Chapter 7

PLANT MANAGEMENT: CHOOSING, PLANTING, AND MAINTAINING PLANTS

IDAHO MASTER GARDENER
UNIVERSITY OF IDAHO EXTENSION

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Plant Management: Choosing, Planting, and Maintaining Plants

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INTRODUCTION

Creating a productive and beautiful garden requires care at several stages. It is important to choose plants that will thrive in your climate, soil, and light conditions. Proper planting procedures are key to ensuring successful plant establishment. From the time of planting through maturity, the plant's water needs must be met through proper irrigation. This chapter discusses each of these topics.

PLANT SELECTION

When choosing a plant, consider both the limitations of the site and the intended purpose of the plant. Maintenance issues and plant disease problems often result from selecting the wrong plant for a location.

Begin by analyzing the site. A plant needs adequate space both above and below ground. Your garden must be in an appropriate climate zone (both for winter hardiness and summer heat), and the soil must have adequate structure, depth, drainage, pH, and fertility. Choosing a plant that has some resistance to diseases or pests prevalent in the area might also be beneficial.

To determine the best location for a plant, read the plant tag or seed packet. You can also research the plant online or in a garden book. These resources are useful for determining the winter hardiness and heat zones, light exposure, and water required by a plant. Choosing a plant whose requirements match your site will help ensure a healthier plant for years to come and will decrease maintenance, chemical, and labor costs.

Light requirement

Light requirements differ among plants. Plants described as requiring full sun typically need at least 6–10 hours of direct sun per day. Plants adapted to partial sun/partial shade need 3–4 hours of direct sun. Shade-loving plants do best where they receive less than 2 hours of direct sun in early morning or where sun is filtered through a tree canopy.

Light intensity may vary across your yard. The south and west sides of a house receive more intense light (and are warmer) than the east or north sides. For this reason, the south or west sides are generally good locations for a vegetable garden or pollinator flower garden. The north and east sides of a house offer more shade and moisture for shade-loving plants such as hostas. By locating plants in sites with proper light exposure, you can avoid the frustration of having to replace those that died from too much sun or shade.

Climate

Winter hardiness. The United States Department of Agriculture's (USDA) plant hardiness zone map will help you determine which perennial plants will winter over in your garden. The USDA zone map was first published in 1960 and was updated in 1990 and 2012. Each zone represents the average lowest winter temperature for an area; it does not reflect record cold temperatures. Average temperatures are based on the lowest minimum temperature recorded each year from 1976 through 2005.

According to the USDA zone map, hardiness zones in Idaho range from zone 3b to zone 7b. On the current map, most Idaho locations are half a zone warmer than in previous versions. A current USDA hardiness zone map for Idaho can be found at http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx.

Hardiness zones are based on temperatures recorded for large areas, but small areas within a zone can vary significantly. These areas are called microclimates. Sun reflected from a wall or fence can increase the minimum winter temperature, while shade from a tree or on the north side of a building can decrease it. Temperatures in a valley generally are lower than those found on the side or top of a hill. Even dark mulch material can moderate soil temperature by 5–10°F during spring or fall, when plant roots and crowns are not fully dormant, thus increasing winter hardiness. Other factors that affect a plant's ability to withstand cold are plant health, age of the plant, plant dormancy, snow cover, late winter warming, and moisture levels in the plant (especially evergreens) prior to the onset of winter. For these reasons, the hardiness zone map should be used only as a guide.

Heat stress. Heat stress is defined as exposure to high temperatures for a long enough period of time to cause irreversible damage to a plant's physiological functions. Heat stress can be caused by high air or soil temperatures. Stress increases rapidly as air temperature rises above 85°F. Plants can be injured directly by heat, or indirectly when a high transpiration rate causes a water deficit. Transpiration rate depends on plant size, light intensity, temperature, humidity, and wind speed.

It is best to avoid planting heat-sensitive plants near sidewalks, driveways, or buildings that reflect light and heat. Rock mulches can also increase the soil temperature enough to damage heat-intolerant plants.

The American Horticultural Society (AHS) has created a plant heat zone map based on the number of days with temperatures above 86°F. Some plant labels now include the plant's heat zone tolerance. A current version of the AHS plant heat zone map can be found at http://www.ahs.org/gardening-resources/gardening-maps/heat-zone-map.

Growing season. Knowing the length of the growing season is important if you want to grow warm-season vegetables or collect seeds from annual plants. The growing season is the period between the last average spring frost date and the first average fall frost date. Because frost dates vary greatly from year to year, the length of the growing season in any given location will vary. In Idaho, the growing season ranges from 60–90 days in the central mountains to 150–160 days in the southern high desert region.

Figure 1. Season extension methods, such as a hoop house, protect crops from cold temperatures.

