ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

Department of Agricultural Engineering

ADD ON CROP NUTRIENT MANAGENENT

COURSE MATERIAL

Objectives:

- To introduce integrated crop nutrient management.
- Understand the crop nutrient management and establishment procedures
- Learn about the different management practices during crop establishment and growth.

Course outcomes:

- Students will get knowledge on different crop nutrient management practices.
- Students completing this course would have acquire knowledge on integrated crop nutrient management and establishment procedure.
- Students will be able to delineate their role in integrate weed, pest and pathogen management.

Syllabus :

UNIT 1

Essential plant nutrients- definition, classification of nutrients based on utilization and biochemical functions in plants- definition of macro and micro nutrients, primary and secondary nutrients.

UNIT 2

Role of microorganisms in organic decomposition - humus formation. Importance of C:N ratio and pH in plant nutrition.Crop nutrient management – integrated methods of nutrient management .

UNIT 3

NPK fertilizers – definition of fertilizer, their classification, types of fertilizers and composition of nutrients in fertilizers- methods of fertilizers application.

UNIT 4

Integrated plant nutrient management (IPNM)- definition, component of IPNM and their management.– methods and training of application of nutrient to crop.

UNIT 5

Integrated nutrient management(INM), concept and relevance, components and management options of INM-Soil management for sustainable agriculture.

UNIT 1

PLANT NUTRIENTS

There are different basis of classification of essential nutrients:

1. Quantity of nutrient required
2. Mobility of nutrient in soil
3. Mobility of nutrient with in plant
4. Functions in plant

Classification on the basis of quantity of nutrient required:

1. Basic nutrients:

These constitute 96% of total dry matter of plant.

Name of Basic nutrients:

- Carbon
- Hydrogen
- Oxygen

Among these, carbon and oxygen constitute 45% each and hydrogen is 6%.

2. Macro nutrients

The nutrients which are required by plants in large quantities are called macro or major nutrients. These are nine in number.

Name of Macro nutrients:

- Nitrogen,
- Phosphorus,
- Potassium,
- Calcium,
- Magnesium,
- Sulphur,
- Carbon,
- Hydrogen and
- Oxygen.

Macro nutrients have again two categories:

Primary nutrients

Among macro nutrients, Nitrogen, Phosphorus and Potassium are known as primary nutrients which are required in a proper ratio for a successful crop.

Secondary nutrients

Next to primary nutrients, there are three elements such as Calcium, Magnesium and Sulphur which are known as secondary nutrients.

3. Micro nutrients

These nutrients required by plants in small quantities and also known as minor or trace elements. These are eight in number

Name of Micro nutrients:

- Manganese,
- Iron,
- Zinc,
- Copper,
- Boron,
- Molybdenum
- Chlorine and
- Cobalt.

Classification on the basis of mobility of nutrient in the soil:

Mobile nutrients:

The nutrients are highly soluble and these are not adsorbed on clay complexes.

Example: $\mathbf{NO_3^-}$, SO_4^{2-},BO_3^{2-}, Cl^- and $Mn+^2$

Less mobile nutrients:

They are soluble, but they are adsorbed on clay complex, so their mobility is reduced.

Example: NH_4^+, K^+, Ca^+, Mg^{2+}, $Cu2^+$

Immobile nutrients:

Nutrient ions are highly reactive and get fixed in the soil.

Example: $H_2PO_4^-$,HPO_4^{2-}, Zn^{2+}

Classification on the basis of mobility with in plant:

Highly mobile: N, P and K.

Moderately mobile: Zn

Less mobile: S, Fe, Mn, Cl, Mo and Cu

Immobile: Ca and B

Classification on the basis of functions in the plant:

1. Elements that provide basic structure to plant

Example: Carbon, Hydrogen and Oxygen

1. Elements useful in energy storage, transfer and bonding: These are accessory structural elements which are more active and vital for living tissues.

Example: N, S and P.

1. Elements necessary for charge balance.

Example: K, Ca and Mg.

1. Elements involved in enzyme activation and electron transfer.

Example: Fe, Mn, Zn, Cu, B, Mo and Cl.

Beneficial nutrients: These are not included in essential nutrients, but their application increases the yield up to some extent.

Example: Sodium, Silicon, and Vanadium.

Plant nutrition

Nutrition may be defined as the supply and absorption of chemical compounds required for plant life, growth, and metabolism. It is the process of absorption and utilization of essential elements for plant growth and reproduction. Arnon (1954) has defined the following criteria/objectives for the essentiality of any nutrient:

- The plant cannot grow or complete its life cycle in the absence of the element;
- The element is particular and cannot be replaced by another element;

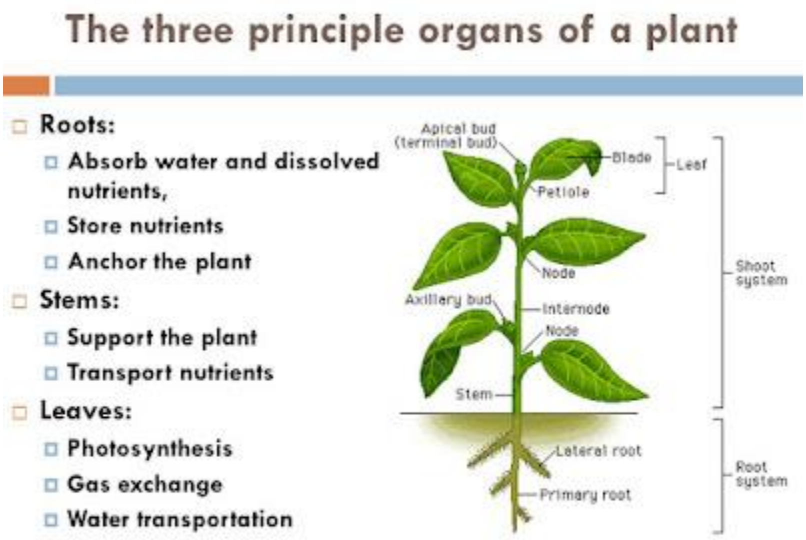
The element plays a direct role in plant metabolism. Major or macronutrient:
Those nutrients required by plants in concentrations exceeding 1000 ppm (0.1%) are termed

major or micronutrients. The term ‘macro’ refers to the amount used (usually 50mg/ kg or more in the plant body) and essential.

- **Primary nutrients:** C, H, O, N, P, K are the primary elements that are essential for seed germination and for plant growth. C, H, O are found abundantly in water and the atmosphere. N, P, K are either obtained from soil or supplied through chemical fertilizers.
- **Secondary nutrients:** They are secondary because they are needed only to grow (secondary growth). They are Ca, Mg and S.

2. Minor or micronutrients:

The elements required by plants in a concentration less than 100 ppm are termed minor or macronutrients. They are also called “trace elements.” The term ‘micro’ refers to the amount used (usually less than 50mg/ kg in the plant body) rather than the essentiality.
Beneficial elements: They are helpful for some specific plants, not for all. e.g., Na, Si (for rice).
Trace elements: Some micronutrients and other non-essential elements (but not macro-nutrients) present in soil or in the plant body in minimal amounts. e.g., Cd, Pb. As, V, Se.
16 essential plant nutrients: C, H, O, N, P, K, Ca, Mg, S, Na, Si, Cd, Pb., As, V, Se.



Sources of plant nutrients (in general)

Plants obtain nutrients in the following ways:

- From the soil solution. i.e., the free water in soil containing dissolved salts.
- From exchangeable ions on the surface of tiny particles of soils and organic matter called “humus” particles, respectively.
- From readily decomposable minerals.
- Through the tiny openings on the surface of leaves, called “stomata.’
- Chief sources of nutrients to plants are clay and humus of soil.

