Soil Fertility and Fertilizers

No matter what you are interested in growing — vegetables, turfgrass, annuals, perennials, trees or shrubs — all plants need nutrients to grow and develop to natural form. There are 16 essential elements that plants get from the soil, air and water. If any one of these is in short supply, the plant will not grow well. The true test of the nutrient supply comes where vegetables or fruits are being harvested as a crop. It is often easy to see the effects of a nutrient deficiency which results in lower yields. At the other extreme, we frequently add fertilizers that are not needed and at the wrong time to do the plant any good. This is a wasteful practice that loads soils with nutrients which run-off or build to toxic levels, reducing plant growth rather than improving it. Calculating how much fertilizer is required to keep plants healthy involves an understanding of how plants use nutrients and the interaction between plant roots and soil.

How Plants Grow

A plant is composed of many chemical elements. The largest percentage of the dry weight of a plant is due to carbon, hydrogen and oxygen (Table 1). These elements account for approximately 96 percent of the dry weight and are supplied to the plant through water from the soil and carbon dioxide from the air. Through a process called photosynthesis, these elements will be used to form sugar and from this, starch, proteins and fats.

Table 1. Relative amounts of the essential nutrients required by most plants

Element (symbol)	***Percent of total nutrient content (based on dry weight***
Carbon (C)	45
Oxygen (O)	45
Hydrogen (H)	6
Nitrogen (N)	1.5
Potassium (K)	0.2
Phosphorus (P)	0.2
Secondary Nutrients	
Calcium (Ca)	0.5
Magnessium (Mg)	0.2
Sulfur (S)	0.1
Micronutrients	
Iron (Fe)	0.01
Chrome (Cr)	0.01
Manganese (Mn)	0.005

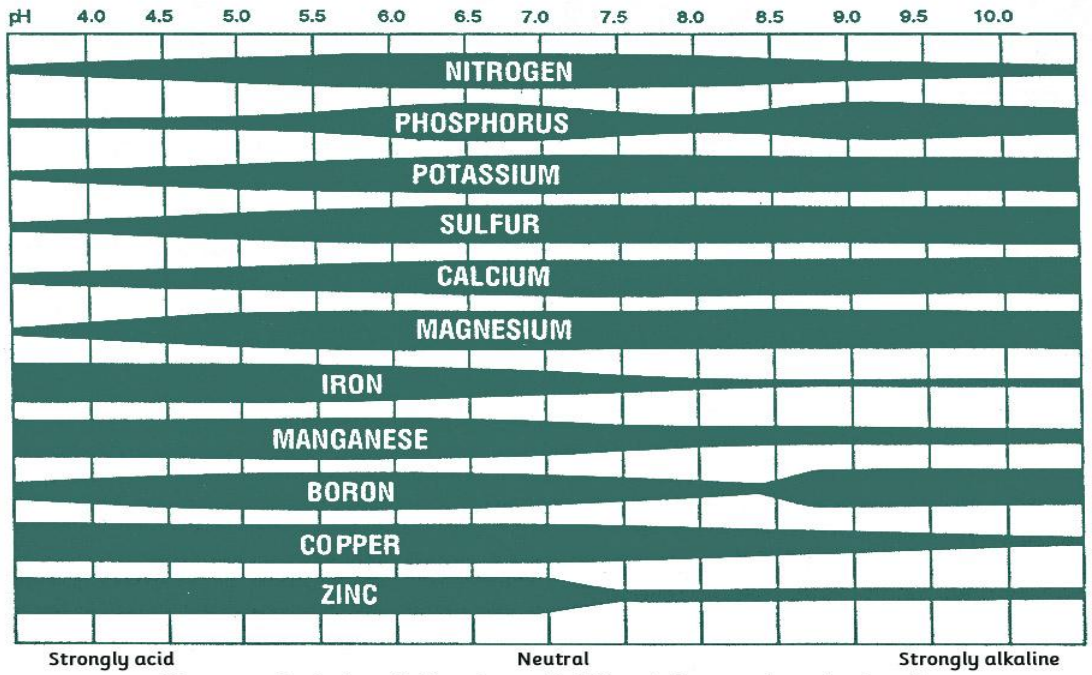
Boron (B)	0.002
Zinc (Zn)	0.002
Copper (Cu)	0.0006
Molybdenum (Mo)	0.00001

The other four percent of the dry weight of a plant is composed of nutrient elements which are supplied from the soil. Three of these nutrients (nitrogen, phosphorus, potassium) are considered major nutrients because they are required in relatively large amounts. These are most likely to become deficient. The remainder of the nutrients that the soil supplies are not as likely to become deficient because they are required in much smaller amounts for growth. These are sometimes referred to as secondary nutrients or micronutrients. Deficiencies in these nutrients are more likely the result of low or high soil pH, poor soil condition or the excess of some other nutrient which competes for uptake into the plant roots.

