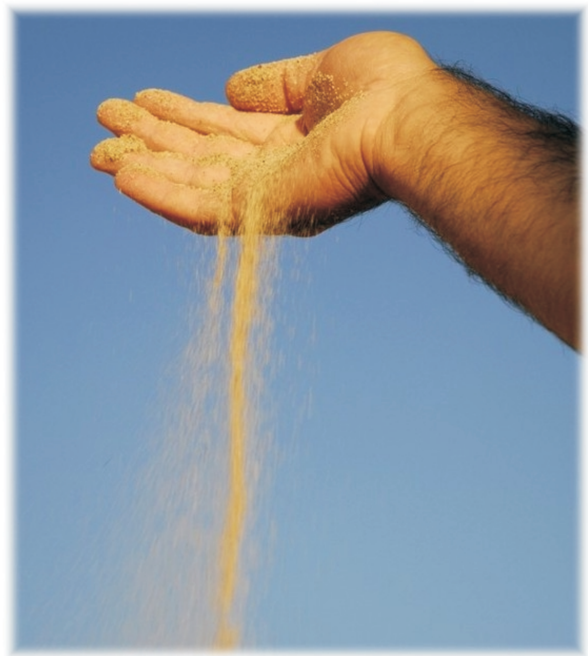
Soil Texture and Structure

HAVE YOU EVER made sand castles and mud pies? If so, think back at how the sand and mud were alike or different. What did they feel like? What happened when they dried? Both had unique properties that will be discussed in this unit.



Objectives:

1. Describe soil texture and soil characteristics related to texture.
2. Explain soil structure and various types of soil structures.

Key Terms:

aggregates	particle density	soil structure
bulk density	peds	soil texture
clay	permeability	soil workability
clods	sand	textural triangle
mineral matter	silt	water-holding capacity

Soil Texture

The inorganic material in soil is called **mineral matter**. Mineral matter began as rock that was weathered into small particles. Most soils have different sizes of mineral particles. These particles are called sand, silt, or clay, based on their size.

Sand is the largest of the mineral particles. Sand particles create large pore spaces that improve aeration. Water flows through the large pore spaces quickly. Soils with a high percentage of sand are generally well-drained. Sandy soils lack the ability to hold nutrients and are not fertile. Sandy soils also feel gritty to the touch.

Silt is a mid-size soil particle. It has good water-holding ability and good fertility characteristics. Silt feels like flour when dry and smooth like velvet when moist.

Clay is the smallest size soil particle. Clay has the ability to hold both nutrients and water that can be used by plants. It creates very small pore spaces, resulting in poor aeration and poor water drainage. Clay forms hard clumps when dry and is sticky when wet.

TABLE 1. Characteristics of Sand, Silt, and Clay

Characteristics	Sand	Silt	Clay
Looseness	Good	Fair	Poor
Air Space	Good	Fair to Good	Poor
Drainage	Good	Fair to Good	Poor
Tendency to Form Clods	Poor	Fair	Good
Ease of Working	Good	Fair to Good	Poor
Moisture-Holding Ability	Poor	Fair to Good	Good
Fertility	Poor	Fair to Good	Fair to Good

