Iron

AGRONOMY

Iron deficiency is the most common and visually dramatic micronutrient problem. Most soil minerals contain approximately 4 percent (40,000 ppm) iron. Even though most soil is loaded with iron, deficiencies still occur because iron rapidly reacts with soil minerals, reducing its availability.

The Role Of Iron In Deficiency Symptoms

In 1860, iron was discovered as an essential nutrient for plant growth. It is taken up by the plant in two cation forms; Fe2+ and Fe3+, with Fe2+ being predominant. It is necessary for production of chlorophyll and activation of many important enzymes. Iron is immobile in the plant, which means visual deficiency symptoms, such as interveinal yellowing, become progressively more severe with newer leaf growth. Soybeans and grain sorghum are two common crops that show dramatic visual symptoms of iron deficiency.

Factor's Affecting Iron Availability

Soil pH and Oxygen

Iron availability is very sensitive to soil pH and oxygen. Iron solubility increases with decreasing soil pH. Soil oxygen reacts with iron to create Fe_2O_3, which is basically soil rust. If the oxygen in the soil increases, more of the soluble iron will be oxidized to form rust. Factors that reduce soil oxygen levels, such as flooding or microbial activity, increase iron availability.

Additions of organic residue can reduce oxygen in the soil because soil microbes consume soil oxygen as they decompose the residue. The relative effects of pH and soil oxygen on iron availability are shown below.

Table 1. Soil Oxygen Concentration

pH	Low	Normal	High
5.0	300,000,000	300,000	300.0
6.0	3,000,000	3,000	3.0
7.0	30,000	30	0.03
8.0	300	0.3	0.0003

Examples of soil conditions with low, normal, and high oxygen concentrations are as follows:

- **Low-oxygen soil** – soil with high water tables or standing water
- **Normal-oxygen soil – medium** – and fine-textured soil with average moisture and compaction, or a compact, coarse-textured soil with high moisture and residue
- **High-oxygen soil** – usually dry, coarse-textured soil.

Organic Matter – Organic matter strongly attracts iron, more than other micronutrients. Therefore, it is a great storehouse for iron and helps to maintain it in a readily available form as chelated iron that can be taken up by plants.

Soil Limestone – Many arid soils contain free limestone ($CaCO_3$). Iron is readily adsorbed to the surfaces of the limestone mineral. Soils with small limestone particle size (clay or silt size) have much more mineral surface area to adsorb iron than soil that contains predominantly sand or gravel-size limestone.

Diagnosing Deficiencies

The substance most commonly used for extracting iron is DTPA, which is a chelate. The critical soil-test range for DTPA-extractable iron is 2.5-5.0 ppm. The interpretation of the iron soil test can be improved when other factors that affect iron availability, as mentioned previously, are factored into the equation. For example, a soil-test level of 4.0 ppm would probably be adequate for a neutral, medium-textured soil. However, a 4.0 ppm soil-test level would result in severe iron deficiency if the soil is arid alkaline sand with less than 1 percent organic matter and 25 percent limestone. Soil most prone to iron deficiency is arid, alkaline, and coarse-textured soil.

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Since there are so many factors that can affect iron availability, a plant-tissue sample is a great diagnostic tool to complete your soil-fertility program. Plant-tissue analysis is especially helpful in managing micronutrients since most of the visual symptoms of micronutrient deficiencies look alike (e.g., interveinal yellowing of new plant growth). For most agronomic plants, the critical plant tissue iron level is 50 to 70 ppm.

Recommendations

Soil-test iron levels cannot be built up. Therefore, annual applications are the only way to correct iron deficiencies. Three suggested application options are:

1. Iron fertilizer (band-applied) with acid-based fertilizer can remedy iron deficiencies. The concept behind this recommendation is that acidifying the band will maintain iron fertilizer availability and perhaps even convert already present but unavailable iron into available iron. A suggested band application rate is 15-20 lbs./acre of iron sulfate with perhaps 50 lbs. of P_2O_5 as MAP and 40 lbs./acre of N as ammonium sulfate. The phosphorous fertilizer immediately acidifies the soil and the ammonium fertilizer acidifies the soil slowly as nitrification progresses. Broadcast application is ineffective, and soil-applied chelates are not as effective as iron sulfate.
2. Manure is one of the best ways to correct an iron deficiency. A 10-ton per acre application of manure has been shown to be more corrective than iron sulfate. The residual effect can last two to three years.
3. Foliar iron applications can generally correct iron deficiency, although repeated applications every two weeks are necessary to treat new growth. Two to three applications of a solution containing 2 percent iron, surfactant, and urea or ammonium sulfate (5 to 10 lbs. N/acre) would be recommended for foliar application. Iron sources can either be iron chelates or iron sulfates.

Conclusion

Iron availability is affected by soil pH, soil oxygen, organic matter, and limestone. Deficiencies are best corrected with band application in combination with acid-forming fertilizers (such as MAP and ammonium sulfate) or 10 tons/acre of manure.