



CONSUMER HORTICULTURE

Fertilizing Woody Plants

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Trees and shrubs need adequate light, moisture, air, and nutrients, plus favorable temperatures, and proper soils and pH for optimum growth. There are 17 plant nutrients essential for plants. Three of these — carbon, hydrogen, and oxygen — are provided by air and water. The other 14 essential nutrients are minerals that plant roots primarily take up from the soil. In many landscapes, soils are often deficient in one or more of these required nutrients.

There are a number of reasons why the soils in your yard are deficient in nutrients. Under forest (or natural) conditions, decaying leaves and plants continually replace the nutrients taken up by living plants. In homes and landscaped areas, however, people generally remove fallen leaves and other plant debris. As a result, soil fertility declines.

The soils around homes and landscaped areas may also have poor soil fertility because of topsoil loss and because builders often use subsoil to fill and grade during construction. Subsoils often have poor physical properties, lack adequate amounts of essential mineral nutrients, and contain very little (if any) organic matter. Many homeowners and landscapers, recognizing this problem, regularly fertilize their lawns but forget that trees and shrubs need similar attention.

This publication examines the basics of why and how to fertilize woody plants in the home landscape.

Why Fertilize Woody Plants?

Here are some common reasons why woody plants require fertilization.

Fertilizer can:

- Correct a nutrient deficiency
- Maximize growth
- Increase flowering
- Increase chlorophyll content

Why Fertilize?

Properly fertilizing any plant is important. A vigorous plant with hardy growth and better resistance to disease and insect pests is the result of providing proper plant nutrition. Plants that receive poor nutrition may show many signs, including smaller leaves, yellowing leaves, mottled leaves, early leaf loss, poor growth, and more. Proper fertilization can help trees and shrubs overcome weak growth and will help them recover from stresses like insect feeding, diseases, and other damage.

Fertilization can accelerate the growth of young plants and can help stimulate the growth of slow-growing species. With proper nutritional care, even the so-called slow-growing trees may grow more rapidly. Although mature trees and shrubs that have reached full size need less fertilization than young specimens, regular light fertilizing will maintain good color and health while limiting excessive growth, which can lead to many health issues.

Figure 1.



This polymer coated, pelletized fertilizer slowly releases nutrients, allowing longer residual of fertilizer to the plant.

Organic and Inorganic Fertilizers

Fertilizers are available in many forms and combinations. Two major categories are organic and inorganic fertilizers:

- Organic fertilizers are made from plant or animal sources such as manure, grass clippings, leaf litter, and bone meal.
- Inorganic fertilizers are made from nonliving sources. Some are mined from mineral deposits while others are made through complex manufacturing processes.

Plants absorb most nutrients as elements that are inorganic ions (electrically charged atoms). Organic forms of elements must be converted to inorganic ions before the roots can take them up. So, organic nutrients are not immediately available to the plant.

But a plant does not distinguish between ions that originate from inorganic or from organic sources. This is not to say that different materials that contain the same amount of a particular nutrient will be equally effective. A fertilizer's effectiveness depends on how soluble the materials are, how they affect the soil's structure or pH, and how long they persist in the soil.

Organic fertilizer sources release their nutrients slowly because soil microorganisms must break them down before they are available to plants. This can be desirable because slow-release fertilizers provide nutrients over a longer period. What's more, quick-release fertilizers can actually injure plant roots.

For these reasons, some synthetic fertilizers have polymer coatings to give them slow-release characteristics (Figure 1). Urea formaldehyde is an example of a slow-release fertilizer. Simple urea, however, is not slow-release and has a high potential to burn plant roots.

The principal advantage of natural organic fertilizers is that they can improve soil structure (called soil tilth) while meeting the nutrient requirement of plants (if supplied in sufficient amounts). For example, if you incorporate manures into surface soils, it can improve the soil's structure and reduce crusting and enhance seedling emergence.

Figure 2.



