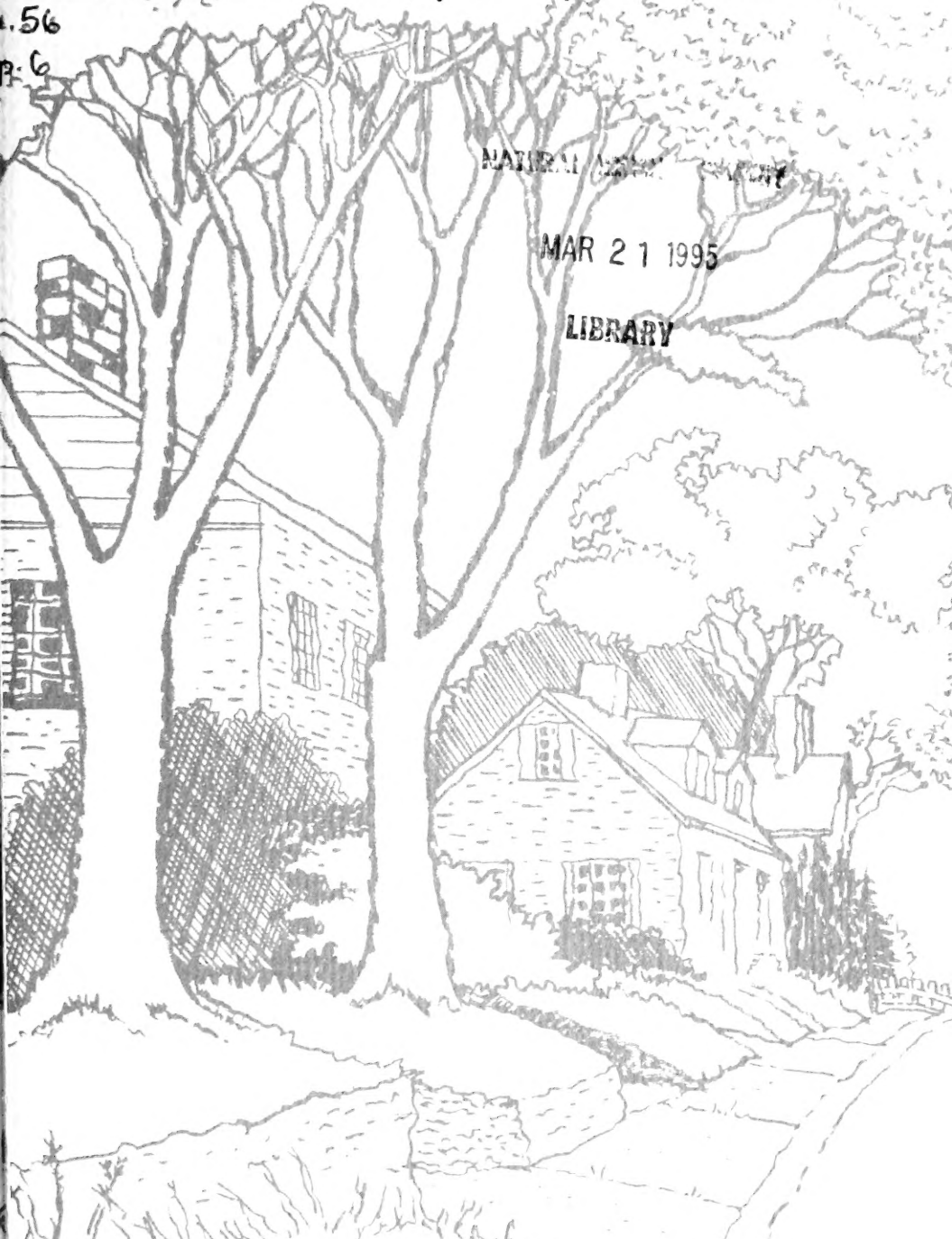


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Fertilizing and Watering Trees

Dan Neely and E. B. Himelick

Fertilizing and Watering Trees



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Illinois Natural History Survey

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TREES are an indispensable part of a pleasing landscape. Their establishment and maintenance concern homeowners, arborists, municipal foresters, and those responsible for the grounds in parks and around public and private institutions and commercial buildings. The care of trees involves several cultural practices, including fertilization, about which this circular gives basic information. A section on watering is also included because the soil solution is the major, if not the only, vehicle for moving nutrients from soil colloids and organic matter to the roots of trees.

Why fertilize?

