Virginia Cooperative Extension
Virginia Tech • Virginia State University

Publication 426-323

Fertilizing the Vegetable Garden

Diane Relf, Extension Specialist, Horticulture
Alan McDaniel, Extension Specialist, Horticulture
Steve Donohue, Extension Specialist, Crop and Soil Environmental Science, Virginia Tech
Reviewed by John Freeborn, Assistant Master Gardener Coordinator, Horticulture, Virginia Tech

The amount of fertilizer to apply to a garden depends on the natural fertility of the soil, the amount of organic matter present, the type of fertilizer used, and the crop being grown. The best way to determine fertilizer needs is to have the soil tested. Soil testing is available through your local Extension agent, through private labs, and with soil test kits which can be purchased from garden shops and catalogs.

Fertilizer Analysis

Fertilizers are identified by the analysis given on the package which refers to the amount of an element present in a formulation based on percentage of weight. By law, all analysis provide three numbers, giving the percentage by weight of nitrogen (N), phosphate (P2O5), and potash (K2O) respectively. Often, to simplify matters, these numbers are said to represent nitrogen, phosphorus, and potassium, or N-P-K. We should remember that it is not N-P-K, but N-P2O5-K2O. For example, if we have a 100-pound bag of fertilizer labeled 10-10-10, there are 10 pounds of N, 10 pounds of P2O5, and 10 pounds of K2O. To convert the P2O5 content to actual phosphorous content, multiply the given weight by 0.43. To convert K2O content to potassium content, multiply the given weight by 0.83.

Fertilizers and pH

The degree of acidity or alkalinity of the soil, as measured by pH, is an important factor in the availability of soil nutrients to plants. At pH extremes, some nutrients become partially or completely locked up in the soil and cannot be used by plants even though they are still present. For example, in a soil with a pH near 8.0, phosphates, iron, and manganese all become less available. At 4.5 or below, availability of calcium, magnesium, and phosphorus, for plant uptake, is low. Other elements may become so readily available that they are toxic to plants, as happens with aluminum at very low pH. Most vegetables do best between pH 6.0 and 7.0. Lime is often added to increase the pH to a desirable level. However, the addition of lime does not eliminate the need to add fertilizer.

Elements

There are 16 elements essential to plant growth. Carbon, hydrogen, and oxygen come from air and/or water. Nitrogen, phosphorous and potassium are considered fertilizer macronutrients because plants require them in a relatively large quantity for maximum growth and may need to be added to the soil annually. Calcium, magnesium, and sulfur are secondary macronutrients but usually are either present in sufficient quantities or are added coincidentally with other materials (e.g., lime). The other 7 nutrients, called micronutrients (or trace or minor elements), are needed in very small quantities, and most soils already contain sufficient supplies. With good soil-building practices (see VCE publications 426-326, Composting and 426-313, Soil Preparation), trace elements do not generally present a problem to the home gardener.

Synthetic fertilizers are relatively pure chemicals and most do not carry the trace elements normally present in organic fertilizers. Therefore, addition of trace elements through purchased or other organic materials such as manure, compost, green manures, and mulching, etc. is recommended.

www.ext.vt.edu

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2015

VT/0215/HORT-144P

Nutrient Deficiency Symptoms

Elements	Deficiency Symptoms	Comments
Major Elements		
Nitrogen (N)	Stunted, yellowing from older to younger leaves and leaf tip back to petiole. Reduced size. Slow, stunted growth.	Heavy application may cause leaf burn; excess promotes luxuriant growth, but inhibits flowering. Easily leached from soil.
Phosphorus (P)	Stunted, short internodes, purple or dark green foliage; old leaves	Phosphorus is poorly available at high and low pH, in dry or cold soils,
	die back; flowers and fruit poor.	and in high-organic container soils.
	Slow growth, delayed maturity.	Apply according to soil test.
Potassium (K)	Older leaves scorched on margin; weak stem; fruit shrivelled, uneven ripening.	Fairly easily leached, primarily on sandy soil. Fertilize according to soil test.
Trace Element		
Boron (B)	Tip of growing plant dies; bud becomes light green; roots are brown in center; fruit is corky; brown in center; flowers do not form.	Some Virginia soils are low in boron. Managed best by organic matter additions.
Calcium (Ca)	Young leaves turn yellow then brown; growing tip bends; weak stem; short dark roots. Causes blossom end rot of tomato.	Properly limed soils usually supply adequate calcium.
Copper (Cu)	Leaves appear bleached, elongated; new growth dies back.	Seldom a problem in Virginia soil.
Iron (Fe)	Young leaves are yellow between veins first, top to bottom; veins, margins, and tips stay green.	Usually due to pH problems. May use iron sulfate or chelated iron.
Magnesium (Mg)	Leaves are thin, lose color from between veins from bottom of plant up; tend to curve upward.	Use dolomitic lime according to soil test. May use epsom salt solution.
Manganese (Mn)	Tissue between veins turns white; leaves have dead spots; plant is dwarfed.	Seldom a problem, except on sandy Coastal Plain soils
Molybdenum (Mo)	Plant is very stunted, pale and distorted leaves.	Seldom a problem.
Sulphur (S)	Lower leaves yellow; stem and root in diameter; stems hard and brittle.	Seldom a problem.
Zinc (Zn)	Terminal leaves are small; bud formation is poor; leaves have dead areas.	Seldom a problem, except on high pH (>6-7) soils.

