NUTRIENT DEFICIENCY SYMPTOMS

Barbara J. Bromley, Mercer County Horticulturist 10

Of all of the symptoms and signs of trouble in plants, possibly the most overlooked are nutrient deficiencies. The interrelationship between a nutrient's availability and soil pH, air and soil temperature, available moisture, excesses of other nutrients, soil organic matter and soil mineral content are complex. Sometimes, though, visual symptoms can be used to identify possible problems. Ideally, deficiencies are determined by soil testing and/or plant tissue analysis. Soil testing is the best way to accurately determine whether primary nutrient levels are optimum for plant survival and growth. Nitrogen is often a special test, but is generally applied to most crops by standardized rates. A rule of thumb for gardeners is that if plant matter (leaves, branches, grass clippings, weeds, etc.) are removed from a site, something needs to be put back to replace those lost nutrients.

MACRONUTRIENTS: Primary

NITROGEN (N)

Nitrogen is mobile in plants. The mobility in soil is dependent on the chemical form of the element used. Organic N is not available to plants until it has been converted to an inorganic form by soil bacteria.

Uptake inhibited by high phosphorus levels. N/K ratio is important: high N/low K favors vegetative growth; low N/high K promotes flowering and fruiting.

Nitrogen is needed for vigorous vegetative leaf and stem growth and dark green leaf color (chlorophyll production). It feeds soil microorganisms as they decompose organic matter. It is part of proteins, enzymes, chlorophyll, and growth regulators.

Deficiency Symptoms

General: Stunted growth and shorter internodes, small pale yellow leaves. Plant may be a light green. Older leaves affected first. Reds and purples may intensify in some plants.

Crops: Older leaves yellow, then dry, fire, or shed. Tomatoes show purpling of veins.

Turf: Grass light green or yellow-green. Leaf dies starting at the tip. Death of older leaves.

Broadleaf plants: Leaves are uniformly yellowish-green; this color is more pronounced in older leaves. The leaves are small and thin, have high fall color, and drop early. Shoots are short and smaller in diameter than usual. Shoots may be reddish or reddish brown. Flowers bloom heavily, but may be delayed. Fruit set is light. Fruits may be highly colored, early to mature, and small.

Conifers: Needles are yellowish, short, and close together. Older plants exhibit poor needle retention. Lower crowns may yellow, while upper crowns stay green.

Sources:

- Organic: dried blood or blood meal (10-0-0), fish meal (5-3-3) and fish emulsion (4-1-1), cottonseed meal (6-2-1), sewage sludge, fresh bat guano (10-3-1), coffee grounds (2-0.3-. 2), crab meal (4-3-0.5), feather meal (11-0-0), hoof and horn meal (12-2-0), soybean meal (7-0.5-2.3).
- Inorganic (NH_4): anhydrous ammonia (82-0-0), urea (45-0-0), ammonium nitrate (34-0-0), ammonium sulfate (21-0-0), diammonium phosphate (18-46-0), ammonium phosphate (10-34-0)
- Inorganic (NH_3): sodium nitrate (16-0-0), calcium nitrate (15.5-0-0), potassium nitrate ((13-0-44)
- Slow-release: urea-formaldehyde, thiourea (sulfur-coated)

N excess: Causes succulent, but often-spindly growth, dark green color. Decreased disease tolerance. If very lush, low or no flowering and fruit set.

PHOSPHORUS (P)

Phosphorus is very mobile in plants; relatively immobile in soil and does not leach. It is stored in seeds and fruit. It is most readily available to plants between a pH of 6 and 7.5 (unavailable in very acid or alkaline soils). Found in greatest concentration in sites of new cell growth. Phosphorus absorption is reduced at low soil temperatures.

Phosphorus is necessary to stimulate early root formation and growth, hasten crop maturity, stimulate flowering and seed production, give winter hardiness to fall plantings and seedings, and promote vigorous start (cell division) to plants.

Phosphorus has a role in fat, carbon, hydrogen, and oxygen metabolism, in respiration, and in photosynthesis.

Deficiency symptoms

General: Red or purplish color (anthocyanin pigment) in leaves, especially undersides. Death of tissue or necrosis may follow. Root growth poor. Lower stems may be purplish. Plants may exhibit stunting and delayed maturity. Loss of lower leaves. May exhibit reduced flowering.

Deficiency is often a problem in cool soils in early spring.

Crops: **corn** has purplish tint, **legumes** bluish green and stunted, **tomato** has yellowing of leaves, appearance of purpling on underside of leaf, and delayed maturity.

