INFLUENCE OF ELEMENTAL SULFUR ON SOIL pH AND SOIL TEST LEVELS

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INTRODUCTION

Soil test summaries from South Dakota State University Soil Testing Lab show that 16 percent of South Dakota soils have a pH of 7.6 or higher. These high pH soils can reduce nutrient availability to plants. A major concern is for reduced phosphorus availability and fertilizer use efficiency. High pH soils also reduce the availability of micronutrients such as iron and zinc.

Due to these issues, questions are often asked on how to reduce soil pH. A number of materials such as sulfuric acid, aluminum sulfate, iron sulfate, gypsum and elemental sulfur are available and can reduce soil pH. Many of the materials are not very effective and extremely large amounts would be needed. Some cannot be readily purchased and/or are quite toxic (concentrated acids). If effective, elemental sulfur is the most cost effective and available material in retail outlets. This study was initiated to determine the short and long term effect that elemental sulfur has on soil pH of a high pH soil in eastern South Dakota.

MATERIALS AND METHODS

The study was established on a Lamoure soil on the Larson agronomy farm near Brookings, South Dakota. Lamoure soil is a somewhat poorly drained silty clay loam soil that has developed under tall grasses in 42 inches or more of medium textured alluvium which is underlain by mixed sand and gravel. It occurs on level and nearly level river bottom lands and is classified as a fine-silty, mixed (calcareous), frigid cumulic haplaquall.

The site is farmed by the SDSU foundation seed division and is used to grow registered and foundation small grain and soybean varieties. The foundation seed division continues to do the tillage and plant the experiment area.

Initial soil tests of the experiment area prior to the application of the elemental sulfur treatments are listed in Table 1. Soil pH was 7.8. The soil was slightly calcareous with the surface soil having a calcium carbonate equivalent (CCE) of 1.1%. The CCE increased to 1.9 and 3.2% for the 6-12 and 12-24 inch depths respectively.

Elemental sulfur rates of 0, 2000, 4000 and 8000 pounds per acre were broadcast by hand on April 25, 1991. A Latin square design was used with four replications. Plot size was 20 feet by 30 feet. Commercially available elemental sulfur

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fertilizer (90% S) was used. Sulfur was incorporated by discing and a field cultivation prior to planting in 1991. Plots were chiseled to 10 inches with twisted shank shovels after harvest in October 1991. Some undisturbed sulfur pellets were still visible and the site was rototilled twice to a depth of six inches to further break up the granules.

The site was chiseled 8 to 10 inches deep each fall and worked with a field cultivator each spring prior to planting. Crops planted on the site from 1991 to 1995 were soybeans, barley, nothing, wheat and soybeans respectively.

Soil samples were taken to a depth of two feet each fall. The surface foot was divided into 3 inch increments. Five soil cores were taken per plot and the four replications combined for analysis. Soil analysis for pH, P, K, Zn, S, Salts, NO_3 - N, and OM was completed on all samples. Fe, Mn, Cu, Ca and Mg analysis was also done on the 0-3 inch and 3-6 inch depths in 1995.

Soybeans (variety DeKalb CX096) were planted at the rate of 186,000 seeds per acre in 30 inch rows on June 5, 1995. No fertilizer was applied in 1995. Soybeans were harvested in 1995 with a small plot combine.

RESULTS AND DISCUSSION

Results of soil analysis for pH and other parameters are listed in tables 2 and 3. The 2000, 4000 and 8000 pound sulfur rates lowered pH in the top 3 inches of soil from a zero treatment of 7.8 to 7.2, 6.6 and 5.7 respectively. The pH values in the sulfur treated plots were 0.2-0.6 units higher than samples taken one year earlier (data not reported). This is the first indication soil pH is beginning to rise again since the 1991 sulfur additions. Soil pH was also reduced in the 3-6 inch depth, but not to the same extent as in the top 3 inches indicating tillage may not be completely mixing the top 6 inches of soil. The pH in the 6-9 inch depth was reduced 0.2 - 0.6 pH units.

The sulfur addition and subsequent lowering of surface soil pH did not influence nitrate, potassium, calcium or magnesium soil tests (tables 2 and 3). Soil test for phosphorus, zinc, iron, manganese and copper were increased, however, with the largest increase associated with the highest sulfur rates (lowest soil pH). The Olsen phosphorus soil test in the surface 3 inches increased from 27 ppm in the check to 57 ppm with the 8000 pound sulfur rate. Zinc soil tests increased from 1.57 ppm in the check to 2.09 ppm and iron tests increased from 28 ppm in the check to 58 ppm.

Sulfate sulfur soil test increased dramatically and is the direct result of the oxidation of elemental sulfur to sulfate sulfur. Over 2200 pounds of sulfate sulfur were in the top two feet of the high rate treatment compared to 205 pounds in the check. Electrical conductivity in soil also increased with increasing sulfur rates. It is likely associated with the increasing sulfate sulfur levels in soil.

