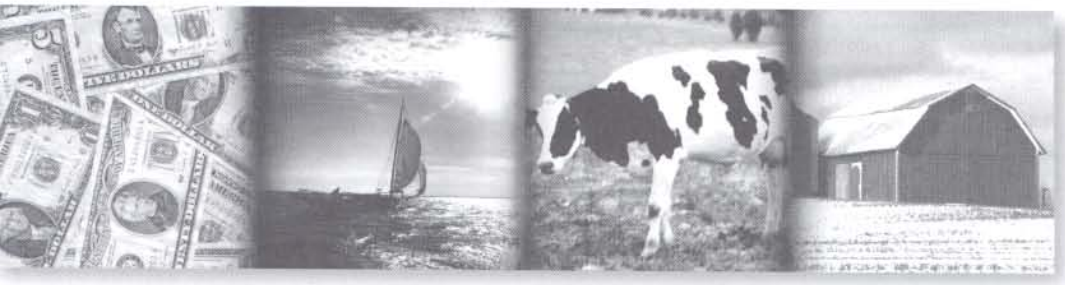

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NUTRIENT MANAGER

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Focus On Sulfur

Sulfur is essential as a plant nutrient, grouped with calcium and magnesium as a secondary macronutrient. Farmers early in this century assumed their fields had adequate sulfur. This was true due to the burning of fossil fuels from the beginning of the Industrial Revolution, the use of nitrogen and phosphorus fertilizers that may have contained sulfur, and the fact that farmers then farmed less intensively than we do now.

Recent spot sulfur deficiencies are occurring in Maryland crops. What is the story behind sulfur? Are the deficiencies of concern?

Why Crops Need Sulfur

Sulfur's main contribution to plant development is in the formation of proteins. It is essential in the formation of vitamins and of amino acids, the building blocks of protein. Although sulfur is not a component of chlorophyll, its presence is necessary for photosynthesis to occur. An abundance of sulfur also improves the quality of the protein within a plant, an important consideration for farmers who grow forage crops for their animals.

Two additional roles for sulfur are in the production of oils in seed crops such as soybeans, and in the supply of flavor and odor to vegetables in the onion and cabbage families.

Sources of Sulfur

All soil sulfur originates from Earth's minerals. In humid, temperate regions, the bulk of the sulfur is bound up in organic matter, which plants cannot use. Organic matter releases sulfate—which is plant-available—when mineralization occurs.

Soil sulfur may come from two other sources. Some commercial fertilizers whose use was common in the past—like ammonium sulfate and ordinary superphosphate—also contained sulfur. Many farmers have replaced these with higher analysis fertilizers.

The atmosphere is the second possible source of sulfur. One byproduct of burning fossil fuels is sulfur, which falls back to the Earth. Farmers have taken advantage of atmospheric deposits of sulfate in the form of dust or rain.

The Sulfur Cycle

Sulfur is bound up in protein and amino acids in soil's organic matter. In order to make the sulfur available to plants, the organic material must be mineralized—changed into a simpler form by soil microorganisms. The process is controlled by environmental factors such as temperature, aeration, and pH. Mineralization releases sulfates, which are readily used by plants.

The reverse process can occur, too. When large amounts of organic material are added to a soil, sulfur in the soil can become immobilized for a time, as microorganisms use it as proteins and amino acids in their bodies.