The correct and timely application of fertilizer benefits most trees. Newly established trees grow more rapidly following fertilization with a nutrient or a combination of nutrients that occur naturally in limited amounts in soil: increased leaf size, increased twig growth, and more rapid increase in height. Slow-growing tree species, many of which have desirable characteristics, can be stimulated to grow faster by fertilization and can thereby be used in situations where slow growth is undesirable.

Stunted leaves and the early loss of leaves often indicate nutrient deficiencies in the soil. Leaf color, especially pale green or yellow, also indicates deficiencies as do leaves with mottled patterns between the veins or leaves with dead spots. The leaves of many trees become a darker green following fertilization, and this change of color makes them more attractive.

Fertilizing also helps to maintain mature trees in a vigorous growing condition. A vigorously growing tree is less susceptible to certain diseases and to insect pests than is a less vigorous tree. Canker-causing fungi occur more commonly on weakened trees, and many noninfectious tree diseases develop when soil nutrients and moisture are

inadequate. Healthy, vigorous trees tend to resist borers, whereas those growing under unfavorable moisture or nutrient conditions are more susceptible to attack.

Established trees weakened by leaf diseases, insect defoliation, mechanical injury, soil compaction, or drought often show poor growth or the dying of branch ends. Fertilization may stimulate additional growth so that the plant can compensate for the conditions that caused the decline.

What is a fertilizer?

A fertilizer is a supplement, usually added to the soil, composed of elements beneficial to plant growth. The essential elements present in plant tissue in relatively large quantities are called macronutrients. They are nitrogen, potassium, phosphorus, calcium, magnesium, sulfur, oxygen, carbon, and hydrogen. The essential elements present in plant tissue in relatively small quantities—the micronutrients—are iron, manganese, copper, zinc, boron, molybdenum, and chlorine.

Magnesium, sulfur, and the micronutrients are adequate in most soils and rarely limit plant growth. The carbon, hydrogen, and oxygen used by plants are components of the atmosphere and of soil water; under normal conditions these three nutrients are never deficient. Calcium in soils is a plant nutrient that primarily serves to neutralize soil acidity and to increase the availability of other nutrients. It can be required as a fertilizer in rare instances when soil pH is 4.0 and below. Nitrogen, phosphorus, and potassium are of primary concern as soil supplements.

Nitrogen

Plant growth is more often limited by a deficiency of nitrogen than by a deficiency of any other element. Nitrogen compounds are rare in the rocks from which soil is formed. Although nitrogen comprises 78 percent by volume of the earth's atmosphere, that is a form not available to plants. Certain bacteria in the soil use atmospheric nitrogen and

change it into a form that can be used by plants. In addition, some atmospheric nitrogen is added to the soil during electrical rainstorms. Most soil nitrogen available to trees, however, is derived from decomposed plant material returned to the soil. Microorganisms in the soil must break down this complex plant material into simple inorganic compounds before the nitrogen can be used by trees.

Nitrogen in plants occurs in proteins, which are the primary components of protoplasm, the living material in plant cells. Nitrogen is a component of chlorophyll pigments and therefore is important in the production of food in plant leaves by photosynthesis. Nitrogen is also found in some plant vitamins and enzymes and is consequently essential in metabolism.

An abundance of available nitrogen in the soil promotes plant growth, particularly of the above-ground portions as compared with the roots. When nitrogen is deficient, stunted top growth, pale green to yellow foliage, and the yellowing or drying of older leaves are common, especially during drought.

Materials commonly used to supplement nitrogen in the soil are ammonium nitrate, ammonium sulfate, and urea. These materials are readily soluble in water. When they are applied to the soil surface and followed by adequate rainfall or supplemental watering, nitrogen is carried down into the soil and made available to roots. Since nitrogen is also carried away by water, nitrogen must be added to the soil at regular intervals to maintain an ample supply.

Phosphorus

Most phosphorus in soil came from the rock material from which the soil was derived. This form of phosphorus is abundant but not readily available to plants. Soils with the greatest amount of readily available phosphorus contain abundant organic matter and a high percentage of clay. Most soils have sufficient phosphorus for adequate plant growth,

but additional quantities supplied as fertilizers may be needed for maximum growth.

Plants use from one-tenth to one-fifth as much phosphorus as nitrogen. Phosphorus is found in all living plant tissues and is essential for good root growth, proper tissue development, and the production of flower buds. It is abundant in seeds and other storage organs. Phosphorus has a direct role as a carrier of energy throughout the plant and is also involved in photosynthesis. When the soil is deficient in phosphorus, plants fail to get a good start at the beginning of the growing season, have poor root growth, and experience delayed flower production.

