Chemical Properties of Soil

Ag. Technologies (Soil Mgmt.)

Soil consists of mineral matter, organic matter, soil air, and soil water. All these four components are closely related with each other. The chemical properties of soil are important as they are closely related to the capacity of the soil to supply plant food Nutrients.

a. Mineral matter :The Mineral matter of the soil consists of inorganic substances derived from rocks. Minerals are of primary and secondary type. Primary minerals are similar to that of parent material and secondary minerals are those derived from chemical weathering of rocks, secondary minerals are also called as clay minerals.

b. Inorganic components: The main chemical compounds in the soil are silicon, calcium, magnesium, iron, potassium, sodium and aluminium. The total amount of elements present in the soil depends partly on the nature of the parent material and partly on their age and extent to which soluble products have been leached down. Also chemical composition of different horizons of a soil shows a great deal of variation.

c. Ion exchange: It is a reversible process by which cations and anions are exchanged between solid and liquid phases and between solid phases which are in close contact with each other. Ion exchange is the most important of all the processes occurring in soil. Cations are the positively charged ions and anions are negatively charged ions. The capacity of the soils to adsorb and exchange cations and anions varies greatly with the nature and amount of clay and the organic matter. The cation-exchange capacity (CEC) is defined as the amount of cation species bound at pH 7 and is expressed as milliequivalents (m.e.) per 100 grams.

d. Soil acidity (pH of soil): - It is a important chemical property of the soil. Suitability of the soil as the medium for the growth of plants and desirable micro-organisms depends considerably on the soil reaction. This reaction is measured in terms of pH. The pH scale has a range from 0 to 14. Its central point i.e. pH 7 indicates a neutral reaction. Values less than pH 7 denotes acidity while more than 7 indicate alkalinity. The pH range for most agricultural soils is about 5 to 8.5.

e. Buffering capacity of soil: Most of the soils can resist the pH changes, when large amounts of either strongly acid or bases forming materials are added. This ability to resist the change in pH is called as buffering capacity of the soil. Carbonates, bicarbonates and phosphates present in soils act as buffering agents. Buffering capacity of soil depends upon the amount and nature of clay and organic matter content.

Standards followed in soil testing

Ag. Technologies (Soil Mgmt.)

Soil test interpretation:

The soil testing laboratories classify the results of soil tests as low, medium and high. These standards generally followed in most of the states.

Sr. No.	item	Low	Medium	High
1	Organic carbon used as a measure of available nitrogen.	Below 0.5 p.c.	0.5 to 0.75 p.c.	Above 0.75 p.c.
2	Available N by alkaline permanganate method in kg/ha	Below 280	280 - 560	Above 560
3	Available P by Olsen's method in kg/ha	Below 10	10 - 24.6	Above 24.6
4	Available K in kg/ha	Below 108	108 - 280	Above 280
5	pH	Acidic	Normal	Alkaline above
		Below 6.0	6.0 to 8.0	8.0 (9.0 harmful for most crops)
6	Conductivity (total soluble salts) millimhos			
	Below-1	Normal		
	1-2	Soluble salt content critical for germination.		
	2-3	Salt content critical for the growth of salt sensitive crops		
	Above 3	Severe injury to most crops.		

Clay Minerals in soil

Ag. Technologies (Soil Magt.)

Introduction

Soil structure is recognized as one of the most important property of soil mass since it influence aeration, permeability, water capacity etc. Soil structure refers to the arrangement of soil particles both primary and secondary. Clays are the secondary minerals they are hydrated alumina silicates.

The clay fraction

In the process of decomposition relatively stable new minerals are formed from the products of weathering which constitutes largely the clay fraction. The clay particle forms are crystalline and composed of sheets of hydrated alumina and silica linked by oxygen atoms. The nature of clay properties depends on the type of minerals that predominately composed the clay. The clay fractions are included

1. clay minerals which are crystalline layers silicates
2. amorphous silicates,
3. oxides of iron, silicon and aluminum and
4. clay-sized primary minerals.

Following are three main groups: -

1. **Kaolinite**

   A unit kaolinite crystal lattice consist of one sheet of silica and one sheet of alumina and called as 1:1 layer silicate these two sheets are held by mutually shared oxygen atoms. It has a low specific surface and low cation-exchange capacity, plasticity, cohesion, shrinkage and the swelling properties.

2. **Montmorillonite**

   A unit montmorillonite crystal lattice consist of two sheet of silica and one sheet of alumina held together by mutually shared oxygen atoms known as 2:1 layer silicate. There is isomorphic substitution of iron or magnesium in the alumina sheet; montmorillonite crystal can expand hence cations and water molecules are able to move in between the crystal units. It has high specific surface and cation-exchange capacity, plasticity, cohesion, shrinkage and the swelling properties.

3. **Illite**

   It has the same general structural organization as montmorillonite about 15% of silica in the silica sheet is replace by aluminum and potassium atoms and they supply the additional connecting linkages between the crystal units. It has properties intermediate between kaolinite and montmorillonite.

Soil colloids

The most active portions of the soil are those which are in the colloidal state. The colloidal state has to phase system; the dispersed phase- fine clay and humus dispersed in the dispersed medium-water. In soils the mineral and organic colloids exists in heterogenous admixture. The clay particles less than one micron in diameter posses colloidal properties and these properties increases with a decrease in the size of the particles. The colloidal material forms a thin gelatinous film around coarser particles serving as a binding material. Soils with a high amount of colloidal clay compete with plant roots for water and mineral nutrients especially at low levels of their availability. The soil colloids have a high exchange capacity, which increases with silica sesquioxide ratio.

Functions/ Properties

a. Clay fractions are highly reactive, being very small.

b. Form the seat of ion exchange in soil.

c. Controls and regulates adsorption retention.

d. Release of many plants viz. potassium, calcium, magnesium and phosphorus.

Various modes of soil formation

Ag. Technologies (Soil Mgmt.)

Soil Formation

The transformation of rocks into soil may be termed as soil formation. It starts with the weathering of rocks. The weathering processes are primarily destructive in nature. It helps to change the consolidated rocks into unconsolidated material. The soil forming processes are constructive and result in a soil profile that has been developed from the surface few feet of parent material.

Factors of soil formation

Five factors, at any specific location on the surface of the earth, act simultaneously to produce soil. They are (1) Climate (2) Parent material (3) Relief /Topography (4) Biosphere (Vegetation, organism, man, etc.) (5) Time. Their relationship to the soil properties has been expressed by Jenny in the following equation.

s = f (cl, b, r, p, t)

Where, 's' = Any soil property e.g. clay content. 'f' = function of or dependent upon 'cl' = climate, 'b' = Biosphere, 'r' = relief, 'p' = parent material, 't' = time (age)

Therefore, any soil property is the function of collective efforts of all the soil forming factors.

1. Climate and soil formation: Climate is dominant factor in soil formation, climate influence soil formation largely through precipitation and temp and air.

a. Precipitation:

i. It primarily regulates the moisture air regime of the soil and determines the leading trends in soil profile depending upon available percolating water.

ii. Rainfall also affects profile development through erosion producing thin soils on steep slopes and deposition of soil material down hill.

iii. The intensity, frequency and distribution of precipitation influence the course of soil formation.

iv. With increasing moisture, nitrogen and carbon content, clay content, aggregation, saturation capacity and exchangeable hydrogen tend to increase.

v. Exchangeable base and pH value tends to decrease with increasing moisture.

b. Temperature: Temperature affects the velocity of chemical reactions, which approximately doubles for every 10^{0}C increase in temperature. It influences the organic matter decomposition and microbial activities in soil though the evapotranspiration phenomenon. Temperature also determines the efficiency of rainfall. In general, with increase in temperature the depth of weathering and clay content show increase on the contrary nitrogen, organic matter, silica, alumina and base alumina ratio tends to decrease with rising temperature.

2. Parent material and soil formation: Rock on the surface of earth is weathered until the essential elements become available to support lichen and other lower forms of plant life. As continuing generations of lichens grows, die and decay, they leave increasing amounts of organic matter. Organic acid further has tendency to decay the rock. Different parent material affect profile development and produce different soil especially in initial stages. The nature of the elements released during decaying of rocks has a specific role in soil formation.

3. Relief / Topography and soil formation: The prominent types of topography designations as given in FAO guidelines are:

i. Flat or almost flat: Land surface with slope less than 2%

ii. Undulating: Land surface with slope between 2-8%

iii. Rolling: Land surface with slope between 8-16%

iv. Hilly: Land surface with slope between 16-30%

v. Steepy dissected: Land surface with slope greater than 30%

a. Soil formation on slopy land: The soils on steep slopes are generally shallow, storey and have weakly developed profiles with less distinct horizonation. It is due to

i. Accelerated erosion, which removes surface material before it has time to develop.

ii. The reduced percolation of water through the soil because of surface runoff.

iii. Lack of water for the growth of plants, which are responsible for checking erosion and promoting soil formation.

b. Soil formation on level topographic position: On level topographic position, almost then entire water received through the rain percolates through the soil. Under such condition the soil formed may be considered as representative of the regional climate. They have normal solum with distinct horizons.

4. Biosphere and soil formation: Vegetation, microbes, animals and man all greatly influence the soil formation processes. Vegetation exerts its main influence on soil formation through the amount and nature of O.M. that it adds to the soil. Soil developed under biosphere of forest vegetation have more horizon a more highly leached. Vegetation also aids in control of erosion. Burrowing animals causes constant mixing within soil. Man through his land use cause both beneficial and harmful effect on soil.

5. Time and soil formation: The length of time required for a soil to develop horizons depends upon many unrelated factors such as climate, nature of the parent material, burrowing animal and relief. It has been seen that

rocks and mineral disintegrate and /or decomposes at different rates, the coarse particle of limestone are more resistant to disintegration than those of sandstone. There are five stages of weathering that are dependent on minerological features of soil.

Weathering stages in soil formation:

1. Initial – Unweathered parent material.

2. Juvenile – Weathering started but much of the original material still Unweathered.

3. Virile – Easily weatherable mineral fairly decomposes, clay content has increased.

4. Sensile – Decomposition reaches at final decomposition stage only most resistance minerals survive.

5. Final – Soil development completed under prevailing conditions.

Processes of soil formation: The basic processes involved in soil formation are

1. Gains or addition of water, organic and inorganic minerals to the soil.

2. Losses of the above material from the soil.

3. Transformation of mineral and organic substances with the soil

4. Translocation or movement of soil material divided into

i. Movement in solution (leaching).

ii. Movement in suspension (eluviation) of clay, organic matter etc.

A. Fundamental processes of soil formation:

1. Humification: Helps in formation of surface layer, called Ao horizon. Its characteristics depends upon the nature of vegetational residue and the way it becomes decomposes and synthesized into new organic compounds. The percolating water passes through this humus layer dissolves certain organic acids affect the development of lower A and B.

2. Eluviation: Elevation means washing out. It is a process of removal of constituents in suspension or solution by the percolating water from the upper to the lower layer. Mechanical eluviation removes finer suspended fraction of soils, producing textural profiles by a coarse texture.

3. Illuviation: The process of deposition of soil material (Removed from the eluvial horizon) in the lower layer is known as illuviation. The horizons formed by this process are termed illuvial horizons.

B. Specific pedogenic processes:

1. Calcification: It is the process of precipitation and accumulation of

calcium carbonate ($CaCO_3$) in some part of the profile. The accumulation of $CaCO_3$ may result in the development of acidic soil. Such soil belonging to group called pedacal.

2. Decalcification: It is the reverse of classification i.e. the process of removal of $CaCO_3$ or Ca ions from soil by leaching.

3. Podsolization: Podzolization is negative of calcification where as calcification tends to concentrate calcium in the lower part 'B' horizon podsolization reaches the entire solum. Apart from the calcium the other bases are also removed and the whole soil becomes distinctly acidic. Process is mainly acid leaching.

4. Laterization: In this process, silica is removed while iron and alumina remain behind in the upper surface / layers and usually there are no well-defined horizon. Laterization is favoured by rapid decomposition of parent rocks under climates with high temperature and sufficient moisture for intense leaching. Podsolization and latrization produce soils that belong to the pedalfer (iron accumulating) group.

5. Gleization: It is a process of soil formation resulting in the development of glei (or gley horizon) in the lower part of soil profile above the parent material due to poor drainage condition and where water logged conditions prevail such soils are called hydromorphic soils. Gleying may be observed at any depth depending on the depth of ground water.

6. Pedoturbation: Inversion of soil takes place in deep black cotton soils which contain montmorillonite clay colloid (vertisol) has max swelling shrinkage capacity. As alternate weting and drying, expansion and contraction takes place due to which cracks is formed. Due to crack formation A horizon goes down and soil B horizon comes up. These are also known as self ploughed soils. Therefore in dry farming technique ploughing once in three years is recommended to conserve the soil moisture and since the inversion of soil takes place naturally there is no need of ploughing every year.

7. Salinization: Accumulation of soluble salts under dry climate or no rainfall. Salts accumulate on soil surface. Na^+, K^{++}, Ca^{++}, Mg^{++}. Soil becomes saline due to high rate of evaporation, reclaimed by leaching, flooding. (pH8.5) Grow salt tolerant crops, shevri, Dhaincha.

8. Alkalinization: Accumulation of sodium salts only like Na_2Co_3 and $Na_2 (CO_3)_2$.

Biological Properties of Soil

Ag. Technologies (Soil Mgmt.)

Soil contains different kinds of micro-organisms. These living organisms feed on plant residues. The soil micro-organisms are of two types:

a. Microflora: Bacteria, actinomycetes, fungi and algae.

b. Microfauna: Protozoa and nematodes.

a. Microflora: Bacteria, actinomycetes, fungi and algae which come under this category vary greatly regarding their numbers and sizes and also from place to place and season to season. The density of population of these microflora varies due to food supply, moisture, temperature, aeration and reaction of the soil.

Bacteria:There are of two types viz., autotrophic and heterotrophic. The later decompose the organic matter and release plant food nutrients like nitrogen, phosphorus, etc. The autotrophic bacteria comprises nitrosomonas and nitrobacteria which oxidise ammonia to nitrate and nitrate to nitrate compounds respectively.

ii. **Fungi:** These organisms produce microscopic threads called mycelia and are found in the organic matter of plant roots. Some of them are saprophytic which obtain their energy from decomposing organic matter, while others are parasitic thriving on living plant roots. Fungi, which do not cause diseases, are useful to soil because they help in breaking down the organic matter.

iii.Actinomycetes: They are similar in size to bacteria but different in so far as they can grow in deeper layers even under dry conditions of soil and require less nitrogen than bacteria. They are in plenty in soils rich in organic matter and with neutral to slightly acidic reaction. They decompose the resistant parts of organic matter like cellulose.

iv.Algae: They are microscopic or very minute-sized plants having chlorophyll. They are usually found on the surface of wet soils of paddy fields. They help in adding organic matter to soil, improving the soil aeration.

b.Microfauna: There are two groups viz. Protozoa and nematodes.

i. Protozoa:These are unicellular animals, which feed on the organic matter and on the bacterial population in the soil.

ii. Nematodes:These are microscopic worms. Parasitic to plant roots are agriculturally important. A large number of them also feed on soil microflora and also on protozoa.

Soil Structure

Ag. Technologies (Soil Mgmt.)

Importance of soil structure:

Structure is very important in plant growth relationship as it chiefly influences the amount and nature of porosity and regulates the moisture air regime in the soil. The best structures are mechanically stable and strong but when they absorb moisture and are wet they become soft and loose their shape and size. Soils high in water table aggregates are fewer bends to puddle. Structure is one of the properties, which is easily liable to change under different management practices such as ploughing, draining, liming, fertilizing and manuring. Addition of organic matter and its proper decomposition are important for building up and maintenance of soil structure. Grasses are most effective in promoting granulation.

Soil structure

The arrangement of primary soil particles in the compound particles of clusters, that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. Aggregates are secondary units or granules composed of many soil particles bound or cemented together by organic substance iron oxides and carbonates, Natural aggregates are called peds and vary in their water stability.

