BULK DENSITY AND PARTICLE DENSITY

Density of soil

Density of a substance is expresses as weight (mass) per unit volume.

Density = Mass / Volume

Soil density is expressed in two well accepted concepts:

1. Particle density or Absolute specific gravity
2. Bulk density or Apparent specific gravity

Unit of expression

In the metric system, particle density is expressed in terms of mega grams per cubic meter (Mg m^{-3}) (1 Mg = 1000 kg or 1 tonne). Thus if 1 m^3 of soil solids weighs 2.6 Mg, the particle density is 2.6 Mg m^{-3} (since 1 Mg =1 million grams and 1 m^{-3} =1 million cubic centimeters) particle density can also be expressed as 2.6 g cm^{-3}.

Particle Density (Absolute specific gravity)

The weight per unit volume of the solid portion of soil is called particle density. Generally particle density of normal soils is 2.65 grams per cubic centimeter. The particle density is higher if large amount of heavy minerals such as magnetite, limonite and hematite are present in the soil. With increase in organic matter of the soil the particle density decreases. Particle density is also termed as true density.

Particle density of different soil textural classes

Textural classes	**Particle density(g cc^{-1})**
Coarse sand	2.655
Fine sand	2.659
Silt	2.798
Clay	2.837

Bulk Density (or) Apparent specific gravity

The weight of a unit volume of soil inclusive of pore spaces is called bulk density. The bulk density of a soil is always smaller than its particle density. The bulk density of normal soils range between 1.00 to 1.6 g cc^{-1} with an average of 1.35 g cc^{-1}. The bulk density of sandy soil is about 1.6 g cc^{-1}, whereas that of pure organic matter is about 0.5 g cc^{-1}. Bulk density normally decreases, as mineral soils become finer in texture. The bulk density decreases with increase in total pore space present in the soil and gives a good estimate of the porosity of the soil. Bulk density is of greater importance than particle density in understanding the physical behavior of the soil. Generally soils with low bulk densities have favorable physical conditions.

Bulk density of different textural classes

Textural class	Bulk density	Pore space (%)
	(g cc^{-1})	
Sandy soil	1.6	40
Loam	1.4	47
Silt loam	1.3	50
Clay	1.1	58

FACTORS AFFECTING BULK DENSITY

1. Pore space

Soils with high pore space have lower bulk densities than soils with less pore space.

Any factor that influence soil pore space will affect bulk density.

2. Texture

Fine textured surface soils like silt loams, clays and clay loams have lower bulk densities than sandy soils. This is because the fine textured soils tend to organize in porous grains. This results in high pore space and low bulk density. However, in sandy soils, the solid particles lie close together and the bulk density is higher. Also the fine textured soils have high organic matter than sandy soils.

3. Organic matter content

More the organic matter content in soil results in high pore space there by shows lower bulk density of soil and vice-versa.

Field bulk density

The bulk density of an un-disturbed soil in the field is called field bulk density.

Methods of estimation of bulk density

<u>a) Measuring cylinder method</u>

A known weight of soil (w) is taken in a graduated measuring cylinder and the volume is noted (V_1). A known volume of water (V_2) is added and the total volume of soil with water is noted (V_3). From the data, the following parameters are calculated.

Bulk density = g cc^{-1}

Pore space = $V_1 + V_2 - V_3$

Particle density = g cc^{-1}

b) Wax coating / clod method

A small undisturbed soil clod is weighed and then coated with molten wax. The volume of the clod is determined by inserting the clod into a measuring cylinder filled water (water displacement method).

c) Keen-Reczkowski cup method

A brass cylinder with perforated bottom is fitted with a filter paper and filled with air dry soil and placed in a tray containing water. The wet soil weight is noted. The expanded soil over the cup is removed and the weight of expanded soil and soil in the cup are weighed with moisture and after oven drying. From the data observed, the bulk density, particle density, pore space, volume of expansion and water holding capacity are determined.

d) Core sampler method

Core sampling cylinder with guard rings are inserted using a core sampler. The undisturbed soil in the cylinder is oven dried and weighed. From the weight of soil and volume of cylinder, the bulk density of soil is calculated. This is the true field bulk density determined in an un-disturbed soil core.

e) Penetrability test

The resistance offered by the soil to the force delivered by hand using a pin through the profile is assessed and bulk density is rated (rough estimate only).

