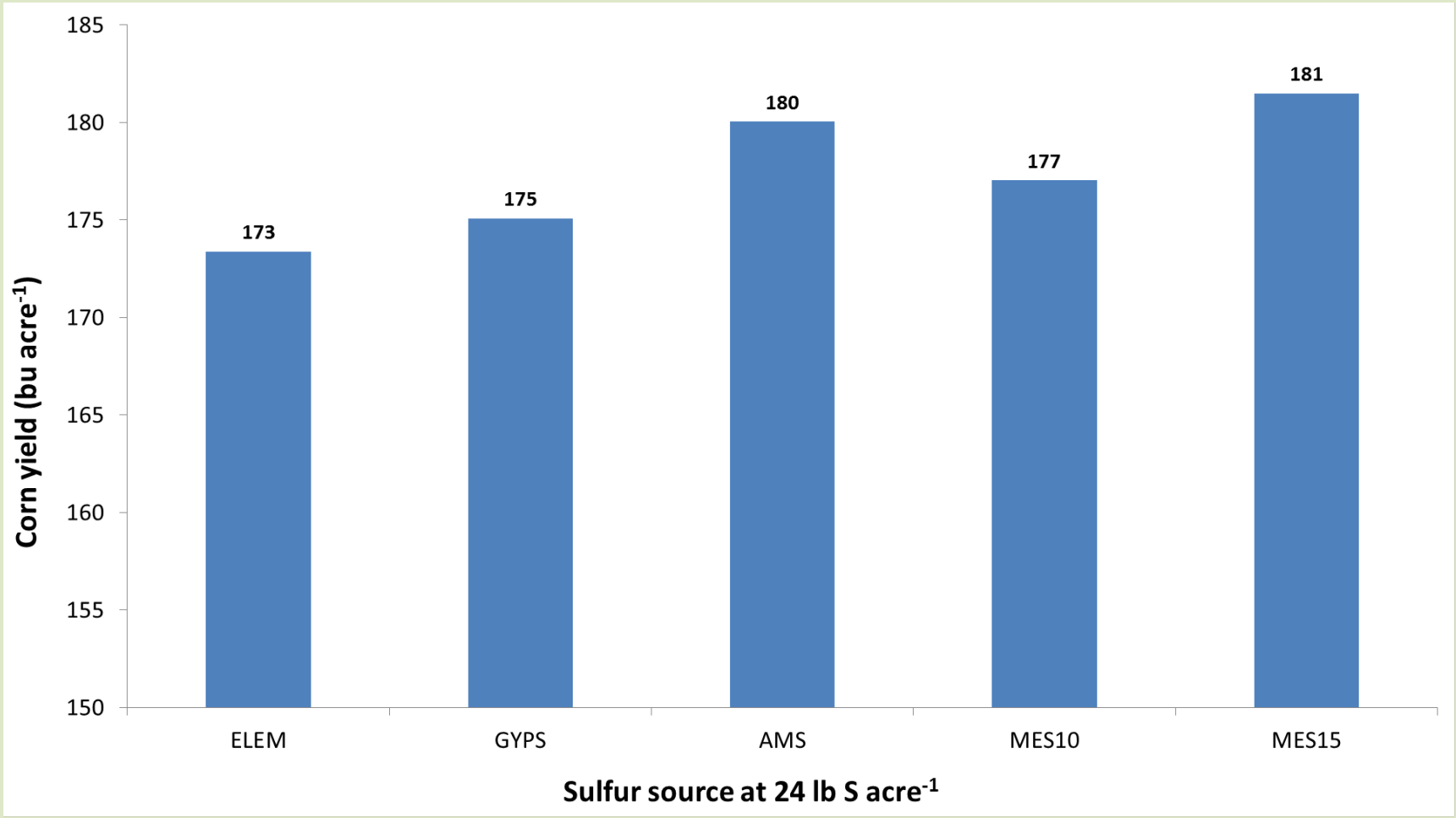
Soil S by Depth at V6 for Various S Rates
(Averaged across years)



