Secondary and Micronutrients

Dr. John E. Sawyer

Associate Professor

Soil Fertility Extension Specialist

Department of Agronomy

IOWA STATE UNIVERSITY
University Extension

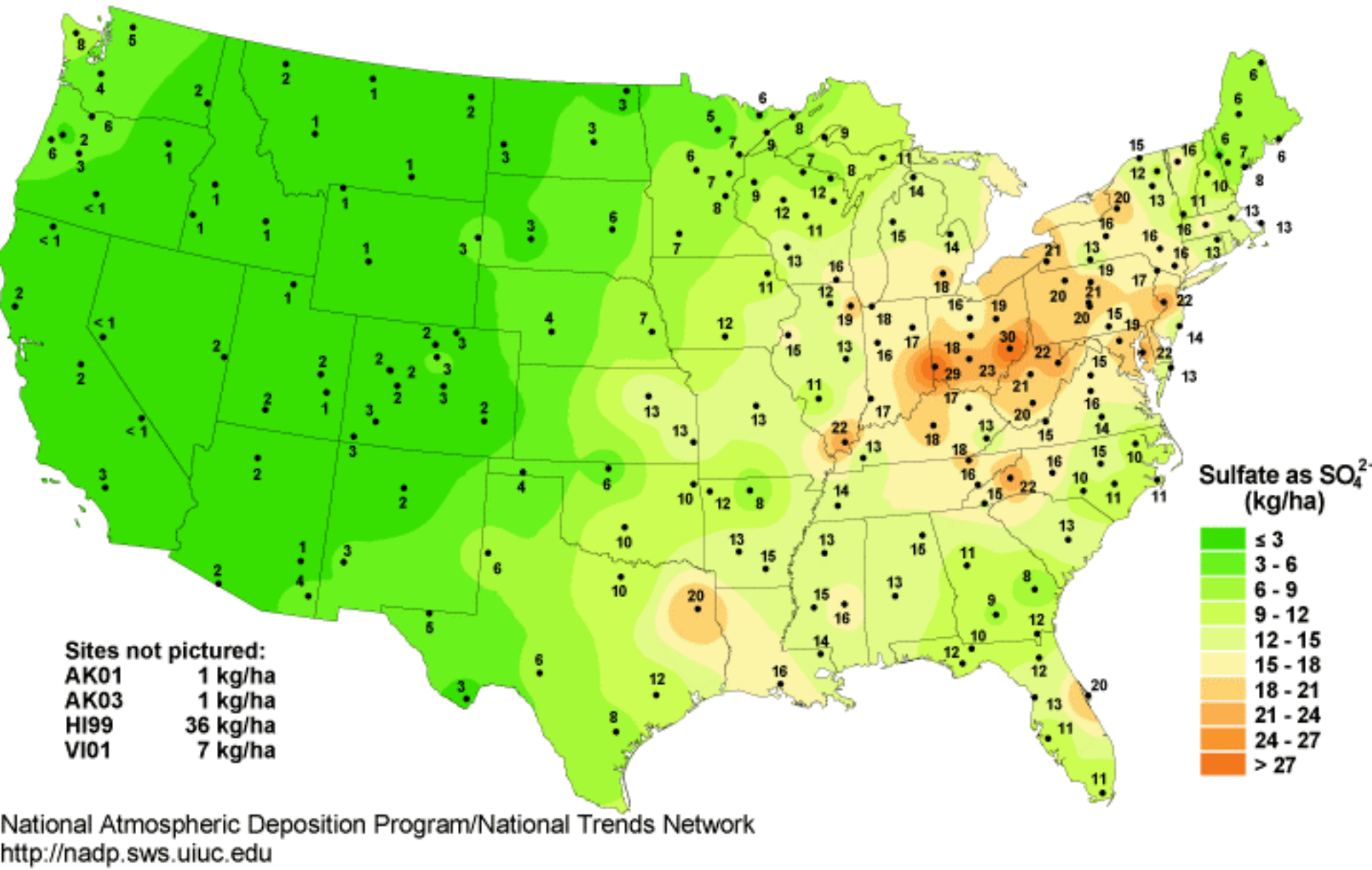
Slide from G. Rehm, Univ. MN

Sulfur Deficiencies

- Soil Situations and Climatic Conditions Aggravating Deficiency Symptoms
  - Coarse textured soils (sandy soils)
  - Low organic matter soils
  - Cold, wet soils
    - Slow release of S from organic matter
  - Low atmospheric deposition
  - No application from
    - Manure
    - Other fertilizers

J.E. Sawyer, Iowa State Univ.

