NATURE OF SOILS

OBJECTIVE:

In this lab you will be introduced to the basic components of soil. You will also become more familiar with the soil quality in and around Rowan's campus.

INTRODUCTION:

What is Soil?

Before discussing the analysis of soil it may be helpful to have some understanding of its origin, the components which make up a soil, and the time involved in the soil formation process. Soil may be defined as the natural deposited unconsolidated material which covers the earth's surface whose chemical, physical, and biological properties are capable of supporting plant growth. Soil is a product of natural decomposition forces acting upon native rocks, vegetation and animal matter over an extremely long period of time, in some cases literally thousands of years. The factors involved in the formation of natural soils are: (1) living matter (plants, animals and microorganisms); (2) climate (cold, heat, snow, rainfall, and wind); (3) parent material (fineness of particle size as well as their chemical and mineralogical composition; (4) relief (slope and land form); and (5) time.

Soils, naturally, vary widely in their composition depending on their origin along with time and the natural forces involved in their formation process. Given the knowledge of the time required to develop a soil, it is of utmost importance that mankind use this natural resource in cooperation with the laws of nature to optimize soil conservation. This involves both chemical and physical conservation implemented by good management practices. Soil analysis is one aspect of soil management which aids in the conservation of this vital natural resource. Soil testing is an important management tool required for maintaining the proper chemical and microbiological balance within a soil necessary to optimize crop production without depleting nutrient reserves. Continued survival and dependence of mankind on soil, demands this balance be maintained through good management practices.

Composition of Soils

Soils are composed of three main constituents, sand, silt and clay. A fourth component, organic matter, although extremely important in the biological, chemical, and physical aspects of soil, is not generally considered in the textural makeup of mineral soils. The different components of a soil are referred to as fractions, namely, the sand, silt, clay and organic fractions. Soils which contain a high clay content are known as clayey or fine textured soils; the silt loams, loams, clay loams, and silts are medium textured soils; and the sands are called course textured soils. Each soil type has been characterized by field and laboratory tests which are based on certain common chemical and physical properties.

Since the sand, silt and clay fractions are predominant in the makeup of mineral soils, the texture of a soil expressed by the use of CLASS names, i.e., clay, sandy clay, silt loam, loamy sand, etc. is based on the relative proportions of these constituents in a given soil. The different CLASS names are shown in the textural triangle in Figure 1.

The colloidal portion (sub-microscopic particle size, large surface area) of soils consists of highly decomposed particles of clay and organic matter and account for a soil's capacity to hold nutrient elements. These minute clay and organic colloids have a net negative charge and therefore attract and hold positively charged nutrient elements such as calcium, magnesium, potassium, iron, manganese, zinc and copper. The positively charged metals are called "cations" and the capacity of a particular soil to hold such cations is called the CATION EXCHANGE CAPACITY (CEC). Hence the capacity of a soil to hold metal cations varies directly with the CEC of individual soils.

The clay content or "colloidal" fraction of soils has a pronounced effect on the nutrient holding capacity, water retention, and case of tillage. Soils high in clay have a high water retention which can cause tillage delays during wet periods. In contrast clay soils become very hard and difficult to till during dry periods. Clay soils as such are not very plyable as compared with soils which have a low clay content, namely the silt loams, loamy sands, etc. The latter soil types are also much easier worked through various tillage operations.

The clay fraction, however, performs a very useful function in soils and should be considered a complimentary component of the soil. In addition to enhancing the nutrient and water holding capacity of soils, clay acts as a binding agent in the soil, thereby, bringing about a sort of stability in the soil. Without this "binding" agent, many sandy soils would have very limited agricultural value. Since the clay fraction accounts for much of the chemical reactivity in soils, it is beneficial in its effects on texture, structure, and consequently fertility status of a soil. An "ideal" soil is generally defined as a soil composed of a mixture of sand, silt and clay; all of which have their unique effect on the chemical or physical aspects of the soil.

MACRONUTRIENTS Elements required in large quantities

The MAJOR essential nutrient elements supplied through the soil are nitrogen (N), phosphorus (P), and potassium (K). The nutrients absorbed from the soil by plants are supplied by several means. These include minerals released from the decomposition of native rocks, decomposition of organic matter, the placement of soil from flood waters, application of limestone and commercial fertilizer materials, and the use of animal or plant manures.

Nitrogen

Nitrogen is a unique element in that it composes 80% of the earth's atmosphere. Plants are literally submerged in an ocean of nitrogen, most of which reap no benefit because they cannot utilize this form of "free" nitrogen. However, a relatively large group of plants, the legumes, have the capability of converting atmospheric nitrogen into a form which can be utilized by the plant. Nitrogen fixation by legumes is conducted through a symbiotic association between the plant root and Rhizobium bacteria in the soil. The site where the nitrogen capturing process occurs is in the visible nodules formed on the plant roots. Some of the most common legumes are peanuts, soy beans, lespedeza, alfalfa, and clover. The most common sources of nitrogen for non-legumes is through the decomposition of organic matter and application of commercial nitrogen fertilizers.