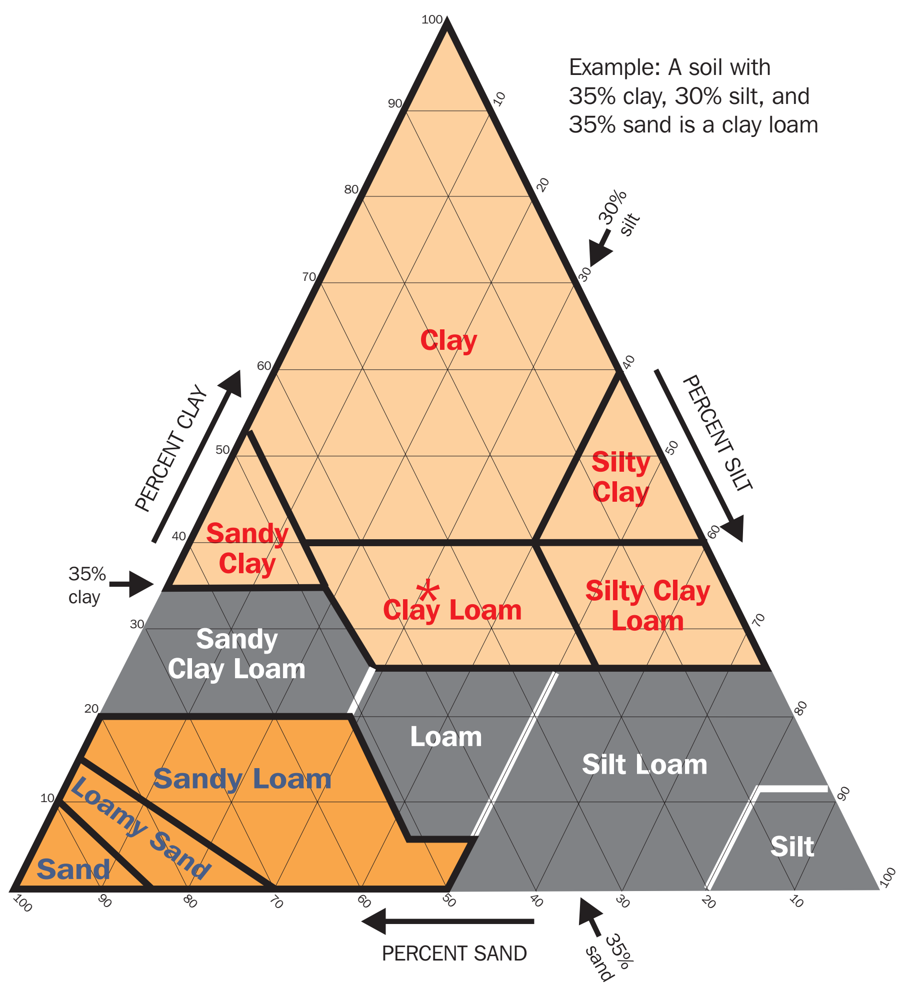


FIGURE 1. The textural triangle can be used to differentiate the several classes of soil.

TEXTURAL CLASSES

Soil texture is the proportion of the three sizes of soil particles that are present and the fineness or coarseness of a soil. Soil texture may be determined in one of two ways. The percentages of sand, silt, and clay may be tested in the lab. Once tested, the textural class of the soil can be determined by referring to the **textural triangle** (a device used to differentiate the several classes of soil). Soils with different amounts of sand, silt, and clay are given different names. For instance, a soil containing 40 percent sand, 20 percent clay, and 40 percent silt is called loam soil. The relative amounts of sand, silt, and clay may also be determined in the field using the ribbon method. Five textural classes may be determined using this method.

FIGURE 2. The ribbon method is used to determine five major textural classes of soil.

- Fine-textured—A ribbon of soil forms easily and remains long and flexible.
- Moderately fine-textured—A ribbon forms but breaks into pieces 3/4 to 1 inch long.
- Medium-textured—No ribbon forms. The sample breaks into pieces less than 3/4 inch long. The soil feels smooth and talc-like.
- Moderately coarse-textured—No ribbon forms. The sample feels gritty and lacks smoothness.

UNDER INVESTIGATION...

LAB CONNECTION: Sedimentation Test of Soil Texture

A simple activity can be performed to determine the percentages of sand, silt, and clay in a given soil sample. Place about two cups of soil in a tall, straight-sided quart jar. Add five tablespoons of 8 percent water softening solution and enough water to almost fill the jar. Tighten the lid and shake vigorously for five minutes. After 40 seconds, measure the depth of the settled soil and record it as the sand depth. Do not shake the jar again. In 30 minutes, measure the depth of the settled soil. Subtract the depth of sand from the measurement to get the silt depth. The next day measure the soil depth and subtract the sand and silt depths to get the clay depth. Also, measure the total depth of the settled soil. Determine the percentage of each soil particle by dividing the particle depth by the total soil depth and multiplying by 100.

- Coarse-textured—No ribbon forms. The sample is composed almost entirely of gritty material and leaves little or no stain.