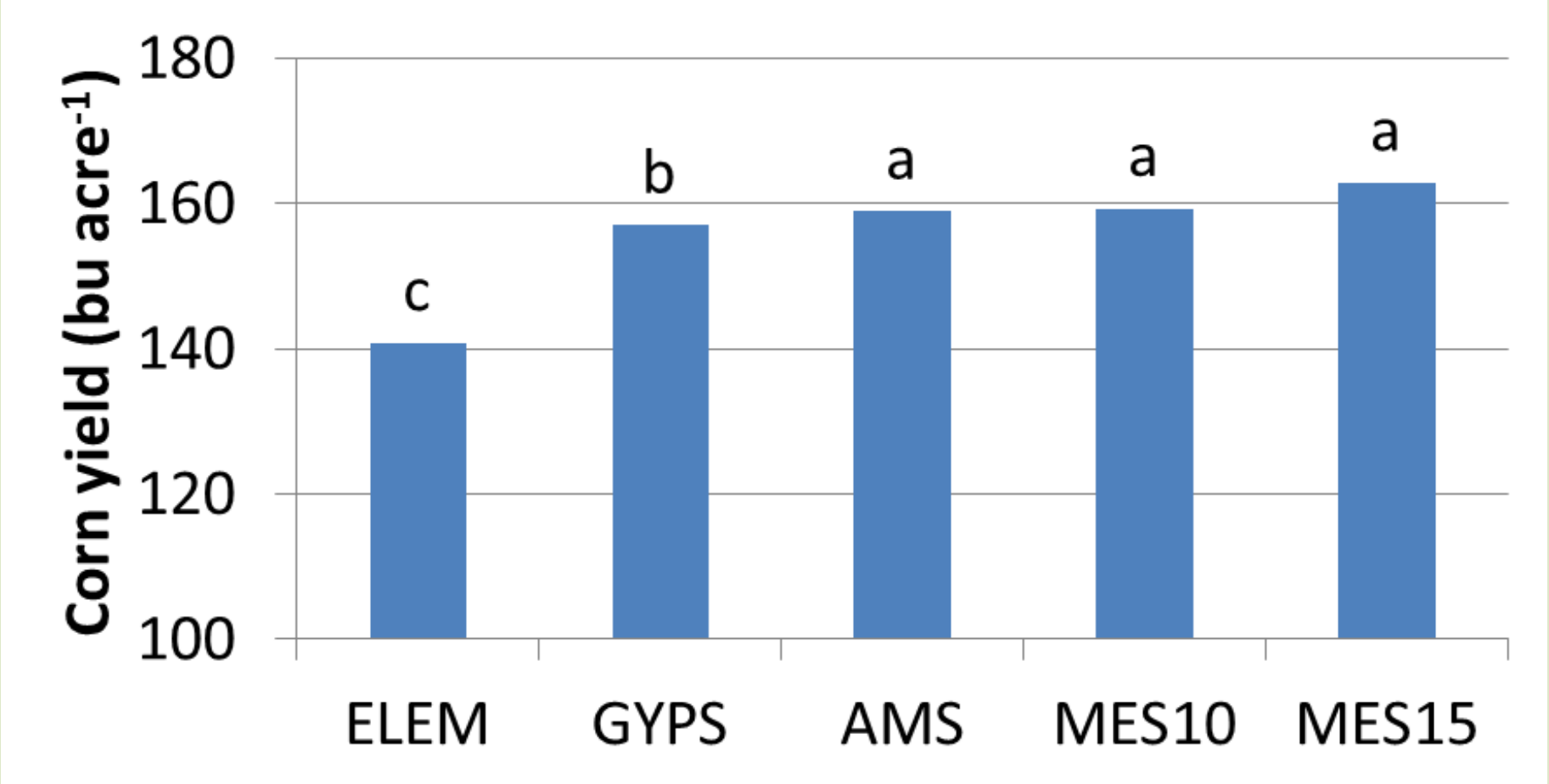
Ear-leaf S Content for Various S Rates (averaged across years)



Corn Response to Sulfur Source (18 site-years)

