FFF Review

Effective Sulfur Management

A secondary nutrient many agriculturists now think of as primary is part of the makeup of every living organism.

Thus far in this series on effective management we've covered the roles N, P, K, and Zn play in crop production. In this fifth of the series we will be discussing what traditionally has been referred to as a secondary nutrient but more and more is being called a primary nutrient: sulfur.

Sulfur (S) is one of nature's super nutrients and one of the oldest elements known to man. It is the thirteenth most abundant element in the earth's crust. S is essential for the production of three amino acids found in both plants and animals. These amino acids are the building blocks in the synthesis of proteins. Without proteins, plants and animals simply could not exist. Proteins provide the sustenance humans require in their diets in order to survive. Because S is used to produce amino acids, it is a part of the makeup of every living organism.

Elemental S is a natural, non-toxic element. It is used in the manufacture of many health products such as sulphadrugs and ointments for skin diseases. It is also used in petroleum refining, production of fertilizers, and preservation of fruits and vegetables.

S in soil

Inorganic soil S (that form available to plants) occurs as the sulfate anion (SO_3-). Because of its negative charge, the sulfate anion is not attracted to soil clay and organic matter surfaces, except under certain conditions. It remains in the soil solution and moves with soil water, so it is readily leached. Certain soils accumulate the sulfate anion in the subsoil, which would be available to deep-rooted crops. In arid regions, sulfates of Ca, Mg, K, and Na are the predominant inorganic S forms.

Much of the soil S in humid regions is associated with organic matter. Biological transformations. similar to those of N, produce plant-available sulfate and sulfate compounds.

The sulfur cycle (Figure 1) shows the relationship among atmospheric, fertilizer, and soil sources of S. Proper management ensures S uptake efficiency with minimal leaching or erosion. As shown in the figure, there is no net gain or loss of S in nature.

S-deficient soils

The number of S-deficient soils is increasing. Contributing factors include:

- bigger crop yields removing larger amounts of S
- increased use of high-analysis fertilizers containing little or no incidental S
- decreased use of high-S fuels and improved S removal techniques from stack gases
- less use of S-containing pesticides
- increased conservation tillage that immobilizes S in accumulated organic matter.

Remedial action

To minimize S deficiency problems in soils, scrupulous accounting for the following should help in any well planned fertility program:

Crop selection. High-yielding forage crops, such as hybrid bermudas and alfalfa, remove more S and generally respond to S additions more frequently than most grain crops.

