Micronutrients in Mississippi Soils & Plant Nutrition

Plants require very small amounts of certain essential elements. These micronutrients are often called minor or trace elements. These nutrients — boron (B), zinc (Zn), molybdenum (Mo), iron (Fe), manganese (Mn), copper (Cu), chlorine (Cl), and nickel (Ni) — are needed for plant growth, development, and reproduction. Plants obtain these nutrients by uptake from the soil (Hänsch and Mendel, 2009; Tripathi et al., 2015). Most Mississippi soils have sufficient levels of these nutrients occur naturally and are ideal for crop production.

Micronutrient availability in soils is dynamic and greatly influenced by soil pH. Most micronutrients are moderately available for plants in soils with pH 6 to 6.5. Zinc, iron, manganese, copper, and boron decrease in solubility and availability, whereas molybdenum solubility and availability increase through the pH 4 to 7 range.

Higher concentrations of Cu, Fe, Mn, Ni, and Zn are potentially toxic to plant life in certain circumstances (Edelstein and Ben-Hur, 2018). For example, Mn and aluminum (not an essential nutrient) are quite soluble in severely acidic soils (pH below 5) and are often toxic to growing plants. Conversely, molybdenum is insoluble in low pH soils, and deficiencies often occur. At a pH of 5 to 5.5, certain plants may experience both manganese toxicity and molybdenum deficiency.

Soil pH values over 7 reduce B, Zn, Fe, and Mn bioavailability and lead to deficiencies. These high pH values can occur naturally, as in some soils of the Blackland Prairie, or in other unique situations. They are more likely to be present in early spring under cool, wet conditions.

Boron (B)

Boron is important in many plant processes, including protein synthesis, translocation of nutrients, respiration, and metabolism of plant hormones. More than 90 percent of plant boron is in the cell walls. It is non-mobile in plants, and a continuous supply is needed throughout the growing season (Hänsch and Mendel, 2009). It is unique among the essential plant growth elements in that the B form taken up by plants is uncharged and not in ionic form (Brdar-Jokanovic, 2020; Camacho-Cristóbal et al., 2008).

Boron is more likely to be deficient under dry conditions on low-exchange capacity, well-limed soils. Deficiency symptoms include chlorosis of young leaves, death of the terminal buds, and initiation of secondary lateral buds. In cotton, plants are stunted, fruiting is reduced, leaves stay green, and plants remain vegetative past the normal time of maturity. Dark rings appear on leaf petioles and some leaves may become deformed.

Boron Recommendations

Primary sources of boron are fertilizers that contain fertilizer borates such as sodium borates (14–20 percent B), and Solubor (20.5 percent B) . Excessive rates of boron can be toxic to seeds or seedlings. Damage to stands can occur at fairly low rates, especially when banded near the seed drill.

- Cotton: 0.3–0.5 lb/A
- Alfalfa: 1–3 lb/A
- Clover: 0.5–1 lb/A (especially for seed production)
- Kale and cole crops: 2–4 lb/A
- Peanuts: ½ lb/A (on non-Delta soils)

Zinc (Zn)

Zinc is important in over 200 plant enzyme systems for protein synthesis and energy production. It maintains the structural integrity of biomembranes and has functional roles in the plant. It is involved in the synthesis of indoleacetic acid (IAA), an important plant growth regulator. It is important in seed development and internode elongation.

Zinc deficiencies may occur on high pH soils with sandy to sandy-loam textures. Other contributing factors for plant Zn deficiencies include low soil organic matter content or compacted soils (Noulas et al., 2018).

Corn and pecans often show signs of zinc deficiency. Zinc-deficient leaves show interveinal chlorosis, particularly between the margin and midrib, which creates a striping effect. Because zinc plays a major role in internode elongation, zinc deficiency will cause plants to be stunted. Stunting, resetting, and pale green leaves are typical deficiency symptoms in pecans (DalCorso et al., 2014).

Common Zinc Sources

Zinc sulfate: 36 percent Zn, a soluble source
Zinc oxide: 70–80 percent Zn, a non-soluble source
Zinc chelates: 10 percent Zn, a soluble source
Corn fertilizers containing zinc: 1–2 percent Zn

Zinc Recommendations

Corn: 2–3 lb/A (if conditions warrant)

Pecans: 1 lb zinc sulfate per tree per inch of diameter or an equivalent amount from other soluble sources. This amount is applied to the soil. About ½ lb sprayed on the foliage in early spring has also been found effective. Soil application is preferred as foliar sprays can cause the burning of young, tender leaves. Chelates are also very effective but more expensive.

Molybdenum (Mo)

Molybdenum is vital to nitrogen assimilation as a component of the enzyme nitrogenase. It is necessary for nitrogen-fixation by Rhizobia bacteria in legumes. Molybdenum also affects sulfur metabolism, phytohormone biosynthesis, and stress reactions.

