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SULFUR for minnesota soils

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Plants use large amounts of sulfur, yet sulfur is called a secondary nutrient, primarily because it does not need to be added as often as the major nutrients: nitrogen (N), phosphorus (P), and potassium (K).

An inadequate supply of sulfur may seriously affect crop growth and yield.

The role of sulfur in the plant

Sulfur is involved in the synthesis of specific amino acids: cystine, cysteine, and methionine. Most of the sulfur entering plants combines as amino acids to form various proteins that affect plant growth and color.

Sulfur is essential in the formation of nodules on roots, making it essential to nitrogen fixation in legumes. Corn, small grain, and pasture grasses have relatively low sulfur requirements compared to legumes such as alfalfa and clover.

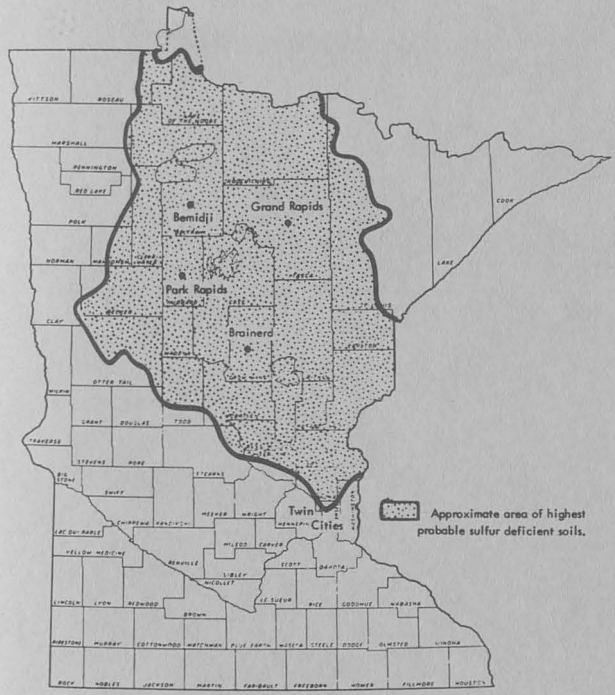
Deficiency symptoms

Sulfur deficiency reduces growth because of its involvement with protein. Maturity is delayed and foliage yellows. With legumes, the entire leaf area, including veins, becomes discolored. In corn, interveinal patterns appear on young leaves while the veins remain green. Sulfur deficiency in corn can be mistaken for zinc, iron, or magnesium deficiencies.

Soils in which sulfur shortages may occur

Sulfur shortages occur mainly in sandy, low organic matter soils that were originally forested. The accompanying map shows the approximate boundaries of the highest probable sulfur deficient areas. It helps to know the pH of a soil when trying to sort out whether the problem could be an iron or zinc deficiency. The latter two occur mainly on alkaline soils, whereas sulfur and magnesium deficiencies usually occur on acid soils. Where sulfur deficiencies generally occur, soils are quite acid. Magnesium problems also occur in this deficient area, and frequently plants must be tissue tested to decide which nutrient is lacking.

Most sulfur in the soil is in the organic form, which must be transformed by soil organisms into the inorganic sulfate form before it can be absorbed.



Sulfur removal by crops

Table 1 shows sulfur removal from some average yields of selected crops. When applications are made to correct deficiencies, 100 percent efficiency cannot be obtained, so amounts greater than this must be added to soils known to be deficient.

Table 1. Sulfur removed from selected crops

Crop	Yield/acre*	Sulfur removed lb./acre*
Alfalfa	4 tons	20 to 24
Red clover	2½ tons	5 to 10
Corn	100 bushels	8 to 10
Potatoes	240 sacks	10 to 20
Sunflowers	3,000 pounds	11 to 15

*For irrigated crops, assume yields and removal 50 percent higher.

Plant tissue analysis

Plant tissue analysis is available at various laboratories, and tests can be helpful in diagnosing problems. The figures in table 2 are threshold levels; below the sufficient level, a sulfur deficiency can be expected.

Table 2. Threshold levels for plant sulfur*

Crop	Plant part and sampling stage	Threshold levels		
		Deficient	Low	Sufficient
		% sulfur		
Alfalfa	Upper 1/3, harvest	<.20	.20 to .30	>.30
Corn	Ear leaf, silking	<.10	.10 to .20	>.20
Small grain	Top leaves, boot stage	<.10	.10 to .15	>.15
Soybeans	Upper fully developed trifoliolate	<.10	.10 to .15	>.15
Grass	Above ground part, not headed	<.10	.10 to .16	>.16
Sunflowers†	5th leaf		.25 to .50	

*Adapted from Agriculture Fact Sheet 104, Michigan State University, 1976; Extension Bulletin E-997, University of Wisconsin; and soil testing and plant analysis, ASA.

† Values subject to modification as research develops.

Sulfur in manure

Even though the sulfur content of manure is low, 10 to 20 tons per acre will supply enough sulfur to prevent deficiencies. Table 3 shows the resulting sulfur per acre if 20 tons from various sources were spread on a field.

Table 3. Sulfur content in 20 tons of manure

Animals	Pounds
Dairy cows	20
Beef cattle	34
Hogs	54
Horses	28
Sheep	36
Poultry	100

Other sulfur-containing materials

There are many products on the market that contain varying amounts of sulfur. Some of these are shown in table 4.