Pin enters easily and neatly: 1 g cc^{-1} : soil is very loose

Pin enters easily with slight force : 1.2 g cc^{-1}: soil is loose

Half of the pin enters : 1.4 g cc^{-1}: moderately compact

Little part of pin enters : 1.6 g cc^{-1}: compact

Pin will not enter : 1.8 g cc^{-1}: very compact

Soil volume - weight relationship

1) **Void ratio (e)** : ratio between pores (void) and solids
2) **Porosity (N)** : ratio between pores (voids) and total volume of soil
3) **Water content (w)** : ratio between weight soil water and soil solids expressed in percentage
4) **Degree of saturation(S)** : ratio between volume of water and volume of pores (voids) expressed in percentage

5) **Specific gravity (G)** : ratio between unit weight of unit volume of soil and the weight of unit volume of water at 4ºC

6) **Bulk density (B.D.)** : ratio between dry weight of soil and the total volume of soil mass

7) **Particle density (P.D.)** : ratio between dry weight of soil and the volume of soil solids

8) **Moisture content** : ratio between weight of soil water and bulk weight of wet soil expressed in percentage (on wet weight basis) (or) ratio between weight of soil water and oven dry weight of soil expressed in percentage (on oven dry weight basis)

PORE SPACE

The pore space of a soil is the space occupied by air and water. The amount or ratio of pore space in a soil is determined by the arrangement of soil particles like sand, silt and clay. In sandy soils, the particles are arranged closely and the pore space is low. In clay soils, the particles are arranged in porous aggregates and the pore space is high. Presence of organic matter increases the pore space.

Calculating Pore Space

% Solid = (Bulk Density/ Particle Dens.) *100

% Pore Space = 100 - solids

% Pore Space = 100 - (Bulk Density/Particle Dens.*100)

Porosity = 1 – (bulk density/particle density)

Void ratio = porosity/(1-porosity)

Factors influencing pore space

Soil texture

Sandy surface soil	: 35 to 50 %
Medium to fine textured soils	: 50 to 60 %
Compact sub soils	: 25 to 30%

Crops / vegetation

Some crops like blue grass increases the porosity to 57.2 % from the original 50 %. Cropping reduces the porosity as cultivation reduces the organic matter content and hence decreases in granulation. Virgin soils have more pore space. Continuous cropping reduces pore space than intermittent cropping. More the number of crops per year, lesser will be the pore space particularly macro pores. Conservation tillage and no tillage reduces porosity than conventional tillage

Biological activity

Root penetration of higher plants, activity of animals, excreta and exudates of plants and roots, decomposition of organic matter.

Size of pores

Macro pores (non-capillary pores) : >0.05 mm

Micro pores (capillary pores) : diameter < 0.05 mm

In macro pores, air and water moves freely due to gravitation and mass flow. In micro pores, the movement of air and water is very slow and restricted to capillary movement and diffusion.

Sandy soil has more macro pores and clay soils have more micro pores. In sandy soils, water and air movement is rapid due to macro pores though the total pore space is lower. In clay soils the air and water is slower due to micro pores though the total pore space is higher. Loamy soils will have 50% porosity and have equal portion of macro and micro pores.

Specific surface of soil particles

The total surface area per unit volume of soil or per unit weight of soil is called specific surface and expressed as ($cm^2\ cm^{-3}$) or ($m^2\ g^{-1}$ soil). Specific surface of soil is an important parameter as most physical and chemical reactions in soil depends on and occur on the surface of soil particles. Clay and silt are the most reactive parts of soil and hence their surface area is also important. The smaller the particle size, the higher will be the specific surface area and hence clay will have more specific surface area than sand.

Montmorillonite clay	500 to 800 ($m^2\ g^{-1}$)
Illite clay	60 to 120 ($m^2\ g^{-1}$)
Kaolinite clay	20 to 40 ($m^2\ g^{-1}$)
Clay soil	150 to 250 ($m^2\ g^{-1}$)
Silty clay loam	120 to 150 ($m^2\ g^{-1}$)
Loam	50 to 150 ($m^2\ g^{-1}$)
Sandy loam	10 to 40 ($m^2\ g^{-1}$)
Silt soil	5 to 20 ($m^2\ g^{-1}$)

3.5 SOIL COLOUR

Colour is an optical phenomena perceived by our eyes. Human eyes can perceive the visible range of electromagnetic radiation (EMR) consisting of various colours ranging from red to blue. Combination of all colours result in white (light) and absence of all colours is perceived as black. Colour of an object is due to absorption of certain wavelengths of the visible spectrum (light) and reflection of the others. The combination of different reflected wavelengths of the EMR produce different colours.