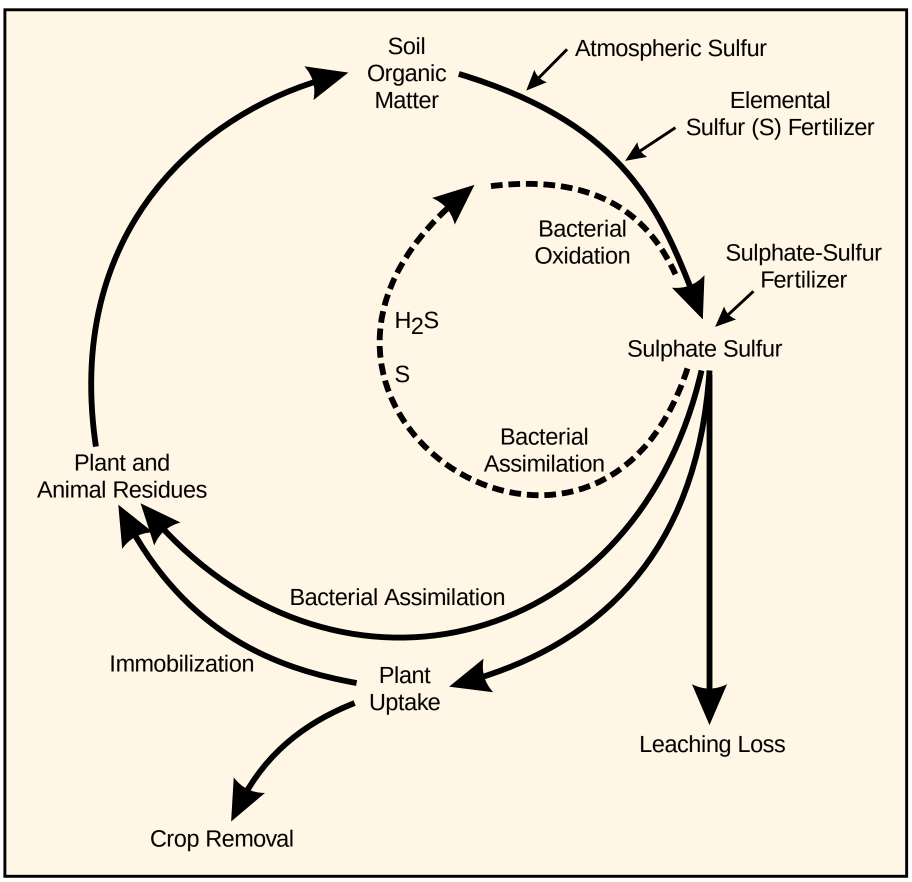


Figure 1. The sulfur cycle.

Soil texture. Leaching of sulfate-S from sandy soils is more likely than from finer-textured loams and clays. Crop response to S is most common on coarse-textured soils.

Organic matter. Soils containing less than two percent organic matter are most commonly S deficient. However, deficiencies do occur on soils containing higher levels. Each percent of organic matter releases about 5 lbs of S per acre per year.

Water quality. Lakes and rivers usually contain higher levels of S than do deep water wells. When irrigating, analyze water sources in order to determine their S concentrations.

Plant analysis and soil testing for 5, including subsoil, are also recommended on those soils suspected of being marginal or deficient.

Role of S

S is absorbed by plant roots as the sulfate anion. It can also enter plant leaves from the air as sulfur dioxide (SO_2). In the plant it:

- helps develop enzymes and vitamins
- promotes nodulation for N fixation by legumes
- aids in seed production
- aids in protein formation
- is necessary in chlorophyll formation, although it is not a constituent of chlorophyll.

NS boosts yields

The need for S is closely related to the amounts of N available to crop plants. This close relationship should not be surprising, since both are constituents of proteins and are associated with chlorophyll formation. Scientists have suggested that N:S ratio in plants is a good diagnostic guide for determining S deficiency. While some of the ratios used in experimentation may he open to questioning, the strong relationship between N and S is nevertheless one that cannot be ignored when N fertilizer-use efficiency is evaluated. Research in Minnesota (Figure 3) showed how best corn yields were obtained when ratios were between 5:1 and 8:1 (N:S).

N and S are further linked by sulfur's role in the activation of the enzyme nitrate reductase, which is necessary for the conversion of nitrate to amino acids in plants. Low nitrate reductase activity depresses soluble protein levels, while

Corn (deficiency right) | Soybeans (deficiency left) | Wheat (deficiency left)

Alfalfa (deficiency left) | Clover (deficiency right) | Cotton (dificiency left)

Peanuts (deficiency left) | Lettuce (deficiency left) | Tomato (deficiency left)

Figure 2. Specific symptoms of sulfur hunger in crops.

raising nitrate concentrations in plant tissue.

High nitrate levels, which accumulate when S is deficient, drastically inhibit seed formation in sensitive crops such as canola. Nitrate can also be toxic to animals consuming S-deficient for-ages. Adequate S levels improve Mg digestion in ruminants by reducing for-age (feed) non-protein N levels.

Deficiency symptoms

Sulfur, like nitrogen, is a constituent of proteins, so deficiency symptoms are similar. N-deficiency symptoms are more severe on older leaves because N is a mobile plant nutrient and moves to new growth. 5, on the other hand, is immobile in the plant, so new growth suffers first when S levels are not adequate to meet crop needs. This difference is important in distinguishing between the two, particularly in early stages of a deficiency.

