Module 7: Micronutrient Management

To view the chapter for this topic click here.
Introduction

- Micronutrients are those essential elements required only in small quantities for plant growth and reproduction.

- Seven essential elements considered micronutrients and form taken up by plants (in brackets)
  - boron (B) – [B(OH)$_3$ and B(OH)$_4$-]
  - copper (Cu) – [Cu$^{2+}$]
  - chlorine (Cl) – [Cl$^-$]
  - iron (Fe) – [Fe$^{2+}$ and Fe$^{3+}$]
  - manganese (Mn) – [Mn$^{2+}$]
  - molybdenum (Mo) – [MoO$_4^{2-}$]
  - zinc (Zn) – [Zn$^{2+}$]

- While the micronutrient amounts needed are small, without them plants would not grow and reproduce and a deficiency can have dramatic impact on growth and yield.
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Introduction

• Most important sources of micronutrients:
  o those naturally present in soil
  o impurities in fertilizers and pesticides

• In some areas, deficiencies of micronutrients have been diagnosed frequently and producers are taking a closer look at their general availability.

• When micronutrients become a limiting factor, other inputs such as seed, water, fertilizer, etc. are less efficiently utilized.
Micronutrient uptake by crops

- Total micronutrient uptake is typically quite small compared to macro and secondary nutrients.

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Corn</th>
<th>Soybean</th>
<th>Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.16</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Cu</td>
<td>0.1</td>
<td>0.1</td>
<td>0.06</td>
</tr>
<tr>
<td>Fe</td>
<td>1.9</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Mn</td>
<td>0.3</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Mo</td>
<td>0.008</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Zn</td>
<td>0.27</td>
<td>0.2</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Source: University of Purdue Extension publication AY-239.
Boron

- **Function of B:**
  - cell wall formation
  - sugar transport in plants
  - flower retention
  - pollen formation
  - germination

- **Boron deficiency symptoms:**
  - first appear at the growing points
  - stunting bushy appearance near the top of the plant
  - yellowing of newer leaves
  - barren ears due to poor pollination
  - hollow stems and fruit (hollow heart)
  - brittle, discolored leaves and loss of fruiting bodies
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Boron deficiencies

- Are found mainly:
  - sandy soils with high pH
  - in regions of highly weathered soils
  - in soils with low organic matter
  - during drought periods when root activity is restricted in the upper profile

- Crops sensitive to B deficiency: alfalfa, canola, sugar beet, sunflower.

- Boron fertilizer application can correct deficiencies but the application rate, method, crop and crop rotation should be carefully considered because toxicity can easily occur.

- Application in the seed furrow is not recommended because of toxicity potential.
Copper Management

- **Functions of Cu:**
  - component of enzymes
  - required for lignin synthesis
  - strengths cell wall and prevents wilting

- **Copper deficiency symptoms:**
  - stunting of plants
  - reduced nodulation and N fixation in legumes
  - delayed flowering and maturity
  - pollen sterility
  - dieback of leaf tips, stems, and twigs
  - yellowing of leaves
  - pale green leaves that wither easily
Copper Deficiencies

- Are mainly found:
  - on organic soils
  - sandy soils
  - with pH above 7.5
  - with excessive P and Fe levels
  - in cool and wet conditions

- Crops sensitive to Cu deficiency: corn, wheat, and oat.

- Broadcast application of Cu mixed with N, P, or K fertilizers is a common application method.

- Since Cu is slowly converted to unavailable forms in most soils, an application can correct deficiencies for several years and total application should be monitored.
Iron

• Functions of Fe:
  o production of chlorophyll in plants
  o component of many enzymes
  o associated with energy transfer, N transformations, N fixation, and lignin formation

• Iron deficiency symptoms:
  o yellowing of leaves due to low levels of chlorophyll (interveinal chlorosis)
  o leaves may turn completely yellow or almost white
  o if severe deficiency, leaves turn brown and tattered as leaf tissues die
Iron Deficiencies

- Are found mainly in:
  - high pH soils
  - sandy soils
  - organic soils
  - cool, wet conditions
  - poorly aerated or compacted soils

- Crops sensitive to Fe deficiency: soybean and grain sorghum.

- Foliar or planter-band applications are the most effective Fe fertilization methods.

- Variety selection is typically a more effective solution than Fe fertilization.
Manganese

- Functions of Mn:
  - involved in enzyme activation for plant
  - related to nitrogen metabolism
  - plays a role in the synthesis of various compounds

- Manganese deficiency symptoms:
  - interveinal chlorosis (similar to Fe)
  - brown necrotic spots may appear
  - delayed maturity is a deficiency symptom in some species
  - white or gray spots on leaves of some cereal crops
Manganese Deficiencies

- Mainly occur:
  - on organic soils with pH above 5.8
  - high pH mineral soils with free carbonates
  - soils with poor drainage and high organic matter levels
  - saturated conditions with poor aeration
  - sandy soils

- Crops sensitive to Mn deficiency: soybean, oat, and wheat.

- Foliar or band applications often are the most effective Mn fertilization method.

- Foliar applications of Mn sulfate are commonly used, but use of chelates is becoming more common.
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**Molybdenum**

- Functions of Mo:
  - involved in enzyme systems related to symbiotic N fixation in legumes
  - related to N and S metabolism, and protein synthesis
  - has a significant effect on pollen formation

- Molybdenum deficiency symptoms:
  - in legumes are similar to N deficiency
  - are not confined to the youngest leaves because Mo is mobile in plants
  - irregular leaf blade formation known as whiptail
  - interveinal mottling
  - marginal chlorosis of older leaves
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Molybdenum Deficiencies

- Are mainly found in:
  - very acid soils
  - highly weathering conditions
  - sandy soils
  - humid regions

- Molybdenum availability and uptake by plants increases with increasing soil pH, which is the opposite of other micronutrients.

