

# THE SOIL

## A Plant and Its Requirements

Our goal is to create the healthiest root system possible. Without adequate roots plants will appear stressed even when irrigation and fertilization are adequate. The major portion of a root system of a typical plant exists from the soil surface to about 8-10" deep. Rooting depth is heavily dependent upon air penetration (the soil's permeability). Roots consume oxygen and release carbon dioxide just as animals do. Roots can live deeper (10'+) in sandy or gravelly soils where permeability is high. A woody plant's root system extends far wider than the plant is tall. A 20 year-old tree often has roots that reach 100' away, but rarely more than 2' deep. Plants require from the soil the following:

1. Water storage
2. Oxygen and gas exchange
3. Nutrient (minerals) storage
4. Support
5. Insulation from heat and cold

If any of the above is lacking symptoms of stress occur. These include:

1. Small foliage and stunted growth
2. Off-colored or dull foliage
3. Yellow and brown-edged foliage
4. Branch dieback
5. The plant develops a lean

## What is Soil?

Soil is a complex mixture combining material derived from rock (mineral) along with air, water and organic material.

Soil is typically a *3-layered cake* in profile. The top layer is called the **topsoil**. The middle layer is the **subsoil** and the bottom layer is the **parent material**. These layers rest on the bedrock. Any of these layers can be a fraction of an inch to several feet thick. Generally the *cake* is 3'-6' deep. We are mostly concerned with the topsoil.

*Unfortunately local homebuilders are not required to save and put back the topsoil after a home is completed. Owners of new homes often have to work with parent material or even bedrock.*

**Loam** is the term given to topsoil containing all 3 of the major particle sizes: SAND, SILT, and CLAY.

1. Sand-particles from 2mm-0.1mm
2. Silt-particles from 0.05mm-0.002mm
3. Clay-flakes less than 0.002mm

The percent volume of these 3 components can range from nearly 100% to nearly 0%. The presence of all three is required to create good growing conditions. Without sand there is very little airflow. Without clay there is very little moisture or nutrient retention. A good loam has a sand:silt:clay ratio of about 40:40:20. Soils that are mostly sand, by virtue of the empty spaces between particles, are lighter than clay soils.

*Actually clay soils contain more space (higher porosity) but this space is normally always filled with water molecules. A sack of kiln-dried clay weighs less than a sack of kiln-dried sand, but natural clay soil is heavier.*

Soils containing high volumes of sand are called "**light**" soils. Soils with significant percentages of clay are called "**heavy**" soils.

Clay absorbs more water adding to its weight. Clay can hold 2" of water per foot while sand only holds about 1/2". Water molecules are strongly attracted to soil particles in a layer one molecule thick. The collective surface area of the particles doubles when the particle size (average diameter) decreases by half. The water holding potential of the soil is called its **field capacity**. Mineral nutrients dissolved in water also accumulate to a higher extent in soils with a higher field capacity.

*Sandy Loam* is a technical term for the soil type that farmers prefer. It is a mixture of sand:silt:clay in a ratio that is roughly 6:3:1. Compared to loam, a *sandy* loam has higher permeability (airflow) for more vigorous roots but loses some nutrient and water retention. It is also more resistant to compaction from heavy equipment.

It doesn't require a high percentage of clay for a loam soil to be considered a *clay loam*. When the clay content reaches just over 30% it completely fills all the gaps between the larger particles and permeability declines dramatically.

*The gaps that exist between soil particles are where air and water can move and be stored. If the soil particles were uniform in size and perfect spheres the unfilled space would be 36%.*

**Permeability (often incorrectly called the porosity)** represents the ease of gas (air) exchange. Each type of plant has a minimum value that they can remain vigorous in. Most easy-to-grow plants get by with low permeability. Conversely just about any plant that has a reputation for being difficult requires high permeability. The table below represents the lowest volume of the soil occupied by air that that list of plants can tolerate.

