MANGANESE FERTILITY IN SOYBEAN PRODUCTION

Manganese Fertility in Soybean Production

Crop Insights by Keith Diedrick, Area Agronomist

Summary

- Soybeans are more often deficient in manganese than in other micronutrients, and respond well to manganese fertilizers when deficient.
- Manganese is more likely to be deficient in sandy soils, dry soils, high organic matter soils, and soils with high pH levels.
- Fields with manganese deficiency are seldom affected uniformly. Manganese deficiency symptoms may also vary from field to field, and are strongly tied to soil properties.
- Plant tissue analysis is the best tool for confirming a manganese deficiency. Randomly select a number of plants, picking the youngest fully-opened trifoliate from each.
- To correct manganese deficiencies, a number of manganese sources may be used, with preference to chelated forms of manganese (as opposed to salt forms) supplied by foliar application.
- To avoid weed control efficacy and nutrient absorption issues when tankmixing with glyphosate:
  - Use the label-recommended rate of spray-grade ammonium sulfate (usually 8.5 to 17 lb per 100 gallons) in the carrier, and

- Add the products in the correct order: 1) water, 2) AMS, 3) glyphosate, 4) chelated manganese (EDTA preferred).

Essential Elements for Crop Production
Supplied by air and water: carbon, hydrogen, oxygen
Primary macronutrients: nitrogen, phosphorous, potassium
Secondary macronutrients: sulfur, calcium, magnesium
Micronutrients: boron, chlorine, copper, iron, **manganese**, molybdenum, zinc

Figure 1. Manganese deficient soybeans. Manganese is not very mobile in the plant, so newest leaves are most affected.

Introduction

Manganese (not to be confused with the macronutrient *magnesium*) is one of the 16 elements essential to plant growth and production. Since manganese is needed in relatively small amounts compared to elements such as nitrogen and potassium, manganese is considered a micronutrient.

Manganese has several very important roles in the plant, including functioning as an activator or cofactor of at least 35 enzymes. Manganese is part of the structure of an important antioxidant (superoxide dismutase) that protects plant cells by deactivating free radicals, which can destroy plant tissue. Manganese plays vital roles in photosynthesis, as a structural component of the photosystem II water-splitting protein. It also serves as electron storage and delivery to the chlorophyll reaction centers.

Manganese is sufficient in most soils to supply crop needs, but may be deficient in dry conditions, sandy soils, high organic matter soils (especially peat and muck), and soils with high pH. When deficient, manganese can be supplied by fertilizer in several forms, by foliar and soil-applied methods.

Of all micronutrients, manganese tends to be the most common deficiency noted in soybean production. Manganese deficiencies, however, tend to respond positively to remedial treatments of manganese (when they are timely). As with all nutrients, yield responses are only attainable when manganese is deficient and therefore limiting yield. This *Crop Insights* will describe manganese requirements, deficiency symptoms, soil and plant sampling, and fertilization practices in soybean production.

Chemical Properties and Availability of Manganese in the Soil

Manganese exists in a number of forms in the soil, including soil solution Mn^{2+}, exchangeable Mn^{2+}, organic compounds, various minerals, and as other ions. However, the only form known to be plant available is the manganese ion Mn^{2+} in soil solution. Manganese availability to plants largely depends on soil texture, organic matter, pH, and weather conditions.

Soil pH: Manganese is most soluble and therefore available to the plant at a pH of 5 to 7. In alkaline soils (pH above 7.0), manganese may form insoluble compounds, making it unavailable to the plant. For every increase of 1 pH unit, manganese availability decreases 100-fold. In very acidic soils, however, manganese can reach toxic levels. Liming soils to appropriate pH can help avoid this situation.

Soil organic matter: Organic matter and manganese ions will combine to form insoluble compounds that are not accessible by plant roots. This reaction is exacerbated by high soil pH.

Soil Aeration and Moisture: Available manganese is affected by soil aeration and moisture. Waterlogged and anaerobic (or “reducing”) environments are conducive to more Mn^{2+} in solution. In contrast, very dry soils tend to have less Mn^{2+} in soil solution. Additionally, low moisture conditions will slow the growth and activity of soil microbes that also cycle manganese in the soil.

Weather conditions: Hot and dry conditions result in less manganese in available form as they typically cause dry soils.

Other Nutrients: High levels of copper, zinc, and iron can reduce uptake of manganese. Conversely, acid-producing fertilizers including ammonium sulfate, MAP, and DAP can increase manganese availability. Potassium chloride (0-0-60 potash) also has the potential to increase plant uptake of manganese.

Manganese Deficiency Symptoms in Soybeans

Visual deficiency symptoms include interveinal chlorosis (yellowing between the veins) on the younger leaves, followed by necrosis (brown/black spots of dead tissue) and yield loss if the deficiency progresses.

Figure 2. Manganese deficient soybean plants. Uppermost (youngest) leaves show interveinal chlorosis while the veins remain green. (Photo courtesy of Ron Gehl, NC State University).

Areas of deficiencies will likely vary across the field, and since the availability of manganese is tied to soil factors, knowing the field's history over time can be helpful in diagnosis. Fields or field areas with a history of manganese deficiencies will be more likely to show deficiencies in future soybean crops.

Figure 3. Manganese deficiency on a muck soil near Lansing, MI. (Photo courtesy of Ron Gehl, NC State University.)