Phosphorus is available in commercial fertilizers as superphosphate, double superphosphate, and with nitrogen as ammonium phosphate. The available phosphate in these fertilizers reacts rapidly with the soil and remains in the area of application. For this reason fertilizers containing phosphorus must be placed in the soil near the tree roots. Surface-applied phosphorus remains near the soil surface and is available only to plants with roots in this region. Almost no phosphorus is carried away by water.

Potassium

Most of the rocks from which soils were formed contained potassium. Soils, therefore, usually contain more potassium than nitrogen or phosphorus. The salts of potassium are readily soluble in water and may be carried away in areas of heavy rainfall, especially in sandy soils. Soil containing clay or organic matter has a large amount of potassium in a form unavailable to plants; however, this potassium is slowly released in a form that plants can use.

Potassium is present in woody plants in quantities larger than those of all mineral nutrients except calcium. It is not found in any permanent structure but is involved in changing a plant's food into forms that can be used for growth and other functions. It acts as a balancing agent

between root growth and top growth and between nitrogen and phosphorus utilization. A deficiency of potassium is not readily apparent in most trees and shrubs.

The most important commercial fertilizer containing potassium is potassium chloride, commonly called muriate of potash. Potassium is distributed from the point of application in the soil somewhat faster than phosphorus but not nearly as rapidly as nitrogen. Fertilizers containing potassium should therefore be placed in the soil and not applied to the soil surface. Only roots quite near the point of application are able to absorb ample quantities of potassium.

Formulations

Most granular or crystalline commercial fertilizers contain nitrogen, phosphorus, and potassium in specified amounts. Some calcium, magnesium, sulfur, and micronutrients are also included either as impurities or in combination with nitrogen, phosphorus, or potassium. The guaranteed analysis of most fertilizers is shown on the bag as three numbers, for example, 12-12-12. The first number gives the percentage of nitrogen (N); the second gives the percentage of phosphorus as phosphoric acid (P_2O_5); the third gives the percentage of potassium as potash (K_2O). In many areas the application of all three primary nutrients is not desirable, beneficial, or economical. Each of the three can be purchased separately.

The value of organic versus inorganic fertilizers is often debated. Organic sources contain a much lower percentage of nutrients, are slower to release those nutrients, are more difficult to obtain and apply, and are more expensive per pound of nutrient received. Organic fertilizers containing humus, such as manure or composts, improve soil aeration, soil structure, and the capacity of soil to hold water. When plant nutrients are of primary interest, the economics of fertilizing definitely favor inorganic fertilizers.



Should you fertilize?

A number of factors should be considered before fertilizing trees. Annual growth and leaf color can indicate nutritional deficiencies. If trees have poor growth or pale green leaves, fertilizer may make them grow faster and give their leaves a darker green color. If trees are subject to attack by canker-causing fungi or borers, fertilizer makes them more vigorous and less subject to these attacks. The condition of the soil also affects the fertilizer needs of trees.

Rate of annual growth

The annual shoot growth of a tree can be easily determined on species with terminal bud scale scars. Bud scales enclose and protect buds on the ends of twigs during the winter and leave scars that encircle the twig after the scales fall in the spring. These scars remain evident for several years on many tree species.

The distance from the tip of the branch to the ring of bud scale scars nearest the tip is the current season's growth. The growth of previous years can be determined by observing the distance from bud scale scars to bud scale scars as they occur down the twig (Figure 1). By observing the length of growth for the preceding 3 or 4 years on several twigs, you can estimate whether the growth rate was satisfactory or unsatisfactory, increasing, decreasing, or stable, and suitable for the species.

Growth rates among tree species vary and the growth rate of a given tree is in turn affected by its age. Soil types, the spacing of trees, and other environmental conditions also affect rate of growth. As a general guide, terminal twig growth on most trees should be 9–12 inches or more a year. Trees approaching mature size may grow only 6–9 inches a year.

A second method of determining growth rate in many tree species is to measure the width of annual wood rings produced in the trunk. This measurement is taken with most

ease and least damage to the tree with an increment borer or increment hammer (Figure 2), which are available at most garden supply stores by special order. Both are commonly used by arborists and foresters, who compare cores of wood from trees to determine their growth-rate characteristics.

Condition of the soil

In addition to the condition of the plants, the condition of the soil must be known. In most instances, the best tool is a soil-profile tube (Figure 3), but a spade or trowel can also be used for taking samples of the soil. Several factors affecting the condition of the soil should be considered.