2-5%	Conifer, Palm, Rose, Turf
5-10%	Hydrangea, Lily, Mum
10-20%	Begonia, Gardenia
20%+	Azalea, Fern, Orchid

Nature can improve permeability of heavy soils. **Lignin** (the glue that holds a plant together) is released into the soil when dead leaves or any other plant tissue decomposes on the surface. Lignin along with the activity of soil bacteria glues the smaller clay particles into large clumps (granulation, agglutination) that act like building blocks. **Worms** (macroscopic and microscopic), amoebas and other small organisms create airways. There are fungi called **Mycorrhizae** (see page 4) associated with nearly all plants that grow a network of hyphae (fungal strands resembling roots) that hold everything together like the girders of a building. Living soils in a well-established plant community look similar to Swiss cheese in cross section and resist compaction.

**Humus** is the **organic matter** found in Nature's soils. Humus is essentially inert. It is either charcoal or plant fibers that won't decompose further. In Nature's soils the humus content ranges from less than 1% to just less than 3%. Humus, especially charcoal, holds on to nutrients better than any other material found in Nature. The **rich black soils** found in many areas around the World are due to charcoal deposited after wildfires. Just a small amount (2-3%) of charcoal makes the soils appear black and become mineral rich. (see *Misconceptions about Soil* below)

## Drainage

**Drainage** is the ability of the soil to relieve itself of a saturated condition. Saturated soils have all spaces filled with water, making gas exchange very poor. Roots don't require as much oxygen as animals but certain species will suffocate if the water stagnates for more than 35 hours. (By this time the roots and other soil dwelling organisms have consumed all the oxygen available in the water. Both rainwater and unheated tap water are well oxygenated.) Chronically saturated soil results in a very shallow root system. Root rot diseases are promoted when oxygen levels drop. Plants would much rather grow in soils that are moist but not saturated.

*Note that just about any small plant will survive indefinitely with their roots sitting in a bucket of clean water.*

*The oxygen circulates freely when the water movement is not impeded by soil particles.*

Poor drainage can be due to:

1. Water applied into the soil faster than it can drain.
2. The soil below is *hardpan* or bedrock and won't drain at all.
3. There is a sudden change in soil texture in a layer below, resulting in a *perched water table*. (See *soil in containers*)

Farmers like soils that have good drainage at least 6' deep.

Drainage can be improved for extended periods either by:

1. Installing a *French drain*
2. Digging a *dry well*
3. Raising the entire bed (most effective when dealing with clay)
4. Breaking up any *hard pan*.

## Misconceptions About Soil

Be aware that many of the symptoms of poor drainage and/or overwatering can be attributed to the fairly recent tradition of amending the native soil with significant amounts of compost or organic mulches.

This standard practice can only benefit annual row crops involving plants that are harvested in less than 6 months, or incredibly permeable soil where oxygen availability is excellent, but water and nutrient retention are lacking. Compost lowers the oxygen level of the soil with which it is mixed with usually resulting in a shallow, sparse or unhealthy root system. If compost has any nutritional value it is still capable of decomposing and consuming oxygen. When it is finished decomposing there is virtually no volume remaining.

In the year 2000 the University of California published a soil report card where the soil on California farms of the present was compared to a similar study on California farms back in 1950. The researchers were pleasantly surprised that the organic component of the soil had actually increased from 0.9% to 1.1%. Both numbers are considered to be within the *ideal* range.

A heavy soil often turns *black* after it is amended with a lot of compost. This black color is due to the presence of **sewer gasses** (like hydrogen sulfide) that form when decomposition occurs under low oxygen levels. This is poisonous to the roots. **A black soil created by adding compost *instead of charcoal is dead, not rich!***

There are soils in nature that are 100% organic. These are called **peat bogs** and they contain *muck*. Nothing will grow (except small plants with shallow roots) due to the lack of oxygen penetration. This lifeless condition can exist for thousands of years.