Soil and Plant Analysis for Manganese

Because yellowing of plants can be due to a number of factors (iron, potassium, or magnesium deficiency, herbicide or insect injury, soybean cyst nematode damage, poor nodulation, etc.), good scouting practices and tissue sampling are often needed to confirm a specific nutrient deficiency. For example, potassium deficiency causes leaf yellowing that may be confused with manganese deficiency symptoms (Figure 4). Though these symptoms may look the same from a distance, careful scouting could detect differences in the yellowing pattern. The treatments for these two deficiencies are very different – be sure to scout and diagnose carefully for proper treatment. Plant tissue analysis is the usual method to confirm a suspected manganese deficiency, as soil testing tends to be much less predictive.

Figure 4. Potassium deficiency in soybeans. Note the differences in the yellowing pattern compared to Figure 2. Photo courtesy of Robert Mullen, Ohio State University.

Plant Sampling

The standard plant sampling technique for soybeans is to take the newest trifoliate leaves that are fully opened (keeping in mind that manganese is not very mobile and new leaves will show deficiencies). Randomly sample plants to get a representative sample of the affected area, though consider a separate sample of non-affected plants to make a comparison. When sampling leaves, remove the petiole (or stem-like structure that holds the leaf to the soybean stem) so just leaf tissue is represented in the sample. Be sure to follow your diagnostic laboratory's specific sampling and shipping procedures.

Plant Tissue Test Interpretation / Fertilizer Recommendations

Typically, plant tissue contains from 20-500 parts per million (ppm) of manganese. A level of 21 or fewer ppm is generally considered deficient, though some recent research shows that deficiencies (and response to fertilizer) are sometimes noted at 30-40 ppm. Also, some varieties of soybeans seem to be more sensitive to manganese deficiencies than others. Since relatively small quantities are necessary for treatment, foliar applications of manganese could be used. Some fields with a known history of deficiencies (e.g., muck soils) may require multiple applications and soil amendments of manganese.

Manganese Fertilizer Sources and Application

Choosing a Source of Manganese

Generally, "blanket" application of any nutrient without confirmation of a deficiency is not recommended. **Applications of manganese to soybeans with sufficient manganese can result in toxic concentrations and yield loss**. Once a deficiency is identified and confirmed, a fertilizer source and method can then be determined. There are a few different fertilizer sources of manganese effective for correcting deficiencies. These sources can be grouped as:

- Inorganic products as salts and oxides - manganese sulfate, manganese chloride, and manganese oxide
- Organic chelates - Mn-EDTA, Mn-Glucoheptonate, Mn-Citric Acid, and others
- Organic non-chelates (natural organic complexes)

Table 1. Common manganese fertilizer sources.

Manganese Fertilizer **% Manganese**	**Comments**
Manganese sulfate ($MnSO_4 \cdot 4H_20$) ~ 26-28%	Suitable for soil or foliar application, though foliar is preferable to soil application. May chelate glyphosate in tankmix solution and lessen weed control efficacy.
Manganese chloride ($MnCl_2$) 17%	See above.
Manganese oxide (MnO) 41 – 68%	Low solubility. Must be finely ground to be effective in the soil. Not recommended for foliar use.
Synthetic manganese chelates (Mn-EDTA and others) 5 to 14%	Preferred foliar fertilizer source because of lower rates and decreased interactions with tankmix partners such as glypho-sate (EDTA seems to be the least detrimental). Not recommended for soil application.
Organic residues and manure 0.01 to 0.05%	Manure and other organic residues contain a number of micro-nutrients, including manganese.

Method of Application
Soil applications of manganese tend not to be very effective as broadcast applications compared to foliar treatments, as soil can render the treatment unavailable in a short period and may not be timely enough for remediating a deficiency in-season.

Foliar applications are the preferred method of supplying manganese to a growing soybean crop. Usually 0.2 to 0.5 pounds of manganese per acre is sufficient per application. If a grower is **not** tankmixing manganese with glyphosate, the manganese sulfate form will work as well as the chelated forms for foliar feeding, so cost per pound can be the deciding factor in product choice.

Special Considerations when Tankmixing Manganese with Glyphosate
Some growers may decide to include a manganese product with glyphosate for post-emergent weed control in glyphosate-tolerant soybeans, saving application costs for two

products. In the past, studies have shown that mixing glyphosate with micronutrients and other herbicides can cause antagonism, that is, loss of effectiveness in controlling weeds and reduced absorption of the nutrient. This is a result of “hard” water interacting with the glyphosate molecules. “Hard” water typically describes water containing a high level of metals, including the familiar calcium, magnesium, and iron found in well water, but also metal nutrients that might be added for fertilizer purposes (like manganese). Glyphosate will interact with (or chelate) these metals, and reduce the effectiveness of weed control and nutrient absorption. In order to avoid this interaction, a grower can either:

1) Spray the products separately (glyphosate application followed by manganese 7 to 10 days later), or

2) Use spray-grade ammonium sulfate (AMS) in the carrier for tankmixing with a chelated form of manganese (EDTA preferred).

Ammonium sulfate is used to “soften” the carrier water before glyphosate and manganese are added to the tank. Refer to the glyphosate label for the appropriate amount of AMS (usually 8.5 to 17 pounds per 100 gallons of carrier). Manganese EDTA is the form of manganese that is least antagonistic when tankmixed with glyphosate.

When mixing products for application, the mixing order is important to assure that the carrier is “conditioned” before the potentially-chelating products are added to the tank. Add products to the tank in this order:

- **Step 1**. Add water
- **Step 2**. Add AMS
- **Step 3**. Add glyphosate
- **Step 4**. Add manganese EDTA

As with any product, carefully read all label directions before proceeding.

References and Further Reading

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