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Sulfur for Minnesota Soils

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Sulfur (S) is an essential element in the life processes of all living things including micro-organisms, higher plants, animals, and humans. Sulfur plays a major role in the formation of the proteins needed to sustain life in all biological organisms.

Sources of Sulfur for Plants

The S necessary for crop growth in Minnesota can come from one or more sources. The major ones are:

1. *Soil Organic Matter*—Approximately 95 percent of the total amount of S in soils is found in the organic matter. As this soil organic matter is broken down, the S in the organic forms is converted (mineralized) to sulfate-sulfur (written as SO_4-S). This SO_4-S is the only form of S that is absorbed by plant roots. Mineralization of all the S in organic matter does not take place in one year. This breakdown process is continuous and takes a considerable amount of time. Different soils release different amounts of SO_4-S in the mineralization process (table 1). The mineralization process releases very small amounts of SO_4-S from sandy soils. This is in contrast to the higher amount of SO_4-S released from fine-textured soils throughout the state.

2. *Soil Minerals*—Several minerals found in soils contain S in one form or another. The S in the various minerals is transformed to available SO_4-S as these minerals are weathered or broken down during the growing season. As would be expected, there is a wide range in the total S content of Minnesota soils (table 2).

3. *The Atmosphere*—Most fuels that are burned for heat, power, and transportation contain some S. When these fuels are burned, the S escapes as the gas—sulfur dioxide (SO_2). The SO_2 is absorbed in rainfall and reaches the soil as SO_4-S. As would be expected, the SO_2 content of the atmosphere is high in industrialized areas. Except for areas near the Twin Cities, the concentration of SO_2 in the air over Minnesota is quite low.

4. *Pesticides*—Some pesticides contain S. However, their contribution to the total amount of S in the soil system is quite low.

5. *Fertilizers*—In the past, commercial fertilizers supplied considerable S in addition to the usual N, P_2O_5, and K_2O. Today, as the fertilizer products become more concentrated and the analysis increases, S contents are less.

Table 1. The amount of SO_4-S released from the mineralization of soil organic matter for four Minnesota soils at the end of either two or four weeks

Soil type	Time (weeks) 2	4
	SO_4-S Mineralized (lbs./acre)	
Fayette silt loam	10.4	17.4
Webster silty clay loam	4.5	6.0
Menagha loamy sand	.3	0.0
Seaten silt loam	0.0	2.4

Table 2. The total sulfur content of some representative Minnesota soils

Soil series	Total S content
	lbs./acre
Fayette	560
Esterville	900
Glencoe	1526
Fargo	1858
Nebish	704
Port Byron	910
Webster	1214

6. *Irrigation Water*—This can be an important source of S for limited areas in Minnesota. Where soils are sandy, the S content of the water is expected to be low. Sulfur is present in irrigation water as SO_4-S.

Removal of Sulfur from the Soil System

Sulfur is removed from the soil system by two major mechanisms. These are:

1. *Crop Removal or Uptake*—Removal of S from the soil varies with crop and the yield of that crop. In general, relatively small amounts of S are absorbed by crops. For example, a 100 bu. per acre corn crop will remove about 10 lb. S per acre in the grain. Alfalfa will remove approximately 6 lb. S per acre for each ton of hay produced. A wheat yield of 40 bu./acre will remove about 12 lb. S per acre in the grain. In Minnesota, fertilizer recommendations for S are not adjusted for yield goal. Therefore, there is no real need to remember the exact amounts of S removed by the various crops.

2. *Leaching*—Like nitrate, SO_4-S is mobile in soils and can be moved out of the root zone by leaching. The SO_4-S does not leach as rapidly as nitrate-nitrogen (NO_3-N). But, excessive rainfall or irrigation water can move SO_4-S below the root zone where soils are sandy. It is doubtful if there is any leaching of SO_4-S from the root zone for the fine-textured soils in Minnesota.

Table 3. Deficient, marginal, and sufficient levels of S in tissue of several crops

Crop	Plant part and sampling state	Levels: Deficient	Marginal	Sufficient
		%		
Alfalfa	Whole plant at harvest	<.20	.20-.30	>.30
Corn	Ear leaf at silking	<.10	.10-.20	>.20
Small grains	Top leaves at boot stage	<.10	.10-.15	>.15
Soybeans	Upper, fully developed trifoliate	<.10	.10-.15	>.15
Sunflowers	5th leaf	—	.25-.50	—

Figure 1. Sulfur deficient alfalfa has a light green color. Sulfur deficient alfalfa is shown on the left. Normal alfalfa is on the right.

Deficiency Symptoms in Crops

When S is deficient, growth is reduced and maturity is delayed. With inadequate supplies of S, there is a reduction in protein formation with a subsequent yellowing of the foliage. With alfalfa and red clover, the entire leaf area has a light green color (figure 1). The leaves on S deficient corn become light green. This is accompanied by a distinct striping of the leaves. An S deficient young corn plant is shown in figure 2.