Late spring frosts can damage warm-season vegetables and fruits. Because cold air is heavier than warm air, it flows downhill to low-lying areas. Thus, a garden positioned at the top of a sloped yard may not experience as much frost damage as one at the bottom of the slope. In densely populated areas, closely spaced houses, solid fences, walls, and thick hedges can prevent free drainage of cool air, thus increasing frost damage.

The growing season can be lengthened by using hot beds, cold frames, frost cloths, high tunnels, and "reflector ovens" (figure 1). These structures protect crops from cold temperatures and inclement weather. For information on season extension structures, see chapter 24, "Houseplants."

Avoiding weeds and poisonous plants

Avoid purchasing invasive species, noxious weeds, or plants that are poisonous to animals and children. Weeds compete with garden and landscape plants for water, nutrients, and space. Without adequate weed control, a garden can become unproductive and a source of frustration instead of joy. Many weeds were brought to the United States as ornamental plants or were used as inexpensive packing material in shipping containers coming from other countries. Plants that behave well in one region can become noxious weeds in another.

A noxious weed is defined by the State of Idaho as any plant having the potential to cause injury to public health, crops, livestock, land, or other property. The spread of noxious weeds and their damage to Idaho's agriculture can be reduced by proper identification and handling of certain plants. Before purchasing mail-order plants, exchanging seeds with friends from other regions, or bringing plant materials home from vacation, check Idaho's noxious weed list. See chapter 14, "Weeds," for more information on weeds and control methods.

Some common ornamental plants, such as myrtle spurge (*Euphorbia myrsinites*), can cause eye and skin irritation, while others can cause illness or death in children or pets. Teach children not to put any plant material in their mouth, unless you have intentionally introduced them to it. Various Extension publications list poisonous garden or landscape plants. The American Society for the Protection of Cruelty to Animals (ASPCA) keeps a database of plants known to be poisonous to cats, dogs, and horses.

SITE PREPARATION

Prepare the site for planting by removing rocks, weeds, and other debris. Preparation may include grading, tilling, amending the soil, and installing an irrigation system. Grading the soil allows water to drain away from your home or the crowns of plants. In a steeply sloped area, terracing is an option.

If the soil is compacted, turning the soil with a shovel or rototiller may help loosen the soil and increase aeration for better root growth. Amendments are often added at this time. Choose appropriate amendments, based on a recent soil test, your soil's structure, and plant requirements. Humus (composted organic matter) is a good amendment for most soils, as it increases soil fertility and improves soil structure. For more information, see chapter 5, "Soils and Fertilizers."

With heavy clay soil or a high water table, raised beds, mounds, or berms may be needed to improve drainage. In areas with a high water table, tile drains can also be installed.

PLANTING

Seeds

Starting vegetables, herbs, and annual flowers from seed is economical and can be fun and rewarding. For more information, see chapter 21, "Principles of Vegetable Culture," or University of Idaho publications.

Bareroot plants

Bareroot plants are dormant herbaceous or woody perennial plants that have been dug and stored without soil around their roots. The roots are usually wrapped in damp sphagnum moss, sawdust, or paper to keep them moist. Bareroot plants weigh less and are easier to ship than plants with soil. Flower bulbs, flowering ornamentals, strawberries, asparagus, caneberries, grapes, fruit trees, and some shrubs, vines, and shade trees are commonly sold as bareroot plants.

Bareroot plants must be planted as soon as possible, while they are still dormant. For this reason, they are usually sold and planted in early spring or late fall.

If you purchase a mail-ordered bareroot plant, check to make sure the plant is healthy when it arrives. Look for mold or mildew, and make sure the roots do not smell rotten. Roots, rhizomes, and bulbs should feel heavy for their size, not lightweight or dried out.

The roots of a bareroot plant must not be allowed to dry out before planting. If you must hold a plant for a day or two, keep the roots shaded and wrapped in plastic, wet paper, or moist sawdust. If you cannot plant for several days, place the plant in a container with potting soil and leave the container in a cool, shaded location. Another technique for holding bareroot material is called heeling in. This procedure consists of digging a trench large enough to accommodate the roots and burying them until you are ready to plant. Keep the roots cool and moist to avoid breaking dormancy.

Before planting, make sure the roots are moist. If you have any doubt, soak the roots overnight. Prune off broken roots.

Dig a hole large enough to accommodate the roots without bending or cutting them. Build a conical-shaped mound of soil in the bottom of the hole and spread the roots over the mound so that they will grow down and outward. Adjust the plant so that the old soil line at the base of the trunk or crown is at ground level or slightly higher. On fruit trees, the graft union should be well above ground. If a stake is needed for stability, add it now. For information on staking trees, see chapter 18, “Woody Landscape Plants.”

In most loamy soils, it is not necessary to amend the backfill. In heavy clay soils, you may want to add some humus to improve aeration and drainage. In very sandy soils, humus can improve the soil’s nutrient- and water-holding capacity. Any amendment should not represent more than 25 percent of the backfill volume, so that the backfill does not vary greatly from the surrounding soil.

