UNIT 6: SOIL ORGANIC MATTER

INTRODUCTION

Soil organic matter is the organic component of the soil and it includes all parts of living and dead plants and animals, micro-and macro-organisms and products of decaying processes that occur in the soil. In addition to clay minerals in the soil, organic matter is a major source of plant nutrient elements. The organic matter of most soils ranges between 1-5% mostly in the top 25cm of soil, and the concentration reduces with depth except, relatively in cases in which deep ploughing is being used to incorporate organic materials into the soil.

Definition: Soil organic matter (SOM) could be defined as any material produced originally by living organisms (plant or animal) that is returned to the soil and goes through the decomposition process.

Composition of Soil Organic Matter

About 75% of green tissue is made up of water while 90% of the remaining dry matter is made up of carbon, oxygen and hydrogen. Nitrogen and other mineral elements constitute the remainder of organic matter. The major source of soil organic matter (plant tissue) is made of very complex substances such as carbohydrates (Sugar, starch, hemicellulose, cellulose, pectiles, muscilages) lignins, proteins (soluble proteins and crude proteins), fats (oil), waxes, tannin, resins, pigments and organo-mineral compounds.

Sources of Soil Organic Matter

There are two main sources of organic matter in soils and these include:

(i) **Plant sources:** These are the most prevalent and they include dead and decayed plant roots, leaf droppings, crop residues, green manures and dead and decayed “above ground” parts of plants.

(ii) **Animal sources:** They include all residues of animals and micro-organisms, domestic wastes, animal faeces, animal feeds, and animal manures.

Importance of Soil Organic Matter

Organic matter is so important to the soil that it has been described as the life blood of the soil. Its importance is enumerated as follows:

(1) It is a storehouse of plant nutrients. (2) The stable organic fraction (humus) adsorbs and holds nutrients in a plant available form. Hence, it contributes to the cation exchange capacity of the soil. (3) It improves soil physical conditions. (4) It provides medium for microbial growth and activities. (5) Humus adds substantially to the buffering capacity of soils making it less amenable to pH changes by bases or acids. (6) Organic acids released during decomposition of the soil organic matter aid in the process of rock mineral weathering.

Decomposition of Soil Organic Matter

When plant residues are returned to the soil, various organic compounds undergo decomposition.

Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules by the activities of microorganisms.

Humic substances are series of relatively high-molecular-weight, brown to black colored substances formed by secondary synthesis reactions. It comprises of humic acid, fluvic acid and humins.

Nonhumic substances are compounds belonging to known classes of biochemistry, such as carbohydrates, lipids and amino acids.

Factors Affecting the Rate of Organic Matter Decomposition

(i) The quality of organic material such as the type of plant material, age of the plant and the chemical composition (ii) The physical environment which could be categorized into two:

a) Soil factors such as aeration, temperature, moisture, pH, and fertility status

b) Climatic factors such as rainfall and temperature

(iii) Population of soil microorganisms such as bacteria, fungi, actinomycetes and protozoa

Mineralization of Organic Matter: This is the process involved in the release of plant nutrients from organic matter. Mineralization of organic matter to release mineral nutrients is a two step process, namely:

i. **Aminization** which is the decomposition of organic matter by heterotrophic bacteria to release amino acids and amides.

ii. **Amonification** which is the release of ammonium ion from amino acids and amides. Amino acids + amides heterotrophic bacteria NH_4^+

Maintenance of Soil Organic Matter

The maintenance of the organic matter in soils used for agricultural production is an important practice. The practices involved in the maintenance of soil organic matter include:

i) Addition of new organic materials ii) Sound cropping system that reduces the intensity of cultivations and keeps the soil protected e.g. cover cropping and good crop rotation. iii) Green manuring

iv) Management of crop residues: Crop residues provide varying amounts of organic carbon when incorporated into the soil or used as mulch.

