Soybean Nutrient Profile

Sulfur

This nutrient profile is a part of a weekly series dedicated to the function of the 16 essential nutrients in soybean. After excluding carbon, hydrogen, and oxygen, we are left with a thirteen part series in which we will explore how nutrients are used throughout the plant as well as how to identify deficiency symptoms and develop nutrient management decisions.

In the Plant

Sulfur (S) is found in legume plants, such as soybean, at about 0.25 to 0.3% dry matter. Similar to nitrogen (N), S is essential for the makeup of three amino acids needed for protein production in plants. These two nutrients are so intertwined, in fact, that a reduction in S will often reduce N use efficiency in most plants. The function of S in proteins is the formation of disulfide bonds that help hold proteins together. Sulfur is also essential for the synthesis of several coenzymes and vitamins needed for plant metabolism, as well as chlorophyll synthesis, although it is not a direct constituent.

Sulfur is taken into the plant mainly as sulfate (SO_4^{-2}), although the roots can also absorb thiosulfate ($S_2O_3^{-2}$). Similar to the reactions required for the reduction of nitrates, the reduction of SO_4^{-2} to a plant usable form is one of the most energy-intensive reactions that occurs in plants.

In the Soil

Sulfate reaches the roots mainly through mass flow, the movement of nutrients with the soil solution due to transpirational water uptake by the plant. Therefore, reduced transpiration in the plant due to drought or reduced plant function can reduce S movement to the roots. Water-logged soils will also reduce S uptake as roots remove have little capacity for nutrient uptake in anaerobic conditions. Sulfate reacts in the soil in a way similar to N and would most likely be treated as such in annual fertility programs were plant needs similar to the levels needed of N. It is important to remember that just like N, SO_4^{-2} can leach from soils and the potential for leaching losses increase with increasing quantities of water moving through the soil (i.e., more rain or irrigation).

In acid soils, adsorbed SO_4^{-2} is also an important fraction of total S, especially in areas of high Al/Fe oxides. Adsorbed amounts of SO_4^{-2} are typically greater in acid subsoils as SO_4^{-2} is leached from surface soils. On the other end of the spectrum, SO_4^{-2} availability decreases in calcareous soils with increasing pH due to its coprecipitation with calcium compounds, though this is fairly uncommon in Louisiana soils.

Elemental, or inorganic, S is often used as a fertilizer source although it must be oxidized before becoming plant available. This oxidation process can be slow depending on the environmental conditions and must be considered when determining what fertilizer source will best fit a producers program. Factors affecting the rate of S oxidation include soil microbial activity, S source characteristics, and soil conditions such as temperature, moisture, and pH.

Deficiency Symptoms

Because both S and N are both constituents of amino acids and proteins, the deficiency symptoms are strikingly similar. Sulfur deficiency symptoms include pronounced stunting and yellowing, or chlorosis, of leaves (figure 1). The main difference between the symptoms of S and N are the location with which the yellowing of leaves will begin in the canopy. Sulfur, being fairly immobile in the plant, will typically begin showing deficiency symptoms in young, new leaves. Plants deficient in sulfur can also look spindly with thin stems.

Figure 1. *Soybean sulfur deficiency symptoms appear as a general stunting and chlorosis of the leaves beginning with young, new growth. (IPNI, V. Casarin, 2018)*

Deficiency Corrections

Sulfur deficiencies can be corrected during the growing season but only with SO_4^{-2} containing fertilizer sources. Common sources of immediately available S include ammonium or potassium sulfates. Elemental S should not be used during the season to correct a deficiency except for early season applications with which 20-25% of the applied S must be in the readily available SO_4^{-2} form.

If low soil test S is discovered prior to the growing season then producers can broadcast and incorporate elemental S alone in the fall or in the spring if 20 to 25% of the total S applied is in the readily available SO_4^{-2} form. When utilizing elemental S, broadcasting and incorporating the product will increase the rate and amount of oxidation compared to banded or non-incorporated applications. Uniform incorporation of elemental S can also help to minimize the acidifying effects of the oxidation process.

Oxidation rates of elemental S will depend on the characteristics of the product, particularly the size of the individual particles. With decreasing particle size, oxidation rates are increased due to an increase in particle surface area for oxidation to occur. Regardless of elemental S fertilizer source or application, the farther ahead of planting that elemental S is applied, the greater the SO_4^{-2} availability will be for the crop.

Takeaways

- Sulfur (S) is a secondary plant nutrient essential in the development of three amino acids and subsequent protein development.
- Sulfur deficiency symptoms include chlorosis of young foliage along with a pronounced stunting of all new tissues.
- Sulfate (SO_4^{-2}), although immediately available for plant uptake, is highly mobile in the soil solution and has an increased leaching potential similar to nitrates. Elemental S however, must be oxidized to be plant available and should not be used to correct in-season deficiencies.

References

Images: IPNI, V. Casarin. 2018. IPNI Crop Nutrient Deficiency Image Collection. Version 2018 05-07.

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