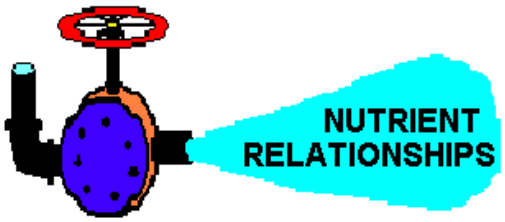

ESSENTIAL NUTRIENTS - Deficiencies and Relationships

Plants need 17 elements for normal growth; (Other nutrients: Ni, Si, Na…)

Carbon, Hydrogen and Oxygen are found in the air and water.

Nitrogen, Potassium, Magnesium, Calcium, Phosphorus and Sulfur are found in the soil. These are called macronutrients.

Iron, Zinc, Molybdenum, Manganese, Boron, Copper, Cobalt and Chlorine are found in the soil. These are called micronutrients.

Most of the nutrients that a plant needs are dissolved in water and then absorbed by the roots. 98% of these plant nutrients are absorbed from the soil solution and only about 2% are actually extracted from the soil particles by the root. Most of the elements are absorbed as charged ions. Cations have positive charges and anions have negative charges.

Balance of ions in the soil is very important. Opposite charged ions attract each other and ions with the same charge repel each other and they compete for chemical interactions and reactions in the soil and root environment. For example, both calcium and magnesium are cations with two charges, however, magnesium is more active. If both are in competition to be absorbed, the magnesium will be absorbed before the calcium. This is why soil tests may indicate there is sufficient calcium in the soil while the plant exhibits calcium deficiency when magnesium is excessive. Deficiencies of a micronutrient may be caused by excessive amounts of other competing ions.

Ions must be in solution to be absorbed. When ions combine they form precipitates and fall out of solution. Many ions in the soil form complexes with calcium and phosphorus and precipitate out of the soil solution so the nutrients can not be easily taken up by the plant.

pH greatly affects chemical reactions. If the soil pH is extremely high (alkaline), many of the micronutrients precipitate out of the solution and are unavailable to the plant. When soil pH is extremely low (acid), some of the micronutrients become extremely soluble and ion levels may become high enough to injure the plant. The effect of pH varies with the ion, the types of ions in the soil and the type of soil. Therefore, not only is the amount of the nutrient important, but also the soil pH.

Adequate water and oxygen must be available in the soil. Water is required for nutrient movement into and throughout the roots. Oxygen is required because the mineral ions must be moved into the root cells across their membranes. This is an active (energy requiring) process utilizing energy from respiration. Oxygen is not transported to roots from the shoot. Without adequate oxygen from the soil, there is no energy for nutrient absorption. This also stops active water adsorption in which the water flows into the cell due to the higher concentration of nutrients that were absorbed (osmosis). Oxygen is also required for other soil organisms that mineralize and immobilize nutrients in biological cycles making them available for the whole soil system (soil factory). Anything that reduces oxygen supply to the soil solution prevents plant uptake of nutrients, reduces nutrient ion form to one that is less available and lowers biological diversity, thereby, further reducing nutrient availability.

Anything that reduces oxygen supply to the plant or reduces photosynthetic activity (overcast, extreme temperatures, dry or too wet conditions or disease) will reduce nutrient uptake, transport and utilization by the plant. Think of the plant as one of many components in a dynamic system composed of; other organisms, 17 essential nutrients, water, and oxygen (other gasses CO_2). If any component is missing, deficient or excessive all others are affected. Unfortunately we often see deficiencies in the form of crop failure. Our only tool to prevent this is field scouting, soil and tissue testing on a regular basis.

MACRONUTRIENTS

Nitrogen (N) **Absorbed as NO_3^-, NH_4^+**
Leaches from soil, especially NO3-
Mobile in the plant

Excess **Succulent growth, dark green color, weak spindly growth, few fruits, Brittle growth (under high temperatures)**

Deficiency **Reduced growth, yellowing (chlorosis), reds and purples may intensify with some plants, reduced lateral breaks. Symptoms first appear on older growth.**

Notes **In general, the best NH_4^+/NO_3^- ratio is 1/1.**
High NH_4^+ under low sugar conditions (low light) can cause leaf curl.
Uptake is inhibited by high P levels.
N/K ratio is extremely important. Generally the best ratio is 1:1.
In soils with high carbohydrate to N ratio (excessive organic matter) more N should be supplied (This does not apply to muck soils).

Phosphorus (P) **Absorbed as $H_2PO_4^-$, $HPO_4^=$**
Does not leach from soil readily
Mobile in the plant

Excess **Shows up as micronutrient deficiencies of Zn, Fe or Co**

Deficiency **Reduced growth, color may intensify, browning or purpling in foliage in some plants, thin stems, reduced lateral breaks, loss of lower leaves, reduced flowering.**

Notes **Rapidly "fixed" on soil particles when applied under acid conditions.**
Fixed with: Fe, Mg and Al. Under alkaline conditions fixed with Ca.
Important for young plant and seedling growth.
High P interferes with micronutrient absorption and N adsorption.
Used in relatively smal amounts when compared to N and K.
May leach from soil high in bark, peat or organic matter.