Soil also absorbs certain wavelengths of the EMR and reflects the other. Soil colour is due to the reflection of EMR by different soil constituents like minerals, organic matter, water, salts, *etc*. Generally organic matters absorb all the colours and so black in colour. Different minerals absorb different colours. Iron oxides reflect red, brown and yellow colours. Salts reflect all the colours and hence look white. Combination of these various colours (composite) gives the soil colour. The occurrence of two or more patches of colours in soil is called 'mottling'. This is due to the presence of iron, manganese and copper in soil in patches.

Kinds of Soil colour

Soil colour is inherited from its parent material and that is referred to as lithocromic, e.g. red soils developed from red sandstone

Besides soil colour also develops during soil formation through different soil forming processes and that is referred to as acquired or pedochromic colour. e.g. red soils developed from granite gneiss or schist.

Measurement of soil colour

Soil colour is measured using Munsell colour chart (refer to practical manual for details) and expressed in terms of Hue, Value and Chroma. These three parameters are called as soil colour notations or Munsell colour notations.

Hue denotes the **D**ominant spectral colour

Value denotes the **I**ntensity of colour

Chroma denotes the **P**urity of colour

These three parameters are expressed in the following format.

Hence, 10YR 5/4 means, the Hue is 10YR, 5 is the Value and 4 is the chroma

Significance of soil colour

Soil colour influences soil temperature and moisture. It serves as an indicator for climatic condition under which a soil was developed. It also indicated the nature of the parent material on which the soil is developed.

Soil productivity is judged from the colour of the soil. Darker the colour. More is the productivity. Dark colour is due to high organic matter content. Also dark coloured soils have high clay content with high CEC. Light coloured soils have low organic matter, high sand content and hence low nutrient storage capacity. Black soils have more montmorillonite and vermiculite clays while light coloured soils have kaolinite and illite clays.

Soil colour is used as an important element of soil classification both in earlier system and in the comprehensive system of USDA soil classification.

Soil colour and temperature

Dark coloured soils absorb and retain more heat. Light coloured soils reflect most of the heat and hence remain cooler than dark coloured soils. Most of the physical, chemical reactions and biological activities are influenced by temperature and hence soil colour also influences these properties indirectly.

Factors influencing soil colour

1. **Parent material**: Quarts rich parent material produce light coloured soils. Fine grained extrusive and basic rocks produce dark coloured soils. Presence of iron and manganese containing minerals in soil impart red, brown and yellow colours.
2. **Soil moisture**: soil moisture absorbs more colour and hence moist soil will be darker than dry soils. Continuous stagnation of water results in reduced soil condition and mottling occurs in patches.
3. **Organic matter**: Organic matter absorbs colour and hence the soil looks darker.

Mixture of organic matter and iron oxides.

Very often soil contain a certain amount of organic matter and iron oxides. As a result of their existence in soil, the most common soil colour is found as brown.

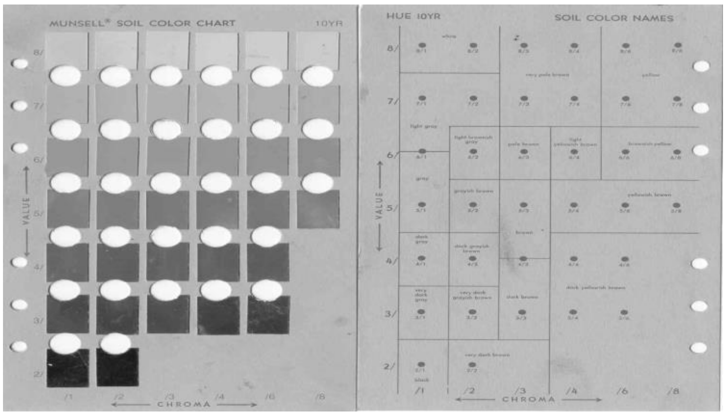
Alternate wetting and drying condition.