Fragment

Fragment consists pieces of broken ped. Concretion is formed within the soil by the precipitation of salts dissolved in percolating water. Structure is best studied in the field under natural condition and it is described under three categories.

¶ **Type:** Shape and forms and arangement pattern of ped.

· **Class:** Size of peds.

¸ **Grade:** Degree of distinctness of ped.

Types of structures

Following are the principle geometric forms of soil structure.

1. Platee or platelike:

The horizontal dimensions are much developed than the vartical giving a flattened, compressed or lens like appearance to the peds. When the units are thick then they are called platy and when the units are thin they are called laminar plate often overlap and impair permeability. Generally this type of structure is found in forest and clay pan soils.

2. Block or Blocklike: (Blocky)

All 3 dimensions are of about the same size and the peds are cube like with flat or rounded faces. When the faces and edges are mainly rounded it is called subangular blocky found in B-horizon. Either some of the block like structure were called nutty or nuciform.

3. Granular:

In case of spheriodal structures, the aggregates are rounded but when curved or irregular and less porous the structure is called granular. Granular structures are not fitted to adjoining aggregates. It is found in horizon A.

4. Columnar:

It is pillar like ped, which is rounded at the top structure, is known as columnar. It is laterally bounded by columnar aggregates, which forms the cost for the peds.

5. Prism like or prismatic:

The vertical axis is more developed than other with flattened sides giving a pillar like shape, when the top of such ped is rounded the structure is termed as columnar and when flat it is termed as prismatic. Prismatic aggregates form the cast for the peds. Some prismatic aggregates break into smaller blocky peds.

6. Crumb structure:

Spheroidal structure, the aggregates are rounded and relatively porous, it is called crumb structure. Small and spheroidal peds not filled to adjoining aggregates. Amongst all kind of structures described above the crumb structure is the most ideal for crops. It is closely related to various soil properties like

i. Good drainage, aeration and removal of excess water.

ii. Spread of plant roots

iii. Resistant to erosion etc.

Classes of Structure

There are following classes based on their size they are:

1) Very fine or very thin (2) Fine or thin (3) Medium (4) Coarse or thick

Grades of structure

Grade indicates the degree of distinctness of the individual peds. Four terms commonly used to describe the grade of the soil structure are:

1. Structureless: There are no noticeable peds such as conditions exhibited by loose sand or cement like conditions of some clay soils.

2. Weak: Instinct formation of peds, which are barely durable.

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

4. Strong: Strong well developed peds are durable and distinct.

Ag. Technologies (Soil Magt.)

Soil profile

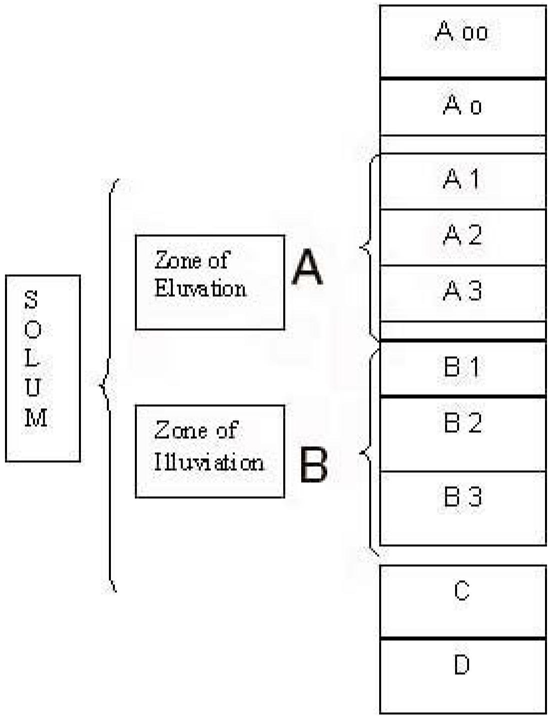
Introduction

Soil is one of the most important national resources of any country. The soil not only grows a variety of food and fodder crops required for men and animals but also produces raw materials for various agro-industries viz., sugar and starch factories, textile mills, canning and food processing units. It is a complex body showing great many variations in depth, colour, composition and behaviour. Every soil cosists of hard materials called mineral matter, soft and spongy organic matter, water, air and living organisms. Their proportion may vary, the soil has three dimensions namely, length, breadth and depth. Soils have primarily developed from different types of rocks. There are three principals kinds of rocks viz. igneous rocks, sedimentary rocks and metamorphic rocks.

Soil profile

A vertical section of the soil through all its layers and extending into the parent rock is known as soil profile. A soil profile is a historic record of all the soil forming processes and forms the unit of study in pedological investigation. It also helps in soil classification and forms the basis for practical studies of soils. A study of the soil profile is important from crop husbandry point of view, since it reveals the surface and the subsurface characteristics and qualities, namely depth, texture, structure, drainage conditions and soil-moisture relationships, which directly affect plant growth. It helps to classify the soils and to understand soil-moisture-plant relationships.

The profile is divided into four broad horizons called A, B,C and D. Depending upon further variations within these A_2,A_3,B_1,B_2,B_3,C and D. The various organic layers lying above the surface mineral horizon also form a part of the soil profile. Both A and B horizons collectively are called as **Solum**. Solum plus parent material is sometimes referred to as **regolith**. The parent material is termed as **bedrock** of D horizon.



The surface of some soil in forested area has an organic horizon (o) above the mineral soils. In this layer the original forms of the plant and animal residues are observed. In the '02' horizon the original plant and animal forms cannot be distinguished. Such '0' horizon is absent in arable lands.

'A' horizon- It consits of sub horizons A1, A2 and A3. A1 is the topmost mineral horizon containing a strong admixture of humified organic matter and dark colour.

A2- It is lighter in colour having maximum eluviation of clay, iron and aluminum oxides having maximing leaching.

A3 – It is the transitional layer with properties more like A than B, sometimes absent.

'B' horizon – It may be incorporated at least in part in the plough layer or they may be considerably below the plough layer in the soils with deep 'A' horizon having sub-horizons.

'B1' – Transitional layer but more like B than A; sometimes absent.

'B2' – Usually deeper coloured, maximum accumulation of clay minerals, iron and organic matter.

'B3' –Transitional to C, more like 'B' than 'C'.

'C' horizon – This horizon excludes the bedrock from which 'A' and 'B' horizons have been formed. This horizon is less affected by pedogenic processes. Its upper layers may in time become a part of the solum as weathering and erosion continues. Accumulation of $CaCO_3$ and

$CaSO_4$ accur in this zone.

'D' horizon – It is bed rock.

Affecting factors

The formation of soil and the development of profiles are dependent on the genetic and environmental factors, which vary considerably within and between regions, the variation in horizonation are frequent and common. The soils developed in a recent flood plain may have 'AC' profile without any A2 whereas those in the red and lateritic soil area may have A1, B2 and 'C'.

When a virgin soil is put under cultivation, the upper horizons become the furrow slice. Cultivation destroys the original layered condition of this portion of the profile and the furrow slice becomes more or less homogenous.

Many times, serious erosion produces a truncated profile. As the surface soil is swept away, the plough-line is gradually lowered in order to maintain a sufficiently thick furrow slice. The furrow is almost entirely within the 'B' zone and the 'C' horizon is correspondingly near the surface.

Study

In deep soils, the soil profile may be studied upto 1m and a quarter and in others upto the parent material. The layers (horizons) in the soil profile, which vary in thickness, may be distinguished from the morphological characteristics which include color texture, structure etc.

Classification

Soils are classified by such characteristics as the kind and number of horizons or layers that have developed in them. The horizons are distinguished by texture, kind of minerals present and presence of salts and alkalies.

The main groups of soils that are commonly recognised in India are as follows:

i. Red soils
ii. Laterites and lateritic soils
iii. Black soils
iv. Alluvial soils
v. Forest and hill soils
vi. Desert soils
vii. Saline and alkaline soils
viii. Peaty and marshy soils

Soil Plant Relationship

Ag. Technologies (Soil Magt.)

Introduction

Soil is one of the most important national resources of any country. The soil not only grows a variety of food and fodder crops required for men and animals but also produces raw materials for various agro-industries viz., sugar and starch factories, textile mills, canning and food processing units. Soil is a habitat for plant growth bears certain physical, chemical and biological properties, which determined degree of workability, suitability to the specific crop varieties, physical and chemical capacities as well as productivity. The physical capacities of a soil are influence by the size, proportion, and arrangement on mineral composition of the soil particles. The physical and biological properties of soil need careful studies because soil is a natural medium for the plant growth and gives mechanical support to plant.

Physical properties of soil

Some of the important physical properties of soil connected with growing of crops,are as under:

a. Texture

Soil texture refers to the relative amounts of inorganic particles viz. Sand, Silt and Clay. Sand grains are large and coarse, clay particles are vary fine and smooth, and silt particle intermediate.

b. Structure

The way in which soil particles are grouped or bound together to form lumps or aggregates is known as soil structure. There are two main types of soil structure viz. single grained and compound structure. Soil structure can be changed or modified and improved or damage by adopting various soil management practices like tillage, manuring, liming, rotation of crops, irrigation, drainage etc.

c. Density

The density of soil that is weight per unit volume can be expressed in two ways viz; the density of **'solid' (particle density)**, particles of the soil and the density of the **'whole' (Bulk density)** soil that is inclusive of pore space. Generally soils with low bulk density have better physical condition than those with higher bulk densities. Texture and structure of a soil, its total pore space and organic matter content are all related to bulk densities.

d. Porosity

In between the particles there are empty spaces which are occupied by air and water and are termed as pore spaces. Pore spaces between the aggregates of soil particles are macro-pores and those between the individual particles of the aggregates are micro-pores. The percentage of macro pores is more in sandy soils these soils never remain water logged and allow water to percolate down so rapidly that their moisture content is very low,crops suffer due to shortage of soil moisture. The percentage of micro pore is more in clayey or fine texture soils. In this soil water logging condition causes adverse effect on respiration of roots and bacterial activities. A proper balance between the macro and micro pores can be maintain by timely cultivation and addition of organic matter so as to that crop neither suffers from shortage of excess of water.

e. Soil consistence

It is a combination of properties that determine the resistance of the dry soil to crushing or pulverising action by implements and when wet its ability to be moulded or changed in shape. All soils have cohesive and adhesive properties. Sandy soils have these properties to a much lesser degree than fine texture clay soils. A good tilth soils has both the macro and micro pores in more or less equal proportion, ensures adequate retention of water and also free drainage of excess water. The effect of such physical condition of soil on germination of seed and growth of plant is very beneficial.

f. Colour

Soils have various shades of black, yellow, red and grey colours useful in soil classification. Parent material e.g. red sandstone, organic mater, presence of certain minerals e.g.titanium compounds imparts darker colour, hematite give red colour, limonite-yellow colour, predominace of silica or lime. Soil colour is indirectly helpful in indicating many other properties of soils e.g. a dark brown or black coloured soil indicates its high organic matter content and fertility. A red or yellowish soil shows good aeration and proper drainage. A white or black colour due to accumulation of certain salts of alkali indicates deterioration of soil fertility and its unsuitability for normal growth of many crops

g. Soil temperature and plant growth

Soil micro-organisms show maximum growth and activity at optimum soil temperature range. All crops practically slow down their growth below the temperature of about 9^0C and above the temperature of about 50^0 C. The biological processes for nutrient transformations and nutrient availability are controlled by soil temperature and soil moisture. Soil temperature has a profound influence on seed germination, root and shoot growth, and nutrient uptake and crop growth. Seeds do not germinate below or above a certain range of temperature but Micro-organisms functioning in the soil are very active while a certain range of temperature, which is about 27^0 to 32^0C. It is necessary to know whether the soil temperature is helpful to the activities of plants and micro-organisms and the temperature could be suitably controlled and modified. The various factors that control the soil temperature are soil moisture, soil colour, slope of the land, vegetative cover and general tilth of the soil. Soil temperature can be controlled by regulating soil moisture, proper soil management practices viz. good drainage, proper mulch, good crumby structure, addition of sufficient organic matter help in keeping the soil sufficiently warm and help in the chemical and biological activities in the soil.

Biological properties of soil

A variety of organisms inhabit the soil. They decompose organic matter, fix atmospheric nitrogen, cause denitrification and plant disease. Cultivated soils harbour bacterial, actinomycetes, fungi, algae, protozoa, nematodes, worms, insects and rodents. Specific groups of organisms are responsible for specific activities in the soil. Such activities may be beneficial or harmful to the crop or its yield potential.

Bacteria

They decompose the organic matter and release plant food nutrients like nitrogen, phosphorus etc. nitrogen fixing bacteria like ***rhizobium*** and ***azotobacter,*** and phosporus-solublising bacteria***.*** ***Nitrosomonas*** and ***nitrobacter*** bacteria, which oxidize ammonia to nitrate and nitrate to nitrite compounds respectively, the process is called nitrification. These are generally confined to the surface 20 to 30 cm.layer and work best when there is good aeration, a neutral reaction, soil moisture content at about half of the water holding capacity and temperature between 25^0 c and 38^0 c. Phosphate fertilization of legumes also helps to increase the yield of green matter and more nitrogen is fixed to the soil.

Fungi

These organisms produce microscopic threads called mycelia and ae found in the organic matter of plant roots. Fungi help in breaking down the somewhat resistant parts of the organic matter like cellulose, lignin, gums etc. A large part of slowly decomposing soil humus is made up of the dead remains of fungi.

Actinomycetes

They can grow in deeper layers even under dry conditions of soil, and require less nitrogen. Their main function lies in decomposing the resistant parts of organic matter like cellulose.

Algae

They are microscopic or very minute sized plants having chlorophyll and are usually found on the surface of wet soils of paddy fields. They help in adding organic matter to soil, improving the soil aeration and fixing atmospheric nitrogen e.g. blue-green algae.

Texture and other soil properties and plant growth

Many of the important soil properties are related to texture. Clayey soils show high water holding capacity, high plasticity, and stickiness and swelling whereas sandy soils are conspicuous by the absence of these properties. The most important way in which soil texture affects plant growth is water and with it the nutrient supply. The available water holding capacity of soil is related to soil texture.

Soil structure and plant growth

Soil structure influences plant growth rather indirectly. The pores are the controlling factors governing water, air and temperature in soil, which in turn, govern plant growth. One of the best e.g. of the effect of soil structure on plant growth is the emergence of seedlings in the seedbed. The seedlings are very sensitive to soil physical condition so that there should not be any hindrance to the emergence of tender seedlings and there should be optimum soil water and soil aeration. The soil in the seedbed should have a crumb structure so that the peds are soft and porous and roots of the seedling can penetrate it easily. The hard compact layer impedes root growth.

Soil water

Water is essential for plant growth. Soil is capable of being a storehouse of water and becoming the main source of water for land plants. Soil water plays a significant role in several natural processes- evaporation, infiltration and drainage of water, diffusion of gases, conduction of heat, and movement of salts and nutrients are all dependent upon the amount of water present in soil.

Plants meet their water requirement from water stored in soil.

Effect of crops and cropping practices on soil structure

Crops affect soil structure through their vegetative canopy above the ground and their roots below the ground. Grasses are conducive to well structured soil. Organic residues left by the grassroots, root pressure, pores due to decayed roots and microbial activity in the rhizosphere produce ideal crumb structure. The vegetative canopy protects the soil from the beating action of rain drops and destruction of the structure of the surface soil and prevents crusting. The role of legumes in building up soil fertility is well known. As legumes have place in sound crop rotation practices, the beneficial effect is usually attributed to nitrogen added to the soil by legumes.

Soil Aeration and plant growth

Oxygen is required by microbe and plants for respiration. Oxygen taken up and carbon dioxide evolved are stoichiometric. Under anaerobic conditions, gaseous carbon compounds other than carbon dioxide are evolved. Root elongation is particularly sensitive to aeration. Oxygen deficiency disturbs metabolic processes in plants, resulting in the accumulation of toxic substances in plants and low uptake of nutrients. Certain plants such as rice are adapted to grow under submerged condition. These have large internal air spaces, which facilitate oxygen transport to the roots.