Figure 2. Fertilizer labels provide three numbers that represent the percentage of nutrients by weight. The numbers are always in the same order – nitrogen (N), phosphorus (P), and potassium (K).

But animal manures may also introduce some problems. For example, they can contain weed seeds, burn plant roots, and pollute water sources. That's why manures should always be composted before use and applied well ahead of planting time.

If your primary concern is just supplying nutrients (not improving tilth), inorganic fertilizers are usually preferable to organic forms. Inorganic fertilizers cost less per unit of nutrient, contain greater percentages of a given element, do not vary in nutrient concentrations, and are easier to handle and apply because they are more concentrated and less bulky.

Furthermore, the nutrients in inorganic fertilizers are more quickly available to the plants and do not depend on the rate of organic decomposition. The rate at which a fertilizer decomposes depends on temperature, moisture, and soil composition, which can slow uptake by the plant.

Using Inorganic Fertilizers

The term “complete fertilizer” refers to a fertilizer that contains nitrogen (N), phosphorus (P), and potassium (K). The “analysis” on the fertilizer label indicates the percentage by weight of these three nutrients, always listed in the same order (Figure 2). Thus, a fertilizer product with a 10-6-4 analysis contains 10 percent nitrogen, 6 percent phosphorus (expressed as P_2O_5 or phosphate), and 4 percent potassium (expressed as K_2O or potash).

Put another way, a 100-pound bag of 10-6-4 fertilizer contains 10 pounds of actual nitrogen (N), 6 pounds of phosphate (P_2O_5), and 4 pounds of potash (K_2O). A 50-pound bag of the same fertilizer would contain half as much of each nutrient. The rest of a fertilizer's weight consists of material or “carrier” that makes it possible to spread the fertilizer evenly and easily. To calculate how much fertilizer you need for your trees and shrubs, use the actual amount of each active ingredient in the bag.

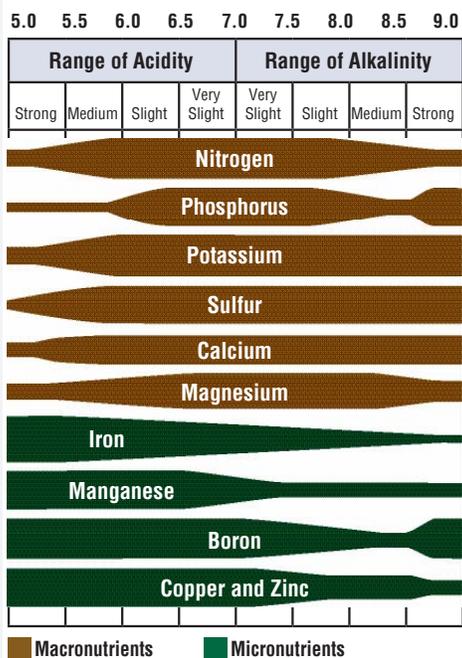
If you have trees and shrubs growing in a lawn where you follow a complete fertilizer program to promote healthy turf, your woody plants may not need additional fertilizer. However, if the trees and shrubs are in beds where the shrub roots are not under the lawn, you should fertilize the woody plants as detailed below and after reviewing test results.

Note that you should never use products that contain mixes of both fertilizer and herbicides that are designed for turf (unless the product is specifically labeled for such use). In general, you should not apply turf herbicides (such as 2,4-D and dicamba) over the roots of trees or shrubs, because they may enter the plants through the root system and damage them. Damage can include disfigured new growth (epinasty), dieback of twigs and branches, and in severe cases, plant death.

Soil pH and Fertilizers

A soil's pH significantly affects how easily a plant can use the nutrients in the soil — called nutrient availability. We measure pH on a scale from 0 to 14 to measure acidity and alkalinity. A soil with a pH of less than 7 is considered acidic, a soil with a pH greater than 7 is considered alkaline (basic).

Figure 3.