With the exception of carbon, hydrogen and oxygen, nitrogen is the most prevalent nutrient element in the makeup of plants. It is a major constituent of essential compounds such as amino acids, nucleic acids, enzymes, and many vitamins. In fact, nitrogen is involved in almost all the biochemical processes which compose and sustain plant and animal life.

Nitrogen is a component of the chlorophyll (green color) in plants, thus giving plants the rich green color characteristic of a healthy plant. Nitrogen stimulates the utilization of phosphorus, potassium and other essential nutrient elements.

Nitrogen is truly an "indispensable" nutrient element but like many other production items, it must be utilized properly to reap its maximum benefit. However, areas of high nitrogen content can be harmful to humans and animals. Nitrates are the main ingredient in fertilizers. Soil Bacteria reduces nitr**a**tes into nitr**i**tes. Nitrites in excess are dangerous.

Phosphorus

Phosphorus is necessary for the hardy growth of the plant and activity of the cells. It encourages root development, and by hastening the maturity of the plant, it increases the ratio of grain to straw, as well as the total yield. It plays an important part in increasing the palatability of plants and stimulates the formation of fats, convertible starches and healthy seed. By stimulating rapid cell development in the plant, phosphorus naturally increases the resistance to disease. Life, either plant or animal, cannot exist without phosphorus, and of course, the soil is the chief source of this constituent. A lack of phosphorus, therefore, not only retards growth but also lowers the tone and vigor of both plant and animal. Animals secure their phosphorus indirectly by utilizing plants for food, while the plants, themselves, secure the phosphorus directly from the soil.Soil, as a rule, contains less than 0.1% of total phosphorus (available and unavailable).

The phosphorus content in many soils is not only low, but is often present in forms which are not available for effective plant uptake. In acid soils, particularly, phosphorus may be converted into iron and/or aluminum phosphates both of which have relatively lower plant availability. On the other hand, calcium phosphate is more available; therefore, it is desirable to apply phosphates to soils which are properly limed and show slightly acid reaction. An excess of phosphorus does not cause the harmful effects of excessive nitrogen and has an important balancing effect upon the plant.

Potassium (K+)

Potassium (K+3 is a positively charged basic metal cation whose total content in most mineral soils, except sandy natured soils, is greater than most other major nutrient elements. The average potassium content of the earth's surface is estimated at 2.3 percent, most of which is not readily available to plants because it is either bound in primary minerals or is "fixed" in the inter layers of clay minerals (illite, vermiculite and other expanding type clay minerals).

Since clay soils develop from the decomposition of potassium - rich primary minerals (feldspars and micas), it follows that soils high in clay content usually have a relatively high potassium content. Soil potassium can be divided into three components; interlayer potassium (trapped between clay layers and relatively unavailable to plants), exchangeable potassium absorbed on the surface of soil colloids, and potassium present in the soil solution. As potassium in the soil solution is diminished by plant uptake it is replenished by exchangeable potassium from soil colloids. Potassium "fixed" in the interlayers of clay minerals also contributes to the soil potassium supply even though it is not considered as "readily available". Depending on the type of clay mineral and its resistance to weathering actions, the potassium supply may or may not be adequate for maximum crop production. Soils which are predominantly sand with little or no clay have extremely low levels of native potassium and are subject to sever leaching.

Potassium is not a component of the structural makeup of plants, yet it plays a vital role in the physiological and biochemical functions of plants. The exact function of potassium in plants is not clearly understood, but many beneficial factors implicating the involvement and necessity of potassium in plant nutrition have been demonstrated. Some of these factors are: it enhances disease resistance by strengthening stalks and stems; activates various enzyme systems within plants, contributes to a thicker cuticle (waxy layer) which guards against disease and water loss; controls the turgor pressure within plants to prevent wilting; and is involved in production of amino acids (the building blocks for protein), chlorophyll formation (green color), starch formation and sugar transport from leaves to roots. In short, potassium is an essential element for all living organisms, both plant and animal.

SOIL SAMPLING METHOD

Procedure:

1. Holding the tube in a vertical position, force it into the soil approximately six to nine inches. Leave about one inch of the cutaway portion of the tube showing above the surface of the soil. Deeper penetration will compress the soil in the tube, making it difficult to remove.

2. Twist the tube back and forth to sever the core.

3. Continuing to twist the tube back and forth with a rapid motion, lean the tube toward you with the cutaway portion facing up and slowly withdraw the tube from the soil. The twisting motion will insure that the tube is withdrawn without breaking soil or turf, resulting in a perfect soil sample. The wetter the soil, the more carefully these instructions must be followed.

