Circular 52

FERTILIZING AND WATERING TREES

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ILLINOIS NATURAL HISTORY SURVEY

This paper is printed by authority of the State of Illinois, IRS Ch. 127, Par. 58.12. It is a contribution from t Section of Applied Botany and Plant Pathology of the Illinois Natural History Survey.

Illinois Natural History Survey Circular 52, September, 1966

(31847—10M—9-66)30 2

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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 care of grounds in parks and around public and private institutions and commercial buildings. The proper care of trees involves the knowledge and use of many cultural practices, including fertilization, about which this circular gives basic information. A section on watering trees is included because of its importance and close relationship to fertilizing.

WHY FERTILIZE?

Proper and timely application of fertilizer will produce beneficial results on most trees. Newly established trees will grow more rapidly following fertilization with a nutrient or a combination of nutrients that occur in limited amounts in the soil. This is shown by increased leaf size, length of current-season twig growth, and more rapid increase in height. Slow-growing tree species, many of which have desirable characteristics, may be stimulated to grow faster by fertilization. This should encourage their use in situations where slow growth has been considered undesirable.

Leaf color and leaf size often indicate nutrient deficiencies in the soil. Various colors or patterns of color indicate deficiencies of specific essential nutrients. Symptoms include one or more of the following: pale green or yellow color, leaves with mottled patterns between the veins or with dead spots, stunted leaves, and early loss of leaves. The leaves of many trees become darker green following fertilization and this makes them more conspicuous and attractive.

Fertilizing can help maintain mature trees in a vigorous growing condition. A vigorously growing tree is less susceptible to certain diseases and insect pests than is a less vigorous tree. Canker-causing fungi occur more commonly on weakened trees. Also, many of the noninfectious tree diseases develop when soil nutrient and moisture conditions are unfavorable. Healthy, vigorous trees tend to resist borers, while those growing under unfavorable moisture or nutrient conditions are more susceptible to attack by these insects.

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

WHAT IS A FERTILIZER?

A fertilizer is a supplement, usually added to the soil, composed of elements essential or 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. Those essential elements present in plant tissue in relatively small quantities are called micronutrients. The micronutrients are iron, manganese, copper, zinc, boron, and molybdenum.

Magnesium, sulfur, and the micronutrients are usually adequate in most soils and rarely limit plant growth. The carbon, hydrogen, and oxygen used by plants come from the atmosphere or from soil water, and under normal conditions occur in sufficient amounts. Nitrogen, phosphorus, and potassium are of primary concern as soil supplements.

Nitrogen

Plant growth is more often limited by deficiency of nitrogen than of any other element. Although nitrogen comprises 78 percent by volume of the earth's atmosphere, it is in a form not available to plants. Nitrogen compounds are rare in the rocks from which soil is formed. Certain bacteria in the soil use atmospheric nitrogen and change it into a form that can be used by plants. Also, some atmospheric nitrogen is added to the soil during electrical rainstorms. However, most soil nitrogen available to trees 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 nutrients can be used by trees.

Nitrogen in plants occurs in proteins. Proteins are 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 nitrogen in the soil promotes plant growth, particularly of the above-ground portions as compared with the roots. When nitrogen is deficient, it is common to see stunted top growth, pale green to yellow foliage, and yellowing or drying of the older leaves, especially during droughts.

Materials commonly used to supplement nitrogen in the soil are ammonium nitrate, ammonium sulfate, and urea. These materials are readily soluble in water. When applied to the soil surface and followed by adequate rainfall or supplemental watering, nitrogen will be carried down into the soil where it is available to all roots. Nitrogen is also carried away by water so that it is necessary to add nitrogen to the soil at regular intervals to maintain an ample supply.

Phosphorus

Most of the 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. The 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 the best 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 flower bud production. It is abundant in seed 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 have delayed flower production.

Commercially, phosphorus fertilizers are available 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 phosphorus-containing fertilizers must be placed in the soil near the tree roots. Surface-applied phosphorus remains near the soil surface and is available only to the 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 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, it is slowly released in a form which plants can use.

