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Understanding the Texture of Your Soil for Agricultural Productivity

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Have you ever been to a field- or farm-related event, seen the soil and subsequent produce, and wished you had that kind of soil? If you have, you are most likely not alone! However, many people who work and use their land for private gardening, community farming, or other commercial agricultural production activities have an incomplete idea of what healthy and productive soil should look like. Texture, density, structure, nutrients, and organic matter are some of the most common parameters of healthy, productive soils. This paper explains the textural qualities of soils and allows readers to assess the qualities of the soil they manage.

What Is Soil?

Soil is defined as the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants (SSSA 2008). Soil is a living ecosystem full of living organisms, with physical qualities and chemical interactions that play important roles in defining its health and quality. Soil formation is a result of the interactions of soil-forming factors, which are parent materials, climate, biological activities (biota), topography, and time. Soils of different characteristics are formed in different places, and they often reflect the degree to which these soil-forming factors have interacted.

Soil can be described by the relative abundance of solid primary particles it contains. These particles, depending on their size, can be classified as sand, silt, or clay. The relative proportion of sand, silt, and clay in the soil is known as soil texture. These particles are categorized by their sizes, with sand particles being the largest. Sand particles range from 0.05 to 2.00 millimeters (mm) in diameter; silt particles range from 0.002 to 0.050 mm; and clay particles are smaller than 0.002 mm (fig. 1A; USDA-NRCS 1999). They are commonly identified as coarse-textured soils, medium-textured soils, and fine-textured soils, respectively (fig. 1B).

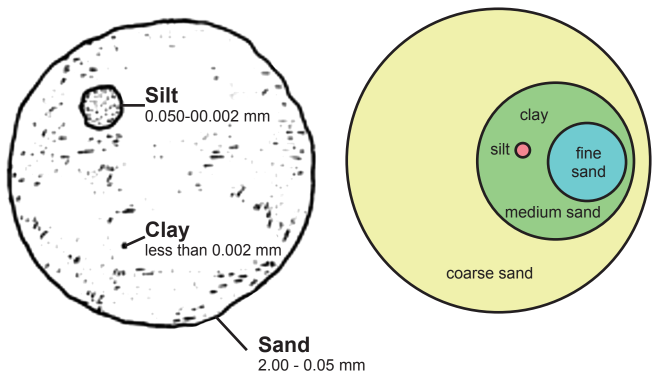

Figure 1. A, soil separates relative to each other; B, identification of soil separates. (1A, reproduced with permission from University of Nebraska-Lincoln Extension [1999, fig. 2.2]; 1B, reprinted from Colorado State University Extension [see Whiting et al.; 2016, fig. 1].)

Texture is one of the most important properties of a soil, and it greatly affects crop production, land use, and management. Soil texture is directly related to nutrient retention and drainage capabilities. The texture of a soil in the field is not readily subject to change, so it is considered a permanent soil attribute (Brady and Weil 2007). Since "these components of soil are largely unalterable, there's not much you can do to change them" (Gershuny 1993, 6). Therefore, according to Berry et al. (2007, 2), "It is very impractical (expensive) and thus ill-advised to modify a soil's texture."

In order to know the texture of your soil, its components are classified by their combined percentages into a textural class with the aid of the

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textural triangle (USDA-NRCS 1999; fig. 2). The triangle has 12 different soil textural classes that are associated with various proportions of sand, silt, and clay, but soils can be generally categorized as one of the four major textural classes: sands, silts, loams, and clays (Berry et al. 2007). The dominant particle within each class gives the soil its characteristic texture, and there is hardly any soil that is 100 percent of one separate. Invariably, we have sandy soils, silty soils, clayey soils, loamy soils, and their combinations based on their location on the textural triangle.

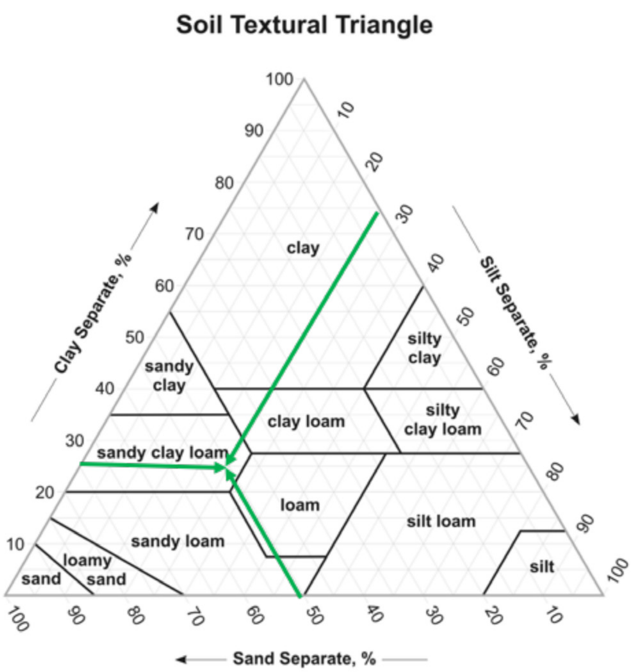

Figure 2. The textural triangle showing the 12 classes with arrows pointing to the area for 50 percent sand, 25 percent clay, and 25 percent silt separate. This soil is classified as sandy clay loam. (Reprinted from USDA-NRCS [1999].)