Fill the planting hole halfway with backfill, making sure to work it in and around the roots. Water to help remove voids. Let the water soak in, and then fill the remainder of the hole with soil. Finish by watering again. Do not keep newly planted bareroot materials too wet after planting, since they are dormant and require little water.

Balled-and-burlapped stock

Balled-and-burlapped (B&B) plant materials are trees or shrubs dug from the ground with a portion of their root system and soil intact. The root ball is wrapped in burlap and secured with twine. If the plant is held at the nursery for a long time, new roots may grow through the burlap. If the ball is very heavy, a metal basket may be added to protect it from breaking and for easier handling. Plants often sold as B&B stock include needled evergreens, rhododendrons, and azaleas, as well as many deciduous trees and shrubs.

B&B plants can be planted almost anytime the ground can be worked. Because of their limited root system, however, it is best to plant them in the spring or fall when it is cool and moist so they can establish rapidly. If B&B plants are planted in summer, they must be adequately watered to ensure that the roots do not dry out.

Careful handling of the root ball is very important. If it is cracked or broken, the plant most likely will die. Never drop the root ball on the ground. Always support the root ball on the bottom when moving the plant; do not lift only by the trunk, as doing so can stress the root ball and cause it to break from the trunk. Keep the root ball moist, shaded, and covered with soil or sawdust until you are ready to plant.

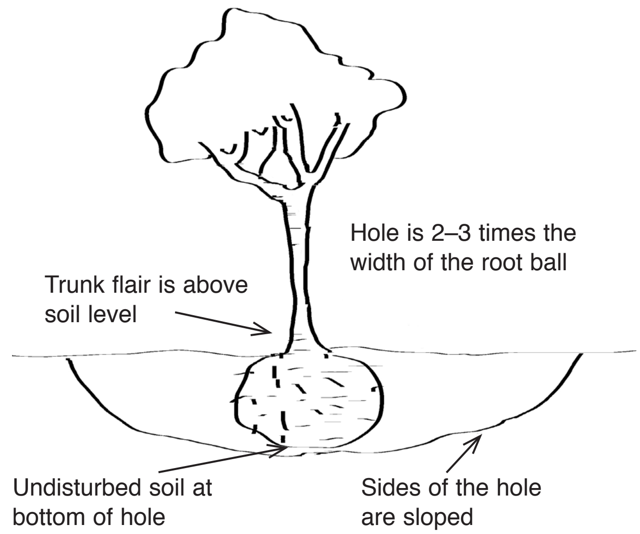

Figure 2. Planting hole size and configuration for balled-and-burlapped plants.

The size of the root ball determines the size of the planting hole. To prevent settling of the plant, dig the hole no deeper than the depth of the root ball. Make the hole at least two to three times wider than the width of the ball. Slant the sides of the hole outward so that the top is wider than the bottom (figure 2). This will allow water to enter the hole more easily and will provide space for the delicate roots to grow outward into the backfilled soil.

Place the root ball in the hole and half-fill the hole with soil. Water to settle the soil and remove voids. Next, untie the burlap from the trunk and lay it back on the soil, but do not remove it. Burlap should be removed only if it is *not* jute, but rather nylon or some other nondecomposable material. Fill the remainder of the hole with soil and then water again. If the burlap is not untied and buried, it will wick moisture from the root ball. For information on staking trees, see chapter 18, “Woody Landscape Plants.”

Containerized stock

Most plant materials sold at nurseries and garden centers are in containers. Container-grown plants need the same careful planting as other plant materials. Their advantage is that they can be planted anytime the ground is workable.

The planting hole should be as deep as the soil in the pot and two to three times wider than the container. Slant the sides outward. Remove the container, no matter what it is made of. The only exception is a small plant in a thin peat pot with roots growing through the pot. Even with peat pots, however, remove the top half of the pot to prevent wicking of soil moisture, and damage or remove the bottom of the pot to allow roots to escape. Thick paper or cardboard pots, sometimes erroneously called "peat" pots, should always be removed.

If roots are circling inside the pot or have taken on the shape of the pot, make four vertical knife cuts, one on each side of the root ball, to a depth of ¼ to ½ inch. Also make an "X" cut across the bottom of the root ball. If the roots are woody, use a hand clipper or sharp spade. New roots will grow from the cut roots.

Once cut, spread the roots slightly without breaking them, and place the plant in the hole. Fill the hole with backfill soil as described under "Balled-and-burlapped stock."

FERTILIZING

Plants need nutrients for proper growth and health. It is important to choose the proper fertilizer and method of application. For more information, see chapter 5, "Soils and Fertilizers," or the chapter that covers the relevant type of plant.