Potassium is present in woody plants in quantities larger than those of all mineral nutrients but calcium. It is not found in any permanent structure but is involved in changing a plant's food into forms it can use for growth and other functions. It acts as a balancing agent between root growth and top growth and between nitrogen and phosphorus utilization. A visual symptom indicating potassium deficiency is not readily apparent on 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. Potassium-containing fertilizers should therefore be placed in the soil and not applied to the soil surface. Only those roots quite near the point of application can absorb ample quantities of potassium.

Formulations

Most granular or crystalline commercial fertilizers contain nitrogen, phosphorus, and potassium in guaranteed amounts. Also some calcium, magnesium, sulfur, and micronutrients are 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 number gives the percentage of phosphorus as phosphoric acid (P_2O_5); the third number gives the percentage of potassium as potash (K_2O).

In many areas it is not desirable, beneficial, or economical to apply all three primary nutrients. Each of the three can be purchased separately.

The value of organic vs. inorganic fertilizer materials is discussed fully in other publications (see selected references). The organic sources contain a much lower percentage of nutrients, are slower to release nutrients, are more difficult to obtain and apply, and are more expensive per pound of nutrient received. Those organic fertilizer materials containing humus, such as manure or composts, have some advantage in improving soil aeration, structure, and water-holding capacity. 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. The general condition and color of the plants must be noted. If trees have poor growth or pale green leaves, fertilizer may make them grow faster and give them a darker green color. If trees are attacked by canker-causing fungi or borers, fertilizer will make them more vigorous and less subject to these troubles.

Determine the rate of annual growth

The amount of annual shoot growth of a tree can be easily determined on tree 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.

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 (Fig. 1). By observing the length of growth for the preceding 3 or 4 years on several twigs, it is possible to estimate whether the growth rate is satisfactory or unsatisfactory, increasing or decreasing.

The growth rate will vary with tree species, soil type, and environmental conditions. 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.

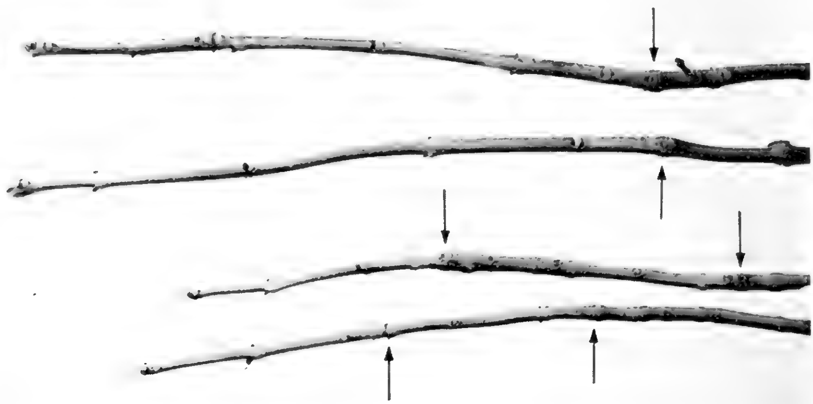

Fig. 1.—The upper two twigs are from a vigorous white ash. The current season's growth—the part between the tips of the twigs and the bud scale scars (indicated by arrows) nearest the tips—is long and thick and has plump buds. The previous season's growth (partially shown to the right of the arrows)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

A second method of determining growth rate in many tree species is measuring the width of annual wood rings produced in the trunk. This is accomplished with most ease and least damage to the tree with an increment borer or increment hammer (Fig. 2). These tools are available through special purchase at most garden supply stores. Both are commonly used by the trained arborist and forester, who can compare cores of wood from trees to determine their growth-rate characteristics.

Determine the soil conditions

In addition to the condition of the plants it is desirable to know the condition of the soil. In most instances, the best tool for such use is a soil profile tube (Fig. 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) Topsoil depth is important. The greater the depth, the greater the volume of soil with physical, chemical, and biological characteristics favorable for root growth.

