Animal, Plant & Soil Science

D3-7

Characteristics and Sources of Secondary Nutrients and Micronutrients

Interest Approach

- Obtain samples of minerals that serve as sources of calcium, magnesium, and sulfur and allow students to inspect them. Ask students if they can identify the minerals and their value to agriculture.

Objectives

- 1 **Identify the forms of calcium, magnesium, and sulfur in soil and identify their fertilizer sources.**
- 2 **Identify the fertilizer sources of micronutrients.**
- 3 **Identify and describe symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients.**

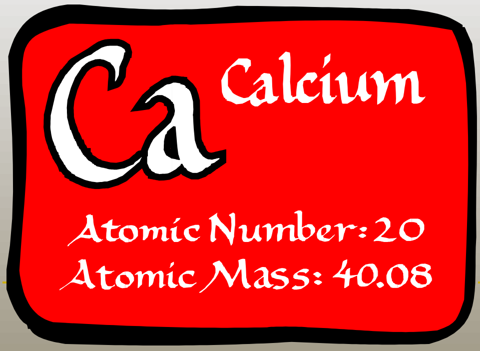
Terms

- calcite
- chelates
- chlorosis
- dolomitic limestone
- frits
- gypsum
- necrotic
- salts

What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

- I. Calcium, magnesium, and sulfur are considered to be secondary nutrients. However, they hold great importance to plant growth and development.

- A. Calcium is not naturally found in its elemental state. Instead, it occurs most commonly as calcite, dolomite, and gypsum minerals in sedimentary rocks.



What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

- 1. ***Calcite*** ($CaCO_3$) is one of the most widely distributed minerals on earth. It is a component of limestone (31% Ca).
- 2. Dolomite is a sedimentary rock consisting of $CaMg(CO_3)_2$. Limestone that is partially replaced by dolomite is called ***dolomitic limestone*** (21% Ca).

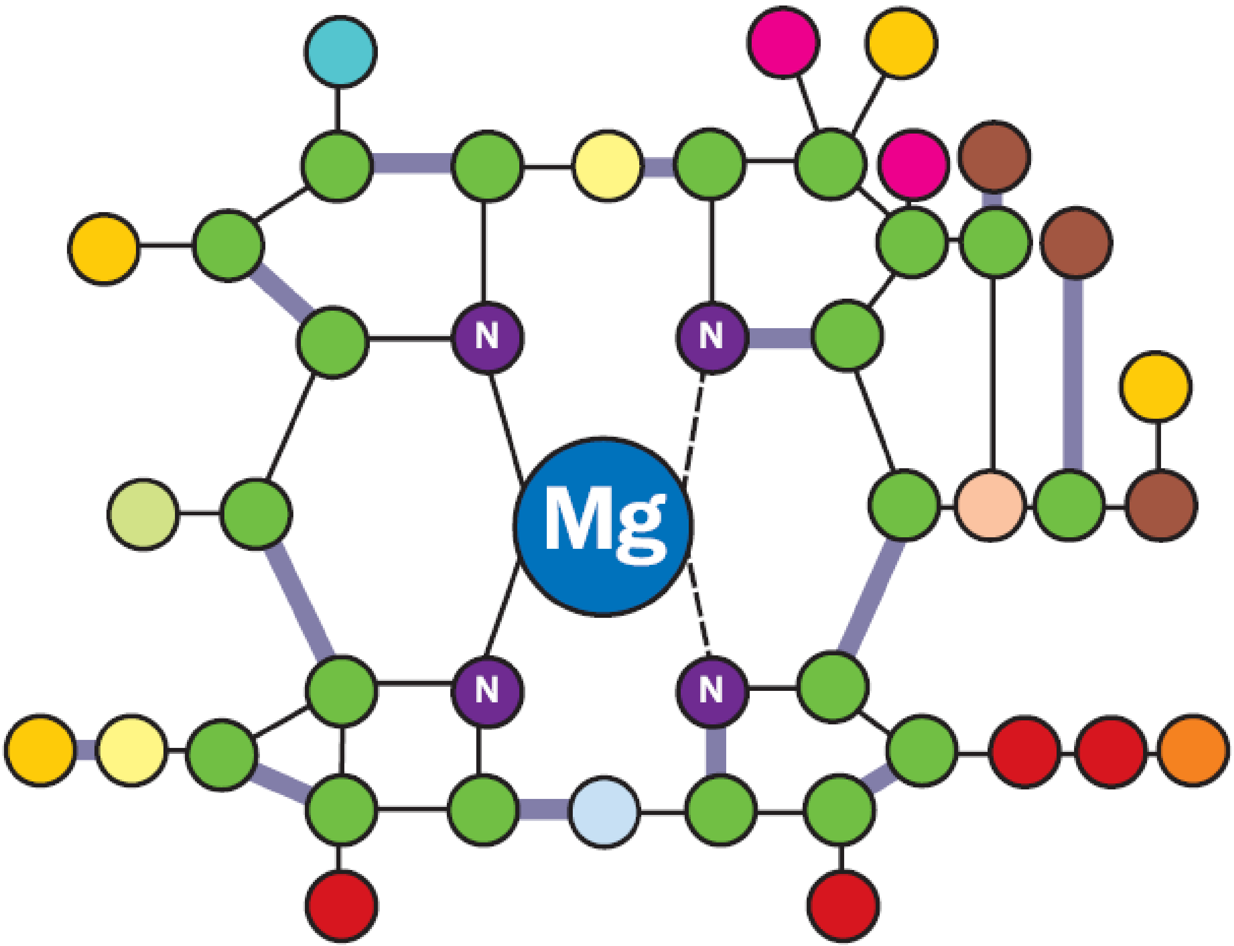
What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

