RESEARCH LABORATORY TECHNICAL REPORT

BARTLETT TREE EXPERTS
SCIENTIFIC TREE CARE SINCE 1907

Soil Drainage

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Water is essential for plant growth. However, either too little or too much water can result in decline and death of plants. A well-drained soil consists of half soil solids and half air space (Figure 1). Of this air space, half is made up of large spaces and half of small spaces. Under normal periods of irrigation or rainfall, the small pore spaces are able to hold water while the larger ones release the water to the pull of gravity and refill with air. This maintains a balance of air space and water capacity in the soil.

Impact of soil drainage on plants

Roots absorb oxygen from the soil and expel carbon dioxide back into the soil in their normal process of respiration. This happens in the pore spaces between soil particles that do not fill with water. Without this normal exchange of gases, carbon dioxide builds up, oxygen is less available, and roots die.

For this reason, internal drainage characteristics of soils are among the major factors that determine what types of plants will grow on a particular landscape site. When soils retain too much water, or restrict water movement through them, the result can be root suffocation, root disease, and eventual root death.

On somewhat poorly drained sites, plants might not die but show chronic decline symptoms associated with root loss. These symptoms might include yellowing of leaves (chlorosis), defoliation, marginal scorching, dwarfed foliage, and dieback. Trees and shrubs experiencing root decline from excess water are also more susceptible to attack and invasion by secondary diseases and insects.

Factors that contribute to wet soils

Wet soils stay wet for several possible reasons. These include:

Figure 1: Fine feeder roots growing in well drained soil

Compaction

When pore spaces (macropores) on the soil's surface are removed by compression with heavy equipment, vibration, or heavy foot traffic, water will not readily percolate (move downward) through soil. Instead, water runs off of sloped aspects or puddles on flat areas, which may remain wet.

Limiting subsurface layers

Soils can have layers below the surface that restrict percolation. In this case, the water "perches" in the soil above the restrictive layer and keeps it wet. Some soils naturally have impermeable layers as a result of how they developed. A common, human-caused impermeable layer or "hardpan" can be found on land that was plowed for many years. This layer is usually located 8"-10" below the surface, the depth to the bottom of the plow.

High water table

When the water table is near the surface, the soil may be wet where roots grow. Water tables are highest in winter and spring.

Clay soils

Soils vary tremendously in their composition due to differences in texture and chemistry, the amount of large and small pore spaces, and the structure of the soil. These natural soil characteristics determine how quickly water moves down through the soil to the water table. Soils with an overabundance of small poor spaces (micropores) hold more water and for a longer period, thus restricting oxygen. On soils in which the main particle size is in clay range, the soil might naturally drain very poorly.

Matching plants to soil drainage

In nature, the right plant is often found matched to a particular soil. If rainfall remains normal and soil drainage patterns are not changed, native trees and plants can thrive. In horticulture, a common mistake is matching a plant that requires good drainage with a poorly drained soil. Lists of plants grouped according to their tolerances of "wet feet" can be found in many horticulture books or in the Bartlett Technical Reports entitled "Shrubs for Poorly Drained Soil" and "Trees for Poorly Drained Soil." See Table 1 for a short list of shrubs suited for poorly drained sites.

Table 1: Shrubs for Poorly Drained Soils

Common name	Scientific name
Florida anise	*Illicium floridanum*
Sarcococca	*Sarcococca hookeriana*
Viburnum	*Viburnum* spp.*
Inkberry holly	*Ilex glabra*
Yaupon holly	*Ilex vomitoria*
Winterberry holly	*Ilex verticillata*
Chinese witchhazel	*Hamamelis mollis*
Butterfly bush	*Buddleja davidii*
Sweetshrub	*Calycanthus floridus*
Summersweet	*Clethra alnifolia*
Crapemyrtle	*Lagerstroemia indica*
Mockorange	*Philadelphus coronarius*
Arborvitae	*Thuja* spp.

* Numerous evergreen and deciduous viburnum are available. Consult Dirr (*Manual of Woody Landscape Plants*) for a complete listing and description of species and cultivars.

Determining soil drainage characteristics

The most reliable method for assessing soil drainage is to have a soil expert examine the soil, looking at texture, color patterns, and limiting soil layers. Indicators of wetness include gray or white mottling.

Another simple method of assessing internal soil drainage is called a percolation test. The soil should not be excessively dry or saturated when this test is performed. Directions for performing this simple test are on the following page.

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Instructions for performing a percolation test

1. With a shovel, auger, or posthole digger, dig hole 18" to 24" deep. Hole diameter should be a minimum of 4 inches. The diameter of the hole should be uniform from top to bottom with the bottom being flat.

2. Fill hole with water to the top and let stand for at least an hour to pre-wet the soil.

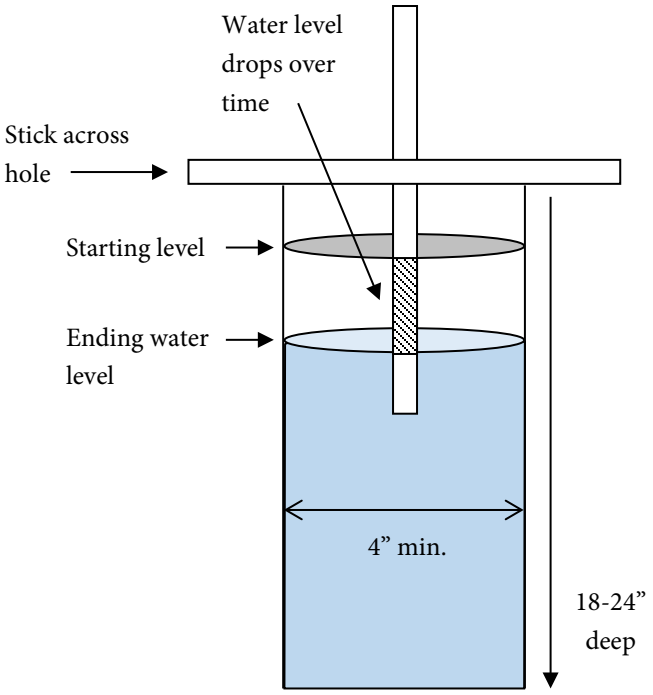
3. Refill hole to within a couple inches of the top. Don't allow water to overflow the hole.

4. To aid in measurement, place a stick across the top of the hole and use a ruler or measuring tape to mark periodic drops in water level.

5. Allow the hole to drain for at least one hour. A longer period (2 to 3 hours) will give a more accurate reading of average percolation rates.

6. Determine average drop in water level per hour and refer to the table below to interpret results.

Figure: Percolation test hole



How to interpret results

If water level in hole drops…	**Site is…**
Less than one-half inch per hour	Poorly drained and suited to wet-site species
One-half inch to one inch per hour	Moderately well drained and acceptable for many species including wet-site species
More than one inch per hour	Well drained and suitable for all species including sensitive species