TABLE 2. Soil Textural Classes

Sand	Dry—Loose and single grained; feels gritty. Moist—Will form very easily—crumbled ball Sand: 85-100%, Silt: 0-15%, Clay: 0-10%
Loamy Sand	Dry—Silt and clay may mask sand; feels loose, gritty. Moist—Feels gritty; forms easily—crumbled ball; stains fingers slightly. Sand: 70-90%, Silt: 0-30%, Clay: 0-15%
Sandy Loam	Dry—Clods easily broken; sand can be seen and felt. Moist—Moderately gritty; forms ball that can stand careful handling; definitely stains fingers. Sand: 43-85%, Silt: 0-50%, Clay: 0-20%
Loam	Dry—Clods moderately difficult to break; somewhat gritty. Moist—Neither very gritty nor very smooth; forms a ball; stains fingers. Sand: 23-52%, Silt: 28-50%, Clay: 7-27%
Silt Loam	Dry—Clods difficult to break; when pulverized feels smooth, soft, and floury, shows fingerprints. Moist—Has smooth or slick buttery feel; stains fingers. Sand: 0-50%, Silt: 50-88%, Clay: 0-27%
Clay Loam	Dry—Clods very difficult to break with fingers. Moist—Has slight gritty feel; stains fingers; ribbons fairly well. Sand: 20-45%, Silt: 15-53%, Clay: 27-40%
Silty Clay Loam	Same as above, but very smooth. Sand: 0-20%, Silt: 40-73%, Clay: 27-40%
Sandy Clay Loam	Same as for Clay Loam. Sand: 45-80%, Silt: 0-28%, Clay: 20-35%
Clay	Dry—Clods cannot be broken with fingers without extreme pressure. Moist—Quite plastic and usually sticky when wet; stains fingers. (A silty clay feels smooth, a sandy clay feels gritty.) Sand: 0-45%, Silt: 0-40%, Clay: 40-100%

SOIL CHARACTERISTICS RELATED TO TEXTURE

The texture of a soil is important because it determines soil characteristics that affect plant growth. A few of these characteristics are water-holding capacity, permeability, and soil workability. **Water-holding capacity** is the ability of a soil to retain water. Most plants require a steady supply of water, and it is obtained from the soil. While plants need water, they also need air in the root zone. The ease with which air and water may pass through the soil is called **permeability**. **Soil workability** is the ease with which soil may be tilled and the timing of the work.

Soils with a larger percentage of sand are easier to work than soils with a larger percentage of clay. Clay soil tends to be tighter, making it more difficult to break up or cultivate, whereas sandy soil is looser. It also takes longer for a clay soil to dry after a rain than a sandy soil.

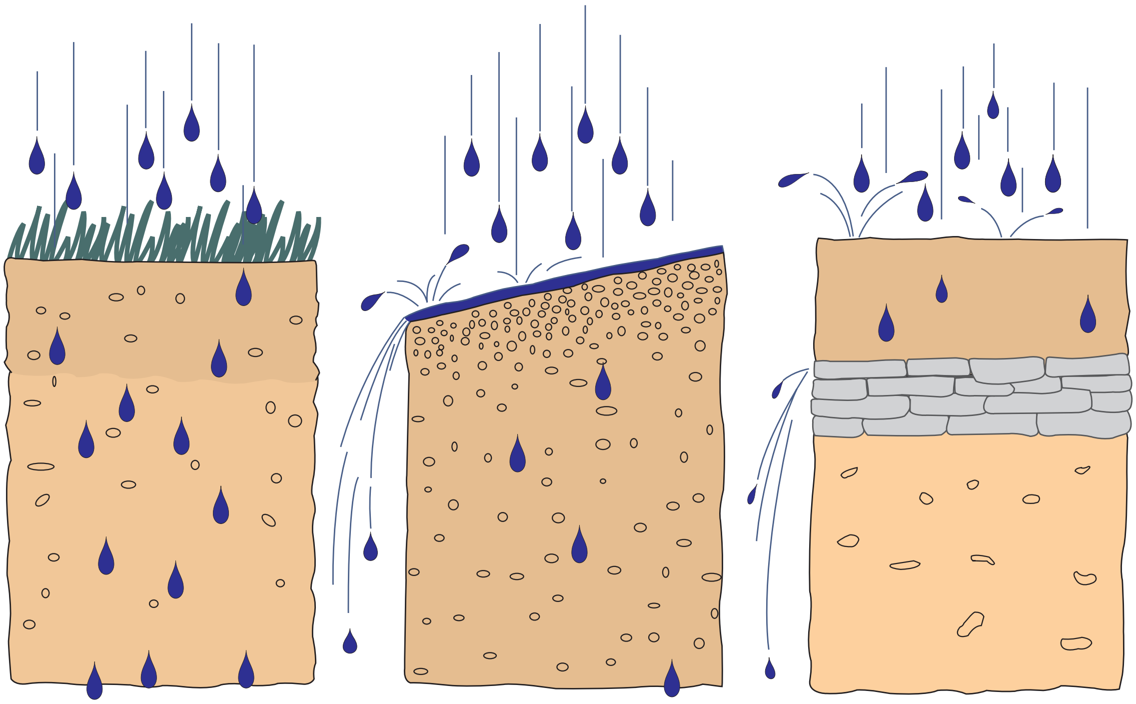


FIGURE 3. Soil with good permeability allows water to be easily absorbed.

