

Basic Sulfur Management

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Essential Plant Nutrients

- 1) Nutrient required for plant to complete life cycle:
C-H-O-N-P-K-Ca-Mg-S---Zn, Mn, B, Cu, Fe, Cl, Mo
- 2) Generally classified as: "Macro" or "Micro" nutrients
- 3) Macro: N-P₂O₅-K₂O-Mg-S (200 bu/ac crop removal)
- 4) 140 – 75 – 50 – 15 – 15 (lb/ac for 200 bu/ac crop)
- 5) Micro: Zn-Mn-B-Cu (200 bu/ac crop removal)
- 6) 0.22 – 0.06 – 0.05 – 0.03 (lb/ac for 200 bu/ac crop)
- 7) How are these essential nutrients supplied to plants?

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Nutrients Come From?

- 1) Air, Soil, and Water
- 2) For most essential nutrients...A, S, & W supplies needs
- 3) If not, then external nutrients should be added
- 4) For corn production, N/P/K often needed as fertilizer
- 5) Ca and Mg applied in lime
- 6) What about Sulfur?

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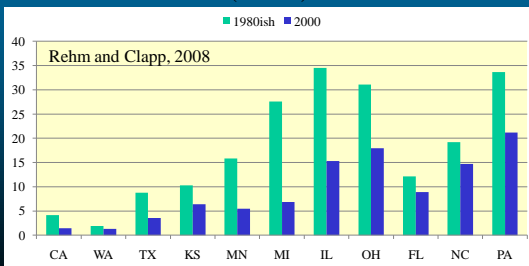
SULFUR

- 1) Traditional recommendations have been to apply S on:
- 2) Sandy soils that are low in organic matter
- 3) Organic Matter is an excellent source of S
- 4) Older fertilizer P sources contained significant S
- 5) The air has historically been a reliable source of S
- 6) Air quality issues, however, have greatly reduced the amounts of S coming from the air?
- 7) In recent years, increased interest in potential S needs

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Annual Sulfur Deposition

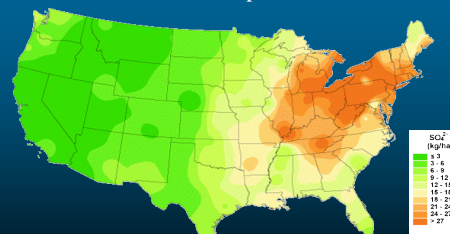
(lb S/ac)



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Atmospheric Sulfur Deposition

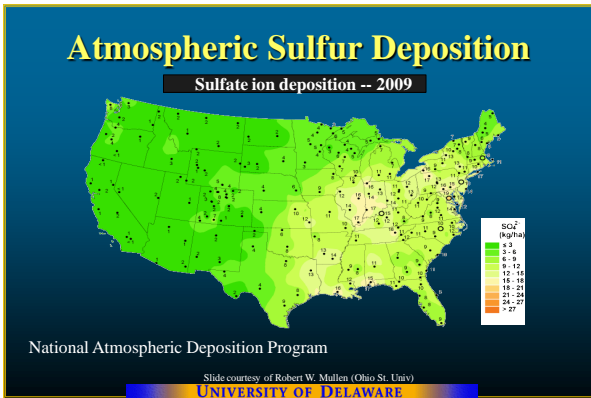
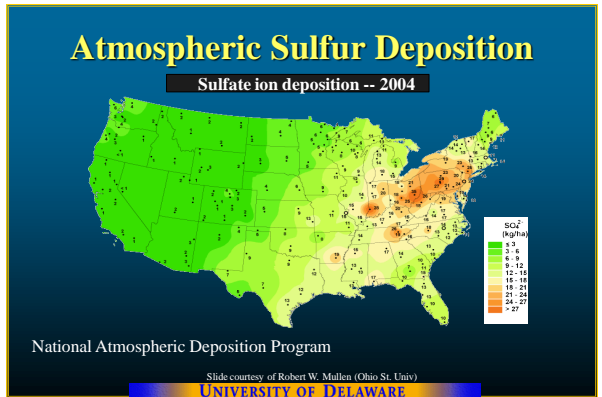
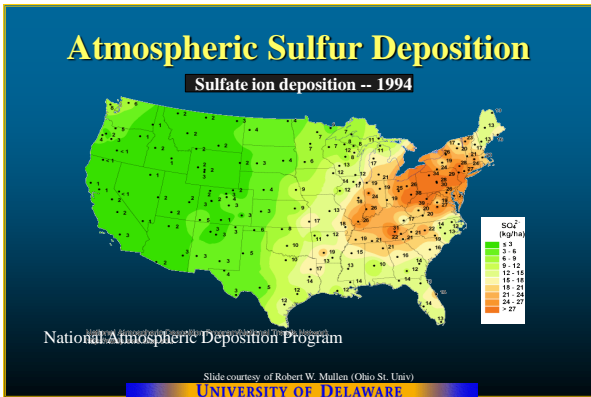
Sulfate ion deposition --1985