During monsoon period due to heavy rain the reduction of soil occurs and during dry period the oxidation of soil also takes place. Due to development of such alternating oxidation and reduction condition, the colour of soil in different horizons of the soil profile is variegated or mottled. This mottled colour is due to residual products of this process especially iron and manganese compounds.

Oxidation – reduction conditions.

When soils are waterlogged for a longer period, the permanent reduced condition will develop. The presence of ferrous compounds resulting from the reducing condition is waterlogged soils impart bluish and greenish colour.

Munsell colour chart



3.7 SOIL AIR

Soil air is a continuation of the atmospheric air. It is in constant motion from the soil pores into the atmosphere and from the atmosphere into the pore space. The circulation of air in the soil and renewal of component gases like oxygen and carbon dioxide is known as soil aeration. Soil aeration is essential for the respiration and survival of soil organisms and plant roots.

Composition of Soil Air

Soil air contains gases like nitrogen, oxygen, carbon dioxide, water vapour and others. The composition of soil air is different from atmospheric air. Soil air contains more carbon dioxide and less oxygen than atmospheric air. It also contains more water vapour than atmospheric air. The nitrogen content of soil air is almost equal to atmospheric air.

Composition of soil and atmospheric air

	Per cent by volume		
	Nitrogen	**Oxygen**	**Carbon dioxide**
Soil air	79.2	20.0	0.35
Atmospheric air	79.0	21.0	0.03

Measurement of soil aeration

Oxygen Diffusion Rate (ODR) - the rate at which O_2 in soil air is replenished. ODR decreases with soil depth.

Oxidation - Reduction (Redox) potential (Eh)

It indicates the oxidation and reduction states of soil system. In oxidized soil, ferric (Fe^{3+}), Manganic (Mn^{4+}), Nitrate (NO_3^-) and sulphate (SO_4^{2-}) ions dominate. In reduced soil, ferrous (Fe^{2+}), manganous (Mn^{2+}), ammonium (NH_4^+) and sulphides (S^{2-}) are present. The redox potential is denoted by the symbol *Eh* and measured using platinum electrodes and expressed in millivolts. A positive Eh value indicate oxidized state and a negative Eh value indicate reduced state.

Factors affecting the composition of soil air

Nature of soil

Soil with more pore space volume will have more air. The drainage of excess water from soil macro pores improves soil aeration. If the volumes of soil macro pores are high, soil aeration will be good. Soil texture, bulk density, aggregate stability and organic matter contents influence the soil macro pores. The quantity of oxygen in soil air is less than that in atmospheric air. The oxygen content of the air reduces with increasing depth of soil. Surface soil will have more oxygen than sub soil because of quick replenishment from the atmospheric air through diffusion. Light textured soil or sandy soil contain more air than heavy soil. The concentration of CO_2 is more in subsoil due to slow rate of replenishment and low aeration in lower layer than in the surface soil. High clay containing soils will have high soil moisture potential - which reduces the oxygen diffusion rate and increases the CO_2 accumulation.

Type of crop

Plants roots require oxygen, which they take from the soil air and deplete the concentration of oxygen in the soil air and release CO_2. Soils on which crops are grown contain more CO_2 than fallow lands. The amount of CO_2 is more near the plant than further away due to respiration by roots.

Microbial activity

The microorganisms in soil require oxygen for respiration and they take it from the soil air deplete its concentration. Decomposition of organic matter produces CO_2 because of increased microbial activity. Hence, soils rich in organic matter contain higher CO_2.

Seasonal variations

The oxygen content of soil air is higher in dry season than during the monsoon. During dry season, most of the soil pores are and the exchange of gases between soil air and atmosphere is more. During monsoon seasons, most of the soil pores are filled with water. Temperature also influences the gaseous composition of soil air. High temperature enhances the gaseous exchange between soil air and atmosphere. High temperature also increases the microbial respiration and releases more CO_2 in the soil air.

Soil aeration problems in the field

Under field conditions, poor soil aeration occurs due to two conditions: a) when the moisture content is too high occupying most of the pore space b) when the exchange of gases with the atmosphere is slow. When the field is completely submerged with water, all the plants except some plants like rice, die for want of oxygen.

Exchange of Gases between Soil and Atmosphere

The exchange of gases between soil air and atmosphere is facilitated by two mechanisms.

