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Sulfur deficiency in alfalfa

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Sulfur (S) deficiency has recently been reported in a number of alfalfa fields in southwestern Wisconsin according to Carrie Laboski at the Univ. of Wisconsin **(see ref. 1)**. Quite a few sulfur deficiencies in alfalfa and corn have been reported since 2005 in northeast Iowa by John Sawyer and Brian Lang **(see ref. 2, 3)**. In Indiana we have documented S deficiency in wheat and corn in recent years and are conducting some research on S deficiency as well **(see ref. 4)**.

Factors Affecting Sulfur Deficiency

Sulfur deficiency of alfalfa and other crops may be becoming more prevalent because less S is deposited from the atmosphere to the soil due to reductions in power plant S emissions **(Fig. 1)**. Higher yields result in greater crop S removal from the field - about 5-7 lb for each ton of alfalfa hay. Additionally, less incidental S applications in fertilizers and pesticides may contribute to more S deficiency. In the case of row crops, increases in no-till, early planting, and heavy residue from high yields have also been implicated in contributing to S deficiency.

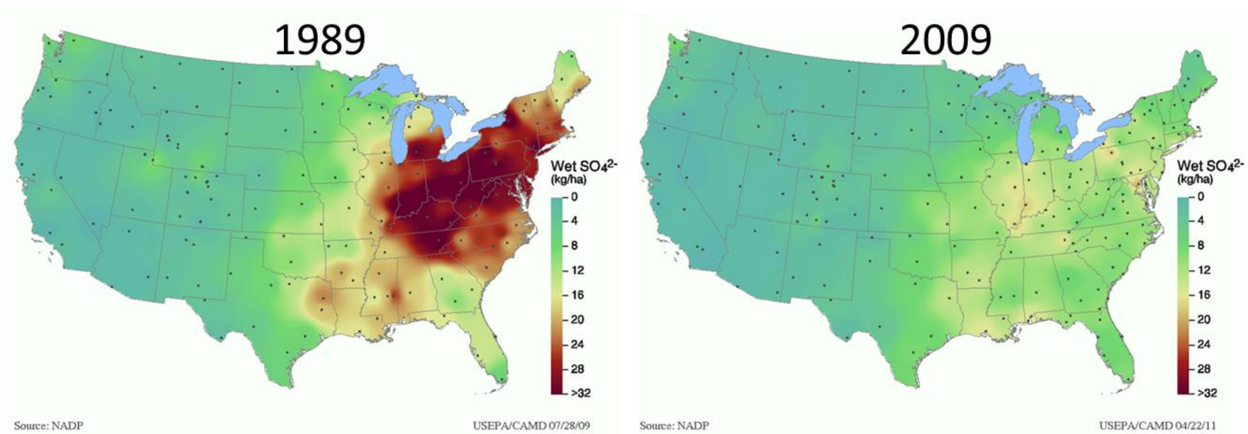

Fig. 1. The amount of sulfate (SO_4^{2-}) deposited on the land in rainfall has been greatly reduced since 1989. Red colors indicate high deposition and green low deposition. To convert the values given on the maps from SO_4^{2-} in kg/ha (see legend) to SO_4-S in pounds per acre, the more common term used in agriculture, multiply by 0.3. For example 32 kg SO_4^{2-} /ha equals 9.6 pounds per acre. Data from: http://epa.gov/castnet/javaweb/wetdep.html. (URL accessed April 2012).

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Soil Factors Resulting in Sulfur Deficiency

The main source of S in most soils is organic S. Each percent organic matter in the plow layer contains about 100 pounds of sulfur per acre. Organic S must be mineralized to sulfate-S (SO_4-S) to be taken up by crop plants, in much the same way that organic N is made available to crop plants. Therefore the lower the organic matter content of the soil the more likely S deficiency is to occur.

Since mineralization is a process carried out by living microorganisms, soil temperature and moisture largely determine when and how much of the organic S is made available to the crop. Cold and excessively wet or dry conditions reduce microbial activity and reduce S availability from soil organic matter and crop residues. Thus, alfalfa is more likely to be S deficient in the early spring before soil temperatures warm substantially.