National Atmospheric Deposition Program

Slide courtesy of Robert W. Mullen (Ohio St. Univ)

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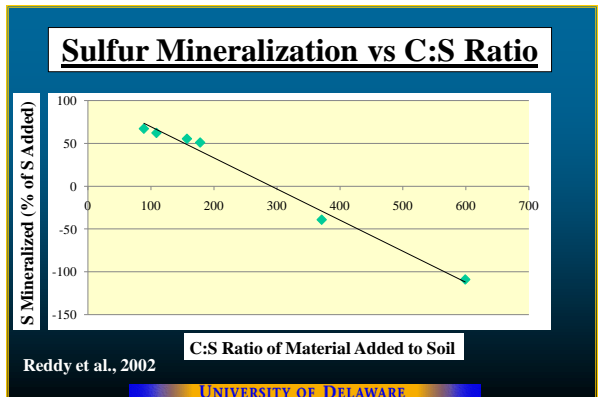


- ### Sulfur Cycle Similar to Nitrogen
- 1) Most S in soils is in an organic form
 - 2) Has to “mineralize” to become plant available
 - 3) Plants take up S primarily as sulfate (SO_4^{2-})
 - 4) Sulfur can be lost from soils as gas but insignificant
 - 5) Sulfur can be immobilized like N
(C:S >400:1 = immobilization; <200:1 = mineralization)
 - 6) Sulfur can be adsorbed to soil Al & Fe like P, but normally only an issue in highly weathered, acidic soils
 - 7) Sulfur can be leached from soils like nitrate
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	C:N Ratio	C:S Ratio
Farmyard Manure	31	89
Poultry Manure	14	109
Soybean Straw	35	371
Wheat Straw	80	599

Reddy et al., 2002

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Sulfur Deficiency Symptoms

- 1) Sulfur is an “immobile” nutrient in plants
- 2) Deficiency symptoms show up on youngest tissue
- 3) Deficiency causes yellow tissues on newest growth
- 4) In corn, yellowing of the “top” leaves on the plant

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Diagnosing Sulfur Problems/Needs

- 1) Soil testing for sulfur is not reliable
- 2) Tissue sampling useful to diagnose
- 3) Best is to compare, "normal" crop to "sick" crop
- 4) N:S Ratio of tissues can be useful
- 5) What is one of the main roles of S in plants?
- 6) Amino acids, which are building blocks for proteins
- 7) Nitrogen is important component of proteins
- 8) Sulfur deficiency with adequate N causes N to increase
- 9) Ratio of N:S increases with increasing S deficiency