Mass flow

During rain fall or during irrigation, a part of the soil air is replaced by water and the replaced air moves out into the atmosphere. When soil moisture is lost due to evaporation, plant absorption, internal drainage *etc*., atmospheric air re-enters into the soil pore space. The variations in soil temperature cause changes in the temperature of soil air. Also, when soil air gets heated during the day, it expands and the expanded air moves out into the atmosphere. When the soil cools during night, the soil air contracts and the atmospheric air is drawn in.

Diffusion

Most of the gaseous interchange in soils occurs by diffusion. Atmospheric and soil air contains gases such as nitrogen, oxygen, carbon dioxide*etc*., each of which exerts its own partial pressure in proportion to its concentration. These gases move from higher concentration (higher partial pressure) to lower concentration (lower partial pressure). Oxygen moves from the atmosphere into soil sir and CO_2 moves out of soil air into the atmosphere through diffusion without the movement of entire air mass because of the difference in their concentration or partial pressure. This movement is called diffusion and this will continue till equilibrium is established.

Importance of Soil Aeration

Soil reactions and properties

Microbial breakdown of soil organic residues is reduced under poor aeration and hence organic matter is accumulated. In well aerated soil, aerobic microorganisms are active and they convert simple sugars to CO_2 and water using oxygen. In submerged or reduced soil, anaerobic microorganisms are active and they convert sugars to less CO_2 and more CH_4 (methane) which is an atmospheric pollutant. This process also gives out some organic acid; ethylene gas *etc*., which are toxic to plant roots and some microbes. The aerobic decomposition will be faster than anaerobic decomposition.

Oxidation and reduction of inorganic elements

The oxidized state of nitrogen and sulphur are easily utilized by plants. Reduced forms of some of the elements are toxic. Though solubility of iron and manganese increases, they become toxic to plants. Soil colour is also altered by aeration. Well aerated soils have red, yellow and reddish brown colours. Reduced soils have grey and blue colours. The dis-colouration of soil in patches is called mottling.

Plant and root growth

Soil aeration is important factor for normal growth of plants. Roots absorb oxygen for their respiration and release CO_2. The supply of oxygen to roots in adequate quantities and the removal of CO_2 from the soil atmosphere are very essential for healthy plant growth. When the supply of oxygen is inadequate, the plant growth either retards or ceases completely as the accumulated CO_2 hampers the growth of plant roots. The abnormal effect of insufficient aeration on root development is most noticeable on the root crops. Abnormally shaped roots of these plants are common on the compact and poorly aerated soils. The penetration and development of root are poor. Such undeveloped root system cannot absorb sufficient moisture and nutrients from the soil.

Microorganism population and activity

The microorganisms living in the soil also require oxygen for respiration and metabolism. Some of the important microbial activities such as the decomposition of organic matter, nitrification, sulphur oxidation *etc.,* depend upon oxygen present in the soil air. The deficiency of oxygen in soil air slows down the rate of microbial activity. The decomposition of organic matter is retarded and nitrification arrested. The microorganism population is also drastically affected by poor aeration.

Formation of toxic material

Poor aeration results in the development of toxins and other injurious substances such as ferrous oxide, H_2S gas, CO_2 gas, ethylene, organic acids, *etc.,* in the soil.

Water and nutrient absorption

A deficiency of oxygen has been fo und to check the nutrient and water absorption by plants. The energy of respiration is utilized in absorption of water and nutrients. Under poor aeration in water logged soils, plants exhibit water and nutrient deficiency

Development of plant diseases

Insufficient aeration of soil leads to the development of some diseases like, wilt of gram and dieback of citrus and peach.

3.8 SOIL TEMPERATURE

1. Soil temperature: is an important plant growth factor like air, water and nutrients. Soil temperature affects plant growth directly and also indirectly by influencing moisture, aeration, structure, microbial and enzyme activities, rate of organic matter decomposition, nutrient availability and other soil chemical reactions. Specific crops are adapted to specific soil temperatures. Apple grows well when the soil temperature is about 18□C, maize 25□C, potato 16 to 21ºC, and so on.

2. Sources of soil heat

The sources of heat for soil are solar radiation (external), heat released during microbial decomposition of organic matter and respiration by soil organisms including plants and the internal source of heat is the interior of the Earth - which is negligible. The rate of solar radiation reaching the earth's atmosphere is called as solar constant and has a value of 2 cal cm^{-2} min^{-1}. Major part of this energy is absorbed in the atmosphere, absorbed by plants and also scattered. Only a small part of it reaches soil. Thermal energy is transmitted in the form of thermal infrared radiation from the sun across the space and through the atmosphere.