Turf: reddish-purple cast appears from the tip of the leaf blades (especially apparent in cool weather), dull blue-green color, poor growth. Sod slow to knit. Fescue leaves have a cupped appearance.

Broadleaf plants: Leaves are green to dark green. Veins, petioles, and lower surfaces may become reddish, dull bronze, or purplish. Foliage may be sparse, slightly smaller than normal, and distorted. Leaves drop early. Shoots are normal in length unless the deficiency is severe, but they may be small in diameter.

Conifers: Needles turn purple in young seedlings, starting at the tips of lower needles and progressing inward and upward. Few or no secondary needles may appear. Needles die, starting in the lower regions and spreading upward through the tree. Buds may set early or seedlings remain dormant longer than usual. Older trees take on a dull blue or gray-green color.

Sources:

- •Organic: bone meal (1-11-0), animal manures (vary)
- •Inorganic (rock powders): colloidal phosphate (0-2-2), rock phosphate (0-3-0)
- •Inorganic synthetic: triple superphosphate (0-46-0); superphosphate (0-16-0); monoammonium phosphate (11-48-0), diammonium phosphate (18-46-0)

P excess: Shows up as micronutrient (Zn, Fe, or Co) deficiency; high P also interferes with N absorption.

POTASSIUM (K)

Potassium (potash - K_2O) is highly mobile in plants, and generally immobile in soil. Tends to leach.

Potassium promotes vigor and disease resistance, helps development of root system, improves plant quality, and increases winter hardiness due to carbohydrate storage in roots. Increases protein production, and is essential to starch, sugar and oil formation and transfer and in water relations.

Deficiency symptoms

General: Bronzing and dying of leaf margin. Some spotting between veins; chlorotic with brown spots throughout leaf. Tendency to wilt readily. Stunted internodes and roots.

Turf: Yellow-streaked leaves, followed by browning and death of tips and margins. Wilts sooner during droughts, lowered resistance to disease and cold injury, reduction in turf density.

Broadleaf plants: Leaves exhibit marginal and interveinal chlorosis (yellowing), followed by scorching that moves inward between the main veins to the entire leaf. Older leaves are affected first. Leaves may crinkle and roll

upward. Shoot tips die back late in the season. Shoots from lateral buds result in zigzag growth that is short and bushy. Flower buds are few. Fruit is small and poorly colored.

Conifers: Older foliage takes on a dark blue-green color that progresses to yellow and reddish-brown; finally, necrosis (death) occurs at needle tips. Needle retention is poor; needles are often stunted. Seedlings have short, thick, abundant buds; Frost injury is frequent.

Sources:

- Organic: kelp meal (1.5-0.5-2.5), wood ash (0-1.5-8), plant residues
- Inorganic (rock powder): granite meal (4% total potash), greensand (7% total potash), langbeinite (sulfate of potash magnesia, 0-0-22 +22% S+11% Mg), muriate of potash (0-0-60),
- Inorganic: sulfate of potash (0-0-50), potassium nitrate (13-0-44), sul-po-mag (0-0-22 +22% S +11% Mg)

K excess: May create an N deficiency. Very high K levels can create a magnesium deficiency.

MACRONUTRIENTS: Secondary

CALCIUM (Ca)

Calcium is immobile in plants, and relatively immobile in soil. Moderately leachable. Sometimes difficult to differentiate between calcium deficiency and magnesium toxicity.

Calcium is necessary for cell elongation and division, protein synthesis, root and leaf development, and plant vigor. It influences intake of other nutrients and increases calcium content of plants. Important in cell wall structure and as an enzyme activator.

Deficiency symptoms (relatively rare)

General: Newest leaves hooked. Inhibition of bud growth; Terminal bud dies. New leaves are yellow, while older leaves dark green. Cupping of mature leaves.

Turf: Reddish-brown between veins along younger leaf margins; tips die and curl.

Broadleaf plants: Leaves become chlorotic and/or necrotic; young leaves are small and distorted with tips hooked back. Shoots are stunted with terminal dieback. Apple fruit may have bitter pit. Roots are usually affected first, with dieback of root tips severely reducing growth.

Conifer: Primary needles are usually normal, but secondary needles may be stunted or killed. Terminals are stunted and needles may hook at tips. Symptoms are most severe in the youngest foliage in the upper crown.

