G A R D E N I N G S E R I E S

Colorado
MASTER GARDENER

Plant Nutrition

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Outline. . .

Plant Nutrients

Many people confuse plant nutrition with plant fertilization. **Plant nutrition** refers to the need for basic chemical elements for plant growth.

The term **fertilization** refers to the application of plant nutrients. Nutrients may be applied as commercial manufactured fertilizers, organic fertilizers or other soil amendments. Organic fertilizers and soil amendments are typically low in nutrient content. For additional information about fertilizers and soil amendments, refer to the fact sheets 7.731, *Understanding Fertilizers* and 7.741, *Organic Soil Amendments.*

Plants need 17 elements for normal growth. Carbon, hydrogen, and oxygen come from the air and water. Soil is the principle source of other nutrients. **Primary nutrients** (nitrogen, phosphorus, and potassium) are used in relatively large amounts and are often supplemented as fertilizers. **Secondary nutrients** (calcium, magnesium, and sulfur) are also used in fairly large amounts but are typically readily available and in adequate supply. **Micronutrients** or trace elements are needed only in small amounts. These include iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine.

Roots take up nutrients primarily as **ions** dissolved in the soil's water. The ions may be positively charged (**cations**) or negatively charged (**anions**). The nutrient ion soup in the soil's water is in a constant state of flux as the variety of ions dissolve in and precipitate out of solution.

Clay particles and organic matter are negatively charged, attracting the positively charged cations (like ammonium, NH_4^+, and potassium, K^+) and making the cations resistant to leaching. Negatively charged anions (like nitrate, $N0_3^-$) are prone to leaching and can become a water pollution problem. Both ammonium and nitrate are important plant nitrogen sources and are commonly found in salt forms in fertilizers.

The **Cation Exchange Capacity, CEC** is a measurement of the soil's capacity to hold nutrients. More precisely, it's a measurement of the negatively charged soil particle's and organic matter's capacity to attract the positively charged cations. CEC is useful in comparing the potential for different soils to hold and supply nutrients for plant growth.

Fertility and Fertilization

Adequate soil fertility is only one of the many soil-related growth factors. Fertilizers will increase plant growth only if the plant is deficient in the nutrient applied and other growth factors (such as soil compaction, water stress or water-logging, insect and disease problems, and weed competition) are not also limiting plant growth.

Colorado State University Cooperative Extension

Putting Knowledge to Work

Table 1. Essential plant nutrients.

Nutrient Ions	Absorbed by Plants
Structural elements	
Carbon, C	CO_2
Hydrogen, H	H_2O
Oxygen, O	O_2
Primary nutrients	
Nitrogen, N	NO_3^-, NH_4^+
Phosphorus, P	$H_2PO_4^-$, HPO_4^{-2}
Potassium, K	K^+
Secondary nutrients	
Calcium, Ca	Ca^{+2}
Magnesium, MG	MG^{+2}
Sulfur, S	SO_4^{-2}
Micronutrients	
Boron, B	$H_2BO_3^-$
Chlorine, Cl	Cl^-
Cobalt, Co	Co^{+2}
Copper, Cu	Cu^{+2}
Iron, Fe	Fe^{+2}, Fe^{+3}
Manganese, Mn	Mn^{+2}
Molybdenum, MO	MoO_4^{-2}
Zinc, Zn	Zn^{+2}

From the nutritional perspective, a plant cannot tell if applied nutrients come from a manufactured fertilizer or a natural source. Plants use nutrients in ionic forms. Soil microorganisms must break down organic soil amendments, organic fertilizers and many manufactured fertilizers before the nutrients become usable by plants.

From a nutritional perspective, the primary difference between manufactured and organic soil amendments/organic fertilizers is the speed at which nutrients become available for plant use. For manufactured fertilizer, their release is typically, but not always, a few days to weeks.

Some are specially formulated as *controlled release*, *slow release* or *time release* products that release over a periods of months. With natural-organic fertilizer, nutrients typically become available over a period of years. However, there are exceptions to this general rule. The high salt content of some manufactured fertilizers and some organic soil amendments could slow the activity of beneficial soil microorganisms.