A nutrient's availability to plants varies by soil pH. In this illustration, the wider the band, the more available the nutrient; the narrower the band the less available the nutrient. Adapted from the *Corn & Soybean Field Guide* (Purdue Extension publication ID-179).

Some nutrients are more available to plants when the soil is acidic, while other nutrients are more available when the soil is alkaline (Figure 3). Several factors determine soil pH. The most significant factor is the material that the soil was made from (called parent material). Generally, soils in the Midwest have a high pH because the parent materials of many soils is limestone. Special local conditions (such as highly sandy or organic soils) may be more acidic.

For more information about soil pH and how it affects nutrient availability, see *Commercial Greenhouse and Nursery Production: Soil pH* (Purdue Extension publication HO-240-W), available from the Education Store (edustore.purdue.edu).

Soil and Tissue Testing

Repeatedly applying any fertilizer can result in an overabundance of certain nutrients, which can be toxic to plants and pollute water sources. You should always test your soil to determine the pH and nutrient levels before you apply any fertilizer. You can use a soil probe to collect samples for the test (Figure 4). A soil test will guide you to apply the optimum amount of fertilizer for the plant with minimal impact to the environment.

We also recommend that commercial plant growers and maintenance professionals sample plant tissues at the time of the soil test to determine if the plants are actually taking up the nutrients available in the soil. In general, tissue testing is impractical for home landscapers except for diagnosing specific elemental deficiencies.

For more information about soil testing, see *Collecting Soil Samples for Testing* (Purdue Extension publication HO-71-W), available from the Education Store (edustore.purdue.edu).

Macronutrients and Micronutrients

The various nutrients that a plant needs can be classified in two broad categories: macronutrients and micronutrients. Macronutrients are elements that plants need in relatively large quantities. Micronutrients are elements that plants need in lesser amounts. All macronutrients and micronutrients are necessary for healthy plants.

Nitrogen (N) is a macronutrient that is always in short supply, because plants require it in large quantities. What's more, nitrogen leaches out of the root uptake zone, volatilizes (escapes into the air), and can become immobile (locked in the soil), so you must replace nitrogen annually. You should apply nitrogen as needed to maintain green leaves and vigorous growth. For rapidly growing plants, an annual application in the fall is preferred to ensure adequate amounts.

Phosphorus (P) and potassium (K) are also macronutrients, but in general, an application every three to five years is adequate for satisfactory growth of young woody plants. Phosphorus forms relatively insoluble compounds in the soil and becomes available slowly through several growing seasons. Phosphorus has become a particular concern because it can harm the water quality of lakes, rivers, and streams. Be sure your soils actually need phosphorus and potassium before you apply them, particularly in runoff areas around ponds, lakes, and streams.



Figure 4.

A soil probe is a tool you can use to collect soil samples. Laboratories require good soil samples to test your soil's nutrients.

When Should You Fertilize Woody Plants?

Here's when you should fertilize your woody plants:

- After a soil and tissue test
- When nutrient deficiency symptoms are present
- When the plants are providing less than desired annual growth

Don't Apply Too Much Fertilizer

Over-fertilizing your woody plants can:

- Cause plants to grow excessively (which makes plants susceptible to stress and pests)
- Increases your costs
- Damages the environment

In established plantings, you should only apply phosphorus and potassium if your soil test results recommend it. If a soil test shows that phosphorus and potassium are at low or medium levels, use the appropriate fertilizer mix such as 10-10-10, 16-8-8, or 20-10-5. If the soil is adequate in phosphorus and potassium, use a nitrogen-only fertilizer such as 21-0-0, 33-0-0, or 45-0-0.

Soil texture (the amount of sand, silt, and clay in your soil) affects fertilization, too. Imagine that your soil is a giant magnet for soil nutrients. Clay and organic matter in the soil have a negative charge. So, naturally they attract positively charged nutrients and repel negatively charged nutrients. This explains why cations (positively charged nutrients) find an easy home in the soil while anions (negatively charged nutrients) are repelled and easily leached out of the soil. The cation exchange capacity (CEC) measures a soil's charge.