3. Factors affecting soil temperature

The average annual soil temperature is about 1ºC higher than mean annual air temperature. Soil temperature is influenced by climatic conditions. The factors that affect the transfer of heat through the atmosphere from sun affect the soil temperature also.

3.1 Environmental factors

Solar radiation: The amount of heat received from sun on Earth's surface is 2 cal cm^{-2} min^{-1}. But the amount of heat transmitted into soil is much lower. The heat transmission into soil depends on the angle on incident radiation, latitude, season, time of the day, steepness and direction of slope and altitude. The insulation by air, water vapour, clouds, dust, smog, snow, plant cover, mulch *etc*., reduces the amount of heat transferred into soil.

3.2 Soil factors

a) Thermal (Heat) capacity of soil: The amount of energy required to raise the temperature by 1□C is called *heat capacity*. When it is expressed per unit mass (Calories per gram), then it is called as *specific heat*. The specific heat of water is 1.00 cal g^{-1} where the specific heat of a dry soil is 0.2 cal g^{-1}. Increasing water content in soil increases the specific heat of the soil and hence a dry soil heats up quickly than a moist soil.

b) Heat of vaporization: The evaporation of water from soil requires a large amount of energy, 540 kilocalories kg^{-1} soil. Soil water utilizes the energy from solar radiation to evaporate and thereby rendering it unavailable for heating up of soil. Also the thermal energy from soil is utilized for the evaporation of water, thereby reducing the soil temperature. This is the reason that surface soil temperatures will be sometimes 1 to 6ºC lower than the sub-surface soil temperature. That is why the specific heat of a wet soil is higher than dry soil.

c) Thermal conductivity and diffusivity: This refers to the movement of heat in soils. In soil, heat is transmitted through conduction. Heat passes from soil to water about 150 times faster than soil to air. So the movement of heat will be more in wet soil than in dry soil where the pores will be occupied with air. Thermal conductivity of soil forming materials is 0.005 thermal conductivity units, and that of air is 0.00005 units, water 0.001 units. A dry and loosely packed soil will conduct heat slower than a compact soil and wet soil.

d) Biological activity: Respiration by soil animals, microbes and plant roots evolve heat. More the biological activity more will be the soil temperature.

e) Radiation from soil: Radiation from high temperature bodies (Sun) is in short waves (0.3 to 2.2 m) and that from low temperature bodies (soil) is in long waves (6.8 to 100 m) Longer wavelengths have little ability to penetrate water vapour, air and glass and hence soil remains warm during night hours, cloudy days and in glass houses.

f) Soil colour: Colour is produced due to reflection of radiation of specific wavelengths. Dark coloured soils radiate less heat than bright coloured soils. The ratio between the incoming (incident energy) and outgoing (reflected energy) radiation is called *albedo.* The larger the albido, the cooler is the soil. Rough surfaced soil absorbs more solar radiation than smooth surface soils.

g) Soil structure, texture and moisture: Compact soils have higher thermal conductivity than loose soils. Natural structures have high conductivity than disturbed soil structures. Mineral soils have higher conductivity than organic soils. Moist soil will have uniform temperature over depth because of its good conductivity than dry soils.

h) Soluble salts: Indirectly affects soil temperature by influencing the biological activities, evaporation *etc*.

4. Effect of soil temperature on plant growth

a) Soil temperature requirements of plants: The soil temperature requirements of plants vary with the species. The temperature at which a plant thrives and produces best growth is called ***optimum range*** (*temperature*). The entire range of temperature under which a plant can grow including the optimum range is called ***growth range*.** The maximum and minimum temperatures beyond which the plant will die are called ***survival limits*.**

Range	Maize (ºC)	Wheat (ºC)
Optimum range	25 - 35	15 - 27
Growth range	10 - 39	5 - 35
Survival limits	0 - 43	0 - 43

b) Availability of soil water and plant nutrients: The free energy of water increases with temperature. Up to wilting point limit, warming of soil increases water availability beyond which it decreases. Low temperatures reduce the nutrient availability, microbial activities and root growth and branching. The ability to absorb nutrients and water by plants reduces at low temperatures.