- 3. ***Gypsum*** (22% Ca) is a common mineral consisting of calcium sulfate dihydrate (CaSO4 2H2O). It is very soft.
- 4. Calcium in the form of Ca2+ is an exchangeable component of the soil solution. Some fertilizers, such as ammonium, displace calcium from the cation exchange complex and increase leaching of the nutrient.

What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

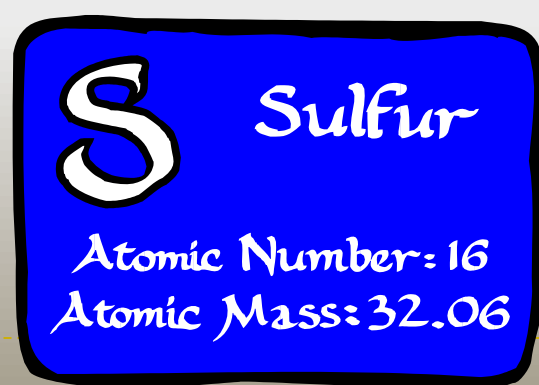
- B. Magnesium makes up about 2 percent of the earth's crust. The free element is not found in nature. However, magnesium is soluble in water, providing the magnesium ion Mg2+. The main sources of magnesium include dolomitic limestone (11% Mg); magnesium sulfate, or Epsom salts (16% Mg); and magnesium oxide (45% Mg).

MAGNESIUM IS THE CENTRAL ATOM IN THE CHLOROPHYLL MOLECULE



What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

- C. Sulfur can be found in nature as the pure element or as sulfate (SO_4^{2-}) and sulfides (S^{2-}) minerals. Sulfur can be found near volcanoes and hot springs. It is widely distributed in the forms of iron pyrites, galena, sphalerite, cinnabar, stibnite, gypsum, Epsom salts, celestite, and barite.



What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?

- 1. Sources of sulfur include ammonium sulfate (23% S), calcium sulfate (15% S), magnesium sulfate (14% S), potassium sulfate (17% S), single superphosphate (14% S), and elemental sulfur (30–99% S).
- 2. Calcium sulfate and magnesium sulfate may be applied to the soil without influencing the soil pH. Heavy applications of ammonium sulfate decrease soil pH.

What are the fertilizer sources of micronutrients?

- II. A deficiency of any of the micronutrients may adversely affect plant growth and development. Nutrient demands for micronutrients vary with the plant.

- A. A number of factors, including soil pH, soil texture, soil moisture, soil temperature, and micronutrient interaction, affect micronutrient availability.

What are the fertilizer sources of micronutrients?

- 1. Soil pH impacts the availability of all micronutrients, with the exception of molybdenum. All the micronutrients (except molybdenum) become less available to plants as the soil pH becomes less acidic.

What are the fertilizer sources of micronutrients?

- 2. Sandy soils have low cation exchange capacity and, therefore, are poor at holding micronutrients for plant use. Organic soils also have low micronutrient content. Mineral soils with significant clay content have good cation exchange capacity and tend to provide necessary micronutrients.

What are the fertilizer sources of micronutrients?

- 3. Soil moisture influences the rate of leaching. Wet soils cause the reduction of iron, copper, and manganese to forms that are easily leached from the soil. In some areas, boron becomes deficient in dry soils.