Soil properties influenced by soil texture include drainage, water-holding capacity, aeration, susceptibility to erosion, organic matter content, cation exchange capacity, pH buffering capacity, and soil tilth (Berry et al. 2007).

Sand Separates (Coarse-Textured Soils)

Sandy soils have a higher percentage of the sand fraction for any coarse-textured soil. For example, a soil with 72 percent sand, 10 percent silt, and 18 percent clay will be classified as sandy loam texture (fig. 2). Sandy loam will feel gritty to the touch and falls apart easily if formed into a ball when moist. It may form a weak ribbon — often less than 1 inch — before it breaks. Sandy soils are also referred to as coarse-textured and have the tendency to drain quickly after rainfall or irrigation. Because they drain faster than other soil textures, they are subject to nutrient losses through leaching, and they also warm faster in the spring. Sandy soils tend to have a low pH and very little buffering capacity; hence, are often acidic.

Silt Separates (Medium-Textured Soils)

Silt-sized particles, which have separates that range from 0.002 to 0.05 mm (fig. 1A), are smaller than sand separates but larger than clay separates. Because they are intermediate-size separates, they might be fairly well-drained, but they usually retain more water than sandy soils. Soils with a greater percentage of silt separates have a floury appearance when dry and a smooth feel when moist, and they occasionally form some ribbons when pressed between the fingers. These soils have the tendency to compact easily when moist and form crusts when wet.

Clay Separates (Fine-Textured Soils)

Clay separates are fine-textured, with the smallest separates among the three main types at less than 0.002 mm in diameter (fig. 1A). Also known as heavy soils, clay separates are sticky and smooth when moist and easily form into a ball or a ribbon if pressed between your fingers or rolled across your palm. Due to their small size, fine-textured soils tend to drain water slowly, can easily be compacted if trampled while wet, and harden when dry. Because of their tendency to hold more water and drain slowly, fine-textured soils also warm up slowly during the spring.

Loams (Medium-Textured Soils)

Loams have relatively even amounts, or percentages, of sand, silt, and clay separates. The predominance of each soil separate indicates if it a sandy loam, silt loam, or clay loam. Loams are slightly gritty, relatively well-drained, and easy to work with agricultural tools. When moist, loam can form into a ball and hold its shape, but it still crumbles when gently squeezed. Loams usually hold water well and drain easily. The composition of loams on the textural triangle (USDA-NRCS 1999) is about 40 percent sand, 40 percent silt, and 20 percent clay (fig. 2). Though generally considered the ideal soil texture, loams only signify the proportion of the separates they contain, which does not necessarily mean that the soils have all the important components, especially soil organic matter.

How To Determine Soil Texture

There are several ways to determine the texture of soil. Methods that can be used for textural determination include the laboratory method, texture by feel, and the jar method. The soil map could be useful for surface soil determination if the area has been mapped or classified.

Laboratory Method

Analysis by a soil testing laboratory is an accurate way to determine soil texture. Organic matter is removed before the analysis can be performed. Soil testing laboratories use several methods for analyzing soil texture (Klute 1986) and can require the help of an extension educator. You can contact a local Natural Resources Conservation Service office or the county agricultural and natural resources extension agent who can assist with locating a soil testing laboratory and provide information on soil sampling protocols.

Soil Texture by Feel

Soil texture by feel is usually more of an estimation of the percentages of the separates based on feeling a moist soil with the fingers. Organic matter is not removed with the feel method and could influence the feel of sandy textures.

There are three types of soil-texture-by-feel tests (Berry et al. 2007; Whiting et al. 2016):

1. General feel tests - Rub some moist soil between fingers.
2. Ball squeeze tests - Squeeze a moistened ball of soil in the hand.
3. Ribbon tests - Squeeze a moistened ball of soil out between thumb and fingers.

Figure 3 provides a schematic representation of the methods.

Following are some guidelines for judging soil texture by feel. Use about 25 grams of soil to conduct the three types of tests. Add a few drops of water to moisten the soil if it is dry.