Understanding Fertilizers

Types of Fertilizers

Organic Fertilizers. The word organic, applied to fertilizers, simply means that the nutrients contained in the product are derived solely from the remains or 3 by-products of a once-living organism. Urea is a synthetic organic fertilizer, an organic substance manufactured from inorganic materials. Cottonseed meal, blood meal, bone meal, hoof and horn meal, and all manures are examples of organic fertilizers. When packaged as fertilizers, these products will have the fertilizer ratios stated on the labels. Some organic materials, particularly composted manures and sludges, are sold as soil conditioners and do not have a nutrient guarantee, although small amounts of nutrients are present. Most are high in one of the three major nutrients and low in the other two, although you may find some fortified with nitrogen, phosphorus, or potash for a higher analysis. Many are low in all three. In general, organic fertilizers release nutrients over a fairly long period. The potential drawback is that they may not release enough of their principal nutrient quickly enough to give the plant what it needs for best growth. Because organic fertilizers depend on soil organisms to break them down to release nutrients, most of them are effective only when soil is moist and soil temperature is warm enough for the soil organisms to be active. In addition to providing nutrients, organic fertilizers increase organic content of the soil; improve the physical structure of the soil; and increase bacterial and fungal activity, particularly the mycorrhiza fungus, which makes other nutrients more available to plants.

Synthetic Fertilizers. In general, synthetic fertilizers act more quickly than organic types, though some organic materials release their nutrients quite rapidly. It isn't possible, therefore, to make a blanket statement about the long-term effects of fertilizers, except that organic materials such as manures and plant waste do usually help improve the soil structure while adding nutrients while chemical fertilizers do not affect soil structure. General-purpose synthetic fertilizers have the advantage of being readily available to the gardener and relatively inexpensive. If applied incorrectly, synthetic fertilizers "can be detrimental to earthworms" because most are in a salt formulation. Always follow label directions.

Complete vs. Incomplete Fertilizers. A fertilizer is said to be complete when it contains nitrogen, phosphorus, and potassium (10-10-10, 5-10-10, 5-30-5, etc.). An incomplete fertilizer contain one or two of the major components. Examples would include triple super phosphate (0-46-0) and potassium nitrate (13-0-44), ammonium nitrate (33.5-0-0). An incomplete fertilizer might be used in situations where the soil tests very high for phosphorus and potassium. In this example, a nitrogen-only fertilizer such as ammonium nitrate (33.5-0-0) would be an appropriate material to use. Application rates for this product are typically 1/2 lb. per 100 sq. ft.

Fertilizer Formulation

Fertilizers come in many shapes and sizes. Different formulations are made to facilitate types of situations in which fertilizer is needed. Packaging for all formulations must show the amount of nutrients contained, or the analysis, and sometimes it tells how quickly a nutrient is available. Some of the formulations available to the homeowner are: granular solids, water-soluble powders, slow-release spikes, liquids, and tablets.

In most fertilizers, a "filler" is added to bulk up the fertilizer. This is done to lower the analysis, allowing a more even spreading pattern as compared to trying to spread a small amount of a high analysis over an area. A filler is generally an inert material such as sand, lime, ground corn cobs, etc. Some fillers are used to enhance the fertilizer's handling qualities.

Not all types of formulations are commonly used by homeowners for vegetable gardens. The most common and readily available formulations are:

Dry/Granulated Fertilizers. This is the most common type of fertilizer applied to the garden. Examples are 10-10-10, 5-10-5, and 5-10-10. The manufacturer treats the material so that it has large more evenly sized grains. Granules spread more evenly and easily. Sometimes granules are coated to prevent moisture absorption.

Liquid Fertilizers. Liquid fertilizers come in a variety of different formulations, including complete and incomplete. All are made to be diluted with water; some are concentrated liquids themselves, while others are powder or pellets. Fertilizer solutions

are often used to water-in transplants, providing an immediately-available supply of nutrients for fast root growth and plant establishment. Liquid fertilizers may also be applied to plant foliage where the nutrients are absorbed directly through the leaf surface. This foliar feeding provides nutrients to the plant very quickly.

There are several choices of fertilizers for liquid application. Commercial soluble fertilizers, or transplant starter, are readily available and easy to use. Granular fertilizers are not satisfactory because the phosphorus is not soluble. Fish emulsion and liquid kelp (a seaweed) are good commercial organic sources. Follow label directions for each of these.

Application Methods

There are different methods of applying fertilizer depending on its formulation and the crop needs.