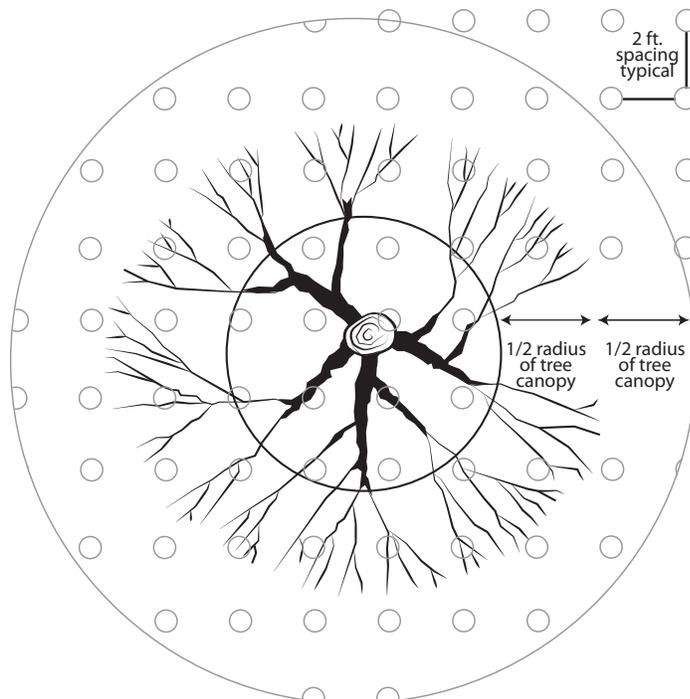
You can use your soil's CEC to plan how much fertilizer to use and how often to apply it. Soils with a very low CEC (such as soils with a higher sand content) require small quantities of fertilizer but require frequent applications. Low-CEC soils cannot hold excess fertilizer. Therefore, you should be careful not to over-apply and aim to frequently replenish what your plant uses.

Adding organic matter (such as compost) will help improve CEC. However, soils with excessive sand content may allow greater leaching through the soil profile, which may require more fertilizer.

On the other hand, soils with a very high CEC (such as soils with a heavy textured clay content) can go for longer periods without fertilizer because of the larger reserves stored on the soil particles. When heavy textured soils are deficient, however, it takes considerably more fertilizer to correct the deficiency. That is why fertilizer application recommendations are always higher for soils with high CEC. It is always a good practice to know your soil texture to help determine application rates.

Figure 5.

Placing fertilizer in holes that are evenly spaced around a tree and back-filled with organic matter is known as vertical mulching. This technique supplies nutrients into the root zone and corrects compaction by providing organic matter to improve soil structure. Figure 8 shows a cross-section of one of these holes.



Application Rates and Timing

Apply fertilizer when there is an adequate supply of water and when uptake is at a maximum. Woody plants generally take up fertilizer when their roots are growing, which typically peaks in early spring and again in the fall.

To determine the amount of fertilizer your plants require, calculate the size of the planting bed or lawn area that contains the woody plants. You should apply fertilizer to the feeder root zone of shrubs and trees. For shrubs, consider the feeder root zone to be either the entire bed area or an area twice the diameter of the shrub. Tree feeder roots occur in an area below and on either side of the tree canopy dripline (end of branch spread).

To calculate an appropriate area to fertilize, include the area one-half the canopy radius from the trunk extending to one-half the canopy radius beyond the dripline. If the yard has several trees, calculate the entire yard as the tree root zone.

Some fertilizer recommendations tell you to calculate the rate based on the diameter of the plant's trunk. However, it is a better practice to calculate fertilizer amounts based on the size of the bed or spread of the tree.

The optimal rate is 2-4 pounds of nitrogen per 1,000 square feet of soil.