Soil compaction

Soil compaction is the process of increasing dry bulk density of soil, reducing the pore space by expulsion of air through applied pressure on a soil body. Soil compaction creating problems for seed germination, water transmission and aeration. Crusting of soil is a form of soil compaction. The crusts present a serious barrier for seedling emergence. Lowering the exchangeable sodium percentage and incorporation of organic matter prevent crust formation.

Soil Erosion

Ag. Technologies (Soil Mgmt.)

Introduction

Soil and water are most essential for the growth and sustenance plant life. Soil is important as it provide foothold for plants and majority nutrients needs by them. Alongwith soil, water is another important factor essential for all life and production of food. If rainwater not conserved properly will not only cause scarcity and famine but also wash away the soil, which is a valuable national asset. It is therefore the prime responsibility to conserve soil, which is the main capital of the farmer as well as the nation, at all costs. Soil and water conservation involving collective efforts on the part of farmers, technicians and government. Recognising the seriousness of erosion problem, the central govt. established the Central Board of Soil Conservation to assist the states and River Valley Projects. It takes centuries to form one-inch layer of soil but does not take long to lose it by erosion. In Maharashtra, over 70% of the cultivated land has been affected by erosion in varying degrees and 32% of the land have been highly eroded is no longer cultivable. The denudations of forests and vegetation have resulted in floods, which destroy good agricultural land.

Types

Soil erosion is the wearing away, detachment and transportation of soil from one place to another place and its deposition by moving water, blowing wind or another causes.

- **Normal or geologic erosion**

Weathering of parent rock and erosion are natural processes by agencies like water and wind. There is always equilibrium between the removal and formation of soil. There is not many harms done unless the equilibrium is disturbed by some outside agency.

- **Accelerated soil erosion**

The removal of the surface soil from areas denuded of their natural protective cover, grazing of grasses, excessively ploughed the land and expose it to nature accelerates erosion by removing top soil.

- **Wind erosion**

It is caused by strong wind mainly in arid and desert areas. Wind erosion causes dust storm forms sanddunes and buries localities with deposition of sand. Thus fertile lands are rendered unfit for cultivation. It is more common in Rajasthan.

- **Water Erosion**

If the rain occurs in torrents there is not enough time for the water to soak through soil and it run off causing erosion. Soil erosion caused by water can be distinguished in following forms:

i. **Splash Erosion**

It is caused by the falling torrential rain. With this falling the rain drop beat the soil surface into flowing mud which splashes as much as 60 cm. high and 150 cm. away.

ii. Sheet Erosion

The uniform removal of a thin layer or 'sheet' of soil from entire area, takes place in this type of erosion. Sloping land having a shallow loose topsoil overlying a compact subsoil are the most susceptible to sheet erosion which continuously make the soil shallower and decrease crop yield. It can be detected by the muddy colour of the run-off from the fields.

iii. Rill Erosion

It is the removal of soil by run off water through small finger-like channels. It is an intermediary stage between sheet erosion and the gully erosion.

iv. Channel or Gully Erosion

As the volume of concentrated run off increases and attains more velocity slopes, it enlarges the rills into gullies are the most spectacular evidence of the destruction of the soil and often starts along bullock cart tracks, cattle trails and burrows of animals. At an advance stage, gullies result into ravine soils and make the soil unfit for cultivation.

- **Land Slide or Slip Erosion**

This is caused by the pressure of moisture going deep into the soil during heavy rains which being unable to go down further due to hard soil or rocky strata below, move down a big mass of overlying soil on the deep land. Such land slides are more common in ghat areas.

- **Stream Bank Erosion**

Rivers and streams meander and change their course by cutting one bank and depositing sand and silt on the other. During floods, there is considerable damage and large masses of soil, boulders and plants are carried away and deposited down stream. These deposit in turn reduce the transporting capacity of the torrent resulting in overflows and the meandering of the course and in the erosion of the banks.

Factors Affecting Soil Erosion

- **The amount and intensity of rainfall and wind velocity**

The rainfall is most forceful factor causing erosion through splash and excessive runoff. Runoff that causes erosion depends upon intensity, duration, amount and frequency of rainfall. Rain occurred in torrents, as usually in monsoon cause runoff resulting in erosion.

- **Topography with special reference to slope of land**

The speed and the extend of runoff depend of the slope of the land.

According to the laws of hydraulics of four-time increase in slope doubles the velocity of flowing water. This doubled velocity can increase the erosive power four times and the carrying capacity by 32 times.

- **Physical and chemical properties of soil**

The erodibility of the soil is influenced by its texture, structure, organic matter, nature of clay and the amount and kind of salts present. There is less erosion in sandy soil because water is absorbed readily due to high permeability. As organic matter decreases the erodibility of soil increases. Fine textured and alkaline soils are more erodiable. Clay particles are more difficult to detach than sand, but are easily transported on a level land and much more rapidly on slopes.

- **Ground cover, its nature and extent**

The presence of vegetation, retards erosion as it intercepts the erosive beating action of falling raindrops, retard amount and velocity of surface run off, permits more water flow into the soil and creates more storage capacity in the soil.

Damage Caused by Erosion

- **Washing away of fine soil**

The top 18 cm of soil is most important from the point of plant growth. If the top soil is washed away by erosion, the water holding capacity of the soil is decreased and productivity goes down.

- **Deposition of coarse material in low lying areas**

Low lying areas are exposed to the danger of deposition of coarser particles which are washed from higher hilly areas, this makes the soil less productive.

- **Silting of tanks**

Tanks get filled every year during monsoon season by water from catchment area. This water also brings with it large quantities of silt and clay. If the proper care is not taken, reservoirs get silted and their storage capacity is considerably reduced.

- **Lowering of the underground water table**

If surface run off is allowed to go on unchecked, the quantity of water that should infiltrate into the soil is very much decreased.

Soil and Water Conservation Methods

To minimize loss of soil and water and to cultivate land without much harm to the soil, following agronomic and mechanical measures are followed:

A. Agronomic Measure

I. Strip cropping

This consists of growing erosion permitting crops and erosion resisting crops in alternate strip. The soil which flows from the strips growing erosion permitting crops is caught by the alternating strips of erosion resisting crops. Erosion permitting crops- cotton jowar, bajra, etc. The erosion resisting crops- groundnut, matki, hulga (Dolichos biflorus), soybean.

II. Mulching

A mulch is natural or artificially applied layer of plant residues or other materials on the surface of the soil with the object of moisture conservation, reduction of runoff and erosion and soil losses e.g. jowar or bajra stubbles, paddystraw or husk, sawdust etc. The quantity of mulch use @ 5 tonnes per/ha.

III. Crop rotation

Rotation means growing a set off crops in a regular succession over the same field within a specified period of time. Continuous growing jowar or bajra crop causes more erosion, but if followed by a legume crop namely Hulga, Matki or Gram which covers the soil it causes less erosion.

IV. Contour cultivation

Tillage operations viz. ploughing, harrowing, sowing and Inter Cultural should be done across the slope of land this will help creating obstruction to the flow of water at every furrow, which acts like a small bund and result in uniform distribution of water, less runoff and erosion.

V. Planting of grasses for stabilizing bunds

Grasses prevent soil erosion and improved soil structure. Several grasses as well as legumes were tried on bunds should give maximum root growth and canopy coverage and stabilize bunds effectively e.g. anjan, marvel-8, rhodes, thin napier, blue panic, kusal.

VI. Planting of trees and afforestation

Forests conserve soil and water quite effectively. They not only obstruct the flow of water, but the falling leaves provide organic matter, which increases the water holding capacity of soil.

VII. Cashewnut plantation

In coastal districts of Maharashtra, which receive more than 1250mm. Rainfall, cashewnut plantation has been undertaken on hills having slope between 10 and 20 p.c.

A. Mechanical Measures

These measures requiring engineering techniques and structures.

a. Bunding

(i) Block bunding: It was not uncommon to found tals i.e. big bunds across large blocks of sloping lands. These bunds are constructed of earth or stone or both to impound water and arrest soil washed from the fields lying above.

i. Contour bunding

It consists of construction of a series of earthen bunds of suitable sizes along contours at a lateral distance of every 60m, or a fall of 1 to 1.5m.The slope of land is thus broken into smaller and more level compartments which hold soil as well as rain water. The size, cross-section and interbund spacing depends upon the nature of rainfall, soil and slope of the area.

ii. Graded bunding

In high rainfall areas, drainage of surplus water has to be attended to, for avoiding waterlogged conditions of soil. The bunds are therefore slightly graded longitudinally about 7.5 cm, per running 33 m to prevent safe disposal of water into the nala. For safe removal of excess runoff water it is essential to provide suitable waste weirs or outlet structures at proper places so that no damage is done to bunds e.g. Stone outlets, Channel weirs or pipe outlets in low rainfall area,

Grass outlets in heavy soil.

b. Terracing

It is suitable on bigger slope upto 10 p.c. and rainfall is higher than 1250mm. Terrace bunds consist of comparatively narrow embankments constructed at intervals across the slope and the vertical spacing between bunds may varied from 1 to 2 m., depending upon the slope, types of soil, rainfall etc. Bench terracing is done when gradient is stripper than 10 p.c. as in hilly ranges of Himalayas, Sahyadri etc. These terraces are like table tops slopping outwards and provided with stone waste weirs to drain away surface water.

c. Gully or nala control

The slopping sides are planted with grass and trees to prevent its extension and further destruction of cultivated lands and grassland. Small gully can be stabilized by converting them into paddy fields e.g. Check dams, Overflow dams and drop structures.

d. Control of stream and river banks

This should be protected by providing spurs, jetties, rivets and retaining walls. Adjoining areas should be stabilized under permanent vegetation.

Micronutrients in Soil

Ag. Technologies (Soil Magt.)

Introduction

It is known that at least 16 plant food elements are necessary for the growth of plants. These plant nutrients are called as essential elements. In the absence of any one of these essential elements a plant fails to complete its life cycle, the disorder caused can be corrected by the addition of that element. Out of 16 essential element 7 nutrients viz. Iron, Manganese, Boron, Zinc, Cooper, Molybdenum and Chlorine are used by field crops in very small quantities and hence called as micronutrients. These are also called as trace, minor or rare elements. Micro- nutrients are as essential to plant growth as the macronutrients.

Important functions and deficiency symptoms

1. **Iron:**

   Functions – Helps in chlorophyll formation, absorption of other nutrients. Essential for the synthesis of proteins contained in the chloroplasts.

   Deficiency - Causes chlorosis between the veins of leaves, the veins remaining green.

2. **Manganese:**

   Functions- Acts as catalyst in oxidation and reduction reactions within the plant tissues. Helps in chlorophyll formation, supports movement of iron in the plant, counteracting the bad effect of poor aeration.

   Deficiency- Leads to chlorosis in the inter veinal tissue of net veined leaves and parallel vein leaves. In cereals it produce grey streak, white streak dry spot and lip spot, marash spot, streak disease and pahala blight in sugarcane, yellow diseases in spinach and beans.

3. **Boron:**

   Functions- It is a constituent of cell membrane and essential for cell division. Acts as a regulated of potassium/calcium ratio in the plant, helps in nitrogen absorption and translocation of sugars in plant.

   Deficiency- In lucerne yellows and rosetting, snakehead in walnuts, die back and corking in fruits, corking and pitting in tomatoes, hollow stem and bronzing of curd Cauliflower, brown heart disease in table beets, turnips etc.

4. **Zinc:**

   Functions- Constitute of several enzyme system which regulate various metabolic reaction in the plant. Associated with water uptake and water relation in the plant.

   Deficiency- Deficiency symptoms appear in younger leaves starting with interveinal chlorosis leading to a reduction in shoot growth and the shorting of internodes. Mottle leaf, little leaf etc.in the case of trees, the buds of severely deficient maize plants become white, interveinal chlorosis and mottled leaf occur in citrus.

5. **Copper:**

   Functions- Act as "electron carrier" in enzymes, helps in utilization of iron in chlorophyll synthesis. It neutralizes the harmful conditions in certain peat soils when applied in large quantity.

   Deficiency-Variation in deficiency symptoms occurs in case of copper e.g. multiple bud formation, staining and splitting of fruits, dieback of shoots, the marginal or spotted necrosis and cholorsis of leaves.

6. **Molybdenum:**

   Functions- Acts in enzyme systems which bring about oxidation reduction reactions. Essential for the process of atmospheric nitrogen fixation.

   Deficiency –Reduces the activity of the symbiotic and non-symbiotic nitrogen fixing micro-organisms. Produces whiptail in cauliflower, broccoli and other Brassica crops.

7. **Chlorine:**

Functions- The exact role which, chlorine plays in plant nutrition has not yet been clearly defined. It requires for proper plant development e.g. sugarbeets, carrots, lettuce, barley, wheat, cotton and clovers. From the point of view of soil fertility, plants requires one kg of chlorine for each four thousand kg of dry matter which they produce.

Deficiency- Plants display symptoms of wilt, chlorsis, necrosis, and an unusual bronze discoloration on tomatoes.

Soil condition causes to micronutrient deficiency

1. highly leached acidic sandy soils;
2. soils with a high-water table;
3. soils with a very high content of organic matter e.g. peat and muck soils of Kerala;
4. calcareous and saline-alkaline soils very high in pH e.g. UP, Punjab and Bihar;
5. intensively cropped soil with high doses of commercial fertilizers;
6. application of high doses of lime at one time.

Range of micronutrient concentrations required for normal plant growth

Trace elements	**Concentration in ppm (parts per million)**
Fe (Iron)	0.5 to 5.0
Mn (Manganese)	0.1 to 0.5
B (Boron)	0.1 to 1.0

Z (Zinc)	0.02 to 0.2
Cu (Copper)	1. to 0.05
Mo (Molybdenum)	0.01 to 0.05

Source: Chemical fertilizers and range of application

Elements	**Fertilizers-Content**	**Range of application (kg/ha.)**	
		Soil	**Spray**
Iron	Ferrous sulphate- 19% Fe	16.8-56.0	5.6-7.8
Manganese	Manganese sulphate- 30.5% Mn	16.8-33.6	4.5-9.0
Boron	Borax-10.50% B	5.5-56.0	2.3-22.4
Zinc	Zinc sulphate- 21% Zn	2.3-56.0	0.56
Copper	Copper sulphate 24% Cu	5.6-33.6	-
Molybdenum	Ammonium molybdate- 52% Mo	0.07-2.3	0.028-0.035

Chelating compounds

To increase the availability of micronutrients and make them slowly available over a longer period, chelated compounds are formed. For this Chelating agent e.g. EDTA is commonly used. This agent combines with iron, copper, calcium or magnesium to form chelated compounds that supply secondary nutrients of micronutrients. The use of also some synthetic Chelating agents are also used e.g. HEDTA, DTPA, EDDHA, NTA. The use of chelated compounds of micronutrients has become very important for correcting micronutrient deficiencies particularly in horticultural crops.

Methods of application

The common methods of micronutrient application are given below:

I. Soils Application: - The require quantities of materials are broadcast or placed by adding dry soil or fine sand before planting the crop e.g. B,Cu,Zn.
II. Foliar Application: - Low doses of micronutrients are applied through sprays on plant foliage. Crops in younger stages require less solution, while crops more foliage or fruit trees like oranges, require more solution for spraying e.g. Fe,Mn,B.
III. Addition through mixed fertilizers: - Uniform of spreading of the micronutrients essential for different regions are added to the spread fertilizer or to fertilizer mixture used e.g. phosphates mixed with boron, molybdenum or zinc.
IV. Seed soaking: - Low concentration of micronutrient solution is used to soak the seed for about 12 hours before planting e.g. Mo.
V. Seed coating:- Micronutrient mixed with a small amount of soil made into a pest is coated around the seeds, dried and then used for sowing e.g. Mo.

Nutrient fixation in soil

Ag. Technologies (Soil Magt.)

Introduction

For plant growth and development 16 mineral elements are essential. The growing plants have three sources from which they get necessary nutrients: air, water and soil. The number of nutrients obtain form soil is over four times the number of nutrients obtained from air and water. Most of the plant tissues, in general from 94-99.5% is made of carbon, oxygen and hydrogen that is nutrients obtained from soil and water and only 0.5 to perhaps 5-6% of the plant tissue is synthesized from soil constituents.