Broadcasting — A recommended rate of fertilizer is spread over the growing area and incorporated into the soil with a rototiller or spade. Broadcasting is used over large garden areas or when time or labor is limited.

Banding — Banding is one way to satisfy the needs of many plants (especially tomatoes) for phosphorus as the first roots develop. When fertilizers are broadcast and worked into soil, much of the phosphorus is locked up by the soil and is not immediately available to the plant. By concentrating the phosphorus in the band, the plant is given what it needs even though much of the phosphorus stays locked up.

Narrow bands of fertilizer are applied in furrows 2 to 3 inches from the garden seeds and 1 to 2 inches deeper than the seeds or plants. Careless placement of the fertilizer band too close to the seeds will burn the roots of the seedlings. The best technique is to stretch a string where the seed row is to be planted. With a corner of a hoe, dig a furrow 3 inches deep, 3 inches to one side, and parallel with the string. Spread 1/2 the suggested rate of the fertilizer in the furrow and cover it with soil. Repeat the banding operation on the other side of the string, then sow seeds underneath the string.

For widely spaced plants, such as tomatoes, fertilizers can be placed in bands 6 inches long for each plant or in a circle around the plant. Place the bands 4 inches from the plant base. If used in the hole itself, place the fertilizer at the bottom of the hole, work it into the soil, and place a layer of soil about 2 inches deep over the fertilized soil before putting the plant in the hole.

Recommended application rate: Apply one pound of 10-10-10 or two pounds of 5-10-5 (or 5-10-10) per 100 feet of row.

Starter solutions — Another way to satisfy the need for phosphorus when setting out transplants is through the use of a liquid fertilizer high in phosphorus as a starter solution. Follow directions on the label.

Side-Dressing — Dry fertilizer is applied as a side dressing after plants are up and growing. Scatter fertilizer on both sides of the row 6 to 8 inches from the plants. Rake it into the soil and water thoroughly.

Recommended application rate: Apply one pound of 10-10-10 or two pounds of 5-10-5 (or 5-10-10) per 100 feet of row.

Foliar Feeding — Foliar feeding is used when insufficient fertilizer was used before planting, when a quick growth response is wanted, when micronutrients (such as iron or zinc) are locked into the soil, or when the soil is too cold for the plants to use the fertilizer applied to the soil. Foliar-applied nutrients are absorbed and used by the plant quite rapidly. Absorption begins within minutes after application and, with most nutrients, it is completed within 1 to 2 days. Foliar nutrition can be a supplement to soil nutrition at a critical time for the plant, but not a substitute since greater amounts of plant material are needed than what can be absorbed through the plant leaf at any given time. At transplanting time, an application of phosphorus spray will help in the establishment of the young plant in cold soils. For perennial plants, early spring growth is usually limited by cold soil, even when the air is warm. Under such conditions, soil microorganisms are not active enough to convert nutrients into forms available for roots to absorb; yet, if the nutrients were available, the plants could utilize them. A nutrient spray to the foliage will provide the needed nutrients immediately, allowing the plants to begin growth.

Liquid feeding is appropriate for container plants to supply needed nutrients throughout the growing season. The commercial forms are generally cost-prohibitive for continued use in the garden where

a greater soil volume is available to the plant roots. Instead, liquid feeding is more a one-time procedure, either as a transplant starter or as a foliar feeding to correct a deficiency in a major or trace element.

If a foliar feeding is desired, follow directions carefully. Using too much fertilizer, especially the synthetic forms, can quickly burn the foliage.

Timing of Fertilizer Application

Soil type dictates the frequency of fertilizer application. Sandy soils require more frequent applications of nitrogen and other nutrients than do clay-type soils. Other factors affecting frequency of application include the type of crop, the level of crop productivity required, frequency and amount of water applied, and type of fertilizer applied and its release rate.

The type of crop influences timing and frequency of application since some crops are heavier feeders of particular nutrients than others. Root crops require less nitrogen fertilization than do leafy crops. Corn is a heavy feeder of nitrogen, and may require nitrogen fertilization every four weeks. A general rule of thumb is that nitrogen is for leafy top growth; phosphorus is for root and fruit production; and potassium is for cold hardiness, disease resistance, and general durability. Proper use of nutrients can control plant growth rate and character. Nitrogen is the most critical nutrient in this regard. If tomatoes are fertilized too heavily with a nitrogen fertilizer or sidedressed before fruit set, the plants may be all vine and no fruit. This is also the case with potatoes, which will show excess vining and poor tuber formation. If slow-release fertilizers or heavy amounts of manure are used on crops that form fruit or vegetables, leaf and vine growth will continue into late summer, and fruit and vegetable development will occur very late in the season.

Remember that a nitrogen application will have its greatest effect for three to four weeks after application. If tomatoes are fertilized heavily on June 1, there may be no flower production until July 1, which will, in turn, delay fruit ripening until late August. For this reason, it is important to plant crops with similar fertilizer needs close together to avoid improper rates of application.