Sources:

- Organic: egg shells, oyster shells (33.5% calcium), wood ash, bone meal (24% calcium)
- Inorganic (rock powder): calcitic limestone (65-80% calcium carbonate), dolomitic limestone (51% calcium carbonate), and gypsum (22% calcium)
- Inorganic: calcium nitrate, super phosphate, triple superphosphate, burnt lime, hydrated lime.

Ca excess: Interferes with Mg absorption. High Ca usually causes high pH, which in turn creates micronutrient deficiencies.

MAGNESIUM (Mg)

Magnesium is mobile in plants, mobile in acid soils, and fairly immobile above pH 6.5. Leaches from soil.

Magnesium is necessary for formation of sugars, proteins, oils, and fats, regulates the uptake of other nutrients (especially P), is a component of chlorophyll, and is a phosphorus carrier.

Deficiency symptoms

General: Mottled yellowing between veins of older leaves while veins remain green. Yellow areas may turn brown and die. Yellowing may also occur on older leaves. Leaves may turn reddish purple due to low P metabolism. Decreased seed production.

Deficiencies most likely on leached sandy soils and where high levels of N and K have been applied.

Turf: Green or yellow-green stripes, changing to cherry red. Older leaves affected first. Increased winter injury.

Broadleaf: Leaves are thin, brittle, and drop early. Older leaves may show interveinal and marginal chlorosis, reddening of older leaves, with interveinal necrosis late in the season followed by shedding of leaves. Shoot growth is not reduced until deficiency is severe. Fruit yield is reduced in severe deficiencies; apples may drop prematurely.

Conifer: Needle tips are orange-yellow and sometimes red. Primary needles remain blue-green in young seedlings, but in older plants, older needles and the lower crown show symptoms first. In affected needles, the transition to green may be sharp.

Sources:

- Organic: none
- Inorganic (rock powder): dolomite (dolomitic limestone- 40% magnesium carbonate) in acid soils.
- Inorganic: magnesium sulfate (Epsom salts, 10% magnesium) in neutral or alkaline soils.

Mg excess: Interferes with calcium uptake.

SULFUR (S)

Sulfur is mobile in plants, somewhat immobile in soil. Organic sulfur is converted into available sulfate sulfur by soil bacteria. Leachable. It is rarely deficient.

Sulfur is necessary to maintain dark green color, stimulate seed production, and promote root and general plant growth. Part of proteins, amino acids, and vitamins. Important in respiration.

Deficiency, when it occurs, is most likely on sandy, low-organic matter soils.

Deficiency symptoms

General: General yellowing of the whole plant, starting with the younger leaves. Plants may be light green. Plants may be stunted and exhibit delayed maturity.

Deficiencies most likely on sandy soils that are low in organic matter.

Crops: Corn has striping of the upper leaves, notably on young plants.

Turf: General yellowing of leaves. Gradual firing starting at leaf tip.

Broadleaf: Leaves are entirely pale yellow-green in both young and old plants; they are small on some species and exhibit other symptoms associated with nitrogen deficiency. Shoots are stunted.

Conifers: Symptoms similar to those associated with nitrogen deficiency, needle tips may be yellow, red, or mottled, particularly on older needles. Necrosis may follow. Needle retention is poor.

Sources:

- Acid rain
- Organic: plant residue
- Inorganic (mined) gypsum (17% sulfur), elemental sulfur (30-99% S)
- Inorganic: ammonium sulfate (24% S), potassium sulfate (17% S), super phosphate (12% S)

S excess: Usually from air pollution so is difficult to control.

MICRONUTRIENTS

MANGANESE (Mn):

Manganese is immobile in plants; mobility in soil decreases with increasing pH. Soils very high in organic matter or poorly drained are deficient at pH 5.8 to 6.5. For other soils, deficiency usually occurs between pH 6.5 and 8.0, especially where soil has been heavily limed.

Toxic in very acid soil. Excessive water, poor aeration, and excess heavy metals influence Mn uptake.

Manganese increases availability of Ca, Mg, and P and is necessary for chlorophyll synthesis and photosynthesis. Component of enzyme systems.

Deficiency symptoms

General: Yellow to white colored leaves, but with green veins. First noted on new growth. May have a typical "gray speck" symptom.

Crops: **Tomato**: retarded growth, failure to blossom, and chlorosis in areas farthest from the veins followed by necrotic spotting on younger leaves. **Snap beans**: each new leaf becomes more chlorotic. **Corn** and **strawberry:** interveinal chlorosis of younger leaves and general stunting; depressed yield. **Spinach**: strong interveinal chlorosis of leaves at growing tips. **Small grains**: gray speck.