Because of the better drainage, a sandy soil can be worked sooner. In the case of wet clay soil, the producer or gardener must wait longer for the soil to dry sufficiently.

Soil texture may limit which crops can be grown. For example, root crops, such as carrots and onions, perform best in a sandy soil because it is loose and allows the plant to expand. However, growth of some plants is stunted when growing in sandy soils because they lack the water- and nutrient-holding ability.

Soil Structure

Sand, silt, clay, and organic matter particles in a soil combine with one another to form larger particles of various shapes and sizes and are often referred to as **aggregates**, or clusters. **Soil structure** is the arrangement of the soil particles into aggregates of various sizes and shapes. Aggregates that occur naturally in the soil are referred to as **peds**, while clumps of soil caused by tillage are called **clods**.

Aggregates are created through a number of ways, including freezing and thawing, wetting and drying, fungal activity, tillage, and by plant roots that surround the soil and separate the clumps. Weak aggregates are cemented to make them distinct and strong. Clay, iron oxides, and organic matter often act as cements. When soil microorganisms break down plant residues, gums are produced that glue peds together.

SOIL STRUCTURAL CATEGORIES

There are eight primary types of soil structure, including blocky, columnar, crumb, granular, massive, platy, prismatic, and single grain.

- Blocky—The units are block-like. They consist of six or more flat or slightly rounded surfaces.
- Columnar—The units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns are very distinct and normally rounded.
- Crumb—The aggregates are small, porous, and weakly held together.
- Granular—The units are approximately spherical or polyhedral. The aggregates are small, non-porous, and held together strongly.
- Massive—There is no apparent structure. Soil particles cling together in large uniform masses.
- Platy—The units are flat and plate-like. They are generally oriented horizontally. Plates overlap, usually causing slow permeability.
- Prismatic—The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically. The tops of the prisms are somewhat indistinct and normally flat.
- Single grain—There is no apparent structure. Soil particles exist as individuals and do not form aggregates.

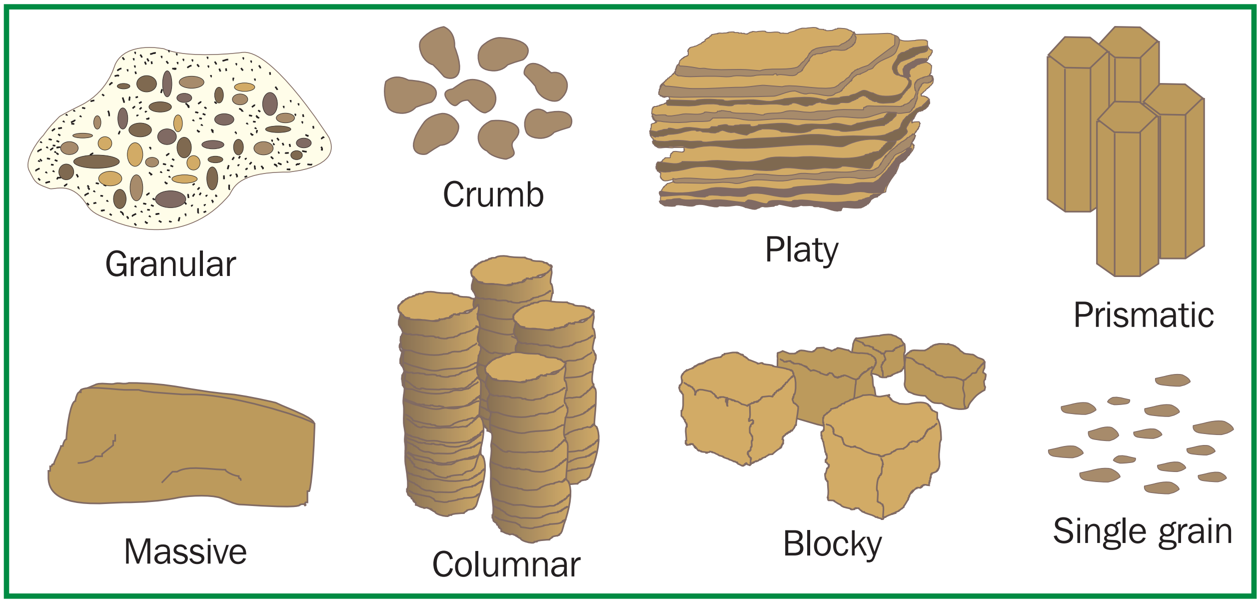


FIGURE 4. The eight different categories of soil structure

Of all the soil structure types, granular is the most desirable, because it has the greatest proportion of large openings between the individual aggregates.