Sulfate ion wet deposition, 2001



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

J.E. Sawyer, Iowa State Univ.

10 kg SO_4/ha = 3 lb S/acre

Concentration of Secondary Plant Nutrients in Animal Manures

Element	Poultry Layer	Swine Slurry
	lb/ton	lb/1,000 gal
Calcium	179	7.8
Magnesium	5.7	2.7
Sulfur	8.8	2.3

J.E. Sawyer, Iowa State Univ.

Effect of Sulfur Source and Rate at Six Sites in Iowa

Average across all sites, 2000

	Corn		Corn Ear Leaf		Soybean	
S Rate	CaS	S	CaS	S	CaS	S
lb S/acre	bu/acre		SPAD		bu/acre	
0	161	159	60	60	50.0	50.0
10	158	159	60	60	49.3	49.6
20	158	159	60	60	48.9	49.9
40	158	159	60	60	49.0	49.6
	NS		NS		NS	

Calcium Sulfate; Elemental Sulfur; App. spring 2000

Iowa State University

J.E. Sawyer, Iowa State Univ.


Ames, 2001
J.E. Sawyer, Iowa State Univ.

Effect of Sulfur Source and Rate – Year After Application

Corn grain yield, 2001

	Ames		Atlantic		Crawfordsville	
S Rate	CaS	S	CaS	S	CaS	S
lb S/acre	- - - - - - - - - - - - - - bu/acre - - - - - - - - - - - - - -					
0	159	159	147	147	118	111
10	154	156	145	152	110	109
20	158	164	148	147	113	117
40	155	153	147	147	118	108
	NS		NS		NS	

Calcium Sulfate; Elemental Sulfur; App. spring 2000

Iowa State University

J.E. Sawyer, Iowa State Univ.

Effect of Sulfur Source and Rate at Six Sites in Iowa

Extractable Soil Sulfate-S concentration

Sample	Ames		Atlantic		Crawfordsville	
Depth	Corn	Soybean	Corn	Soybean	Corn	Soybean
inches	- - - - - - - - - - - - - - - - - - ppm - - - - - - - - - - - - - - - - - -					
0-6	23	13	8	11	6	7
6-12	6	6	11	5	2	4
12-24	9	25	7	7	2	5
24-36	13	42	7	16	3	2

Soil samples collected spring 2000
Iowa State University

J.E. Sawyer, Iowa State Univ.

Effect of Sulfur Source and Rate at Six Sites in Iowa

Extractable Soil Sulfate-S concentration

Sample	Doon		Kanawha		Castana	
Depth	Corn	Soybean	Corn	Soybean	Corn	Soybean
inches	- - - - - - - - - - - - - - - - - - ppm - - - - - - - - - - - - - - - - - -					
0-6	2	11	7	7	4	--
6-12	2	4	4	7	5	--
12-24	8	7	10	15	2	--
24-36	--	--	9	10	4	--

Soil samples collected spring 2000
Iowa State University

J.E. Sawyer, Iowa State Univ.

Corn and soybean response to S rate and source, 1977 to 1990.

Location	Control	30 lb S/acre		60 lb S/acre	
		ES	ATS	ES	ATS
	bu/acre				
Corn					
Castana	113	110	113	112	112
Kanawha	168	164	166	163	163
Doon	126	126	125	126	125
Nashua	177	175	175	175	174
Sutherland	145	143	145	143	142
Mean	148	146	147	146	143
Soybean					
Castana	26.5	26.7	27.1	26.1	26.1
Kanawha	40.9	38.9	40.8	40.0	39.8
Doon	44.5	43.7	43.7	42.9	43.9
Nashua	45.1	44.1	45.2	44.9	45.5
Sutherland	40.7	41.9	41.1	40.4	40.4
Mean	40.0	39.4	39.9	39.2	39.4

Research by J. Webb, summarized by Pierce et al., 1997.