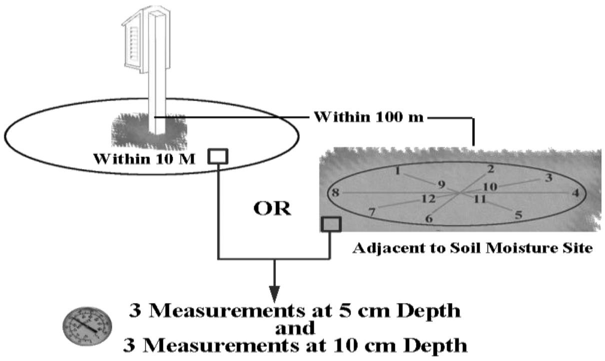
5. Soil temperature management

5.1. Use of organic and synthetic mulches: Mulches keep soil cooler in hot summer and warm in cool winter.

5.2. Soil water management: High moisture content in humid temperate region lowers soil temperature.

5.3. Tillage management: Tilling soil to break the natural structure reduces the heat conductance and heat loss. A highly compact soil looses heat faster than loose friable soil.

6. Methods of measuring soil temperature: Mercury soil thermometers of different lengths, shapes and sizes with protective cover are buried at different depths to measure the temperature. Thermo couple and thermister based devices are also available. Infra-red thermo meters measure the surface soil temperature. Automatic continuous soil thermographs record the soil temperatures on a time scale. The International Meteorological Organization recommends standard depths to measure soil temperatures at 10, 20, 50 and 100 cm.



3.8 PROBLEM SOILS

Physical problems

An optimum physical environment of soils is essential for better growth of plants, consequently for better yields. Based on soils physical properties viz., infiltration, bulk density, hydraulic conductivity, porosity (capillary and non capillary) aggregates etc soil physical constraints are identified as below.

1. Slow permeable soils
2. Excessively permeable soils
3. Subsoil hardening
4. Surface crusting
5. Fluffy paddy soils
6. Shallow soils

Slow permeable soils

Slow preamble soils are those having infiltration rates less than 6 cm/day due to high clay content of the soil. Due to low infiltration rates, the amount of water entering the soil profile is reduced thus increasing the run-off. Further, it encourages erosion of surface soil leading to nutrient removal in the running water. More ever, due to heavy clay content, the capillary porosity is relatively high resulting in impeded drainage and reduced soil conditions. This results in increase of some soil elements to the level of toxicity to the plants. It also induced nutrient fixation in the clay complex thereby making the nutrient becoming unavailable to the crop, eventually causing deficiency of nutrients. Such soils are spread over Tamil Nadu in an area of 7,54,631 has, which is 7.5% of total geographical area.

Management

The constraints in such soils can be managed by adopting suitable practices like

1. Provision of drainage facilities either through open or closed sub surface drains.
2. Forming contour and compartmental bunding to increase the infiltration rates of soils.
3. Application of huge quantities of river sand or red soils of coarser texture to dilute heaviness of the soil.
4. Application of liberal doses of organic manures like Farm Yard Manure, Compost, Green manure, Composted coir pith, sewage waste, press mud etc.

5. Adopting ridges and furrows, raised beds, broad bed and furrow systems.
6. Application of soil conditioners like H-concentrate, Vermiculite, Jalasakti etc to reduce run-off and soil erosion.

Excessively Permeable Soils : Excessively permeable soils are those having high amount of sand exceeding 70- percent. Due to this, the soils are inert and unable to retain nutrient and water. These soils being devoid of finer particles and organic matter, the aggregates are weakly formed, the non-capillary pores dominating with very poor soil structure. Due to low retaining capacity of the soils, the fertilizer nutrients are also lost in the drainage water. These soils are spread over 24, 12, and 086 ha in Tamil Nadu (23:97% of total geographic area).

Management

The excessively preamble soils can be managed by adopting the techniques given below.

1. Compacting the field with 400kg stone roller (tar drum filled with 400 kg of sand or stones can also be used) 8-10 times at optimum moisture conditions.
2. Application of clay soil up to a level 100 t ha^{-1} based on the severity of the problem and availability of clay materials.
3. Application of organic materials like farm yard manure, compost, press mud, sugar factory slurry, composted coir pith, sewage sludge etc.
4. Providing asphalt sheet, polythene sheets etc. below the soil surface to reduce the infiltration rate.
5. Crop rotation with green manure crops like Sunhemp, sesbania, daincha, kolinchi etc.

