Manganese

Introduction

Manganese (Mn) is one of nine essential micronutrients for plant growth. It is needed in chloroplast formation and photosynthesis, nitrogen metabolism, and synthesis of various enzymes. Most New York mineral soils contain adequate quantities of Mn for crop growth and Mn deficiency is not a common micronutrient problem in New York field crops. However, deficiencies can occur in high pH soils (or recently limed soils) and in organic (muck) soils. In this factsheet we describe the Mn cycle and Mn deficiency symptoms, and give guidance for Mn management for field crops.

Manganese cycle

Manganese in soils is present in three oxidation states: Mn^{+2}, Mn^{+3} and Mn^{+4} of which Mn^{+2} is the primary form in which Mn is absorbed by plants. Manganese becomes plant available after release of Mn^{+2} into the soil solution, Mn^{+2} transport to the root surface by mass flow and diffusion, followed by uptake into the root.

Soil conditions that impact Mn availability to plants include:

- pH: Mn can precipitate at high pH, lowering Mn availability so deficiencies are most likely to occur in high pH soils (calcareous soils or over-limed soils). Manganese is most available at soil pH levels of 5 to 6.5. At very low pH (below 5), Mn may become too available to plants, and lead to Mn accumulation and toxicity in plants.
- Organic matter: organic (muck) soils are more likely to show Mn deficiencies as Mn^{+2} is readily chelated by organic molecules which makes the Mn less available. With mucks, a pH above 6.5 could lead to Mn deficiency.
- Moisture and temperature: under dry soil conditions, the availability of Mn is reduced. In addition, cold and wet conditions cause Mn deficiency due to the combined effects of reduced mineralization of soil organic matter, reduced root growth, and reduced metabolic activity in roots affecting Mn uptake. Waterlogged soils may have excessively high soluble Mn because of chemical reduction of Mn oxides to soluble Mn^{2+}.
- Other nutrients and heavy metals: high amounts of copper (Cu), iron (Fe), nickel (Ni), and zinc (Zn) in soils may inhibit Mn uptake by plants and induce Mn deficiency.

Manganese deficiency

Field crops with a high Mn requirement include soybeans, wheat, barley, and oats. Corn has a medium Mn requirement. Manganese is highly immobile in the plant so Mn deficiency symptoms are first seen in the young leaves. A Mn deficiency is recognized by interveinal chlorosis (yellowing between the veins of the leaves) while the veins themselves remain dark green (Figure 1). Manganese deficiency looks similar to magnesium (Mg) deficiency but Mg deficiency occurs in older leaves. Manganese deficiency can co-exist with an iron deficiency and symptoms can easily be confused; both deficiencies show first in the younger leaves but iron deficiency shows sharp distinctions between veins and chlorotic areas while for Mn deficient plants, the distinction between veins and chlorotic areas is diffuse.

Figure 1: Manganese deficiency symptoms in corn and soybeans (Photos courtesy of Robert Lippert, Clemson University).

Although Mn is an essential nutrient for all crops, it can also be toxic present in excess. Although only a very small percentage of soils tested in NY are excessive in Mn, a Mn toxicity can occur on acidic and poorly drained soils. Manganese toxicity is recognizable by a darkening of leaf veins, usually on older foliage, and interveinal chlorosis with leaf cupping or necrotic blotching of foliage. In soybean, leaves are crinkled and cup down (Figure 2). Corn is tolerant while alfalfa, dry edible beans, and small grains are more sensitive to Mn toxicity.

Figure 2: Manganese toxicity in soybeans (Photo courtesy of Robert Lippert, Clemson University).

Manganese Soil and Tissue Testing

If a crop does not show a Mn deficiency, there is no need to apply Mn. Manganese availability is influenced by soil conditions (temperature and moisture) making it important to test both soil and tissue to determine a deficiency. The Cornell Morgan soil test for Mn is classified as normal when less than 100 lbs/acre or excess when exceeding 100 lbs/acre. Of almost 52,000 soil samples from New York State agricultural soils submitted to the Cornell Nutrient Analysis Laboratory in 2002-2006, only 3% tested excessive in Mn.

Tissue testing should be done on specific plant parts and at specific times in the growing cycle. For example, for soybeans, recently matured, trifoliate leaves (20-30 plants) should be collected before or during bloom. For corn, leaves below and opposite from the ear should be collected from tasseling to silking. Tissue test results below 20 ppm indicate a Mn deficiency while between 30 to 200 ppm is considered optimal and greater than 300 ppm may signal a toxicity problem.

Fertilizer and Management

Manganese fertilizer can be band-applied, or sprayed on the foliage. Broadcast application of Mn is not recommended because of high fixation potential of most Mn deficient soil. Foliar application of Mn is recommended when deficiency symptoms are visible and verified (tissue test), no band-application can take place, and Mn application can be combined with regular fungicide and insecticide sprays. Potential mineral sources are manganese sulfates, manganese chloride, or manganese oxides. Also used are chelated forms such as manganese ethylenediamine tetraacetate, manganese diethylene triamine pentaacetic acid, and Mn-lignosulfonate for foliar application. The optimum rate for foliar application is 1 to 2 lbs/acre while for soil banding of 3 to 5 lbs/acre is recommended.

In Summary

A Mn deficiency has seldom been observed on mineral soils in New York. Field crops with a high Mn requirement include soybeans, wheat, barley, and oats. Manganese deficiency is most likely on high organic matter (muck) soils and calcareous soils due to lack of Mn release into solution, as well as on some acid and sandy soils due to lack of a sufficient Mn pool. Soil and tissue testing can help identify Mn deficiencies or toxicities. Band application or foliar application of Mn fertilizer can eliminate Mn deficiency while broadcast application of Mn to soil is not cost-effective and therefore not recommended.

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For more information

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2010