ES = Elemental S, ATS = Ammonium Thiosulfate. Broadcast applied.

Summary of Sulfur Fertilization Research

- Past 30+ years research across Iowa
  - Two site-years with yield increase
  - One study with multi-year average yield decrease
- Recent research across Iowa
  - No yield response to S application

Gypsum Application

- **Calcium Sulfate**
  - $CaSO_4 \cdot 2H_2O$
    - 16% S
    - 22% Ca

Why Apply Gypsum to Iowa Soils?

- **Iowa Soils have:**
  - **High organic matter**
  - **High (adequate) calcium and magnesium content for plant growth and soil structure**
  - **Low sodium**
  - **Ca:Mg ratios within a range that will not influence plant growth**
  - **Calcareous soils have soil exchange complex saturated with calcium/magnesium and have free lime and sometimes free gypsum**

J.E. Sawyer, Iowa State Univ.

Gypsum Used as Aid in Reclamation of Saline-Sodic and Sodic Soils

- **Saline-Sodic Soils**
  - Not dispersed soil structure
  - Conductivity > 4 mmhos/cm
  - > 15% exchangeable sodium
  - pH < 8.5
- **Sodic soils**
  - Dispersed soil structure
  - Conductivity < 4 mmhos/cm
  - > 15% exchangeable sodium
  - pH > 8.5

J.E. Sawyer, Iowa State Univ.

Exchangeable Cations of Several Iowa Surface Soils

Soil Type	pH	CEC	Ca	Mg	K
		meq/100g	lb exchangeable/acre		
Kenyon	5.9	14.0	3400	624	156
Readlyn	6.3	19.5	5800	1008	156
Klinger	5.8	26.2	8000	1248	156
Dinsdale	5.9	20.5	5840	1008	312
Tama	5.7	20.6	5560	816	390
Muscatine	6.1	28.3	8160	1704	312

J.E. Sawyer, Iowa State Univ.

Gypsum Application to Iowa Soils

Corn and Soybean Yield - Average Across Six Sites in Iowa, 2000

	Gypsum Application		Corn		Soybean	
S Rate	Product	Calcium	CaS	S	CaS	S
lb S/acre	lb/acre	lb Ca/acre	- - - - - - - - bu/acre - - - - - - - -			
0	0	0	162	159	50.0	50.1
10	62.5	14	158	160	49.3	49.6
20	125	28	158	159	48.9	49.7
40	250	56	158	159	49.0	49.6
Significance (0.05)			NS		NS	

CaS = Calcium Sulfate; S = Elemental Sulfur. Applied Spring 2000.
Sawyer and Barker, Iowa State University

Gypsum Application to Iowa Soils

Effect of Sulfur & Calcium on Kenwood 94 Soybean at Western Research Farm, 1996

S Rate	Gypsum	Ca Applied	Yield
lb S/acre	lb/acre	lb Ca/acre	bu/acre
0	0	0	62
10	59	13	58
20	118	26	58
40	236	52	61
60	354	78	56
Sign (0.05)			NS

Gypsum preplant broadcast and incorporated.

Soil S = 3 ppm. Shibles et al., ISRF96-10,1996.

Application of Flue-Gas Scrubber Desulfurization Sludge (Gypsum)

Wynoose silt loam (F. Thicke, Ph.D. Thesis, 1988, Univ. Illinois)

Product Rate	3-yr Corn	4-yr Soybean	Soil pH 3 yr	ex. Ca 1 yr	ex. Mg 1 yr	1 yr Bulk Density
lb/acre	bu/acre	bu/acre		ppm	ppm	g/cm^3
0	159	36	6.8	1608	407	1.42
1,000	159	38	6.9	1615	371	1.41
10,000	156	36	6.8	1705	368	1.45
50,000	142	35	6.7	2110	330	1.38
100,000	145	33	6.9	3960	294	1.39
Stats:	S	S	NS	S	S	NS

Material applied spring 1984, moldboard plow incorporation. Newton, IL

J.E. Sawyer, Iowa State Univ.

Corn Yield Response to Sulfur & Magnesium Fertilization, Northwest Research Farm, 1995 – 1999

Treatment	S	K_2O	MgO	5-year Mean
	lb/acre			bu/acre
Sulpomag	60	60	30	138
KCl + S	60	60	--	138
Elemental S	60	--	--	138
KCl	--	60	--	135
FLSD(0.05)				NS

A.P. Mallarino et al., 1999 ISRF99-29.31.