To reduce the risk of fertilizer injury, divide this total amount into two or more portions, then apply those smaller amounts during the growing season.

For plants growing in turf, however, you should make these split applications to avoid damage to the turf.

A complete nutrition program would be to apply 1 or 2 pounds of nitrogen per 1,000 square feet in the early fall (September to early October), and then apply 1 or 2 pounds again in the spring just as buds are swelling (late March to April).

As long as soil temperatures are above 40°F, roots can absorb nutrients (see Table 1). An added advantage is that in spring and mid-fall, soil moisture conditions usually favor plant nutrient uptake. Research has shown that most trees take up nitrogen in the largest quantities in late fall as plants are entering dormancy.

Table 1. Average spring and fall soil temperatures at a 4-inch depth (°F) in Tippecanoe County, Indiana (based on an 18-year period).

		SOIL TEMPERATURE UNDER BARE SOIL ¹	AVERAGE SOIL TEMPERATURE UNDER TURF ¹
Spring			
March	15	38.1	38.2
	22	41.1	41.1
	29	43.9	43.7
April	5	46.7	46.1
	12	49.4	48.7
	19	52.2	51.1
	26	55	53.7
Fall			
October	20	55.1	55.6
	27	52.5	53.4
November	3	49.9	51.2
	10	47.2	49.1
	17	44.5	46.9
	24	41.9	44.7
December	1	39.3	42.5
	8	36.5	40.3

¹ Soil temperatures will vary depending on whether there is bare soil or it is covered by turf. If you wish, you may apply quick-release nitrogen in late spring or late fall. Well-informed landscapers avoid fertilizing during midsummer. Cold temperatures could injure the supple growth stimulated by midsummer treatments, and such treatments may delay the time when a woody plant goes dormant for the winter, which could result in significant cold injury.

To calculate the amount of a fertilizer product you need to supply 2 pounds of nitrogen per 1,000 square feet, use the percent nitrogen figure in the fertilizer analysis. Nitrogen is the first number of the three numbers in a fertilizer analysis. If the fertilizer has a 10-6-4 analysis, a 50-pound bag contains 5 pounds of nitrogen (10 percent of 50 pounds = 5 pounds).

If you apply 20 pounds of fertilizer (2 pounds of actual nitrogen) per 1,000 square feet, the 50-pound bag will cover 2,500 square feet. Stated another way, use 20 pounds of 10-0-0 fertilizer for every 1,000 square feet, or for smaller beds, apply 2 pounds for every 100 square feet. Table 2 provides rates for applying some common fertilizers.

Table 2. Nitrogen rates for common fertilizers.

	APPROXIMATE POUNDS OF FERTILIZER NEEDED		
	To Apply 4 lbs. Actual N	To Apply 2 lbs. Actual N	To Apply 1 lb. Actual N
Urea (46-0-0)	8	4	2
Ammonium nitrate (33-0-0)	12	6	3
Ammonium sulfate (21-0-0)	20	10	5
(10-10-10)	40	20	10
(12-12-12)	32	16	8

Figure 6.



You can use a rotary-type spreader in landscape beds and around trees to apply fertilizers based on the soil test.



Figure 7.

You can use a hand-held spreader to apply fertilizer in areas where push-type rotary spreaders are not feasible.

Factors to Consider

Here are some important factors to consider when you develop a fertilizer program for your woody plants:

- The availability of nutrients in your soil
- The relative proportion of soil nutrients to each other
- When you will apply the fertilizer
- The availability of moisture

Caution: Applying too much fertilizer can lead to weak, excessive growth or to damaged plant tissue (including burned roots, split bark, and more insect and disease pressure. When excess fertilizer injures a plant's root system, it can result in a nutrient deficiency within the plant even when soil nutrient levels are adequate. If a fertilizer application injures plant roots, two or more heavy waterings can help leach excess fertilizer salts from the soil.

