Chapter 4

Physical Analysis of Soil

4.1 Collection and Preservation of Soil

(1) Composite Soil Sample

Soil samples are collected from a number of sites (cores/furrow slices) of a soil unit (8-10 or 20-30 sites depending on the area of the soil unit). The samples are thoroughly mixed. This mixture sample is termed composite soil sample. It represents the properties of the soil unit. Its analytical value is equivalent to the mean analytical value of the individual sites (i.e. cores or furrow slices).

(2) Collection

- Core or furrow-slices should have the uniform volume.
- Cores or furrow-slices should be taken at random or in a zigzag or criss-cross manner.
- The cores or furrow-slices should not be positioned on the rows or on the crop hills.
- Sufficient numbers of cores or furrow-slices are to be taken throughout the entire soil.

(3) Preparation

Drying: The soil samples are air dried under shade at room temperature. On drying the ferrous iron (Fe^{2+}) oxidize to ferric iron (Fe^{3+}), exchangeable K content increases in some soils (May be increased more than two folds) and decreases in some soils high in exchangeable K and to some extent hydrogen ion activity (i.e. soil pH) changes. Hence, iron (Ferrous), potassium, soil pH etc.

should be determined on field moist soils.

Grinding: The soil samples are grinded by wooden mortar, roller, motorized grinder etc. to break the soil aggregates. Care should be taken so that primary sand and gravel particles are not crushed.

Mixing: The grinded soil samples are spread uniformly over a piece of polythene paper or cloth (size 2ft × 2ft) or as required.

(4) Steps for Mixing Soil Samples

1. The corner (1) is grasped and pulled diagonally across the sample slowly so that the soil particles roll over towards the opposite corner no (3). The corner no (1) is pulled back to its original position.
2. The corner no (3) is grasped and pulled diagonally across the sample slowly so that the soil particles roll over towards the opposite corner no (1). The corner no (3) is pulled back to its original position.
3. Thus a rod or ribbon of soil extending from corner no (2) to (4) if formed. Following the same method, the other two corners (2 and 4) are pulled. The whole process is repeated at least five times.

Sieving: Sieves of 20 and 80 meshe sized made of brass or nylon possessing round hole are used. Fine sieve (i.e. 80 meshes) is used for determination of oxidizable organic carbon and elements. Coarse sieve (i.e. 20 meshes) is used for determination of soil pH and electrical conductivity. The entire soil volume should pass through the sieve. Sieving only a fraction of the sample volume increases the concentration of elements in the sample.

Storage: The prepared soil sample should be kept in tightly sealed dry polythene jar or poly packet with label. The sample should be kept away from laboratory fumes and ammonia gas.

4.2 Moisture Content of Soil (Gravimetric Method)

(1) Principle

Even after drying, the soil retains variable quantities of moisture. This determination provides a means for comparing the analytical values of samples with different moisture contents on moisture free basis.

(2) How to Express Moisture

Soil moisture is normally expressed as percentage on weight basis (g of water per 100g of oven dry soil). It can, however, be expressed on volume basis.

Moisture on dry weight basis $M_w = Wm/Ws \times 100$

Moisture on volume basis $Mv = Vm/Vs \times 100$

Where, Wm = Weight of moisture box in g

Ws = Weight of oven dry soil

Vm = Volume of moisture in cubic cm

Vs = Volume of soil in cubic cm

(3) Materials Required

Aluminium moisture box with lid.

1. Physical balance with weight box.
2. Dessication with dessicant viz. Anhydrous or fused $CaCl_2$.
3. Oven with thermometer 0-110^{0}C.

(4) Procedure

- Take weight of empty moisture box with lid.
- Place about 50 to 70g of soil and weigh (upto 2nd decimal place).
- Dry the soil for 24 hours at 105^{0}C. This can be done in 2 or 3 stages of 8 to 12 hours each.
- Cover the box with lid.
- Cool it in dessicator.
- Weigh it.
- Repeat the above procedure till the consecutive weights are constant.

(5) Calculation

Weight of empty box with lid = Xg

Weight of box + lid + moist or air dry soil = Yg

Weight of box + lid + oven dry soil = Zg

Thus, weighing water loss during drying = (Y-Z)g

Weight of oven dry soil = (Z-X)g

Percentage moisture by dry weight = $(Y-Z)/(Z-X) \times 100$

Percentage moisture by volume = (Y-Z)/(Z-X) × 100 × Db

Here, Db = Bulk density

Or

$$\text{Percentage moisture by volume} = \frac{\text{Moisture volume in cm}^3,\ \ (Y-Z)\text{cm}^3}{\text{Soil volume in cm}^3\ (Z-X)\text{cm}^3}$$

4.3 Bulk Density of Soil (Core Tube Method)

(1) The Bulk Density

The bulk density (also known as apparent density) is defined as the mass per unit volume which include volume (space) occupied by solid as well as pore spaces. This is expressed as:

Bulk density (Bd) = Mass (w) in g /Volume (V) in cc

The Bd is influenced by a variety of factors such as particle size and distribution, pore space, organic matter content, depth of soil and mechanical manipulation like tillage, plaughing, compaction etc. Increase in clay and organic matter content decrease the bulk density. The bulk density of the soil generally increases with depth which is due to low organic matter content and compaction resulting from overburden pressure.

(2) Significance of Bulk Density

Bulk density is used in estimating porosity, void ratio, weight of the furrow slice (0-15cm) and converting soil moisture from weight to volume basis.