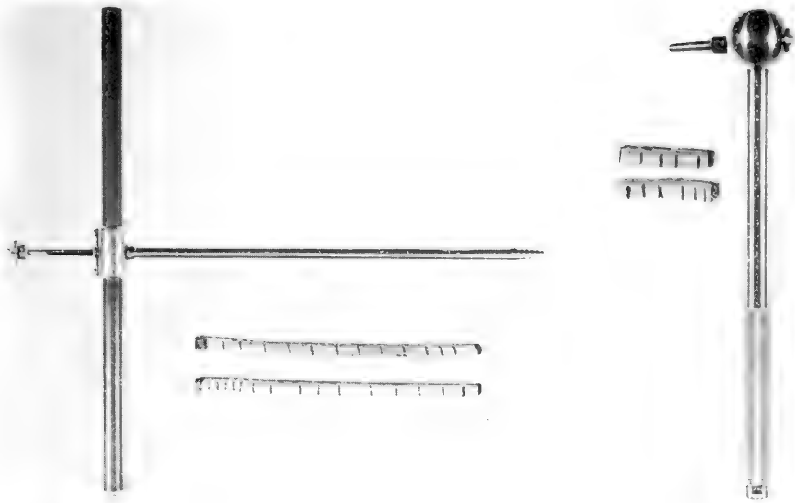

Fig. 2.—The increment borer (left) and the increment hammer (right) are tools used by the arborist or forester to obtain cores from the wood of standing trees. The cores obtained with each (insets) have been marked with ink to make the widths of the annual rings more evident. In each inset the lower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

2) Soil texture should be noted. Is it composed predominately of sand, silt, or clay?

3) Soil structure is best determined when the soil is moist. Does it stick together to form a tight ball or, more desirably, remain in crumbs that can be sifted through the fingers?

4) Is the subsoil tight clay, stony, or gravelly?

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

A soil with a deep topsoil, silty loam texture, aggregate structure, high organic matter content, high nutrient content, good aeration, moderately high water-holding capacity, and a subsoil allowing internal draining is ideal. An agronomist, farm adviser, or extension agent should be contacted for assistance with local soil problems.

Two types of chemical tests are currently used to determine soil deficiencies—soil tests and plant tissue analysis. No method of determining soil nutrient deficiencies is applicable to all plants under all conditions. Soil tests indicate general soil deficiencies.

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

These tests will help to determine if the phosphorus or potassium content is low in the soil around shade trees.

Diagnosing soil deficiencies by analyzing plant tissue currently serves as a good research tool but is not considered practical for use in shade tree fertilization.

Consider the disadvantages of fertilizing

Although the advantages usually far outweigh the disadvantages, certain points should be kept in mind. Fertilizing trees or shrubs in lawns will also stimulate grass growth, and frequent mowing may be necessary. Unless regularly pruned, small ornamental shrubs, through fertilization, may become too large for their locations in a few years. Heavy nitrogen applications tend to increase twig growth and reduce flowering in some ornamental shrubs. Some woody species may become tall, spindly, or succulent and develop a weeping appearance after prolonged fertilizing.

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

WHEN SHOULD YOU FERTILIZE AND WITH WHAT?

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 also 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 either spring or fall, whichever is more convenient.

Rate of application

To fertilize trees and shrubs, fertilizer should be distributed throughout the area where roots are most likely to occur. Nutrient-absorbing roots of woody plants usually occur in the soil area covered by the branch spread. However, trees that have narrow tops or crowns, such as some poplars and columnar maples, have roots that extend well beyond the branch spread.

The amount of fertilizer to be applied should be based on the area of soil to be treated and not on the diameter of the tree trunk. When a square or rectangular area is fertilized, it is easy to calculate the area involved. Also it simplifies uniform distribution of fertilizer around each tree. Four stakes should be placed in the ground to designate the corners of the area. The stakes should be located so that the entire branch spread of the tree will be included in the area to be fertilized (Fig. 4). The

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

area in square feet is determined by multiplying the length times the width.

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 actual nitrogen per 1,000 square feet of area.

The amounts of phosphorus and potassium in soils vary greatly, and in some areas it may not be necessary to add either to the soil. In others an occasional application may be necessary to provide an optimum supply. Applications of phosphorus and potassium are of little or no benefit if sufficient quantities are already present. The need for phosphorus and potassium and frequency of application should be determined by chemical tests of soil taken from the area to be fertilized.

To prevent the soil from becoming deficient in phosphorus or potassium following annual nitrogen applications, it is desirable to add these nutrients (at intervals of 3–5 years) 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 successfully used methods of fertilization are surface application, placement of dry fertilizers in holes in the soil, and injection of liquid fertilizers into the soil. Only fertilizer sources that contain nitrogen alone should be surface applied.