Forms in which nutrients are utilized by plants

Plants absorb the nutrient from the soil as (i) single nutrient, uncombined with other elements and (ii) essential nutrients combine width other elements to form nitrate, phosphate and sulphate. Mineral nutrients are available to the plant both in ionic and molecular forms. The proportions depending on the nature of the soil solution and the condition. Most of the nutrient uptake by plants is in the form of ions. The ion penetrate the absorbing tissues of plants with greater ease than the molecular forms or compounds or salts. Most of the nitrogen is absorb in either the ammoniacal or nitrate form. The nitrate ion can be superior for use by most plants under many varied soil condition such as strongly alkaline, strongly acidic, water logged or dry regions. However, in rice cultivation ammoniacal ion has proved superior. The use of a particular phosphate ion by plants is determined largely by the pH of the soil solution. In alkaline condition the PO_4= ion is predominant. In neutral and slight to moderate acid condition the HPO_4= and H_2PO_4 ions prevail. While in strongly acidic condition the HPO_4=ion is largely predominant. Sulphur is absorbed mostly in the form of SO_4= iron under favourable condition for oxidation by micro-organisms. The SO_2 (gas) molecule from the air can be utilized by green plants to some extent. Among the trace elements with different forms of ion, iron manganese and copper are absorbed largely in divalent form, while boron and molybdenum are absorbed in monovalent ionic forms. The predominant of any ionic form is largely governed by the oxidation-reduction condition of the soil. If the soil is well aerated the ion of higher valance in each case tends to predominate. In poorly drained soil with reduction conditions, ion with lower ionic valence will be present. In the process of nutrient absorption, the nutrient ions are transferred by a mechanism of ion exchange across the interfaces of soil and root into the cellular structure of the plant.

Fixation of major nutrient

- **Sources of N to the soil**

1. Rainfall: Rain drops when come to an earth, minute quantity of N is dissolved in it and added to soil. N oxides formed due to atmospheric electrical discharges, sulphur, hydrogen and oxygen are also added to soil through rainwater. 2-3 kg N/ha.

2. Soil Reservoirs: Parent material.

3. Crop Residues, Green manures, FYM, compost etc. Proteins, amino acids, amino sugars.

4. Atmospheric N fixation

By symbiotic and nonsymbiotic N fixing organisms.

- **Process of mineralization**

The process of breakdown of organic nitrogen compounds from the organic materials by the microorganisms to the mineral nitrogen i.e. NO_3N is termed as minerlization. The process takes place essentially in three steps;

a. Aminization – Heterotrophic

Organic matter $\xrightarrow[\text{Heterotrophic Bacteria \& fungi}]{\text{Group 1 ecomposition}}$ Proteins $\xrightarrow[\text{Hetero trophic Bacteria}]{\text{Group II}}$ Proteins $\longrightarrow$ R NH_2+CO_2+ Energy+other products

a. Ammonification (Mineralization)

The amines and amino acid so released are further utilised by still other groups of heterotrophs with the release of ammoniacal compounds and step is terms as ammonificaiton.

$$R\text{-}NH_2+HOH \xrightarrow{\text{Heterotrophic}} NH_3+R \xrightarrow{\text{OH+Energy}}$$

The ammonia so released is subject to several fates in the soil.

i. It may be converted to nitrites and nitrates by the process of nitrification.

ii. It may be absorbed directly by higher plants.

iii. It may be utilised by heterotrophic organisms in further decomposing organic carbon residues.

iv. It may be fixed in a biologically unavailable form in the lattice of certain expanding type clay minerals.

a. Nitrification

Some of the NH_4^+ (ammonia) released by the process of ammonification is converted to nitrate nitrogen. This biological oxidation of ammonia to nitrate is known as nitrification. It is a two step process in which the ammonia is first converted to nitrite (No^-_2) and then to nitrate (No_3). Conversion to nitrite is brought about largely by a group of obligate autotrophic bacteria known as *Nitrosomonas.*

$$2NH_4+3O_2 \longrightarrow 2NO_2+2H_2O+4N^+$$

The conversion from nitrite to nitrate is effected largely by a second group of obligate autotrophic bacteria termed *Nitrobacter.*

$$2\ No_2 + O_2 \longrightarrow 2No_3$$

Some few heterotrophs mostly fungi will also produce nitrates, Nitrosomonas and Nitrobacter are usually referred to collectively as the Nitrobacteria.

Retention of ionic nitrogen in soil

The cationic nature of NH_4+ permits its absorption and retention by soil colloidal material. It is necessary that the soils have a sufficiently high exchange capacity to retain the added ammonium nitrogen or it will be removed in percolating water. Sandy soils with low exchange capacities permit appreciable movement of ammonium N to the soil. Once ammonium is nitrified it is subject to leaching Nitrate N is completely mobile in soils and within limits moves largely with the soil water. Under conditions of excessive rain it is leached out of the upper horizons of the soil. During extremely dry weather nitrates will accumulate in the upper horizons of the soil or even on the soil surface when capillary movement of water is possible. Both ammonium N and No_3N can be immobilized by soil microflora and N is not lost by leaching.

- Ammonium fixation

One of the possible fates of NH_4+ nitrogen in soils is its fixation by clays with an expanding lattice. It comes about by a replacement of NH_4+ for interlayer cations in the expanded lattice or clay minerals. The fixed ammonium can be replaced by cations which expand the lattice (Ca^{2+}, Mg^{2+},Na^+,H^+) but not by those that contract it (K^+,Rb^+,cs^+). The clay minerals largely responsible for ammonium fixation are montmorillonite, illite and vermiculite. As a rule, fixation occurs to a much greater extent in subsoils than in topsoils. The moisture content and temperature of the soil will affect the fixation of added ammonium compounds. Freezing and drying of soils increase ammonium fixation.

- Nitrogen fixation

Nitrogen fixation is also a biological process. Some species of bacteria, algae actionmycetes can absorb free nitrogen gas N_2 and convert it to ammonium NH_4+ which plants can use. Some nitrogen fixing bacteria are free livings, such as *Azotobacter* and require carbohydrates in their substrate. Others are symbiotic, such as *Rhizobia*, that infect root mainly of legumes. The infected roots eventually from nodules in which the free nitrogen is fixed from them it is translocated to other parts of the plant. However the account of nitrogen fixation is reduced when nitrogen is applied as fertilizer. Other microorganisms known to free nitrogen as blue green algae, which flourish in rice, paddy. Among anaerobic bacteria one should mention *clostridium*.

Phosphorus

Phosphorus is the second most important plant nutrient next to N for plant growth and development. Retention refers to that portion of the P which is loosely held by the soil and which can generally be extracted with dilute acids. This P is largely available to plants.

Phosphorus compounds in soils

- Forms of organic phosphorous

Phospholipids
ucleic acids.
Inositol phosphates

- Inorganic soil phosphorus

Orthophosphate ions- H_2Po_4 and HPO_4

Inorganic P availability in acid soils

1. Precipitation by Fe, Al and Mn

   These ions found in strongly acid mineral soils. These ions combine with Phopsphate to form insoluble compounds of Al, Fe and perhaps Mn. The resulting compounds may be precipitated from solution or absorb on the surface of iron and aluminum oxides or on clay particles. As clay becomes more acid they tend to contain more absorbed Al and Fe. Hence in acid soils the products of P fixation are largely complex phosphates of iron and Al.

2. Fixation by silicate clays

This is the another mechanism of P fixation. It is the reaction of phosphates with silicate clays. Soil clays are composed of layer of silica and Al combined to form silica alumina sheets. Phosphate ions may combine directly with these clays by (a) replacing a hydroxyl group from Al atom of. (b) forming a clay ca phosphate linkage. It is known that clays with low Sio2, R2o3 ratio will fix larger quantities of phosphate that will clays with a high ratio.

Inorganic P availability in alkaline soils

In alkaline soils, phosphate precipitation is caused mostly by calcium compounds. Such soils are plentifully supplied with exchangeable ca and in most cases with $CaCo_3$. Available phosphate will react with both the ca ion and its carbonate.

1. An increase in the pH favours the formation of diphosphate ions. In addition the solubility of the calcium orthophosphates decreases in the order of mono-di-tricalcium phosphate.

2. In alkaline soils that contain $CaCo_3$ is responsible for decreasing the activity of P. Phosphate ions coming in contact with solid phase $CaCo_3$ are precipitated on the surface of these particles. Finer the size of $CaCo_3$, more will be "P" fixation.

3. For P fixation in alkaline soils the retention of phosphate by clays saturated with Ca. Clays saturated with these ions can retain greater

amount of P than those saturated with sodium or other monovalent ions. The concentration of phosphorus in the soil solution in alkaline or calcareous soils will be largely governed by three factors as below:-

1. Ca^{2+} activity.
2. The amount and particle size of free$CaCo_3$ in the soil.
3. The amount of clay present.

The activity of phosphorus will be lower in those soils, that have a high Ca^{2+} activity, a large amount of finely divided. $CaCo_3$ and large amount of calcium saturated clay. In order to maintain a given level of phosphate activity in the soil solution, it is necessary to add large quantities of phosphate fertilizers to such soils.

Factors affecting phosphorus retention/fixation in soils

1. Type of clay (1:1) Kaolinite

   Phosphorus is retained to a great extent by 1:1 than 2:1 clays. Soils high in Kaolinitic clays such as those found in areas of high rainfall and high temperatures, will fix or retain larger quantities of added phosphorus than those containing the 2:1 type. Soils containing large amounts of clay will fix more P than those containing small amounts. The more the surface are a exposed with a given type of clay, the greater the amount of fixation taking place.

2. Time of reaction

   The greater the time the soil and added P are in contact the greater the amount of fixation. The time between application and utilization of P is short in soils with high fixing capacity. This time period will determine whether the fertilizer P should be applied at one time or in split application.

3. Soil reaction

   In most soils, P availability is at a maximum in the pH range 5.5 to 7.0 decreasing as the pH drops below 5.5 and decreasing as this value goes above 7.0. E.g. 5.5-7-fixation by hydrous oxides of Fe, Al, Mn, 6-8-fixation by silicate minerals, 6.5-8.5-fixation by the calcium.

4. Temperature

   The soil of warmer climates are generally much greater fixers of P than the soils of more temperate region.

5. Organic matter

Addition of organic materialize either through green manuring or decomposed manures increase availability of soil and added P during the decomposition process by the evolution of Co_2. This gas when dissolved in water forms carbonic acid, which is capable of decomposing certain primary soil minerals in calcarious and acid soils. Co_2 production plays important role in increasing P availability.

Potassium fixation

Potassium is the major nutrient, which imparts increased vigour and disease resistance to plants and improves the quality of final products. Relative proportions of the total soil potassium in available, slowly available and readily available forms only 1-2% is rated as readily available of this 90% is exchangeable and only 10% appears in the soil solution at any time.

Potassium fixation: Slowly available forms

The potassium fixation is the result of reentrapment of K^+ ions between the layers of 2:1 minerals especially illite. Alternate wetting and drying of 2:1 type clay minerals may aid in slow release of fixed potassium. In the presence of vermiculite, illite and other 2:1 type minerals, the potassium of such fertilizers as m/p not only became absorbed but also may become definitely fixed by the soil colloids.

Non exchangeable K ⇌ Exchangeable K ⇌ soil solution

Factors affecting potassium fixation

1. Clay minerals

   The soils containing 2:1 type of clay minerals like illite, vermiculite and montmorillonite can fix considerable amounts of potassium. A laterite soil containing kaolinite type or clay mineral fixed very little amount of potassium. The potassium and ammonium ions are attracted between the crystal units by the same negative charges responsible for the internal absorption of these and other cations. The tendency for fixation is grates in minerals where the major source of negative change is in the silica sheet.

2. Potassium concentration

   An increase in K concentration is likely to increase K fixation because more K goes into the exchange complex by mass action.

3. Wetting and drying

   The K fixation is strongly influenced by wetting and drying of soils. Fixation occurs when initial level of exchangeable and soluble K is high and release occurs when the level of such K is low. Thus, the process of drying favours attainment of equilibrium in distribution of K in soils.

4. Temperature

   Higher temperature favours dehydration and contraction of the crystal lattice resulting higher K fixation.

5. Soil pH

Increase in soil pH leads to higher fixation of potassium. But all the soils may not exhibit this phenomenon.

6. Exchangeable cations

   The size of K and other ions replacing K is important in K fixation. The cations of smaller size of the hydrated ions can easily enter into clay lattices and replace some of the fixed potassium.

7. Timek fixation proceeds from surfaces and edges to the interior of the soil particles.

8. Texture Finer the texture more is the k fixation.

9. Anions The k fixation from KH_2PO_4 was greater than from kcl and k_2so_4, but there was no difference in k fixation from k_2so_4 and kcl.

10. Organic matter The addition of organic matter decreases the k fixation by inorganic colloids.

Sulphur

It is an essential constituent of many proteins, enzymes and certain volatile compounds and helps in root growth, seed formation and nodule formation. Forms of sulphur: sulphides S^{--}, sulphates SO_4, organic forms and elemental sulphur.

Role of sulphur compounds in soils

Sulphur acts much like nitrogen as it is absorbed by plants and micro organisms and moves through the sulphur cycle.

a. Mineralisation

Organic sulphur	→	Decay Products	→	So_4^{2-} + H^+
(protein and other organic combinations)		(H_2S and other sulfides)		Sulphates

b. Immobilisation

   Immobilisation of inorganic forms of sulphur occurs when low sulphur, energy rich organic materials are added to soils not plentifully supplied with inorganic sulphur only when the microbial activity subsides does the inorganic sulphate form again appear in the soil solution. These facts suggest that, like N, sulphur in soil organic matter may be absorbed with organic carbon in a reasonably content ration. 130:10:1.3, AC/N/S ratio.

c. Volatilisation

During the microbial breakdown of organic materials, several sulphur containing gases are formed e.g. H_2S,CS_2,Cos,CH_3Sh. All are more prominent in anaerobic soils.

Sulphur oxidation and reduction

During the microbial decomposition of organic sulphur compounds. Sulphides are forms alongwith other incompletely oxidized substances such as elemental sulphur, thiosulphates and polythionates. In poorly drained soils the sulphide ion will react immediately with iron or manganese which in anaerobic conditions would be present in the reduced forms.

$$Fe^{2+} + S^{2-} \longrightarrow FeS$$
$$Mn^{2+} + S^{2-} \longrightarrow MnS$$

Sulfites, thiosulphates and elemental sulphur are rather readily reduced to the sulfide form by bacterial and other organisms.

Soil Management for sustainable agriculture

Ag. Technologies (Soil Magt.)

Introduction

With the current foodgrain production standing at abut 200 million tonnes, India needs to produce an additional 5-6 million tonnes of foodgrains annually in the next decade to meet the requirement of an estimated population of nearly 1120 million in 2010 AD. This high population also necessitates significant increase in the production of other agricultural products like oilseeds, cotton, animal products, fruits, vegetables etc. The added problem is that, now we will have to produce more food and other agricultural commodities under conditions of diminishing per capita arable land and irrigation water resources and expanding biotic and abiotic stresses.

Commercialisation of agriculture in response to domestic and world market changes will induce drastic shifts in cropping patterns and resource use. Nearly all agricultural production of the future must come from productivity of the soil, which is now mostly sick and substandard.

Sustainability is defined as "the successful management of resources to satisfy changing human needs while maintaining or enhancing the quality resources". It is measured as the ratio of output to input taking into account stock depletion.