What are the fertilizer sources of micronutrients?

- 4. Soil temperature influences the absorption of all nutrients. Plants are less able to absorb nutrients in cold soil. The availability of zinc, in particular, decreases as soil temperatures drop.

What are the fertilizer sources of micronutrients?

- 5. Micronutrient availability is influenced by interactions between micronutrients and other nutrients within the soil. For instance, excess iron can limit the availability of manganese and copper, while excess manganese and copper can restrict iron availability. Similarly, high phosphorus levels can reduce the uptake of zinc.

What are the fertilizer sources of micronutrients?

- B. Micronutrient sources include salts, chelates, and frits.

- 1. ***Salts***, such as sulfates, chlorides, and nitrates, are the most common source of micronutrients. They are sold in crystalline or granular form.

What are the fertilizer sources of micronutrients?

- 2. ***Chelates*** are materials consisting of a micronutrient, such as copper, iron, manganese, or zinc, that is incorporated into an organic molecule. The chelated micronutrient is held in the organic molecule, safe from soil fixation. Synthetic inorganic chelates are also available. An effective chelate is one in which the rate of substitution of the chelated micronutrient for other cations in the soil is quite low. The low rate of substitution helps to maintain the applied micronutrient in chelated form.

What are the fertilizer sources of micronutrients?

- 3. ***Frits*** are glassy products. Micronutrient concentrations vary from 2 to 25 percent, and more than one micronutrient may be included in a fritted product. Frits have a limited use. Generally, they are applied only on sandy soils in regions of high rainfall where leaching occurs. Frits are more appropriate for maintenance programs than for correcting severe micronutrient deficiencies.

What are the fertilizer sources of micronutrients?

- C. Micronutrients may be supplied to plants through a number of fertilizer sources.

- 1. Iron fertilizer sources include iron sulfates (19–23% Fe), iron oxides (69–73% Fe), iron ammonium sulfate (14% Fe), iron ammonium polyphosphate (22% Fe), and iron chelates (5–14% Fe).

What are the fertilizer sources of micronutrients?

- 2. Some manganese fertilizer sources are manganese sulfates (26–28% Mn), manganese oxides (41–68% Mn), manganese chelate (12% Mn), manganese carbonate (31% Mn), and manganese chloride (17% Mn).
- 3. Zinc fertilizer sources include zinc sulfates (23–36% Zn), zinc oxide (78% Zn), basic zinc sulfate (55% Zn), zinc-ammonia complexes (10% Zn), and zinc chelates (9–14% Zn).

What are the fertilizer sources of micronutrients?

- 4. Fertilizer sources of boron include borax (11.3% B), sodium pentaborate (18% B), sodium tetraborate (borate 46 (14% B), borate 65 (20% B)), boric acid (17% B), colemanite (10% B), and solubor (20% B).
- 5. Copper fertilizer sources include copper sulfate (22.5% Cu), copper ammonium phosphate (30% Cu), and copper chelates (% Cu variable).

What are the fertilizer sources of micronutrients?

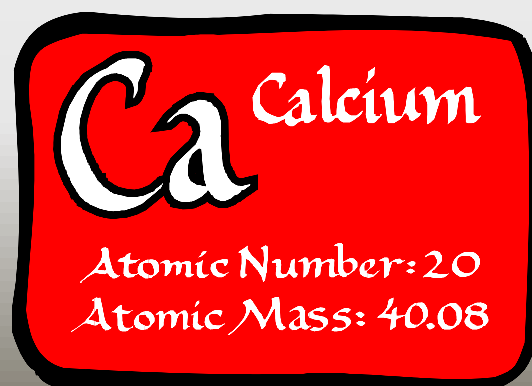
- 6. Ammonium molybdate (54% Mo), sodium molybdate (39–41% Mo), and molybdic acid (47.5% Mo) are fertilizer sources of molybdenum.
- 7. Muriate of potash (KCl) is the most practical source of chlorine (47%).

What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- III. Secondary macronutrients and micronutrients serve important roles in plant growth and development. When supplies are inadequate, deficiency symptoms may surface. Deficiencies of calcium, sulfur, iron, manganese, boron, copper, and zinc usually appear first on juvenile growth because these elements are immobile in the plant. When supplies are overabundant, damage from excess may occur.

What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- A. Calcium is extremely important to leaves and stems because it is responsible for the strengthening and thickening of cell walls. It is a component of many plant proteins, enzymes, and hormones, as well as chlorophyll. Calcium readily leaches from the soil. It is relatively immobile in plants.