- Nutrients such as NH_4^+, Ca^{++} k^+, Mg^+, etc., are held on clay particles in an exchangeable and available form for use by plants.
- Soil organic matter serves as the principal storehouse for the supply of anions such as $H_2PO_4^-$ or SO_4^{--} to the plants.

Plants absorb nutrients through the following organs.

- **Root hair:** All higher plants uptake nutrients in ionic forms are from soil solution through the root hairs.
- **Stomata of leaves:** O_2 and CO_2 are uptaken in gaseous forms through stomata. Besides, foliar-applied nutrients are also uptaken.
- **Cuticle:** Woody perennials and shrubs can absorb foliar-applied nutrients through the cuticle of bark.
- **Special organ:** Haustaria: in case of dodder.
- **Velamen tissue:** in case of orchid.

UNIT 2

The soil organic matter (SOM) is a complex combination of living organisms, fresh organic residues, actively decomposing material, and stabilized organic matter (otherwise known as humus). Generally, samples containing 50% or more of carbon are referred as soil organic carbon (SOC). Soil organic matter (SOM) is mainly composed of carbon, hydrogen and oxygen but also has small amounts of nutrients such as nitrogen, phosphorous, sulphur, potassium, calcium and magnesium contained within organic residues. Soil organic matter also exists as four distinct fractions which vary widely in their in size, composition and turnover times in the soil.

Components of soil organic matter The size, turnover rate and composition of the four soil organic matter fractions are presented in Table [20]. Fraction Size micrometers µm & millimeters (mm) Turnover time Composition Dissolved organic matter < 45µm (in solution) to days Soluble root exudates, simple sugars and decomposition by-products. It generally makes up less than 5% of total soil organic matter. Particulateorganic matter 53 µm-2mm 2-50 years Fresh or decomposing plant and animal matter with identifiable cell structure.Makes up between 2-25% of total soil organic matter. Humus < 53 µm Decadal Older,decayed organic compounds that have resisted decomposition. Can make up more than 50% of soil organic matter. Resistant organic matter < 53 µm-< 2mm 00s-000 years Relatively inert material such as chemically resistant materials or organic remnants (for example, charcoal). Can be up to 10% of soil organic matter.SOM comes either from plant and crop residues, such as stems, leaves, or shoots, or indirectly from sewage or manure,Animal tissue and excretory products etc. There are two parts in the SOM, the "living" part and "nonliving" part. The "living" part of SOMconsists bacteria, fungi, and insects; the "nonliving" part of SOM includes dead plants, animal matters, and excreta from soil organisms. The non-living soil organic matter can be divided into a number of fractions based on a combination of physical size and chemical form [21]. Classification of soil organic matter Soil organic matter can be classified in to two types. Aboveground organic matter consists of Plant and animal residues and Belowground organic matter comprises living soil fauna and microflora, partially decomposed plant and animal residues, and humic substances [39, 40].

Main functions of soil organic matter

Soil organic matter improves the physical, chemical and biological functions.

Physical functions

1. It improves soil structural stability
2. Influences water retention
3. Changes in temperature by acts a buffer

Chemical functions

1. Soil organic matter has the ability to hold the nutrients (carbon exchange capacity)
2. It buffers pH
3. Soil organic matter immobilizes the heavy metals and pesticides.

Biological functions

• It acts as an energy source for biological process such as microbial decomposition, nutrient transformation, degradation of pollutants, and helps in binding soil particles and soil aggregates. It acts as a major source of plant nutrients and it improves soil resilience.
Soil organic matter is influenced by decomposition process.

What is decomposition?

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. (24) It is a part of the nutrient cycle and is essential for recycling the finite matter that occupies physical space in the biosphere. Study of decomposition is called Taphonomy and it is derived from Greek word-Taphos; meaning-Tomb. Decomposition process The continual addition of decaying plant residues to the soil surface contributes to the biological activity and the carbon cycling process in the soil. Breakdown of soil organic matter and root growth and decay also contribute to these processes. Carbon cycling is the continuous transformation of organic and inorganic carbon compounds by plants and micro-and macro-organisms between the soil, plants and the atmosphere.

Carbon cycle

Speed and rate of decomposition Decomposition of organic matter is largely a biological process that occurs naturally. Its speed is determined by three major factors: soil organisms, the physical environment and the quality of the organic matter (6). In the decomposition process, different products are released: carbon dioxide (CO2), energy, water, plant nutrients and resynthesized organic carbon compounds. The rate of decomposition is dependent on litter quality and environmental conditions. Litter quality factors important to decomposition and mineralization include: nutrient content (e.g., C/N ratio), composition of organic matter, especially lignin concentrations (lignin/nitrogen ratio), and concentrations of polyphenols (including tannins). Litter with higher concentrations of nutrients and lower concentrations of lignin and polyphenols will decompose more rapidly and net mineralization begins earlier. Availability of nutrients from other soil pools also enhances decomposition rates if nutrient concentrations are low in litter. Soil temperature, moisture content and mean residence time also affects the rate of decomposition. Modes/Types of organic matter decomposition There are two modes in the degradation of organic matters into simpler substances i.e. aerobic and anaerobic decomposition. Micro-organisms such as fungi, bacteria, actinomycetes and mouldplay a dominant role depending on the availability of oxygen. Both bacteria and fungi are facultative aerobic or anaerobic.

Aerobic decomposition of organic matter A lot of heat is generated during aerobic decomposition. About two- third of carbon released during aerobic decomposition. Nitrogen is liberated as free ammonia; this ammonia is oxidized as nitrate. This process includes mechanical forces acting on the litter. e.g. (Thawing/freezing and drying/wetting, Bioturbation by earth worms and Light i.e U.V. photo oxidation [46].

Anaerobic decomposition of organic matter

Anaerobic decomposition is mainly a reduction process. Due to incomplete degradation of organic matter, methane (CH_4) and hydrogen (H_2) are evolved. In waterlogged situation (anaerobic), in addition to above organic acids some important organic acids such as acetic acid, formic acid and butyric acid are also evolved.
e.g.: Bacterial and fungal decomposers (95%) and Water acts as a medium for transport of substrate [29]. In this condition, organic matter is decomposed by primary as well as secondary microorganisms. The primary microorganism, initially convert the complex carbohydrates and proteins into simple carbon sources.

Optimal conditions for good decomposition of organic matter in soil
1. Adequate water
2. Adequate supply of nitrogen
3. Optimum pH
4. Good aeration
5. Warm climate
6. A fine state of mechanical disintegration

Humus

In the decomposition process, different products are released: carbon dioxide (CO_2), energy, water, plant nutrients and resynthesized organic carbon compounds. Successive decomposition of dead material and modified organic matter results in the formation of a more complex organic matter called humus [24]. This process is called humification. Humus affects soil properties. As it slowly decomposes, it colours the soil darker; increases soil aggregation and aggregate stability; increases the CEC (the ability to attract and retain nutrients) and contributes N, P and other nutrients.

Usually humus is dark or brown in colour. They are high molecular weight compounds, complex, resistant, polymeric compounds. They are amorphous and colloidal organic substances. Humus is a very stable, long- lived pool of organic matter in the soil with a turnover rate of 10-100 years.

Composition of humus

Humus is a heterogeneous mixture of complex organic compounds. It comprises 58% of carbon and 3-6% of N and C: N ratio of 10:1 to 12:1. Formation of humus Humus formation is a complex two stage process in which organic residues of plant and animal origin undergo profound transformation.
1. Complete mineralization (CO_2, NO_2, NO_3, NH_3, CH_4, H_2O etc.)
2. The synthesis of organic compounds with the formation of high molecular weight humic substances of specific nature.