Soil Management

Land, water, climate, flora and fauna are the basic natural resources for agricultural development, which are subject to various kinds of deteriorating influences. Production of more food require new agricultural technologies and management system and providing increased productivity per unit of plant, water, energy, labour and investment by suitable location, specific crop production technology, tillage operations, seeding, weed control, water and fertilizers application and crop management. Because of continuous cultivation over centuries and intensification of agriculture in recent years, there has been progressive and substantial depletion of the soil reserves. Of late, secondary and micronutrient deficiencies are also emerging and the crop response to these nutrients is increasing. The factors responsible for higher yield are high soil productivity, supply of balance crop nutrients are the most important. Soil productivity is based on the mineral composition and structure of the soil, depth and drainage facilities, organic matter, intensity of earthworm and microbial activities. Fairly well productive soil in combination with assured irrigation and optimum supply of nutrients can enhance the crop yields by 200-300%. Despite increasing use of chemical fertilizers over the years, there has been continuos nutrient mining of the soils. The nutrient remove from the soil for production of foodgrains and other agricultural crops far exceeds the nutrient applied. The threat to long term sustainability of agricultural is not due to alleged excessing use but primarily due to under use of fertilizer and the resultant nutrient mining of the soils. This is necessary for maintaining soil and ensuring sustainable agriculture.

Management Practices

Soil productivity can be enhanced through following practices:

- Soil Testing

Nutrient supplying power of soils, crop responses to added nutrient and amendment needs can safely be assets through soil testing choosing of right targets and application for appropriate amounts of nutrient, help to sustained soil fertility and crop yields.

- Soil and water conservation

To avoid loss of productive soil, agronomical and mechanical measures namely contour bunding, strip cropping, establishment of live hedges, mulching etc. should be followed.

- Use of organic manure and bio-fertilizers

To maintain or to improved soil fertility physical and chemical properties of soil and increased water holding capacity of soil use of organic manures viz. FYM compost, vermi compost, rural agricultural waste, tank silt application will help to built the soil organic matter base as a reliable index of fertility. Earthworms occuring in the soil are an indicator of the agro eco-system's health for stable aggregation of clay organic matter complexes and efficient nutrient recycling.

- Improving physical condition of soil

Physical constraints affecting productivity and cultivation practices e.g. hard pans can be corrected by breaking (deep tillage), compaction for excessively permeable soils, preventing crust formation by organic mulching.

- Improvemental problematic soils

For favorable crop production salt affected soils can be improved by adding soil amendments viz. Acidic soils- Liming, Alkaline soils- Gypsum, sulphur, pyrites and adding soil conditioners e.g. crop residues, manures and other organic substances.

- Increasing use of secondary and micro nutrients

Application of major nutrients through chemical fertilizers has a direct influence on crop yields, also crops shows secondary and micro nutrient deficiencies and crop response to these nutrients hence attention has to be paid to increasing use of these nutrients which have appeared as major limiting factor.

Management of black soil

Ag. Technologies (Soil Magt.)

Introduction

Soil serves as a natural medium for the growth of plants. Soils of one location may vary from that of others depending on the genesis and environmental factors. Soil contains four major components, mineral material, organic matter, water and air, the proportions of which vary with respect to time, site and depth. The soils of India are derived from a wide variety of minerals. They differ physically, chemically and biologically. Their distribution does not follow any regular pattern. The soils of India are broadly divided into five major groups: - Alluvial soil (Entisol, Inceptisol, Alfisol), black soil (Vertisol, Inceptisol, Entisol), red soils (Alfisol, Inceptisol, Ultisol), laterite soil (Alfisol, Ultisol, Oxisol), and desert soil (Entisol, Aridisol).

Black Soil

The typical soil derived from the Deccan trap is the *regur* or black cotton soil. These soils vary in depth from shallow to deep. It is common in Maharashtra, western parts of Madhya Pradesh, parts of Andhra Pradesh, parts of Gujarat, and some parts of Tamil Nadu. Many black soil areas have a high degree of fertility. They are darker, deeper and richer and are constantly enriched by the additions washed down from the hills. In the uplands, these are poor, light-coloured and thin.

Black soils are highly argillaceous, very fine-grained and dark and contain a high proportion of calcium and magnesium carbonates. They are poor in P_2O_5, N and organic matter. These soils contain abundant iron and fairly high quantities of lime, magnesia and alumina.

Problem

These soils have high plasticity and stickiness. They are very tenacious and exceedingly sticking when wet. Owing to considerable contraction on drying large and deep cracks are formed. Thus cracking on drying and water logging are the major problem of black soils alongwith low in nitrogen, organic matter and phosphorus.

Management

Successful farming concerns the appropriate management of soils, plants and the environment in such a way that a maximum return can be obtain not only in a season or year but also over centuries. The most important consideration in soil management is the correct application of the relationship among the soil, the environment and the crop to be grown. Soil management varies according to the soils and their situation in the land the climatic conditions, biotic influences and crops to be grown. For black soil following measures are taken:

- Good soil tilth

It is the first feature of good soil management which means suitable physical condition of the soil and implies satisfactory regulation of soil moisture and air, also it minimizes erosion hazards. These soils, being self ploughed need not to plough every year. Ploughing once in 3 years.

- Proper drainage

Due to poor drainage of excess water, water logging conditions occur in these soils, hence proper drainage should be provided to minimize the damage cause due to excess water.

- Irrigation frequency

In deep clay soils a huge quantity of water is lost in filling up cracks before it reaches saturation level and in flowing further to cover the entire area; if the clay soils are not irrigated immediately after development of small cracks these cracks deepen on widen resulting in tearing of roots on and accelerate, evaporation from the manifold area exposed due to vertical cracking. Under such situation the frequent application of light irrigation may be needed.

- Addition of organic matter

Due to low in organic manures and nitrogen, the productive capacity of the soil should be improved and maintained by providing adequate organic manures and plant nutrients through fertilisers and by including legumes in the rotation and the use of biofertilisers.

Soil Management for dryland area

Ag. Technologies (Soil Magt.)

Introduction

Dry farming or dry land farming is the practice of crop production entirely with rain-water received during the crop season or on conserved soil moisture in low rainfall areas of arid and semi-arid climates and the crop may face mild to very severe moisture stress during their life cycle. Dry land farming is characterized by having:

a. limited rainfall less than 800 mm,

b. shortage of moisture availability,

c. growing season less than 200 days,

d. single crop or intercropping system and

e. having constrains of wind and water erosion.

Soil types in dryland areas

Five types of soils observed are black, alluvial, red (laterite and lateritic), sierozems and submontane soils. In the north and northwest of the country, alluvial, sierozemic and submontane soils predominate. In central and south India, black and red soils occupy the highest area. In the higher rainfall regions and coastal areas, the laterites and lateritic soils predominate.

a. Black soils

The black soils are deeper, clay to clay loam and characterised by low permeability and high water holding capacity. Low infiltration rate, high plasticity and stickiness, low organic matter content, high CEC, the calcareous nature and slightly alkaline reaction, pose problems of management practices, Vertisoils, when kept fallow during Kharif, are exposed to soil erosion hazards.

b. Red soils

The red soils are light textured, shallow to medium in depth and usually underlain by compact subsoil, fairly porous and low water holding capacity. Soils are prone to erosion and surface crusting. Because of crust formation run off Alfisols is more than in Vertisols. Crusting just after seeding results in the poor emergence of seedlings, particularly in the case of small seeded crops such as finger millet and pearl millet.

c. Alluviai soils

These soils are fairly level, deep, light to medium in texture with favourable physical characteristics and good permeability. Small showers are useful and there is the utilisation of most of the water held by the soil due to low moisture content at wilting point.

d. Sierozemic soils

Very deep alluvial sandy loams, low soil moisture storage, instability of soil structure, and poor soil fertility is the major problems of soil management in the desert ecosystem. High wind velocity leads to servere wind erosion. Soil drifting leads to soil and nutrient losses. Surface crust formation after sowing following light showers limits the desirable crop stand. These soils are observed in Dantiwada, Hisser and Jodhpur.

e. Submontane soils

Such soils are distributed in the dry subhumid environment of Hosiarpur in Punjab and Rakh Dhiansar in Jammu and Kashmir and in the humid tract of Dehradun. The lands are sloping, the soils range from loamy sands to sandy loams, silty loams and clay loams with soil moisture storage capacity improving in that order. Soil crusting occur in soils of dry and sub-humid regions.

Constraints

Edaphic Problems associated with dryland farm.

a. Poor and marginal lands with soils low in fertility and productivity;
b. Uneven topography with high erodability;
c. Difficulty in workability particularly in Vertisols;
d. Shallow or very deep in depth with extreme permeability;
e. Low moisture storage and release capacity particularly in Alfisols;
f. Presence of dissolved injurious salts in ground water;
g. Problem soils with respect to soil reaction (pH) and high concentration of soluble salts in the surface soils;
h. Water logging in level lands; flooding and breaking small field bunds resulting in poor conservation of soil and water;
i. Movement of sand and soil;
j. High surface crusting that leads to poor crop stand and high cracking to a high rate of evaporation and mechanical injury to roots.

Management Techniques

Reduction of moisture loss due to Evaporation and Transpiration

Following measures are taken to reduce the loss of moisture received by the soil.

a. growing early maturing adaptable crop varieties with a deep and ramified root system and with a reduced number, size and horizontally orientation of leaves.

b. maintaining optimum plant population per unit area.

c. sowing crops either in dry soil anticipating rainfall suitable for early crop establishment with the first shower, and subsequent growth and development with subsequent rainfall, or in optimum soil moisture but with a minimum expenditure of seasonal moisture for land preparation and sowing;

d. keeping the field free from weeds,

e. adoption mixed or intercropping to utilise the slow growth phase of wide spaced crops, to restore soil fertility and to check soil and water loss,

f. using mulches,

g. using agri-chemicals;e.g. anti-transpirants, plant modifiers or growth retardants, desiccants or defoliants, crop ripeners, anti-evaporants, antiseepage.

Cropping systems

Cropping systems differ according to climate and soil types. The areas with 400 to 750 mm annual rainfall, mono cropping with traditional long duration crops is common. Generally adaptable crops are cercals, oil-seeds, pulses.

When the rainfall is between 500 to 700 mm with a distinct period of moisture surplus, the intercropping system can be adopted. Intercropping facilitates the growing of either cereal + legume or legume + legume. e.g. are: sorghum + pigeonpea, pearl millet + pigeonpea, sorghum + green gram, sorghum + soybean, groundnut + pigeonpea and foxtail millet + pigeonpea.

In areas with more than 750 mm annual rainfall with a soil storage capacity of 150 mm or more of available moisture sequential cropping is possible. e.g. pulses and oil-seeds, rice followed by chick-pea, maize followed by chick-pea, sorghum or green gram followed by safflower or sorghum- chick-pea and maize-chick-pea.

Mechanical Methods

- Advantages

1. These break up the slope.
2. Intercept runoff before its volume and velocity become sufficient to cause serious erosion
3. gives more time for infiltration
4. water is diverted into the channels down safe gradients of suitable discharge or outlet points which carry away water in such a way as to

minimize erosion damage to other land and

5. Finally leading to better conservation of run-off water for agriculture.

- Methods

a. Contour bunding

The bund section is 1.61 m^2 in Vertisols and 1.05 m^2 in Alfisols. The vertical distance is about 0.9 m. The area occupied is upto 5.0 per cent by the bund and the area lost from cultivation due to stagnation in Vertisols would be 10 to 15 per cent.

b. Graded bunding

Graded bunds are of 0.8 m^2 cross section in Vertisols and at vertical internal of 0.7m with a channel on the upstream side. The area lost due to the structure would be not more than 3-5 per cent and there would be no water stagnation and graded bund with grassed waterways and box-type masonry drainage outlets in arable fields.

c. Tie-ridging

The practice of tie-ridging, where adjacent ridges are joined at regular intervals by barriers or ties of the same height, allows the water to infiltrate and prevent run-off except during intense storms. This method is adequate in moderate rainfall areas, except on very steep slopes.

d. Bench terracing

On steeply sloping lands, the slopes where such terraces are found useful vary from 6 to 30 per cent. Bench terraces with 100 m length, longitudinal grades in the range of 0.2 to 0.8 per cent are recommended for Alfisols of high rainfall regions.

e. Ploughing

Ploughing across the slope and growing low value crops in catchment areas, the ploughing of deep soils should be done once in three to four years immediately after *rabi* crops. The light, shallow and medium soils should be hoed instead of ploughing which help to receive and retain moisture.

f. Reclaiming problem soils

Reclamation of Acidic Alkaline and Saline soils should be reclaim by adding lime, gypsum, sulphur, or pyrites respectively. Growing high value crops in level run-off concentrated strips and incorporating a liberal quantity of organic matter.

Maintenance of soil fertility and yield stability

Dryland areas have low yields and high yield fluctuations. The maintenance of soil fertility is a problem in such areas as for a considerable period of the year the soil remains uncropped and there is a loss of plant nutrients, loss of the fertile surface due to erosion leads to a decline in soil fertility to build up soil fertility and reduce the fluctuation of crop yield.

a. the combined use of farmyard manure and green manure with inorganic fertiliser,

b. the incorporation of crop residues,

c. the inclusion of fodder-legumes/legumes in the cropping system/rotation,

d. the use of bio-fertilisers,

e. suitable methods of application of fertilisers, and mulching ,

f. checking loss of surface soil by using soil stabiliser and chemicals e.g. Na_2,Co_2,polythene sheet, mulches and plastic sheets.

g. developing small agricultural watersheds for run off collection and recycling for life saving irrigation to crops in moisture stress,

h. allowing a portion of the holding as chemical or legume fallow which on cultivation provides a substantial yield during famine,

i. adopting alternate land use planning in conjunction with regular cropping to improve the income of the farming families from fibre, fuel, fruit, furniture-timber, fodder and farm animals along with food.

Conservation of soil and water in dryland areas are inter-related and where one is tried the other is also achieved.

Biophysical Management of soil

Ag. Technologies (Soil Magt.)

Soil biology

The dead plants contribute to the formation of soil organic matter, which in turn provides food, energy and nutrients to microorganisms and also higher plants – a process of cycling of plant nutrients. Continuous decay of plant roots adds organic matter to soil, thereby changing the soil properties, viz. Soil aggregation, cation exchange capacity, water and nutrient retention capacity, etc. of soil. If the vegetation is removed, the soil characters change completely. When the roots decay, the vacant space makes room for water and air to move in.

Soil microflora

Biological nitrogen fixation plays an important role in the economy of crop production. The microbes in this class of microflora are, besides bacteria, fungi, actinomycetes and algae. Of these, bacteria are the most abundant in soil, next in order are actinomyeetes, followed by fungi. Soil microorganisms are divided into two broad groups – heterotrophs and autotrophs.

Factors

- **Moisture: -** In the presence of excess water, waterlogging, anaerobic condition occur the aerobes become suppressed and inactive. In the absence of adequate moisture in soil, some of the microbes die due to tissue dehydration and some of them change their form into resting stages of spores or cysts.

- **Temperature: -** Temperature is the most important environmental factor influencing the biological processes and the microbial activity. When the temperature is low, the number and activity of microorganisms fall. Most of the soil organisms are mesophiles and grow well between 15^0C and 45^0C. A temperature of 37^0C is considered to be optimum for most mesophiles.

- **Aeration: -** Microbes consume oxygen from soil air and give out carbon dioxide. In the absence of such gaseous exchange, carbon dioxide accumulates in soil air and becomes toxic to the microbes. Rate of oxygen intake and simultaneous evolution of carbon dioxide are measures of microbial activity. Direct sunlight is injurious to most of the microorganisms except algae.

- **Reaction: -** Bacteria prefer near neutral to slightly alkaline reaction between pH 6.5 and 8.0; fungi grow in acidic reaction between pH 4.5 and 6.5; actinomyeetes prefer slightly alkaline conditions.

- **Food: -** Well-aerated soil rich in organic matter is an essential prerequisite for maximum number and activity of heterotrophic microorganisms. The microbial cells undergoing senescence serve as a source of food for the organisms.

- **Soil factor: -** A soil in good physical condition has good aeration and moisture supplying capacity, which are so essential for optimum microbial activity.