IRRIGATION

Adequate soil moisture is essential for plant growth and vigor. A healthy plant is 75–90 percent water. Plants need water to carry out vital functions such as photosynthesis, structural support, transpiration, and transport of nutrients and sugars. Poor irrigation practices can lead to problems such as iron chlorosis, wilting, leaf scorch, foliar diseases, root rots, and ground or surface water pollution. There is much to lose by not irrigating properly. Landscape plants can be expensive, and fully grown shade trees are impossible to replace.

Many gardeners underwater their plants by irrigating frequently for short periods of time. While a lawn can grow well enough with short, frequent irrigations, shrubs and trees do better with long, slow, infrequent irrigations.

Overwatering is as serious as underwatering. Roots require soil oxygen and can be damaged when excess water excludes oxygen from the soil profile. Excess irrigation also encourages root rots and other plant diseases.

Watering a landscape requires balancing the water needs of several types of plants. A typical suburban landscape includes an expansive lawn with a few mature trees. Flower and shrub beds may be located near the home's foundation or scattered around the lawn. There might be a vegetable garden in the back yard and a compacted path through the lawn leading to the back. There likely is a confusing mix of plants with varying drought and heat tolerances, such as pansies planted under junipers. Add a couple of planted containers on the front porch, and you have a typical suburban landscape that is challenging to irrigate.

Furthermore, moisture conditions vary throughout a landscape. A planted berm that continually loses water downhill will make the area below it overly wet. Areas shaded by mature trees likely will remain moist, but thickly matted tree roots inhibit grass growth. The north and east sides of a house are shaded and hold water longer than the south and west sides. Foundation plantings on the south and west sides of a house may need to be drip irrigated, as they will dry out quickly due to heat radiating off the house. Plants near a driveway or sidewalk face the same fate.

Factors affecting irrigation

Many variables affect the amount of water available to a plant. Soil type, slope, soil organic matter content, mulch, plant rooting depth, soil compaction, plant competition, evapotranspiration, and sprinkler efficiency all affect the availability of soil water.

Plant roots. The structure and growth habit of healthy plant roots strongly influence plant size and vigor. Since roots are out of sight, they often are misunderstood and their significance overlooked.

The depth and width of a root system depends on the growth characteristics of the plant, as well as on soil texture and structure. A root extracts most of its moisture from the top half of the root zone. This area is known as the effective root depth (figure 3). The effective root depth determines the amount of soil water accessible to the plant.

Newly emerged vegetable seedlings tend to have very shallow roots and must be irrigated frequently. Roots of most mature flowering perennials and

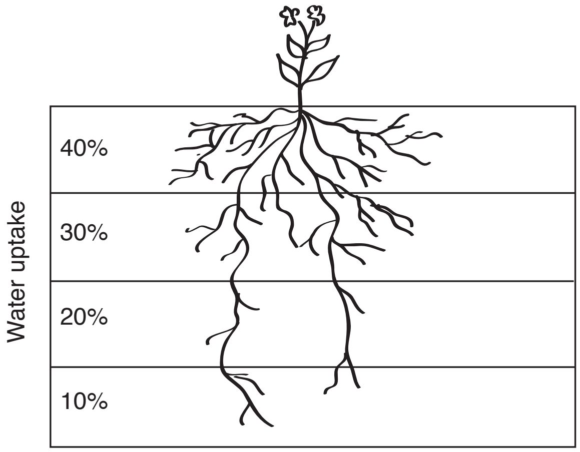

Figure 3. Effective root zone depth. Seventy percent of the moisture is extracted by the roots from the top half of the root zone.

vegetable plants exceed 24 inches in depth and width. See table 1 for effective root depths of common vegetables, fruits, and flowering plants.

On larger plants, it can be difficult to estimate the depth and width of the root system. Roots of deciduous trees growing in favorable conditions can spread two to three times the width of the canopy (branches). The horizontal root spread of evergreen trees is about twice the height of the tree. In both cases, the majority of the roots (the effective root depth) are in the top 2 feet of soil.

The rooting depth of turfgrass depends on the species. Kentucky bluegrass can have a rooting depth of 12 inches, while roots of turf-type tall fescue can be 4 to 6 feet deep! The effective root depth, where the turf obtains the majority of its water, is in the top half of the rooting zone. See chapter 15, "Turfgrass Establishment and Management," for more information.

In general, most plants need to have the soil thoroughly moistened around their roots with each watering. Allow enough time for the roots to extract most of the available water before irrigating again. See "Irrigation scheduling" and "Irrigating sections of the landscape" for information about determining how often and how much to water.

Evapotranspiration. Water moves to the atmosphere from the soil surface by evaporation and from plants by transpiration through plant stomata. Together, these processes are called evapotranspiration (ET), usually expressed as the depth of water (in inches) used in a specific period of time. Sunlight, temperature, relative humidity, wind, and

Table 1. Effective root depth in unrestricted soils.

