Exchangeable Calcium and Magnesium

Calcium and magnesium are extracted from the soil by mixing 10 milliliters of one normal, neutral, ammonium acetate with a 1-gram scoop of soil and shaking for 5 minutes. The filtered extract is analyzed with an inductively coupled plasma atomic emission spectrometer (ICP-AES) for calcium and magnesium. The results are reported in parts per million (ppm) calcium (Ca) and magnesium (Mg) in the soil.

Diagnosing Nutrient Deficiency and Toxicity Symptoms in Fruit and Vegetable Crops

The following list describes general symptoms associated with nutrient disorders in plants. It should be remembered that nutrient deficiencies or toxicities can resemble nonnutritional disorders such as disease or herbicide damage. Use of soil and/or tissue analysis may help confirm whether symptoms are nutritional. More detailed information on determining nutrient disorders based on visual symptoms can be found at: http://www.extension.umn.edu/distribution/horticulture/M1190.html.

Nitrogen (N): Deficiency—Leaves turn pale green to yellow. Oldest leaves are affected first, but in severe cases the whole plant may be yellow. Growth is usually stunted. Occurs most frequently on sandy soils. **Excess**—Nitrogen excess can occur with high rates of nitrogen fertilizer. The result is usually excessive vegetative growth and poor fruit growth.

Phosphorus (P): Deficiency—Leaves appear reddish-purple. Oldest leaves are affected first. Plant growth is stunted. Common in acid and alkaline soils or those soils low in native phosphorus. Frequently occurs on cool wet soils in the spring; however, plants may grow out of phosphorus deficiency as soil warms. **Excess**—High rates of phosphorus fertilizer may induce zinc or iron deficiency.

Potassium (K): Deficiency—Leaves develop gray or tan areas near the margins. Oldest leaves are affected first with characteristic symptoms of scorching around the leaf margins. Occurs on sandy soils and soils low in native potassium. **Excess**—High rates of potassium fertilizer can cause salt burn. Soils with high potassium levels can induce magnesium deficiency on sandy soils.

Calcium (Ca): Deficiency—Growing points of plant may die. Younger leaves are affected. Root tips die and root growth is slow. Tipburn of cabbage, cauliflower, lettuce; black heart of celery; and blossom end rot of tomatoes are due to localized calcium deficiency within the plant. These disorders may occur on high calcium soils. Calcium deficiency may occur on acid and/or dry soils. **Excess**—Not known to occur in Minnesota.

Magnesium (Mg): Deficiency—Oldest leaves turn yellow between the veins. In severe cases, younger leaves may be affected and older leaves may drop off. May occur on acid soils, sandy soils, or soils with high potassium levels. **Excess**—Not known to occur in Minnesota.

Sulfur (S): Deficiency—Symptoms of sulfur deficiency are similar to nitrogen deficiency except that youngest leaves are usually affected first. Can occur on sandy soils low in organic matter. **Excess**—Rare, usually associated with saline conditions.

Boron (B): Deficiency—Usually occurs on younger plant tissue. Growing points die and leaves appear distorted. May cause hollow stem and internal browning in cauliflower and broccoli; cracked stem in celery; internal browning in beets and turnips. Can occur on sandy soils in crops with a high boron requirement. **Excess**—Boron can be highly toxic to some plants at low levels. Avoid excess boron applications. Toxicity symptoms usually occurs on oldest leaves as a scorching of the margins.

Chlorine (Cl): Deficiency—Rare. Not known to occur in the field. **Excess**—Marginal scorch of older leaves. Can occur on salt-affected soils, near streets where deicing salt is used, or when excessive rates of fertilizer containing chlorine are used.

Copper (Cu): Deficiency—Yellowing or dieback of youngest leaves. Sometimes yellowing between the veins. Most copper deficiencies occur on organic soils (peats or mucks). **Excess**—Can occur due to continuous use of copper-containing fungicides. May induce iron chlorosis and cause stunted root systems.

Iron (Fe): Deficiency—Yellowing between the veins on youngest leaves; veins remain green (often referred to as interveinal chlorosis). Occurs frequently on high pH soils (pH greater than 7.2). Some plant species more susceptible than others. With acid-loving plants (e.g., blueberry), chlorosis may occur at a pH as low as 5.5-6.0. **Excess**—Rare. High levels of iron may induce manganese deficiency.

Manganese (Mn): Deficiency—Similar to iron deficiency. Yellowing between the veins of youngest leaves. Usually only the main veins remain green causing a fishbone-like appearance. In some plants older leaves may develop gray streaks or dots. Occurs on high pH soils (pH greater than 7.2). Can also occur on organic soils with pH greater than 6.0. **Excess**—Manganese toxicity can occur on acid soils (pH less than 4.5) or after heat sterilization of greenhouse soils. Excess symptoms include brown spots on leaves and chlorosis (yellowing).