Soil bacteria

- **Function: -** Through a number of transformations and biochemical reactions in soil and thereby directly or indirectly help nutrition of biological fixation of nitrogen-symbiotic and non-symbiotic; decomposition of carbohydrates and lignins; decomposition of proteins with the liberation of ammonia or ammonification, nitrification and denitrification, the transformation of carbon, nitrogen, phosphorous, sulphur, iron, manganese etc. All these processes play a significant role in plant nutrition. The process of conversion of molecular nitrogen into complex proteins through the agency of biological organisms is known as biological nitrogen fixation. Symbiotic nitrogen fixing bacteria e.g. *Rhizobium* and Nonsymbiotic nitrogen fixing bacteria e.g. *Azotobacter, Clostridium pasteurianum*

- **Nitrogen transforming bacteria: -** nitrogen is utilized by micro-organisms and higher plants in inorganic form as nitrate or ammonium. The complex proteinaceous and nitrogenous organic compounds are broken down to produce ammonia through a microbiological process known as ammonification and the microbes responsible for this are ammonifiers or ammonifying bacteria. In nitrification, first, nitrites are formed by nitrite forming bacteria (*Nitrosomonas*) and then to nitrate by nitrifying bacteria or nitfifier *(Nitrobacter*). The immobilized nitrogenous is dead bodies of the organisms is again converted by microbes into inorganic forms, ammonium or nitrate, which can be utilized by plants and micro-organisms.

- **Denitrifying bacteria or denitrifiers: -** Denitrification is the process by which nitrates are reduced to oxides of nitrogen and even too gaseous nitrogen. The bacteria, which are responsible for this transformation, are known as denitrifying bacteria or denitrifiers. e.g. *Pseudomonas, Bacillus* and *Paracoccus*. These microbes are aerobic, but Denitrification mostly takes place under anaerobic condition.

Soil Fungi

Fungi are heterotrophic plants larger than the bacteria. Those that live on the dead tissues of organic substances are saprophytic. Fungi may be regarded as the scavengers who will decompose in soil almost anything of organic nature that bacteria cannot tackle and many of them serve as food for the bacteria.

- **Cellulose and hemicellulose decomposing fungi**

In acid soils, the fungi are the main decomposers of cellulose as under acidic conditions, bacteria and actinomycetes become inactive. In acid soils, *Penicillium* and *Trichoderma* take part in cellulose decomposition, whereas in other soils the fungi species are *Aspergillus, Fusarium*, etc*.*

- **Humus forming fungi**

Certain species of fungi, *Alternaria, Aspergillus*, etc. produce substances similar to humic substances in soil and may be important in the synthesis of soil humus. The black or dark brown colour of soil humus may be due to their presence.

Soil Actinomycetes

Actinomycetes have characteristics, which are transitional between bacteria and fungi and are sometimes called fungi-like bacteria. Actinomycetes are more abundant in dry soil than in wet soils and more in grassland and pasture soils than in the cultivated soils. They are responsible for the decomposition of the more resistant organic matter of soil and produce a number of dark black to brown pigments, probably contributing to the dark colour of soil humus.

Soil algae

Soil algae are microscopic, chlorophyll containing organisms, being the simplest chlorophyllous plants. Moisture and adequate sunlight are the most significant environmental conditions influencing the algal population. One of the important roles of certain strains of blue-green algae is the fixation of nitrogen from air.

Soil macrofauna

- **Earthworms: -** They transform the food so as to be more beneficial for the higher plants. These animals are more abundant in moist soils having high organic matter and undecomposed plant residues. They are more common in fine textured soils than in the coarse sandy soils.

- **Moles: -** Molehills, frequently observed in some fields, are composed of subsoil deposited by moles. They need a good reserve of calcium in soil.

- **Ants: -** More active in humifying insects than plants.

Soil Microfauna

- **Soil protozoa**

Form only a small part of the soil population. They are more abundant in surface soil. Feeds on decaying organic matter are called saprohytic; those on earthworms, other nematodes, etc. are predatory, and those on roots of higher plants are parasitic. As they feed on the bacteria and actinomycetes, they probably help to maintain a favourable balance of the microflora in soil. Nematodes are the abundant soil microfauna in soil. They cause loss of vigour of the root system and make plants growing in nematode infested soil liable to diseases.

- **Soil viruses**

The viruses in soils are known to parasitize bacteria and are specifically known as bacteriophages. Clay and organic matter in soil adsorb bacteriophages and thus cause their retention and spread in soil.

Beneficial role of soil organisms

The soil organisms play a significant role in the life cycles of plants and animals through a number of processes such as decomposition, synthesis and transformation. The most important reactions which the micro-organisms carry out and have significant bearing on soil properties and plant growth are decomposition of organic matter and synthesis of humic substances in soil, biological fixation of nitrogen, microbial transformation of nutrients and nutrient recycling in soil. From the animal and plant bodies, through processes of decomposition, nitrogen enters into the bodies of soil organisms and organic substances (humus) in soil and is recycled through plants and animals. Carbon and nitrogen cycles are the two major biological processes, which take part in the decomposition of added organic matter to soil and formation of humus substances in soil.

Synthesis of humus substances in soil

The carbon and nitrogen cycles show the probable pathways of breakdown of added organic substances in soil. They ultimately lead to the formation of microbial cells in soil and soil organic matter. The main partners are plants, microorganisms, and soil. The organic residues, which undergo breakdown and transformation, are complex in nature, containing carbohydrates, proteins and other nitrogenous compound lignins, fats, etc. in course of the microbial reactions, the soil is enriched with the dead tissues of organisms forming part of its organic matter. Humus is a complex mixture of amorphous and colloidal organic substances. The whole process of decomposition of organic matter, mainly of plant origins, is due to the microbes.

Phosphorus: - microbial grown a requires available and utilizable forms of phosphorus. Immobilization of available soil phosphate may occur when large amounts of available carbon and nitrogen are present in the decomposing material. Thus addition of straw and similar materials causes biological phosphorus depletion and immobilization.

Sulphur: - Sulphur ion in soil is the major source of sulphur for plants, which can also utilize a small amount of sulphur dioxide from air. When plant and animal residues are incorporated in soil, organically bound sulphur is mineralized by micro-organisms into sulphate ions. Part of the mineralized sulphur is immobilized by the microflora and part is available to the plants for their nutrition. The autotrophic bacteria, chiefly members of the genus Thiobacillus, are capable of oxidizing inorganic sulphur compounds. Hydrogen sulphide, it should be noted, is toxic to plants even in small concentration.

Other elements: -Other plant nutrient elements that undergo microbial transformations and influence their availability for plant growth are potassium, calcium, magnesium, iron, manganese, copper, zinc, molybdenum, boron, etc. certain bacteria and fungi are capable of decomposing alumina silicate minerals in soil, thus releasing a portion of the potassium contained therein. The potassium thus liberated to satisfy the demand of the microbial nutrition becomes ultimately available to plants due to the release of soluble potassium ion during decomposition of microbial cells. Iron transformation in soil depends on the activity of the microorganisms which, in turn, depend upon the compounds of iron. The iron bacteria may be performing the function of oxidation and reduction, and iron precipitation. Bacteria are more dominant in these transformations. Deficiency of manganese is closely related to the number of manganese oxidizing bacteria in soil.

Biofertilizers

Biofertilizers are the cultures of micro-organisms used for inoculating seed or soil or both under ideal conditions to increase the availability of plant nutrients. Their purpose is to supplement chemical fertilizers and not to replace them. Some of the microorganisms have the beneficial role of biological nitrogen fixation to supply nitrogen to crops, solubilizing insoluble phosphates to soluble forms to make them available to crops, synthesizing biomass for manuring crops, particularly rice, and hasten the process of decomposition of cellulose in composts and farmyard manures through cellulolytic organisms.

Soil Aggregation

Some organisms may play a beneficial role indirectly be creating better soil physical condition, e.g. by improving soil aggregation. Soil microorganisms cause soil aggregation probably by the gum or polysaccharides produced by them. *Azotobacter, Beijerinckia* and *Rhizobium* are examples of gum producing bacteria.

Effects of cultural practices on soil organisms

Cultural practices, viz. Cultivation, crop rotation, application of manures and fertilizers, liming and gypsum application, application of pesticides for crop production have their effect on the soil organisms. **Ploughing** and **tilling** operations facilitate air movement in soil and expose soil surface to sunshine, and thereby increase biological activity, particularly of bacteria. Cultivation of a single crop causes accumulation of a particular group of microbes, which dominate over the others. **Crop rotation** disturbs the unfavourable population balance. Crop rotation with a legume is the common practice. **Irrigation** of soil brings about a significant proliferation of soil microbes.

Soil amendments: - Liming of acid soil increases activity of bacteria and actinomycetes and lowers the fungal population. **Gypsum** application of sodic soil is favourable for bacterial activity. Application of fertilizers and manures increases crop production supply food and nutrition not only to the crops but also to the microbial population in the soil. Phosphatic fertilizers applied to berseem (*Trifolium alexandrimum*) increase significantly the activity of nitrogen fixing bacteria. Organic manures provide a readily available source of carbon for the heterotrophs. Repeated heavy fertilization with nitrogenous fertilizer alone promotes rapid growth of fungi. Oilcakes, viz. Neem, karanj and groundnut encourage the growth of nematode-trapping fungi. Application of chemicals (pesticides) to control damage to crops by insects, fungi, nematodes and weeds is imperative. The pesticide molecules may interact with soil constituents and get adsorbed on the soil particles or they may move with water to find their way into ground water, rivers and stems. The pesticides are systemic in nature, they persist in soil and may be taken up by plants and ultimately by animals. Some pesticides are biodegradable by soil organisms, other are liable to leave toxic residues, which are likely to be hazardous. The usual dosage is not high enough to cause any profound change in the normal microbial activity of soil.

Physical Properties

Soil is a heterogeneous mixture of silicate particles, humus, and a variety of insoluble salts and oxides of metals called the solid phase, a liquid phase and a gaseous phase. Depending on the relative proportions of the various size groups we can define soil texture. Depending on the size and shape of the aggregates we can define soil structure.

- **Texture**

Many of the important soil properties are related to texture. Clayey soils show high water holding capacity, high plasticity, stickiness and swelling whereas sandy soils are conspicuous by the absence of these properties. The most important way in which soil texture affects plant growth is water and with it the nutrient supply. The available water capacity of soil is related to soil texture.

- **Soil structure**

This kind of arrangement and organization of secondary and primary particles under natural condition brings about what has been termed as soil structure. Under natural soil conditions, the primary particles (clay, silt and sand) are mostly bonded together by cementing agents into secondary aggregates of varying sizes.

- **Bulk and particle density and Pore space**

Bulk density of a soil is defined as the mass per unit volume of soil consisting of solid and gas phases. Particle density of a soil is the mass per unit volume occupied by the soil particles alone. Bulk density of soil is influenced by soil texture, organic matter content and cultivation practices. The constituents of soil organic matter contribute significantly to aggregation of soil particles. The humus portion in the aggregation is susceptible to biodegradation. To maintain soil aggregation status of cultivates soils, renewed addition of organic matter is essential.

Management practices

The management practices for crop production have a profound effect on the formation and stability of soil aggregates

- **Cultivation: -** Continuous cultivation of arable land year after year, without incorporation of organic matter, deteriorates soil structure, lowering the level of soil structure, lowering the level of soil organic matter. Addition of organic matter helps in improving the structural status of soil. The tillage operation affects the size distribution of peds, density and packing of soil particles, amount of organic matter and moisture content of soil. Tillage is to loosen the surface soil, to facilitate water infiltration and aeration. Friable conditions of soil are the optimum soil condition for tillage operation to produce aggregates of suitable size.

- **Crops and cropping practices: -** Crops affect soil structure through their vegetative canopy above the ground and their roots below the ground. Grasses are conducive to well structured soil. The vegetative canopy protects the soil from the beating action of raindrops and destruction of the structure of the surface soil and prevents crusting, improve soil structure. The role of legumes in building up soil fertility is well known and legumes have, therefore, their place in sound crop rotation practices. The beneficial effect is usually attributed to nitrogen added to the soil by legumes. The structure is built up with the advancement of stages of crop growth. Legumes treated with phosphatic fertilizers significantly improve soil structure.

- **Manures and fertilizers**

Organic matter level and structural improvement of soil can be built up, to a varying degree, and maintained by continuous judicious application of manures. The degree of improvement depends upon the quantity and length of application of manure, the climatic conditions, and nature of soil. Phosphatic fertilizers used in conjunction with nitrogenous fertilizers improve and maintain soil structure.

Management of soil structure

The objective of soil structure management is the improvement and maintenance of soil structure. Inclusion of a suitable legume in a crop rotation is the most effective way of improving and maintaining soil structure. Coupled with phosphatic fertilizers, legumes improve soil structure still further. Use of balanced fertilizers for raising crops is the other means. Judicious application of adequate quantities of well-decomposed manures, as frequently as possible, improves soil structure. In coarse-textured soils, use of organic manures is the only way of improving structure. Application of pond sediments or clay soil brought from another locality is helpful in this respect. In the case of very fine-textured soils, organic manure is no doubt helpful, but the quantity required well be high. Crop rotation and use of phosphatic fertilizers are better methods for such soils. Structural management of acid soils involves liming followed by organic manuring. Highly alkali soil application of gypsum or other amendments in combination with green manuring or manures or incorporation of crop residues has been successful in improving structure and helps in reclamation of such soils.

Water infiltration into soil

Water infiltration is the process of water entry into soil through the surface and the direction of entry may be either downward or lateral or both. Water infiltration characteristics of soil are of practical significance in soil and water conservation, irrigation and watershed management. Factors influencing infiltration- texture, structure and initial moisture content of soil control infiltration rate. Coarse textured and well aggregated soils have usually high infiltration rate. Dry soil condition is conducive to rapid infiltration. Vegetative covers help infiltration while the presence of a somewhat impervious subsoil layer reduces it. The volume of water that enters into soil and the depth to which water moves and wets the soil below the surface are of utmost importance in the soil water plant relationship as this is one of the main sources of water supply to plants.

Importance of soil water studies

Infiltration studies are important for soil and water conservation. The design of furrows or basins for ensuring even distribution of irrigation water will, therefore, depend upon the infiltration rate. Plants meet their water requirement from water stored in soil. Microbes and plants require, besides water, an adequate level of oxygen in soil for their growth and activity. Low porosity and hydraulic conductivity of soil cause inadequate aeration. Proper drainage ensures adequate aeration and removal of salts and other toxic substances from the root zone. Recharge of groundwater is often necessary where excess of rainfall is lost as surface runoff, due to low infiltration capacity of the soil. The soil air and soil temperatures are closely related to water content of soil.

Soil Aeration and plant growth

Oxygen is required by microbes and plants for respiration. Oxygen taken up and carbon dioxide evolved are stoichiometric. Root elongation is particularly sensitive to aeration conditions. Oxygen deficiency disturbs metabolic processes in plants, resulting in the accumulation of toxic substances in plants and low uptake of nutrients. Certain plants such as rice are adapted to grow under submerged conditions. These plants have large internal air spaces, which facilitate oxygen transport to the roots.

Soil temperature and management

Soil micro-organisms show maximum growth and activity at optimum soil temperature range. Soil temperature has a profound influence on seed germination, root and shoot growth, and nutrient uptake and crop growth. Seeds do not germinate below or above a certain range of temperature. Root elongation is very much dependent on soil temperature. Each crop plant has a specific optimum range of soil temperature for its rapid growth and maximum yield.

Soil temperature under field conditions can be altered by suitable cultural practices such as mulching, irrigation, drainage, and tillage. Tillage loosens the surface soil, increases its porosity and decreases its thermal conductivity. Soil compaction has the reverse effect on porosity and soil temperature. Mulching the surface soil with plastic cover or crop residues may increase or decrease surface soil temperature, depending upon environmental conditions. Mulches conserve soil moisture also. In tropical areas, irrigation generally causes rapid and substantial reduction in maximum temperature in summer and increase in minimum soil temperature in winter. In the cold season, the higher temperature of irrigation water relative to soil, and high heat capacity of irrigation water check lowering of minimum soil temperature.