How much of these soil nutrients should be added to the soil as a fertilizer is related to what levels are presently available in the soil and other factors such as the kind of plant, how fast the plant grows, condition of the soil and weather (temperature and rainfall). The nutrient level in the soil can be determined through a soil test. Generally, fertilizer recommendations are based upon the types of crop or plant in question. Vegetables require more; trees and shrubs less.

The basic soil test should give you several important pieces of information; a measure of pH (acidity/alkalinity), percentage of organic matter and levels of available phosphorus and potassium. More extensive tests can be done, but are rarely necessary for the typical gardener unless you are having problems and need to diagnose the condition more fully.

Table 2. Effects of soil acidity/alkalinity on plant nutrient availability



The general relation of pH to the availability of plant nutrients in the soil: the thicker the bar, the more available the nutrient.

Soil pH

The soil pH is a relative measure of soil acidity. How acid or basic (alkaline) the soil is affects plant growth by limiting the availability of nutrients to the roots for uptake (Table 2). It also affects the activity of microorganisms whose job is to breakdown organic matter to liberate nutrients as well as convert nutrients to a more usable form for root absorption.

Generally, most plants require a soil pH in the range of 6.0 to 7.0. The pH of distilled water is 7.0 and is considered neutral. A pH of 6.0 is slightly acidic. While most plants do well in this range (6.0-7.0), some favor more acid conditions. Azaleas, rhododendrons and blueberries grow better in acid soils of pH 4.5 to 5.5. On the other hand, plants in the bean family (legumes) favor slightly alkaline conditions of 7.0 to 7.5 for good growth.

Raising the Soil pH

Table 3. Pounds of ground limestone needed per 1,000 square feet to raise pH to 6.8

	Soil texture		
Initial Soil pH	**Sandy**	**Loamy**	**Clayey**
6.5-5.5	25	35	45
5.5-5.0	40	55	70
5.0-4.5	55	75	105

Individual applications should not exceed 25 to 50 pounds per 1,000 square feet

If the soil test report says that the soil is too acidic for your crop or plant, then you will need to add a liming material to raise the pH. Limestone is most commonly used and can be purchased as dolomitic limestone (calcium magnesium carbonate), calcitic limestone (ag lime) or hydrated lime. Dolomitic limestone contains about 10 percent magnesium as magnesium carbonate. Ag lime is composed of about 30 to 40 percent calcium as calcium carbonate. Both of these materials can be used to lime a soil. The amount required depends upon the type of soil and the initial soil pH (Table 3). Never apply more than 50 pounds per 1,000 square feet of lime at once. If more is required, space applications about one week apart. Hydrated lime is generally too strong for common use and may result in over liming the soil. It can also be unsafe to apply and should be treated as a hazardous chemical which should never be allowed to contact wet skin.

Lowering the Soil pH

Table 4. Pounds of sulfur needed per 1,000 square feet to lower pH to 6.5

	Soil texture	
Initial Soil pH	**Sandy**	**Clayey**
7.5	10-15	20-25
8	25-35	35-40
8.5	35-40	40-50

If the soil is too alkaline for the crop or plant, then you will need to lower the pH by adding an acid forming material. Iron sulfate or elemental sulfur is typically used to do this. If you are raising rhododendrons or blueberries, the soil pH should be adjusted prior to planting. Several applications of a sulfur compound incorporated into the top 6 inches of soil will be necessary initially. Repeat applications may be in order as determined through a subsequent soil test every other year. Table 4 above can be used to guide this application. The amount of sulfur needed depends upon the initial pH of the soil and the type of soil present. Never apply more than 5 pounds per 1000 square feet of material at once to a growing plant or crop. Wait several weeks before reapplying more if the soil test requires it.

