Soil Texture Analysis

Introduction

Soil is defined as unconsolidated mineral matter on the earth's surface that is subjected to an influence by climate, parent material, organic matter, and topograqphy, acting over a period of time and producing a product-soil that differs physically, chemically and biologically from the material from which it was derived. Soil is composed of particles of three different size-classes: 1) **sand** (0.05-2.0mm in diameter), 2) **silt** (0.002-0.05mm in diameter), and 3) **clay** (<0.002mm in diameter). In addition to these mineral particles, soil also contains organic matter - material of organic origin. Inorganic material greater than 2.0mm in diameter is called **gravel**, and by definition is not considered to be soil at all (Brady 1984).

The relative proportions of sand, silt and clay define a soil's **texture**. If these properties are known, a soil can be classified according to its texture, using a texture triangle such as the one provided on page 5.

Soil texture can influence plant growth in several ways. An important soil property that is directly related to texture is soil water-holding capacity. Water adheres to soil particles because of the physio-chemical properties of surface tension and capillary movement. Water is inherently sticky, and will adhere to the surfaces of soil particles. Since the surface-to-volume ratio increases as particle size decreases, soils composed of smaller particles can potentially hold more water than soils composed of larger particles.

The amount of water held in a soil that is available for plant uptake is a function of two soil properties - field capacity and the wilting coefficient (or permanent wilting point). **Field capacity** is the soil water content beyond which water drains freely from the soil, or in other words, the maximum amount of water that a soil can hold against the forces of gravity. By definition, this is water that is held by the soil at pressures near 0.01 to 0.02 Mpa (1 Mpa (megapascal) = 10 atmospheres). (Note that although it is conventional to discuss water potential in terms of pressure units such as megapascals or atmospheres, it might be helpful to remember that we are actually talking about osmotic potentials, and that water potential concerns ability to "do work". Therefore, water potential can be expressed in terms of energy units such as kilojoules. One Mpa = one kJ/kg of water). Since the water potential of pure water at atmospheric pressure is zero, soil usually has a negative water potential.

As soil dries, some water is held so tightly by the soil particles that it is unavailable for plant uptake. Since the average plant can exert a pull equivalent to about -1.5 Mpa (=-15 atmospheres), the **wilting coefficient** is the amount of water that is held by a soil at pressures less than -1.5 Mpa. Therefore, the amount of water that a soil is capable of holding at pressures between -0.01 and -1.5 Mpa is water that is theoretically available for plant uptake (plant-available soil moisture).

Plant-available soil moisture is a function of particle size. **Sandy soils** have large pores that fill or drain quickly. Since particles are large, little water is held above -1.5 Mpa. **Clay soils** hold large amounts of water because they are composed of very small particles that hold onto water tightly. However, they also hold large amounts of water at pressures less than -1.5 Mpa, which are not available for plant use. Plant-available water is actually often greatest in **loamy soils**, which hold less water than clay soils, but do not hold large amounts of water at pressures less than -1.5 Mpa. **Loamy soils are often the soils best suited for plant growth and agriculture.**

In a uniform aqueous suspension, large particles will settle out faster than small particles (Stoke's Law). This phenomenon results in the deposition of sands along riverbanks during floods, while clay particles remain in suspension longer, and are deposited further away from river margins. By suspending a soil sample in a uniform liquid medium, and then measuring the change in specific gravity over time as particles settle out, we can estimate the relative proportions of sand, silt, and clay in that soil. This is known as the Bouyoucos method of soil texture analysis. We will use the Bouyoucos method to estimate the sand, silt, and clay contents of the three types of soil that were also used in the "Plant Nutrients in Soil and Soil pH" lab exercise.

Objectives

- use proper lab techniques to determine percent sand, silt and clay of soil samples
- determine soil texture category using information gathered in this exercise

and the provided soil triangle

Hypothesis

- *the commercial potting soil will have a loamy soil texture and will provide the best texture for growing plants*

Materials

- sieve (2mm)
- balance
- sodium hexametaphosphate solution, 5%
- parafilm
- plastic sedimentation cylinder (1L)
- thermometer
- marking pen
- amyl alcohol (w/eyedropper)
- disposable plastic gloves
- blender
- graduated cylinder (100ml)
- hydrometer
- paper bags, small
- rinse bottles
- mortar and pestle

Procedure

1. Work in groups by lab table.
2. Each lab table will process one sample of soil (either potting, fill or compost)
3. Obtain approximately 75g of your assigned soil.
4. Use the mortar and pestle to composite (mix thoroughly, removing coarse root material) the soil sample to a homogeneous mixture.