- Lignin -------------- broken into Polyphenols, Phenolic acids
- Proteins ---------- Polypeptides and Amino acids

• Carbohydrates ------------- Simple sugars
• High molecular weights humic acids (HAs) and Fulvic acids (FAs)
Properties of humus
• Improves soil aggregation, water and nutrient holding capacity and acts as an important source of nutrients for higher plants. As it has slowly decomposing nature, it colours the soil darker
• Its formation has adhesive capacity in Sandy soils and in clay soils increases its cohesive capacity
• It has a high ion adsorbing capacity (4-6 times that of clay) and CEC is very high (300-350 m.eq./100gm) and it is insoluble in water and it behaves like a weak acid and forms salts with bases
• It acts as buffering agent and an oxidation reduction buffer and it also serves as a source of energy and food for the development of various microorganisms

Role of microbes in organic matter decomposition

A soil organic carbon (SOC) is simultaneously a source and sinks for nutrients and plays a vital role in soil fertility maintenance. Several Microorganisms are present in soil ecosystem and they have various properties to decompose the organic carbon fraction like Cellulose, lignin, hemicelluloses, chitin and lipids present in soil organic matter. Organic matter decomposition is primarily a microbiological process and its actual rate and extend are influenced by environmental variables, including soil temperature, moisture, oxygen, nitrogen content, the quality and quantity of available carbon substrates as well as soil management. Decomposition is carried out by heterotrophic microflora and microfauna comprising bacteria, fungi, actinomycetes and protozoa. In contrast to autotrophic organisms which can synthesize their own food from simple substances, heterotrophy derives energy and carbon for their growth solely from organic compounds. Besides the micro flora and micro fauna, many species of mesofauna such as earthworms also play an important role in the initial breakdown of organic residues. Organic matter decomposition serves three functions for the micro flora:
i) Providing energy for growth
ii) Supplying carbon for the formation of cell material
iii) Providing other nutrient, elements needed for cell growth

Interactions between microorganisms and soil fauna

The role of microorganisms in formation and decomposition of soil organic matter cannot be discussed without reference to the interactions of microorganisms with the soil micro-and macrofauna. A diverse range of biota is present in soil, including micro-fauna (e.g., nematodes and protozoa), mesofauna (e.g., Collembola, mites and acari) and macro-fauna (e.g., earthworms, molluscs and termites). The impact of invertebrates on soil organic matter turnover has been studied since Darwin’s pioneering work [8]. Soil invertebrates mediate about 15% of the carbon and 30% of the nitrogen turnover in a range of ecosystems

[2]. Earthworms, microarthropods can play key roles in influencing the activities of microorganisms in organic matter processing in soil [11]. It is well established that there are larger populations of fungi, bacteria and actinomycetes, and higher enzymatic activity in earthworm casts than in bulk soil. Higher proportions of cellulolytic, hemicellulolytic, nitrifying and denitrifying bacteria and larger, more diverse fungal populations have been recovered from casts than surrounding soil [42]. Soils in terrestrial ecosystems are major carbon sinks. This pool of organic carbon is of particular interest because even small changes in flux rates into or out of pools of soil organic matter could have a strong influence on atmospheric carbon dioxide concentrations and associated climate change.

Decomposers

Decomposers are organisms that break down dead or decaying organisms, and in doing so, they carry out the process of decomposition. They are heterotrophic. There are two types of decomposers. Soil fauna (Physical decomposers) Micro-fauna-Nematodes and protozoa; Meso fauna-Collembola, mites and acari; Macro-fauna-Earthworms, molluscs and termites.

Soil microorganisms (Chemical decomposers)

•Bacteria, fungi, actinomycetes and protozoa.

Some of the functions are performed by different members of soil biota

Functions Organisms involved Maintenance of soil structure and Regulation of soil hydrological structure Bioturbating invertebrates, mycorrhizae and some other microorganisms and plant roots Gas exchange and carbon sequestration Microorganisms and plant roots, invertebrate aggregates. Soil detoxification Mostly micro organismsNutrient cycling and Decomposition of organic matter microorganisms and plant roots, soil, saprophytic and litter feeding invertebrates Suppression of pests, parasites and diseases Plants, mycorrhizae, other fungi and other micro organismsSources of food and medicines

Plant roots, various insects and micro organisms and their by productsSymbiotic and asymbiotic relationships Rhizobia, mycorrhizae, actinomycetes, diazotrophic bacteria and various other micro organisms Plant growth control Plant roots, rhizobia, mycorrhizae, actinomycetes, pathogens, biocontrolagents, indirect effects; soil biota

Role of enzymes in organic matter decomposition

Organic matter decomposition is largely an enzymatic process.

Constitutional enzymes are produced by microbial cells, irrespective of the substrate in the environment; inducible enzymes are formed in the presence of a specific substrate. Further, an enzyme may metabolize its substrate within or outside the cell. Accordingly, they are known as intracellular or extracellular enzymes. Extracellular enzymes are essential for the decomposition of polysaccharides because the microbial cell is impenetrable to the large polysaccharide molecules. Monosaccharides, such as glucose, are metabolized by intracellular enzymes. Organic residues added to the soil are first broken down into their basic components by extracellular enzymes; and the basic components are subsequently utilized by intracellular enzymes. Decomposition of plant residues Organic constituents of plants Plant biomass is collectively referred as (ligno cellulose) abundant raw

material on earth

Composition of organic residues

Plant residues contain 75% moisture and 25% dry matter. This 25% is Carbon, (10-12%), Oxygen (9-10%), Hydrogen (1.5-2.5%), N (1-2%) and mineral matter (1-3%). Composition of plant tissues
Plant tissues contain Cellulose-40 to 50% Hemicellulose-20-40%; Lignin-20 to 35%. Water soluble fraction: simple sugar, amino acids, aliphatic acids, 5 to 30% of tissue weight. Ether and alcohol-soluble constituents: fats, oils, waxes, resins and a number of pigments proteins.

The organic matter is also classified on the basis of their rate of decomposition
1. Rapidly decomposed: Sugars, starches, proteins etc.
2. Less rapidly decomposed: Hemicelluloses, celluloses etc.
3. Very slowly decomposed: Fats, waxes, resins, lignin etc.

The process of decomposition is initially fast, but slows down considerably as the supply of readily decomposable organic matter gets exhausted. Sugars, water-soluble nitrogenous compounds, amino acids, lipids, starches and some of the hemicellulases are decomposed first at rapid rate, while insoluble compounds such as cellulose, hemicellulose, lignin, proteins etc. which forms the major portion of organic matter are decomposed later slowly. Thus, the organic matter added to the soil is converted by oxidative decomposition to simpler substances which are made available in stages for plant growth and the residue is transformed into humus.

Decomposition of soluble substances

Under aerobic conditions
When glucose is decomposed under aerobic conditions the reaction is as under:
Sugar + Oxygen → CO_2 + H_2O
Partially oxidized conditions
Sugar + Oxygen → aliphatic acids (Acetic, formic etc.) or hydroxyacids.
(Citric, lactic etc.)or Alcohols (ethyl alcohol etc.).

Ammonification
- Organic N-Polypeptides-Peptides-aminoacids-NH_3 or NH_4
- Conversion of Organic nitrogenous compounds-ammonia.

Nitrification
- NH_3 → NO_2→ NO_3 (nitrosomonas and nitrobacter)
- It is an aerobic process by autotrophic bacteria.

The net reactions are as follows: NH_4 + O_2 → NO_2 + $2H^+$ + H_2O + energy.
NO_2 + O_2 → NO_3 + energy

Denitrification

Nitrate → N_2 gas (Pseudomonas/Bacillus).
Decomposition of insoluble substances
Under anaerobic conditions $C_6H_{12}O_6$ (Glucose) converted in to Lactic acid, butyric acid Ethyl alcohol are formed. Protein and other N compounds are converted into elemental N.

