Soil texture

Soil texture refers to the relative proportion of particles or it is the relative percentage by weight of the three soil separates viz., ***sand, silt and clay*** or simply refers to the size of soil particles.

It is often thought of as the fineness or coarseness of soil particles determined by the percentages of sand, silt, and clay in the surface layer of soil. Soil particle size is important because it affects the water-holding capacity and workability of soil.

Sand, the larger particles in a soil, can be seen with the naked eye. Soils with a high percentage of sand are infertile because they do not provide nutrients to growing plants. Sandy soils dry out quickly and are droughty.

Silt particles are between sand and clay particles in size. Until they weather to fine-sized particles, they provide few nutrients for growing plants. After rainfall, topsoil with a high percentage of silt tends to run together and forms a surface crust. Silt type soils erode very easily.

Clay, the smallest of the soil particles, holds soil nutrients, influences soil acidity, and holds more moisture than sand or silt. Clay particles are microscopic in size; their expansion and contraction depend on the amount of moisture present. In presence of water, a film of moisture separates clay particles; as the moisture evaporates and the soil becomes dry, the soil contracts and leaves cracks in the ground. Clay soils dry out slowly and become cloddy unless properly managed. The size limits of these soil particles (separates) have been established by various organizations.

Naming soil separates:

There are a number of systems of naming soil separates. And they are as follows;

(a) The American system developed by USDA

(b) The English system or British system (BSI)

(c) The International system (ISSS)

(d) European system

I) USDA: United States Department of Agriculture

Soil separates	*Diameter (mm)*
Clay	< 0.002 mm
Silt	0.002 – 0.05
Very Fine Sand	0.05 – 0.10
Fine Sand	0.10 – 0.25
Medium Sand	0.25 - 0.50
Coarse Sand	0.50 - 1.00
Very Coarse Sand	1.00 – 2.00

ii) BSI: British System

Soil separates	**Diameter (mm)**
Clay	< 0.002 mm
Fine Silt	0.002 – 0.01
Medium Silt	0.01 – 0.04

Coarse Silt	0.04 – 0.06
Fine Sand	0.06 - 0.20
Medium Sand	0.20 - 1.00
Coarse Sand	1.00 – 2.00

iii) ISSS: The International System

Soil separates	***Diameter (mm)***
Clay	< 0.002 mm
Silt	0.002 – 0.02 mm
Fine sand	0.02 – 0.2 mm
Course sand	0.2 – 2.0 mm

IV) European System

Soil separates	***Diameter (mm)***
Fine clay	< 0.0002 mm
Medium clay	0.0002 – 0.0006
Coarse clay	0.0006 – 0.002
Fine silt	0.002 - 0.006
Medium silt	0.006 - 0.02
Coarse silt	0.02 - 0.06
Fine sand	0.06 - 0.20
Medium sand	0.20 - 0.60
Coarse sand	0. 60 - 2.00

Particle Size Analysis

Sieves can be used to separate and determine the content of the relatively large particles of the sand and silt separates. Sieves, however, are unsatisfactory for the separation of the clay particles from the silt and sand. Thus hydrometer was preferred.

The hydrometer method is an empirical method that was devised for rapidly determining the content of sand, silt, and clay in a soil.

In the hydrometer method a sample (usually 50 grams) of air-dry soil is mixed with a dispersing agent ***(such as a sodium pyrophosphate solution)*** for about 12 hours to promote dispersion. Then, the soil-water suspension is placed in a metal cup with baffles on the inside, and stirred on a mixer for several minutes to bring about separation of the sand, silt, and clay particles.

The suspension is poured into a specially designed cylinder, and distilled water is added to bring the contents up to volume.

The soil particles settle in the water at a speed directly related to the square of their diameter and inversely related to the viscosity of the water.

A hand stirrer is used to suspend the soil particles thoroughly and the time is immediately noted. A specially designed hydrometer is carefully inserted into the suspension and two hydrometer readings are made.

The sand settles in about ***40 seconds*** and a hydrometer reading taken at 40 seconds determines the grams of silt and clay remaining in suspension. Subtraction of the 40-second reading from the sample weight gives the grams of sand. After about ***8 hours,*** most of the silt has settled, and a hydrometer reading taken at 8 hours determines the grams of clay in the sample.

(See Figure 3.2). The silt is calculated by difference: add the percentage of sand to the percentage of clay and subtract from 100 percent.

The following calculation example is very helpful;

PROBLEM: Calculate the percentage of ***sand, clay, and silt*** when the ***40-second*** and ***8-hour*** hydrometer readings are ***30*** and ***12***, respectively; assume a ***50*** gram soil sample is used:

$$\text{Sample weight} - \frac{\text{40-second reading}}{\text{Sample weight}} \times 100 = \quad \%\text{sand}$$

$$50\text{ g} - \frac{30\text{ g}}{50\text{ g}} \times 100 = \quad 40\%\text{ sand}$$

$$\frac{\text{8-hour reading}}{\text{sample weight}} \times 100 = \quad \%\text{ clay}$$

$$\frac{12\text{ g}}{50\text{ g}} \times 100 = 24\%\text{ clay}$$

100% - (40% + 24%) = 36% silt.