UNIT 7: TYPES AND ACTIVITIES OF SOIL ORGANISMS

INTRODUCTION

All the organisms living within the soil are collectively termed **soil life** or **soil biota. Soil organism** is any organism inhabiting the soil during part or all of its life. Soil organisms range in size from microscopic cells that digest decaying organic material to small mammals that live primarily on other soil organisms. They play an important role in maintaining fertility, structure, drainage, and aeration of soil. They also break down plant and animal tissues, releasing stored nutrients and converting them into forms usable by plants.

Classification of Soil Organisms

The soil organisms are classified into two broad groups, these include:

1. **Soil flora** – subdivided into: (a) microflora size range 1-100 micrometres, e.g. bacteria, actinomycetes, fungi and algae (b) macroflora: size range 20 mm upwards, e.g. roots of higher plants

2. **Soil fauna** – subdivided into: (a) Megafauna: size range 20 mm upwards, e.g. moles, rabbits, and rodents. (b) Macrofauna: size range 2–20 mm, e.g. woodlice, earthworm, beetles, centipedes, slugs, snails and ants. (c) Mesofauna: size range 100 micrometer - 2 mm, e.g. tardigrades, mites and springtails. (d) Microfauna: size range 1-100 micrometres, e.g. protozoa, nematodes and rotifers.

Bacteria: Bacteria are single-celled microbes that are so abundant that a square inch of soil contains millions of these microorganisms. Bacteria primarily act as decomposing agents and usually break down organic material in its initial stage of decomposition due to high moisture levels conducive for their growth. Some common soil bacteria are the species of Pseudomonas, Arthrobacter, Achromobacter, Bacillus, Clostridium, Micrococcus, Flavobacterium, Chromobacterium and Mycobacterium. Chemosynthetic autotrophic bacteria present in the soil are the species of Thiobacillus, Ferrobacillus, Nitrosomonas and Nitrobacter.

Fungi: Fungi are microscopic cells made up of spores, hyphae and gills. They are aerobic and largely distributed in forests. These organisms benefit the soil as they function as decomposers and also act as soil binders, making the earth's water retention more efficient. Some important soil inhabiting microfungi are the species of Aspergillus, Botrytis, Cephalosporium, Penicillium, Alternaria, Monilia, Fusarium, Verticillium, Mucor, Rhizopus, Pythium, Cunninghamella, Chaetomium and Rhizoctonica. Some microfungi, such as species of Alternaria, Aspergillus, Cladosporium and Dematium, are helpful, are helpful in the preservation of organic materials in the soil.

Actinomycetes: A large number of actinomycetes are particularly abundant in the soil rich in decomposed organic materials; species .of Streptomyces, Micromonospora and Nocardia are some common actinomycetes occurring in soils. They are responsible for the characteristic musty or earthy smell of a freshly ploughed field. They are capable of degrading many complex chemical substances and thus play an important role.

Algae: Many microalgal forms occur on the surface of moist soils, where sufficient light is available. The growth of microalgae is helpful for soil conservation and in improving soil structure. In paddy fields, blue-green algae play a significant role in nitrogen fixation. Species of Chlorella, Chlorococcum, Protosiphon, Aphanocapsa, Anabaena, Chroococcus, Nostoc and Scytonema are some common microalgae present in the soil

Protozoa: Protozoans are single-organisms slightly larger than microbes that are organized into three general categories: cilliates, amoebas and flagellates. Protozoans are helpful in maintaining equilibrium of the microbial flora in the soil. Some important protozoans present in the soil are species of Allantion, Biomyxa, Nuclearia, Trinema, Balantiophorus,Colpoda, etc.

Nematodes: Nematodes are a group of tiny roundworms that demonstrate the wide diversity and the inextricable food web that exists in a healthy soil. Most soil nematodes eat bacteria, fungi, protozoa, and other nematodes, making them important in nutrient cycling. Others are plant parasites and cause disease symptoms such as malformed or dwarfed plants, or root structures with deformities such as galls and cysts.