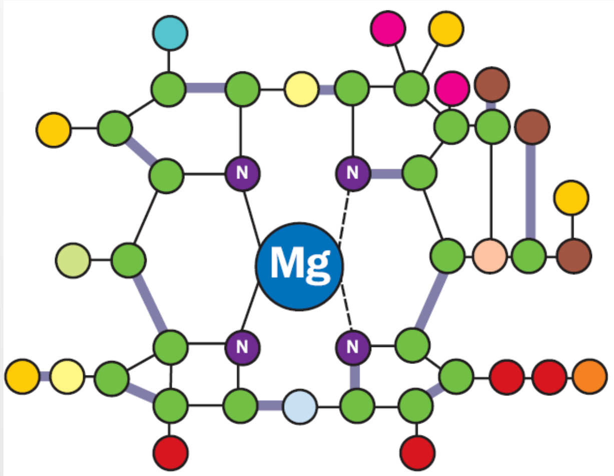


What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- 1. Calcium deficiency symptoms vary with the crop. In general, it involves some type of leaf distortion and, often, marginal chlorosis. ***Chlorosis*** is a condition in which leaves lack chlorophyll and take on a yellow appearance. Marginal necrotic areas may develop. ***Necrotic*** means the death of tissue. Low calcium levels that do not cause visible symptoms often increase susceptibility to diseases, such as botrytis. Calcium deficiency may be caused or aggravated by slow plant transpiration rates.
- 2. Excess calcium may contribute to deficiencies of magnesium and boron.

What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- B. Magnesium is needed in chlorophyll. It is used in vitamins and amino acids, in the formation of fats and sugars, and for seed germination.

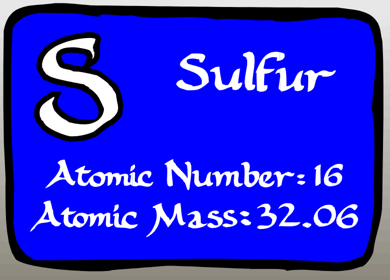


- 1. Magnesium deficiency is seen most often as interveinal chlorosis that is more pronounced at leaf margins and moves in toward midvein as the deficiency becomes more severe. Symptoms are often more intense near leaf tips. Necrotic tissue can develop in severe situations but is less common than with potassium deficiency.
- 2. High concentrations of magnesium are tolerated in plants. Excess magnesium levels may cause calcium deficiency.

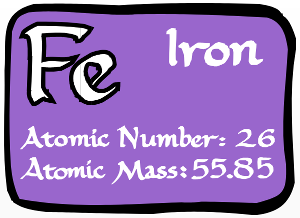
What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- C. Sulfur is absorbed as sulfate (SO4 -2), which is reduced to sulfide before it is incorporated into amino acids and other organic sulfur compounds.

- 1. Sulfur deficiency is very uncommon. Symptoms include leaves that may show general chlorosis that is more pronounced near the top of the plant.
- 2. An excess is rarely a problem.

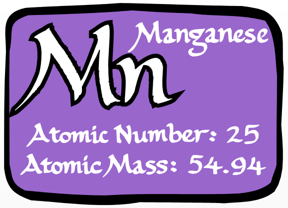


What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



- D. Iron is found in enzymes. It helps to form a variety of compounds and serves as a catalyst in chlorophyll synthesis.
- 1. Iron deficiency symptoms first appear as interveinal chlorosis with a netted appearance. As symptoms progress, small veins yellow first, followed by larger veins. The newest leaves can have general chlorosis, and older ones show interveinal chlorosis. Necrotic areas occur only in the worst situations. Iron deficiency is most often caused by high media pH. High levels of manganese can also promote iron deficiency.
- 2. Excess iron causes initial symptoms of chlorotic spots on middle and older leaves. The spots enlarge and become necrotic. Excess is commonly caused by low media pH.

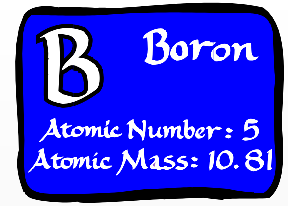
What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



- E. Manganese helps synthesize chlorophyll and serves as a coenzyme.

- 1. Manganese deficiency symptoms are interveinal chlorosis, similar to the first stages of iron deficiency, but manganese is less likely to cause general chlorosis. As the problem progresses, necrotic margins or spotting may develop. It is normally caused by high media pH and may be promoted by high iron levels.
- 2. Excess manganese causes initial symptoms of brown spots surrounded by a chlorotic circle on middle and older leaves. The spots enlarge and become necrotic. Excess is commonly caused by low media pH.