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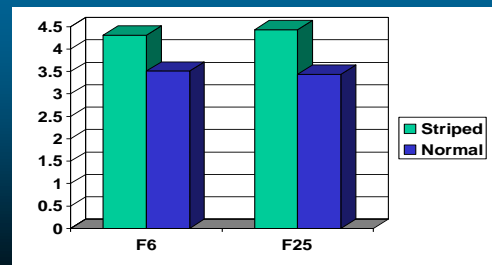
		Yellow	Green	Normal Range
Nitrogen	%	5.41	2.67	3.5 - 5.0
Phosphorus	%	0.33	0.31	0.3 - 0.5
Potassium	%	2.67	2.66	2.5 - 4.0
Calcium	%	0.31	0.32	0.3 - 0.7
Magnesium	%	0.32	0.28	0.15 - 0.45
Sulfur	%	0.08	0.11	0.15 - 0.50
Manganese	ppm	49	32	20 - 300
Zinc	ppm	17	14	20 - 60
Copper	ppm	5.0	5.0	5 - 20
N:S Ratio	---	69	24	15:1

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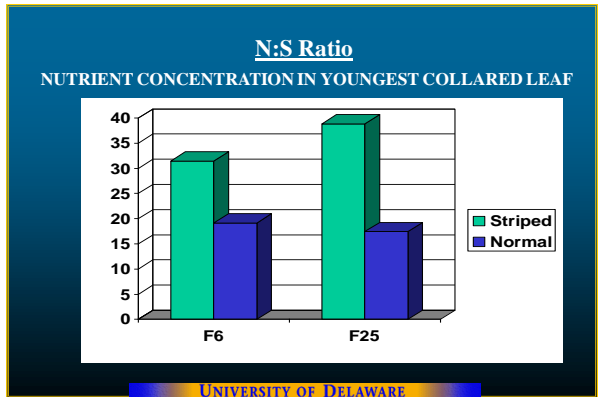
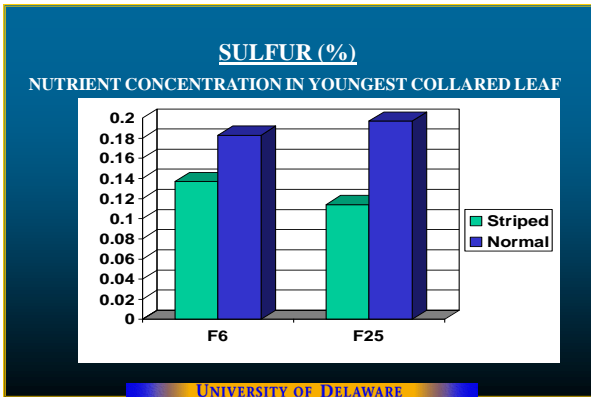


NITROGEN (%)

NUTRIENT CONCENTRATION IN YOUNGEST COLLARED LEAF



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- ### Sulfur Fertilizers
- 1) Can be very soluble or quite insoluble?
 - 2) Important to know depending on S needs
 - 3) Soluble sources will supply S quickly
 - 4) Insoluble source might be cheaper but consider needs
 - 5) What are the common S fertilizers available?
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Elemental Sulfur

- 1) Concentrated source of S (85 to 100% S)
- 2) Insoluble source of S
- 3) Would not use if correcting visual S deficiencies
- 4) Apply before planting, has long residual effect
- 5) Acidifying form of S, which may be undesirable

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Ammonium Sulfate

- 1) 21-0-0-24 (dry) or 8-0-0-9 (liquid)
- 2) 100% water soluble; available immediately
- 3) Expensive source of N, but good S source
- 4) Sulfur does NOT acidify when in sulfate form
- 5) Ammonium sulfate creates acidity from nitrification of nitrogen not from oxidation of sulfur

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Gypsum

- 1) About 18% Sulfur
- 2) Gypsum is NOT a liming material
- 3) Can be a Ca and S source but Ca seldom needed
- 4) Used Gypsum to reclaim soils high in sodium (Na)
- 5) Moderate in solubility

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Other S Fertilizers

- 1) Sul-Po-Mag (22% S & K and 11% Mg)
- 2) Potassium Sulfate (17 to 18% S)
- 3) ATS: liquid product, 26% S & 12% N, acid forming, should not be applied in direct contact with seeds
- 4) New products, such as Mosaic's Microessentials, which contains a 50:50 ratio of sulfate-S to elemental
- 5) Animal manures can be good S sources...ranges from 1 to 14 lb S/ton depending on animal type

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How much S do crops remove?