Table 4. Sulfur content of some available products

Material	% sulfur
Agri-sol	89
Gypsum	18
Ammonium sulfate (21-0-0)	23.7
Potassium chloride (0-0-60)	0.4
Potassium sulfate (0-0-50)	18
Sul-Po-Mag and K-Mag	22
Superphosphate (0-20-0)	11.5
Concentrated superphosphate (0-46-0)	0.7
Mixed grades with superphosphoric acid	0
16-20-0	15
Copper sulfate	12.8
Zinc sulfate	18
Epsom salt	14

Soil testing

Testing for sulfur is most frequently done with samples from 0 to 6 inches or from plow depth. This is usually the same sample used for P, K, and lime needs and for other tests.

Most laboratories test for extractable sulfate, which is the inorganic form and does not account for sulfur in the organic form. Since most sulfur in soils is in the organic form, the soil test for sulfur is not reliable on medium and fine textured soils.

More than soil testing needed

Farmers who depend only on sulfur tests made on surface soil samples may be purchasing unneeded sulfur. Sulfur in the gypsum form is sometimes 2 to 3 feet deep in the soil profile; this situation is common in western Minnesota. Even though a test is low in the surface, no response from sulfur will be obtained if this gypsum layer is present.

As mentioned previously, another shortcoming of sulfur testing is a lack of information on organic sulfur. Since the sulfur test measures only the inorganic form, soils with high organic matter could test low but have adequate sulfur from organic sources. The supply will vary with the usual conditions that affect bacterial action and subsequent organic matter decomposition. These conditions are soil moisture, temperature, pH, and aeration. Research in Minnesota indicates little chance of a sulfur response in soils with high organic matter.

Except on sandy textured soils, no response to sulfur has been measured across all of southern and western Minnesota for crops such as corn, soybeans, or small grains.

Iowa data have indicated the same results at five experimental locations across northern Iowa. Researchers measured no benefit from sulfur for corn or soybeans at rates up to 60 pounds per acre of sulfur during the years 1977 and 1978. Sales figures show that 37,627 tons of sulfur, valued at nearly $13 million, were sold in Iowa in 1979.

Money spent for sulfur in much of the nonshaded area shown on the map apparently is spent unwisely. For these areas of the state, sulfur is recommended only on sands, loamy sands, and sandy loam soils.

Recommendations and methods of application

In Minnesota, alfalfa is the crop most likely to respond to sulfur. Corn and pasture grasses also have responded in sulfur deficient areas.

Crops that are cultivated annually, thus causing a stepped up release of sulfur from the organic matter through increased biological activity, are less likely to respond. The area of chief concern is shaded on the map. Where deficiencies are suspected outside the shaded area (on sandy soils), sulfur should be applied on a trial basis, making sure that all other treatments are equal on both treated and untreated land.

To follow the recommendations in table 5, 300 pounds per acre of gypsum must be applied to get 50 pounds of sulfur. With elemental sulfur, 50 pounds is simply 50 pounds of material and can be blended into NPK fertilizers. Your dealer will know what percentage of the mixture is sulfur and will explain how much of the total mixture is needed to get the desired sulfur rate.

Mixtures of magnesium, sulfur, and potash are marketed as K-Mag or Sul-Po-Mag. These products contain 22 percent sulfur, 22 percent potash, and 11 percent magnesium. About 225 pounds per acre of this product will supply 50 pounds per acre of sulfur. The sulfur in these products is in the sulfate form, which means it is more readily available than elemental sulfur. On sandy textured soils, there is a likelihood that the magnesium and potash also will be beneficial.

If you grow other crops such as corn, soybeans, or small grains in the shaded area shown on the map, broadcast 20 pounds per acre of actual sulfur or 10 pounds in the row if the test is below 7 parts per million (ppm). Even in cases in which tests fall below 7 ppm in the unshaded area, no sulfur is recommended except on sandy textured soils (see table 5).

When elemental sulfur is used, a quick response is not possible because sulfur must first be converted to the sulfate form before uptake by the plant occurs. Spring applications of this form may not be entirely effective until midsummer.

Table 5. Sulfur soil test interpretation and recommendations for soils with low or medium organic matter and coarse texture (sands, loamy sands, and sandy loams)*

Sulfur soil test interpretation

Sulfur soil test (ppm)	Relative level	Yield increase expected from sulfur applications
0-6	Low	Highly possible
7-12	Medium	Possible
More than 12	High	Unlikely

Sulfur recommendations

Crop	Sulfur soil test (ppm) 0-6	7-12	More than 12
	sulfur to apply, lb./acre		
Alfalfa			
Irrigated	50 every 2 yr.	50 every 2 yr.	None
Nonirrigated	50 every 3 yr.	Trial only†	None
Corn, edible beans			
Irrigated	20 broadcast; 10 row‡	Trial only†	None
Nonirrigated	20 broadcast; 10 row‡	None	None
Potatoes			
Irrigated	30 broadcast; 15 row‡	30 broadcast; 15 row‡	None
Nonirrigated	30 broadcast; 15 row‡	None	None
All other crops	20 broadcast; 10 row‡	None	None

*Sulfur is not recommended on fine textured soils except on a trial basis.

† When recommended on a trial basis, apply sulfur on part of a field at rate recommended for a 0-6 ppm test. Compare with no sulfur treatment, being sure other nutrients are the same for both areas.

‡ When sulfur is row applied, use the sulfate not the elemental form.

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