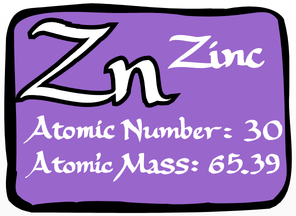
What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



- F. Boron affects pollen germination, cell division, metabolism of nitrogen, fruiting, water regulation, and hormone movement.

- 1. Boron deficiency is not common. When it does occur, the primary symptoms are thickened and smaller leaves and shorter internodes. The leaves may turn a darker green at first and then develop chlorotic and necrotic spots. When the deficiency is severe, the tips die back, which may result in proliferation of lateral shoots with stunted growth (an appearance referred to as "witches' broom"). Low levels of boron in tissues can be caused by low transpiration rates.
- 2. Excess boron symptoms surface on middle and older leaves primarily with yellowing along leaf margins, followed by necrosis. Necrotic spotting within leaves may also appear. Necrotic spots have a reddish or orangish appearance. Leaves get a scorched appearance and later fall off. A common cause is low media pH.

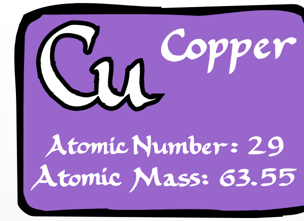
What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



- G. Zinc is involved in the formation of chloroplasts, auxins, and starch. It also aids in the manufacture of certain amino acids. Zinc is needed by legumes for seed development.

- 1. Zinc deficiency is not common. Symptoms of deficiency may be mild interveinal chlorosis, but primary symptoms are distortions of new growth. Internodes will be shortened, leading to a rosetting appearance. New leaves will be smaller. Death of growing tips may occur.
- 2. Zinc excess symptoms appear on middle and older leaves. Marginal chlorosis leads to necrosis. Problems are uncommon. Excess zinc may cause iron deficiency in some plants. Excess zinc may result from running low pH spray solutions through galvanized pipes.

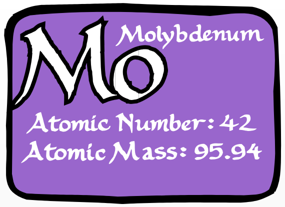
What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



- H. Copper is a component of enzymes and proteins. It is used in chlorophyll synthesis, as a catalyst in respiration, and for carbohydrate metabolism.

- 1. Copper deficiency symptoms are distortions of new growth and mild interveinal chlorosis, similar to zinc deficiency. Copper deficiency is not common.
- 2. Symptoms of copper toxicity appear on middle and older leaves. Marginal chlorosis leads to necrosis. Problems are uncommon, but they may be caused by frequent use of copper-based fungicides.

What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?



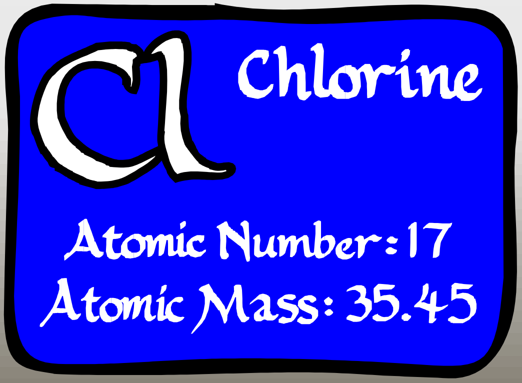
- I. Molybdenum plays a role in protein synthesis and is needed for some enzymes. It is an important element for nitrogen fixation.

- 1. Molybdenum deficiency appears as a distortion of new leaves. The leaves may have marginal chlorosis or necrosis. Deficiency is not common.
- 2. Molybdenum excess is rare in field-grown plants. A symptom of excess is yellowing of the plant.

What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?

- J. Chlorine helps in shoot and root growth.

- 1. Chlorine deficiency symptoms include wilting of plants, yellowing, and leaves turning bronze.
- 2. Symptoms of chlorine excess include the burning of leaf tips or margins and the premature yellowing and loss of leaves.



REVIEW

- 1. What are the forms of calcium, magnesium, and sulfur in soil, and what are their fertilizer sources?
- 2. What are the fertilizer sources of micronutrients?
- 3. What are the symptoms of nutrient deficiency and toxicity from secondary macronutrients and micronutrients?