Organic Matter

Table 5. Organic mateials for mulching and improving soils.

Organic material	Material per 1,000 sq. ft.	Nitrogen to be added per 100 lbs. of material
Corncobs (ground)	50 lbs.(2 bushels)	1 to 1 1/2 lbs.
Sawdust	50 Ibs.(2 bushels)	1 1/4 to 1 1/2 lbs.
Wood chips	50 lbs.(2 bushels)	1 1/4 to 1 1/2 lbs.
Leaves	75 Ibs.(3 bushels)	1/2 to 1 Ib.
Straw	60 lbs.(1 bale)	1/2 to 1 Ib.
Peat moss	6 to 10 cu. ft.	None
Compost	10 to 20 cu.ft.	None
Lawn clippings	4 bushels	None

Many gardeners recognize the value of adding organic matter to planting beds to improve drainage, soil compaction, aeration and moisture conditions. Soils which are dominated by clay benefit from amending with organic matter to break-up the clay particles so that root penetration is improved. Commonly, the soil test report will show values in the range of 2 to 10 percent organic matter. These are good levels. Below one percent is considered deficient. These soils should receive some organic matter in the form of leaf mold, compost, peat moss, straw or some other plant material. When starting a new bed, apply organic material just prior to turning it over (Table 5).

Over a period of several years, the organic material will decompose to its lowest stable form called humus. Humus is good, but loses some of its soil improvement qualities over time. In this case, it is good to reapply organic matter to the surface as a mulch. Eventually, this will work down into the soil and improve the soil condition. Mulch will also buffer soil moisture stress and add some nutrients.

The nutrient supplying capacity of organic matter is limited for some crops such as vegetables which require larger amounts during a growing season. Gardeners, who grow organically, supply their nutrients by applying organic matter in large quantities. The nutrient amounts found in organic fertilizers vary as discussed below.

Phosphorus

Phosphorus is an element important to flower and seed producing energy systems and primary root growth. It is relatively immobile in the soil even under the best conditions. When it is applied as a fertilizer, it stays in the zone of application for long periods. For this reason, it is often not necessary to reapply fertilizers containing phosphorus each season. Phosphorus availability is dependent upon soil pH. When the pH is below 5.0 and above 7.5, it becomes less soluble in the soil and therefore, not available for root uptake. Phosphorus deficiencies also can occur when the soils are cold. Cold soils result in slow root growth and therefore, limited contact with phosphorus reserves which do not move about. This is one reason why early plantings of vegetables and newly seeded turfgrass should be accompanied by a starter fertilizer containing phosphorus. A phosphorus test should register in the area of 6 pounds per 1000 square feet. This is a desirable range for most crops and plants. If the level is below this, only then should it be applied.

Potassium

Potassium is an element that supports many plant functions including photosynthesis, strengthening cell walls and water regulation. It is moderately mobile in the soil and rarely at levels considered deficient even under extremes of pH. Potassium levels are affected by crop removal, rainfall, and the soil texture. As vegetables are harvested or grass clippings removed, potassium levels drop. These are two cases where it

would be important to monitor potassium quantities in the soil through soil tests. If grass clippings are not removed, then the need to fertilize with potassium-containing fertilizers is rare.

Soil test levels around 10 pounds per 1000 square feet are desirable. If your soils are less than this, then the potassium supply should be built up. However, because it is possible to burn plants with potassium applications, each application should not exceed 1.5 pounds per 1000 square feet. Additional applications should be spaced 4 to 6 weeks apart.

Nitrogen

Nitrogen levels are typically not assessed in a soil test because this element is very soluble in water and leaches away from the root system, requiring some replacement each year. Nitrogen is an element that is important for stimulating vegetative growth. The basis for making nitrogen recommendations is dependent upon an understanding of how much the plant or crop will use during the growing season. This in turn is dependent upon when the plant begins to grow relative to the temperature and growth rate of the plant. Vegetables require more total nitrogen each season than trees and shrubs because the growth rate is higher and fruit production demands a larger nutrient supply. A high maintenance turfgrass can also require more nitrogen over the season because the growth rates are expected to be high. Plants growing in shade do not need high levels of nitrogen. Their expected growth rate will be low and excess nitrogen will not be used. If amounts of nitrogen exceed what is required, it will leach from the soil and into soil ground water. Applying too much nitrogen can also burn plants, especially if supplied at a time when the plant is actively growing.