1. *How deep is the topsoil?* Depth is important because topsoil contains the organic matter and the microorganisms essential to the recycling of mineral elements in plant debris. It is the volume of soil with the physical, chemical, and biological properties favorable for root growth. The greater the depth of topsoil, the greater the water storage capacity and the greater the depth of root penetration.



FIGURE 1. The upper two twigs are from a vigorous white ash. The current season's growth—the part between the tips of the twigs and the bud scale scars (indicated by arrows) nearest the tips—is long and thick and has plump buds. The previous season's growth (partially shown to the right of the arrows) is also long and thick. The lower two twigs are from a less vigorous white ash. The current and previous seasons' growths are shorter and more spindly and have smaller buds.

2. *What is the color of the soil?* Soil color often indicates organic matter content (dark or black soils usually have abundant organic matter) and the degree of weathering that the soil has undergone.

3. *What is the texture of the soil?* Texture reflects the relative proportions of sand, silt, and clay in the soil. A loam soil contains all three soil-grain sizes, has optimum water-percolation rate and water-holding ability, and is highly resistant to soil compaction.



FIGURE 2. The increment borer (left) and the increment hammer (right) are tools used by the arborist or forester to obtain cores from the wood of standing trees. The cores obtained with each have been marked with ink to make the widths of the annual rings more evident. In each instance, the upper core's most recent annual rings are closely spaced, indicating a slow growth rate; the rings of the lower cores are widely spaced, indicating the rapid growth of healthy trees.

4. *What is the structure of the soil?* Soil structure reflects organic matter content and results from the aggregation of the various soil particles. Soil that remains in clusters or is crumbly when sifted through the fingers even when moist is most desirable.

5. *Is the subsoil compacted, a tight clay, or does water move into it readily?* When water remains in a soil hole for 24 hours following a rain, the soil is poorly drained. Much of the pore space in such a soil is saturated with water for extended periods during the growing season; in effect, that saturation reduces the depth of topsoil suitable for tree growth.

6. *Has the soil been disturbed?* Soil compaction, a change in drainage, the removal of a layer of topsoil, or a fill of clay above the original topsoil often reduces plant vigor and growth.

Soil with deep topsoil, silty loam texture, aggregate structure, high organic matter content, good aeration, moderately high water-holding capacity, and a subsoil that allows internal draining is ideal for growing trees and seldom, if ever, will fertilization of trees be required. Soil with a clay subsoil and less than 8 inches of topsoil that is light brown or gray in color, sandy in texture, and sticky when wet, is much less satisfactory for optimum tree growth. Under these soil



FIGURE 3. The soil-profile tube is a handy tool for removing cores from the upper 10–14 inches of soil. Many properties of the soil can be observed by examining such cores.

conditions, trees often benefit from fertilization, and annual applications may be required for several years. An agronomist, farm adviser, or extension agent should be contacted for assistance with local soil problems.

Two chemical tests are used to determine soil deficiencies—soil tests and plant tissue analyses. Although no method of determining deficiencies in soil nutrients is applicable to all plants under all conditions, soil tests reveal general soil deficiencies and help to determine if the phosphorus or potassium content is low in the soil around shade trees. Diagnosing soil deficiencies by analyzing plant tissue is a useful research tool but is impractical for determining the fertilizer needs of trees.

Disadvantages of fertilizing

Although the advantages of fertilizing usually far outweigh the disadvantages, certain outcomes should be kept in mind. Fertilizing trees or shrubs in lawns also stimulates grass growth, and frequent mowing may be necessary. Unless regularly pruned, small ornamental shrubs that have been fertilized may become too large for their locations in a few years. Heavy nitrogen applications tend to increase twig growth and to reduce flowering in some ornamental shrubs. Prolonged fertilizing may cause some woody species to become tall, spindly, or succulent and to develop a weeping appearance.

American beech, white oak, and some varieties of crab apple are reported to have been injured by fertilizer formulations containing nitrogen, phosphorus, and potassium. All fertilized plants should be observed critically each year to determine the effect of fertilization.

Where should you place the fertilizer?

Roots grow where the soil environment is favorable. They do not grow where oxygen is unavailable or where the soil is compact and difficult to penetrate. Since soil pores and

oxygen decrease with depth, most active, absorbing roots are near the soil surface.