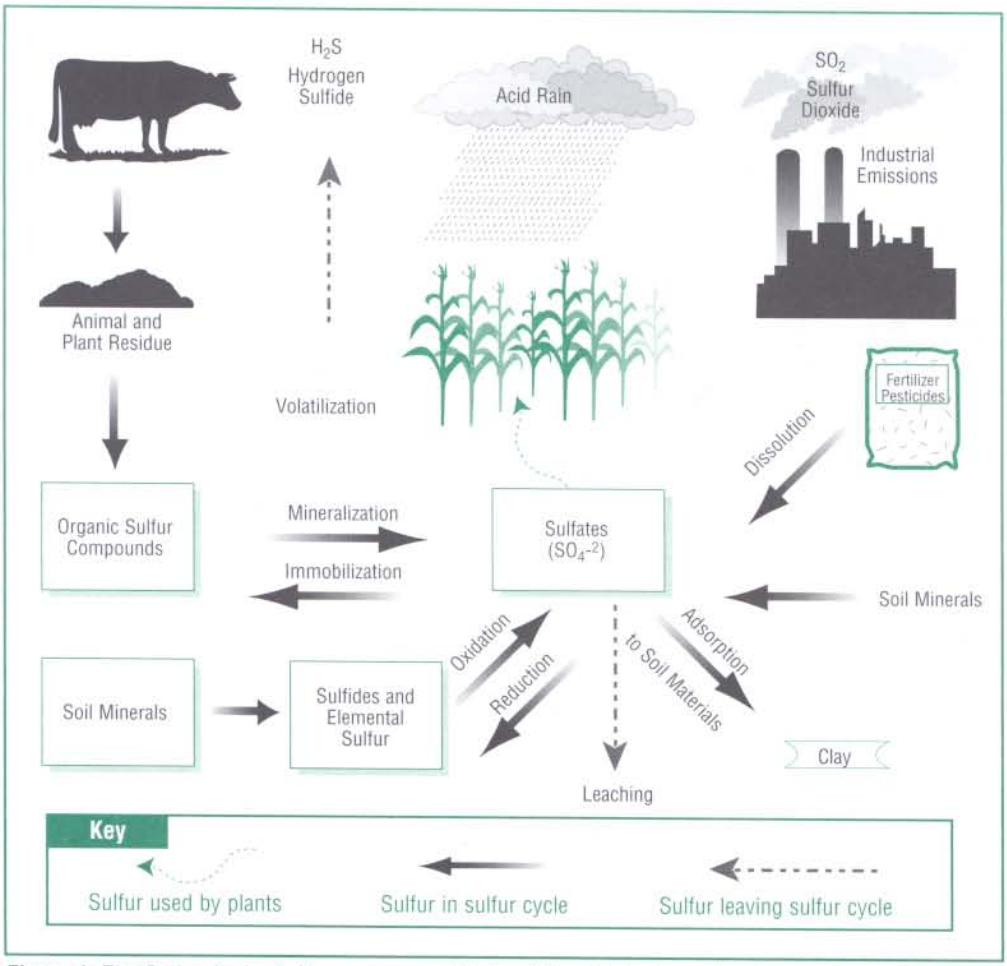

Figure 1. The Sulfur Cycle. Sulfur sources and their relationship in the soil and atmosphere.

When the microorganisms die and decompose, the sulfates become available once again.

In poorly drained soils, sulfur compounds can be transformed to hydrogen sulfide gas, the reason for a rotten-egg smell in marshy and swampy areas. The gasses escape the soil, or volatilize, into the atmosphere.

Reduced forms of sulfur—sulfides and elemental sulfur—react with the oxygen in air, or **oxidize**, producing plant-available sulfate and hydrogen ions. The production of hydrogen ions acidifies the soil. This explains the addition of elemental sulfur to fields of acid-loving blueberry bushes to lower the pH and to potato fields to prevent scab disease.

Sulfur Resembles Nitrogen

Sulfur's complex cycle resembles that of nitrogen. Like nitrogen, sulfur

- exists in gaseous forms in the atmosphere;
- is bound into organic matter as a component of protein, which plants cannot use;
- is released from organic matter by the action of soil microorganisms into the sulfate form that plants can use; and
- like nitrate nitrogen, plant-available sulfate sulfur carries a negative charge. It is repelled by negatively charged soil particles and, therefore, leaches into the subsoil.

Sulfur's Recent History

Industrial emissions are one source of sulfur and other chemicals in our air. Wet deposition of sulfur with a pH below 4 is "**acid rain**," which acidifies soil and waterways and damages forests. The detrimental effect of acid rain was one impetus for the passage of the 1970 and 1992 Clean Air Acts, which mandated lowered industrial emissions. Levels of atmospheric sulfur have now dropped and we are breathing cleaner air than before, but crops receive less "free" atmospheric sulfur. As shown in Figure 2, EPA data reports that between 1970, when the Clean Air Act was passed, and 1990, sulfur emissions in the nation declined 28 percent.

However, the Bay area still receives a fair amount of sulfur emissions. As you can see in Figure 3, the airshed for the Chesapeake Bay—the region that significantly contributes to deposition of sulfur on its drainage basin—covers 350,000 square miles. Because this airshed encompasses some large cities, sulfur-emitting industrial activity is high. Since 1984, the National Atmospheric Deposition Program has recorded sulfur depositions

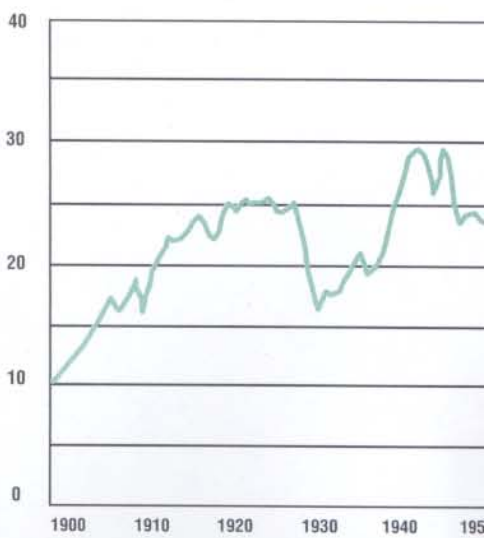

Figure 2 The nationwide rise and fall of sulfu
Source: *National Air Pollutant Emission Trends, 1900-199*

Sulfur Fact

In the fall of 1997, Johns Hopkins University researchers found an additional role for sulfur: it is a component in the organic compound sulforaphane, which stimulates cell production of cancer-blocking enzymes. Large amounts of sulforaphane are found in broccoli sprouts.