Fertilizer Types

There are two broad categories of fertilizers; organic and inorganic. Both have advantages and disadvantages when used to supply nutrients to plants.

Organic Fertilizers

Organic fertilizers are derived from animal and plant remains. However, some organic fertilizers are synthetically made from carbon-based chemicals. The term “organic” chemically means that carbon forms the base skeleton of the fertilizer, If you are an organic grower, then classically, you are interested in fertilizers of plant and animal origin only. These materials usually release nutrients slowly which reduces the potential for fertilizer burn.

Before organic nutrients can be taken up by plants, they first have to be broken down to an inorganic form by microorganisms. This is a form of slow release of nutrients. For perennials, this is desirable because these are typically slow growing and do not require large amounts of nutrients at any one time. One application of an organic fertilizer will often supply all the nutrients necessary for one growing season.

Organic fertilizers not only supply nutrients, they also supply organic matter to the soil. This benefits root growth by improving soil aeration, water, nutrient holding capacity and soil texture. Generally, this is the largest benefit of applying organic fertilizers. If large amounts of organic materials with low nitrogen content are added to soils, it is possible to get a nitrogen deficiency. This occurs because microorganisms breakdown the organic matter, using nitrogen for their growth. If the nitrogen in the organic matter is not enough to assist the microorganisms, they will deplete any excess nitrogen left in the soil and limit the supply to the plant. In this case, supplemental nitrogen applications may be required. A good example is the application of sawdust which contains very little nitrogen. It is not unusual to see some nitrogen deficiency in plants mulched or soil-amended with this material.

The time to apply organic fertilizers is primarily in the fall. This provides necessary time to begin

decomposition and subsequent liberation of nutrients so that it will be available to plants earlier in the growing season.

Forms of Organic Fertilizer

How much organic fertilizer is needed to supply all that is required for the plant or crop in question depends upon the type of organic material used. Some organic fertilizers do not contain balanced amounts of nitrogen, phosphorus and potassium. Therefore, you may need to mix different forms or organic fertilizers or supplement with inorganic forms. Table 6 lists some organic fertilizers and their nutrient composition. Those which contain less than 1.5 percent of nitrogen will deplete the soil of nitrogen and potentially cause a nutrient deficiency unless additional nitrogen is supplied.

Table 6. Nutrient levels in organic fertilizers

	Average percent of		
	Nitrogen	**Phosphate**	**Potash**
Ashes	0	1.5	7.0
Blood	12.9	1.5	0.6
Bone meal, raw	7.2	22.5	0
Bone meal, steamed	2.5	27.4	0
Coffee grounds	21.0	0.3	0.3
Compost, general mixture	0.3	0.2	0.4
Corncobs, ground	4.0	0.05	0.4
Corn fodder, sweet corn	1.5	0.4	12.0
Corn stover	0.9	0.1	0.5
Cottenseed meal	6.4	2.6	1.7
Fish scraps	9.0	7.0	0
Green sand	0	1.4	6.3
Green manure, rye	2.0	0.2	1.0
Green manure, oats	1.3	0.2	1.1
Hay, mixed	1.5	0.4	1.8
Hoof & horn meal	13.8	1.0	0
Kelp or seaweed	1.5	1.0	4.9
Lawn clippings	1.2	0.3	2.0
Leaves, sugar maple	0.7	0.1	0.8
Leaves, white oak	0.6	0.1	0.5
Oyster shells	0.2	0.3	0.03
Peat moss	1.9	0.2	0.2
Pomace, apple (wet)	0.2	0.04	0.1
Pomace, grape (dried)	2.0	0	0
Sawdust & wood shavings	0.2	0.1	0.2
Sewage sludge	15	1.3	0.4
Silage, corn	0.4	0.1	0.4
Straw, oat	0.7	0.2	1.6
Straw, wheat	0.8	0.2	1.0
Manure			
Beef (fresh)	0.6	0.4	0.5
Beef (dried)	1.2	2.0	21.0
Chicken (fresh)	0.9	0.5	0.5
Chicken (dried)	1.6	1.8	2.0
Dairy (fresh)	0.6	0.2	0.5
Dairy (dried)	1.6	1.8	2.0
Duck (fresh)	1.1	1.4	0.5