The placement of fertilizer for the most efficient uptake of the mineral elements by tree roots cannot be determined with precision because the location of the absorbing roots is usually unknown. Between four and ten major woody roots originate from the root collar of most trees. These grow horizontally through the soil and are most often limited to the topsoil. They decrease in diameter rapidly within a distance of 3 to 15 feet from the trunk and form an extensive network of long, ropelike roots $\frac{1}{4}$ to 1 inch in diameter. At the ends of these roots, a network of smaller roots branch to form fans or mats composed of thousands of fine, short, nonwoody tips. These fine roots, with accompanying fungi, are the primary sites for the absorption of water and minerals.

These fans of fine, absorbing roots are not uniformly distributed around the tree. In a mature tree, a circular area four to seven times the area covered by the branches will encompass these scattered fans. In newly established trees, in specimen trees in open lawns, and in trees in parkways, the distance and direction of root spread can be estimated with reasonable judgments. Determining the root area for a particular mature tree in a grove or wood lot is difficult, if not impossible, and the efficiency of fertilization is greatly reduced.

For ease in calculation and application, we recommend that fertilizer be applied in square or rectangular areas and that the soil area available, not the size of the tree, be the determining factor in placing the fertilizer. The minimum area should have its four corners positioned so that all the surface area beneath the drip line of the tree is treated (Figure 4). Increasing the size of the treatment area may encourage additional tree growth but with decreasing cost effectiveness.

When should you fertilize and with what?

Tree branch and trunk growth occurs primarily during May, June, and July, but roots grow and actively absorb nutrients throughout the year whenever the soil temperature is above 40°F. Scheduling of the time and rate of application will depend on the types of fertilizers to be used.

Time of application

Nitrogen fertilizers should be applied annually. Little available nitrogen remains in the soil from year to year, since most of it is used by plants or carried away by water. Nitrogen fertilizers are most efficiently utilized by trees when applied in April or May; however, applications in October or November will stimulate growth the following year.

Phosphorus and potassium fertilizers are chemically bound in the soil and become available slowly throughout several growing seasons. They should be added to the soil every 3–5 years in spring or in fall, whichever is more convenient.



FIGURE 4. Stakes have been placed at the four corners of the area to be fertilized. They are far enough from the tree so that its entire branch spread is included.

Rate of application

Nitrogen is the nutrient most often lacking in the soil and, therefore, the first to limit plant growth. Nitrogen fertilizers can safely be added to the soil annually at the rate of 6 pounds of nitrogen per 1,000 square feet of area.

The amounts of phosphorus and potassium in soils vary greatly. In some areas additions of either are unnecessary; in others, an occasional application may be required to provide optimum supplies. Applications of phosphorus and potassium are of little or no benefit when sufficient quantities are already present. The need for phosphorus and potassium and the frequency of application should be determined by chemical tests of soil. Contact your cooperative extension agent for the locations of experiment station or private soil-testing laboratories.

To prevent the soil from becoming deficient in phosphorus or potassium following increased tree growth from annual nitrogen applications, add these nutrients at intervals of 3–5 years and at these rates: phosphorus at 3.6 pounds of phosphoric acid (P_2O_5) per 1,000 square feet and potassium at 6 pounds of potash (K_2O) per 1,000 square feet.

How should you fertilize?

Three successful methods of fertilization are surface application, the placement of dry fertilizers in holes in the soil, and the injection of liquid fertilizers into the soil.

Surface application

Nitrogen fertilizers applied directly to the soil surface are as effective as or more effective than nitrogen fertilizers applied by other methods. With rainfall or supplemental watering, inorganic nitrogen fertilizers readily move down into the soil. These fertilizers can be uniformly distributed over the root area with one of two types of spreaders used to fertilize lawns (Figure 5). Lawn spreaders are the easiest, simplest, and most economical means of applying fertilizers containing only nitrogen.

Fertilizer should be applied when grass blades are dry. Immediately after the fertilizer has been distributed, it should be washed from the grass blades with a lawn sprinkler or a spray nozzle on a hose. Fertilizer remaining on grass blades that become wet following a light rain or the formation of dew occasionally causes burning.

The amounts of fertilizer by source materials that will supply the required 6 pounds of nitrogen per 1,000 square feet and can be safely used in surface applications are listed below (select only one):

Material	Pounds per 1,000 sq. ft.
Urea 45-0-0	13
Ammonium nitrate 33.5-0-0	18
Ammonium sulfate 21-0-0	29

Fertilizers containing phosphorus and potassium should not be broadcast or spread on the surface except at rates recommended for lawn fertilization. Applying such fertilizers as 10-10-10 at the recommended rate for nitrogen of 6 pounds per 1,000 square feet may cause severe damage to grass. Do not use nitrogen fertilizers that have gotten wet and become lumpy or caked for surface application.