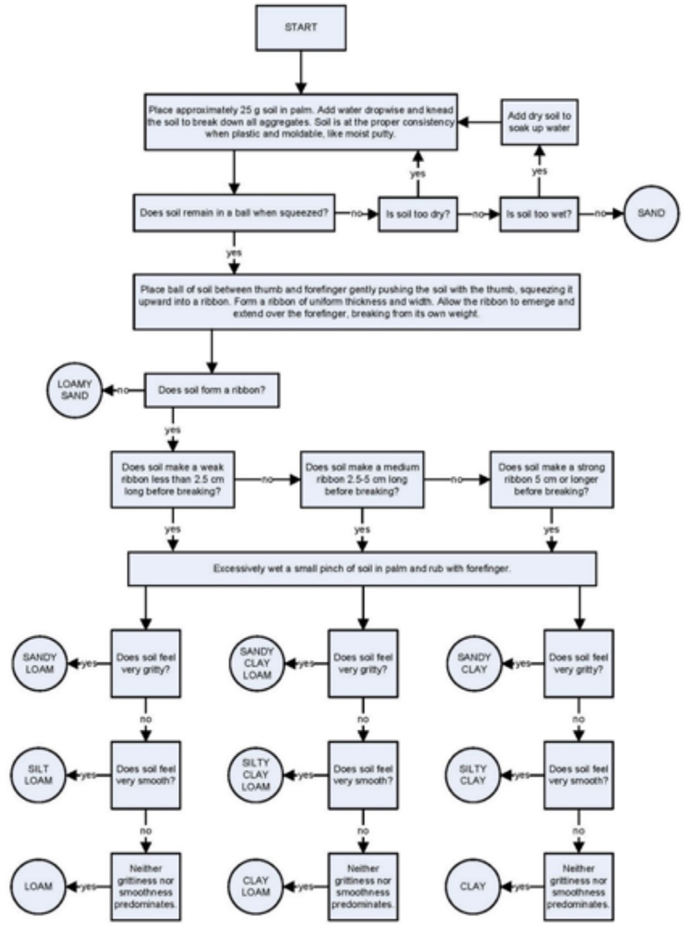

Figure 3. A flow diagram for texture by feel. (Reprinted from USDA-NRCS [1999]. Originally adapted from S.J. Thien, "A Flow Diagram for Teaching Texture-by-Feel Analysis," Journal of Agronomic Education 8 [1979]: 55.)

Sand

- Feels gritty when rubbed between fingers.
- Falls apart easily if formed into a ball and dropped from hand to hand.
- Forms a ribbon that is less than 1 inch long when a moistened ball is squeezed between the thumb and fingers.
- High organic matter, indicated by very dark soil colors, could make a longer ribbon and feel less gritty than light-colored soils.

Silt

- Feels smooth when moist and has a floury appearance when dry.
- Changes shape easily and breaks apart with slight pressure.
- Occasionally forms a ribbon when squeezed between fingers and thumb; the length of the ribbon depends on the clay content.

Clay

- Feels sticky and is bendable when moist.
- Forms a ball easily and resists breaking even when pressed.
- Forms a ribbon that could get up to 2 inches in length before breaking; a longer ribbon formed before it breaks indicates a greater percentage of clay.

Loam

- Feels somewhat gritty, yet is easy to work.
- Holds its shape if formed into a ball when moist, yet still breaks apart easily when squeezed.
- Should form a ribbon that is more than 1 inch in length that breaks when gently pressed.

The Jar Method

The jar method is not very accurate, but it gives a general idea of what your soil texture could be. Organic matter is not removed before using the jar method, but it does not influence the results. You can independently use this method by following these steps:

1. Collect a few random samples of about 15 cm in depth from the intended field.
2. Spread out the sample on a newspaper to air-dry, removing all debris, roots, rocks, and boulders.
3. Collect the samples from different sections of the field and thoroughly mix all the soil samples when properly dried.
4. Crush the soil and lumps.
5. Measure out soil to fill about one-quarter of a tall, clear, slender jar.
6. Add a teaspoon of powdered Cascade or other nonfoaming dishwasher detergent.
7. Cover with a tight-fitting lid and shake vigorously for about 15 minutes.
8. Set the jar where it will not be disturbed for two days or more, which allows the soil separates to settle according to their sizes (fig. 4).
9. After one minute of settling, mark the obvious separate on the jar, indicating the sand.
10. After two hours, mark the depth of silt.
11. After the water clears — about two or more days — mark the depth of clay.
12. Measure the thickness of each depth — the sand, silt, and clay — record it, and then add them up. The sum will provide the total thickness of all separates.
13. To calculate the percentage of each separate, use the formula

$$\frac{\text{clay (or silt or sand) thickness}}{\text{total thickness}} = \text{percent clay (or silt or sand).}$$

The summed percentages of clay, silt, and sand will be roughly 100 percent, and the soil texture can be estimated using the textural triangle (fig. 2). You can also use a soil texture calculator where you input the calculated percentages to get your soil texture (USDA-NRCS 2000). Now that the dominant component of the soil has been determined to be sandy, silty, clayey, or loamy, it is easier to plan on making the most of the soil texture.

