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) – [Cu^{-}]
  - 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.

Introduction

- Most important sources of micronutrients:
  - those naturally present in soil
  - 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.

Micronutrient	Corn	Soybean	Alfalfa
	150 bu	60 bu	6 ton
	---------- lb/acre ----------		
B	0.16	0.1	0.3
Cu	0.1	0.1	0.06
Fe	1.9	1.7	1.8
Mn	0.3	0.6	0.6
Mo	0.008	0.01	0.02
Zn	0.27	0.2	0.24
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

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

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

- Iron deficiency symptoms:
  - yellowing of leaves due to low levels of chlorophyll (interveinal chlorosis)
  - leaves may turn completely yellow or almost white
  - 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.

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

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.

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

Micronutrient	Fertilizer Name	Formula	Nutrient %
B	Sodium tetraborate	$Na_2B_4O_7 \cdot 5H_20$	14
	Boric acid	H_3BO_3	17
	Solubor	$Na_2B_8O_{13} \cdot 4H_2O$	20
Cl	Potassium chloride	KCl	47
Cu	Copper sulfate	$CuSO_4 \cdot 5H_20$	25
	Copper chelates	Various	Varies
Fe	Ferrous sulfate	$FeSO_4 \cdot 7H_20$	20
	Ferric sulfate	$Fe_2(SO_4)_3 \cdot 4H_2O$	23
	Iron chelates	Various	Varies
Mn	Manganese sulfate	$MnSO_4 \cdot 3H_2O$	27
	Manganese chelates	Various	Varies
Mo	Ammonium molybdate	$(NH_4)_2MoO_4$	49
	Sodium molybdate	$Na_2MoO_4 \cdot 2H_2O$	39
Zn	Zinc sulfate	$ZnSO_4 \cdot H_2O$	36
	Zinc oxide	ZnO	78
	Zinc-ammonia complex	$ZnSO_4 \cdot NH_3$	10
	Zinc chelates	Various	Varies

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.

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.