Protein decomposition

- Aminization: The process of conversion of proteins to aminoacids
- Ammonification: The process of conversion of aminoacids and amides to ammonia and enzymes
- Aminization or Ammonification: Which is brought about by certain enzymes, collectively known as "proteases" or "proteolytic" enzymes secreted by various microorganisms

Cellulose decomposition
Cellulose is the most abundant carbohydrate present in plant residues/organic matter in nature. When cellulose is associated with pentosans (e.g. xylans&mannans) it undergoes rapid decomposition, but when associated with lignin, the rate of decomposition is very slow.
The decomposition of cellulose occurs in two stages:
i) In the first stage the long chain ofcellulase is broken down into cellobiase and then into glucose by the process of hydrolysis in the presence of enzymes cellulase and cellobiase
ii) In second stage glucose is oxidized and converted CO_2 and water.

Cellulose is a structural polysaccharide that contains glucose. In order to access this glucose for catabolism, the cellulose must be decomposed by extracellular enzymes. These pieces are then transported into the cell for energy generation (catabolism) or production of biomass (anabolism). Fungi such as Penicillium and Aspergillus and bacteria such as Streptomyces and Pseudomonas are important participants in the extracellular cleavage of cellulose

Enzymes: Fungi produces three types of cellulolytic enzymes that cooperate in the degradation of cellulose: endoglucanases (EG I to EG V), cellobiohydrolases (CBH I and CBH II), and β-glucosidases (BGL I and BGL II).

Hemicelluloses decomposition
Hemicelluloses are water-soluble polysaccharides and consist of hexoses, pentoses, and uronic acids and are the major plant constituents second only in quantity of cellulose, and sources of energy and nutrients for soil microflora. The hydrolysis is brought about by number of hemicellulolytic enzymes known as "hemicellulases" excreted by the microorganisms. On hydrolysis hemicelluloses are converted into soluble monosaccharide/sugars (e.g. xylose, arabinose, galactose and mannose) which are further converted to organic acids, alcohols, CO_2 and H_2O and uronic acids are broken down to pentoses and CO_2. Various microorganisms including fungi, bacteria and actinomycetes both aerobic and anaerobic are involved in the decomposition of hemicelluloses. Even though hemicelluloses decomposition is much quicker than cellulose decomposition, cells will utilize simple as substrates before hemicelluloses.

Enzymes: Hemicellulases are xylanases, mannanases, arabinofuranosides and pectin lyases.

Chitin decomposition

Chitin is a special compound which can be found in the integument of arthropods and cell wall of fungi. The polymer is not easily degraded, and requires a variety of enzymes to do so shows the decomposition process of chitin and chitosan. The dominant chitin degrades are the actinomycetesStreptomyces and Nocardia, and (less importantly) fungi as Trichoderma and
Verticillium

Enzymes: Microbes produced Chitinase enzymes for chitin degradation and Chitosanase for chitosan degradation.

Lignin decomposition

Lignin is the third most abundant constituent of plant tissues, and accounts about 10-30 percent of the dry matter of mature plant materials. Lignin content of young plants is low and gradually increases as the plant grows old. It is one of the most resistant organic substances for the microorganisms to degrade however certain basidiomycetes fungi are known to degrade lignin at slow rates. The final cleavages of these aromatic compounds yield organic acids, carbon dioxide, methane and water. Lignin is the main component of wood in trees. Lignin has a varied, unique, and complicated chemical structure which contains many aromatics. These aromatics can be released from the lignin structure by fungal enzymes such as peroxidases and oxidases. The enzymes utilize H2O2 and OH radicals to break the bonds in the lignin. Common types of fungi which degrade lignin are white rot (Phanerochaetechrysosporium), brown rot, and soft rot. Once the aromatics are released from the original lignin structure they are incorporated into the metabolic pathway as pyruvate, acetyl CoA,
and into the TCA cycle

Enzymes

Lignin peroxidase, Mn (II)-Dependent Peroxidases, Quinone Reductasesare produced by microbes for lignin degradation.
Lipids decomposition Soil lipids, a complex series of 500 different fatty acids, are mostly derived from plants and microorganisms. The lipid content of soil organic matter ranges from 2% to 20%. Phospholipids are the primary lipids composing cellular membranes.

Enzymes

Phospholipases are enzymes that degrade phospholipids through hydrolytic cleavage of carboxy and phospho-diester bonds. Phospholipases A, B lipases fatty acid esters and Phospholipases of the C, D types cleave phosphate ester bonds.

Breakdown of Starch

It is chemically a glucose polymer and is first hydrolyzed to maltose by the action of amylases. Maltose is next converted to glucose by maltase. The process is represented as under

$(C_6H_{10}O_5)_n + nH_2O \rightarrow n(C_6H_{12}O_6)$

Decomposition of ether soluble substances
Fats → glycerol + fatty acids
Glycerol → CO_2 + water
Sulphur containing organic compounds
It is converted to sulphates and energy by sulphur oxidizing bacteria.
Factors influencing the rate of decomposition biological activity
If the microbial activity in soil is high, the decomposition rate will be high.

Temperature

Initiation of bacterial activity was started when temperature greater than 4000F-. For every increase in 100o F-microbial population will double. So organic matter breaks down faster in summer.

Aeration and soil type
In Loose texture soils availability of oxygen is faster decomposition will occur. A tight texture soil contains high clay content results in less biological activity and slower organic matter breakdown.

Soil pH
In Low pH soil (acidic soil < 6) the decomposition rate will slow.
Litter quality
The rate of decomposition depends on the structural and chemical properties of litter. For e.g., the litter of bryophytes are decomposed at a slower rate due to the presence of lignin like complex chemicals. Inorganic chemicals After decomposition, the elements like potassium, sodium, calcium, magnesium are released into the soil. Some of these are used by the microorganisms for their growth. Thus it affects the rate of decomposition.

Moisture

The amount of water in the soil both indirectly and directly affects the decomposition rate of organic matter. In Wet soil-slower break down; Dry soil-decreases organic matter decomposition, microorganisms cannot survive without water. So soils that undergo constantly wet and dry periods organic matter will be decompose more quickly

Importance of C: N ratio in decomposition
C: N ratio or C/N ratio
A carbon to nitrogen ratio is a ratio of the mass of organic carbon to the mass of total nitrogen in a soil or organic matter. It is the relationship between organic matter and nitrogen content of soils or plants. When composting, microbial activity utilizes a C/N ratio of 30-35:1

and a higher ratio will result in slower composting rates. For practical agricultural purposes, compost should have an initial C/N ratio of 20-30:1

Measurement of C: N ratio

CHN analyzer, Continuous-flow isotope ratio mass spectrometer (CF- IRMS).

Importance of C: N ratio

1. C: N ratio mainly controls decomposition rate in soil Wide C: N ratio-slow decomposition rate, nutrient immobilization. Narrow C: N ratio-Carbon and energy starvation occur, Plant residues decompose quickly and release nitrates readily.
2. It is a source of food and energy for plants Soil organisms require carbon for building essential organic compounds and to obtain energy for life process, but they must also obtain sufficient N to synthesize N containing cellular components, such as amino acids, enzymes and DNA.
3. Influence of C/N ratio on N releaseC: N ratio ->25:1, the soil microbes will have to scavenge the soil solution to obtain enough N. C: N ratio -<20: 1, Organic matter helps in increase in N content of soil for plants and organisms.
4. The decay of organic matter can be delayed.
5. Influence of C/N ratio on Soil ecology Saprophytic bacteria and fungi and nematodes, protozoa and earthworms that grow rapidly on organic residues as food source.
6. C: N is related to release of available N, total organic content and accumulation of humus C: N ratio's of some of the organic material Organic materials C:N ratio Organic materials C:N ratio Alfalfa 20:1 Rye straw 200:1 Microbial population 10:1 Saw dust400:1 Soil organic matter 10-12:1 Clovers (mature) 20:1 Maize stalk 40:1 Soil humus 11:1 Rice straw 100:1 cereal straws > 100

Research evidences for organic matter decomposition

The optimum and perfect C:N ratio for decomposing compost was found to be in the ratio of 2:1 and a ratio of 1:2 grew mold [34]. Organic matter retention was high in conventional tillage at the time of sowing and decreased at different stages due to without intercultivation operations and further increased at the time of sowing. Inter cultivation and ploughingpractices increases the organic matter retention and increased in microbial activity [14]. The temperature below 0 ℃ the accumulation of soil matter increases due to the slow rate of decomposition results in decrease in microbial activities and biochemical processes [1] but if the soil temperature lies between 2 ℃-38 ℃ increases the organic matter decomposition by
increasing the movement of soluble substrates in the soil and stimulating microbial activities [13, 15].