Figure 3. The Chesapeake Bay's airshed—5.5 times the size of the Bay's watershed.
Source: *Bay Journal*, v. 5, no. 8. Alliance for the Chesapeake Bay. 1995.

averaging 20 pounds per acre per year at the White Rock site in Carroll County and the Wye site in Queen Anne's County.

Crop Response in Maryland

Betsy Gallagher, Dorchester County Extension educator, agricultural science, reports that she first noticed sulfur deficiencies around 1980. The number of deficiencies has increased over time.

emissions.
EPA. 1996.

Table 1. Amount of Sulfur in Manures.

MANURE	AMOUNT
Broiler Manure	8 lbs/T
Dairy Manure, solid	2 lbs/T
Horse Manure, solid	2 lbs/T

Gallagher notes that she has seen sulfur deficiencies "primarily on sandy soils but also on heavier soils." She has also noticed particular problems with no-till fields and credits this to the immobilization of sulfate due to the large amount of organic matter, where microorganisms bind the sulfate into their cells. Alternatively, soils low in organic matter (<1.5%) also tend to be low in sulfur.

Gallagher notes that crops can naturally outgrow a sulfur deficiency later in the season when crop roots extend to the subsoil where sulfate has leached from the upper soil horizon and accumulated.

Should I be Concerned?

Intensive farming methods have increased the demand for soil nutrients. The higher the crop yield, the more nutrients are needed. Certain crops, such as alfalfa, corn, sorghum and tomatoes, are particularly high in their sulfur requirement. Figure 4 lists the sulfur requirements of some Maryland crops.

The likelihood of a sulfur deficiency depends on factors such as soil parent material, rainfall, soil texture, organic matter content and crop yield. If you grow crops in soil that is highly weathered, coarse textured or low in organic matter, they may be prone to sulfur deficiency. Other factors to consider are the past history of fertilizer use, your farm's distance from a sulfur-emitting industrial site, and previous sulfur deficiencies. You might be wise to be concerned if several of these factors affect your crop.

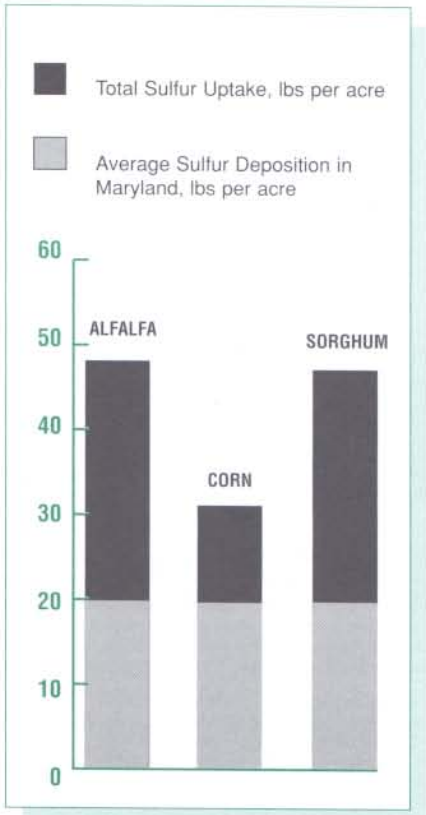

Figure 4. Sulfur requirements of selected Maryland crops.
Source: Potash and Phosphate Institute.

Manure as a Sulfur Source

Manure contains sulfur, about 2 to 8 pounds per ton, depending on the animal. Approximately half the sulfur in manure is plant available the year of application. The remainder is tied up in organic compounds, and needs to be mineralized to become plant available. For precise information about the sulfur content of your manure, have it tested by the University of Maryland Soil Testing Lab.

Table 2. Sulfate Fertilizer Materials.

FERTILIZER	%N	$\%P_2O_5$	$\%K_2O$	%S
Ammonium sulfate	21			24
Ammonium thiosulfate	19			43
Superphosphate		18		12
Potassium sulfate			50	18
Potassium-magnesium sulfate			22	22
Gypsum				15

BMP'S FOR SULFUR

Test your soil periodically for sulfur, particularly if you suspect a deficiency.

Take soil tests at <0 to 8 inches and at 8 to 24 inches because sulfur moves readily through the soil, often accumulating in the subsoil where roots of young plants do not reach. If your soil test reports a sulfur deficiency only at the plow level, fertilization may not be necessary. The crop may "grow out of" sulfur deficiency as it matures, when its elongating roots reach sulfates in the subsoil.

When the test detects sulfur deficiency in the subsoil, follow the recommendations of the Soil Testing Laboratory or contact your county Extension educator for application recommendations.

For nutrient management planning services, call your Cooperative Extension educator at the county Extension office.

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If you do not receive this newsletter by mail and would like to, contact your county Extension office or the address above.

(Masthead sailing photo courtesy of Skip Brown.)