Activities of Soil Organisms

Healthy soil is a jungle of rapacious organisms devouring everything in sight (including each other), processing their prey or food through their innards, and then excreting it. The activities of these organisms have been categorized into two, namely, beneficial and detrimental activities.

A) Beneficial Activities

1. Nutrient cycling: Cycling of nutrients involves the following transformation processes: **decomposition**: turning organic compounds into other organic compounds **mineralization**: turning organic matter into inorganic compounds that may be used by plants **immobilization**: turning inorganic compounds into organic compounds. **mineral transformation**: turning inorganic matter into other inorganic compounds.
2. Enhancing soil structure, which improves water and air movement.
3. Controlling disease and enhancing plant growth.

B) Detrimental Activities

1. Some cause plant diseases e.g. fusarium wilt caused by fungus attack.

2. Some cause root damage e.g. root knot nematode.

3. Some cause tuber destruction e.g. yam beetles in the soil.

Factors Affecting Distribution, Activity and Population of Soil Microorganisms

Soil microorganisms (Flora & Fauna), just like higher plants depends entirely on soil for their nutrition, growth and activity. The major soil factors which influence the microbial population, distribution and their activity in the soil are:

1. Soil fertility 2. Cultural practices 3. Soil moisture 4. Soil temperature

5. Soil aeration 6. Light 7. Soil pH 8. Organic matter 9. Food and energy supply 10. Nature of soil and 11. Microbial associations.

UNIT 8: ORGANIC AND INORGANIC FERTILIZERS

What is a fertilizer?

A fertilizer is any material, organic or inorganic, natural or synthetic, which supplies plants with one or more of the nutrient elements required for normal growth and development. Fertilizers are of two types namely **organic** and **inorganic.** The primary nutrients supplied by fertilizers are nitrogen, phosphorus and potassium. Their concentration in a fertilizer is expressed as percentage of N, P_2O_5 and K_2O.

Inorganic (or mineral) fertilizers are fertilizers mined from mineral deposits with little processing (e.g., lime, potash, or phosphate rock), or industrially manufactured through chemical processes (e.g., urea). Inorganic fertilizer could be classified into three based on the nutrient composition as follows:

1. **Straight fertilizers**: These are fertilizers which contain and supply one or single nutrient element only. They could be nitrogenous, phosphatic or potassic fertilizers supplying nitrogen, phosphorus or potassium, respectively.

a) **Nitrogenous fertilizers**: Nitrogen is the first fertilizer element of the macronutrients usually applied in commercial fertilizers. In the case of nitrogenous fertilizers, nitrogen may be in the ammoniacal, nitrate (or a combination thereof) or amide form. Examples are Ammonium Sulphate, Urea, Ammonium Chloride, Ammonium Nitrate, Calcium Ammonium Nitrate (CAN) etc.

b) **Phosphatic fertilizers**: Phosphorus is the second fertilizer element and it is an essential constituent of every living cell and for the nutrition of plant and animal. Examples are Single Superphosphate, Double Superphosphate, Triple Superphosphate, Basic Slag, Dicalcium Phosphate and Rock Phosphate.

c) **Potassic fertilizers**: Potassium is the third fertilizer element. Potassium acts as a chemical traffic policeman, root booster, stalk strengthener, food former, sugar and starch transporter, protein builder, breathing regulator, water stretcher and as a disease retarder but it is not effective without its co-nutrients such as nitrogen and phosphorus. Examples are Murate of potash and Potassium sulphate.

2. **Complex/Compound fertilizers**: These are fertilizers which contain two or more nutrient elements usually combined in a homogeneous mixture by chemical interaction. Examples are Ammonium Phosphate, Ammonium Phosphate Sulphate, Ammonium Phosphate Sulphate Nitrate, Nitrophosphate, Urea Ammonium Phosphate, Mono Potassium Phosphate etc.

