Physical Properties of soils

Physical properties are the soil properties which depend largely on the size, shape, arrangement and mineral composition of the soil particles. Plant growth is influenced by various physical, chemical and microbial properties of soil in addition to other environmental factors. Different soil properties have different effects on plant growth. Physical properties influence the germination and emergence of young seedlings and root penetration as well as root growth in the soil.

In addition to direct effect of these soil properties on plant growth, physical properties of soil affect

1. Movement of water within the soil
2. Composition of soil air
3. Availability of plant nutrients, thus indirectly affecting plant growth

Soil physical properties must be favourable to crop growth which means that surface soil conditions must the adequate for successful emergence of crop seedlings. Sub surface soil conditions must permit adequate root growth. Important physical properties include:

1. Texture
2. Structure
3. Particle and bulk density
4. Porosity
5. Air and moisture content
6. Consistency
7. Colour
8. Temperature

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Soil Texture

Natural soils are mixtures of soil separates of intimate combinations. Soil texture may be defined as "relative proportion of various soil separates namely sand, silt and clay". Size of particles in mineral soil is not easily changed. So the proportion of each size group in a soil can not be changed easily. Hence, texture is the basic property of soil.

Soil Separates

Mineral particles of a soil are separated into various groups on the basis of their size. These groups are called soil separates. Thus, soil separates may be defined as "the individual size groups of mineral soil particles which are 2 mm or less in diameter". Soil separates are known as fine earth.

Classification of soil separates

Name of soil separates	Particle diameter (mm)
Coarse sand	2.0 – 0.2
Fine sand	0.2 – 0.02
Silt	0.02 – 0.002
Clay	< 0.002

Soil Textural Classes

Soil textural class is a grouping of soil textural units based on the relative proportion of the sand, silt and clay. It is a defined range of particle size distribution with similar behavior and management needs. The textural triangle is used to determine the soil textural name after the percentage of sand, silt ad clay is determined. There are three soil textural classes:

i) Sandy Soils: In this textural class, sand is at least 70 % and clay is ≤ 15 % by weight. Low water holding capacity, low CEC, high drainage and aeration are characteristics of these soils.

ii) Loamy Soils: Mixture of sand, silt and clay separates in equal proportions. It has good drainage, medium water holding capacity, medium CEC, nutrient supply power and retention power is medium. Loamy soils are called **"ideal soils for crop production".**

iii) Clayey soil: Must have at least 35 % clay. These are called as fine textured soils. This class is characterized by very high CEC, high capacity for water retention and plant available water content. Internal drainage is very poor.

Importance of soil texture

Knowledge of texture is important in determining the suitability of soils:

1) For production of different crops
2) Foundation of buildings
3) Construction of roads
4) Retention and transmission of water as well as soil aeration
5) Determining nutrient supplying ability of soils

Soil Structure

The term structure relates to the grouping or arrangement of primary soil particles into secondary particles or units called peds or aggregates which are separated from each other by surfaces of weakness.

Ped: An individual natural soil aggregate is called ped such as platy ped, blocky ped and prismatic ped etc.

Types of soil structure

Classification of soil structure based on the shape of the peds or aggregates and their arrangement in the profile determines various types of structure. Principal types of soil structure are platy like, block-like, prism like and sphere like structures.

a) **Plate like structure**: In this case, aggregates are arranged in relatively thin horizontal plates, leaflets or lenses. When horizontal axis is longer than vertical axis giving plate like appearance of ped, structure is called plate like.
b) **Prism like structure**: When vertical axis is longer than horizontal axis giving prism like appearance of ped, structure is called prism like. These are characterized by vertically oriented aggregates or pillars that are longer than wide (prism).
c) **Block like structure**: In this case, aggregates are reduced to blocks, irregular six faced with their three dimensions more or less equal. When horizontal and vertical axes are similar in length giving round or block like appearance of ped, structure is called block like.
d) **Sphere like structure:** Soils with mostly spherical or rounded aggregates are placed in this category. This type of structure is the best for crop production.

Importance of soil structure

- Soils with good physical condition are important to good yield.
- The rate of water infiltration, water holding capacity, heat transfer, aeration, porosity, and root development are greatly influenced by soil structure.
- Aggregated soil is generally the most desirable condition for plant growth, particularly in critical early stages of germination and seedling establishment.
- Erodibility of soils decreases as aggregates stability increases.

Bulk Density

It is defined as the mass of dry soil solids per unit bulk volume. Bulk volume means the volume of soil particles plus pore space. So the density for a volume of soil as it exists naturally is called bulk density. Bulk density of soil ranges from 1.0 to 1.8 Mg/m^3. Ideal bulk density of a soil is 1.33 Mg/m^3. The value is expressed in Mg/m^3 or g/cm^3 or kg/m^3.

$$\text{Bulk density} = \frac{\text{Mass of oven dry soil}}{\text{Total volume of soil including pore spaces}}$$

Importance of Bulk density

- It is used to estimate the mass of a volume of a soil too large to weigh. (average wt of soil for a hectare or acre = soil volume × bulk density)
- It is used to convert water percentage by weight to content by volume.
- It is also used for calculating porosity when particle density is known.
- It can indicate the differences in compaction of a given soil resulting from heavy tillage equipment.
- Plant roots are hindered by soils high in bulk density.

