

Sulfate -vs- Elemental Sulfur Part I: There is A Difference

- Sulfate-Sulfur is the only form of S the plant can utilize.
- Elemental S is dependent upon time, temperature and moisture to be available to the plant.
- Sulfate-Sulfur will not acidify the soil.

For various reasons, sulfur (S) deficiencies are increasing in many areas of the country. The use of this nutrient in fertility programs is therefore becoming more routine. The most common chemical forms of S used in fertilizers are sulfate S (SO₄) and elemental S (S⁰). But these two forms of S react quite differently in soils. It's very important to understand the differences between SO₄ and S⁰ in order to use these two forms in the most effective manner possible.

Sulfate Sulfur

Although S exists in many different chemical forms in nature, plants can only absorb S through their root systems in the SO₄ form. Small amounts of sulfur dioxide gas can be absorbed through leaves, but this is of little consequence in the overall S nutrition of plants. This obviously means that all soil S must be converted to SO₄ in order to be utilized by plants.

The SO₄ anion carries two negative charges, so it is not absorbed by soil colloids to any extent. As soil acidity increases, some positive charge sites develop on clay particles and organic matter, which allows for a limited amount of SO₄ absorption. But for the most part, SO₄ moves freely with soil moisture, especially in the upper levels of the soil profile. It thus reacts much like nitrate nitrogen in soils. As a result, SO₄ levels frequently increase with increasing depth in the soil profile, at least in humid climates. Table A shows the increase of SO₄ with depth in several Southeastern U.S. soils.

Table A. Sulfate - S (ppm) Extracted At Various Soil Depths.

Soil Depth (Inches)	Norfolk Sandy Loam 1	Norfolk Sandy Loam 2	Chewacla Silt Loam	Fannin Clay Loam	Magnolia Fine Sandy Loam
0-6	0	2	1	3	1
6-12	1	7	1	83	54
12-18	63	114	1	100	95
18-24	93	131	6	58	106
24-30	97	135	24	44	146
30-36	110	127	47	28	87

For this reason, small amounts of SO₄ applied in a starter fertilizer is sometimes all that's needed to get young roots off to a fast start, quickly growing down through the profile to greater depths where supplies of SO₄ are more plentiful. Work in Arkansas has shown that wheat yields were increased from 15 to 44 bushels per acre by the application of just 5 lb/A of S in the potassium sulfate form. However, a more typical recommendation for sulfur would be in the range of 25-30 lb/A of S.

Elemental Sulfur

Elemental S is totally unavailable to plants. Plants simply cannot absorb S⁰ through the root system. Elemental S is inert and water insoluble. Commercially, it is stored in the open, and it can remain in place for years, unaffected by moisture or temperature. However, when S⁰ is added to soil, it's an entirely different matter. In the soil, S⁰ is converted (oxidized) to the plant-available SO₄ form and the rate at which this conversion takes place is the determining factor regarding the effectiveness of S⁰ as a fertilizer source of S. (See Part II.)

The following are the most important considerations regarding the use of these two chemical forms of S in fertility programs.

- When relying on S⁰ for the total sulfur needs, best results are usually observed if application is made prior to planting the crop. Broadcasting followed by

incorporation is preferable to band placement.
Surface applications of S⁰ are not recommended.

- If fertilizer is applied at the time of planting of Spring-seeded crops, SO₄ fertilizers will usually give best results. This is especially true if conditions are such that S⁰ oxidation rates are depressed; i.e., cool temperatures, excessive moisture. In starter or row fertilizers, SO₄ forms of S generally give better results.
- If fertilizer is applied in the Fall for Spring-seeded crops, there is less likely to be any difference between S⁰ and SO₄ sources. Elemental sulfur sources usually have better residual effects.
- Elemental sulfur sources are highly acidifying. This can be beneficial under alkaline soil conditions, but detrimental under acid conditions. Sulfate sources can be either acidifying or neutral in reaction. Ammonium sulfate is an acid-forming material; K-Mag, potassium sulfate and calcium sulfate are neutral materials and have no effect on soil pH.