Soybean yields (Table 4) were not increased by the reduction in soil pH. The 2000 and 4000 pound rates had no influence on yields. However, the 8000 pound rate reduced yields 8 bushels per acre. This reduction in yield was likely due to high salt levels (2.0 mmhos/cm) in the top 6 inches of soil associated with high sulfate sulfur levels in this treatment. Visual observations early in the season (2nd trifoliate leaf stage) noted typical salt injury symptoms (browning of leaf margins and stunting). A white "salt" crust was also observed on the soil surface of this treatment. Iron deficiency (chlorosis) was not observed on any of the treatments. The variety planted (DeKalb CX096) is rated as having good iron chlorosis resistance.

Information on soil test levels from previous years (1991-1994) can be found in the South Dakota State University Plant Science Department Soil/Water progress reports, TB99, PR 92-5, PR 93-8 and PR 94-14.

Table 1. Sulfur Oxidation Study Initial Soil Test Levels[1], Spring, 1991

OM, %:	3.7	Zinc, ppm:	1.49
NO_3 -N, lb/A 2 ft.	20	Iron, ppm:	9.9
Phosphorus, Bray 1 ppm:	64	Manganese, ppm:	6.1
Potassium, ppm:	235	Copper, ppm:	1.03
pH:	7.8	Sulfur, ppm:	9.0
Salts, mmho/cm:	0.40	Calcium, ppm:	4737
$CaCO_3$ equivalent, %:		Magnesium, ppm:	1061
0 - 6 inch	1.1		
6 - 12 inch	1.9	Texture:	medium
12 - 24 inch	3.2		

[1] sampled April, 1991

Table 2. Influence of Elemental Sulfur on Soil pH and Other Soil Test Levels, Brookings, 1995

Treatment/ Soil Depth	Soil Tests[1] pH	P^3	K	Zn	NO_3-N	SO_4-S	Salts	OM
inches	ppm	ppm	ppm	ppm	ppm	ppm	mmho/cm	%
0 Sulfur								
0-3	7.8	27	360	1.57	5	15	0.4	3.7
3-6	7.8	24	258	1.46	6	29	0.4	3.7
6-9	7.9	23	231	1.49	6	26	0.4	3.6
9-12	8.0	14	218	0.34	6	27	0.4	2.5
12-24	8.2	8	186	0.10	4	27	0.4	1.6
2000 Sulfur[2]								
0-3	7.2	33	362	1.80	3	45	0.5	4.2
3-6	7.4	29	256	1.52	6	60	0.7	3.5
6-9	7.7	26	242	1.69	6	62	0.7	3.5
9-12	7.9	16	200	0.37	5	64	0.6	2.5
12-24	8.1	7	171	0.12	4	59	0.6	1.4
4000 Sulfur[2]								
0-3	6.6	39	336	2.13	4	208	1.1	4.0
3-6	7.1	28	275	1.88	5	185	1.5	3.8
6-9	7.6	26	250	1.55	6	159	1.0	3.9
9-12	7.8	17	210	0.46	6	151	0.9	3.0
12-24	8.0	7	203	0.11	4	116	0.8	1.8
8000 Sulfur[2]								
0-3	5.7	52	290	2.09	3	649	2.0	3.5
3-6	6.6	42	249	2.07	5	493	2.1	4.0
6-9	7.3	28	229	1.39	5	211	1.6	3.5
9-12	7.8	15	190	0.38	5	218	1.4	2.7
12-24	8.0	7	171	0.08	3	166	1.0	1.5

[1] Soil Sampled 11/9/95
[2] Applied 4/25/91
[3] Olsen P Soil Test

Table 3. Influence of Elemental Sulfur on soil pH and soil test levels, Brookings, 1995

	Soil Tests[1]					
Treatment/Soil Depth	pH	Fe	Mn	Cu	Ca	Mg
inches	ppm					
0 Sulfur						
0 - 3	7.8	20	16	1.03	4343	949
3 - 6	7.8	20	13	0.92	4697	1263
2000 Sulfur[2]						
0 - 3	7.2	46	29	1.47	4444	778
3 - 6	7.4	24	16	1.05	4697	1414
4000 Sulfur[2]						
0 - 3	6.6	68	40	1.55	4293	818
3 - 6	7.1	35	29	1.32	4868	1212
8000 Sulfur[2]						
0 - 3	5.7	58	94	1.91	3838	869
3 - 6	6.6	60	59	1.57	4798	1313

[1]Soil Sampled 11/9/95
[2]Applied 4/25/91

Table 4. Influence of Soil pH on Soybean Yield, Brookings, 1995

	Soybean	
Soil pH	Yield	Test Weight
	bu/a	lb/bu
7.8	40.7	57.3
7.3	42.8	57.4
6.9	43.6	57.4
6.2	35.6	57.3
Pr > F	0.07	0.98
CV %	9.8	1.0
LSD (.05)	6.3	

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