3. **Fertilizer blends or mixed fertilizers:** These are fertilizers formed by physically blending mineral fertilizers to obtain desired nutrient ratios. Two or more of the separate fertilizer carriers or straight fertilizers are mixed to obtain the desired nutrient ratios. Examples are NPK 15-15-15, NPK 20-10-10 etc.

Common Terms used in Fertilizer

1. Fertilizer Grade: This is the numbering system of a particular element in the mixture or the compound. It is usually written in real figures for mixed or compound fertilizers. It is often expressed in a set of three numbers e.g. 15-15-15 indicating manufacturer's guarantee of the percentage of N, P_2O_5 and K_2O.

2. Fertilizer Ratio: This is the relative proportion or ratio of two or more nutrient elements in fertilizer grade e.g. NPK 10-10-10 has a ratio of 1:1:1.

3. Fertilizer Material or Carrier: This is a material which contains at least one plant nutrient. **4. Filler:** This is a material added to a mixed fertilizer to make up weight requirements in a ton (1000 kg). Examples are sand, soil, coal powder, ground lime etc. Advantages and Disadvantages of Inorganic Fertilizers

Advantages and Disadvantages of Inorganic Fertilizer

Advantages	Disadvantages
• Works immediately	• Leaching occurs beyond plant's rooting zone
• Contains all necessary nutrients that are ready for use	• Too much may burn and kill plants
• Affordable	• Some are not affordable
• Convenient to use, it is easy to apply	• Accumulation of toxic wastes

ORGANIC FERTILIZERS

These are natural materials of either plant or animal origin, including livestock manure, green manures, crop residues, household waste, compost, and woodland litter. Organic fertilizers include both plant and animal bi-products. They are slow acting.

Organic fertilizers are categorized into two:

1. **Bulky:** This consists of the slow acting organic manures with large quantities of organic matter. Examples are Cattle, Sheep Poultry, Pig, Goat, Horse manures, Compost, Green Manures, and Sewage Sludge.

2. **Concentrated:** This consists of the quick acting organic manures with small quantity of organic matter. Examples are Groundnut cake, Castor cake, Bone meal, Blood meal, Horn meal, Wood ash, Cotton and Linseed Meal.

Advantages of Organic Fertilizers

(1) Organic fertilizers mobilize existing soil nutrients, so that good growth achieved with lower nutrient densities while wasting less. (2) They release nutrients at a slower, more consistent rate, helping to avoid a boom-and-bust pattern. (3) They help to retain soil moisture, reducing the stress due to temporary moisture stress. (4) They improve the soil structure. (5) They help to prevent topsoil erosion. (6)The necessity of reapplying artificial fertilizers regularly to maintain fertility. (7) Extensive runoff of soluble nitrogen and phosphorus leading to eutrophication of bodies of water (which causes fish kills). (8) Costs are lower for if fertilizer is locally available. (9) Organic fertilizer nutrient content, solubility, and nutrient release rates are typically much lower than mineral (inorganic) fertilizers.

Disadvantages of Organic Fertilizers

Organic fertilizers have the following disadvantages: (1) Generally require large amounts to have desired effects. (2) As a dilute source of nutrients when compared to inorganic fertilizers, transporting large amount of fertilizer incurs higher costs, especially with slurry and manure. (3) The composition of organic fertilizers tends to be more complex and variable than a standardized inorganic product. (4) Improperly-processed organic fertilizers may contain pathogens from plant or animal matter that are harmful to humans or plants. (5) More labor is needed to compost organic fertilizer, increasing labor costs. (6) Unavailability of seed for green manures is one of the major limitations. (7) Green manures must occupy land at a time when other food crops could be grown.

