SOIL INVESTIGATION: The Wealth Beneath Your Feet

BACKGROUND

Unless you are a farmer or a gardener, you probably think of soil as "dirt" -- as something you don't want on your hands, clothes, or carpet. Yet your life, and the lives of most other organisms, depends on soil, especially topsoil. Soil is not only the basis of agricultural food production, but is essential for the production of many other plant products such as wood, paper, cotton, and medicines. In addition, soil helps purify the water we drink, and is important in the decomposition and recycling of biodegradable wastes.

Nations, including the United States, have been built on the riches of their soils. Yet since the beginnings of agriculture people have abused this vital, potentially renewable resource: entire civilizations have collapsed because of mismanagement of the topsoil that supported their populations. Today, we are not only facing loss of soil from erosion, we are also depleting nutrients in some soils and adding toxins to others.

SOIL TEXTURE

SOIL COMPONENT	WATER INFILTRATION CAPACITY	WATER HOLDING CAPACITY	NUTRIENT HOLDING CAPACITY	AERATION	WORKABILITY ("TILTH")
CLAY	POOR	GOOD	GOOD	POOR	POOR
SILT	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
SAND	EXCELLENT	POOR	POOR	GOOD	GOOD
ORGANIC MATTER	GOOD	EXCELLENT	EXCELLENT	POOR TO GOOD	POOR TO GOOD

Through the process of weathering, mineral rocks are broken down over long periods of time into fine particles of clay (very fine particles less than 0.002 mm in diameter), silt (0.002 to 0.05 mm) and sand (0.5 to 1.0 mm). The relative amounts of the different sizes of particles control two very important properties of soil: its fertility and its ability to hold water (see Table 1).

Table 1: Relationship between soil components and various important properties of soil

Soil fertility is measured by the amount of nutrients available for plant growth. These nutrients in soils are usually found in the form of positively charged ions such as NH^+, Ca^+, or K^+. Since the very small particles of clay (called ***micelles***) often have a negative charge, these ions can be held in the soil on the surface of the micelles. The larger particles of silt and sand do not have this negative charge. Thus soils with more clay tend to be more fertile.

The infiltration (absorption) and retention of water in soil are also important. Soils with low infiltration, such as clay, are more likely to have high runoff after rain and the potential for flooding. Yet these soils can retain a good deal of water. In contrast, sandy soils have very high infiltration rates, but are unable to retain much water (most of the water continues to flow through the soil to the water table). High infiltration can result in leaching, the loss of nutrient ions from the layers of soil where roots are most abundant. These soils are more likely to be infertile, and the leachate can have high concentrations of nutrients and pesticides, polluting both the water table and adjacent rivers and lakes.

Thus the "best" soils, called ***loam***, are a mixture of sand, silt, and clay. These soils contain the best of each of the textural components, and have relative high fertility and at the same time relatively high water holding capacity.

SOIL ORGANIC MATTER

Organic matter is another very important component of soils. Not only is the organic matter the source of most nutrients (derived from the decomposition of dead plant and animal materials), but it, too, is composed of small, negatively charged micelles. Thus, like clay, organic matter in the soil is important in retaining nutrient ions. In addition, organic matter is excellent at absorbing and holding water in the soil. In some cases, the addition of organic matter can increase the water-holding capacity of a soil 9-fold! *Peat moss* is an example of organic matter that can be added to soil.

