MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #231

Plant Nutrition

Outline:

Fertility and Fertilization

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 to supplement the nutrients naturally occurring in the soil. Nutrients may be applied as commercially manufactured fertilizers, organic fertilizers and/or other soil amendments. Organic fertilizers and soil amendments are typically low in plant-available nutrient content. For additional information about fertilizers and soil amendments, refer to the *CMG GardenNotes* #232, **Understanding Fertilizers,** and #241, **Soil Amendments**.

Adequate soil fertility is only one of the many soil-related growth factors. Fertilizers will increase desirable plant growth only if the plant is deficient in the nutrient applied and other growth factors are not also significantly limiting plant growth. Fertilization will not compensate for poor soil preparation, the lack of water, weed competition and other non-nutrient growth limiting factors! Fertilization will not enhance desired growth if the nutrients applied are not deficient.

From a 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. Manufactured fertilizers release rates are typically, but not always, a few days to weeks. Some are specially formulated as “controlled

release", "slow release" or "time release" products release over a period of months, but some organic fertilizers are quickly available. With natural-organic fertilizer, nutrients typically become available over a period of months or years. However, there are exceptions to this general rule. High salt contents of *some* manufactured fertilizers and *some* organic soil amendments can slow the activity of beneficial soil microorganisms and subsequent nutrient release.

Benefits of organic fertilizers and soil amendments include improvements in soil tilth (suitability of the soil to support plant growth). This should not be confused with "fertilization", a distinctly different soil management objective.

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

Plant Nutrients

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 by plants, and often are supplemented as fertilizers. [Table 1]

Secondary nutrients (calcium, magnesium, and sulfur) are also used in large amounts but are typically readily available and in adequate supply. M***icronutrients*** or trace elements are needed only in small amounts. These include iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine. [Table 1]

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}

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 in the soil 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 cation nutrients. More precisely, it is a measurement of the capacity of the negatively charged clay and organic matter to attract and hold positively charged cations. CEC is useful in comparing the potential for different soils to hold and supply nutrients for plant growth.

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) develop excessive vine growth at the expense of fruiting with excess nitrogen. 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 routine nitrogen applications. 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. General symptoms of nitrogen deficiency are shown in Table 2 and Figure 1.

Table 2 and Figure 1. 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

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

Nitrogen is useable 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 below the root zone with excess rain/irrigation in sandy soils. Prevent water pollution by avoiding over-fertilization of nitrogen, particularly on sandy soils.

Soil microorganisms release nitrogen tied-up in organic matter over a period of time. Release rates from compost are very slow (i.e., over a period of years). The need for nitrogen fertilizer is based on the organic content of the soils. [Table 3]

Table 3.
Need for Nitrogen Fertilizer Based on Soil Organic Content

Soil Organic Content	Routine Application Rate For Gardens
1%	2 pounds actual N / 1000 square feet
2-3%	1 pound actual N / 1000 square feet
4-5%	0

Iron

Iron chlorosis refers to a yellowing of leaves caused by an iron deficiency in the leaf tissues. Primary symptoms include interveinal chlorosis (i.e., a general yellowing of leaves with veins remaining green). Symptoms appear first and are more pronounced on younger leaves and on new growth. In severe cases, leaves may become pale yellow or whitish, but veins retain a greenish tint. Angular shaped brown spots may develop between veins and leave margins may scorch (brown along the edge). Symptoms may show on a single branch or on the entire tree. General symptoms of iron chlorosis are shown in Table 3 and Figure 2.

Table 3 and Figure 2. Symptoms of Iron Chlorosis

Leaves
- **General yellowing of leaf with veins remaining green**
- **More pronounced in younger leaves and new growth**
- Angular brown spots and marginal scorch
- Smaller
- Curl, dry up and fall early

Branches
- May show on a single branch or the entire plant

In western, high pH soils, iron is not deficient; but rather unavailable for plant uptake due to the soil's high lime (calcium carbonate) content. In western soils, iron chlorosis is a general symptom of other problems, including the following:

- **Springtime over-watering** is the primary cause of iron chlorosis in western soils! Attention to irrigation management, with seasonal changes of the irrigation controller will generally correct iron chlorosis.
- **Soil compaction** and low soil oxygen contributes to iron chlorosis.
- Iron chlorosis is an early symptom of **trunk girdling roots.**
- Iron chlorosis appears as a complication of **winter trunk/bark injury**.

Attention to these contributing factors is much more effective than adding iron products. For additional details on dealing with iron chlorosis, refer to *CMG GardenNotes* #223, **Iron Chlorosis**.

Phosphorus

Note: ***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*.

Phosphorus may be present in high concentrations, however it may not be in a plant available form. 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, the use of starter fertilizers with phosphorus may be beneficial to herbaceous flowers and vegetable transplants.

Phosphorus deficiency is difficult to diagnose, because 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. Many home gardener soils are significantly over fertilized with phosphates, aggravating soil salts and iron chlorosis. Typically the over fertilization results from over application of composts.

Potassium

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

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, because 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. Many home garden soils are over fertilized with potash, leading to salt problems.

Zinc

Zinc deficiency occasionally occurs in sandy soils containing excessive lime and in 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 vegetables to be 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 become 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 zinc deficiency (less than 1 ppm), apply a zinc-containing fertilizer according to label directions.

Additional Information – *CMG GardenNotes* on Soils, Fertilizers and Soil Amendments:

#211	Introduction to Soils	#232	Understanding Fertilizers
#212	The Living Soil	#233	Calculating Fertilizer Rates
#213	Managing Soil Tilth	#234	Organic Fertilizers
#214	Estimating Soil Texture	#241	Soil Amendments
#215	Soil Compaction	#242	Using Manure
#218	Earthworms	# 243	Using Compost
#219	Soil Drainage	#244	Cover Crops and Green Manure Crops
#221	Soil Test	#245	Mulching with Wood/Bark Chips, Grass Clippings and Rock
#222	Soil pH		
#223	Iron Chlorosis	#246	Making Compost
#224	Saline Soils	#251	Asking Effective Questions About Soils
#231	Plant Nutrition		

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