Fertilizers spring incorporated each year before corn.

1999 0-6 inch SO_4-S: 5-8 ppm with K only; 30-46 ppm average with applied S.

Effect of Broadcast Potash and Sulpomag on Corn Yield, Webster Soil

Year	Control	KCl	$KMgSO_4$
	- - - - - - bu/acre - - - - - -		
1967	146	160	161
1968	148	161	160
1969	144	139	144
1970	108	130	124
1971	147	157	160
1972	129	150	152
1973	115	129	129
1974	120	133	130
8-yr avg.	132	145	145

Fertilizers applied at 160 lb K/acre annually
Sul-po-mag supplied 199 lb S/acre annually
J. Webb, 1978.

Sul-po-mag supplied 98 lb Mg/acre annually

Managing Ca and Mg on Iowa Soils

- Critical soil test level (sufficiency)
  - No Ca or Mg soil test interpretation for Iowa soils
  - Neither generally deficiency in Iowa soils
    - May be Mg – K – NH_4 grass tetany concern in some soils
- Ca and Mg are managed by limestone application from local quarry to acidic soils

J.E. Sawyer, Iowa State Univ.

J.E. Sawyer, Iowa State Univ.

Zinc Deficiencies

- **Sensitive crops**
  - Corn, sorghum
- **Soil Situation**
  - Low organic matter, high pH (>7.4), eroded soil
  - Coarse texture, restricted rooting
  - High P application in conjunction with borderline or low zinc availability
  - High soil P alone does not create deficiency
  - Organic soils
- **Climatic Conditions**
  - Cool and wet soil

J.E. Sawyer, Iowa State Univ.

Iowa State University
Zn Recommendations for Corn and Sorghum

	Zinc (Zn) Soil Test (ppm)		
Soil Test Category:	**Low**	**Marginal**	**Adequate**
DTPA Extractable Zn:	**0 – 0.4**	**0.5 – 0.8**	**0.9 +**
	Zn to apply broadcast (lb/acre)		
	10	**5**	**0**
	Zn to apply in band (lb/acre)*		
	2	**1**	**0**

Recommendation for amount to apply in band is based on other states' information.

J.E. Sawyer, Iowa State Univ.