(3) Materials Required

(i) Balance
(ii) Weight box
(iii) Moisture box
(iv) Core tube with hummer
(v) Vernier caliper
(vi) Oven
(vii) knife
(viii) Dessicators

(4) Procedure

- Measure accurately the length and diameter of the core tube with the help of vernier caliper.
- Select a representative area in the field, clean the surface litter, if any and press the core tube vertically into the soil by hand; place the wooden block and press further by steady hammering till the core sampler is driven down to the surface of the soil, filling it completely.
- Remove the soil from outside the core tube to facilitate easy withdrawal of the tube along with the core from the field.
- Put your palm at the bottom of the core tube while withdrawing it from the field in order to check falling of soil from tube.
- Remove the excess soil sticking to the core tube with the help of a knife.
- Remove the soil from the core tube and weigh it.
- Take a homogenous sample of core soil, say 20-30g in a weighed moisture box.
- Weigh the moisture box and place it in an oven for drying at 105^0C to constant weight. (Normally this may take 24 hours)
- Take out the moisture box and determine the percent moisture content in the soil.
- Calculate the moisture content for the entire core.
- Subtract the moisture content from the original weight of the core and get the weight of the dry core.

(5) Calculation

Length of the core tube = h (cm)

Diameter of the core tube = D(cm)

Weight of the dry core = W(g)

Thus, volume of the core tube = $\Pi\ (D/2)^2h$ in cc

Bulk density (Bd) = $W/\ \Pi(D/2)^2h$ = g/cc

(6) Precautions

- Do not take soil core sample in very wet or dry soil condition.
- Place a block of wood over the core while hammering.
- Use metal core tube to reduce the error arising due to compression of soil

during sampling.

- Weigh immediately after taking the core sample.

4.4 Particle or Real Density of Soil

(1) Particle Density

Particle density refers to the actual density of soil solids. It is defined as the mass per unit volume of soil solids only. Particle density of soil is expresses in g/cc. Since the volume is exclusive of poor spaces, the volume of particle density is higher than that of bulk density.

(2) Factors Affecting Particle Density

Particle density of most ranges between the narrow limits of 2.50 to 2.75 g/cc with an average value around 2.60 g/cc. This is because most mineral particle are quartz, feldspars and other silicates whose densities also vary within the same limits. However, particle density of soil differs from the usual range due to presence of large amounts of organic matter and heavy minerals. Unlike bulk density, particle density of a soil is not altered by mechanical manipulation.

(3) Principle

Particle density requires the measurement of two variables i.e. mass and volume of soil. Mass is determined by weighing oven dry soil. Volume of soil is determined by the volume of water displaced when soil is immersed therein. The accuracy of method depends upon how closely the volume of displaced water approaches that of the true volume of soil solids.

(4) Materials Required

(i) Pychnometer (specific gravity bottle)

(ii) Analytical balance and weight box

(iii) Pipette

(iv) Blotter/ordinary filter paper/piece of clean cloth

(5) Procedure

- Weigh a clean dry pycnometer with stopper on.
- Transfer 10g of oven dry soil into the pycnometer.

- Fill the pycnometer to about half its volume with water using a pipette, washing into the flask any soil particles sticking inside the neck. Allow enough time for the water to completely soak into the soil.
- Remove the entrapped air by filling the bottle with distilled water to the brim.
- Insert the stopper and wipe out the outer surface of the pycnometer with a blotter to remove water adhering to it and weigh the pycnometer, record this weight.
- Empty the pycnometer, fill it again with distilled water replace the stopper, wipe out water adhering on the outside with a blotter, weighs the pycnometer and record this weight.

(6) Calculation

Weight of ovendry soil =W= 10g

Weight of Pycnometer with soil and water $=W_1$g

Weight of Pycnometer filled with water alone $=W_2$g

Thus particle density (Pd) = Wt of oven dry soil/volume of oven dry soil

$= 10g/W_2+10g-W_1) \times$ water density (g/cc)

Here, volume of oven dry soil = Volume of displaced water

$= (W_2 + 10g - W_1) \times$ water density

(7) Precaution

- Take organic debris free soil.
- Use boiled and cooled distilled water/rain water.
- Ensure the removal of all entrapped air (bubbles) from the soil submerged in water.

4.5 Pore Space or Porosity of Soil

(1) Introduction

Pore space refers to the portion of soil volume not occupied by the solid particles. It is filled with air, water or both. The amount of pore space in a soil is expressed as a percentage of the total volume.

Several important soil and plant processes such as retention and movement of water in soil, get exchanged between the soil and the atmosphere, solute movement and proliferation and penetration of roots depend on the amount and size distribution of pores.

In general two types of pores–micro and macro pores are recognized. Generally, the micropores hold water while air is held in macropores. In order to maintain a favourable air-water relationship for plant growth, there should not only be sufficient total pore space but also a proper balance between the two kinds of pores. In an ideal soil, total pore space should be more or less equally distributed between two types of pores.

(2) Materials Required

All materials required for bulk density and particle density are necessary.

(3) Procedure

Determine bulk density by bulk density procedure and particle density by particle density procedure.

(4) Calculation

Particle density of soil (g/cc) =Pd

Bulk density of soil (g/cc) = Bd

Therefore, Percent pore space = $(1\text{-}Bd/Pd) \times 100$