Understanding 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 structure.

Key Terms:

aggregates	permeability	soil texture
clay	ribbon method	soil workability
clods	sand	textural triangle
mineral matter	silt	water-holding capacity
peds	soil structure	

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 labeled 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 the mid-size soil particle. Silt has good water-holding ability and good fertility characteristics. It 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

TEXTURAL CLASSES

Soil texture describes the proportion of three sizes of soil particles 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**. Soils with different amounts of sand, silt, and clay are given different names. For instance, a soil containing 40 percent sand, 40 percent silt, and 20 percent clay is called loam soil. The relative amounts of sand, silt, and clay may also

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 2 cups of soil in a tall, straight-sided quart jar. Add 5 tablespoons of 8 percent Calgon 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 the 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.

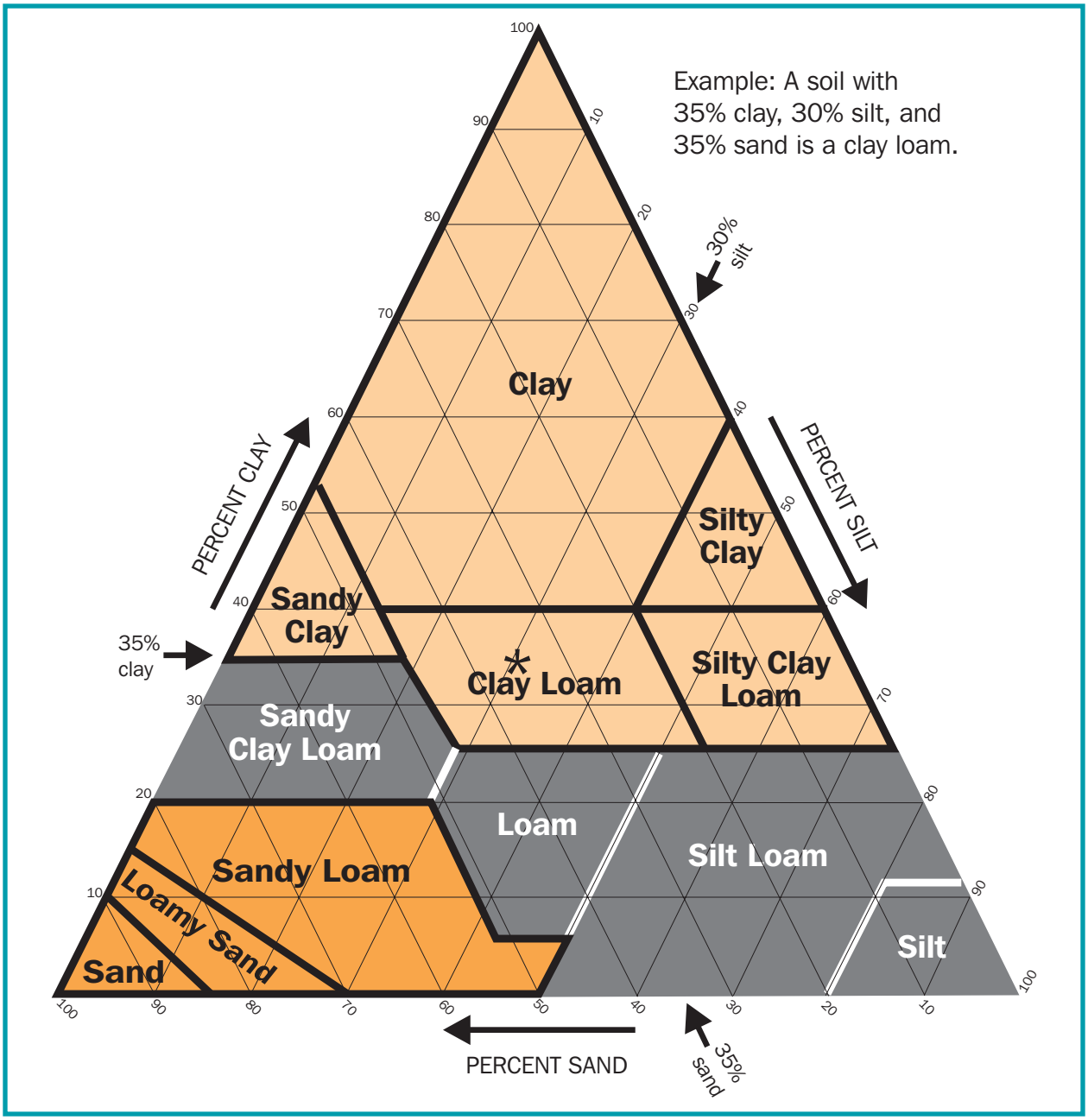

FIGURE 1. The textural triangle is used to classify soils.

be determined in the field using the **ribbon method**. Five textural classes may be determined using the ribbon method.

- **Fine textured—**A ribbon 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.

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 and 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 slightly 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%

- **Moderately coarse textured—**No ribbon forms. The sample feels gritty and lacks smoothness.
- **Coarse textured—**No ribbon forms. The sample is composed almost entirely of gritty material and leaves little or no stain.

SOIL CHARACTERISTICS RELATED TO TEXTURE

The texture of a soil is important because it determines soil characteristics that affect plant growth. Three 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. **Permeability** is the ease with which air and water may pass through the soil. **Soil workability** is the ease with which soil may be tilled and the timing of the work.

Soils with large percentages of sand are easier to work than soils with large percentages of clay. Clay soils tend to be tighter, making them more difficult to break up or cultivate, whereas sandy soils are looser. A clay soil also takes longer than a sandy soil to dry after a rain. Because of the better drainage, a sandy soil can be worked sooner. With a 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 plants to expand. On the other hand, some crops may experience stunted growth in a sandy soil because the soil lacks 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. These larger particles, or clusters, are often referred to as **aggregates**. The arrangement of the soil particles into aggregates of various sizes and shapes is **soil structure**. Aggregates that occur naturally in the soil are called **peds**, whereas clumps of soil caused by tillage are called **clods**.

Ways in which aggregates are created include freezing and thawing, wetting and drying, fungal activity, tillage, and the surrounding of the soil by plant roots that 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

The eight primary types of soil structure are blocky, crumb, columnar, granular, massive, platy, prismatic, and single grain. Granular is the most desirable structure type because it has the greatest proportion of large openings between the individual aggregates.

- **Blocky—**The units are block-like. They consist of six or more flat or slightly rounded surfaces.
- **Crumb—**The aggregates are small, porous, and weakly held together.
- **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.
- **Granular—**The units are approximately spherical or polyhedral. The aggregates are small, nonporous, and held strongly together.
- **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.

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 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. Either condition leads to the clay particles clogging the pore spaces. The soil becomes compacted and very dense; and when it dries, it becomes very hard. It is extremely difficult for most plants to survive in a soil whose structure has been destroyed.

FIGURE 2. Heavy equipment on construction sites often destroys soil structure, resulting in poor water drainage.

Summary:

Most soils have different sizes of mineral particles called sand, silt, and clay. Sand is the largest of the mineral particles. Silt is the 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 characteristics that affect plant growth. Three of these characteristics are 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 of various shapes and sizes. Soil structure is the arrangement of the soil particles into aggregates. The eight primary types of soil structure are blocky, crumb, columnar, 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.

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? See if you can determine the texture and the type of soil structure.

Web Links:

Soil Texture and Structure
http://www.public.iastate.edu/~arossi/page%202.htm

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