Potassium (K) **Absorbed as K^+**
Leaches from soil
Mobile in plant

Excess **Causes N deficiency in plant and may affect the uptake of other Positive ions.**

Deficiency **Reduced growth, shortened internodes, marginal burn or scorch (brown leaf edges), necrotic (dead) spots in the leaf, reduction of lateral breaks and tendency to wilt readily. Deficiency first noticed on younger leaves.**

Notes **N/K balance is very important**
High N/low K favors vegetative growth; low N/high K promotes Reproductive growth (flower & fruit formation)

Magnesium (Mg) **Absorbed as Mg^{++}**
Leaches from soil
Mobile in plant

Excess **Interferes with Ca uptake**

Deficiency **Reduction in growth, marginal chlorisis, interveinal chlorosis (yellow between veins) in some species. May occur with middle or lower leaves, reduction in seed production, Cupped leaves.**

Notes **Mg^{++} is commonly deficient in foliage plants because it is leached And not replaced. Magnesium can be foliar applied in relatively weak solutions. Dolomitic limestone should be used in magnesium deficient soils to correct pH.**

Calcium (Ca) **Absorbed as Ca^{++}**
Moderately leachable
Limited mobility in plant

Excess **Interferes with Mg absorption. High Ca usually causes high pH which othen precipitates many of the micronutrients so that they become unavailable to the plant.**

Deficiency **Inhibition of bud growth, death of root tips, cupping of maturing leaves, weak growth, blossom end rot of many fruits, pits on root vegetables.**

Notes **Calcium is important to soil pH control and is rarely deficient if the correct pH is maintained. Water stress, too much or too little, can affect calcium relationships within the plant causing deficiency in the location where calcium was needed at the time of stress.**

Sulfur (S)	**Adsorbed as $SO_4^=$** **Leachable** **Not mobile**
Excess	**Sulfur excess is usually in the form of air pollution.**
Deficiency	**S is often a carrier or impurity in fertilizers and rarely deficient. It may be also absorbed from the air and is a by-product of combustion.** **Symptoms are a general yellowing of the affected leaves or the entire plant.**
Notes	**Sulfur excess is difficult to control.**

MICRONUTRIENTS

The majority of the micronutrients are not mobile; thus, deficiency symptoms are usually found on new growth. Their availability in the soil is highly dependent upon pH and the presence of other ions. The proper balance between the ions present is important as many micronutrients are antagonistic to each other. This is especialy true of the heavy metals where an excess of one element may show up as adeficiency of another. If the pH is maintained at the proper level and a fertilizer which contains needed micronutrients is used, deficiency symptoms are rarely found on plants.

Iron (Fe) **Absorbed as Fe^{++} and Fe^{+++}**

Excess **High Iron levels often cause manganese deficiency in a plant first, because of the two micronutrients' competitive behavior. Manganese deficiency exhibits similar symptoms as iron deficiency, such as yellowing of leaves, except manganese deficiency affects both young and old foliage, while iron deficiency affects only young foliage. Iron and manganese toxicity have similar symptoms in plants as well.**

In addition, excess Iron can/will:

- Interfere with phosphorus absorption.
- Require use of higher levels of potassium to regulate.
- Can cause Zinc deficiency.

May be found under the following conditions even if Fe is in the soil: Soil high in Ca, poorly drained, soil high in Mn, high pH, high P, soil high in heavy metals (Cu & Zn), oxygen deficient soils or when nematodes attack the roots. Fe should be added in the chelate form: the type of chelate needed depends upon the soil pH.

Deficiency **Interveinal chlorisis primarily on young tissue, which may become White or pale green.**

Toxicity **May be observed on flooded acid soils.**

Notes **Iron is immobile and is not transported from older to younger.**

Boron (B) **Absorbed as BO_3^-**

Excess **Blackening or death of tissue between veins.**

Deficiency **Failure to set seed, internal breakdown, death of apical buds.**

Zinc (Zn) **Absorbed as Zn^{++}**

Excess **Appears as Iron deficiency. Interferes with Magnesium uptake.**

Deficiency **"Little Leaf" , reduction in size of leaves, short internodes, puckered or distorted leaf margins, interveinal chlorosis**
Deficiency begins from the base of the leaf extending towards the tip as interveinal light striping or whitish band with the margins, midrib and leaf tip will remain green.

Notes **Deficiency are favored by high soil pH, soil low in organic matter with high pH, in cool/wet soil. High P soils that are borderline Zn.**

Copper (Cu) **Absorbed as Cu^{++} or Cu^{+}**

Excess **Occur's at low pH or high pH. Shows up as Fe deficiency.**

Deficiency **New growth is small, misshapen, wilted. Found is peat soils.**
Young leaves are yellow as they unfold. The tip of new growing points may die. The edge of older leaves may appear necrotic similar to K deficiency. Young leaves may turn up at the margins (cupping upward).

Notes **Copper is relatively immobile in the plant. Soils very high in organic matter often show copper deficiency. High pH soils or low pH soils may show copper deficiency.**

Manganese (Mn) **Absorbed as Mn^{++}**

Excess **Reduction in growth, brown spotting on leaves. Shows up as iron deficiency. Found in acid soils.**

Deficiency **Interveinal chlorosis of leaves followed by brown spots producing a checkered effect.**
Leaves turn olive green and may be slightly streaked.
If deficiency is severe the leaves have elongated white streaks that turn brown in the center, deteriorate and fall out.

Notes **Manganese is immobile within the plant.**
High soil pH, sandy soils high in organic matter and peat or muck soils favor Mn deficiencies.

Molybdenum (Mo) **Absorbed as MoO_4^-**

Deficiency **Interveinal chlorisis on older or midstem leaves, twisted leaves (whiptail)**
Reduced nodulation in legumes.

Older leaves may die at the tips, along the margins and then between the veins.

Notes **Often deficient in weathered soil with low pH.**

Chlorine (Cl) **Absorbed as Cl^-**

Deficiency **Wilted leaves which become bronze then chlorotic then die, club roots.**

Toxicity **Salt injury, leaf burn, may increase succulence.**

Notes **Conditions favorable for chlorine deficiency have not been identified.**

Cobalt (Co) **Absorbed as Co^{++}**

Notes **Need by plants recently established.**
Essential for nitrogen fixation.
Little is known about its deficiency or toxicity.

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