Methods of Fertilizer Application: Fertilizers can be applied to soil before seeds are sown, at the time of planting and while the plants are growing.

http://www.ehow.com/account/simple_login.aspxThe method of fertilizer application to be used is dependent upon the following factors:

i) Type of plant being fertilized ii) Type of soil, iii) Type of fertilizer, and

iv) Size of the area that needs fertilizing.

The following methods are adopted to apply fertilizers:

A) Application of fertilizer in solid form

1. Broadcasting: This type of application method basically refers to the spreading of the fertilizer uniformly over the entire area. This is usually done with a spreader of some sort.

2. Band Placement: This is a method in which fertilizer is placed in a band about 5 cm to the sided of the plant.

3. Drilling: This is a method where fertilizer is applied with a drill at the same time as the seed is sown.

4. Side Dressing: This is a method in which the fertilizer is placed either in a continuous band 4-5 cm deep near the crop or in between the plants in a row.

5. Foliar Application: This refers to the spraying on leaves of growing plants with suitable fertilizer solutions.

6. Starter Solutions: This is a method where solutions of fertilizers, generally consisting of N, P_2O_5, K_2O in the ratio of 1: 2: 1 and 1: 1: 2 are applied to young vegetable plants at the time of transplanting.

7. Application through irrigation water: This is a method where fertilizers are allowed to dissolve in the irrigation stream and the nutrients are carried into the soil in solution.

UNIT 9: SOIL TEXTURE AND SOIL STRUCTURE

SOIL TEXTURE

Soil texture is the relative proportion of various soil separates in a soil. It is usually expressed on percentage basis. Soil separates are group of soil particles of given size range i.e. different size of particles which together make up a given soil. The main textural classes are sand, silt and clay. These textural classes may be modified by addition of suitable adjective based on relative amount of each separate that make up the soil e.g.

Loam: Soil material with clay, silt and sand in close proportion (e.g. 7-27% clay; 28-50% silt and <50% sand).

Loamy sand: Materials with about 80-90% sand.

Sandy loam: <7% clay; <50% silt; about 52% sand.

Other modifications include silty loam, sandy clay loam, clay loam, gravelly loamy sand etc.

Determination of Soil Texture

Soil texture may be determined on the field by textural feel and in the laboratory by soil mechanical analysis or soil particle size distribution. The mechanical analysis in the laboratory may be carried out either by Pipette or hydrometer method. After the proportion of each of the soil separates are determination, the textural class of the soil is identified using a USDA Soil Textural Triangle. The sides of the soil texture triangle are scaled for the percentages of sand, silt, and clay.

Systems of soil particle size classification

There are two widely used systems of soil classification. These are: United State Department of Agriculture (USDA) and International Soil Science Society (ISSS)

USDA Classification system

Fraction	Diameter (mm)
Very coarse sand	2.00 – 1.00
Coarse sand	1.00 – 0.50
Medium sand	0.50 – 0.25
Fine sand	0.25 – 0.10
Very fine sand	0.10 – 0.05
Silt	0.05 – 0.002
Clay	<0.002

ISSS Classification system

Fraction	Diameter (mm)
Coarse sand	2.00 – 0.2
Fine sand	0.2 – 0.02
Silt	0.02 – 0.002
Clay	<0.002

Materials : >20 mm diameter – stone; 20-2 mm diameter – gravel; <2mm diameter – Fine earth (soil)

SOIL STRUCTURE

Soil structure is the arrangement of soil particles to form peds. Or, the arrangement of primary particles into secondary particles (aggregate). Each individual unit of soil is called a ped.

Classification of soil structure

There are three basic groups of classification

1. Classification based on shape of aggregate

(i) Simple structure: this includes (a) Single grain and (b) Massive structure

(ii) Compound structure: under this we have: Spheroidal (Granular, crumb), Block-like (Blocky; sub-angular blocky), Prism- like (Prismatic; columnar), Platy – flat, plate like. These are soil found in compacted soils.