FIGURE 5. Two types of spreaders used to apply fertilizer to lawns can also be used to apply nitrogen fertilizers to the soil around trees. A kitchen scale and a bucket help to ensure accurate application rates.

Dry fertilizers in holes

Another method of fertilizing trees is to place dry fertilizers in holes in the soil. Because phosphorus and potassium fertilizers applied to the soil surface are not readily available to the nutrient-absorbing roots of trees, these materials should be placed in the soil occupied by plant roots. Contrary to popular belief, approximately 90 percent of the nutrient-absorbing roots of trees are not deep but are located within the top 12 inches of soil. Here moisture, aeration, and nutrient conditions are favorable for root growth.

Holes can be punched in the soil with a punch bar or drilled with an auger attached to an electric drill (Figure 6). Holes may be drilled if the soil is dry and punched if it is wet.

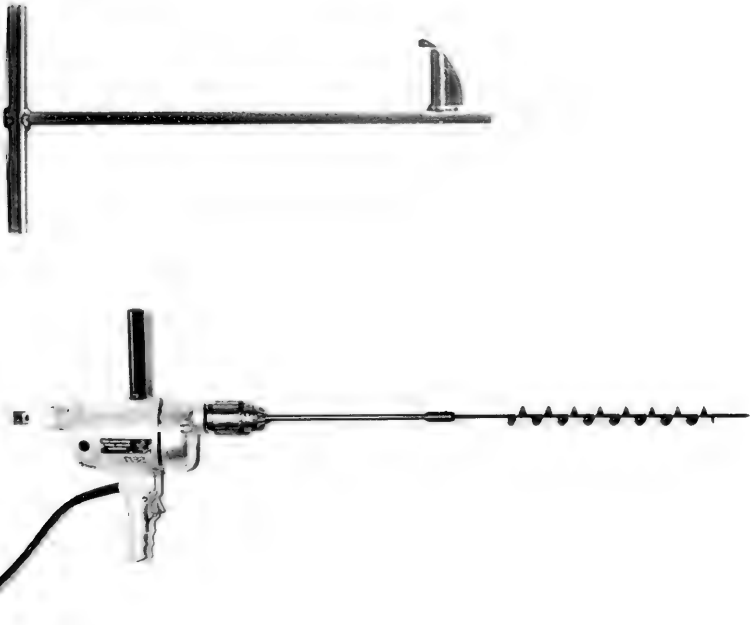


FIGURE 6. A punch bar (top) or an electric drill with a soil auger (bottom) can be used to prepare holes for the application of dry phosphorus and potassium fertilizers.

Holes should be 12–15 inches deep and placed at 2-foot intervals in a series of parallel lines 2 feet apart throughout the area to be fertilized (Figure 7). Holes should not be made within 2½ feet of the tree trunk. Approximately 250 holes are required in each 1,000 square feet of area to be fertilized.

If holes are properly spaced, the following quantities of fertilizers by source materials should be placed in each hole (select one P and one K source or an NPK source):

Material	Amount per hole
Phosphorus (P)	
Superphosphate 0–20–0	2 level tablespoons
Double superphosphate 0–40–0	1 level tablespoon
Potassium (K)	
Muriate of potash 0–0–60	1 level tablespoon
Nitrogen, phosphorus, and potassium (NPK)	
10–10–10	½ cup
12–12–12	slightly less than ½ cup

Preparing and filling holes is time consuming and labor intensive, but merely drilling holes in a circle around the drip line of a tree is unsatisfactory because the fertilizer is inadequately distributed. In addition, root injury may occur if too much fertilizer is placed in too few holes.

Injection of liquid fertilizers

Nitrogen, phosphorus, and potassium fertilizers in solution may also be injected into the soil with a hydraulic pump and a soil needle (Figure 8). Relatively expensive equipment is required for this method of fertilizing, and fertilizer materials must be completely soluble in water. Water-soluble fertilizers containing both phosphorus and potassium are much more expensive per pound of nutrient than are farm and lawn fertilizers not soluble in water. Potassium chloride and potassium nitrate are water-soluble sources of potassium. Ammonium phosphate and potassium phosphate are water-soluble sources of phosphorus. These materials can be purchased from chemical supply stores.