After the hydrometer readings have been obtained, the soil-water mixture can be poured over a screen to recover the entire sand fraction. After it is dried, the sand can be sieved to obtain the various sand separates.

Importance of Soil Texture.

Presence of each type of soil particles makes its contribution to the nature and properties of soil as a whole;

- Texture has good effect on management and productivity of soil. Sandy soils are of open character usually loose and friable.
- Such type of the texture is easy to handle in tillage operations.
- Sand facilitates drainage and aeration. It allows rapid evaporation and percolation.
- Sandy soils have very little water holding capacity. Such soils cannot stand drought and unsuitable for dry farming.
- Sandy soils are poor store house of plant nutrients
- Contain low organic matter
- Leaching of applied nutrients is very high.
- In sandy soil, few crops can be grown such as potato, groundnut and cucumbers.
- Clay particles play a very important role in soil fertility.
- Clayey soils are difficult to till and require much skill in handling. When moist clayey soils are exceedingly sticky and when dry, become very hard and difficult to break.
- They have fine pores, and are poor in drainage and aeration.

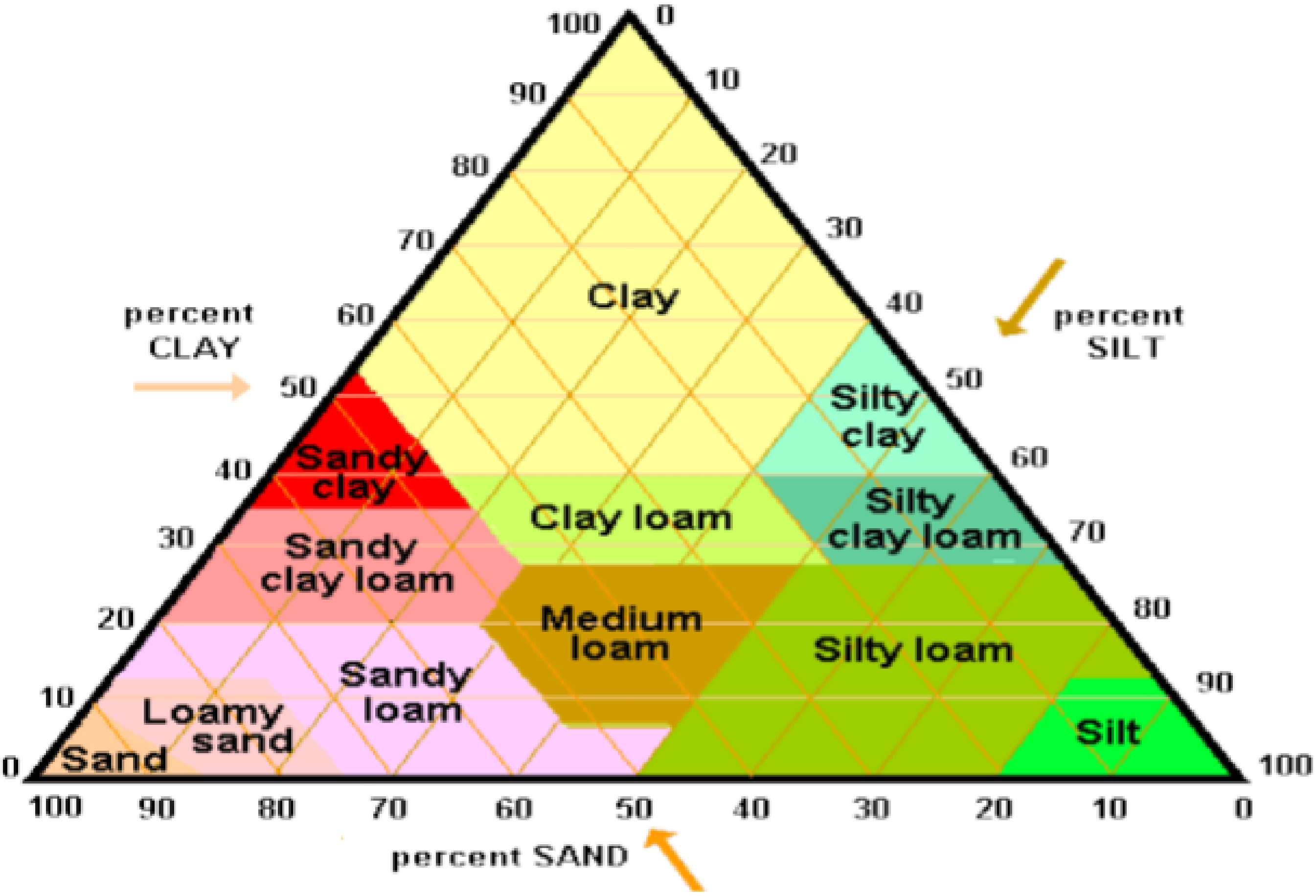

Fig 1: 12 major textural classes.