2. Classification based on size and shape of pores

Coarse pore – >200 µm

Medium pore – 200 - 20 µm

Fine pore – 20 - 2 µm

Very fine pores - <2 µm

3. Classification based on grade

Poor e.g single grain structure

Weekly developed: contains high level of sand and silt

Well developed: contains some amount of binding agents

Strongly developed: contains high level of binding agents e.g. soil Organic matter.

Importance of soil structure

1) It affects water and nutrient holding capacity of the soil (2) It affects germination and root growth and development 3) It affects water retention and transmission of fluid in soil

1) It affects soil aeration 5) It influences soil thermal properties

UNIT 10: SOIL MANAGEMENT

Soil management refers to the practices adopted for a particular soil, such as methods of cultivation, erosion control measures, fertilizer practices and pest control. Soil management should include a practice of suitability classification where various farm activities (such as cropping, grazing, shelter belts, woodlots and irrigation) are assigned to the most suitable soil unit.

TILLAGE PRACTICES

Tillage is a physical /mechanical manipulation of the soil for the purpose of crop production. Tillage affects soils structure, soil water conservation, weed infestation, rate of decomposition of soil organic matter, population of soil fauna, soil temperature, seed germination, seedling emergence, crop growth and yield.

Types of tillage

There are three basic types of tillage:

1. Zero tillage: this involves planting on a piece of land without the use of any farm machinery such as tractor; plough. Under zero tillage weeds are destroyed with the aid of herbicides before planting.

<u>Advantages of zero tillage</u>

i. maximum soil erosion control ii. soil moisture conservation iii. minimum fuel and labour cost. iv. promotes soil carbon and nitrogen sequestration

2. Minimum tillage: this involves the use of primary tillage implements such as plough for soil preparation before planting. It is also called reduced tillage.

<u>Advantages of minimum tillage</u>

i. less erosion control ii. well adapted for lighter or medium textured, well-drained soil

iii. excellent incorporation of plant materials

3. Conventional tillage: this involves the use of primary tillage implements such as plough followed by the use of secondary tillage implement such harrow or ridger.

Advantages of conventional tillage

i. excellent control of weeds ii. provides ease of seed planting

iii. seed germination or seedling emergence is faster

SOIL WATER MANAGEMENT

There are 3 basic approaches to soil water management

1. Conservation of natural precipitation 2. Addition of water to supplement the amount of natural precipitation 3. Removal of water from wet land

IRRIGATION

Irrigation is the artificial supply of water to the crops to supplement rainfall

Methods of irrigation

i. Flood irrigation ii. Furrow irrigation iii. Sprinkler irrigation iv. Drip irrigation

DRAINAGE

Drainage or dewatering is the removal of excess water that has accumulated on the soil surface.

Types of drainage

1. Surface drainage: collection and removal of water from the soil surface through open ditches.

2. Subsurface drainage: installation of drainage ditches under ground with the aid of a trenching machine. It is usually laid around 1 m depth to the soil surface.

SOIL EROSION CONTROL

Soil erosion is the wearing away of the soil surface either by water or by wind

Types of water erosion

i. Splash erosion ii. Sheet erosion iii. Rill erosion iv. Gully erosion

Control of water erosion

1. Agronomic practices: these include vegetative cover, cropping systems (e.g. mixed cropping, strip cropping, intercropping and contour cropping).

2. Engineering practices:

Contour bounding: making embankment with a narrow base at intervals across the slope and along the contour.

Gully plugging: this done with live edges, earth, sand bags, brick masonry and boulders.

Small gully can be controlled by clearing, levelling and constructing diversion/check bunds and disposal of excess runoff at the end of the bounds

into grassed slope.

Wind erosion

This is the movement of soil and loss by the action of wind.

Control of wind erosion

i. Construction of windbreak and shelterbelts

ii. Cropping system e.g. cover cropping, strip cropping

iii. Residue of crop left over following harvest

iv. Avoidance of overgrazing

v. Vegetative cover