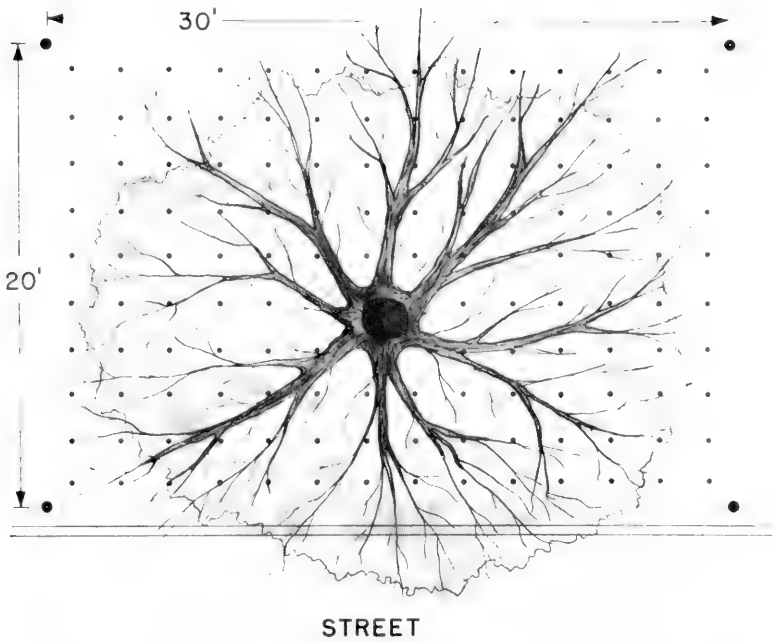


FIGURE 7. Sites for placing phosphorus and potassium fertilizers in the soil should be uniformly spaced in parallel lines throughout the area to be fertilized. If dry fertilizer is to be placed in holes, the holes should be at 2-foot intervals. If liquid fertilizer is to be injected, sites should be 2½ feet apart.



FIGURE 8. A soil needle that is fed by a hydraulic pump may be used to inject water-soluble fertilizers into the soil. It may also be attached to a hose and used to water trees.

The readily available, commercial, water-soluble fertilizers are mixtures containing nitrogen, phosphorus, and potassium. A satisfactory NPK ratio is approximately 1:1:1 or 2:1:2. Suggested formulations of water-soluble nitrogen, phosphorus, and potassium fertilizers are listed below with the number of pounds that should be dissolved in 200 gallons of water and injected into 1,000 square feet of soil (select one):

NPK formulations	Pounds per 200 gallons
20-20-20	30
23-19-17	26
25-10-20	24

Fertilizer solutions are injected into the soil at a depth of approximately 18 inches. Injection sites are placed at intervals of 2 ½ feet in a series of parallel lines 2 ½ feet apart throughout the area to be fertilized. Approximately 160 injections should be made for 1,000 square feet. Each injection site should receive 1.2 gallons of solution. About 150-200 pounds of pressure is required to force the liquid into the soil. Experience is required to distribute the material uniformly.

Why should you water trees?

Water in plants has three vital functions. The hydrogen in water is a true nutrient and is indispensable to photosynthesis. Water also serves as the sustaining liquid in plant cells, filling them and keeping them turgid. This turgidity keeps stems upright and leaves fully extended. In addition, water serves as a carrier. Nutrients can enter plants and be used only in their ionized state, which requires an aqueous solution.

Water in the soil is classified into four groups: water bound chemically to mineral salts, water bound hygroscopically to solid soil particles as a very thin film, water held in the soil by capillary action, and water moving due to the influence of gravity.

Water that is chemically or hygroscopically bound is not available to plants. Gravitational water rapidly seeks a lower level in the soil or runs off on the surface and is of limited importance. The amount of suspended capillary water in soil depends on the texture and structure of the soil. The maximum amount of capillary water a soil can hold, after the gravitational water has percolated through, is called field capacity. Water available to plants is at its maximum when field capacity has been reached.

How and when should you water trees?

Plant roots require both moisture and air for normal development, but trees can be overwatered. Adding large quantities of water too frequently to heavy clay soils may bring about a water-logged condition. With the exclusion of air, roots decline and die, and trees and shrubs may be killed. Such losses occur most frequently in disturbed soils when plants are located in clay fill or in potholes in clay subsoil following construction work. The soil around plants in such sites should be tile drained.

Recently planted trees

Trees or shrubs that have been transplanted may need to be watered for 2–3 years to provide an adequate water supply while their root systems are becoming established. Some trees are not fully established for 3–6 years. Trees and shrubs planted with bare roots normally require longer to develop adequate root systems than do plants moved with balls of soil. Older and larger plants require more time to become established than do younger and smaller plants.

A newly planted tree or shrub is most easily watered if a circular mound of earth 3–4 inches high is prepared around the plant at the edge of the planting hole (Figure 9). This mound serves as the dike of a reservoir that should be filled with water at 7- to 10-day intervals during the growing season. The reservoir holds a supply of water adequate to soak the soil of the backfill and the soil in the ball around the plant roots.