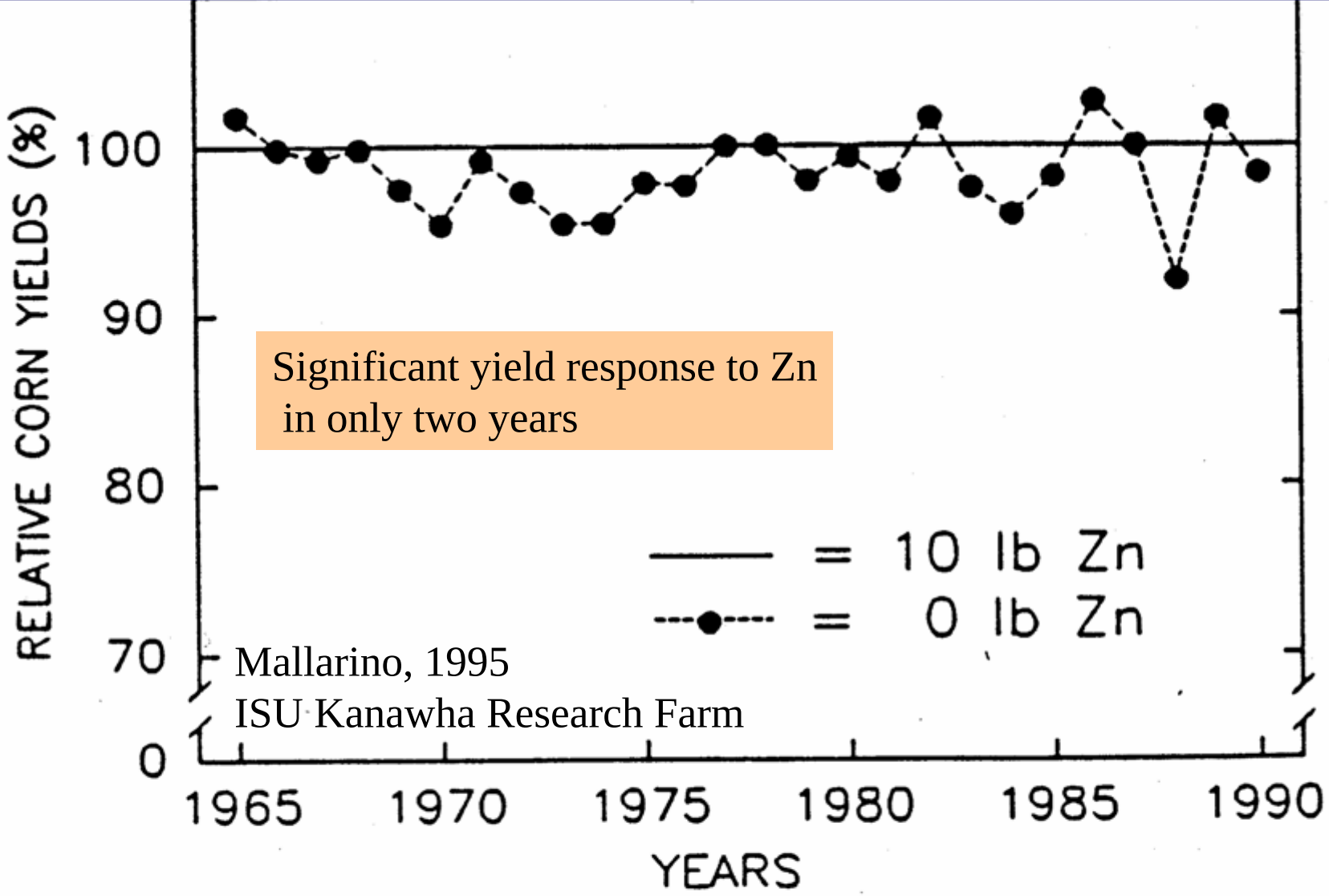


Figure 4. Change with time of corn yields from plots receiving no zinc fertilizer and 160 lb. P_2O_5 A./year expressed as percentages of yields from plots receiving a similar P rate and 10 lb. zinc.

Spatial Response of Corn to Zinc Application in Iowa (Bickel and Killorn, 2001)

- Twelve sites over three years- primarily in North Central Iowa
- Zn fertilizer ($ZnSO_4$, 30% water soluble) was applied in 2 by 2 starter at 5 lb Zn/acre in replicated strips
- The strips were divided into paired treatments with and without applied Zn within soils for comparison

Conclusions
(Bickel and Killorn, 2001)

- There were no consistent trends in corn response to addition of Zn fertilizer
- Responses to addition of Zn were not consistently related to Zn soil test, soil pH, or a combination of the two
- Note: "Insurance" applications of Zn fertilizer applied in a 2 x 2 band at planting may result in yield reductions more often than yield increases

J.E. Sawyer, Iowa State Univ.


J.E. Sawyer, Iowa State Univ.

Iron Deficiencies

- Sensitive Crops
  - Soybean
- Complicated-Interrelated Soil Conditions
  - High pH (usually >7.4 in Iowa) with free calcium carbonates in surface soil
  - Salt level
  - Poorly aerated soils
  - Partial pressure CO_2
- Climatic Conditions
  - Cold, wet

J.E. Sawyer, Iowa State Univ.


J.E. Sawyer, Iowa State Univ.

Management of Iron Deficiencies

- Soybean variety choice
- Not soil applied fertilizer treatments
  - Not iron or sulfur
- Not seed coated iron treatments
  - Expensive and limited yield response
- Maybe high seeding rate in wide rows
  - High inter-row plant density

Management of Iron Deficiencies

- Maybe foliar applied chelated iron
  - (Sequestrene 138 Fe)
  - Early - when plants have two fully developed trifoliolate leaves
  - Application within 7 days after chlorosis symptoms expressed
  - 0.15 lb Fe plus surfactant in 15 to 30 gal water over plants
  - May require multiple applications

J.E. Sawyer, Iowa State Univ.


J.E. Sawyer, Iowa State Univ.