Increase in soil temperature-increase in metabolic activities of microorganisms and increased in nutrient uptake and stimulate the available nutrients but low soil temperature-nutrient uptake by plants reduce as a result of high soil water viscosity and low activity of root nutrient transport [27]. The influence of soil moisture and temperature on decomposition of four waste materials. The average rates of CO_2 generation during the 50-day incubation period. As a whole, rice straw generated CO_2 at the highest rate followed by bagasse, rice chaff and coir dust in this order, and the CO_2 generation rate was higher at 35 ºC than at 20 ºC. The rate of CO_2 generation from bagasse, coir dust and rice chaff in submerged soil was lower than that in saturated and half-saturated soils, but that from rice straw was comparable to that in saturated and half-saturated soils at both 20 and 35 ºC. Interestingly, however, the rate of CO_2 generation from rice straw incubated in submerged soil had a peak at 40 and 20 days after the start of incubation at 20 and 35 ºC, respectively. This means that rice straw in submerged soil decomposed more rapidly at 35 ºC than at 20 ºC [41].

The addition of readily available substrates significantly increases Q_{10} values because substrate saturation eliminates the cancelling effect of Km on the measured Q_{10} values [17] When Vmax and Km cancel each other out, respiration is controlled by temperature sensitive processes that alleviate substrate limitation, e.g. decomposition of stabilised SOM pools is a process that produces available substrate.

The reduction of soil disturbance through zero-tillage, the use of cover crops and the preservation of crop residues on the soil surface results in increased activity of the soil and in the accumulation of organic matter, mainly in the topsoil.(14) The physical properties (bulk density, moisture content, water holding capacity and porosity) of the different types of compost (cattle manure and herbal plants residues (50:50), cattle manure and sugar cane plants residues (50: 50), herbal plants residues and sugar cane plants residues) were analyzed. The results indicate the C/N ratio values ranged from 14.22:1 to 18.52:1. The bulk density value ranged from 420 to 655 kg m^{-3}. The moisture content values ranged from 23.50 to 32.10%. The water holding capacity values ranged from 3.50 to 4.40 g water/g dry. The porosity values ranged from 60.69 to 72.47% for different compost [36].

Decomposition of green manures

Green manure can be defined as the practice of plant cultivation until the flowering stage or until the incomplete development of seeds, with subsequent cutting and/or incorporation of its biomass into soil the basic purpose of this technique is to improve chemical, physical, and biological soil characteristics in order to increase or stabilize the production of one or more crops in an area. Famers usually use legumes as green manure because of the high biomass yield, biological nitrogen fixation (BNF) and cycling of nutrients from deeper soil layers[45]. The Selection of the green manure crop is based on prevailing climatic conditions, cropping system practiced, availability of seed, and other factors, including local habits and prejudices.

Main factors influencing the decomposition of crop residues and green manures in tropical environments The decomposition of crop residues or green manures in the soil is a complex process, which is the result of the interaction between different factors (biotic and abiotic) specific of each environment. However, the main abiotic factors that drive this process are related to their influence on soil organisms, since the decomposition is essentially a biological process [23].

Initially, the decomposition consists in the physical fragmentation process of the organic residues into smaller particles. Physical fragmentation of residues provides an increase in surface area, facilitating microbial colonization and subsequent hydrolysis by microbial extracellular enzymes. Thus, complex polymers are degraded into monomeric compounds and ions, which can be absorbed by microbial cells or plants. C/N, C/P and C/S ratios in crop residues and green manures

The use of green manures and crop residues provides various conditioning effects to the soil; however, the main objectives of this practice in low-fertile tropical soils are increasing soil cation exchange capacity (CEC) and provide nutrients for the plants. Thus, the nutrient contents present in these plants (mainly N, P and S) are one of the first characteristics to be observed. However, N, P and S contents in the residue do not necessarily mean that they will be released synchronously with the plant needs during the decomposition process. After the decomposition, monomeric compounds and ions can be absorbed by microorganisms present in the soil, which use them as energy supply or metabolic precursors. After these requirements are satisfied, excess ions may be released into the soil solution and be available for the plants.

Types of soil, Crop and crop growth stage at which it is incorporated, and prevailing climatic conditions [12].Quantity and quality of green manure crops. Soil factors: soil texture, structure, soil reaction, microbial activity, and the status of soil nutrients [10]. Decomposition and mineralization of OM mainly depend upon the availability of N in soil [18, 23]. Due to low C/N ratio, lower lignin content, and high quantity of easily decomposable material, LGM generally leads to rapid and fast mineralization as compared to cereal residues [22, 18]. Decomposition rate of green manure legume was higher in sandy soils than the fine-textured soils [44]. The incorporation of hairy vetch legume green manure rapidly released N within 15 days after incorporation [43]. Legume residue incorporation into soils under field conditions led to that of the <30% of legume N recovered by a subsequent non-legume cereal crop and a major amount of it is retained in soil as organic forms of N [19, 26]. Fractional C and N release was greater in dried and rewetted soil for green manuring legumes compared to continuously moist soil for all parts except for nodules .

Mobilization and immobilization of nutrient in green manures in soil

Decomposition rate for Crotalaria juncea and Canavaliaensiformesreported in the study based on precipitation. Higher decomposition rate was observed in Crotalaria juncea, with half-lives ranging between 94 and 103 days. In that study the precipitation may have been decisive for the rate of decomposition even if Crotalaria juncea had high C/N ratio. Canavalia ensiformes showed the highest decomposition constant, with a half-life of 120 days. being the legume that has the lowest C/N ratio. Despite the low values of C/N ratios, it can be observed decomposition of residues was quite slow, being justified by the almost complete absence of precipitation during the period of decomposition.

Biological health of soil improved considerably in terms of population of fungi, bacteria, actinomycetes, total microbial count, microbial biomass carbon and nitrogen Improvement of soil environment in the Gliricidiarhizosphere in the field bund soil could be due to improvement of organic carbon and root activity and rhizodeposition. Under protected cultivation in greenhouse showed that cowpea has a higher mineral composition than dhaincha under wetland rice

Cover crop is one of the major pillars for conservation agriculture as it satisfies two major principles of conservation agriculture. Cover crops were mainly grown as green manure earlier, as animal feed or to surpass the drought period in rainfed areas but now-a-days the most imperative use of cover crops is for the conservation agriculture mainly in no-tillage or minimum tillage farming.

The rate of substrate availability in mediating the response of soil microbial respiration rate (SMRR) relative to temperature was investigated using soils from southern Inner Mongolia. Two independent experiments were performed: the first one was to provide natural soils with different soil water contents (non-incubation experiments), and the second one was to incubate soils under two .