Goose (fresh)	1.1	0.5	0.5
Hog (fresh)	0.6	0.3	0.4
Hog (dried)	2.2	21.0	1.0
Horse (fresh)	0.6	0.3	0.5
Rabbit (fresh)	2.4	1.4	0.6
Sheep (fresh)	0.9	0.5	0.8
Sheep (dried)	1.6	1.2	2.0

Inorganic Fertilizers

Inorganic fertilizers are derived from nonliving materials. Some are obtained from nature in mining rock or mineral deposits (rock phosphate and potassium). However, most are produced through chemical reactions. The nutrients in inorganic fertilizers are usually readily available shortly after application and are taken up during active growth.

Commercial grades of inorganic fertilizers are typically available as a bagged product with an identification of nutrient content expressed on the container. Usually, there is a series of three numbers such as 5-10-5 which represents the percentages of nitrogen (N), phosphorus ($P_2 0_5$) and potassium (K as $K_2 0$) in the bag. In 100 pounds of fertilizer with the above analysis, 5 percent or 5 pounds is nitrogen, 10 percent or 10 pounds phosphorus and 5 percent or 5 pounds is potassium. The rest of the product in the bag (80 pounds) is carrier or anti-caking material.

Forms of Inorganic Fertilizer

Inorganic fertilizers come in many grades. “Grade” refers to guaranteed analysis stated on the package like 5-10-5 or 10-10-10. These “complete” fertilizers contain the three nutrients used most by plants: nitrogen, phosphorus and potassium. Other fertilizers may contain only one or perhaps two of these three elements. The advantage of using single or double element fertilizers is that you can add to the soil only those elements which are in short supply. The soil test may indicate that you only need nitrogen for the crop or plant in question. It would, in this case, be wasteful to apply a complete fertilizer containing all three elements when only one is needed. Since the price of fertilizer is dependent upon what elements are in the bag, it also would be more expensive to apply a complete fertilizer when not all of the elements are required.

Inorganic fertilizers come in several forms; granulated, pelleted, slow-release, concentrated solids and concentrated liquids. Granular fertilizers are the most commonly used materials. They are easy to spread and relatively inexpensive.

Pelleted fertilizers are coated granules of uniform size. These are very easy to spread and more expensive than plain granular fertilizers.

Slow-release fertilizers are granulated organic forms which must be broken down by microorganisms in order to release inorganic nutrients to the plant root. Other slow-release fertilizers include granulated inorganic forms which have been coated with a material to delay the release of nutrients to the soil. Sulfur coated urea and plastic coated fertilizers are examples of this type. In both cases, these types of fertilizer do not have to be applied often because they deliver nutrients slowly over a period of 3 to 9 months. This avoids fertilizer burn.

Concentrated solid and liquid fertilizers are water soluble forms which must be diluted in order to be applied. The most common example of this form is general house plant fertilizer. For outdoors, a solid type is represented by the familiar spikes use to fertilize trees and shrubs.

The following is a list of commonly used inorganic fertilizers and their grades (Table 7).

Table 7. Inorganic Fertilizers

Fertilizer	Grade (%)	Soil Reaction	Approximate volume per pound	
			Cups	Tablespoons
Ground limestone	98	Alkaline	1 1/2	24
Sodium nitrate	16-0-0	Alkaline	1 1/2	24
Potassium sulfate	0-0-50	Neutral	1 1/2	24
Calcium nitrate	15-0-0	Alkaline	2	32
Superphosphate	0-20-0	Neutral	2 1/4	36
Triple superphosphate	0-45-0	Neutral	2 1/4	36
Muriate of potash	0-0-50	Alkaline	2 1/4	36
Ammonium nitrate	33-0-0	Acid	2 1/2	40
Ammonium sulfate	20-0-0	Acid	2 3/4	44
Ammonium phosphate	11-48-0	Acid	2 3/4	44
Sulfur (elemental)	98	Acid	4	64
Urea	45-0-0	Acid	2 1/2	42
Potassium chloride	0-0-60	Neutral	2	32
Potassium nitrate	14-0-47	Alkaline	1 1/2	24
Diammonium phosphate	22-54-0	Alkaline	2 3/4	44
Complete fertilizers	10-10-10	-	2 1/4	36
	12-12-12	-	2 1/4	36
	5-10-5	-	2 1/4	36

Types of Fertilizer Application

Fertilizers can be applied in a variety of methods. The easiest way is to apply them to the surface of the soil either by broadcasting, top-dressing or side-dressing.