Crop	Effective root depth (inches)
Vegetables	
Asparagus	36
Beets	18
Broccoli	18
Cabbage	18
Carrots	18
Cauliflower	18
Celery	12
Chives	6
Corn (sweet)	24
Cucumbers	18
Eggplant	18
Kale	18
Kohlrabi	18
Lettuce	6
Melons	24
Peas	18
Peppers	18
Potatoes	18
Pumpkins	24
Radish	6
Snap beans	18
Spinach	6
Squash	24
Swiss chard	12
Tomatoes	24
Turnips	18
Fruits	
Cane fruits	24
Grapes	36
Strawberries	6
Flowers	
Annual flowers	6
Bulbs, corms, rhizomes	12
Ground cover plant	6
Perennial flowers	18

the moisture level inside the plant affect the evapotranspiration rate. By providing an estimate of the amount of moisture used by a crop and lost through evaporation, ET rates indicate the amount of water that must be replaced with the next irrigation.

Daily ET values for crops and pastures are available from the AgriMet Weather Station Network, a service of the U.S. Department of the Interior Bureau of Reclamation. Unfortunately, these values do not accurately represent water use by biologically diverse plantings, such as those found in home landscapes or vegetable gardens. In general, ET rates often reach 0.3 inch or more in Idaho locations with hot summer days, low humidity, and high winds.

To reduce evaporation, water early in the morning if possible. Mulches (any material applied to the soil surface as a protective cover) improve water retention. They also reduce weeds and moderate soil temperatures. Organic mulches such as bark, wood chips, leaves, compost, grass clippings, and newspaper also improve soil structure and add some nutrients.

Inorganic mulches (solid plastic sheeting, woven nylon landscape fabrics, rocks, and gravel) retain moisture and reduce weed growth, but can have detrimental effects on plants. During hot, dry weather, rocks can absorb and reflect heat back to landscape plants and your home, making the area inhospitable for both plants and people. The weight of rocks also compacts the soil. Solid plastics do not allow oxygen or water to freely enter or leave the soil; these materials should be used only temporarily in vegetable gardens and never in a landscape. Both plastic sheeting and woven fabrics must be pinned down and covered with another mulch, such as wood chips, to prevent deterioration by ultraviolet light. Plastics and fabrics can migrate to the surface over time, even when secured with pins and covered with organic mulch, causing a landscape to look unsightly.

Water infiltration rate. Infiltration is the movement of water into the soil. The rate of infiltration is measured in inches or centimeters per hour. Clay soils have a slow infiltration rate, while sandy soils have a faster infiltration rate. For example, a sandy loam soil accepts ½–3 inches of water per hour, while a clay loam soil absorbs less than ½ inch of water per hour. If water is applied faster than the soil can accept it, either through precipitation or irrigation, the excess will pond or run off.

Compacted soils do not allow water to penetrate the soil surface. In a vegetable garden, tillage and organic matter additions will reduce compaction over time, but soils are very slow to change. Even with the addition of 1–2 inches of humus every year, it may be 4–5 years before any difference is noted in soil structure. Designated paths and planting beds will help prevent compaction in vegetable and flower gardens. For landscape beds, a 3- to 4-inch layer of organic mulch will reduce compaction by cushioning the soil from foot traffic and the pounding of water droplets.

In lawns, water infiltration can be reduced by compaction or a thick thatch layer. The best treatment for soil compaction in lawns is annual core aeration, followed by topdressing with ¼ inch of humus or good topsoil. Core aeration is usually done in spring or fall to reduce moisture loss around exposed turf roots.

Thatch is a spongy, brown layer made up primarily of dead grass stems and roots. Thatch production is a normal process for rhizomatous grass species, such as Kentucky bluegrass. To check for thatch, remove a section of turf, leaving the root system attached. The thatch layer is below the green grass blades but above the soil and roots.

A ½-inch-thick thatch layer is beneficial. Thicker thatch can harbor diseases and insects, and can interfere with water movement into the soil. Excessive thatch is often caused by overuse of nitrogen fertilizers, which causes grass to grow and die rapidly. Overwatering, poor drainage, and excessive use of fungicides or insecticides can also cause thatch buildup by harming the beneficial soil microbe populations responsible for decomposing thatch. A power rake or dethatcher is used to repair a lawn with an excessively thick thatch layer.

See chapter 15, “Turfgrass Establishment and Management,” for information about core aeration and thatch removal.

