Sulfur for Field Crops

There are 18 essential nutrients for plant growth meaning these nutrients are needed for plants to complete their life cycle (from seed to seed). These essential nutrients can be divided into two main groups; macronutrients (9) and micronutrients (9), based on the amount required by plants; macronutrients are needed in larger quantities than micronutrients. Sulfur (S) is one of the nine macronutrients.

Sulfur is a component of numerous protein enzymes that regulate photosynthesis and nitrogen fixation. Sulfur deficiency can lead to a crude protein deficiency, and reduce milk production and overall feed efficiency on dairy farms. Sulfur is a main component of the amino acids methionine, cysteine, and cystine. Animals need to consume methionine in their diet as they cannot generate it from other compounds (it is an essential amino acid for dairy cattle). Furthermore, sulfur deficiency will result in greater import of feeds onto the farm, a costly practice that negatively impacts farm profitability and long-term sustainability.

In this fact sheet we describe the sulfur cycle and give guidance for sulfur management for field crops.

Sulfur Deficiency

Sulfur deficiency looks similar to nitrogen deficiency (yellowing and interveinal chlorosis), but because sulfur is not very mobile in the plant, the younger leaves will show the deficiency first versus the older leaves in the case of a nitrogen deficiency (Figure 1).

Figure 1. Sulfur deficiency in corn. Photo credit: Owen Plank, University of Georgia.

Sulfur deficient plants will grow slower and have a delayed maturity. The plants tend to develop thin stems and petioles, and become spindly. Sulfur deficiency could occur early in the season when soils are still cold and in younger plants before their root systems have fully developed but if a limited root mass and organic matter mineralization cause sulfur deficiency, the plants will likely overcome the sulfur deficiency later in the season when soil mineralization rates increase and a larger root system allows the plants to explore a greater volume of soil.

Sulfur Cycle

Figure 2 shows a simplified version of the sulfur cycle. Sulfur can appear in many forms in the environment. The major forms of sulfur present in the atmosphere include sulfur dioxide (SO_2) and hydrogen sulfide (H_2S). Both forms of sulfur enter the atmosphere from natural events like volcanic eruptions or man made activities such as the burning of fossil fuels. In the soil, S can be found as organic sulfur compounds, sulfides (S^-), elemental sulfur (S), and sulfate (SO_4^{2-}), the latter of which is the form required for plant uptake.

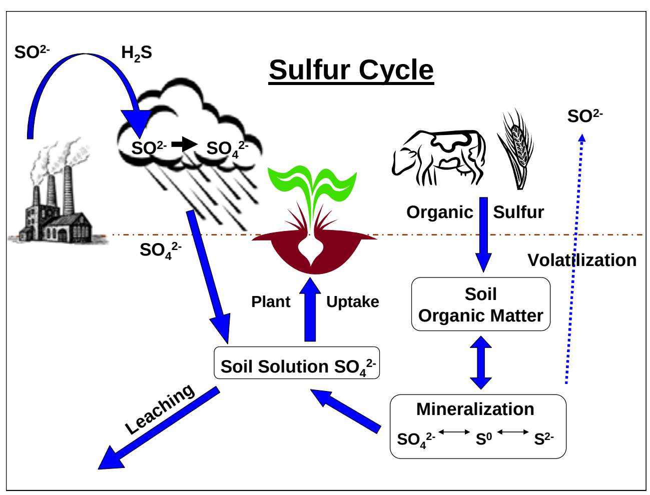

Figure 2: Schematic of the sulfur cycle.

Most of the sulfur in soil is in the soil organic matter and unavailable to the plant. This organic sulfur will slowly go through a process called mineralization to become available to the plant in the sulfate form. Sulfur enters the soil by deposition through rainwater and plant and animal residues. Sulfur can leave the soil profile as a result of plant uptake, leaching, and volatilization which increases with increased soil disturbance. Overall, sulfur moves from one form to another in a cycle very similar to nitrogen (see Agronomy Fact Sheet #2: Nitrogen Cycle) and can leach easily through sandy soils.

Reduced Sulfur Supply

Work in the '80's in New York showed no response of alfalfa, wheat or corn to sulfur addition, indicating that sufficient amounts were available through organic matter mineralization, manure addition, use of P fertilizers that contained S (superphosphates), and atmospheric deposition.

Since the Clean Air Act was passed in 1970, emissions of sulfur dioxide have decreased dramatically resulting in reduced sulfur deposition in many parts of the state. For trends in sulfur deposition in New York see the New York State DEC website (http://www.dec.ny.gov/chemical/29847.html). In addition, the fertilizer market shifted towards more concentrated fertilizers such as monoammonium and diammonium phosphates (MAP and DAP). Also, some sulfur- containing pesticides that were once readily used (e.g. fungicidal copper sulfate), have been replaced by organic materials that do not contain sulfur.

Reduced use of sulfur containing fertilizers and pesticides, decreased sulfur deposition, and increased yields through improved management and crop varieties, raise questions about the sulfur status of New York soils and sulfur management options.

Sulfur Management

Crop removal

Because of the role of sulfur in N fixation, it is needed at higher levels for legumes like alfalfa and soybeans than for grass hay and corn. Higher yielding fields have a higher rate of sulfur removal when compared with lower producing fields. Sulfur removal rates for most common field crops grown on dairy farms in New York are listed in Table 1. Using the average values in Table 1, a 20 ton/acre corn silage crop (35% DM) would remove almost 14 lbs S/acre while a 4 ton alfalfa hay crop would remove about 20 lbs S/acre.

Table 1: Sulfur removal estimates for New York field crops.

Crop	S removal
Corn silage	0.693 lbs S/ton of silage (35% DM)
Shell corn*	0.048 lbs S/bu of grain (85% DM)
Ear corn*	0.057 lbs S/bu of grain (85% DM)
Alfalfa hay	4.88 lbs S/ton of hay (90% DM)
Alfalfa silage	1.72 lbs S/ton of silage (35%DM)
Grass hay	3.11 lbs S/ton of hay (90% DM)
Grass haylage	1.44 lbs S/ton of silage (35% DM)
Soybeans*	0.16 lbs S/bu of soybean (87% DM)

*Assuming a test weight of 56 lbs/bu for shelled corn, 68 lbs/bu for ear corn, and 60 lbs/bu for soybeans.

Fields to watch

The risk for sulfur deficiency varies with soil type, the crops grown on the soil, the manure history, and the level of organic matter in the soil. A deficiency is more likely to occur on acidic, sandy soils, soils with low organic matter levels and high nitrogen inputs, and soils that are cold and dry in the spring which decreases sulfur mineralization from soil organic matter. Manure is a significant supplier of sulfur and manured fields are not likely to be S-deficient; however sulfur content in manure can vary.

Fields containing crops with the higher removal rates combined with less than ideal organic matter levels and coarser (sandy) soils are the most likely candidates for sulfur deficiencies.

Sulfur sources

If sulfur is deficient, it can be applied as ammonium sulfate or other S-containing fertilizers. As mentioned earlier, manure is also a good source of sulfur.

Disclaimer

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu

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