Broadcasting involves spreading dry fertilizers evenly over the top of the ground. This can be done by hand, however, inexpensive spreaders are better able to distribute the materials uniformly. If you broadcast fertilizer, it should be done when the leaves are dry. Granules which can stick to a wet surface will likely burn the leaves and stems. After the fertilizer has been distributed, it should be watered into the soil.

Top-dressing involves applying a ring of dry fertilizer around the base of a plant several inches away from the stem. For smaller plants like vegetable transplants, bulbs and annuals, the ring might be 3 to 4 inches away from the stem and 2 to 3 inches wide. For shrubs, the inner part of the ring should be parallel with the outside diameter of foliage canopy and the width of the band about 1 to 2 feet beyond. This is where the feeder roots are located.

Side-dressing is similar to top-dressing except that a band of fertilizer is placed in a continuous strip on one side of the plant. The band should be located away from the stem several inches and 2 to 3 inches wide. This works very well for rows of flowers and vegetables.

While applying fertilizers to the surface is fast and easy, the quickest way to get fertilizers to the root system is to work them into the soil. Subsurface applications can be done by tilling dry fertilizers into a bed following broadcast application, banding, plugging, lance feeding and spike or tablet application.

Broadcast incorporation involves first making a broadcast application of dry fertilizer, then spading or tilling the material to the proper depth. This is an especially good method for initial bed preparation for planting and is most commonly used for vegetable gardens.

Banding is similar to side-dressing a row, only after the band of dry fertilizer is laid down, it is incorporated into the soil through light tillage.

Plugging is a technique used to apply fertilizer to trees and shrubs. An auger or bar is used to create a narrow hole to a depth of 12 to 18 inches. A series of these holes spaced 1.5 to 2 feet apart are made within the feeder root zone typically in the area parallel with and past the drip line of the plant. A specific amount of dry fertilizer is funneled into each hole and the hole is plugged with soil.

Lance application of fertilizer involves dissolving fertilizer in water and by use of a pressurized system, forcing the liquid into holes created in the same root zone area as that for the plugging technique. It is generally faster than plugging, however, can be quite time consuming and requires specialized equipment.

Spikes and tablets of solid fertilizer have become popular methods of fertilizing trees and shrubs. The material is forced into the soil around the feeder root system. This technique has also become useful in fertilizing house plants.

Fertilizing Ornamental Plants

The amount of fertilizer, when it is applied and how it is applied will depend upon the plant or crop that you plan to grow. Soil tests are good indicators of the amounts of total fertilizer that you may need, but typically do not cover all the applications. For example, younger plants grow fast and need a quick supply of nutrients to establish themselves. They, however, are not big consumers of large quantities of fertilizer. Therefore, the amount and the timing of fertilizer is important to raising young plants. Older plants such as established trees and shrubs do not need frequent feedings of fertilizer. They have a general growth period in the spring and early summer and afterward, remain relatively inactive. The timing of fertilizer application is not so critical; it is best to make the application close to the growth period. However, fertilization need not take place every year and the amount of fertilizer required for a good response is much higher than with young plants.

The following are some generalizations for making fertilizer applications for certain plants and crops. A soil test will give you more specific directions on amounts of individual nutrients to apply. However, if you have not taken a soil test then the recommendations provided here could be followed. Assume that when recommendations call for a “complete fertilizer”, that means one that contains nitrogen, phosphorus and potassium. The grade called for could be 10-10-10, 12-12-12 or for lighter amounts, 5-10-5 (see below for calculating amounts of specific nutrients).

Flowers

Before planting annuals and perennials, make an application of 20 pounds of complete fertilizer (10-10-10) per 1000 square feet and till this into the soil bed. For annuals, in late June make another application by side-dressing 10 pounds of complete fertilizer per 1000 square feet. For perennials, repeat the early application with the complete fertilizer each of the first two years then, once every three years. In other years, apply about 1 pound of nitrogen to the bed.