Plant analysis is also a management tool that can be used to detect shortages of S in crop production. Deficient, marginal, and sufficient levels of S in plant tissue are summarized in table 3.

Testing the Soil for Sulfur

Soil testing procedures for several nutrients have been widely accepted. The soil organic matter, however, is the major storehouse of S and soil testing procedures for nutrients in organic matter have proven to be less reliable. Several research trials have shown that the most widely used soil test procedure for S is appropriate only on sandy soils. The sandy soils in Minnesota are outlined in figure 3. The soil test for S is not recommended for use on the fine-textured soils of Minnesota.

Table 4 summarizes the interpretation of the soil test for S for the sandy soils of Minnesota.

Table 4. Interpretation of the S soil test for sandy soils

Sulfur soil test	Relative level	Expected response to S
ppm		
0-6	Low	Highly possible
7-12	Medium	Possible
>12	High	No reponse expected

Table 5. The sulfur content of some common fertilizers

Material name	S Content (%)
Gypsum	18
Ammonium sulfate (21-0-0-24)	24
Ammonium thiosulfate (12-0-0-26)	26
Potassium chloride (0-0-60)	0.4
Sul-Po-Mag or K-Mag	22
Potassium sulfate (0-0-50)	18
Concentrated superphosphate (0-46-0)	0.7
Copper sulfate	12.8
Zinc sulfate	18
Epsom salt	14

Figure 2. Sulfur deficient corn has a light green color and shown striping in the whorl.

Recommendations and Method of Application

Annual applications are suggested where a response to S is anticipated or predicted from the results of a soil test or tissue analysis. Minnesota research shows that an annual rate of 25 lb. S/acre is adequate for top yields of alfalfa grown on sandy soils. When needed, the S should be topdressed to established stands in early spring. Sulfur should be broadcast and incorporated before seeding in the establishment year.

For corn production on sandy soils, S can either be broadcast and incorporated before planting or applied in a starter fertilizer at planting. Use 25 lb. S/acre for broadcast applications. The rate can be reduced to 12 lb./acre if S is applied in a starter fertilizer. Use of S in a starter fertilizer is the preferred method of application for corn production.

Small grains may respond to S fertilization when grown on very sandy soils. For these soils, S can be broadcast at a rate of 20 lb./acre and incorporated before planting or used at a rate of 10 lb./acre in the row close to the seed. It is doubtful if use of S will increase the yields of other agronomic crops grown in Minnesota.

Sulfur Fertilizers

There are several fertilizer materials that can be used to supply S when it is needed in a fertilizer program. These materials are listed in table 5. The choice of the S source is highly dependent on the crop to be grown.

For alfalfa, red clover, and other forage legume production, all sources of S have had an equal effect on yield. The fertilizers that supply S in the sulfate form are preferred for corn and small grain production. Plants absorb S in the sulfate (SO_4) form. Elemental S must be converted to SO_4-S before it is available to plants. This conversion takes time and is slowed by cool spring temperatures. So, the application of S in the SO_4 form is preferred for corn and small grain production.

Summary

When needed, S fertilization can produce dramatic and profitable increases in yield for some crops. *Sulfur is not needed for all soils in Minnesota.* Those who farm sandy soils should be most concerned about the use of S in a fertilizer program.

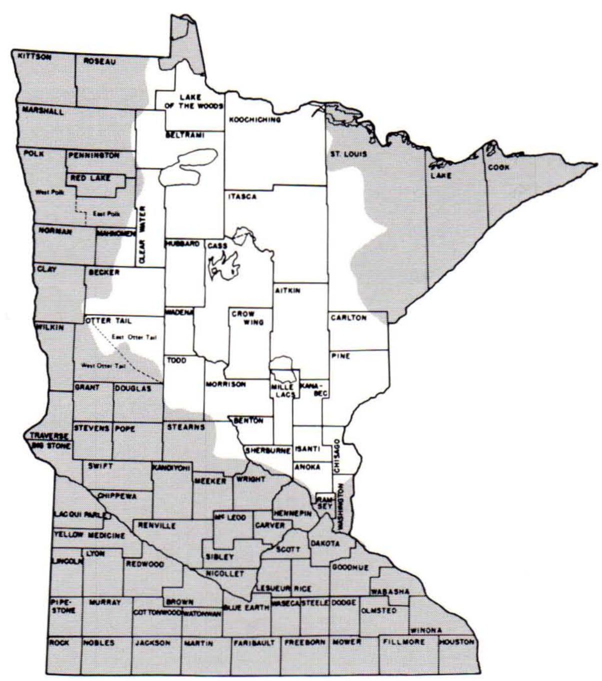

Figure 3. A response to use of sulfur in a fertilizer program can be expected in the non-colored areas on the Minnesota map.

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