Microbial breakdown of soil organic matter influences the potential for terrestrial ecosystems to sequester carbon, and the amount of carbon dioxide released to the atmosphere. Predicting the sensitivity of microbial decomposition to temperature change is therefore critical to predicting future atmospheric carbon dioxide concentrations and feedbacks to anthropogenic warming. According to enzyme .

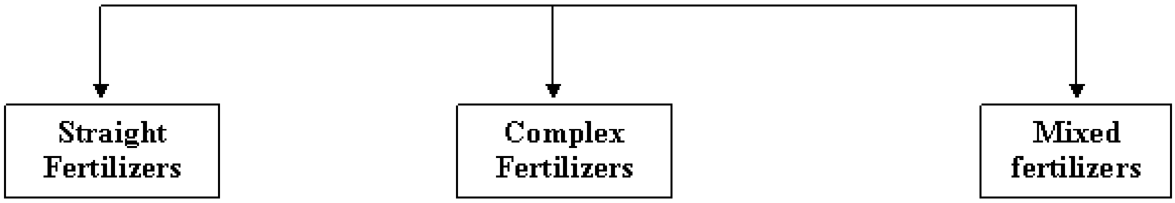
UNIT 3

FERTILIZER

Fertilizer is any material of natural or synthetic origin added to the soil to supply one or more plant nutrients.

CLASSIFICATION OF FERTILISERS

Fertilisers



1. Straight fertilizers: Straight fertilizers are those which supply only one primary plant nutrient, namely nitrogen or phosphorus or potassium. eg. Urea, ammonium sulphate, potassium chloride and potassium sulphate.

2. Complex fertilizers: Complex fertilizers contain two or three primary plant nutrients of which two primary nutrients are in chemical combination. These fertilisers are usually

produced in granular form.
eg. Diammonium phosphate, nitrophosphates and ammonium phosphate.

3. **Mixed fertilizers**: are physical mixtures of straight fertilisers. They contain two or three primary plant nutrients. Mixed fertilisers are made by thoroughly mixing the ingredients either mechanically or manually.
Fertilisers can also be classified based on physical form:

1. Solid
2. Liquid fertilizers

Fertilizer

Solid fertilizers are in several forms *viz*.

1. Powder (single superphosphate),
2. Crystals (ammonium sulphate),
3. Prills (urea, diammonium phosphate, superphosphate),
4. Granules (Holland granules),
5. Supergranules (urea supergranules) and
6. Briquettes (urea briquettes).

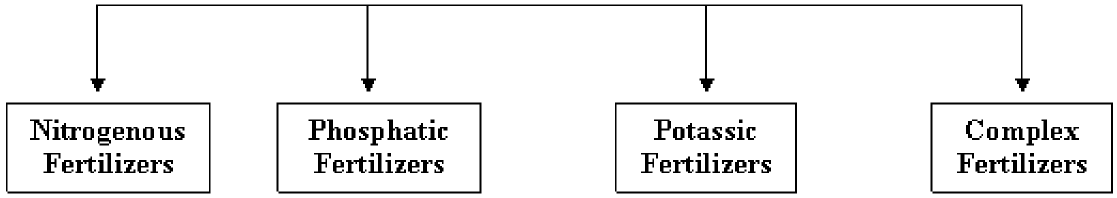


Urea prills **Granulated urea** **Ammonium sulphate**

Liquid fertilizers:

1. Liquid form fertilizers are applied with irrigation water or for direct application.
2. Ease of handling, less labour requirement and possibility of mixing with herbicides have made the liquid fertilisers more acceptable to farmers.

Fertilizer



Nitrogenous fertilizer

Ammoniacal	Nitrate	Ammoniacal and Nitrate	Amide fertilizer
1. Ammonium Sulphate 2. Ammonium chloride 3. Anhydrous ammonia	1. Sodium Nitrate 2. Calcium Nitrate 3. Potassium Nitrate	1. Ammonium Nitrate 2. Calcium Ammonium Nitrate 3. Ammonium Sulphate Nitrate	1. Urea 2. Calcium Cynamide

A. Nitrogenous fertilizers

1. Nitrogenous fertilizers take the foremost place among fertilizers since the deficiency of nitrogen in the soil is the foremost and crops respond to nitrogen better than to other nutrients.
2. More than 80 per cent of the fertilizers used in this country are made up of nitrogenous fertilizers, particularly urea.
3. It is extremely efficient in increasing the production of crops and the possibilities of its economic production are unlimited.

The nitrogenous fertilizers can be further classified as given below:

1. Ammoniacal fertilizers

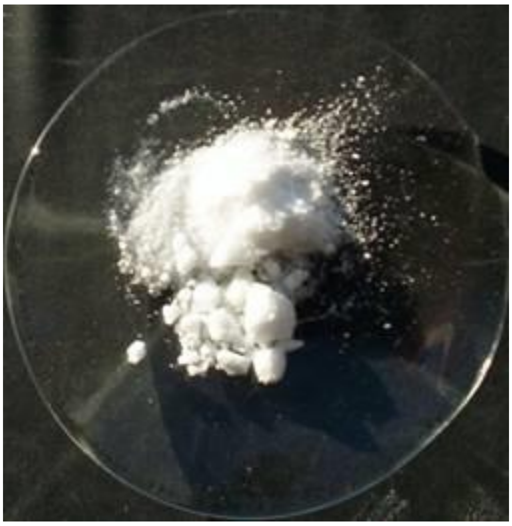
1. Ammoniacal fertilizers contain the nutrient nitrogen in the form of ammonium or ammonia.
2. Ammoniacal fertilizers are readily soluble in water and therefore readily available to crops.
3. Except rice, all crops absorb nitrogen in nitrate form. These fertilizers are resistant to leaching loss, as the ammonium ions get readily absorbed on the colloidal complex of the soil.

a) *Ammonium sulphate* [(NH4)2 S04]

1. It is a white salt completely soluble in water containing 20.6 .per cent of nitrogen and 24.0 per cent of sulphur.
2. It is used advantageously in rice and jute cultivation.
3. It is easy to handle and it stores well under dry conditions. But during rainy season, it sometimes forms lumps.
4. It can be applied before sowing, at the time of sowing or as a top-dressing to the growing crop.

b) *Ammonium chloride* (NH4Cl)

1. It is a white salt contains 26.0 per cent of nitrogen.
2. It is usually not recommended for tomato, tobacco and such other crops as may be injured by chlorine.



c) *Anhydrous ammonia* (NH4)

1. It is a colourless and pungent gas containing 82.0 per cent nitrogen.
2. It is the cheapest and can be applied directly to soil by injection using blade type applicator having tubes.

3. It becomes liquid (anhydrous ammonia) under suitable conditions of temperature and pressure.

2. Nitrate Fertilizers

1. Nitrate fertilizers contain the nitrogen in the form of NO3
2. These ions are easily lost by leaching because of the greater mobility of nitrate ions in the soil.
3. Continuous use of these fertilizers may reduce the soil acidity as these nitrogenous fertilizers are basic in their residual effect on soils.

a) *Sodium nitrate* (NaNO3)

1. Sodium nitrate is a white salt containing about 15.6 per cent of nitrogen.
2. It is completely soluble in water and readily available for the use of plants as such, without any chemical change in the soil.
3. It is easily lost by leaching and denitrification.
4. When large quantities of sodium nitrate are added year after year, the nitrate ions are absorbed by crops and sodium ions accumulate and affect the structure of the soil. Sodium nitrate is also known as *chile salt peter* or *chilean nitrate*.
5. Sodium nitrate is particularly useful for acidic soils

b) *Calcium nitrate* [Ca (NO3)2]

1. It is a white crystalline hygroscopic solid soluble in water containing 15.5 per cent nitrogen and 19.5 per cent calcium.
2. The calcium is useful for maintaining a desirable soil pH.