Bulbs

For fall-planted hardy bulbs, make an application of 20 pounds of complete fertilizer per 1000 square feet of bed before planting and till to a depth of 8 to 10 inches. Do not apply more fertilizer in the spring. After bloom, make an application of 20 pounds of complete fertilizer per 1000 square feet or 1 heaping tablespoon per plant. Incorporate this into the soil lightly if possible.

Roses

When all danger of frost has past and new growth is well established, apply 20 pounds of complete fertilizer per 1000 square feet or 1 heaping tablespoon per plant. Repeat this application in 4 to 6 weeks, but not after July 15.

Vegetables

Before planting in the spring, incorporate about 30 pounds of complete fertilizer (10-10-10) per 1000 square feet. Broadcast half of this application, then till to a depth of 12 inches. Spread the other half and mix to a depth of 6 inches. In 3 to 4 weeks, follow up with another application of nitrogen fertilizer at the rate of 1 pound of nitrogen per 1000 square feet and incorporate this lightly with tilling. For perennial vegetables, such as asparagus, in the first two years after planting apply 10 to 15 pounds of complete fertilizer before the plants emerge in spring. In the third year and thereafter, apply the same amount of fertilizer after harvest is completed incorporating the material to a shallow depth. For rhubarb, apply 15 pounds of complete fertilizer when the shoots are about 6 inches tall spreading on the soil surface and work in with light cultivation. This application only needs to be made once each year.

Fruits and Nuts

Initially, do a soil test. Apply complete fertilizer only when phosphorus and potassium levels are low. Otherwise, apply a nitrogen fertilizer in the spring before bud break at the rate of one quarter pound for every year of age up to 4 years. For older trees, apply 1 pound of nitrogen per tree annually in the spring or fall. Applications can be made by broadcasting onto the soil surface, side-dressing or by the plugging technique. Soil test every 5 years.

Small Fruits

For blueberries which require a pH of 4.5 - 5.0, use nitrogen fertilizer (urea 45-0-0) in the spring at the rate of 1 ounce per plant for the first three years after planting. Increase this to 6 ounces per plant up to 8 years and 1.5 pounds of nitrogen per 1000 square feet thereafter. Conduct a soil test before planting to determine pH and levels of phosphorus and potassium. Make adjustments to the pH with elemental sulfur according to Table 2. Check the nutrient levels and pH every other year.

For raspberries, blackberries and grapes, apply one-quarter ounce per plant of urea or 2 ounces of complete fertilizer to each newly set plant two weeks after planting in the spring. Increase the nitrogen rate to one-half to three-quarters of a pound per 1000 square feet in year two to be applied in the spring. Thereafter, apply 1.5 pounds of nitrogen per 1000 square feet of bed. Only annual applications are necessary.

For June bearing strawberries, broadcast complete fertilizer at the rate of 5 pounds per 1000 square feet before planting and work into the soil. Four weeks after planting, apply 1 pound of complete fertilizer at the rate of 10 pounds per 1000 square feet. In the second year and thereafter, apply 10 pounds of complete fertilizer in late summer.

Indoor Plants

Many soil mixes contain some fertilizers. Check the package before fertilizing to make sure you are not adding more fertilizer to the mix. If the soil mix does not have amended fertilizer, before planting or repotting incorporate fertilizer into the potting mix following label directions. Slow-release materials can also be used and are highly recommended for otherwise slow-growing house plants.

The time to fertilize indoor plants is when they are in an active state of growth. Foliage plants, ferns and flowering plants can be fertilized once each or twice month with any complete, water-soluble fertilizer like 20-20-20 or a similar grade following the label direction. If plants begin to yellow during the active growth stage, a supplemental fertilizer application may be necessary. Yellowing may also be a sign of overwatering, the most common problem of indoor plants. This can be done by using a water-soluble material or addition of more slow-release material and shallow incorporation into the surface soil. Generally, indoor plant do not require large amounts of fertilizer and 2 to 3 applications are all that are necessary during non-growth periods. Some indoor plants like cacti and succulents go dormant during the winter months. They should not be fertilized at this time. Wait until growth resumes in the spring.