Soil Maps

The soil map is widely known and used by farmers and producers as an alternative method of estimating the surface soil textural class. Digital soil survey maps are readily available on the internet using the Web Soil Survey (USDA-NRCS 2015). Soil maps are much

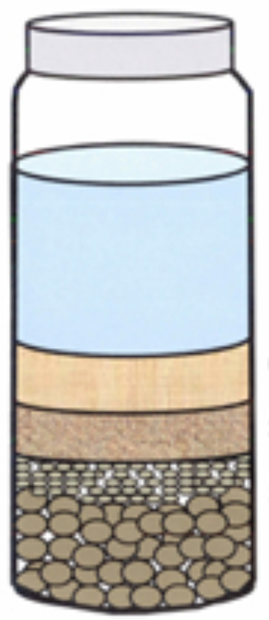

Figure 4. Measuring soil texture using the jar method. (Reprinted from Colorado State University Extension [see Whiting et al.; 2016, fig. 3].)

more useful for estimating soil type (i.e., soil series), soil depth, presence of a natural pan, and other specific soil features. The U.S. Department of Agriculture National Resources and Conservation Service and the Soil and Water Conservation District offices in your region as well as the county agricultural and natural resources extension agent will be helpful in locating areas that have been mapped and how to use the maps.

Soil Texture and Crop Choice

Regardless of the texture, every soil type has an inherent capability and its own advantages. The chemical relationships influencing soil fertility are complex and are affected by the parent material from which soil develops, the type of clay present, and the proportions of the different-sized particles — sand, silt, and clay — which also have important effects on soil structure (FAO 2016). Soil type, texture, and quality vary from region to region and from garden to garden. The soil that is best for plant growth is directly related to the type of plants being grown. This means that each plot of land will have its own blend of minerals, organic matter, and inorganic matter, which largely determines the crops or plants that can grow successfully. Therefore, knowing your soil texture is beneficial because it provides a tool for choosing the right plants for your garden/land and the best opportunity for knowing how to maintain the plants in a healthy and productive soil. Selecting the right crop for the given soil conditions and climate can optimize yields and save water required for irrigation (Spuhler and Carle 2010).

After you have determined your soil texture, the next step is the crop or plant selection based on the soil. What is the general category of crops that would benefit the soil the most? For sandy soils, the categories of crops that would be profitable include vegetable root crops like carrots, potatoes, and shrubs, and bulbs like tulips and sun roses, as well as lettuce, collard greens, tomatoes, raspberries, and blackberries, among others. Clayey soils would be great for perennials and shrubs like aster and flowering quince; summer crop vegetables like corn, cucumbers, and peppers; fruits like grapes, berries, apples, and peaches; and ornamental trees like lavender, cactus, and cherry blossom. Silty soils would be suitable for shrubs such as blackberry, beach rose, and raspberry; climbers such as cucumber, hops, and grapes; grasses such as rye, wheat, and corn; and perennials such as ginger, strawberry, and tomato. Many moisture-loving trees as well as vegetable and fruit crops do well in silty soils that have adequate drainage (Barton 2013).

Loam soils are generally considered the most productive because they have an even mix of all the soil separates. Therefore, loam would be favorable for many crops, including climbers, bamboos, perennials, shrubs, and tubers, as well as most vegetable and berry crops.

Managing and Benefiting From Your Soil Regardless of Soil Texture

Soil needs to be managed to be productive and sustainable. Regardless of the soil texture and its eventual use for production, soil quality can become depleted from continuous use. Therefore, a consistent management plan is needed for soil (Jaja 2015; USDA-NRCS 2011). To improve soil tilth, nutrient status, biological communities, aeration, and structure, organic matter should be added regularly. Adding organic matter does not change the texture of soil, but it does change the physical properties related to the texture. Organic matter will help improve the structure in a heavy clay texture or a loose, sandy texture. Better structure invariably improves drainage, aeration, water retention, and nutrient availability. Adding organic matter also helps lower and prevent soil compaction. While there are several ways to add organic matter to the soil, integrating compost, animal manure, and cover cropping provide a major path to increasing the organic matter content of soil (Clark 2007).

Conclusion

Agricultural production at many levels focuses on yield: The yield of agricultural crops is dependent on how well the soil has been managed. However, sound soil management relies on a good knowledge of soil properties and functions. How do I know what soil texture is good for my crops? How do I know when to replenish soil organic matter to improve the soil's physical properties? The answers to these questions and many others about soils, including its uses and management for sustainability, depend to a large extent on the texture of the soil. When you have the information and knowledge necessary to manage your soil, you will understand and appreciate the quality of your soil.

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