Turf: Chlorosis of younger leaves, yellow green spots on older leaves, withering at tips.

Broadleaf plants: Leaves become yellow or whitish with wide green bands along veins. Later, necrotic interveinal spots will appear and leaves may seem limp. Shoot growth may be reduced. Fruit is often smaller than normal. On deciduous fruits there may be a mottling of tissue between the veins on mature leaves. Chlorosis more complete near leaf margin.

Conifer: The symptoms are difficult to distinguish from those associated with iron deficiency. New growth is stunted and chlorotic; older needles and the lower crown remain green.

Sources:

- Organic: manganese chelate
- Inorganic: manganese sulfate (foliar or soil), manganese oxide (micronized, less available)

Mn excess: Brown spotting of leaves. Shows up as Fe deficiency. Found under very acid conditions.

IRON (Fe)

Iron is immobile in plants and mobility decreases in soil with increasing pH. Deficiencies can be corrected by lowering pH. Excessive P may induce deficiency.

Iron is necessary for chlorophyll maintenance.

Even if enough Fe is in the soil, deficiency can occur under the following conditions: poorly drained soil, high Ca, high Mn, high pH, high P, high heavy metals, oxygen deficiency.

Deficiency symptoms

General: Yellow or white areas on youngest leaves. Older leaves remain green. Veins typically green. Little or no necrosis of chlorotic tissue. Twig dieback.

Turf: chlorotic between leaf veins, eventual loss of most chlorophyll.

Broadleaf plants: Young leaves are yellow with contrasting narrow green veins; older basal leaves remain darker green. Exposed leaves are bleached and will eventually exhibit apical or marginal scorch. Leaves may be small;

symptoms will be severe in cold, wet springs. Shoot length is usually normal, but diameter will be small; twig dieback and defoliation will occur when the deficiency is severe. Fruit has poor color.

Conifers: New growth will be very stunted and chlorotic. Older needles and the lower crown will remain green. In seedlings, cotyledons remain green.

Source:

- Organic: iron chelates and sequestrates
- Inorganic: ferrous sulfate, ferric sulfate, iron frits

BORON (B):

Boron is extremely immobile in plants and is not translocated to new growth, but moves readily in soil. Deficiencies often occur when pH is between 6.0 and 7.5, on deep sandy soils, and when high rates of N, K, and Ca are used. Deficiency more apparent during drought stress.

Boron is necessary to increase the yield and quality of fruits and vegetables and is associated with calcium utilization.

Deficiency symptoms

General: Youngest leaves become light green and may be distorted. Terminal (apical) bud may die. Internal breakdown and external necrosis of stems and roots. Reduced flowering and failure to set seed.

Turf: slow growth, pale green blade tips, bronze tint.

Crops: Unrolled leave, poor pollination, and lack of tip fill in **corn**; black areas in the main stalk of **cabbage**; hollow heart of **crucifers**, discoloration of the curd and young leaves consisting of a corky midrib in **cauliflower**; cracked stem of **celery**; brown spots (black heart) in the interior of turnips and other root crops; yellowing and curling of **tomato** leaves and split fruit; and internal cork in **apples**. **Beets**: elongation and deep reddening of leaves, rosetting of leaves, roots develop black spots and split.

Broadleaf plants: Leaves are occasionally bronzed, or scorched. Young leaves are affected first. Leaves are small, thick, brittle, and sometimes distorted. Shoots exhibit rosetting, discoloration, and dieback of new growth, which becomes zigzag, short, brushy, thick, and stiff. Flowers may be few. Fruit set is light and deformed, with cracked, necrotic, spotty, corky surfaces. Fruit may drop before it is mature.

Conifers: Shoot tips are bent (J-topping) and the meristematic tissue of the main leader may split. Necrotic blotches are visible on magnified cross-sections of buds and cause the death of terminal and some lateral buds. Plants may be more like shrubs than trees.

Sources:

- Organic: plant residues, green manure
- Inorganic: Polybor (foliar spray), Solubor, boric acid, borax. (Boric acid is more soluble in cold water than is borax. 1 1/2 part of borax equals about 1 part of boric acid in boron content)

B excess: Blackening or death of tissue between veins.

MOLYBDENUM (Mo)

Molybdenum is mobile in plants and in soil. It is less available at a lower pH. Generally no deficiency over pH 6.0. Acid leached (forest) and sandstone soils generally low in Mo.

Molybdenum important in metabolism of nitrogen.