Soil pH is the predominant factor affecting Mo bioavailability in soils. It is tightly absorbed in very low pH soils and virtually not absorbed at pH nearing 8.0 (Goldberg and Forster, 1998). Therefore, Mo is recommended for soybeans on Delta soils with a pH of 5.5 or below and elsewhere on all soils except for the high-pH soils of the Blackland Prairie. A seed treatment with ½ ounce sodium molybdate per bushel of planting seed is recommended. Other legumes may respond to seed treatments with molybdenum. No general recommendation is currently made.

General deficiency symptoms are stunting and pale green color. These symptoms resemble those of nitrogen deficiency because of molybdenum's role in nitrogen use by plants. Leaves may be pale and scorched, cupped, or rolled. The leaves may also appear thick or brittle.

Common Molybdenum Supplements

- Sodium molybdate: 38 percent Mo
- Ammonium molybdate: 41 percent Mo

Iron (Fe)

Iron is necessary to form chlorophyll in plant cells. It is necessary in processes such as photosynthesis, respiration, symbiotic nitrogen fixation, hormone biosynthesis, and pathogen defense.

Iron deficiency chlorosis in soybeans is an issue on Mississippi Blackland Prairie soils with high pH levels. Iron solubility is very low in these soils, and other soil chemical factors hinder plant-mediated adoption mechanisms, particularly for dicot species such as soybeans (Gamble et al., 2014).

Deficiency symptoms reflect iron's role in chlorophyll production and include interveinal chlorosis of young leaves, with a sharp distinction between the veins and other areas of the leaf. The entire leaf will become whitish-yellow as the deficiency develops and then die. Plant growth is slow.

No general recommendations are made, but materials such as iron sulfate, which is soluble, or iron chelates are generally used as a soil or foliar application when specific deficiencies occur. Management options such as planting less susceptible, iron-efficient cultivars should be used in high pH soils (Helms et al., 2010).

Manganese (Mn)

Manganese is a key component necessary for photosynthesis in higher plants. It is an enzyme cofactor or a catalyst. While needed in minute amounts by plants, it is just as critical as other nutrients. Besides photosynthesis, Mn plays roles in plant respiration, pathogen defense, and phytohormone signaling (Alejandro et al., 2020).

Soil-related Mn deficiency can be a problem in well-aerated, high pH soils; however, it has seldom been an issue in Mississippi.

Conversely, Mn toxicity potentially is an issue in acid soils throughout most of the state because the bioavailability of Mn increases as pH decreases. Toxicity is seen in cotton and soybeans grown on soils with a pH of 5.3 and lower. No specific recommendations for the nutrient are made; however sound soil testing and the liming program should be followed.

Copper (Cu)

Copper is essential to plant growth for photosynthesis, nitrogen and carbon metabolism, and cell wall synthesis. Copper can become toxic in the plant through enhancing certain reactions that can damage proteins and other molecules. It can decrease yields, chlorophyll synthesis, and overall productivity (Alengebawy et al., 2021).

Copper deficiency symptoms are stunting plants, chlorosis in younger leaves, dieback of terminal buds in trees, wilting, delayed maturity, and death of leaf tips. Deficiencies seldom occur in Mississippi. No recommendations are currently made.

Chlorine (Cl)

Chlorine is a mobile anion in plants, so most of its functions are related to electrical charge balance. It is abundant in most soils, but chlorine deficiencies have been found in wheat in the northern Great Plains, in sandy soils with high rainfall, and in artificially induced experiments. No deficiency symptoms or need for application of chlorine has been identified in crops grown in Mississippi.

Nickel (Ni)

Nickel was reported as an essential nutrient in the early 1980s for some enzymes involved in seed germination; thus it has roles in seedling growth and development. Subsequent work has found Ni in more enzymes, and it appears to be essential in the nitrogen cycle (Shahzad et al., 2018). However, high Ni concentrations in soils are problematic for plants (Kumar et al., 2021; Shahzad et al., 2018).

Deficiency symptoms include poor seed germination, chlorosis, and interveinal chlorosis in young leaves that move to tissue death. Nickel deficiency has not been identified in Mississippi crops.

Regarding Visual Field Diagnosis for All Nutrients

Visual diagnosis is imprecise and only should be used as a first clue for determining potential plant nutrition issues, because:

- Many symptoms have similar appearances,
- multiple nutrient issues can manifest at the same time,
- symptoms can vary between species, or
- 'false' symptoms may occur.

Soil or plant tissue testing should be used to confirm or deny suspected plant nutrient related problems (McCauley et al., 2009). Information about soil and plant tissue sampling and analysis are available at *http://extension.msstate.edu/agriculture/soils/soil-testing* or your local Mississippi State University Extension.

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