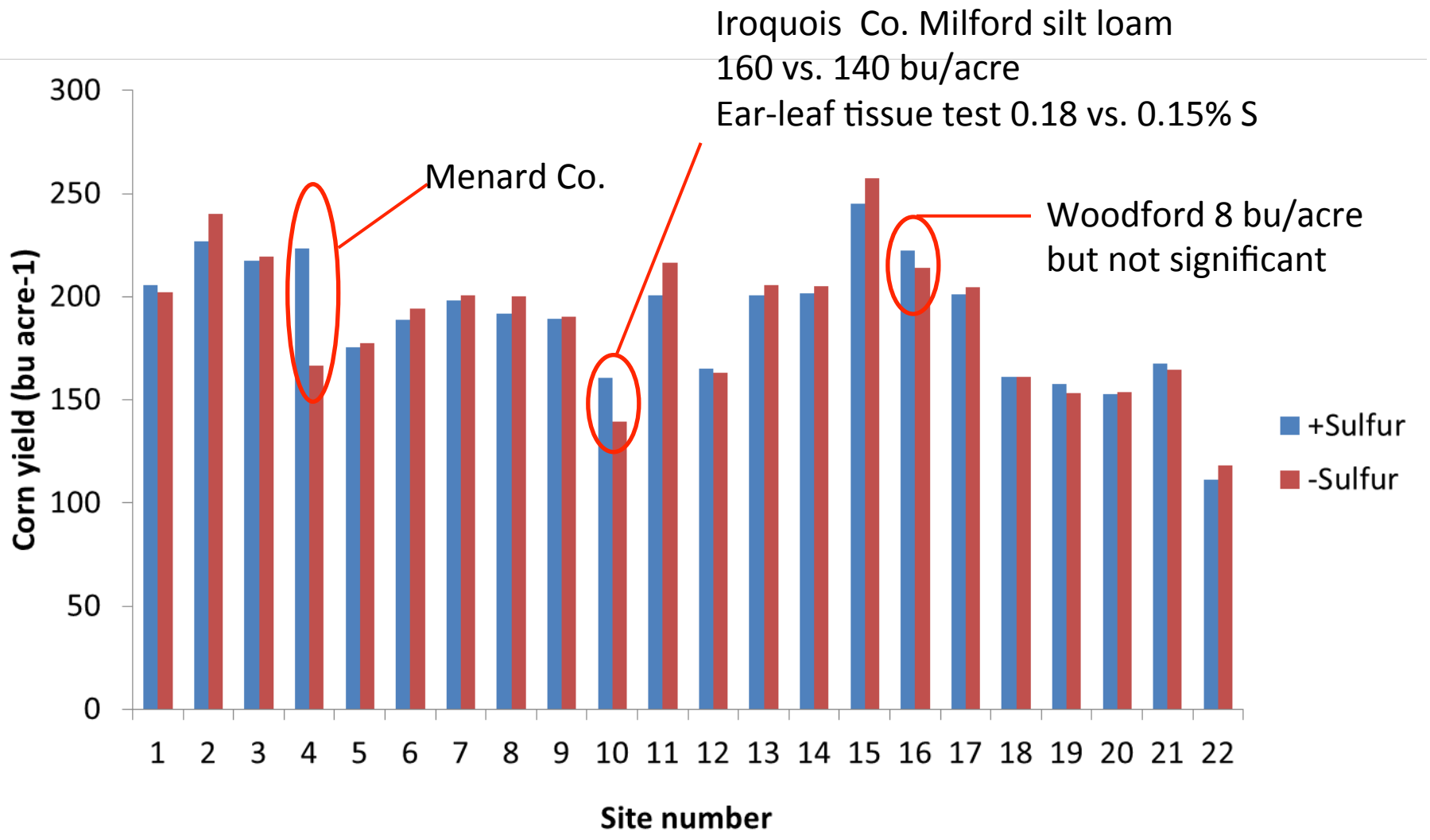


Sulfur Source, Brownstown 2009-10
Cisne sil 1.7% OM

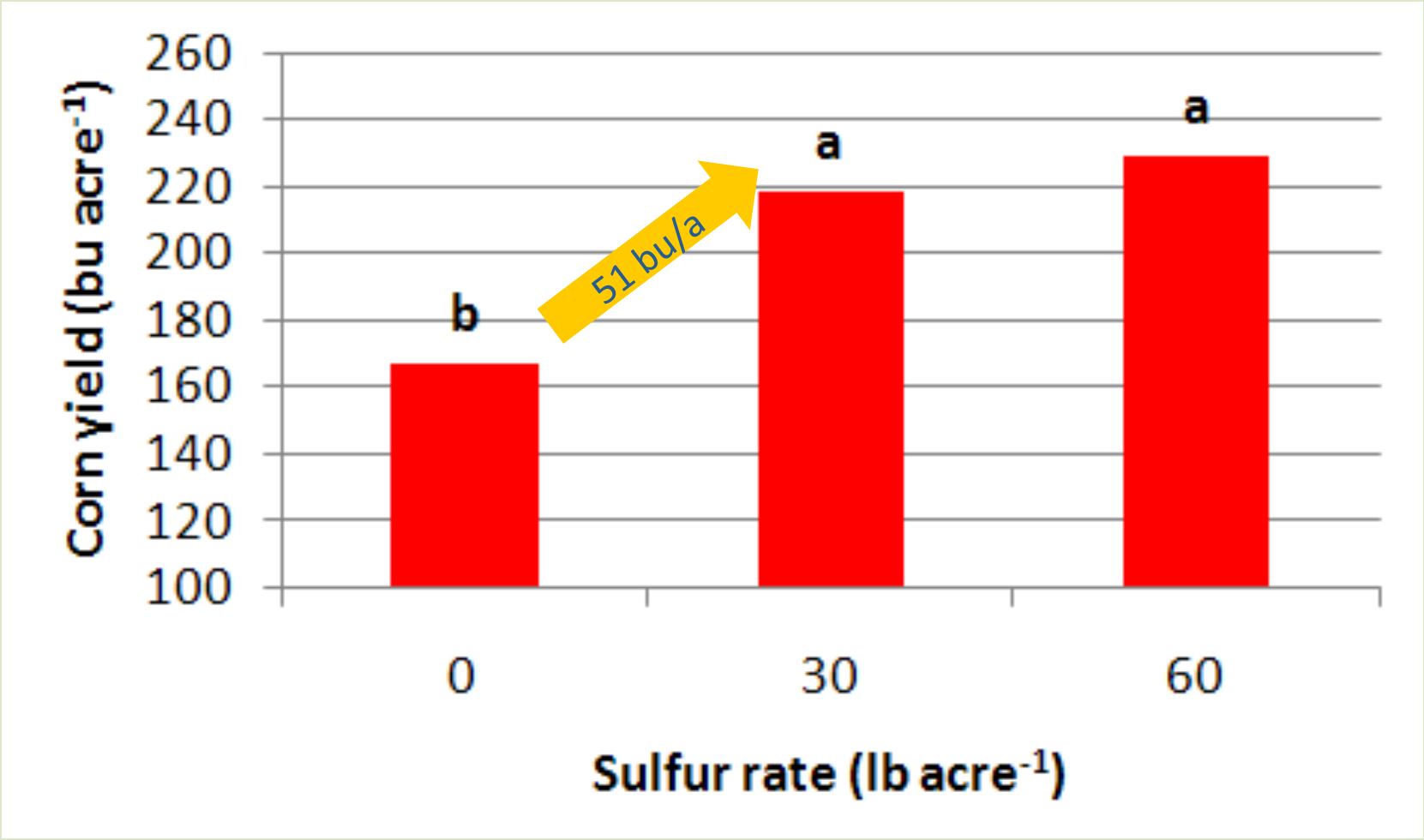


On-Farm Trials

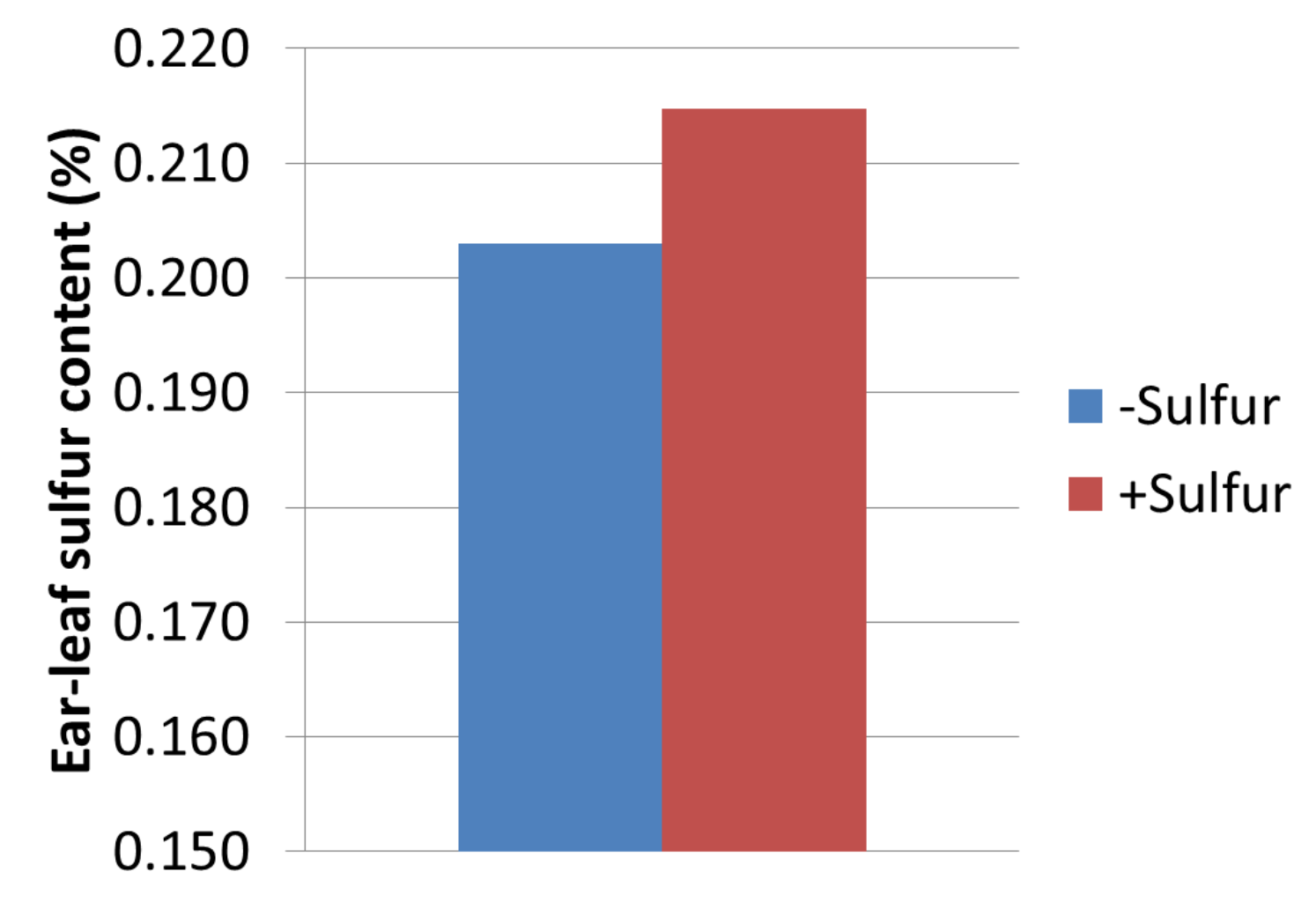
year	County	Soil Type
2010	Bureau	Flanagan silt loam 0-2%
2010	Champaign	Flanagan silt loam 0-2%
2009	Champaign	Kendall silt loam 0-2%
2009	Champaign	Pella silty clay loam 0-2%
2011	Champaign	Flanagan silt loam
2011	Champaign	Drummer silty clay loam
2011	Champaign	Drummer silty clay loam
2010	Champaign	Flanagan silt loam 0-2%
2010	Champaign	Xenia silt loam 2-5%
2010	Christian	Virden silty clay loam 0-2%
2010	Douglas	Sabina silt loam 0-2%
2011	Effingham	Darmstadt silt loam
2009	Ford	Drummer silty clay loam
2011	Franklin	Cisne silt loam
2010	Iroquois	Andres loam