Sulfate-S is relatively mobile in most soils (similar to nitrate) because it has a double negative charge and is repelled by the negative charge of the soil, unlike nutrients such as potassium, calcium, or magnesium. Although SO_4-S can bind to iron and aluminum in the soil, these elements are much more likely to bind phosphate at the exclusion of SO_4-S and as a result SO_4-S is easily leached from soils, especially sandy soils.

At the field level the occurrence of S deficiency may be highly variable since soil S availability varies considerably with soil organic matter and texture. Sulfur deficiency is often seen in sandier, lower organic matter, and higher elevation areas of a field while lower lying, higher organic matter, and heavier textured areas have sufficient S.

Soil testing methods measure the SO_4-S form of S. Unfortunately soil testing is not particularly useful for predicting S deficiency because it does not take into account the organic S component that might become available to the crop. The SO_4-S component that is actually measured may also be leached from the soil between the time of sampling and the time of crop need.

Identifying Sulfur Deficiency in Alfalfa

At the individual plant level, S-deficient alfalfa will have a uniformly yellow appearance because S is not readily translocated from older to younger plant parts. Visually S deficiency may not be easy to distinguish from other nutrient deficiencies or leafhopper damage without close inspection, experience, and/or tissue testing.

The best way to identify a S deficiency is by tissue sampling. Collect the upper 6 inches of stem and leaf tissue from 40-50 plants from the area suspected of deficiency and a healthy area of the field for comparison. If samples are contaminated by soil they can be rinsed quickly in cold distilled water, but do not overdo it because some nutrients, especially potassium, may be leached out of the tissue. Wet samples should be air-dried before shipping to the laboratory in paper bags. Tissue S greater than about 0.25% on a dry matter basis indicates sufficiency.

Correcting Sulfur Deficiency in Alfalfa

If S deficiency is identified, an application rate of 20 to 30 pounds of SO_4-S per year is recommended to alleviate S deficiency in alfalfa based on the most recent research conducted in Iowa **(see ref. 3)**. Although some carryover of S may occur in silt loam soils with deep rooted alfalfa crops it may be necessary to make applications of S every year on sandy soils, particularly if irrigated and high yielding.

Fertilizer Materials

The composition of several fertilizer sources of S are listed in **Table 1**. Potassium sulfate and sulfate-of-potash-magnesia (sul-po-mag or K-mag) are often good choices because alfalfa removes large amounts of potassium from the soil and potassium fertilization is often required. Either of these sources can be blended with muriate of potash (0-0-60) to provide an economical source of both potassium and S. The inclusion of magnesium in sul-po-mag may be an extra benefit compared to potassium sulfate if soil magnesium levels are low.

Ammonium sulfate and gypsum are also potential sources of S for alfalfa. Although there is no benefit to applying ammonium-nitrogen to the alfalfa, there are not likely to be any negative effects either with the rate that would be used to correct the S deficiency. Naturally-occurring mined gypsum and several by-product sources of gypsum can be applied to provide S as well. Unless pelletized, however, higher than necessary rates of S will be applied with gypsum which is difficult to spread at rates less than 500 to 1000 pounds per acre (85 to 170 pounds of S per acre assuming 17% S). If carryover of S occurs, the S will be utilized in later years. However, in sandy soils, where leaching is a problem, the benefit in future years may be minimal.

Table 1. Sulfur-containing fertilizers and their composition **(see ref. 5)**.

Fertilizer	**%N**	**%P_2O_5**	**%K_2O**	**%S**	**%Mg**	**%Ca**
Ammonium sulfate	**21**	0	0	**24**	0	0
Gypsum	0	0	0	**17**	0	**22**
Potassium magnesium sulfate	0	0	**22**	**23**	**11**	0
Potassium sulfate	0	0	**50**	**18**	0	0

Effects of Sulfur Containing Fertilizers on Soil pH

None of the S-containing fertilizers mentioned above affects soil pH except ammonium sulfate. The conversion of ammonium to nitrate generates acidity which lowers soil pH. No acidity arises from the sulfate in any of the fertilizer materials, including the sulfate in ammonium sulfate. Only elemental S or chemically reduced S (thio-S for example) creates acidity. None of the fertilizers increase soil pH either.

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