4. Remove the soil sample through the cutaway portion of the tube. When soil tests are to be performed on sample from a particular depth (e.g., six to eight inches), simply measure downward from the top of the soil core to locate soil for the desired depth. Use a clean utensil to dislodge soil remaining in the tip of the sampler.

SOIL TEXTURE TEST

Procedure:

1. Work in table groups for this. Determine which sample each table will be analyzing. If conditions do not permit soil samples have already been collected for you.

2. Place the three Soil Separation Tubes in the rack.

3. Add the soil sample to Soil Separation Tube "A" until it is even with line 15.

Note: Gently tap the bottom of the tube on a firm surface to pack the soil and eliminate air spaces.

4.Use the pipette to add 1 mL of Texture Dispersing Reagent (5644) to the sample in Soil Separation Tube "A". Dilute to line 45 with tap water.

5. Cap and gently shake for two minutes, making sure all the soil sample is thoroughly mixed with water.

The sample is now ready for separation. The separation is accomplished by allowing a predetermined time for each fraction to settle out of the solution. Be sure that you continue to gently shake the separation tube up to the time of the first separation.

6. Place Soil Separation Tube "A" in the rack. Allow to stand undisturbed for exactly 30 seconds.

7. Carefully pour off all the solution into Soil Separation Tube "B". Return Tube "A" to the rack. Allow Tube "B" to stand undisturbed for 30 minutes.

8. Carefully pour off the solution from Soil Separation Tube "B" into Soil Separation Tube "C". Use one of the larger conical tubes with the red stripe for tube “C”. Return Tube `'B" to the rack. Place your tube “C” in a holder and label it. Allow the sample to sit undisturbed for 24 hrs or longer if your class does not meet tomorrow.

9. Add 1 mL of Soil Flocculation Reagent (5643) to Soil Separation Tube "C". Cap and gently shake for one minute.

10. Place the Soil Separation Tube "C" in the rack and allow to stand until all the clay in suspension settles. Due to the colloidal nature of clay in solution and its tendency to swell and form a gel, the portion of clay remaining in tube "C" is not used to determine the clay fraction present in the soil. The clay fraction is calculated by adding the sand and silt fractions and subtracting this total from the initial volume of soil used for the separation.

Example:

Tube “A” Sand	2	Initial Volume	15
Tube “B” Silt	+8	Total “A” + “B”	-10
Total “A” + “B”	10	Clay	5

11. Read Soil Separation Tube “A” at the top of the soil level. To calculate percentage of sand in the soil, divide the reading by 15. Multiply by 100, this will yield percent of sand.

12. Read Soil Separation Tube “B” at the top of the soil level. To calculate percentage of silt in the soil, divide the reading by 15. Multiply by 100, this will yield percent of silt.

Example:

Soil Separation Tube “A” reads 2
Soil Separation Tube “B” reads 8

$$\text{Percent Sand} = \frac{\text{Reading “A”}}{\text{Total Volume}} \times 100 = \frac{2}{15} \times 100 = 13\%$$

$$\text{Percent Silt} = \frac{\text{Reading “B”}}{\text{Total Volume}} \times 100 = \frac{8}{15} \times 100 = 53\%$$

$$\text{Percent Clay} = \frac{\text{Calculated Volume}}{\text{Total Volume}} \times 100 = \frac{5}{15} \times 100 = 33\%$$