In any case, watering plants well after a fertilizer application will help prevent injury. Significant periods of drought after a fertilizer application will result in dead leaves, leaves that drop early, and reduced nutrient uptake. This reduction of nutrients can lead to stress and/or damage in subsequent years.

If rainfall is sparse or infrequent, it will help to water the plant before you apply fertilizer. Never fertilize drought-stressed plants. Another way to protect plants from fertilizer injury is to use slow-release nitrogen fertilizer (such as urea formaldehyde). This source of nitrogen breaks down gradually over a period of several months and supplies plants with an even amount of nitrogen during this period. Its disadvantage is that it costs more than other fertilizers, and that cost may not be justified because many trees and shrubs only grow in one flush per year, so a continuous nutrient supply is unnecessary.

Methods of Application

Fertilizers are available several forms, but are generally applied dry or wet. Fertilizers are in granular or pelleted forms for dry applications and are in water-soluble or liquid forms for wet applications that can be made with a hose or sprayer.

You can broadcast dry fertilizers with a hand-held spreader or apply them with drop-type or rotary spreaders (Figures 6 and 7).

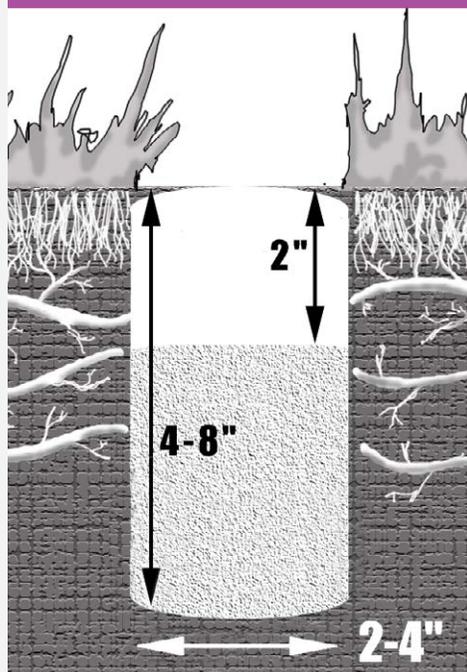
You can also fertilize individual plants using a measuring spoon (a practice called banding) to reduce the amount of fertilizer you use on the whole bed area where no plants are located. Avoid uneven distribution by dividing the fertilizer you need to apply in half, then apply half lengthwise over the area and the remainder crosswise over the area.

If you are fertilizing isolated trees within a lawn, then the application will also stimulate the turf in the application area — that turf will be greener and grow faster than untreated areas. You can avoid this so-called “oasis effect” by extending the fertilizer treatment beyond the area the trees cover.

Water the area thoroughly after application to remove the fertilizer from grass or ground cover and move it down into the soil.

Applying fertilizer to the surface is an efficient means of delivery to trees and shrubs. However, there are some limitations. Turf-covered areas will absorb a significant portion of the fertilizer. If you apply fertilizer on mulch, the mulch will break down faster because of the increased biological activity. In addition, phosphorus may not move into the root area of a woody plant before it is tied up in the mulch and soil. In these situations, it is better to apply the fertilizer below the surface (subsurface application).

Figure 8.



Vertical mulching holes should be 4-8 inches deep and 2-4 inches wide. Figure 5 shows a good spacing pattern for the holes.

Subsurface applications can be applied by drill holes or liquid injections (Figure 5). A drill-hole application requires drilling holes to a depth of 4-8 inches and pouring the specified amount of fertilizer into each hole, leaving at least 2 inches between the top of the fertilizer and the surface of the soil. The hole's diameter should be about 2 inches and the holes should be spaced 12 to 36 inches apart (Figure 8).

Drilling will also help aerate compacted soils. Be sure to evenly space all holes in a grid pattern beneath the tree's dripline. You may need to call 811 to locate underground utilities when drilling in lawns and residential areas.