Calcium nitrate

c) *Potassium nitrate* (KN03)

1. The purified salt contains 13.0 per cent nitrogen and 36.4 per cent potassium.
2. The nitrogen of the potassium nitrate has the same properties and value as that of the sodium nitrate.

3. Ammoniacal and nitrate fertilizers

These fertilizers contain nitrogen in both ammonium and nitrate forms. The nitrates are useful for rapid utilization by crops and the ammonical is gradually available.

a) *Ammonium nitrate* (NH4N03)

1. It is white, water soluble and hygroscopic crystalline salt containing 35 per cent nitrogen half as nitrate nitrogen and half in the ammonium form.
2. In the ammonium form, it cannot be easily leached from the soil.
3. This fertilizer is quick-acting, but highly hygroscopic and not fit for storage.
4. It has an acidulating effect on the soil.
5. It is dangerous in pure form because of explosion hazard.

b) *Calcium ammonium nitrate* (CAN)

1. Calcium ammonium nitrate is a fine free-flowing, light brown or grey granular fertilizer, containing 26 per cent of nitrogen.
2. It is almost neutral and can be safely applied even to acid soils.
3. Half of its total nitrogen is in the ammoniacal form and half is in nitrate form.
4. It is made harmless by adding lime.

Calcium ammonium nitrate

c) *Ammonium sulphate nitrate* [(NH4)2S04 NH4NO3]

1. It contains 26 per cent nitrogen, three fourths of it in the ammoniacal form and the rest (6.5 per cent) as nitrate nitrogen.
2. In addition to nitrogen it contains 12.1percent sulphur.
3. It is a mixture of ammonium nitrate and ammonium sulphate.
4. It is available in a white crystalline form or as dirty-white granules.
5. It is readily soluble in water and is very quick-acting.
6. Its keeping quality is good and it is useful for all crops.
7. Its acid effect on the soils is only one-half of that of ammonium sulphate.

8. It can be applied before sowing, at sowing time or as a top-dressing.

4. Amide fertilizers

1. Amide fertilizers are readily soluble in water and easily decomposable in the soil.
2. The amide form of nitrogen is easily changed to ammoniacal and then to nitrate form in the soil.

a) *Urea* [CO (NH2)2]

1. It is the most concentrated solid nitrogenous fertilizer, containing 46 per cent nitrogen.
2. It is a white crystalline substance readily soluble in water.
3. It absorbs moisture from the atmosphere and has to be kept in moisture proof containers. It is readily converted to ammoniacal and nitrate forms in the soil.
4. The nitrogen in urea is readily fixed in the soil in an ammoniacal form and is not lost in drainage.
5. Urea sprays are readily absorbed by plants.
6. It may be applied at sowing or as, a top-dressing.
7. It is suitable for most crops and can be applied to all soils.

b) *Calcium cyanamide* (CaCN2)

1. Calcium cyanamide or nitrolime contains 20.6 per cent of nitrogen.
2. It is a greyish white powdery material that decomposed in moist soil giving rise to ammonia.

B. Phosphatic fertilizers

1. Phosphatic fertilizers are chemical substances that contain the nutrient phosphorus in absorbable form (Phosphate anions) or that yield after conversion in the soil.

Super phosphate [Ca (H2PO4)2)

1. This is the most important phosphatic fertilizer in use.
2. It contains 16 Per cent P2O5 in available form.
3. It is a grey ash like powder with good keeping or storage qualities.
4. Phosphatic fertilizer hardly moves in the soil and hence they are placed in the, root zone.

Triple super phosphate:

1. The concentrated super phosphate is called as *Triple super phosphate* and it contains 46 per cent P2O5.
2. This fertilizer is suitable for all crops and all soils.

3. In acid soils, it should be used in conjunction with organic manure.
4. It can be applied before or at sowing or transplanting.

C. Potassic fertilizers

1. Potassic fertilizers are chemical substances containing potassium in absorbed form (K+).
2. There are two potassium fertilizers *viz.*, muriate of potash (KCI) and sulphate of potash (K2S04).
3. They are water soluble and so are readily available to plants.

a) *Potassium chloride* (KCI)

1. Potassium chloride or muriate of potash is a white or red, crystal containing 60.0 per cent K2O.
2. It is completely soluble in water and therefore readily available to the crops.
3. It is not lost from the soil, as it is absorbed on the colloidal surfaces.
4. It can be applied at sowing or before or after sowing.
5. The chlorine content is about 47.0 per cent.
6. Its chlorine content is objectionable to some crops like tobacco, potato, etc where quality is the consideration.

b) Potassium sulphate (K2S04)

1. Potassium sulphate or sulphate of potash is a white salt and contains *48* per cent K2O.
2. It is soluble in water and therefore readily available to the crop.
3. It does not produce any acidity or alkalinity in the soil.
4. It is prefered for fertilization of crops like tobacco, potato etc., where quality is of prime importance.
5. It is costly because it is made by treating potassium chloride with magnesium sulphate. .

E. Secondary major-nutrient fertilizers

a. Magnesium fertilizers

These are chemical substances containing the nutrient magnesium in the form of magnesium cations (Mg2+).

Magnesium Sulphate (MgSO4)

The utilization rate of magnesium fertilizers decreases w,ithincr,easing potassium supplies.
b. Calcium fertilizers

1. These are the chemical substances containing the nutrient calcium in absorbable calcium cations ('Ca2+) form.
2. The raw material of calcium fertilizers is lime found in nature.

Calcium Chloride (CaCl2 6H2O)

1. It contains at least 15 per cent calcium.
2. It is highly water soluble and can, therefore, be dissolved for application as a foliar nutrient.

c. Sulphate Fertilizers

1. These are chemical substances containing the nutrient sulphur in the form of absorbable sulphate anions (SO42-).
2. The sulphur requirements of plants are about two third of their phosphorus requirements.
3. Substantial sulphur supplies occur as minor constituents of various N, P and K fertilizers.
4. Fertilization with sulphur becomes necessary with increasing removal from the soil with rising agricultural production especially in plants with high sulphur requirements. e.g. mustard

D. Micronutrient Fertilizers

1. The importance of fertilization of crops with micro-nutrients is increasing mainly because of greater removal from the soil, intensive liming of soil, intensive drainage of soil, higher use of nitrogenous, phosphatic and potassic fertilizers etc.
2. There are seven essential micronutrients required by plants.

These are iron, manganese, zinc, copper, chlorine, boron and molybdenum.

a. lron fertilizers

1. These are generally water soluble substances, predominantly sprayed as foliar nutrients on the crops.
2. Plants absorb iron in the form of Fe2+.

Commonly used iron fertilizers are as follows.

***Ferrous sulphate* (FeSO4 7H2O)**	It is a water soluble fertilizer containing 20 % Fe
Fe – Chelates Fe-EDTA	Suitable for application as foliar nutrients

Fe-EDDPA	

b. Manganese fertilizers

The manganese (Mn) fertilizers are as follows:

Manganous Sulphate ($MnSO_4\ 7H_2O$)	It is the well known water soluble Mn fertilizer. It is pink salt containing 24 % Mn. It dissolves in water and is suitable for foliar application.
Mn – chelates (Mn – DTA)	It contains 13 % Mn. It plays an important role in the crop fertilization.

c. Zinc fertilizers

Zinc (Zn) fertilizers play an important role in Zn deficient areas.