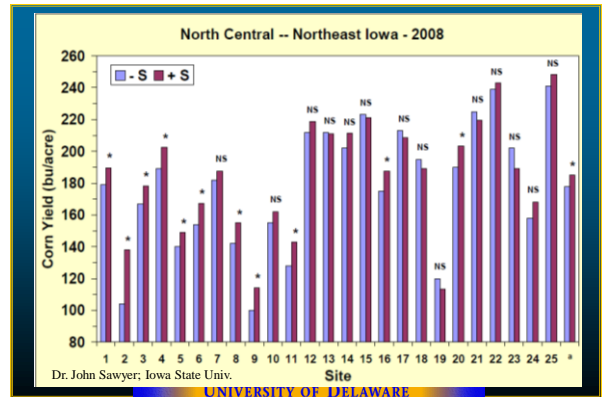
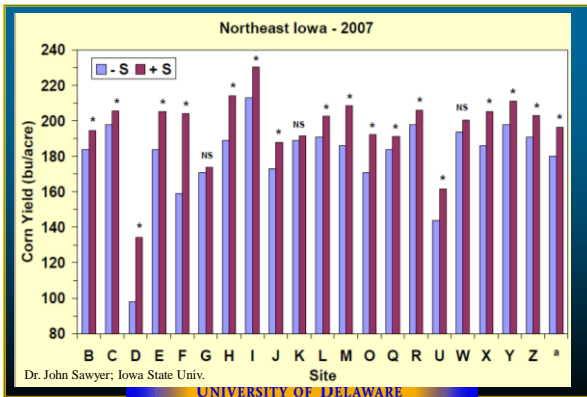
- 1) Alfalfa: ~6 lb/ton...5 ton/ac crop = ~30 lb S/ac
- 2) Corn grain: 0.08 lb/bu...200 bu/ac = 16 lb S/ac
- 3) Corn silage: 1.1 lb/ton...30 ton/ac = 33 lb S/ac
- 4) Soybean grain: 0.18 lb S/bu...60 bu/ac = 11 lb S/ac

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Yield Response to Sulfur

- 1) Historically, ONLY on sandy, low O.M. soils
- 2) Recently, renewed interest in sulfur response
- 3) More frequent responses being found
- 4) Recent work in MN showed response to sulfur
- 5) Lots of work right here in Iowa by ISU's John Sawyer
 - 20 sites in 2007; 25 sites in 2008; no manure history
 - 62% of sites had S response, mostly in NE Iowa
 - 11 strip trials in 2009; 6 of 11 (55%) had S response

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Summarizing S Results in Iowa

- 1) Responses more frequent in NE Iowa
- 2) Average response at the sites that were responsive:
 - 15 bu/ac on fine-textured soils
 - 28 bu/ac on coarse-textured soils
- 3) Optimum rates of sulfur:
 - about 15 lb S/ac on fine-textured soils
 - about 25 lb S/ac on coarse-textured soils
- 4) Sulfur response likely on many IA soils (esp in NE IA)
- 5) More on-farm work is needed to determine frequency of response across the entire state on individual farms

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Final Recommendations on Sulfur

- 1) Clearly, S responses much more frequent in Iowa than historically assumed on soils without manure histories
- 2) Deficiencies of S can result in large yield depressions
- 3) Soil sampling for S not reliable indicator of S needs
- 4) Tissue testing can be good indicator of S deficiency, but visual symptoms are also good indicator
- 5) The On-Farm Network system developed by the Iowa Soybean Association is the perfect tool for determining the frequency and magnitudes of S responses on IA farms

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