Sub soil hardening /hard pan

The sub soil hard pan in red soils in due to illuviation of clay to the sub soil horizon coupled with cementing action of oxides of Fe, Al and Calcium carbonate, which increases the soils bulk density to more than 1.8 Mg m^{-3}. Further, the hard pan can also develop due to continuous cultivation of crops using heavy implements constantly. Besides, the higher exchangeable sodium content in black soils areas also result in compactness. All put together lowered the infiltration and percolation rates, nutrient movement and free air transport within the soils profile. It prevents root proliferation and limits the volume of soils available for nutrients uptake resulting in depleted, less fertile surface soil. Due to this, the contribution of sub soil fertility to crop growth is hampered. The area under this constraint is 10,54, 661 ha in Tamil Nadu (10: 48% TGA).

Management

These soils are managed by adopting following practices

1. Ploughing the soil with chisel plough at 0.5m interval criss cross at 0.5m depth once in 2-3 years.
2. Application of organics to improve the aggregation and soil structure so as to prevent further movement of clay to the lower layers.
3. Deep ploughing of the field during summer season to open up the sub soils.
4. Cultivating deep rooted crops like tapioca, cotton so as to encourage natural breaking of the hard pan.
5. Raising deep rooted semi perennial crops like Mulberry, Jasmine, Match wood tree etc. can also help in opening up the sub surface hard pan.

Surface crusting

Surface crusting is due to presence of colloidal oxides of iron and Aluminium in Alfisols which binds the soil particles under wet regimes. On drying it forms a hard mass on the surface. The ill effects of surface crusting are

1. Prevents germination of seeds
2. Retards/inhibits root growth.
3. Results in poor infiltration.
4. Accelerates surface run off
5. Creates poor aeration in the rhizosphere
6. Affects nodules formation in leguminous crops Area : 4,51,584 ha (4.49% TGA) in Tamil Nadu.

Management

Surface crushing can be managed as below

1. When the soil is at optimum moisture regime, ploughing is to be given.
2. Lime at 2 t ha^{-1} may be uniformly spread and another ploughing given for blending of amendment with the surface soil.
3. Farm yard manure at 10 t ha^{-1} or composted coir pith at 12.5 t ha^{-1} or other organics may be applied to improve the physical properties of the soils, after preparation of land to optimum tilth.
4. Scraping surface soil by tooth harrow will be useful.

5. Bold grained seeds may be used for sowing on the crusted soils.
6. More number of seeds/trill may be adopted for small seeded crops.
7. Sprinkling water at periodical intervals may be done whenever possible.
8. Resistant crops like cowpea can be grown

Fluffy paddy soils

The traditional method of preparing the soil for transplanting rice consists of puddling, which substantially breaks soil aggregates into a uniform structure less mass. Under continuous flooding and submergence of soil for rice cultivation in a cropping sequence of rice-rice-rice, the soil particles are always in a state of flux and the mechanical strength is lost leading to the fluffiness of the soils. Impact of fluffiness is sinking of drought animals and labourers during pudding. This has been thus, an invisible drain of finance for the farmers due to high pulling power needed for the bullocks and slow movement of labourers during the puddling operations. Further fluffiness of the soil lead to very low bulk density and in turn the soil does not provide a good anchorage to the roots and the potential yield of crops is adversely affected. About 25, 919 ha (0.26% TGA) in Tamil Nadu have this problem.

Management

Following practices are need to be adopted to overcome this problem.

1. The irrigation should be stopped 10 days before the harvest of rice crop.
2. After the harvest of rice, when the soil is under semi-dry condition, compact the field by passing 400 kg stone roller or an tar drum filled with 400 kg of sand for 8 times.
3. The usual preparatory cultivation is carried out after compaction.

Shallow soils:

The shallow soils are characterized by the presence of the parent root immediately below the soil surface at about 15-20 cm depth. This restricts the root elongation and spreading. Hence, the crops grown in these soils necessarily are shallow rooted crops, which can exhaust the soil within 2-3 seasons. Therefore, frequent renewal of soil fertility is a must in these soils. These soils can be managed by growing crops which can withstand the hard rocky sub soils like mango, ber, fig, country, goose berry, west Indian cherry, Anona, Cashew, and Tamarind etc. These soils spread over an area of 1, 16,509 ha in Tamil Nadu which is 1-16 per cent of total geographical area.