Permeability. The permeability rate of a soil is the speed at which water moves down through the soil profile. It is measured in inches or centimeters per hour. Soil compaction, plow pans, hard pans, clay layers, caliche layers, rocks, or changes in soil texture can influence permeability. A plow pan is a compacted soil layer created by tillage operations. A hard pan is an impervious layer, typically clay, that impairs drainage or plant growth. Caliche is a layer

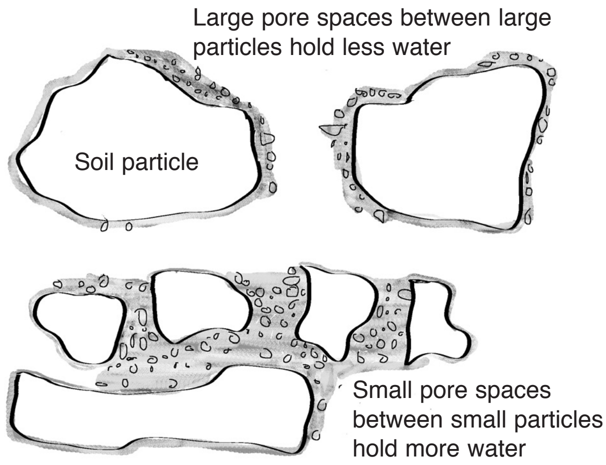

Figure 4. Pore spaces in soil. Soils with lots of large pore spaces, such as sand, hold less water than soils with small pore spaces, such as clay.

of lime (calcium carbonate) whose particles have been cemented together over time. A caliche layer can be so tightly cemented that roots and water cannot penetrate it.

Soil water-holding capacity. Soil stores moisture and supplies it to plants between precipitation events and irrigation. Water is held in pore spaces within the soil by capillary action and gravity.

The size and number of pore spaces is directly related to soil texture and organic matter content. A soil made up of large particles, such as sand, has a lower water-holding capacity than a soil composed of tiny particles, such as clay (figure 4). Regular addition of organic matter helps sandy soils hold water longer. Although clay can hold more water, the water is not necessarily available to plants because it takes more energy for plants to remove water from tiny pores.

See chapter 5, "Soils and Fertilizers," for more information about soil structure.

Soil texture interfaces. Soil texture interfaces occur where there is an abrupt change in the soil texture and the size of pore spaces. Water and oxygen can be very slow to cross an interface boundary.

Interfaces can occur naturally or be created by improper plowing, tilling, or planting methods. Amending the backfill during planting can create an interface by introducing a soil that is different from both the soil in the root ball and the native soil. All three soils will have different pore spaces, water-holding capacity, and water permeability.

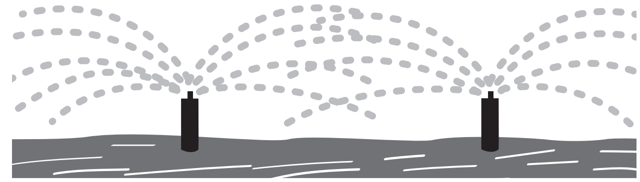

Figure 5. Sprinkler overlap to provide head-to-head coverage.

A severe soil texture interface can inhibit root development and plant growth. Researchers at Washington State University's Research and Experiment Station in Puyallup, Washington, observed that when plants were transplanted into heavy clay soil, using a heavily amended backfill, roots began circling within the hole as though they were in a pot. The surrounding native soil did not have the same oxygen content, nutrient levels, drainage, or water-holding capacity as the amended backfill. For this reason, it is best to avoid amending the backfill when transplanting in most soils. Heavy clay soils or very sandy soils will benefit from some addition of humus, but do not change the backfill by more than 25 percent.

Sprinkler efficiency. Landscapes are typically watered by sprinklers. Sprinkler systems range from hose-end sprinklers to fully automated underground systems. The irrigation principles are the same for all types.

Hose-end sprinklers vary widely in application rate and spray pattern. Some apply more water near the sprinkler and less near the edge of the spray pattern. To ensure uniform coverage, overlap the spray patterns when moving a hose-end sprinkler. The middle of the new spray pattern should be on the outside edge of the previous spray pattern (figure 5). Oscillating fan-type sprinklers give more uniform coverage.

With underground sprinkler systems, the landscape is typically divided into zones. Sprinkler heads are arranged so that one sprinkler sprays all the way to the next, a configuration known as head-to-head coverage. Often, one area is included in two or more zones, especially near the middle of the lawn.

Regardless of the type of sprinkler system, check application rates and uniformity. On a windless day, place several straight-sided containers, such as soup or tuna cans, at regular intervals throughout the lawn. Run the irrigation system normally, noting how long it runs. Measure the depth of water in each container to see how much water is applied during that period of time. Compare containers to see if a similar amount of water is applied to each area.

Irrigation scheduling

Irrigation scheduling involves planning when and how much to water. The goal is to maintain healthy plants without wasting water. Effective irrigation scheduling is possible only with regular monitoring of soil water availability and evapotranspiration. It is easy to think you are watering plants, but in reality you are making a water deposit into the soil.

When to water. Soil texture is an important factor in determining how frequently you should water. Although sandy soils allow quick, deep penetration of water, they tend to dry out more rapidly than clay soils and need more frequent irrigation. Heavy clay soils are more difficult to wet, but dry out much more slowly than sandy soils, allowing less frequent irrigation. Take the time to learn how long it takes for your soil to dry.