2009	Livingston	Crane loam
2009	Logan	Buckhart silt loam till substratum 2-5%
2009	Marion	Cisne -Huey silt loams, 0-2%
2010	McHenry	Dickinson sandy loam 0-2%
2010	McHenry	Dickinson sandy loam 0-2%
2009	Menard	Onarga sandy loam
2009	Peoria	Rozetta silt loam 1-5% eroded
2011	Shelby	Bluford silt loam 0-2%
2010	Vermillion	Drummer silty clay loam
2010	Warren	Sable silty clay loam 0-2%
2010	Woodford	….


Iroquois Co. Milford silt loam
160 vs. 140 bu/acre
Ear-leaf tissue test 0.18 vs. 0.15% S
Menard Co.
Woodford 8 bu/acre
but not significant
Corn yield (bu acre-1)
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Site number
+Sulfur
-Sulfur

Menard Co.
Onarga sandy loam



12 On-Farm Sites (2009-10) Ear-leaf Tissue Sulfur Content



Small Plot (18 site-years)

S rate	2009	2010	2011	3-yr mean
0	186	160	186	177
	Yld. difference over check (bu/a)			
12	-6	3	-3	-2
24	7	6	0	5
36	2	6	-6	1
48	1	5	-5	1

On-Farm (22 site-years)

Sulfur app	2009 (8 sites)	2010 (10 sites)	2011 (4 sites)	3-yr mean
No	200	199	151	192
Yes	202	196	151	192

Where Do We expect S Deficiency?

- Low S supplying power soils
  - Low OM soils
- Coarse textured-soils
  - High leaching potential
- Eroded fine-textured soils
  - Related to low OM
- Consider applications on a trial basis

On Farm Research
Corn Response to Sulfur

We need your help!

– Contact me:

- **217-333-4426**
- **fernande@illinois.edu**

Thank You

- Fertilizer Research and Education Council
- The Mosaic Co.
- Volunteer Farmers and Extension Educators