SOIL pH

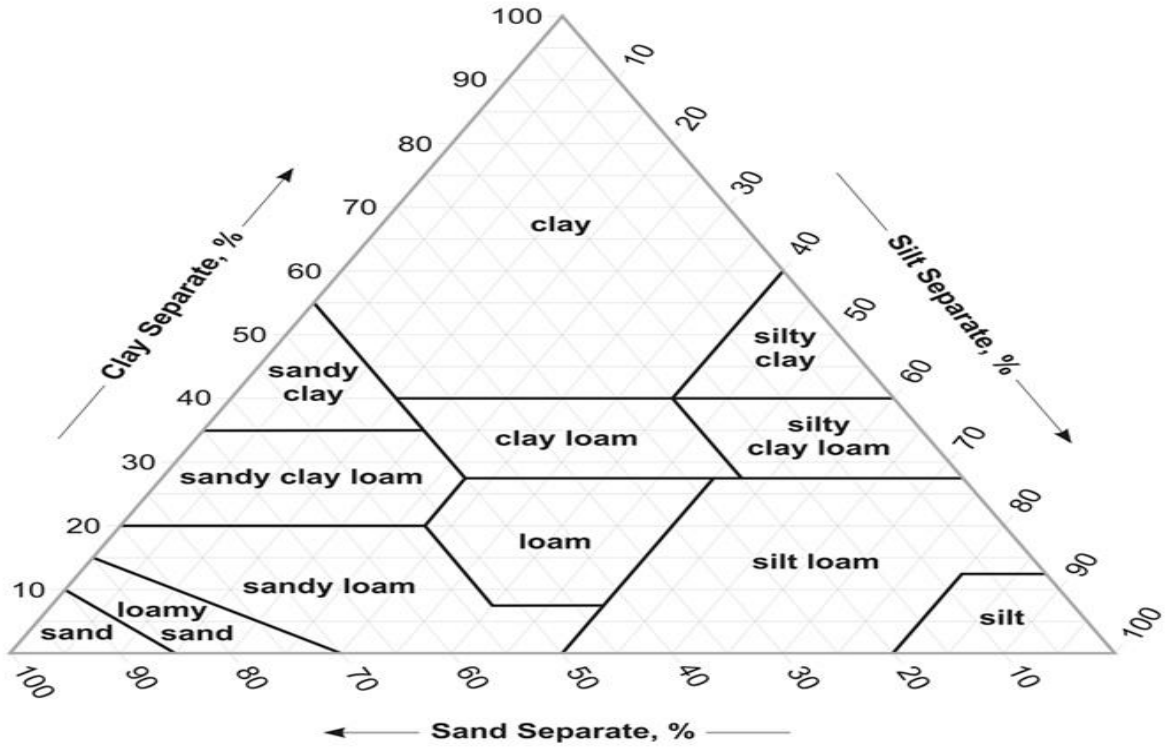
The acidity (pH) of a soil is another factor determining the nutrient status of a soil. In general, more acid soils (lower pH) have lower fertility than more basic soils because the H^+ ions in the acid displace the positively charged nutrient ions in the soil micelle. These nutrient ions can then be leached from the soil.

PROCEDURES- Testing the Characteristics of Soil Components

PART A: DETERMINATION OF SOIL COMPOSITION BY SEPARATION OF LAYERS

PURPOSE: To determine the ratio of clay, silt, and sand in a soil sample by separating the soil into its component layers.
MATERIALS: Soil sample, 100 ml graduated cylinder, foil, Soil Texture Triangle
PROCEDURE:

1) Place approximately 25 ml of soil in a 100 ml graduated cylinder.
2) Add water until there are about 75 ml of material in the cylinder.
3) Cover the cylinder with plastic wrap, place the palm of your hand firmly over the opening, and invert the cylinder several times until the soil is thoroughly mixed.
4) Place the cylinder on the table and leave it to settle for at least 30 minutes.
5) When the soil has settled out, there should be three reasonably distinct layers -- sand, silt, and clay. Measure the volume of each layer and the total volume of the sample.
6) Calculate the percent of each of the components. (Be sure NOT to count the water).
7) Identify the type of soil in your sample from the Soil Texture Triangle.



PART B: INFILTRATION (PERCOLATION) RATE

PURPOSE: To determine the rate at which water passes through a soil sample.

MATERIALS: Samples of clay, silt, sand, peat moss, plastic wine glass, ring stand, clamp, 100 ml graduated cylinder, cotton ball

PROCEDURE:

1) Plug the end of the stem of the plastic bottle with a cotton ball.
2) Set up the ring stand and clamp to hold the glass over the 100 mL graduated cylinder.
3) Fill the plastic bottle 3/4 full with dry soil sample to be tested. Compact the soil by gentle bouncing (compact the clay with your fingers if necessary). Make sure there are no spaces between the edge of the soil and the cup.
4) Note the start time and add 50 ml of water in a steady stream (try not to disrupt the soil surface, but don't be too slow). The stop time is when all the water has been absorbed from the surface of the soil.
5) Measure the diameter of the glass in centimeters.
6) Calculate the surface area in which water contacts the soil. (Remember that the surface area of a circle = πr^2.)
7) Calculate the infiltration rate as ml/min/area.

PART C: WATER-HOLDING CAPACITY

PURPOSE: To determine how much water will be retained by a soil sample.