You can estimate soil moisture by feel and appearance. Obtain a soil sample to a depth of at least 1 foot, using a probe, auger, or shovel. Squeeze the sample firmly in your hand to form a ball. Soil that needs to be watered will be dry, and soil aggregates will separate easily. There will be no water staining on your fingers. In a clay soil, clods will be hard to crumble with applied pressure. Notice how the moisture at the surface compares to the moisture deeper in the soil profile. If the top is very moist but the soil is dry at 1 foot deep, increase the length of irrigations to allow moisture to travel down through the profile.

Resistance to the probe or shovel can be useful in gauging soil moisture content. If the probe enters the soil easily but stops abruptly after several inches, even with all of your weight on the handle, you may have reached dry soil or an impervious layer. Keep in mind, however, that compacted clay soil can be very difficult to probe even when moist, while a sandy soil can be easily probed even when dry.

Rocks or gravel will also stop the probe, but they are easily identified by a metallic sound when hit.

Soil moisture meters, available at nurseries and garden centers, are another method of checking soil moisture levels. These inexpensive meters are often inaccurate, however. If soil fertility is high, meters tend to overestimate soil moisture. If fertility is low, they underestimate moisture. You will need to learn how to interpret meter readings for your soil by trial and error.

Often, close observation of plants can help with irrigation scheduling. The level of drying a plant will tolerate depends on species and plant size. See "Irrigating sections of the landscape" for information relevant to specific plant types.

How much to water. Always water long enough to fill the entire root zone. In a typical garden or landscape, you must learn how long it takes to adequately moisten the root zones of various plants.

Because newly emerged vegetable seedlings have shallow roots, moistening just the top few inches of soil is often recommended. However, for a large shade tree with a root system the width of the yard or beyond, it can take hours to adequately water the entire root zone in clay soil. If the infiltration rate is low, some of this water is likely to run off rather than soaking into the soil. For this reason, some gardeners with clay soil "cycle water." This technique involves watering several times in one day, allowing the water to soak in between irrigations.

The easiest way to determine how long to water is to wait 12 hours after an irrigation and use a shovel or soil probe to dig or probe to a depth of 10–12 inches. Take a small handful of soil from the bottom of the hole or soil core and squeeze it. It should form a weak ball and feel slightly damp, like a wrung-out sponge. If the soil feels drier, water longer. If water drains freely from the soil when squeezed, reduce the length of irrigations. Check the soil moisture at this depth once a month in several areas of your yard.

For more information, see "Irrigating sections of the landscape."

Irrigating sections of the landscape

Lawns. Water lawns deeply but infrequently. Deep watering improves soil aeration, reduces water loss to evaporation, reduces weed populations, and produces a healthy lawn. Water long enough to wet the soil to a depth of approximately 1 foot. Often, irrigating once or twice a week in summer is sufficient, as long as the proper depth is reached.

The frequency of irrigation will change based on the weather, while the amount applied should remain fairly constant. It always takes the same amount of water to fill a 1-foot depth, but the length of time it takes the lawn to use this water depends on the weather. Irrigate less frequently in the spring and fall than in the summer.

It is best to *not* wait for your lawn to show symptoms of drought stress before irrigating. Stress symptoms are a sign that you've stretched the irrigation interval too long. If the grass does not spring back when walked on, or it takes on a bluish-gray cast, it is past time to irrigate and you should water immediately. If healthy turf dries up and turns tan, it may indicate that cool-season grasses have gone dormant. If not left too long, the grass will green up again when it receives adequate moisture.

For more information, see chapter 15, "Turfgrass Establishment and Management."

Trees and shrubs. Whenever possible, avoid overhead watering of woody trees and shrubs. Frequent wetting of leaves provides an environment in which foliar diseases can thrive and increases water loss to evaporation.

The water requirements of trees and shrubs change as they grow and mature. Even a tree or shrub that is described as "drought tolerant" or "low water use" needs to be watered regularly until it is well established.

Mature trees and shrubs need to have water available from their trunks out to and beyond their drip line (the end of the branch tips; see figure 6). Root systems can easily extend beyond the drip line, so watering right next to the trunk does very little, especially for large trees.

If a tree or shrub is surrounded by lawn, the lawn's sprinkler system will supply some water. However, trees and shrubs need deeper, less frequent irrigation than lawns; otherwise, the roots will grow close to the surface and be subject to drought stress. Thus, occasional deep irrigation with a garden hose or soaker hose may be necessary. Water deeply every 1 or 2 weeks in summer. Soak the ground in several areas around and beyond the drip line. If using a garden hose, use a low flow rate and let the water soak in.

