# Manganese

AGRONOMY

Manganese (Mn) is often overlooked as an important micronutrient, yet manganese crop deficiencies are as prevalent as iron deficiencies and many times occur together. Managing manganese nutrition is more difficult than zinc or copper because of the many soil reactions.

## Role and Dificiency Symptoms

In 1922, manganese was discovered as an essential nutrient for plant growth. It is taken up by the plant in three cation forms: $Mn^{2+}$, $Mn^{3+}$, and $Mn^{4+}$, with $Mn^{2+}$ being the most predominant. It is necessary for photosynthesis, production of chlorophyll, and activation of many other enzymes. Manganese is immobile in the plant; therefore, visual deficiency symptoms (i.e., interveinal yellowing) become more severe with newer leaf growth.

## Factor's Affecting Manganese Availability

**Soil pH and oxygen** – manganese availability are very sensitive to soil pH and oxygen. Soil oxygen is affected by any factor that stimulates microbial consumption of soil oxygen or factors that reduce the amount of oxygen/air exchange between the soil and the atmosphere. The relative effects of pH and soil oxygen on manganese availability are shown in Table 1.

Table 1. Soil Oxygen Concentration

| pH | High | Normal | Low |
|---|---|---|---|
| 5.0 | 1,000 | 1,000,000 | 1,000,000,000 |
| 6.0 | 10 | 10,000 | 10,000, 000 |
| 7.0 | 0.10 | 100 | 100,000 |
| 8.0 | 0.0010 | 1 | 1,000 |

Manganese availability can be increased by acidic soil, poorly drained soil, and/or residue which stimulate microbial-activity consumption of soil oxygen. Manganese toxicity is most severe in acid-peat bogs or acidic soil (ph < 5.0). On the other end of the spectrum, well-aerated (sandy-textured) alkaline soil has a great chance of being manganese deficient. Manganese deficiencies are less common in medium-textured soil, and are less severe because of the reduced aeration.

**Soil temperature and moisture** – cold soil temperatures cause more severe manganese deficiencies. Cold, wet soil reduces root growth, manganese uptake, and manganese solubility. A research study showed that a temperature increase of 15°F caused manganese to increase 54 percent, zinc 15 percent, iron 30 percent and copper 24 percent. Plant uptake of most micronutrients is reduced in cold, wet soil but none more everely than manganese.

## Diagnosing Deficiencies

DTPA is a chelate most commonly used for extracting manganese. The critical soil-test level for DTPA-extractable manganese is around 2.0 ppm. Soil with less than 2.0 ppm would be considered deficient. The interpretation of the manganese soil test can be improved when the other factors that affect manganese availability are factored into the equation. For example, a soil test level of 2.0 ppm would probably be adequate for a neutral, medium-textured soil with more than two percent organic matter. However, a 2.0 ppm soil-test level would result in a severe manganese deficiency if the soil is alkaline sand with less than one percent organic matter.

Since there are so many factors affecting manganese availability, a plant tissue sample is a great diagnostic tool to assess your soil fertility program. Plant tissue

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analysis is especially helpful in managing micronutrient deficiencies, since most of the visual symptoms look alike (e.g., interveinal yellowing of new plant growth). For most plants, the critical plant-tissue manganese level is 25 to 35 ppm. Also, the ratio of iron to manganese in the plant is a good indicator, because iron and manganese are interrelated in their metabolic functions. In a healthy plant, the iron/manganese ratio should range from 1.5 to 2.5. Below this range would indicate manganese toxicity and iron deficiency, and above 2.5 would suggest the toxic effects of iron suppressing manganese uptake.

## Recommendations

Soil-test manganese levels cannot be built up. Therefore, annual applications are the only way to correct manganese deficiencies. A suggested corrective manganese application would be 10 lbs./acre of band-applied manganese sulfate in combination with 40 lbs. of nitrogen from ammonium sulfate and 50 lbs. of $P_2O_5$ from MAP or 10-34-0. The concept behind this recommendation is that acidifying the band will maintain manganese fertilizer availability and perhaps even turn unavailable manganese (already in the soil) into available manganese. Fertilization with phosphorous immediately acidifies the soil while ammonium fertilization slowly increases acidity as nitrification progresses. In this case, broadcast fertilization would be ineffective. For severe manganese deficiencies, a combination of soil and foliar application rates of 0.10 to 0.15 lbs./acre applied manganese sulfate or chelate (single or multiple applications) will help correct deficiencies.

## Conclusion

Manganese is a micronutrient in which toxicities and deficiencies can occur. Manganese is extremely sensitive to soil pH, soil oxygen, and temperature. Deficiencies are best corrected with band-applied fertilizers in combination with acid-forming fertilizers such as MAP and ammonium sulfate.