MATERIALS: Same as for infiltration rate, plus tablespoon, drying oven,shallow heat-proof dish, electronic balance

PROCEDURE:

1) After you have determined the infiltration rate for your sample, continue to add water to your sample until water starts to drain out the bottom of the tube and your **soil is completely saturated**. Let the tube drain until no further water drains out. Remove three spoonfuls from the glass and mass them using the electronic balance. Dry the sample in a drying oven until they are completely dry. For fastest drying, spread the sample in a thin layer on a shallow heat-proof container. In some cases, the samples may have to be left in the oven overnight in order to dry completely.
2) The water-holding capacity of a soil is calculated by:

$$\frac{\text{WET MASS - DRY MASS}}{\text{DRY MASS}} \text{ X } (100) = \text{water-holding capacity}$$

PART D: pH

PURPOSE: To determine how well nutrients are retained by the soil sample.

MATERIALS: pH test kit

PROCEDURE:

1) Place 15-18 ml of soil into the sample container.
2) Keep the cap off the sample container and allow the soil in the tube to air dry.
3) Once the soil has dried, pour distilled water into the sample container until the soil is slightly oversaturated (water is at the top of the soil).
4) Place the cap on the sample container and swirl the water and soil mixture.
5) Allow the soil to settle for approximately five minutes.
6) Once the soil has settled, use a pipet to obtain five drops of the soil water suspension. Place this into the cap of the sample container.
7) Now place five drops of universal indicator into the cap.
8) Use the universal indicator color chart to find the corresponding pH of your soil. Record the pH of your sample in the pH of Soil Worksheet.

PART E: NUTRIENT TESTING

1) Follow the directions on the board for these tests.

PART F: DETERMINATION OF SOIL COMPOSITION USING SOIL TEXTURE

PURPOSE: To determine the ratio of clay, silt, and sand in a soil sample by testing its texture.
MATERIALS: Soil samples, wash bottle with water
PROCEDURE:

1) Take about a heaped teaspoonful of soil and moisten it (use water from a wash bottle). Manipulate it to a state of maximum stickiness and plasticity, working out all the lumps. If you encounter any stones (larger than 2000 μm or about the size of a grain of rice) pick them out and discard them. From time to time, you may need to add more water to maintain the soil at its maximum plasticity.
2) What is the predominant feel of the soil?
   - Gritty Go to (3)
   - Silky Go to (5)
   - Sticky Go to (10)
   - Doughy Go to (5)
   - None of these (or not sure) Go to (3)
3) Try to make a ball of soil by rubbing between the palms (not moulding it with the fingers):
   - This is impossible - Sand
   - This can be done only with great care - Loamy sand
   - This is easy - Go to (4)
4) Try to flatten the ball by pressing it between thumb and forefinger:
   - The ball collapses - Sandy loam
   - The ball flattens - Go to (5)
5) Make a ball of soil and try to roll it into a thread, first a thick one (about 1 cm in diameter) and then a thinner one (about 0.5 cm in diameter):
   - Not even a thick thread can be formed - Loamy sand
   - Only a thick thread can be formed - Sandy loam
   - A thick and a thin thread can be formed - Go to (6)
6) Try to bend the thin thread of soil into a horseshoe shape:
   - The thread cracks while this is being attempted - Go to (7)
   - A horseshoe shape can be formed without cracks developing - Go to (9)
7) Manipulate the soil between the fingers and judge the general feel of the soil:
   - Soil feels only rough and gritty - Loam
   - Soil feels silky - Silt
   - Soil feels sticky, rough, and gritty - Go to (9)
8) Remoistening as necessary, make a thin thread of soil (about 0.3 cm in diameter) and bend into a horseshoe shape - Go to (9).
9) Try to make the horseshoe thin thread of soil into a ring about 2.5 cm in diameter by joining the two ends of the thread, without cracks forming:
   - This can be done - Go to (10)
   - This cannot be done - Go to (12)
10) Mould the soil into a ball and rub between thumb and index finger to produce a smeared surface:
   - The smeared surface is smooth with only a few irregularities - Go to (12)
   - The smeared surface is polished but a few gritty particles stand out - Sandy clay
   - The smeared surface is polished with no (or very few) irregularities - Go to (11)
11) Manipulate the soil between the fingers and judge the general feel of the soil:
   - Soil feels like soap and takes a high polish - Clay
   - Soil feels like silk and takes a dull polish - Silty clay
12) Form the soil back into a ball and manipulate between the fingers to judge the general feel of the soil:
   - Soil feels very gritty - Sandy clay loam
   - Soil feels moderately gritty - Clay loam
   - Soil feels doughy and smooth - Silty clay loam