Molybdenum (Mo): Deficiency—Pale distorted narrow leaves. Causes "whiptail" of cauliflower. Can occur on acid soils (pH less than 5.0). **Excess**—Rare.

Nickel (Ni): Deficiency–Small, wrinkled and sometimes cupped leaves; necrotic leaf margins; shortened internodes resulting in stunted plants and witches-broom appearance; referred to as "mouse-ear" disorder in some plants. Occurs in peat-based potting mixes and is accentuated by excess zinc. **Excess**–induces iron and zinc deficiency.

Zinc (Zn): Deficiency—Short internodes may cause rosetting appearance in trees. Younger leaves usually affected first and may show signs of yellowing between the veins. High levels of phosphorus fertilizer may induce zinc deficiency. Can occur on high pH soils or acid sandy soils. **Excess**—May induce iron deficiency.

Plant Analysis for Fruit and Vegetable Production

Plant analysis is a powerful tool growers can use to help diagnose nutrient disorders that may occur during the growing season. Plant analysis can also be used to help fine-tune the efficiency of a fertilizer program before nutrient deficiency symptoms appear and is especially useful for perennial crops. The technique involves determining the elemental composition of plant tissue during the growing season and then comparing these values with those already established for a normal, healthy plant. From this comparison, nutrient deficiencies or excesses can be determined.

It should be recognized that plant analysis is not a substitute for a routine soil test. Soil testing provides information on lime and fertilizer needs prior to planting and is particularly well calibrated for nutrients such as phosphorus, potassium, magnesium, calcium, sulfur, boron, and zinc. Soil tests for nutrients such as nitrogen (eastern Minnesota), iron, manganese, copper (mineral soils), and molybdenum are often not reliable for predicting fertilizer needs. Therefore, when used in conjunction with soil testing, plant analysis can provide additional information related to crop nutrition and the effectiveness of a particular fertilizer program.

What and When to Sample

The basis behind plant analysis is that maximum yields are associated with an optimum range of nutrients in the leaf or tissue sampled. Usually the leaf plus petiole or just the petiole alone is sampled for nutrient determination. If the level of a nutrient falls outside this range, then corrective measures should be taken. These optimum nutrient ranges are based on samples collected at a particular growth stage and tissue maturity. Samples collected too early or late in the growing season may not be interpreted accurately using the established sufficiency values. The proper time and plant part to sample are presented in **Table 45**.

When troubleshooting suspected nutrient deficiency or toxicity symptoms, it may not be possible to collect the samples at the recommended time. For these situations, samples should be collected from plants showing a problem and then compared to those collected from both healthy plants and plants only showing minor symptoms. Comparing nutrient levels in these samples as well as looking at soil test results can help determine whether the problem is nutritional.

Sampling and Handling Procedures

The following instructions may be used as a guide for proper sampling and handling procedures:

1. Refer to **Table 45** for proper times to sample and the plant part to collect.
2. Obtain a representative composite sample from a uniform area. Areas of different soil type should be sampled separately. Each sample should not represent more than 10 acres even in uniform areas. Refer to **Table 45** for the number of plants or leaves required for each sample. Samples should consist of tissue collected over the entire area. Leaves showing insect, disease, or mechanical damage should not be selected for sampling. Do not sample if foliar fertilizers have been recently applied unless you are only interested in nutrients other than those applied.
3. Avoid sampling dirty or dusty leaves. Consult your tissue testing laboratory for specific information on how to handle and send in the samples. Some general guidelines for handling dirty samples are as follows. If leaves are dirty or dusty, they should be rinsed quickly in distilled or demineralized water. A mild non-phosphate detergent may be added if necessary. Do not let the leaves soak in water as the nutrients can leach out. Particulate matter may be removed with a clean cloth dampened with distilled or demineralized water. Dried tissue should not be rinsed. Samples should be dried as rapidly as possible. Forced air drying at 150-170 ° F is preferred, but air drying is also permissible. Transport the samples to the laboratory in loose fitting, clean paper or cloth bags. Do not use plastic bags unless the samples have been previously dried or are transported to the laboratory within a few hours.
4. The University of Minnesota Research Analytical Laboratory (phone: 612-625-3101) offers tissue testing services for a fee. An information sheet along with current prices can be found at the following web site: http://ral.coafes.umn.edu/Forms/DIAGNOSTIC%20PLANT2003a.pdf

   A number of private laboratories also offer tissue testing services. Contact your Extension Office or fertilizer dealer for information about commercial laboratories in your area or look in the Yellow Pages under “laboratories.”

Interpretations

The established sufficiency levels for a healthy crop are presented in **Table 46**. Even though many of these levels have been determined from research conducted outside of Minnesota, they do provide a starting point for interpretation.