If the tree or shrub does not receive water from lawn irrigation, water with a garden hose or drip irrigation system. If using drip irrigation, place emitters around the drip line of the plant, not near the trunk. For more information, see chapter 18, "Woody Landscape Plants."

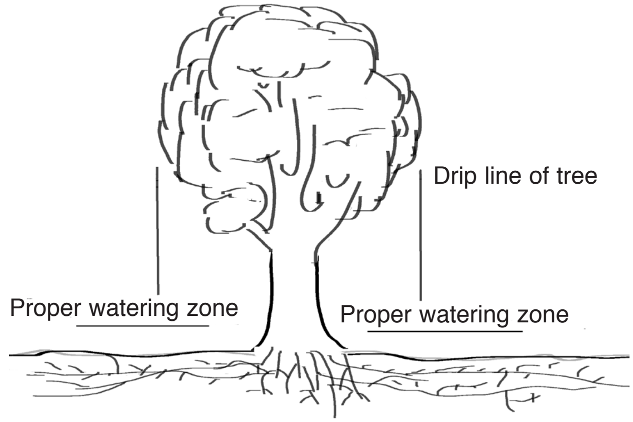

Figure 6. Proper watering area for a mature tree. The root systems of trees extend beyond their crowns.

Flowers and vegetables. In general, most flowers, small fruits, and vegetables require adequately moist soil all season long to produce their best. All of these plants differ in their water requirements, making irrigation a challenge. With inadequate water, lettuce and cucumbers can become bitter, and some flowers (such as peonies) may not bloom. On the other hand, tomatoes and irises may do fine with less frequent watering.

Gardens can be watered by gravity (flood), sprinkler, or drip irrigation. Gravity irrigation is not the most efficient method, but it fits well with a traditional vegetable garden consisting of long rows. Sprinkler irrigation is more efficient, but may increase the risk of foliar diseases. Sprinklers can be difficult to use with tall flowers or crops and with trellised plants. Drip irrigation is well suited to flower beds and vegetable gardens, as it applies water efficiently and keeps the leaves dry. Many types of drip tubing and emitters are available.

When using flood irrigation, make sure the water reaches the end of the row in a third of the time it takes to do a full irrigation (for example, within 10 minutes for a 30-minute irrigation). This ensures that the plants at the ends of the rows will receive enough water to reach into the lower depths of their root zones.

See chapter 19, "Principles of Vegetable Culture," chapter 23, "Small Fruits," and chapter 19, "Herbaceous Ornamentals," to learn more.

Containers. Plants in containers need more water than plants in the ground. Most potting soils dry rapidly. Also, the root zone in a container is limited, and roots are not well insulated from high temperatures. Outdoor container plants may need to be watered several times a day during warm, sunny periods. Check the soil moisture by probing the top inch of soil with your finger. If the soil is dry, it's time to water.

A drip irrigation system on a timer is a very effective way to keep containers adequately watered. However, containerized plants can be watered with a garden hose or watering can if watering is consistent throughout the summer.

Always irrigate several times or until water runs through the drainage holes in the bottom of the container. (Planting containers must have drainage holes for proper watering.) Don't be fooled, however, by a dry root ball that allows water to run around the edges of the pot and out the bottom without moistening the root ball.

Very dry root balls and soils with high peat content are especially difficult to rehydrate once they become dry. You may have to set the bottom of the container in a basin of water to remoisten the root ball or peat moss. Rehydration may take an hour or more, but do not leave a container sitting in water for more than 12 hours, as doing so may cause root damage due to lack of oxygen.

A good test to see whether the soil has taken up adequate moisture is to lift or tip the container. A well-watered container is much heavier than a dry one.

A pot that is too small for its plant will fill with roots, leaving little room for potting soil or water and causing the plant to dry out quickly. Transplant root-bound plants into larger containers.

Unglazed clay pots are porous and need to be watered more often than glazed or plastic pots. However, plastic pots offer poor root insulation. Adding a layer of thin Styrofoam sheeting on the inside of a pot prior to filling it with soil will improve insulation.

FURTHER READING AND RESOURCES

Penick, P. 2016. *The Water-Saving Garden: How to Grow a Gorgeous Garden with a Lot Less Water.* Ten Speed Press, Berkeley, CA.

Natural Resources Conservation Agency. 1998. *Estimating Soil Moisture by Feel and Appearance*. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Websites

American Horticultural Society. Plant Heat Zone Map
http://www.ahs.org/gardening-resources/gardening-maps/heat-zone-map

American Society for the Prevention of Cruelty to Animals. Toxic Plants List
http://www.aspca.org/pet-care/animal-poison-control/toxic-and-non-toxic-plants

USDA Natural Resources Conservation Service. Web Soil Survey
http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

USDA Plant Hardiness Zone Map
http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx

U.S. Department of the Interior Bureau of Reclamation, Pacific Northwest Region AgriMet
http://www.usbr.gov/pn/agrimet/

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