Soil Textural Classes:

Once the percentages of sand, silt, and clay have been determined, the soil can be placed in one of ***12*** major textural classes.

The texture of a soil is expressed with the use of class names. The sum of the percentages of sand, silt, and clay at any point in the triangle is ***100***. A soil containing equal amounts of sand, silt, and clay is ***a clay loam***.

Naming the soil gives an idea not only of the textural composition of a soil but also of its various properties in general.

On this basis, soils are classified into various textural classes which are following in detail;

Sand - Soil material that contain 85% or more of sand and a percentage of silt plus 1 ½ times the percentages of clay not exceeding 15.

Loamy Sand- Soil material that contains at the upper limit 85 to 90% sand, and the percentage of silt plus 1 ½ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

Sandy Loam- Soil material that contains either 20% clay or less and the percentage of silt plus twice the percentage of clay exceeds 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and between 43% and 52% sand.

Loam- Soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

Silt Loam- Soil material that contains 50% or more silt and 12 to 27% clay (or) 50 to 80 percent silt and less than 12% clay.

Silt - Soil material that contains 80% or more silt and less than 12% clay.

Sand Clay Loam – Soil material that contains 20 to 35% clay, less than 28% silt and 45% or more sand.

Clay Loam- Soil material that contains 27 to 40% clay and 20 to 45% sand.

Silty Clay Loam – Soil material that contains 27 to 40% clay and less than 20% sand.

Sandy Clay- Soil material that contains 35% or more clay and 45% or more sand.

Silty Clay- Soil material that contains 40% or more clay and 40% or more silt.

Clay- Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

Determining Texture by the Field Method

When soil scientists make a soil map, they use the field method to determine the texture of the soil horizons to distinguish between different soils.

When investigating a land-use problem, the ability to estimate soil texture on location is useful in diagnosing the problem and in formulating a solution. A small quantity of soil is moistened with water and kneaded to the consistency of putty to determine how well the soil forms casts or ribbons (plasticity). The kind of cast or ribbon formed is related to the clay content and is used to categorize soils as loams, clay loams, and clays.

If a soil is a loam, and feels very gritty or sandy, it is a sandy loam. Smooth-feeling loams are high in silt content and are called silt loams. If the sample is intermediate, it is called a loam. The same applies to the clay loams and clays. Sands are loose and incoherent and do not form ribbons.

SOIL STRUCTURE.

Soil structure is referred to as the arrangement of the soil particles. Sand, silt, and clay particles are typically arranged into secondary particles called *peds,* or *aggregates.*

Soils with good structure contain a large number of crumbs or aggregates, which indicates good tilth.

Good soil structure permits deep root penetration and a large particle area from which plants can secure nutrients.

Types of Soil Structure.

Soil peds are classified on the basis of shape. The four basic structural types are *spheroid, platelike, blocklike, and prismlike.* These shapes give rise to *granular, platy, blocky, and prismatic* types of structure. Columnar structure is prismatic-shaped peds with rounded caps.

Soil structure generally develops from material that is without structure. There are two structureless conditions, the first of which is sands that remain loose and incoherent. They are referred to as ***single grained***.

Second, materials with a significant clay content tend to be ***massive*** if they do not have a developed structure. Massive soil has no observable aggregation or no definite and orderly arrangement of natural lines of weakness. Massive soil breaks up into random shaped clods or chunks.

Note that each horizon of the soil has a different structure. This is caused by different conditions for structure formation in each horizon.

The **A** horizon has the most abundant root and small-animal activity and is subject to frequent cycles of wetting and drying. The structure tends to be ***granular.***

The **Bt** horizon has more clay, less biotic activity, and is under constant pressure because of the weight of the overlying soil. This horizon is more likely to crack markedly on drying and to develop either a ***blocky or prismatic*** *structure*.

The development of structure in the ***E*** horizon is frequently weak and the structure hard to observe. In some soils the E horizon has a weakly developed ***platy*** structure.

Here, the four basic structural types are defined in detail;

Plate-like (Platy):

In this type, the aggregates are arranged in relatively thin horizontal plates or leaflets. The horizontal axis or dimensions are larger than the vertical axis. When the units/ layers are thick they are called *platy*. When they are thin then it is l*aminar*. Platy structure is most noticeable in the surface layers of virgin soils but may be present in the subsoil. This type is inherited from the parent material, especially by the action of water or ice.

