Will Sulfur Limit Bio-fuel Corn Production?

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Background

- The short- and long-term effects of striving for higher corn (*Zea mays* L.) grain yields and removing crop residues for bio-fuels production on soil-nutrient cycling are unknown.
- Because surface soil on hill slopes often is eroded, fertilizer materials contain less sulfur (S) as an impurity, and atmospheric deposition of S has decreased in the upper Midwest, S may quickly become a limiting nutrient.

Objective

Our purpose was to evaluate plant growth and grain yield response to S fertilization of no-till corn grown on eroded, low organic matter soils, and to determine the cost of replacing S removed with grain and residue.

Site & Treatments

- Plots (3.8 m x 76 m; 0.03 ha) established (2006) at Iowa State University Boyd Research Center, Boone County, Iowa
- Clarion loam (fine-loamy, mixed, mesic Typic Haplaquolls), 4 to 7 % slopes
- Previous crop soybean
- Soil samples (0-15 cm) collected with hand probe; deep cores (0-90 cm) collected with hydraulic probe
- Fertilizer treatments:
  - control;
  - 34 kg S ha^{-1} as S-enhanced MAP (13-33-0-15S);
  - 34 kg S ha^{-1} as ammonium sulfate (21-0-0-24S);
  - 34 kg S ha^{-1} applied as liquid ammonium thiosulfate (12-0-0-26S)
- Dry materials applied as a band 5 cm to the side of row and 7.5 cm below the soil surface; liquid applied as surface dribble 5 cm to the side of row
- All plots received a total of 174 kg N ha^{-1}

Methodology

- RCBD with 4 replications
- Corn (Pioneer 36N71) planted 21 April in 76 cm rows (5 rows plot^{-1}) at 74,000 plants ha^{-1}
- Whole-plant samples collected at V5
- Ear-leaf samples collected at mid-silk
- 3 center rows of each plot mechanically harvested 6 October; yield and grain moisture recorded
- Grain and residue samples collected by hand harvesting 6 randomly selected plants from each plot

Table 1. Initial soil test levels in Clarion loam. Range indicates variability among all plots in study. Soil test ratings are not available for extractable S, although values of 10 mg kg^{-1} are considered adequate.

Soil Test Parameter	Composite	Range of Values
Bray-1 P, mg kg^{-1}	35 (VH)	15 (Opt) – 60 (VH)
Exchangeable K, mg kg^{-1}	180 (VH)	123 (Opt) – 304 (VH)
Exchangeable Ca, mg kg^{-1}	2320	1881 – 2585
Exchangeable Mg, mg kg^{-1}	232	192 – 275
Extractable S, mg kg^{-1}	3.6	1 – 7
pH	6.9	6.2 – 7.2
Organic Matter, g kg^{-1}	22	19 – 25
CEC, cmol(+)/kg	14.3	12.6 – 15.4

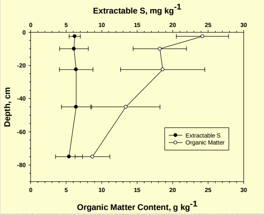

Figure 1. Changes in KH_2PO_4 – extractable S and LOI organic matter with depth in Clarion loam. Error bars indicate standard deviation.

Main Points

- Eroded hill slopes, as found at this site, often have relatively low levels of soil organic matter and extractable SO^{-4} (Table 1, Fig. 1).
- In 2006 field trials, application of 34 kg S ha^{-1} increased mean plant dry weight and whole-plant concentrations of S at the V5 growth stage (Table 2).
- At mid-silk, S concentration in the tissue was below the sufficiency range of 2.1 to 5.0 g kg^{-1}, even when S fertilizer had been applied (Table 3).
- Corn yield was not increased, and grain moisture at harvest was not reduced ($p<.0.05$) by S fertilizer application (Table 4).
- No one S fertilizer source outperformed the others.
- The cost of replacing S removed with the grain and residue (Tables 5 and 6) is relatively low.
- Preliminary 2007 data from a site with similar soil and topography indicate a 627 kg ha^{-1} response to S fertilization.

Results

Table 2. Effect of 34 kg S ha^{-1} on whole-plant dry weight, and sulfur (S), nitrogen (N), phosphorus (P), and potassium (K) concentrations at the V5 growth stage of corn grown on a Clarion loam. Values are means of four replications. Values followed by the same letter are not significantly different at the 0.05 level.

Treatment	Dry Weight	Tissue Nutrient Concentration			
		S	N	P	K
	g plant^{-1}	------------------- g kg^{-1} -------------------			
Control	4.3b	1.7b	31.3b	4.7a	41.6a
13-33-0-15S (SMAP)	7.4a	2.1a	34.3a	4.6a	35.1a
21-0-0-24S (AMS)	6.1ab	2.1a	34.9a	4.4a	38.1a
12-0-0-26S (ATS)	5.8ab	2.3a	31.8b	4.2b	39.2a

Table 3. Effect of 34 kg S ha^{-1} on ear-leaf sulfur (S), nitrogen (N), phosphorus (P), and potassium (K) concentrations at the mid-silk stage of corn grown on a Clarion loam. Values are means of four replications. Values followed by the same letter are not significantly different at the 0.05 level.

Treatment	Nutrient			
	S	N	P	K
	------------------- g kg^{-1} -------------------			
Control	1.6a	28.9a	2.4a	12.4a
13-33-0-15S (SMAP)	1.6a	28.7a	2.6a	12.3a
21-0-0-24S (AMS)	1.5a	28.0a	2.4a	11.7a
12-0-0-26S (ATS)	1.6a	28.2a	2.5a	12.4a

Table 4. Effect of 34 kg S ha^{-1} on yields and grain moisture at harvest in 2006. Values are means of four replications. Values followed by the same letter are not significantly different at the 0.05 level.

Treatment	Grain Yield*	Grain Moisture
	-- kg ha^{-1}--	-- g kg^{-1} --
Control	10,661a	145a
13-33-0-15S (SMAP)	11,100a	146a
21-0-0-24S (AMS)	10,786a	145a
12-0-0-26S (ATS)	10,723a	144a
LSD (0.05)	470	5.4
LSD (0.10)	383	4.4

*Yields adjusted to 155 g kg^{-1} moisture.

Table 5. Estimated removals of sulfur (S) with harvested corn grain and plant (cobs + stover) residue in 2006. Values are means of four replications. Values followed by the same letter are not significantly different at the 0.05 level.

Treatment	S Removals	
	Grain	Residue
	---------- kg ha^{-1}----------	
Control	8.16a	4.95a
13-33-0-15S (SMAP)	9.30a	5.04a
21-0-0-24S (AMS)	9.05a	4.63a
12-0-0-26S (ATS)	8.99a	5.49a

Table 6. Cost of replacing sulfur (S) removed with harvested corn grain and plant residue in 2006.

Treatment	S Replacement Costs*	
	Grain	Residue
	---------- $ ha^{-1}----------	
Control	2.59	1.57
13-33-0-15S (SMAP)	2.95	1.60
21-0-0-24S (AMS)	2.87	1.47
12-0-0-26S (ATS)	2.85	1.74

*Based on NASS estimate of $0.318 per kg ($288 ton^{-1}) ammonium sulfate.

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