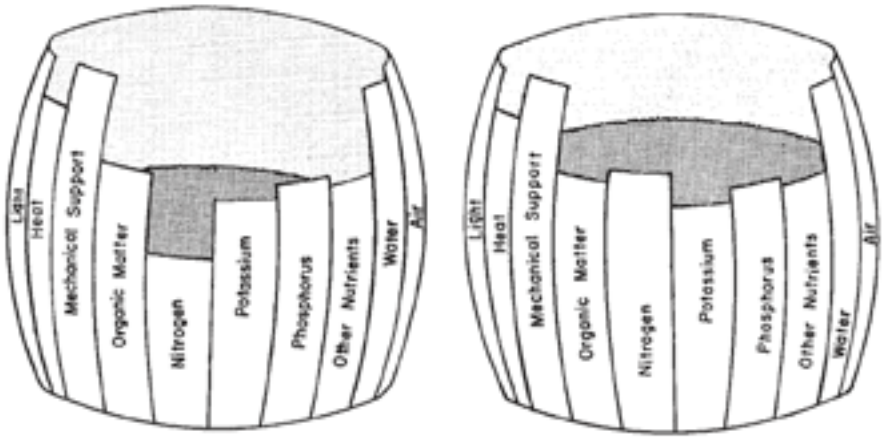

Figure 1. The slats of the barrel represent plant growth factors. On the left, plant growth is limited by low nitrogen levels. In this situation, we would expect to see an increase in plant growth with the addition of a nitrogen fertilizer. On the right, availability of potassium is illustrated as limiting crop growth. Under this situation, applications of potash fertilizer would likely improve growth. In many gardens limiting factors are not nutrients, but rather other growth factors such as soil compaction, weed competition, and watering problems. In these situations, additional fertilizer will not correct poor growth problems.

Remember that fertility is only part of the soil's role in supporting plant growth. The organic content of the soil also directly impacts plant growth due to its influence on soil tilth, and the activity of beneficial soil microorganisms. Relying solely on manufactured fertilizers is not recommended.

Table 2. Symptoms of nitrogen deficiency.

Leaves
- Uniform yellowish-green
- More pronounced in older leaves
- Small, thin leaves
- Fewer leaflets
- High fall color
- Early leaf drop

Shoots
- Short, small diameter
- May be reddish or reddish brown

Colorado Soils and Plant Nutritional Needs

Nitrogen

Nitrogen is the one nutrient most often limiting plant growth. The need for nitrogen varies from plant to plant. For example, tomatoes and vine crops (cucumbers, squash, and melons) will put on excessive vine growth at the expense of fruiting with excess nitrogen. Whereas potatoes, corn, and cole crops (cabbage, broccoli, and cauliflower) are heavy feeders and benefit from high soil nitrogen levels. Bluegrass turf and many annuals also benefit from ample soil nitrogen. Trees and shrubs have a low relative need for soil nitrogen. Colorado soils benefit from nitrogen fertilization of the right amount and frequency to meet plant needs.

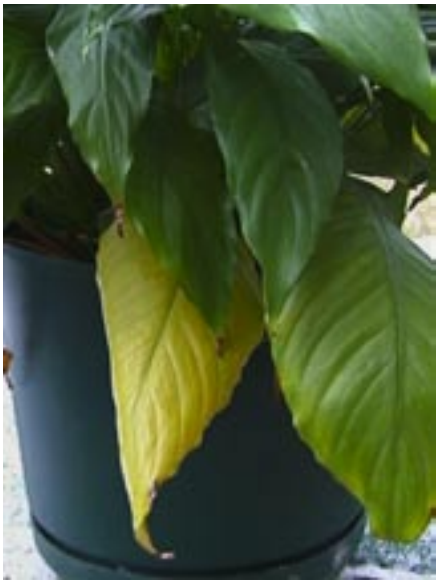

Figure 2. Nitrogen deficiency shows as general yellowing of leaves, typically starting with and being more severe on older leaves.