- Liming acidic soils is the most practical and cost-effective way of correcting Mo deficiency.

- If fertilization is needed, a low Mo rate usually is applied banded with the planter or as a seed treatment.
Zinc

- Functions of Zn:
  - essential component of enzymes
  - important for energy production, carbohydrate metabolism, protein synthesis
  - growth regulation

- Zinc deficiency symptoms:
  - occur mainly in new growth early in the season since it is not mobile in plants
  - short internodes
  - decrease in leaf size
  - broad band of bleached tissue that goes across leaf veins
Zinc Deficiencies

- Zinc deficiencies are mainly found:
  - on sandy soils low in organic matter
  - eroded soils with exposed high pH subsoil
  - with severe root growth restrictions (cold, wet springs)
  - organic soils
  - high P fertilizer rates

- Crops sensitive to Zn deficiency: corn, grain sorghum, and soybean.

- Application to the soil is a common method of applying Zn fertilizers.
Chlorine (Chloride)

- Importance:
  - osmotic functions within the plant (i.e., stomatal opening/closing)
  - electrical charge balance in several physiological functions
  - decreasing the incidence of various diseases

- Chloride deficiency symptoms:
  - wilting, restricted or highly branched root systems (cereal crops)
  - more susceptibility to diseases
Chloride Deficiencies

- Occur mainly in:
  - sandy soils in humid regions
  - soils derived from low chloride Cl\(^-\) containing parent materials.

- Crops sensitive to chloride Cl\(^-\) deficiency: wheat, potato, and barley, but a few crops (like tobacco) are very sensitive to high chloride Cl\(^-\) levels.

- There are few regions with chloride Cl\(^-\) deficiency, mainly because chloride Cl\(^-\) is applied to soils with KCl, the predominantly used K fertilizer.

- In regions with naturally high available soil K, no chloride Cl\(^-\) containing K fertilizer is normally applied so chloride Cl\(^-\) deficiency is more common.
Soil Sampling and Testing

- Soil tests should be calibrated for a particular region, soil, nutrient, and crop.

- The reliability of most micronutrient soil tests is in general lower compared to other tests.

- Some soils have higher levels of micronutrients in the subsoil, which eliminates the response to their addition.

- Confirmation of a deficiency with trial nutrient application, tissue testing, and visual symptoms is helpful.
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Tissue Sampling and Testing

- Plant tissue tests can aid in determining if a particular nutrient is responsible for poor crop growth.

- When a deficiency is detected by tissue testing, a reduction in yield due to restricted crop growth has likely already occurred.

- Plant tissue tests must be also calibrated with field fertilization response trials.

- Calibration of tissue tests is more complex than for soil tests.

- Special care is required in taking plant tissue samples, including soil contamination.

- Tissue test interpretation should be based on calibrations with yield response for:
  - specific crops
  - plant part sampled
  - stage of plant growth
## Micronutrient Fertilizer Sources

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Fertilizer Name</th>
<th>Formula</th>
<th>Nutrient %</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Sodium tetraborate</td>
<td>Na$_2$B$_4$O$_7$•5H$_2$O</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Boric acid</td>
<td>H$_3$BO$_3$</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Solubor</td>
<td>Na$_2$B$<em>8$O$</em>{13}$•4H$_2$O</td>
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</tr>
<tr>
<td>Cl</td>
<td>Potassium chloride</td>
<td>KCl</td>
<td>47</td>
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<tr>
<td>Cu</td>
<td>Copper sulfate</td>
<td>CuSO$_4$•5H$_2$O</td>
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</tr>
<tr>
<td></td>
<td>Copper chelates</td>
<td>Various</td>
<td>Varies</td>
</tr>
<tr>
<td>Fe</td>
<td>Ferrous sulfate</td>
<td>FeSO$_4$•7H$_2$O</td>
<td>20</td>
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<tr>
<td></td>
<td>Ferric sulfate</td>
<td>Fe$_2$(SO$_4$)$_3$•4H$_2$O</td>
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<tr>
<td></td>
<td>Iron chelates</td>
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<tr>
<td>Mn</td>
<td>Manganese sulfate</td>
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<td></td>
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<tr>
<td>Mo</td>
<td>Ammonium molybdate</td>
<td>(NH$_4$)$_2$MoO$_4$</td>
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<tr>
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<td>Sodium molybdate</td>
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<tr>
<td>Zn</td>
<td>Zinc sulfate</td>
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<td></td>
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<tr>
<td></td>
<td>Zinc chelates</td>
<td>Various</td>
<td>Varies</td>
</tr>
</tbody>
</table>
Recommended Practices for Micronutrient Management

• Ensure that poor crop growth in a field or portion of a field is not the result of other factors.

• Determine if a micronutrient deficiency has been identified before in a particular crop or soil type.

• Examine the affected crop for known specific micronutrient deficiency symptoms.

• Take separate soil and plant tissue samples from affected and unaffected areas for complete analysis.
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Recommended Practices for Micronutrient Management

- If most indications point to a micronutrient deficiency, apply the micronutrient to a specific affected area to observe results and compare with non-treated areas.

- In choosing a micronutrient fertilizer, consider the solubility, safety concerning damage to seedlings or foliage, and application method such as soil or foliar.

- If a micronutrient fertilizer is applied with the seed, in bands, sprayed onto foliage, or from a chelated material, the application rates typically would be lower than with broadcast or non-chelated material applications.

- Consider that other crop inputs such as pesticides, lime, or manure can supply micronutrients or may affect the availability of micronutrients in the soil.