Established trees

When rainfall is normal, established trees obtain an adequate supply of water from the soil. During a drought or during extended dry periods in the summer, all trees benefit from watering, but trees weakened by injury, disease, or insect pests are especially benefited. The relative moistness or dryness of the soil can be determined by inspecting a soil core removed with a spade or soil-profile tube. Soil taken from different depths should be examined as it is crumbled between the fingers. Dry soil will be powdery, but moist soil will retain its structure.

Water applied to the soil surface fills the capillary spaces from the top down. A daily surface sprinkling that wets the soil to a depth of 1 inch or so is of little value to trees or grass because most plant roots are at greater depths and remain in dry soil. Instead, water should be applied less frequently and in larger quantities.

Water should not be applied more rapidly than the soil can absorb it. When water is applied too rapidly, it is lost through runoff and erodes the soil surface. Heavy clay soils are



FIGURE 9. A mound of earth 3–4 inches high around a newly planted tree serves as the dike of a reservoir that holds sufficient water to soak the soil of the backfill and the soil in the ball about the plant roots.

difficult to wet and slow to dry out. They require more water per application and applications at less frequent intervals than do sandy soils. Sandy or light soils are easy to wet but must be watered more frequently than heavier soils because their water-holding capacity is less.

The most satisfactory means of supplying and uniformly distributing adequate water to an established tree is with a garden hose and an oscillating lawn sprinkler. To wet the soil thoroughly requires the equivalent of 2 inches of rainfall. During prolonged dry periods in the summer, watering should be repeated at intervals of 2–3 weeks. Coffee cans placed near the sprinkler make handy gauges for measuring the amount of water that has been applied. If water begins to run off the surface before the intended amount has been supplied, half of the volume should be applied one day and the remainder the following day.

Other means of supplying supplemental water are soaker hoses and root-watering needles. Soaker hoses are suited for such limited areas as border, hedge, and foundation plantings. A root-watering needle is conveniently used around small trees or shrubs. The needle has the advantage of injecting water into the immediate area of the roots; however, since only a limited amount of soil is watered at each injection, the needle must be moved at frequent intervals.

Summary of recommendations

Recommendations for the fertilization of shade trees and shrubs should be based on controlled experiments using known plant species and known soil types; however, only a limited number of such studies have been made. These recommendations, therefore, are based primarily on experiments by the authors and on information gleaned from research in arboriculture, pomology, forestry, and agronomy.

Fertilizing

1. Measure accurately the area to be fertilized and determine its size in square feet. For ease in calculating areas and applying fertilizer, plot a square or rectangular area.
2. Weigh accurately the amount of fertilizer to be used. A bucket and kitchen scales are useful.
3. Apply nitrogen fertilizers annually to the soil surface at the rate of 6 pounds of nitrogen per 1,000 square feet. Uniform applications can easily be made with spreaders commonly used to apply fertilizer to lawns. Nitrogen fertilizers are most effective when applied in April or early May before trees break dormancy. To prevent grass burn, wash fertilizer from grass blades immediately after application.
4. Apply phosphorus and potassium fertilizers every 3–5 years. Phosphorus should be applied at the rate of 3.6 pounds of phosphoric acid (P_2O_5) and potassium at the rate of 6 pounds of potash (K_2O) per 1,000 square feet.

One method is to place dry fertilizer in a series of holes 12–15 inches deep at 2-foot intervals in parallel lines 2 feet apart throughout the area to be fertilized. A second method is to use water-soluble materials and inject them into the soil using a hydraulic pump and a soil needle. Injections are 18 inches deep at 2½-foot intervals in parallel lines 2½ feet apart throughout the area to be fertilized.

Phosphorus and potassium may be applied in spring or fall but are often applied in spring when hole preparation and needle injection are easier.

Fertilizing can often be continued indefinitely. Some woody species, however, may become succulent or develop a weeping appearance after prolonged fertilization. All fertilized plants should be carefully observed each year, and fertilization should be discontinued when it fails to accomplish a purpose.

Watering

1. Prepare a dike 3–4 inches high around the planting hole of a recently planted tree or shrub. During the growing season and until the root system has become established, fill this dike with water at 7- to 10-day intervals.
2. During droughts or during extended dry periods in the summer, water established trees with a lawn sprinkler at intervals of 2–3 weeks. Each watering should be the equivalent of 2 inches of rainfall.

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