Soil compaction

Soil compaction is the process of increasing dry bulk density of soil, reducing the pore space by expulsion of air through applied pressure on a soil body. Initially, when water content is low, the soil is stiff and difficult to compress, low density is the result. Compaction of coarse-extured soil, sometimes desirable, for better seed germination, reducing hydraulic conductivity of soil, and enhancing moisture conservation. Continued compaction will practically remove all air. As the water content of soil increases, the water acts as a lubricant, and the soil becomes workable with the expulsion of soil air. Compacting creating problems for seed germination water transmission and aeration.

Soil crusting

Crusting of soil is a form of soil compaction. The crusts present a serious barrier for seedling emergence, high exchangeable sodium percentage, poor structure, low organic matter content of soil and also puddling during tillage operations are some of the factors responsible for crust formation. Lowering the exchangeable sodium percentage and incorporation of organic matter prevent crust formation.

Management of Soil Fertility

Ag. Technologies (Soil Magt.)

Introduction

Soil fertility is concern with the inherent capacity of soil to provide nutrients in adequate amounts and in proper balance for the growth of specified plants when other growth factors such as light moisture and temperature and the physical condition of the soil are favourable. Soil fertility is an aspect of the soil plant relationship viz. plant growth with reference to plant nutrients available in soil. A fertile soil is considered to be one that produces abundant crops under suitable environmental conditions. Only a very small fraction of the total nutrient content of soil can be utilize by plants. To get quickly a measure of nutrient availability following soil fertility evaluation methods used: -

i. biological,

ii. visual symptoms of nutrient deficiency or toxicity,

iii. plant analysis, and

iv. soil analysis.

Soil factors influencing nutrient availability

Soil reaction (pH) is the most important factor, which governs availability of nutrients in soil. The pH range of 6.5 to 7.5 is the optimum for availability of most of the nutrient availability.

- **Nitrogen**

The ammonifiers and nitrifies are active at pH 5.5 to 6.0, below which nitrogen availability decreases.

- **Phosphorus**

Phosphorus availability is maximum in the pH range of 6.5 to 7.5. In red and lateritic soils the phosphate availability depends on the amount of sesquioxides. Liming of acid soils increase phosphate availability.

- **Potassium**

Potassium availability depends on exchangeable potassium, potassium saturation of exchange complex, CEC and pH.

- **Calcium, Magnesium**

Calcium and magnesium are available in cationic form and their availability is decreased governed by the factors which control exchange equilibrium in soil at low pH (below 6.0) their availability decreases.

- **Micro Nutrient Availability**

These are available to at low pH range. Alternate drying and heating the soil increases availability soil manganese. Availability of boron decreases below pH 5.0 and above 7.0 but above pH 8.5 it again increases. Availability of molybdenum increases above pH 6.5.

Maintenance of soil fertility

Nutrients are continuously removed from the soil by crops in addition to losses by leaching and erosion. It is therefore, essential that sound soil and crop management practices are adopted to improve and maintain soil fertility and soil physical conditions for the purpose of sustained crop production. The management practices that play an important role in the maintenance and improvement of soil fertility are given below: -

Crop rotation

The benefits of a good crop rotation are, increased organic matter, nitrogen supply and improved soil structure. Especially deep rooted legumes or crops capable of feeding themselves efficiently at various soil depth. Deep rooted crops increased permeability of soil at lower depths to air and water. The other benefits of crop rotation are keeping soil under crop, control of run off, soil erosion and efficient use of fertilizers e.g. cereals-legumes.

Manures and Fertilisers

Balance fertilization with nitrogen, phosphorus and potassium fertilizers helps in maintaining soil fertility. Application of organic manures and chemical fertilizers helps to improve and maintain soil fertility, soil productivity and soil physical conditions. Soil fertility and agricultural production can be maintain only by efficient and judicious management of nutrient addition to the soil from external sources.

- **Manures**

Organic manures bind the sandy soil and improve its water holding capacity. They open the clayey soil and help in aeration better root growth. They add plant nutrients in small percentage and also add micro nutrients which are essential for plant growth the microbial activity is increased which helps in releasing plant nutrients in available for e.g. bulky organic manures- FYM, compost from organic waste, night soil, sludge, sewage, sheep folding, green manures, concentrated organic manures- oilcakes (edible, non-edible), blood meal, fish meal, bone meal. Organic manures should be incorporated before the sowing or planting because of slow release of nutrients.

- **Fertilisers**

Chemical fertilisers play an important role in crop production as the nutrient elements in fertiliser are present in higher concentration and in forms which can be readily utilize by plants directly or after rapid transformation. Their dose can be adjusted to suit the requirement as determine by soil fertility evaluation. Fertilisers applied through straight fertilisers- providing single nutrient or complex and mixed fertilisers- supplies two or more nutrients. While application of fertilisers following consideration should be taken in account-

- **Soil factors**

The coarse texture soils are poorer in available nutrients than fine texture soils. Hence, it is necessary to apply nitrogenous, phosphatic and potassic fertilisers more frequently than in fine texture soils. Higher the soil fertility the lower is the response of crops to fertiliser. Soil reaction is important in selection of right type of phosphatic fertiliser. Efficient use of fertilisers by the crop is more in the higher organic matter status of soil.

- **Climatic factors**

These include temperature, rainfall, evaporation, and length of day and growing season. The rate of nitrification is slower in a cooler climate that in a warmer climate. Hence, more ammonical nitrogenous fertilisers will needed in a cool climate. In region of high rainfall because of higher yield potential and leaching loss of soil and fertilisers nutrients, require higher fertiliser. In arid region soil moisture is the limiting factor in fertiliser use. If soil moisture is conserve efficiently fertiliser becomes very effective.

- **Application methods**

Application of fertiliser is by using proper methods and time is important in crop production. Nitrogenous fertiliser should be applied in split doses while slow releasing, phosphorus and potassium should be applied at the time of sowing or planting. Instead of broadcasting fertilisers should be applied by placement method or through fertigation.

Reclamation of problem soils

Problematic soils viz. acidic, saline and alkaline soils can be bring in proper condition for raising the crop satisfactorily and economically, special measures have to be adopted. Acidic soils can be corrected by liming. Saline and alkaline soils can be reclaimed by improving drainage scrapping off surface soils and using gypsum, sulphur, molasses and adopting agronomical measures viz. green manuring, adding organic manures, mulching and suitable crops rotation.

Management of Khar Land

Along the coastal districts extensive area have become Khar land and are unfit for economic cultivation. The reclamation of these lands consists of 1- construction of earthen embankment above the highest tide level to guard against the ingress of sea water. 2- Provision of sluice drain away the excess run off water alongwith dissolved salts.3- construction of field ditches at suitable distance in order to hasten desalinization and to channelize the water. 4- cultivate salts resistant paddy varieties, application of liberal doses of FYM or green manuring.

Management of acidic, saline and alkaline soils

Ag. Technologies (Soil Magt.)

Introduction

There is a great variety in their physical, chemical and biological properties, but they can be made to yield a good crop by

a. adopting proper management practices and soil and water conservation measures,
b. applying organic manures and chemical fertilisers and
c. supplementing monsoon rain with irrigation water.

But there are some extreme soil conditions which do not provide a suitable medium for the growth of plants and desirable micro organisms. Such soils are either too acidic or alkaline and special measures have to be adopted to bring them in proper condition before any crop can be raised on them satisfactory and economically. In high rainfall areas, acidic soils are formed due to leaching of bases or salts. In arid regions where rainfall is low and temperature high, soils become saline or alkaline due to alkaline due to accumulation of salts in the surface soil.

Acid soils

The soil may become acidic due to the following factors:

1. Leaching due to heavy rainfall.

   The rainfall carries lime and other bases downwards beyond the reach of plant roots. In areas where rainfall is more than 1,000 mm., there is heavy leaching of calcium and other bases and saturation of the exchange complex by hydrogen ions takes place.

2. Nature of parent material

   Some soils have developed from parent material which is acidic in nature, e.g. granite.

3. Use of acid forming fertilisers

   Some fertilisers like ammonium sulphate and ammonium chloride increase soil acidity. If there is no sufficient free lime in the soil, continuous use of ammonium sulphate or chloride may cause soil acidity.

4. Microbiological action

Micro-organisms decompose organic matter in the soil and organic acids are continuously being formed. If these acids are not neutralized by free lime or bases to make the soil acidic.

Effect of soil acidity on plants

1. It has toxic effect on root tissues and adversely affects the permeability.

2. It disturbs the balance between basic and acidic constituents of the plant affects growth of plants.
3. It affects enzymic changes which are particularly sensitive to pH changes.
4. It affects the beneficial activity of soil micro-organisms.
5. Elements like aluminum, manganese andirons are highly soluble in acid medium excess amount causes toxic effect.
6. Due to soil acidity, calcium and potassium may be deficient.
7. It affects the availability e.g. phosphorus, copper and zinc.
8. Plant diseases are more prevalent in acidic soils.

Management of soil acidity

It can be corrected by liming. The liming material may be ground lime stone ($CaCO_3$), burnt lime (CaO) or hydrated lime Ca $(OH)_{2-}$ When lime is added, the soil solution becomes charged with calcium ions which replace hydrogen ions in the exchange complex. When burnt (CaO) or slaked or hydrated lime Ca $(OH)_2$ is added to acidic soil, it changes into calcium bicarbonate, which in solution reacts with soil colloids.

- Lime requirement of soil

1. pH or intensity of soil acidity. In order to raise the pH by one unit i.e., from 5.0 to 6.0 in one hectare about 1,500 kg., of $CaCO_3$ would be required.
2. Texture of the soil: Clay loam soils require more lime than sandy soils due to higher buffer capacity.
3. Purity of the liming material.
4. Degree of fineness finer the material is ground, more rapidly it goes in solution and is more effective. Material passing through 60 mesh sieve is considered to be standard and quite effective.
5. Chemical composition. The neutralizing value of $CaCO_3$ is taken as 100.

- Method of applying lime

Lime should be applied before ploughing or on ploughed land well before cropping and should be thoroughly mixed with the soil by discing. Efficient way to use lime is to apply it in small quantities every year or once in two years. If the quantity is not more than five tons per hectare it can be applied in one dose. If the dose is more one half is applied before ploughing and the remaining half applied and worked in after ploughing.

- Tolerance of soil acidity by crops

For medium acidic soil with pH upto 5.6- jowar, maize, wheat, sweet potato, tobacco, tur, velvet bean, turnip. In strongly acidic soils with pH upto 5.1.- potato,rice, oats, rye,cowpea, linseed, grasses, tea and coffee.

Saline and alkali soils

Saline and alkali soils are generally noticed in arid and semi arid regions where there is low rainfall and high temperature causing intense evaporation.

- Alkali soil

The percentage of exchangeable sodium is more than 15. The pH is 8.5 and 10.0.and electrical conductivity less than 4 mmhos/cm., at 25^0C.

- Saline soil

The exchangeable sodium percentage is less than 15 and the pH below 8.5 and electrical conductivity value of 4 or more mmhos/. cm. at 25^0C. It indicates white incrustation and therefore called as white alkali soil.

- Saline-alkali soil

It contains exchangeable sodium in excess of 15 p.c. The pH is 8.5 or more and an electrical conductivity more than 4 mmhos/cm., at 25^0C.

Management of saline alkali soils

- Use of gypsum

In these soils the exchangeable sodium is so great as to make the soil almost impervious to water. Large quantities of gypsum are applied to replace sodium and leached downward and out of reach of plant roots. Gypsum is applied on the soil surface and mixed by harrowing tow to four weeks before sowing @ 2.5 to 5.0 tons per hectare.

- Leaching of salts

Leaching and draining away of salts by rain and irrigation water.

- Scraping

Scraping off surface salts from highly saline patches.

- Use of sulphur

In extreme cases sulphur is used to reduce alkalinity. Ground sulphur is incorporated into the soil several weeks before planting of the crop. The quantity of sulphur required is depending upon the soil and climatic conditions. The pH upto 8-1.25to 2.5 tons of sulphur and 5 to 7.5 tons of organic matter per hectare will be required to reduce the pH to about 6.5.

- Use of acidifying fertilisers

Example of superphosphate or ammonium sulphate which increases acidity in soil and maintains fertility of soil impoverished by leaching and cropping.

- Green manuring

In alkali soil green manuring of *dhaincha* has been found to be beneficial along with gypsum in resorting physical condition and enriching the soil in nitrogen and organic matter.

- Use of molasses

Molasses are used to reclaim alkali soils @ 5 tons/ha.alongwith with 2.5 to 5 tons of press mud and 50 to 100kg. It provide source of energy for micro-organisms and on fermentation, produce organic acids which reduce alkalinity while press mud help in reducing exchangeable sodium.

- Growing salt tolerance crops

For moderately alkaline (pH upto 8.4) – Barley, sugarbeet, cotton, sugarcane. For salty soils- date palm, coconut, arecanut. Garden beet, spinach and asparagus are very salt tolerant while radish and beans are sensitive to salt.

Ag. Technologies (Soil Mgmt.)

Challenges Faced in Management of Different Soil

The problem soils are those which, owing to land or soil characteristics, cannot be economically used for the cultivation of crops without adopting proper reclamation measures. Highly eroded soils, ravine lands and soils on steeply sloping lands constitute another set of problem soils. The shallow soil depth, deep gullies and steep and complex slopes are some of the problems, which require to be tackled in such areas. Acid, saline and alkali soils constitute another set of problem soils, in the case of which acidity, soluble salts and exchangeable sodium limit the scope of cultivation.

Problem soils become based waste land if appropriate management practices of soil, plant and environment is not followed. The land is said to be waste land which has been previously used but which has been abandoned and for which no further use has been found. The adverse factors and ceaseless onslaughts leading to major degradation have turned more than half (175 m ha) of the country's area into wastelands in some or the other form, viz., water and wind eroded land (150 m ha), water logged land (6 m ha), saline and alkaline land (4 m ha) and land affected by rive action and other factors (7m ha). These degraded lands cover about 85 m ha of agricultural and 37 m ha of forest land. Forest cover is losing at the rate of 1.3 m ha a year and another 1.0 m ha of non-forest area is going out of productive use due to the factors cited earlier.

The wastelands are ecologically unstable. Over the years of human settlements, these lands have been subjected to different degrees of biotic or ecological interference, as a result, rendering them degraded, infertile and unculturable.

More than 70% of the population is still dependent on agriculture and about 60% of the rural population is living in poverty. Our natural resources, which are the base for generating income and employment are improperly utilised and mismanaged. Over half of the land area measuring 175 million hectares is either unproductive or in a state of neglect. Moreover 75 to 80% of livestock is unproductive of uneconomical. In spite of about 73% cropping area being dependent on rainfall, hardly about 15-20% of the rain water is effectively utilised and the rest is wasted. Nearly a half of the forestlands in the country has been denuded.

Systematic development practices can certainly help in sustainable use of natural resources. With the development of wastelands, there will be an improvement in the micro-climate and soil productivity and thus agricultural production can also be enhanced significantly. With the availability of fodder, the prodcuticvtivity of our livestock can be improved.

Problem Faced

In arid and semi-arid areas during the periods of higher than average rainfall, the soluble salts are leached or washed out from the more permeable high lying areas to the low lying areas, where, if the drainage is restricted, salts accumulate on the surface as water evaporates. The excessive irrigation of the uplands containing salts results in the accumulation of slats in the valleys. In areas having a salt layer at lower depths in the profile; faulty water management or even seasonal irrigation may favour the upward movement of the salts.

A rise in the water table within 2 m of the surface due to irrigation the obstruction of natural drainage by roads or canals and the salutation of natural drainage may also cause soil salinity. In the coastal areas, the ingress of sea water induces salinity in the soil. When sodium ions predominate in the soil solution, and carbonates are present, alkali soils are formed.

Thus the salt affected soils differ a great deal in their physico-chemcial characteristics, as such, methods of their reclamation also differ. If the problem is only of salinity, the salts need to be leached below the root-zone and not allowed to come up. In practice, this might be difficult to accomplish, especially in deep and fine textured soils containing more salts in the lower layers. Under these conditions, a provision, of some kind of subsurface drains becomes important. If the soil contains a sandy layer at a lower depth, the leaching of the salts below this layer will check the rise of salts.

