Soybean Nutrient Profile

Iron

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

Iron (Fe) is taken up and found in the plant as either Fe^{+2} or Fe^{+3}. Iron readily exists in both forms in the plant and because of this, has the ability to either donate or accept an electron dependent upon its current state. This attribute allows Fe to be utilized as a component of enzymes required for the transfer of electrons in photosynthesis and respiration. Iron is also utilized in a similar role during the synthesis of chlorophyll, which is thus reduced in Fe deficient environments.

Figure 1. *Soybean iron deficiency appears as interveinal chlorosis. (LSU AgCenter)*

Iron is also critical in soybean due to its role as a constituent of both nitrogenase and leghemoglobin, both required for nitrogen fixation. Nitrogenase is an enzyme that catalyzes the high-energy reactions necessary for fixation. Leghemoglobin is responsible for transporting oxygen to the respiring, N-fixing bacteria, similar to how hemoglobin in humans transports oxygen to respiring our cells. Leghemoglobin is responsible for the pink color associated with healthy, active nodules on the plant roots.

In the Soil

Iron cation (Fe^{+2} or Fe^{+3}) concentrations are very low in soil solution compared to other cations such as potassium (K^+), calcium (Ca^{2+}), or magnesium (Mg^{2+}). Because of this lack of solubility, Fe often requires organic compounds in the soil to chelate the iron to increase the solubility and supply to plant roots. Chelated iron will then diffuse toward the plant roots where the concentration is lower. The Fe will then dissociate from the chelate due to interactions with the cell walls of the plant roots. The chelating compound will then diffuse away back into the bulk solution, again with the concentration gradient, where the cycle will continue.

Iron solubility in soils is extremely dependent on soil pH. For every unit increase in soil pH, Fe concentration in solution will decrease a thousandfold. This high pH environment is common in many parts of Louisiana and Fe deficiency symptoms are seen annually on many of these soils. Because of the inherent insolubility of iron coupled with the high pH soils we often find in our state, it is of additional importance that soybean, along with many other plants, have the ability to modify the rhizosphere to enhance Fe solubility to increase uptake by the roots. Soybean roots will exude protons (H^+) to acidify the rhizosphere. This, along with additional enzymes in the roots, will increase Fe solubility and allow for increased uptake. This activity will increase in Fe deficient environments.

Deficiency Symptoms

Figure 2. *Soybean iron deficiency symptoms can appear scattered as soil conditions affecting Fe availability vary throughout the field. (LSU AgCenter)*

Iron Deficiency Chlorosis (IDC), as it is often termed, will first appear in young growth in the upper parts of the canopy. Symptoms will begin as interveinal chlorosis, a yellowing of the leaf tissues between the veins of the leaves (figure 1). The veins will remain bright green in the early stages of deficiency symptoms. As the deficiency progresses, the veins will also become chlorotic and the leaf can appear bleached. The chlorosis stems from the requirement of iron for the synthesis of chlorophyll. Eventually, leaves will become necrotic and begin to die back with increasing severity.

Symptoms will often appear scattered as soil conditions will vary throughout the field (figure 2). Soil conditions including soil moisture, compaction, and pH can influence the availability of Fe.

Deficiency Corrections

When IDC is observed in Louisiana, it is commonly due to the current environmental conditions rather than a true deficiency. Environmental conditions limiting Fe uptake include both waterlogged soils and extremely dry soils. Waterlogged soils, often with low oxygen and high carbon dioxide concentrations, reduce Fe availability often due to an increase in bicarbonates in the soil. Dry soils reduce Fe availability due to an increase in the tortuosity of the soil and a reduction of diffusion of chelated Fe to the roots. In either case, symptoms will typically improve with the drying or wetting of the soil, respectively. In cases of IDC not related to environmental conditions, Fe can be applied foliar to soybean with chelated materials at typical rates of 0.1-0.2 lb A^{-1} to correct most deficiencies.

Takeaways

- Iron is essential for the synthesis of chlorophyll and many reactions occurring during photosynthesis and respiration. Iron is also necessary for N-fixation in soybean.
- Iron availability is affected by varying soil conditions and is greatly reduced in high pH soils.
- Iron Deficiency Chlorosis (IDC) symptoms appear as interveinal chlorosis with prominent green veins. Symptoms will appear first on new, young leaves.
- Most IDC observations in Louisiana will be due to environmental conditions associated with either waterlogged or dry soils and will correct themselves as conditions improve. If necessary, applications of 0.1 to 0.2 lb A^{-1} of actual Fe are required to correct IDC using a chelated Fe product.

References

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Taiz, L. & E. Zeiger. 2010. Plant Physiology. Sunderland, MA: Sinauer Assoc. Inc.