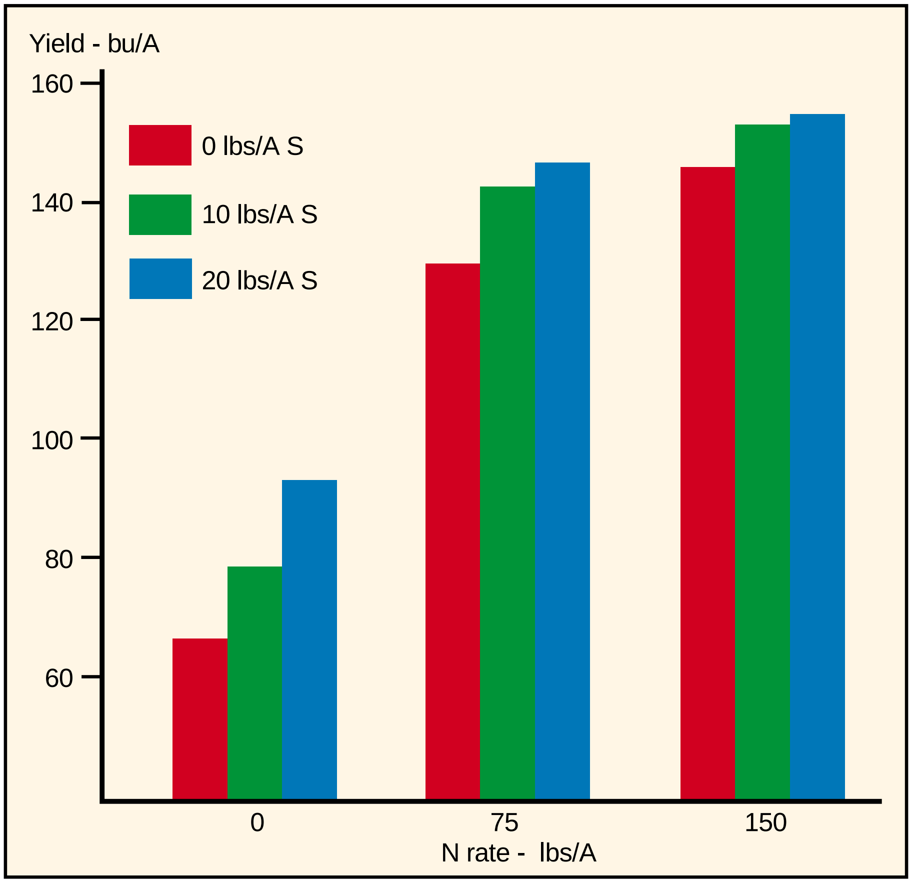
Having set the stage, we'll now explore how to properly identify S deficiencies. Generally, agronomists advise growers to watch for the following signs of S hunger:

- small spindly plants with short, slender stalks
- retarded growth rate and delayed maturity
- light green to yellowish color of leaves, with even lighter colored veins (on most plants, this yellowing shows up first on young, upper leaves, while most N deficiencies show up first on bottom leaves).

However, specific symptoms may vary considerably from one crop to another as the following descriptions and accompanying photographs (Figure 2) demonstrate:

Corn. S deficiency begins with a marked yellowing along the length of the leaves between veins, particularly on newer, upper leaves. Reddening later occurs at the base of the stalk and along leaf margins. Gradually, the reddening spreads across the leaf to the midrib.

Soybeans. To identify S deficiency, watch new leaves for a period of several days. Initially, all new leaves are pale yellow-green, but in a S deficient plant they remain pale. In a healthy plant, they turn dark green. Older leaves may remain dark green longer, but eventually the entire plant turns yellow. Leaf size and length of spaces between nodes are reduced in a deficient plant.



Wheat. S deficiency is first seen in a general yellowing of the plant, usually more pronounced between the veins. Older leaves tend to remain green.

Alfalfa. S deficiency can be identified by a persistent yellow-green cast to new growth, more erect leaflets, and a reddening of stems. Tillering also is markedly reduced.

Clover. In subterranean clover, S deficiency is indicated by general yellowing, although older leaves may turn a pinkish red. Petioles redden and leaflets stand more erect.

Cotton. A persistent yellowing of new leaves and reddening of petioles are sure signs of S deficiency. There is little difference in plant or leaf size between S deficient and healthy plants.

Peanuts. New leaflets are smaller, paler, and stand more erect from the petiole than normal ones, giving trifoliate leaves a "V" shape. Plant size may be reduced, but older leaves remain green despite S shortage.

Lettuce. S deficiency results in slightly paler young leaves, while older leaves remain green. Leaves are normally formed but are thicker, stiffer, and smaller.

Tomatoes. Plants tend to be smaller and lighter in color than normal plants. Yellowing may occur in various parts of the plant. Leaf shape is not affected, but leaves tend to be smaller and closer together. Petioles and stems will show a marked reddening if deficiency is severe.

S-containing fluids

Most fertilizer sources are sulfates and are moderately to highly water soluble. Soluble forms include bisulfites, thiosulfates and polysulfides. Solutions used to provide S to farm crops in different regions of the U.S. are: ammoniurn thiosulfate, ammonium polysulfide, ammonium bisulfate, and sulfuric acid.

These sources have been produced for many years. Choice of which source is usually related to convenience of use.