Surface application

Nitrogen fertilizers applied to the soil surface are just as effective as or more effective than nitrogen fertilizers applied by any other method. With rainfall or supplemental watering, inorganic nitrogen fertilizers will move readily down into the soil. These fertilizers are uniformly distributed over the root area by using one of two types of spreaders used to fertilize lawns (Fig. 5). This is the easiest, simplest, and most economical means of applying fertilizers containing only nitrogen.

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

The amounts of fertilizer 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 (select 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

Fig. 5.—The two types of spreaders that can be used to apply fertilizer to lawns can also be used to apply nitrogen fertilizers to the soil around trees.

Fertilizers containing phosphorus and potassium should *not* be broadcast or spread on the surface. 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 applications.

Dry fertilizers in holes

Another method of fertilizing trees is to place dry fertilizers in holes in the soil. Phosphorus and potassium fertilizers applied to the soil surface are not available to most nutrient-absorbing roots of trees. To become available, these materials must be placed in the soil occupied by plant roots. Contrary to the belief of some, the majority of nutrient-absorbing roots of trees are not at great depths in the ground but are located within 2 feet of the soil surface. Here moisture, aeration, and nutrient conditions are favorable for root growth.

Holes can be punched in the soil with a punch bar or drilled

Fig. 6.—A punch bar (left) or an electric drill with a soil auger (right) can be used to prepare holes for application of dry phosphorus and potassium fertilizers.

with an auger attached to an electric drill (Fig. 6). Holes may be drilled if the soil is dry and punched if it is wet. Holes should be 12–15 inches deep. They are placed at 2-foot intervals in a series of parallel lines 2 feet apart throughout the area to be fertilized (Fig. 7). Holes should not be made within 2½ feet of the tree trunk. Approximately 250 holes should be made in each 1,000 square feet of area to be fertilized.

If holes are properly spaced, the following quantities of fertilizer 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 (N, P, and K)	
10-10-10	½ cup
12-12-12	slightly less than ½ cup

Preparing holes for this method of application requires considerable labor. The method is therefore time consuming and expensive if the proper number of holes is made and filled with fertilizer. Placing holes in a circle around the drip line of a tree is unsatisfactory because there is inadequate distribution of fertilizer. Also, root injury may occur if too much fertilizer is placed in too few holes.

Injection of liquid fertilizers

A second method of placing phosphorus and potassium fertilizers in the soil is injecting solutions into the soil with a hydraulic pump and a soil needle (Fig. 8). Expensive equipment is required for this method of fertilizing. A second requirement is that fertilizer materials be completely soluble in water. Water-soluble fertilizers containing both phosphorus and potassium are much more expensive per pound of nutrient than are the 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.

The readily available commercial water-soluble fertilizers

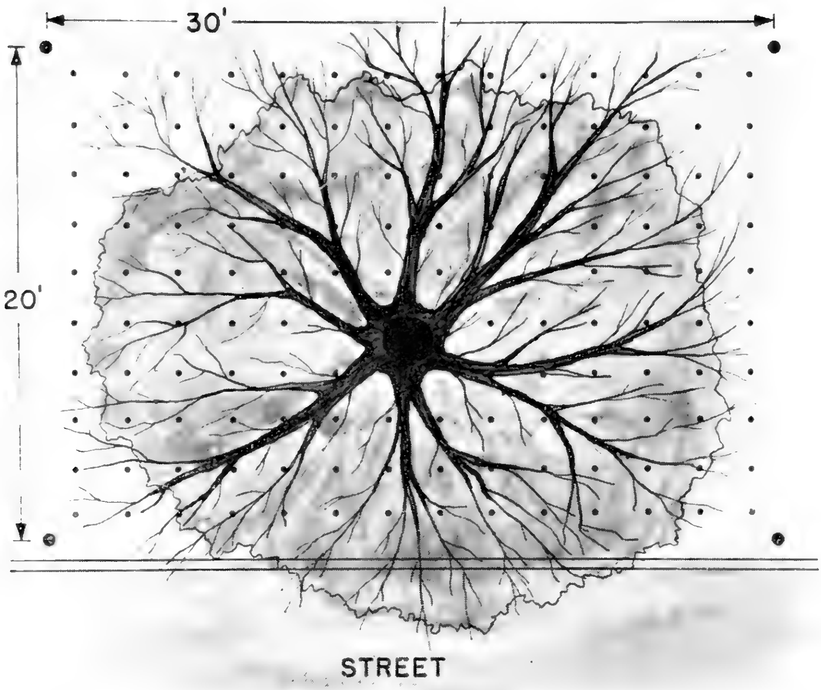

Fig. 7.—The sites for placing phosphorus and potassium fertilizers in the soil should be uniformly spaced in parallel lines throughout the area to be fertilized. If dry fertilizer is to be placed in holes, the holes are at 2-foot intervals. If liquid fertilizer is to be injected, the sites are 2½ feet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