Prism-like (prismatic).

The vertical axis is more developed than horizontal, giving a pillar like shape. Vary in length from 1- 10 cm. commonly occur in sub soil horizons of Arid and Semi-arid regions. When the tops are rounded, the structure is termed as columnar when the tops are flat / plane, level and clear cut – prismatic.

Block like (blocky).

All three dimensions are about the same size. The aggregates have been reduced to blocks .Irregularly six faced with their three dimensions more or less equal. When the faces are flat and distinct and the edges are sharp angular, the structure is named as *angular blocky*. When the faces and edges are mainly rounded it is called *sub angular blocky*. These types usually are confined to the sub soil and characteristics have much to do with soil drainage, aeration and root penetration.

Spheroidal (granular).

All rounded aggregates (peds) may be placed in this category. Not exceeding an inch in diameter. These rounded complexes usually loosely arranged and readily separated. When wetted, the intervening spaces generally are not closed so readily by swelling as may be the case with a blocky structural condition. Therefore in sphere-like structure, infiltration, percolation and aeration are not affected by wetting of soil. The aggregates of this group are usually termed as *granular* which are relatively less porous. When the granules are very porous, it is termed as *crumb*.

This is specific to surface soil particularly high in organic matter/ grass land soils. Classes of Structure: Each primary structural type of soil is differentiated into 5 size classes depending upon the size of the individual peds.

Grade and Class:

Complete descriptions of soil structure include:

Type which refers to the shape of the soil aggregate e.g. granular, platy, crumb, etc.

Class refers to the size of the peds e.g. fine, medium, coarse, etc.

Grade describes how distinct and strong the peds are.

Grades indicate the degree of distinctness of the individual peds. It is determined by the stability of the aggregates. Grade of structure is influenced by the moisture content of the soil.

Grade also depends on organic matter, texture etc. Four terms commonly used to describe the grade of soil structure are:

1. ***Structureless***: There is no noticeable aggregation, such as conditions exhibited by loose sand.

2. ***Weak Structure***: Poorly formed, indistinct formation of peds, which are not durable and much un aggregated material.

3. ***Moderate structure***: Moderately well-developed peds, which are fairly durable and distinct.

4. ***Strong structure***: Very well formed peds, which are quite durable and distinct.

For naming a soil structure the sequence followed is *grade, class and type*; for example *strong coarse angular blocky, moderate thin platy, weak fine prismatic.*

The terms commonly used for the size *classes* are

1. Very fine or very thin.

2. Fine or thin.

3. Medium.

4. Coarse or thick.

5. Very coarse or very thick.

Factors Affecting Soil Structure:

The development of structure in arable soil depends on the following factors:

1. Climate

Climate has considerable influence on the degree of aggregation as well as on the type of structure. In arid regions there is very little aggregation of primary particles. In semi-arid regions, the degree of aggregation is greater.

2. Organic matter

Organic matter improves the structure of a sandy soil as well as of a clay soil. In case of a sandy soil, the sticky and slimy material produced by the decomposing organic matter and the associated microorganism cement the sand particles together to form aggregates. In case of clayey soil, it modifies the properties of clay by reducing its cohesiveness. This helps making clay more crumby.

3. Tillage

Cultivation implements break down the large clods into smaller fragments and aggregates. For obtaining good granular and crumby structure, optimum moisture content in the soil is necessary. If the moisture content is too high it will form large clods on drying. If it is too low some of the existing aggregates will be broken down.

4. Plants, Roots and Residues

Excretion of gelatinous organic compounds and exudates from roots serve as a link. Root hairs make soil particles to cling together. – Grass and cereal roots vs other roots.

Pressure exerted by the roots also held the particles together

Dehydration of soil - strains the soil due to shrinkage

- result in cracks
- lead to aggregation
- Plant tops and residues
- shade the soil
- Prevent it from extreme and sudden temperature and moisture changes and also from rain drop impedance.

Plant residues – serve as a food to microbes – which are the prime aggregate builders.

5. Animals

Among the soil fauna small animals like earthworms, moles and insects etc., that burrow in the soil are the chief agents that take part in the aggregation of finer particles.

6. Microbes

Algae, fungi, actinomycetes and fungi keep the soil particles together. Fungi and actinomycetes exert mechanical binding by mycelia, Cementation by the products of decomposition and materials synthesized by bacteria.

7. Fertilizers

Fertilizer like Sodium Nitrate destroys granulation by reducing the stability of aggregates. Few fertilizers for example, CAN help in development of good structures.

8. Wetting and drying

When a dry soil is wetted, the soil colloids swell on absorbing water. On drying, shrinkage produces strains in the soil mass gives rise to cracks, which break it up into clods and granules of various sizes.