1. Pass the soil sample through a 2mm sieve.
2. Weigh both the **gravel** (the portion that does not pass through the sieve because the particles are >2.00mm) and the soil portion (the portion that did pass through the sieve because the particles are <2.0mm) of the sample. Record this data in Table 1 and on the transparency (or blackboard).
3. Prepare a dispersion as follows:
   a. Place 50g of sieved soil (the portion that passed through the 2.0mm sieve) in a blender.
   b. Add 100ml of 5% sodium hexametaphosphate solution.
   c. Add enough distilled water to bring the level of the liquid up to the 950ml or 3 1/2 cup mark.
   d. Blend for the following lengths of time depending on soil type:
      1) fill: 15 minutes
      2) compost: 10 minutes
      3) potting soil: 5 minutes
4. Transfer the dispersion to a sedimentation cylinder:
   a. Pour the dispersion from the blender into a sedimentation cylinder.

   b. Use a rinse bottle containing distilled water to wash the remnants of the dispersion from the blender into the sedimentation cylinder.
   c. Add distilled water to fill the cylinder to the 1L mark.
5. Cover the top of the cylinder with parafilm and mix the dispersion by holding your palm over the cylinder mouth and inverting repeatedly to create a suspension.
   a. If the surface of the suspension becomes covered with foam, add one drop of amyl alcohol to the surface.
6. Place the hydrometer into the cylinder and begin recording time immediately (this is time = 0 seconds).
   a. Record the hydrometer reading at time = 40 seconds, 15 minutes, 30 minutes, 45 minutes and 60 minutes.
   b. Between each hydrometer reading, carefully remove the hydrometer, rinse with distilled water, and dry it.
   c. Record your hydrometer reading in Table 1 and on the transparency (or blackboard).
   d. After final reading, remove, clean and dry the hydrometer and return it to its box.

Data Analysis

1. Transfer all data from the transparency to your Table 1.
2. Determine the mean mass of the gravel and soil portions of each soil (based on two replicates of each) and record in Table 1 and on the transparency (or blackboard).
3. Determine the mean hydrometer reading at each time interval for each soil (based on two replicates of each) and record in Table 1 and on the transparency (or blackboard).
4. Using the mean hydrometer reading for each time interval for each soil and a "blank" reading provided by your instructor, determine and record in Table 1 and on the transparency (or blackboard) the **corrected hydrometer** reading using the following formula
   a. If "blank" reading is <1.000: corrected hydrometer reading = actual hydrometer reading - (1.000 - "blank" hydrometer reading)
   b. If "blank" reading is >1.000: corrected hydrometer reading = actual hydrometer

reading + ("blank" hydrometer reading - 1.000)

c. The "blank" hydrometer reading was prepared using 900ml of distilled water and 100ml of sodium hexametaphosphate in a sedimentation cylinder with no soil.

5. Determine the % gravel and % soil for each sample based on the mean masses of the gravel and soil portions of the sample relative to the total mass. Record this information in Table 2. Use the following formulae:

% gravel = {(mass of gravel)/(mass of gravel + mass of sifted soil)} x 100

% soil = {(mass of sifted soil)/(mass of gravel + mass of sifted soil)} x 100

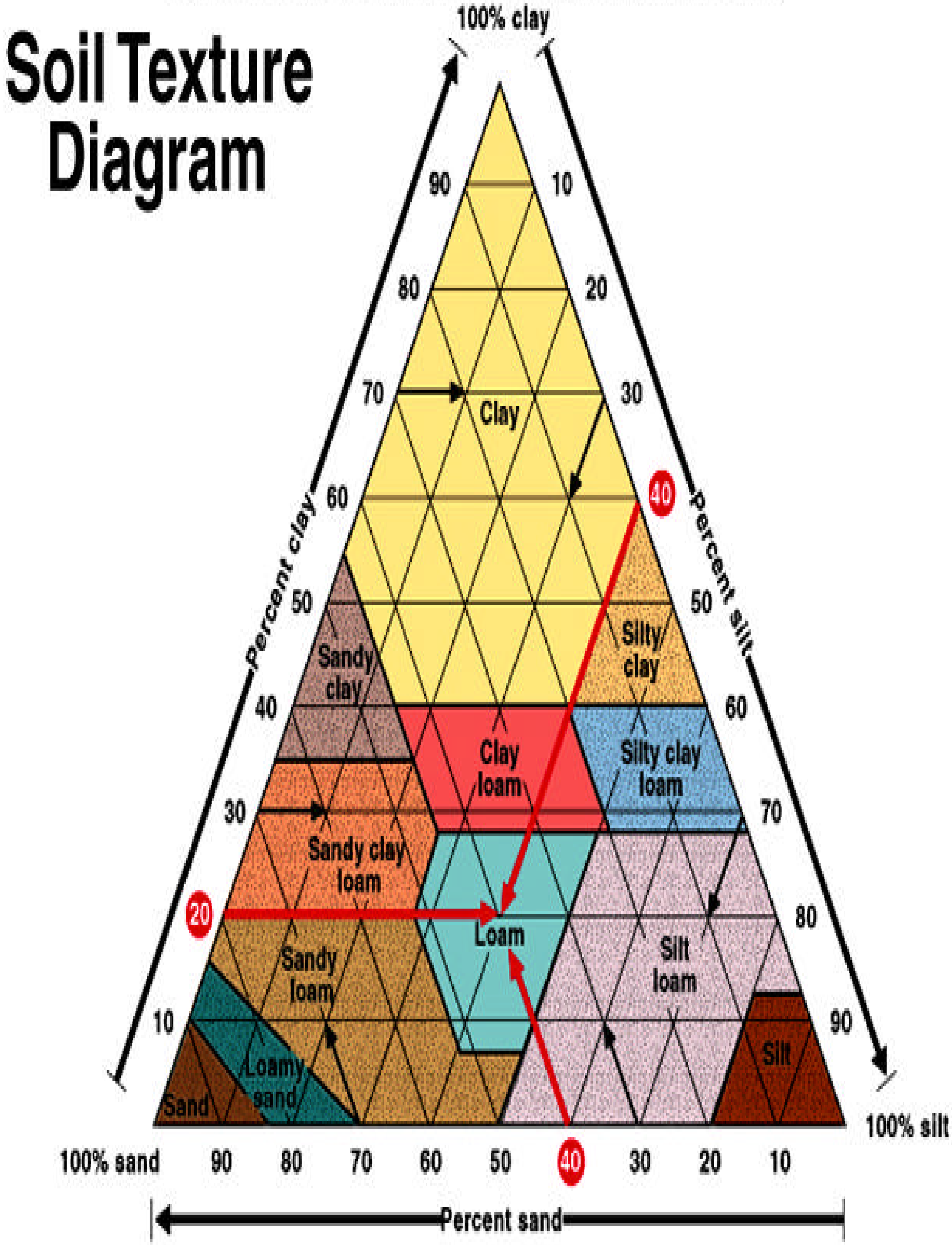
6. For the soil portion of the sample, determine the % sand, % silt, and % clay for each soil type. Record this information in Table 2. Use the following formulae:

% sand 100 - ((corrected hydrometer reading at 40 sec X 100) / 50g)

% clay = (corrected hydrometer reading at 60 min x 100) /50g

% silt = 100 – (% clay + % sand)

7. Using the soil texture diagram provided below, determine the texture category for each soil type. To use this diagram, find the % clay, % sand and % silt for each soil on the appropriate side of the triangle and then follow an adjacent line toward the center of the diagram until the three lines meet. Read the soil texture category under the intersection of the three lines. Record this information in Table 2.


Soil Texture Diagram
100% clay
Percent clay
Percent silt
Percent sand
100% sand
100% silt
90
80
70
60
50
40
30
20
10
Clay
Sandy clay
Silty clay
Clay loam
Silty clay loam
Sandy clay loam
Loam
Sandy loam
Silt loam
Loamy sand
Sand
Silt

Soil Texture Analysis LAB WRITE-UP: Submit pages 7-8

Student Name: ______________________________ Lab Date: __________

Lab Instructor: ______________________________ Lab Section: __________

Table 1. Mass (g) of gravel and sifted soil portions of sample and actual and corrected hydrometer readings at 5 time intervals for three soil types.

		Mass (g) of		Hydrometer Reading at				
Soil Type	**Lab Table**	**Gravel** (>2.0mm)	**Sifted Soil** (<2.0mm)	**40 sec**	**15 min**	**30 min**	**45 min**	**60 min**
Potting	1							
Potting	2							
	Mean ⇒							
		Corrected ⇒						
Fill	3							
Fill	4							
	Mean ⇒							
		Corrected ⇒						
Compost	5							
Compost	6							
	Mean ⇒							
		Corrected ⇒						
Blank								

Table 2. Percent gravel and soil for total sample, percent sand, clay and silt for soil portion, and soil texture category for three soil types.

	Total Sample		Soil			
Soil Type	**% Gravel**	**% Soil**	**% Sand**	**% Clay**	**% Silt**	**Texture Category**
Potting						
Fill						
Compost						

Conclusions (Questions): *For full credit, these questions should be answered thoroughly, in complete sentences, in legible handwriting.*

1. Describe any differences in the texture of the three soil types based on your observations and the results of the analysis in this exercise. Are these differences, or lack thereof, consistent with your expectations based on the sources of these soils?

2. Rank the three soil types in terms of which would provide the best to worst growing environment for plants. Include your reasons for this ranking.