Zinc sulphate ($ZnSO_4\ 7H_2O$)	It is water soluble whitish salt containing 23 % Zn. It is applied as foliar nutrient. Its acidic action causes corrosion damage to plants
Zinc-oxide(ZnO)	It contains 70 % Zn. It is slightly soluble in water It is used as slow acting foliar nutrient

d. Copper Fertilizers

Copper fertilizers have been used to correct copper (Cu), deficiencies.
Copper sulphate ($CuSO_4\ 5H_2O$) – 25 % Cu
Copper sulphate ($CuSO_4\ H_2O$) – 36 % Cu

e. Boron Fertilizers

Borax ($Na_2B_4O\ 10H_2O$)	It contains 11 % B It is water soluble white salt It can be applied as a soil dressing or foliar application
Boric acid (H_3BO_3)	It contains 18 % B It is a white crystalline powder It is applied as a foliar nutrient

f. Molybdenum Fertilizers

Sodium molybdate ($Na_2MoO_42H_2O$)	It contains 40 % Mo
Ammonium molybdate	It contains 54 % Mo

(NH4)6Mo7O244H2O)	

1. These are water soluble salts which contain Mo
2. They are suitable for soil application and foliar application as wel

Fertiliser Grade

1. Fertiliser grade refers to the guaranteed minimum percentage of nitrogen (N), phosphorus (P) and potash (K) contained in fertiliser material.
2. The numbers representing the grade are separated by hyphens and are always stated in the sequence of N, P, and

For example, label on the fertilizer bag with a grade 28-28-0 indicates that 100 kg of fertiliser material contains 28 kg of N, 28 kg of *P* and no potash.

FERTILIZERRATIO

It refers to the ratio of the percentage of N, *P2O5* and K2O in the fertilizer mixture e.g., the fertilizer grade 12-6-6 has a fertilizer ratio of 2:1:1.

SUPPLIERS OF PLANT NUTRIENTS

These are straight fertilizers added to supply the plant nutrient mentioned in the grade.

CONDITIONERS

These are low grade organic materials like peat soil, paddy husk, groundnut hulls etc., which are added to fertilizer mixtures during their preparation for reducing hygroscopicity and to improve their physical condition.

Peat soil **Paddy husk**

FILLER

A filler is a weight make material like sand, soil, coal powder etc, added to the fertilizer ingredients so as to produce a mixture of the desired grade.

Coal powder **Sand**

NEUTRALIZERS OF RESIDUAL ACIDITY

These are the materials like dolomite, lime stone etc, added in fertilizer mixtures to counteract the acidity of nitrogenous fertilizers.

UNIT 4

Definition

IPNM is the intelligent and combined use of inorganic, organic and biological resources so as to sustain optimum yields, improve or maintain the soil chemical and physical properties and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The principal aim of the integrated approach is to utilize all the possible sources of plant nutrition in a judicious and efficient manner.

Concept of IPNMS

- The basic concept of IPNMS is the promotion and maintenance of soil fertility for sustaining crop productivity through optimum use of all possible sources of nutrients like organic, inorganic and biological in an integrated manner appropriate to each farming situation. Improvement of soil fertility and productivity on sustainable basis through appropriate use of fertilizers and organic manures is the key principle and their scientific management for optimum growth and yield of crops in a specific agro ecological conditions.

- Main objectives of IPNMS or INM

1. To reduce the dependence on chemical fertilizers.
2. To maintain productivity on sustainable basis without affecting soil health.
3. To conserve locally available resources & utilize them judiciously.
4. To reduce the gap between nutrients used & nutrients harvested by the crop.
5. To improve physical, chemical & biological properties of soil.
6. To make soil healthy by providing balanced nutrients through different nutrient sources.
7. To overcome or reduce the ill effects of continuous use of only inorganic chemical fertilizers.
8. To improve economical status of farmers.
9. To increase the fertilizer use efficiency (FUE).

Components of IPNM

- IPNM mainly emphasizes the integrated use of all the essential nutrients from different sources like chemical fertilizers, organic manures, green manures, bio-fertilizers, legume crops, locally available plant resources in a balanced proportion for sustainable soil health and productivity.

I Use of inorganic fertilizers:

- They are very important for sustaining and increasing food production. Different kinds of fertilizers are commercially available in the market for all the major and micronutrients. However, they are costly inputs and their excessive use may deteriorate the soil quality and food quality. Hence, there is a need to improve their use efficiency through efficient and balanced fertilizer management and essentially follow the four R's formula for judicious and effective nutrient/fertilizer management. They are

Ø Right Type of fertilizers.
Ø Right Dose of fertilizers.
Ø Right Method of application.
Ø Right Time of application.

II. Use of organic manures/ materials:

- Due to intensive cultivation of soil and less organic manure application, the soils are low in organic matter status. A decrease in soil organic matter results in compact soil, poor aeration and low infiltration and water holding capacity and also low fertility status. The organic matter status in soils can be improved and maintained by constant addition of organic manures such as FYM. compost, green manures, poultry manures, vermicompost, oilcakes etc., Organic matter is good source of macro and micro nutrients, and more over improves physical, chemical and biological properties soil.

III. Use of biological sources/biofertilizers:

- Biofertilizers are cultures of micro organisms (bacteria, fungi, algae). Their use benefits the soil and plants growth by providing N & P and also brings about the rapid mineralization of organic materials in soils. They are capable fixing N, solubilizing and mobilizing the phosphorus and mineralizing organic matter in soil. Their incorporation improves the physical and biological properties of soils.

IV. Maintaining the physical properties of soil:

- Physical properties such as soil aggregation, soil texture, structure, aeration, water holding capacity (WHC), infiltration rate, etc., should be maintained regularly through better cultivation practices and organic manure applications to maintain soil fertility & nutrient availability.

V. Management of problematic soils:

- Problematic soils such as acid soils, saline and alkaline soils, water logged soils are known to decrease the productivity of the soil. Acid soil having the problems like toxicities of Iron, Mn, Al, deficiency of P & Mo. Similarly, saline and alkali soils showing the deficiency of Fe, Mn, Zn and Cu and also toxicities of Mo. These soils should be regularly managed and reclaimed through the application of soil amendments such as lime for acid soil, gypsum for alkali soils and other organic and inorganic materials based on soil test results. It helps to improve soil fertility and productivity and sustain the yield.

VI. Better/Judicious water management practices:

- Plants absorb the nutrients from the soil only in a dissolved state and sufficient moisture is therefore required for utilizing the nutrients of the soil. Management of moisture in the soil by improved and modern irrigation techniques like drip or sprinkler or basin where the rainfall is low and draining the soil where it is subjected to stagnation of water helps to increase water and nutrient availability to the crops.

INTEGRATED NUTRIENT MANAGEMENT

Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.

Inorganic Fertilizers

+

Organic Manures

+

Green manures

+

Biofertilizers

Concepts

1. Regulated nutrient supply for optimum crop growth and higher productivity.
2. Improvement and maintenance of soil fertility.

3. Zero adverse impact on agro – ecosystem quality by balanced fertilization of organic manures, inorganic fertilizers and bio- inoculant

Determinants

1. Nutrient requirement of cropping system as a whole.
2. Soil fertility status and special management needs to overcome soil problems, if any
3. Local availability of nutrients resources (organic, inorganic and biological sources)
4. Economic conditions of farmers and profitability of proposed INM option.
5. Social acceptability.
6. Ecological considerations.
7. Impact on the environment

Advantages

1. Enhances the availability of applied as well as native soil nutrients
2. Synchronizes the nutrient demand of the crop with nutrient supply from native and applied sources.
3. Provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.
4. Improves and sustains the physical, chemical and biological functioning of soil.
5. Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere

Components:

Soil Source:

Mobilizing unavailable nutrients and to use appropriate crop varieties, cultural practices and cropping system.

Mineral Fertilizer :

Super granules, coated urea, direct use of locally available rock PO4 in acid soils, Single Super Phosphate (SSP), MOP and micronutrient fertilizers.

Organic Sources :

By products of farming and allied industries.FYM, droppings, crop waste, residues, sewage, sludge, industrial waste.

Biological Sources :

Microbial inoculants substitute 15 - 40 Kg N/ha