After you fertilize, water thoroughly. You may then fill the holes with sand, topsoil, or organic matter to the top of the soil level. When you combine the fertilizer with organic matter backfill, the hole drilling and filling process is called "vertical mulching."

So-called "food spikes" that you drive into the ground at intervals beneath and around trees and shrubs is an alternative to drilling and filling holes, but they are more expensive than the method described above.

Other fertilizer application methods include:

- Injecting liquid fertilizer below the ground, using a special injector wand and water pressure to force the solution into the soil
- Applying liquid fertilizer to the plant's foliage
- Injecting nutrients into the tree trunk using special equipment

The last two methods are usually reserved for treating deficiencies of specific nutrients such as iron or manganese. Foliage treatments and trunk injections give quick results but can be more costly and less long-lasting than applying nutrients to the root zone.

Homeowners can make foliar applications to small and medium shrubs, but proper coverage of trees and large shrubs will require a professional arborist. Injection methods will also require a professional — the equipment often available to homeowners will not supply an adequate amount of fertilizer.

Special Cases

Deciduous Trees

Mature deciduous trees require little fertilization as long as they have good leaf color and continue to grow reasonably well. Over-fertilizing trees can cause excessive foliage growth at the expense of roots and will make the trees more susceptible to disease and insect pests.

For trees that grow in confined areas where the roots are restricted by pavement, buildings, or other construction, base your fertilizer rates on the area in which the roots are confined and not on the branch spread. Applying too heavy a rate will damage the tree.

On the other hand, a tree with a very narrow crown will have a broader root spread than its crown spread. A narrow tree can be described as having a greater height than spread. In such cases, you should apply fertilizer well beyond the canopy spread (up to two times the distance of the dripline).

Deciduous Shrubs

Surface application is preferred to the drill-hole method for small or shallow-rooted shrubs. You should evenly scatter fertilizer beneath the shrub and beyond, to double the shrub diameter. If plants are close together, you should apply fertilizer to the entire bed. Take care to avoid contact between the foliage and stems or trunks of plants and the fertilizer. Follow a fertilizer application with a thorough watering. If the shrubs are known to be deep-rooted, you may work the fertilizer into the soil.

Newly Planted Trees and Shrubs

In general, we do not recommend fertilizing trees and shrubs at planting time. Adding slow-release fertilizer (of any type) at planting does not generally improve or reduce survival — and the fertilizer could injure roots. There are only a few documented cases when applying fertilizers at or soon after planting increased growth. However, if a soil indicates that you are planting in poor soils, you may apply low rates of nitrogen fertilizer.

But in general, it is better to wait at least a few months to fertilize new trees and shrubs (usually in the spring of the next growing season). If you do apply fertilizer, broadcast applications are more effective. What's more, incorporating fertilizer into the soil at planting can damage roots.

Remember that the main goal for a newly planted tree or shrub is to regenerate its roots. Heavy nitrogen fertilization at planting could be counterproductive, because it could reduce root growth into the soil and stimulate too much top growth. Adding phosphorus and potassium has not been shown to increase root growth unless soil tests reveal the soil as deficient.

Soil additives, such as biostimulant products, have not proven to be consistently effective through research.

Evergreens

Evergreen trees and shrubs appear to require lower rates of nutrients than their deciduous counterparts. Over-fertilizing conifer trees leads to open growth with widely spaced branches. Narrow-leaf evergreen shrubs generally need only enough fertilizer to maintain good foliage color, especially if used in small-scale plantings.

Many broadleaf evergreens have shallow root systems, which are easily burned by highly concentrated chemical fertilizers. Broadleaf evergreens need an acidic soil for efficient nutrient uptake. Most garden centers carry special, acid-based fertilizers formulated for broadleaf evergreens. These fertilizers contain both an inorganic source of acid-type nitrogen (such as ammonium sulfate, urea, or ammonium nitrate, which are quickly available for plant uptake) and an organic source of nitrogen (which will supply nitrogen over a period of time).