THE IMPORTANCE OF SOIL STRUCTURE

Soil structure is important for several reasons. Soil structure affects water and air movement in a soil, nutrient availability for plants, root growth, and microorganism activity. The pore spaces created by peds are larger than those in between individual particles of sand, silt, or clay. This allows for greater air and water movement and better root growth. The larger spaces make passageways for organisms. The aggregates are also better able to hold water and nutrients.

Soil Structure Damage

Soil structure can be destroyed. A major cause of damage is driving heavy equipment over wet soil. Damage is also caused by working soil when it is either too wet or too dry. These conditions lead to the clay particles clogging up the pore spaces. The soil becomes compacted, very dense, and, when it dries, it becomes very hard. It is very difficult for most plants to survive in a soil that the structure has been destroyed.

FIGURE 5. This soil structure has been destroyed due to heavy construction equipment.

BULK DENSITY AND PARTICLE DENSITY

Bulk density is the ratio of the mass of dry solids in a medium to the volume of the medium. It involves the measure of the mass of the entire volume of a soil sample. The density is a major factor in dealing with root movement and stability of the soil. **Particle density** is the ratio of the mass of solids to the volume of the soil solids. It is determined largely by the texture. Particle density involves the measure of the mass of only the solid particles in a soil sample.

Soil texture affects bulk density. Different separates have different masses and have corresponding pore space. Soil structure also determines density because various soil arrangements compact more easily than others.

Bulk Density and Particle Density Importance

Bulk density and particle density are important in the production of crops.

The amount of pore space decreases with higher soil density. As a result, soil aeration and water-holding capacity decrease. This decrease in water-holding capacity is especially significant in the larger pore spaces that are readily available to hold water that plants can utilize.

Erosion can also be affected by density. Water that is slow to infiltrate the soil stays in contact with the topsoil for a longer period of time, thereby increasing the rate of erosion.

Flooding will result from excessive runoff and decreased infiltration in wet years. Puddling can result from localized compaction, as is the case in tractor tire ruts.

The production of containerized crops is influenced by bulk density. Light bulk density eases handling and shipping of potted plants. High or heavy bulk density is needed to provide support for plants. For potted plants, the growing medium's bulk density should be light enough to ease handling and heavy enough to support the plant.

Calculating Bulk Density and Particle Density

Bulk density is calculated by dividing the mass of dry soil by the volume of the soil. The particle density of the soil is determined by dividing the mass of the soils in a soil sample by the volume of solids in the soil sample.

Summary:

Most soils have different sizes of mineral particles called sand, silt, or clay. Sand is the largest of the mineral particles. Silt is a mid-size soil particle. Clay is the smallest size soil particle. Soil texture describes the proportion of the soil particles and the fineness or coarseness of a soil.

The texture of a soil determines soil water-holding capacity, permeability, and soil workability.

Sand, silt, clay, and organic matter particles in a soil combine with one another to form larger particles. Soil structure is the arrangement of the soil particles into aggregates of various sizes and shapes. There are eight primary types of soil structure, including blocky, columnar, crumb, granular, massive, platy, prismatic, and single grain.

Soil structure affects water and air movement in a soil, nutrient availability for plants, root growth, and microorganism activity.

Bulk density is the ratio of the mass of dry solids in a medium to the volume of the medium. Particle density is the ratio of the mass of solids to the volume of the soil solids.

Checking Your Knowledge:

1. How do sand, silt, and clay differ?
2. What is soil texture?
3. How is soil texture determined?
4. What is soil structure?
5. Why is soil structure important?

Expanding Your Knowledge:

Explore the soil around your home. Dig up some soil and squeeze it, crumble it, and feel it. Is the texture gritty or smooth? Does the soil form a ball that easily crumbles apart? See if you can determine the texture and type of structure of the soil.

Web Links:

Soil Properties

http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/soil_systems/soil_development_soil_properties.html

Soil and Water

http://www.fao.org/docrep/R4082E/r4082e03.htm#2.1.3%20soil%20texture