The number and frequency of leaching, the quantity of gypsum to be added and the techniques involved vary from region to region, depending upon the clay mineralogy of the soils, the intensity of the problem, the subsequent use of the soils, the availability and quantity of irrigation water and the economics of these operations.

In irrigated areas, special management practices become necessary to avoid salinity, alkalinity, waterlogging, leaching and the loss of plant nutrients.

The productive capacity of the soil should never be allowed to diminish, but rather should improved and maintained by providing adequate organic manures and plant nutrients. The fertility of land is dependent on the continued addition of organic matter. When and if the process of adding organic matters is abruptly stopped. The deterioration of the land starts.

There is a need for constantly adding about 7 tonnes of biomass every year so as to maintain the fertility of soil. Unfortunately this critical component is totally ignored by all and as such as feasibility of development of wastelands remains to be studies with reference to the methods and relative cost involved in them.

There is growing need for more and more attention on the part of the government towards the development of wastelands, so that some of the socio-economic problems could be done away with.

There are a few programmes at National and Regional levels for the development of wastelands. It requires community participation and the remaining intend to be led by government and non-government organizations. It is reported that neither the community nor the NGOs take active part in these programmes and follow up measure so that a collective and join attempt could not be ensured for development of wastelands. The level of public awareness of such progarmmes is lower than expected.

Wasteland development is not to be seen as an internal problem of the country. There must be international participation, as in the case of development and management of forests, for not only merely greening the wastelands but also for improving the ecology and environment around the world.

The reliability of data to be collected about problem soils depends on the supplying agency since the published data may differ from institution to institution between central and State Agencies. Also there is variation about primary data to be supplied by individual and institution.

Integrated nutrient management in soils for improving crop productivity

Ag. Technologies (Soil Magt.)

Introduction

Modern agriculture largely depends on the use of high cost inputs such as chemical fertilizers, pesticides, herbicides, improved seeds, assured irrigation, scientific management and labour saving but energy intensive farm machinery. The application of such high input technologies increased the production but there is growing concern over the adverse effects of the use of chemicals and soil productivity and environment quality. When population pressure was low, mono-cropping was a rule, with the increase in population various multiple cropping system have become popular.

Similarly, from the use of single nutrient, application of multi-nutrient has adopted. Because no single source of nutrient can satisfy the need of all the essential elements that crop needs for growth and development. Nutrient management in multiple cropping system is more efficient than in individual crop because there is a residual effect of nutrients for e.g. phosphatic fertilizer and organic sources of plant nutrients.

To sustain the productivity of different crops and cropping systems, efficient nutrient management is vital. There is a need to develop more efficient, economic and integrated system of nutrient management for realizing high crop productivity without diminishing soil fertility.

Principle

A two-fold strategy may be useful in nutrient management. First, to continue to encourage the use of fertilizer for a faster growth in agriculture and second, to popularize the use of recycled crop residues, green manures, use of compost (both urban and rural) and biofertilizers as a supplementary source of nutrients, in conjunction with chemical form of plant nutrients. There is need to add plant nutrients to the soil on the basis of soil fertility states. The application of nutrients according to soil-test-based-fertility-assessment ensures better efficiency and improved profitability. Principle: (a) basic soil fertility and climate. (b) nature of crop in cropping system. (c) atleast 30% of the total nutrient levels NPK in organic form.

Organic vs inorganic

Organic sources of nutrients are supplementary to chemical fertilizers and use of biofertilizers considered as environment friendly, in terms of protecting the quality of underground waters, soil property and environment in general. Complete depends on organic sources can sustained a yield target equivalent to that prevailed during pre green revolution era. It would be able to meet only 1/3 of the nutrient requires for the present level of foodgrain production, if the whole of organic resources utilised available for agricultural use.

Bio-fertilizers

These are low agricultural input environments friendly used as seed inoculation and also soil inoculation. Inoculation of *Rhizobium.* Azotobacter and Azospirillum substitute, 19,22 and 20 kg N/ha, respectively. Blue green algae (BGA) applied @ 10 kg/ha gave a saving of 20-30 kg N/ha and Azolla

@ 6-12 t/ha had an N equivalent of 3-4 kg/t.

Organic resources

The potential of rural and urban compost in India is estimated to be 800 and 16 mt respectively. Less than 50% of the manurial potential of the livestock population is utilised at present in crop production. The major contributor of rural compost is animal dung, which has a potential are about 7 mt of NPK. Night soil if properly exploited can provide about 5 mt of NPK nutrients. About 1/3 of the residue potential is available for utilization in agricultural production about 400 mt of crop residues are produced in the country which have potential of supplying about 7.3 mt of NPK.

Legumes/Green manuring

The practice of green manuring for improving soil fertility and supplying apart of nutrient requirement of crop is aged old. Depending on the crop grown the N contribution by green manure crops varies from 60-280 kg/ha. Leguminous green manures can fix large quantity of atmospheric N_2 which generally can accumulate about 100 kg N ha^{-1} in 50-55 days but can reach up to more than 200 kg N ha. The problem with green manure crops is that they compete with cash crops for space, time, water and other inputs.

Steps

- To assess on –farm and off-farm resource availability through survey related to soil and nutrient management.
- Fixing yield target depending on the resource availability.
- Soil test based estimation of nutrient requirement with due consideration on soil amendments.
- Integration of all nutrient resources available for a given circumstances.
- To determine time, method, mode of application considering the type of crops involved in the cropping system.
- To adopt efficient soil and water conservation measures to check soil erosion, soil organic C & nutrient losses.
- Maintaining soil fertility in terms of soil physical, chemical and biological properties and processes.

Limitation

- Small land holdings

The average size of an operational holding is 1.57 ha. small farm size has major implications for fertilizer and water management practices.

- Poor infrastructure facilities

In India there are 519 soil testing laboratories. The total analysing capacity of these laboratories is about 6.5 million samples per annum. In order to provide soil test-based fertilizer recommendations the existing analysing capacity of the soil testing laboratories needs to be augmented almost 15-20 times.

- Lack of participatory approach

Soil fertility will only be maintained and enhanced by the actions of farmers. Farmer's knowledge is essentially local, based on observation and experience within specific farming systems and agro-ecological contexts. Hence farmers participation is important.

- Low availability of organic resources

The annual potential of organic resources ranges between 10.5-16.2 mt of NPK, only around

3.9-5.7 mt of plant nutrients can be made available for agricultural use. Average organic manure use at present is about 2 tonnes ha^{-1}. The coverage under green manure crop is about 6 m ha and the use of bio-fertiliser, against a total bio-fertiliser demand of 1 mt, the current supply is less than 10,000 tonnes. Only 25% nutrient needs of Indian agriculture can be met by utilising various organic resources namely FYM (200 mt), crop residue (30 mt), urban/rural wastes (10 mt) and green manuring (25 m ha).

- High labour demand

For its mobilisation, processing and application, because of low nutrient content and bulkiness it requires high labour.

Future strategies

- Awareness

Greater awareness needs to be created among the farmers for the use of farm resources on generation and its proper recycled and encouragement for the production of compost and green manuring.

- Attention for major components

The major components of the system needs attention are: recycling of solid wastes and crop residues by composting and vermi composting, more popularisation of janata bio-gas plants, encouraging growth of legumes as part of the crop rotation for grain and fodder purposes, using sewage sludge and effluents for agriculture, integration of green manures, green leaf manures. BGA and azolla in rice culture.

- Popularising

Popularising bio-fertilizers to augment N and P supply by improving/strengthening transportation, distribution and storage infrastructure. Also enhancement of shelf life of

bio-fertilizers, development of new strains and easy technique for viability test for bio-fertilizers.

- Soil test techniques

It needs to be refined so as to reduced the time, manpower and cost of chemicals during estimation and soil test laboratories should be strengthened and up graded for soil and plant analysis, promoting balanced use of chemical fertilizers on soil testing and correction of secondary and micro nutrients deficiencies in soils.

- Promoting various approaches

Advantages of introduction of green legumes in the cropping systems should be promoted. Use of phospho-compost should be promoted to supplement phosphatic fertiliser to a great extent. Research on incorporation N fixing ability in non-legumes need to be accelerated.

- Maximize nutrient use

Promotion of appropriate soil, water and nutrient management and other agronomic practices to maximize nutrient use efficiently and economically.

Organic farming

Ag. Technologies (Soil Magt.)

Need

Because of indiscriminate use of chemical fertilizers for decades the organic matter content of soils has come down to less than 1 per cent. In addition, the use of pesticides led to pest resurgence and difficult-to-control weeds species.

The residues of the chemicals cause concern over the safety of food and sustainable production. The addition of chemical fertilizer like nitrogen in plant caused an infant disease like methanoglobinaemia.

Hence, the expectation that organic farming by reverting to the use of manures, green manures, urban waste, rural wastes, etc. can bring sustainability to agriculture with eco-friendliness. Hence, it becomes imperative for the researchers and planners to develop an alternative viable strategy to supplant the chemical farming.

Basic Concepts

Organic farming is a production of crops which avoids or largely excludes the use of synthetically compound fertilizers, pesticides, growth regulators and live-stock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological pest control to maintain, soil productivity and to supply plant nutrients and to control insects, weeds and other pests.

Objectives

1. To develop a sustainable agriculture system for guaranteed adequate food production in the foreseeable future.

2. To develop self-sufficient agriculture system which would rely as much as possible upon resources from within its own resources.

3. To develop an alternative strategy over chemical farming which would be a guideline for working of biological processes in natural eco-systems.

Types

1. Pure organic farming: It includes use of organic manures, and biopesticides with complete avoidance of inorganic chemicals and pesticides.

2. Integrated Farming: It involves integrated nutrient management and Integrated Pest Management.

3. Integrated Farming Systems: In this type, local resources are effectively recycled by involving other components such as poultry, fish pond, mushroom, goat rearing etc. apart from crop components. It is a low input organic farming.

Fertilizers used for organic farming:

The major sources of organic plant nutrients in India are farm yard manure, rural and urban compost, sewage sludge, pressmud, green manures, crop residues, forest litter, industrial waste and by-products.

The number of biofertilizers such as blue green algae (BGA) and azolla are used extensively to meet the nitrogen demand of the crop. Small quantities of powdered neem cake are also used. These organic nitrogen supplements unlike the fertilizer nitrogen do not suffer any loss in the fields.

Phosphorous-solubilising and mobilising organisms such as phosphobacterium and vesicular arbuscular mycorrhizae (VAM) are quite helpful in meeting the phosphorus demand of the crop. Potassium for the crops can be supplied by using potassium rich organic amendments such as burnt rice,, rice straw composted using tricoderna harzianum and composted coconut coir pith.

Effect of Organic farming on Crop yield and quality

Field experiments conducted in Annamalai University to study the impact of organic farming of Rice yield and quality, the results of the study clearly indicated a positive approach towards practicing complete organic farming in attaining premium quality produced with higher grain yield.

Application of 75 per cent N through FYM and 25 per cent N through NC produced the largest rice grain yield - 6.13 t/ha compared to the yield obtained with recommended fertilizer schedule (100:50:50 kg N, P_2O_5, K_2O/ha the yield being 4.3 t/ha). Quality characters viz., milling recovery, head rice percentage, protein percentage also were significantly higher with organic sources.

Soil Fertility

Whereas study carried out in Japan to know the effect of organic farming on soil properties, it found that with time, there was an increase in organic matter content, soil reaction, exchangeable C_aO and M_gO, available phosphorus and trace elements of manganese and boron. However, the potassium content was erratic.

The soils using poultry manure compost for more than 10 years showed much accumulation of calcium and available phosphorus and a serious imbalance of bases.

Soil Management in Water Stress Condition

Ag. Technologies (Soil Magt.)

Having finer differences between dryland and rainfed lands, it is clear that both suffer due to moisture stress or water stress. The core problem of dryland is the scarcity of water as per the requirements of the crop and soil. Therefore to conserve maximum amount of moisture in the soil from low and untimely rainfall which causes abberent weather conditions. Hence emphasis should be given on the productions of reasonable crop yields on economic and sustained basis. As water is most important in scarcity areas, conservation of soil and water are taken which is inter related and where one is tried the other is also achieved.

Management of soil

1. **Tillage**

   Tillage practice conserve the basic resources of soil and water also aim at complementing soil and water conservation measures such as graded bunds and land levelling. All tillage operations should be carried out at optimum soil moisture conditions when the resistance to tillage tools is low, resulting in lower draft and power requirements and better soil tilth. The ploughing of deep soils should be done once in 3-4 years. In case of light, shallow and medium soils instead of ploughing frequent hoeing should be done to receive and retain moisture.

2. **Mulching**

   To conserve soil moisture, temperature control, prevention of crust formation, reduction in runoff and erosion, to improve soil structure mulching is done. Using mulches particularly organic mulches e.g. jowar or bajara stubbles, paddy straw or husk, sawdust @ 5 tonnes per ha.

3. **Crops**

   To reduce the loss of moisture received by the soil and soil losses through erosion,early maturing adaptable crop varieties with deep and ramified root system and having a dense canopy should be grown e.g. cereal - legumes or strip cropping or erosion permitting and erosion resisting crops.

4. **Incorporation of organic matter**

   To improved physical properties of soils,water-holding capacity and to build up the soil fertility a liberal quantity of organic matter, incorporated in combination with green manure, crop residues with inorganic fertilizers.

Mechanical Practices

Dryland soils are subject to serious erosion problems. Following measures are taken which includes the break up of slopes,intercept run off ,give more time of infiltration and divert water into channels.

1. **Contour bunding**

   To retain soil from erosion and rainwater from run off ,the bund section is 1.61 m^2 in vertisols and 1.05 m^2 in Alfisols, vertical distance 0.9 m can be used across the slope of the land on a level that is along the contour.

2. **Graded bunding**

   Graded bunds are of 0.8 m^2 cross section in vertisols and 0.5 m^2 in Alfisols. The area lost should not be more than 3-5% and there would be no water stagnation. Graded bunds with grassed water ways and box type masonry drainage and outlets in arable lands. Formation of percolation tanks which leads to water in due course, find its way into subsoil and recharges the ground water.

3. **Tie-ridging**

   The practice of tie ridging, where adjacent ridges are joined at regular interval by barriers of ties of the same height, allows the water to infiltrate and prevent run-off except during intense storms.

4. **According to soil types**

   In red soils, graded bunds are preferred the contour bunds because of scope for harvesting run off water for supplementary irrigation. In black soils with their low infiltration characteristic, cultivated fields suffer from the problem of water stagnation,runoff losses can be reduced by adopting the graded bunds. Besides bunding, creating corrugations across the slope as the run off water flows along these corrugations at a safe and non-erosive velocity.

5. **Other technologies**

   Growing a shelter belt or forage, fuel and timber trees of protect the land from wind erosion. Adopting water harvesting by inter-plot, inter-row, modified inter-row, broad-bed and furrows system for in *situ* conservation. Thus to utilize available moisture and water for satisfactory growth of crops, both soil management and water management measures are taken in water stress areas as soils are subject to erosion and loss of available moisture.

Use of soil conditioners

Definition

Soil conditioners are materials, which are added to improve or maintain physical condition of the soil. For high-value greenhouse and market garden crops, these are used in the U.S.A. and European countries.

Uses

Crop residues, manures and other organic substances have long been recognized as excellent materials for

(i) improving the soil structure or physical condition of soil.

(ii) increasing the infiltration of water or reducing the runoff.

(iii) soils properly treated with effective soil conditioners may maintain a good structure for a number of years.

(iv) soil conditioners are used with advantage in stabilizing the soils on slopes subject to rapid erosion.

(v) Synthetic organic materials have been produced forming and stabilizing the soil aggregates. These materials are polyelectrolytes, including polyvinytites, polyacrylates, cellulose gums, lignin derivatives and silicates.

Organic matter, though forming a small part of mineral soils, plays a vital role in the productivity and conditioning of the soils. It serves as source of food for soil bacteria and fungi which are responsible for converting complex organic materials into simple substances readily use by the plants. The intermediate products of the composition of fresh organic matter help to improve the physical condition of the soil and it also improves the working quality of the soil.

At present, soil conditioners are very costly and, as such, are not used on field scale.