Nutri-Facts Iron: http://www.ipni.net/publication/nutrifacts-na.nsf/0/A4DFC2ED4998C84985257EE7005FA837/$FILE/NutriFacts-NA-12.pdf

Iron

Iron (Fe) is a nutrient required by all organisms, including microbes, plants, animals, and humans. It was first recognized as a necessary plant nutrient in the mid 19th century when Fe deficient grapes were successfully treated with foliar applications of Fe salts. Iron is a component of many vital plant enzymes and is required for a wide range of biological functions. It is common in the earth's crust and as a result, most soils contain abundant Fe, but in forms that are low in solubility and sometimes not readily available for plant uptake.

Iron in Soils

Iron is abundant in many rocks and minerals and as soils develop there can be either enrichment or depletion of Fe. Depletion commonly leads to deficiency and enrichment can cause toxicity in unique conditions. The main source of Fe in soils for use by plants comes from secondary oxide minerals that are adsorbed or precipitated onto soil mineral particles and organic matter. Although Fe is very abundant, it's availability for plant uptake is quite low.

Iron in Plants

Plant roots absorb Fe from the soil solution most readily as (ferrous) $Fe2+$ but in some cases also as (ferric) $Fe3+$ ions. The chemical nature of Fe allows it to play an essential role in oxidation and reduction reactions, respiration, photosynthesis, and enzyme reactions. For example, Fe is an important component of the enzymes used by nitrogen-fixing bacteria. The Fe concentration in plant leaf tissues varies between plant species, but is generally between 50 and 250 ppm (dry weight basis). If the Fe concentration is less than 50 ppm there are usually signs of deficiency, and toxic effects may be observed when the concentration exceeds 500 ppm. The solubility of Fe oxide minerals in soil is very low, so plant roots have two general ways to access the Fe2+ or Fe3+ ions. The first strategy occurs in dicot species, and non-grass monocot species where Fe3+ ions are reduced to Fe2+ ions before moving into the root across selective membranes. This process involves the root excreting a variety of organic compounds and acids into the soil. In the second strategy, roots of grass species acquire Fe by excreting an organic chelate (siderophore) that solubilizes Fe from the soil, allowing enhanced uptake.

Soil Factors and Iron Deficiency

Most soils contain adequate Fe for plant nutrition, but chemical and environmental factors restrict plant uptake. Iron deficiencies are commonly observed in soils with elevated pH (>7.5), especially where there is abundant calcium carbonate (lime). Iron solubility is greatly increased as soil pH drops into the acidic range. Soils containing abundant calcium carbonate can form bicarbonate ions (HCO3 -) if the soils become overly wet, and bicarbonate interferes with Fe uptake by plants. This inhibition is usually only temporary and Fe deficiency symptoms disappear when the soil drains and warms up. When soils become saturated, Fe3+ becomes converted to Fe2+ by microbial action. The Fe2+ form is much more soluble and can even result in toxicity for some rice varieties in flooded soils under strongly acid conditions. Plants growing in soils with low organic matter content are generally more susceptible to Fe deficiency than with abundant organic matter. Humus compounds are effective at binding and releasing Fe ions into soil solution. Portions of a field that are eroded (low soil organic matter) tend to be more susceptible to Fe deficiency. Since many soil and environmental factors combine to regulate the Fe supply to plants, there is no widely accepted method of testing soils to predict the need for supplemental fertilization.

Deficiency and Toxicity Symptoms

Iron deficiency symptoms are universal among plant species, with general stunting and yellowing of younger leaves. Young Fe deficient leaves develop chlorosis (yellowing) between the leaf veins, while the veins initially remain green. As the deficiency becomes more severe, the younger leaves become pale yellow to white in color. Iron toxicity is relatively rare, but the symptoms include bronzed and striped leaves. These effects are the result of excess Fe-hydroxyl radicals disrupting cellular functions. Due to the importance of maintaining Fe concentrations within safe ranges in plant tissues, the whole process of Fe uptake into roots (i.e., the movement from roots to shoots, and storage and release within plant cells) is highly regulated

Fertilizing for Iron Deficiency

When inorganic Fe fertilizers are added to soil (e.g., ferric sulfate, ferrous sulfate, ferrous ammonium phosphate, ferrous ammonium sulfate, and oxides of Fe), they are rapidly converted to insoluble forms and provide minimal benefit for plant nutrition. Iron fertilizers protected with an organic chelate can be effectively applied to soils to correct plant deficiencies. For example, chelated fertilizers such as Fe-EDDHA and Fe EDTA have been used with reasonable effectiveness (Table 1), but their cost is often prohibitive for large-scale application. Foliar sprays containing Fe salts or chelates are effective at correcting plant Fe deficiencies during the growing season, but they may require repeated applications to prevent reoccurrence of deficiency.

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