Deficiency symptoms

General: Narrow leaves with interveinal yellowing on older leaves. New leaves green at first, becoming mottled as they expand. Twisted leaves (whiptail).

Turf: pale yellow foliage, bleaching and withering of leaves

Crops: deficiency causes "whiptail," a cupping of the leaf margins of the younger leaves, in **cauliflower**.

Broadleaf plants: Leaves are similar in color to those deficient in nitrogen; they exhibit marginal scorching and rolling and reduced width (strapping). Shoot internodes are short when deficiency is severe. Flowers are few and small when deficiency is severe.

Conifers: No description.

Sources:

- Organic: none
- Inorganic: sodium molybdate, ammonium molybdate

ZINC (Zn)

Zinc is mobile in plants; mobility in soil decreases as pH increases. Availability is reduced by high pH, low levels of organic matter in mineral soils, soil compaction, excessive rates of P, and low temperature and wet soil. Organic matter can both inhibit and stimulate zinc uptake.

Deficiency more common in sandy soils.

Zinc is important for plant enzyme system function, seed production, and starch production. Needed for auxin synthesis.

Deficiency symptoms

General: Spotting of older leaves, usually yellow to white between veins (interveinal chlorosis). Early loss of twigs. Distorted or puckered leaf margins. Reduction in size of leaves ("little leaf") and in internodes. Seldom deficient in NJ.)

Turf: Leaves yellow, smaller, grouped together.

Crops: Terminal growth long and slender with few lateral buds. Development of terminal rosettes in **apple.** In **corn** the central bud and leaves turn white forming a broad band of chlorotic tissue along the midrib. Chlorosis pronounced at the base of the leaf. Crinkling and reddening of leaf edges possible. Reddish brown spots on **bean** cotyledons. In **potato** rosetting or "little leaf" formation occurs. Older leaves thickened and brittle and tend to cup upward.

Broadleaf plants: Leaves are uniformly yellow, sometimes mottled with necrotic spots. Leaves are small (little-leaf,) very narrow, and pointed; older leaves drop. Shoots of small diameter have tufts (rosettes) of leaves at their tips, which may die back. Fruit set is light with small, pointed, highly colored fruit. Reduced fruit bud formation.

Conifers: Branches and needles are extremely stunted; foliage yellows. Trees lose all but their first- or second-year needles; terminals die back.

Sources:

- Organic: animal manures, sewage sludge, zinc chelate
- Inorganic: zinc sulfate (foliar or broadcast), zinc oxide, zinc nitrate

Zn excess: Appears as Fe deficiency. Interferes with Mg.

COPPER (CU)

Relatively immobile in soil and plants. Deficient more often in organic than mineral soils, and more often in sandy than heavy soils. Deficient at high pH.

Copper is a constituent of enzyme systems. It is involved in photosynthesis and respiration and the formation of lignin.

Deficiency symptoms:

General: Twisted stems and leaves, lodging.

Crops: **Corn**: leaves yellow and stunted. Dead leaf tips and margins. **Small grains**: young leaves pale green, then wither and die at the tips. **Vegetables**: Young leaves permanently wilted. Leaves develop a bluish green cast, become chlorotic, then curl.

Sources:

Organic: none
Inorganic: copper sulfate (soil and foliar)

Definitions:

Firing: Yellowing of leaf tip, moving down leaf until severe chlorosis results.

Chlorosis: Yellowing of plant tissue.

Mobility: Nutrient in the lower older leaves is translocated to new growing areas of the plant when too little is being supplied through the roots. As a result, deficiency symptoms often appear in the older leaves first. When nutrients are relatively immobile in the plant, deficiency symptoms appear in new growth first.

Necrosis: Death

pH Effects:

Liming acid soils to a pH above 6.5 reduces the solubility and plant uptake of potentially toxic metals, such as zinc, copper, nickel, cadmium, and lead.

Nutrients deficient in strongly acid soils: nitrogen, phosphorus, potassium, calcium, magnesium, and/or molybdenum. Nutrients that become toxic in strongly acid soils: aluminum, iron, and/or magnesium.

Plant Part Affected First

Young leaves (not mobile in plant) - calcium, sulfur, boron, iron, manganese
Mature leaves (mobile in plant) - nitrogen, phosphorus, potassium, magnesium, molybdenum, zinc

Additional information:

Harris, Arboriculture
Follett, Murphy, and Donahue, *Fertilizers and Soil Amendments*
Heckman and Reiners, **Rutgers** fact sheet *Fertilizing the Home Vegetable Garden*