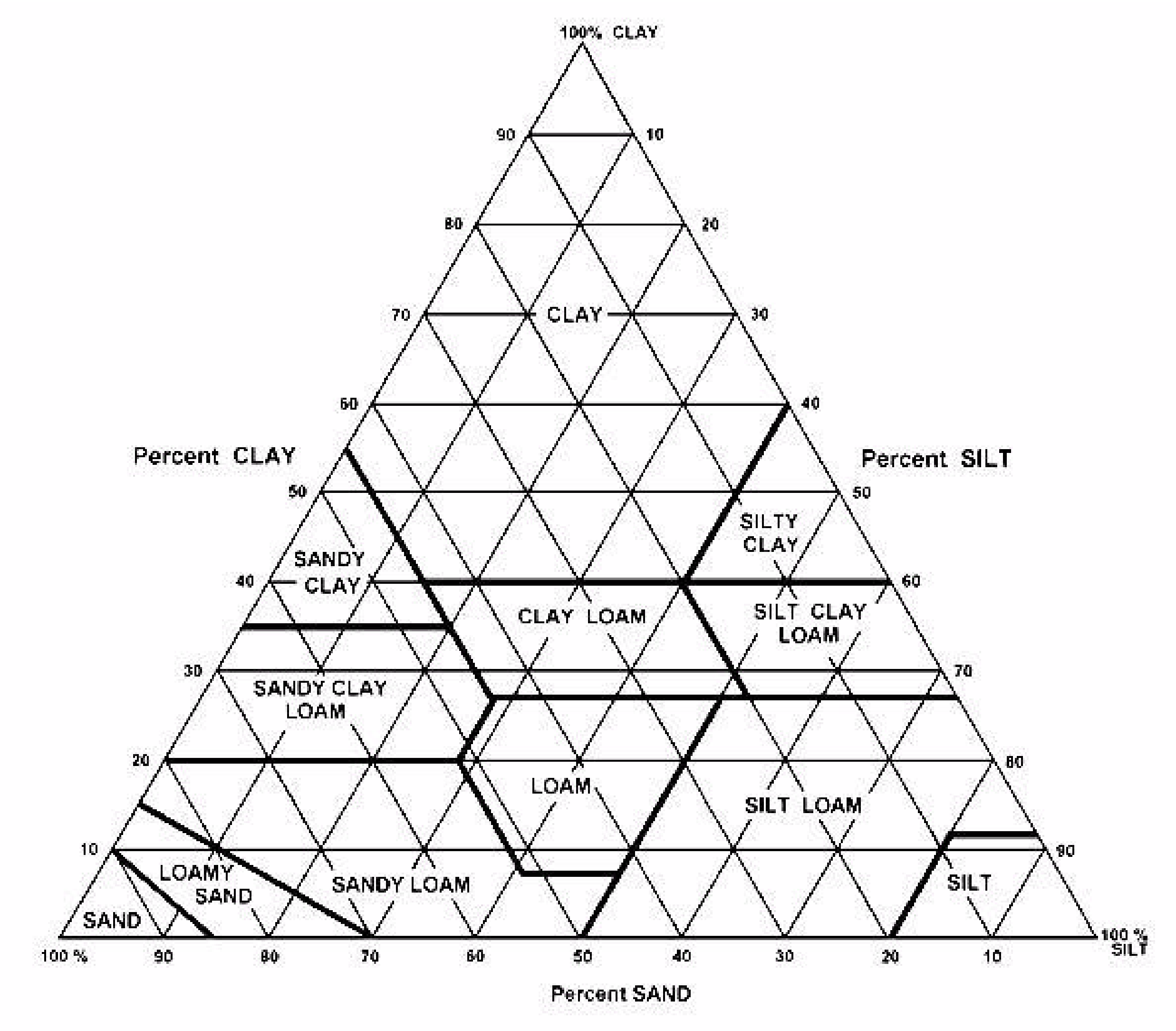
13. Record your results on the Soil Analysis Report Form found at the end of this lab.

Since the scientific basis of the test is the particle size and its mass, as related to its settling time when dispersed in solution, the table below is included for reference.

Soil Particle	**Diameter in mm**
Very Course Sand	2.0 - 1.0
Course Sand	1.0 - 0.5
Medium Sand	0.5 - 0.25
Fine Sand	0.25 - 0.10
Very Fine Sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	Less than 0.002

Interpretation of Soil Texture Data:

Reviewing your numbers that you obtained by performing the Soil Texture test, you can determine general soil texture. Sandy soil is described as soil that contains 85% or more sand, the percentage of silt plus 1.5 times the percentage obtained from clay shall not exceed 15. Silt soil is described as soil material that contains 80% or more silt and less than 12 % clay. Clay soil is described as soil material that contains 40% or more clay, less than 45% sand and less than 40% silt. You can use the texture triangle below to better understand this concept.



Color, Odor, pH, Nitrogen, Phosphorus and Potassium Analysis

Using the soil kits provided, determine the amounts of nitrogen, phosphorus and potassium of your tables sample. Use descriptive words to state your soil characteristics such as odor and color. Also state any unique observations you may find regarding your sample. Record your results on the Soil Analysis Report Form found at the end of this lab.

Soil Analysis Report Form

Sample your table is analyzing_________________________________.   Date soil was analyzed_____ Clay – %

Source or Sample Number	Characteristics		Analysis				Classification		
	Color	Odor	pH	Nitrogen	Phosphorus	Potassium	Sand Gravel %	Silt %	

Additional observations and notes:

Laboratory Questions

Student____________________ **Section_________________**

Date______________________

1) What would be the importance of a farmer knowing the pH of his soil?

2) What were your pH results for the sports fields?

3) Plants are grouped according to what pH is optimal for their growth. Plants in group A prefer a soil pH between 6.0 and 8.0. Plants in group B will grow best at a pH between 5.0 and 5.9. Group C plants do best at a pH between 4.0 and 4.9. Knowing this what group of plants will grow best in the sports fields.

4) Why was potting soil used?

5) What was unique about the potting soil results?

6) Using the attached table, how much hydrated lime in pounds must be added per square yard if you were to plant a Group A plant in the sports fields?

7) What did you find most interesting about the soils you tested?