***Phosphorus,* P,** is a primary nutrient in plant growth. The word ***phosphate,* P_2O_5,** refers to the ionic compound containing two atoms of phosphorus and five atoms of oxygen. The phosphorus content of fertilizer is measured in percent phosphate.

***Potassium,* K,** is a primary nutrient in plant growth. The word ***potash,* K_2O,** refers to the ionic compound containing 2 atoms of potassium and 1 atom of oxygen. The potassium content of fertilizer is measured in percent potash.

Soil tests have limited value in indicating nitrogen needs for a home garden or lawn since the value is constantly changing due to organic content, microorganism activity, and changes in temperature and water.

Nitrogen is usable by plants in two forms, **ammonium** (NH_4^+), and **nitrate** (NO_3^-). Ammonium, being positively charged, is attracted to the negatively charged soil particles and thus is resistant to leaching (movement down through the soil profile). Soil microorganisms convert ammonium to nitrate. Nitrate, being negatively charged, readily leaches pasts the root zone with excess rain or irrigation on sandy soils. Prevent water pollution by avoiding over-fertilization of nitrogen, particularly on sandy soils.

Soil microorganisms release nitrogen in organic matter over a period of time. For example, livestock manure releases around 50 percent of the nitrogen the first year, 25 percent the second year, and so forth. Composted manure releases only 5 to 20 percent the first year.

Phosphorus

Phosphorus levels are adequate in the majority of established Colorado gardens. Deficiencies are most likely to occur in new gardens where the organic matter content is low and the soil has a high pH (7.8 to 8.3). A soil test is the best method to determine the need for phosphorus fertilizers.

Phosphorus is also less available to plants when soil temperatures are cool. In the spring, using starter fertilizers with phosphorus may be beneficial on herbaceous flowers and vegetable transplants.

Phosphorus deficiency is difficult to diagnose, since other growth factors will give similar symptoms. General symptoms include sparse, green to dark green leaves. Veins, petioles and lower leaf surface may be reddish, dull bronze, or purple, especially when young. Phosphorus deficiency may be observed on roses, in the early spring when soils are cold, but the condition corrects itself as soils warm.

Excessive phosphorus fertilizer can aggravate iron and zinc deficiencies and increase the soil salt content.

Figure 3. On this rose, the cold spring soil temperature induces a temporary phosphorus deficiency; note the purple leaf color. It will correct as soil temperatures warm.

Potassium

Potassium levels are naturally adequate and even high in most Colorado soils. Deficiencies occasionally occur in new gardens low in organic matter and in sandy soils low in organic matter. A soil test is the best method to determine the need for potassium fertilizers.

Potassium deficiency is very difficult to diagnose, since other growth factors will give similar symptoms. General symptoms include a marginal and interveinal chlorosis (yellowing), followed by scorching that moves inward. Older leaves are affected first. Leaves may crinkle and roll upward. Shoots may show short, bushy, zigzag growth, with dieback late in season.

Excessive potash fertilizer can aggravate soil salt levels.

Micronutrients

Iron – As for micronutrients, iron deficiency is common in Colorado. This is not from a lack of iron in the soil. In fact it's the iron that gives us our *red rocks*. In high pH soils, typical of Colorado, iron is chemically fixed in an insoluble form that plants cannot absorb. For details on iron chlorosis, refer to fact sheet 7.728, *Iron Chlorosis*.

Zinc – Zinc deficiency occasionally occurs on sandy soils containing excessive lime, and soils low in organic matter (typical of new yards where the topsoil has been removed). Excessive phosphate fertilization may aggravate a zinc problem. It will be seen more in years with cold wet springs.

Sweet corn, beans and potatoes are the most likely affected. Symptoms include a general stunting of the plant due to shortening of internodes (stem length between leaves). Leaves on beans typically have a crinkled appearance and may yellow or brown. On young corn, symptoms include a broad band of white to translucent tissue on both sides of the leaf midrib starting near the base of the leaf but generally not extending to the tip.

Occasional manure applications will supply the zinc needs. If a soil test indicates a zinc deficiency (less than 10 ppm) apply a zinc-containing fertilizer according to label directions (typically 2 to 4 ounces per 1,000 sq. ft.).

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