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 gal.
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 2½ feet in a series of parallel lines 2½ feet apart throughout the area to be fertilized. There should be approximately 160 injections in each 1,000 square feet. Each injection site should receive 1.2 gallons of solution. About 150–200 pounds of pressure is adequate to force the liquid into the soil. Experience is required to distribute the material uniformly.

Fig. 8.—A soil needle, 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.

WATERING TREES

Water in plants has three vital functions. The hydrogen in water is a true nutrient and is indispensable in photosynthesis. Water also serves as the sustaining liquid in plant cells, filling them and keeping them turgid. This 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 in 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 to plant growth. Capillary water is of paramount 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.

It is possible to overwater. Plant roots require both moisture and air for normal development. Adding large quantities of water too frequently to heavy clay soils may bring about a waterlogged condition. With the exclusion of air, roots decline and die, and trees and shrubs in waterlogged soils may be killed. This most frequently happens 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 (see selected references under tree planting and care).

Recently planted trees

Following transplanting it is often necessary to water trees or shrubs for 2–3 years to provide an adequate water supply while root systems are becoming established. Some trees will not be 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. Also, older and larger plants require more time to become established than younger and smaller ones.

A newly planted tree 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 (Fig. 9). The mound of earth 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 will contain a supply adequate to soak the soil of the backfill and the soil contained in the ball about the plant roots.

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

Established trees

With normal rainfall, established trees can obtain an adequate supply of water from the soil. During droughts or extended dry periods in the summer, all trees are benefited by watering. Trees weakened by injury, disease, or insect pests will be 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 while being crumbled between the fingers.

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

Water should not be applied more rapidly than the soil will absorb it. If applied too rapidly, water will be lost through runoff and will erode the soil surface. Heavy clay soils are 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 because their water-holding capacity is less, they must be watered more frequently than heavier soils.

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

Other means of supplying supplemental water are soaker hoses and root-watering needles. Soaker hoses are best used in limited areas, such as border plantings, hedge plantings, or 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, but since only a limited amount of soil is watered at each site, the needle must be moved at frequent intervals.

SUMMARY OF RECOMMENDATIONS

Recommendations for shade tree fertilization should be based on experimentation using known tree species and known soil types. Only limited controlled experimentation on fertilizing shade trees and shrubs has been accomplished. The recommendations here are based primarily on the authors' own experiments and on information gleaned wherever possible from experiments in arboriculture, pomology, forestry, and agronomy (see selected references). The recommendations should be considered as generalizations or guides.

Fertilizing

1. **Measure accurately the area to be fertilized and determine its size in square feet.** For ease in calculating size and applying fertilizers, a square or rectangular area is suggested.

2. **Weigh accurately the amount of fertilizer material to be used.** A bucket and kitchen scales are used by the authors (Fig. 5).

3. **Apply nitrogen fertilizers annually to the soil surface at the rate of 6 pounds of nitrogen per 1,000 square feet.** This is easily and uniformly accomplished 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 off 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 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 of applying phosphorus and potassium is to use water-soluble materials and inject them into the soil using a hydraulic pump and a soil needle. The injections are made 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 the spring or fall. They are often applied in the spring when hole preparation or soil-needle injection is easiest.

5. Discontinue fertilization when it fails to accomplish a purpose or when other factors become of primary concern. Often fertilizing can 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.

Watering

1. Prepare a dike 3–4 inches high around the planting hole of a recently planted tree. During the growing season fill it with water at 7- to 10-day intervals until the root system has become established.

2. During droughts or extended dry periods in the summer, water established trees with a lawn sprinkler with the equivalent of 2 inches of rainfall at intervals of 2–3 weeks.

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