Particle Density

It is defined as mass of dry soil for unit volume of soil solid. Particle density of mineral soils with small percentage of organic matter is about 2.65 Mg/m^3. The value is expressed in Mg/m^3 or g/cm^3 or kg/m^3

$$\text{Particle density} = \frac{\text{Mass of oven dry soil}}{\text{Total volume of soil excluding pore spaces}}$$

Porosity

The pore space or porosity of soil is that portion of total soil volume which is not occupied by solid particles but occupied by air or water. It is normally expressed in percentage. It may also be expressed as pore volume per unit volume of soil (cm^3/cm^3).

Types of Pores: Three types of soil pores are present on the basis of size.

1) Macro pores
2) Meso pores
3) Micro pores

Importance of porosity

- Micro pores are generally filled with water in a moist soil and there is slow movement of air and water into or out of the soil.
- Macro pores allow ready movement of water and air. Thus, movement of water and air is rapid in sandy soils due to more macro pores even though total porosity is relatively lower.

Soil Consistency

Soil consistency is a term used to describe the resistance of soil material to crushing (Rupture) and its ability to be molded or changed in shape. So it indicates the degree of cohesion or adhesion of the soil mass at various moisture levels. Soil consistency is described at three moisture levels; wet, moist and dry.

Importance: Soil consistency has importance for practical use of soils, particularly soil tillage and compaction by farm machinery. It is also useful in estimating the soil's flow or support strength under applied force (building weight, vibration of road traffic).

Soil Colour

Soil colour is one of the most useful and important character5istic for soil identification. It may vary from place to place and from horizon to horizon within the soil profile. Soil is described by its colour such as black, yellow and red soils. Soil colour may be inherited from parent material but often, it is the result of different soil forming processes. Soil colour is composed of three variables called hue, value and chroma. Soil colour is determined by comparing it with Munsell's colour chart.

Hue: It is dominant spectral or rainbow colour and is related to the dominant wavelength of light.

Value: It is the measurement of degree of whiteness or darkness of the colour and is related to the total amount of light reflected.

Chroma: It is the measurement of relative purity or strength of spectral colour. It increases as greyness decreases.

Importance of soil colour

1. Colour is one of the most useful and important characteristics for indentification and classification of soils.
2. It often helps to distinguish different horizons of a soil profile.
3. Soil colour is an indicator of soil moisture regimes. e.g., when a dry soil becomes moist its colour becomes darker.
4. Productivity of s soil can be judged from its colour. Generally darker a soil, higher is tis productivity and light colour is an indication of less productivity.

Soil Temperature

Temperature is the measure of hotness or coldness of a body. Intensity of heat in the soil is called soil temperature and it is expressed in °C, °F or °K. Soil surface is heated by absorption of solar radiations and absorbed heat is conducted down the depth of soil. At any time temperature within a soil varies from layer to layer. Variation in soil temperature is the maximum in the upper most soil layer and it decreases with depth.

Factors affecting soil temperature: Important factors affecting soil temperature are as under:

1. **Mineral composition of soil**: If a soil is sandy, it will be good conductor of heat. Thus, sandy soils will have more temperature than clayey soils.
2. **Water content**: If soil is high in water content, it will resist heat penetration and hence temperature of wet soil will be less as compared to dry soil.
3. **Soil colour**: Dark colour soils usually absorb more heat than light colour soils.

4. **Organic matter content**: Soils rich in organic matter are dark in colour. These soils absorb more heat and become relatively hotter than soils which are poor in organic matter content.

5. **Surface roughness**: A soil with rough surface will absorb more solar radiation and usually be warmer than a soil with smooth surface.

Importance of soil temperature: Soil temperature is very important for plant growth due to:

1. Soil temperature controls the intensity of all physical, chemical and biological processes occurring in the soil.
2. Soil temperature determines the rate and direction of physical processes.
3. Decomposition of soil organic meter is totally dependent on temperature.
4. All microbial activity in the soil controlled by temperature and is very much restricted below 10 °C.
5. Seed germination is highly affected by soil temperature and these effects vary with crops.
6. Soil temperature also affects the root growth and activity and ultimately plays its role in determining the crop yield.
7. Soil weathering is also dependent on temperature.

Soil Aeration

It is the process by which air in the soil is replaced by air from the atmosphere (gaseous exchange). The rate of aeration depends mainly on the volume and continuity of air-filled pores within the soil.

Composition of soil and atmospheric air

In a well-aerated soil, the soil air is very similar in composition to the atmospheric air above the soil. However, poorly aerated soils generally contain a much higher percentage of CO_2 and a correspondingly lower percentage of O_2 than the atmospheric air above the soil. Atmospheric air has about the following composition of the important gases in soils:

Dinitrogen (N_2) = 79.0%, oxygen (O_2) = 20.93%

Carbon dioxide (CO_2) = 0.03%

Water vapor or relative humidity = 20-90%. Soil air is different from atmospheric air as it has lower oxygen content (~~14-20%~~) and relative humidity (95-99%). Plant roots and micro-organisms take oxygen from soil air and release carbon dioxide into it.

Significance

The oxygen contents are the most important for plant growth as are needed for respiration (necessary for life and growth). Except rice, most plants need oxygen to be present in the pores where roots are growing. So the rate at which soil oxygen exchanges with atmospheric oxygen ODR (oxygen diffusion rate) is important.

Organic matter decomposition by soil micro organisms also uses oxygen in soils, when there is little oxygen in soil anaerobes start working and anaerobic micro organisms produce gases (other than CO_2) such as Nitrous oxide (N_2O), methane CH_4) and H_2S. Theses gases are harmful and are source of pollution.