PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY

DA 122

Manures & Fertilizers

Theory

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COURSE MATERIAL

FOR

COURSE NO. DA 122

MANURES & FERTILIZERS

Diploma in Agriculture

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Course No. : DA-122

Course Title : Manures and Fertilizers

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Semester/Year: Second Semester/ First year

Theory lecture outlines

S.No .	Title of the Lecture
1	Concepts of Soil Fertility and Soil Productivity- Definitions and differences– Reasons for decline soil fertility and soil productivity
2	Definition and importance of organic manures – Classification of manures & fertilizers
3	Bulky organic manures – Preparation of Farm Yard Manure (FYM) – Heap method, Pit method and Covered pit method
4	Compost – Different methods of composting- Factors affecting compost process
5	Preparation of compost from agricultural waste (Rural compost) – Urban compost
6	Biogas Plant – Construction– Precautions while preparation of biogas – Management
7	Vermicompost – Preparation of vermicompost beds and suitable earthworm *sps* for vermicomposting
8	Vermicomposting – Advantages of vermicompost & precautions
9	Green manures – Green manuring *in situ* – Criteria for selection of crops – Crops suitable – Nutrient composition
10	Green manuring *in situ* – Advantages and disadvantages- Cultivation techniques of green manuring crops
11	Green leaf manuring – Advantages and limitations – Crops suitable
12	Concentrated organic manures – Plant origin manures – Edible and non edible oil cakes – nutritional composition
13	Animal origin manures – Blood meal, Bone meal, Fish meal, Horn meal and Guano – Nutritional composition
14	Biofertilizers – Classification – Atmospheric nitrogen fixers
15	Symbiotic nitrogen fixers – Associative nitrogen fixers and Free living nitrogen fixers
16	Phosphorus mobilisers – Method of use of biofertilizers – Advantages
17	Differences between organic manures and chemical fertilizers – Classification

	of fertilizers
18	Straight fertilizers – Nitrogenous fertilizers – Nitrate, Ammonical, Nitrate – Ammonical and Amide fertilizers
19	Phosphatic fertilizers – Water soluble – Citric acid soluble and insoluble fertilizers – Potassic fertilizers
20	Secondary nutrient fertilizers – Micronutrient fertilizers – Different types
21	Mineral salt and chelated micronutrients – Nutritional composition
22	Mixed fertilizers – Farm mixtures and Mechanical mixtures
23	Calculation for preparation of mixed fertilizers
24	Complex fertilizers – Different types – Calculation for nutritional values in fertilizers
25	Fertilizer use efficiency
26	Fertilizer application – Time of fertilizer application
27	Methods of fertilizers application – Application of solid form fertilizers – Broad casting
28	Placement of fertilizers - Localized placement – Application of liquid fertilizers
29	Integrated nutrient Management (INM) – Concept- Factors affecting INM – Goals _Components
30	Constraints and Advantages of INM
31	Organic farming – Definition – Methods of cultivation – Merits and demerits
32	Awareness on Fertilizer Control Order (FCO)

PRACTICALS

S.No	outlines
1	Collection of organic manures and chemical fertilizers
2	Preparation of FYM
3	Preparation of Rural compost
4	Preparation of Urban compost
5	Preparation of Vermicompost
6	Identification of green manures
7	Detection of adulteration in fertilizers
8	Quick tests for fertilizer analysis
9	Calculation for recommended doses of fertilizers
10	Awareness on different methods of fertilizer application in experimental plots
11	Precautions while using different fertilizers
12	Experimental observation of crop response to fertilizers
13	Estimation of nutrient contents in different fertilizers using chemical methods
14	Awareness on integrated use of organic manures and chemical fertilizers
15	Awareness on nutrient contents in straight fertilizers
16	Awareness on nutrient contents in complex fertilizers

Lecture 1: Concepts of Soil Fertility and Soil Productivity- Definitions and differences– Reasons for decline soil fertility and soil productivity

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SOIL FERTILITY is defined as the quality that enables the soil to provide proper nutrient compounds in proper amounts and in proper balance for the growth of specified plants.

Soil fertility is also defined as the ability of soil to supply adequately the nutrients normally taken from the soil by plants.

REASONS FOR DECLINING SOIL FERTILITY: The fertility of soil is declining due to various reasons like

Crop removal: Different crops remove nutrients in different proportions, for example rice crop removes 85-15-90 kg nitrogen, phosphorus and potassium to produce 3 tonnes of yield while maize requires 175-35-175 kg nitrogen, phosphorus and potassium to give 5 tonnes of yield.

Removal by weeds: Weeds remove more quantities of nutrients than crop plants

Soil erosion: Due to wind, water and air erosion, the upper fertile surface soil will eroded leading to decline in soil fertility.

Leaching: Soluble nutrients like nitrogen on conversion in to nitrate form are lost due to leaching into lower subsurface layers.

Volatilization: On application of nitrogenous fertilizers, they are partly lost as NH_3 (gaseous form) due to volatilization.

Improper method of application of fertilizers: Loss of nutrients can be reduced by adopting appropriate methods of fertilizer application like band placement or pocketing at the base of the plants.

Use of Complex fertilizers: Indiscriminate use of complex fertilizers (Ex: 28-28-0, 17-17-17 etc.,) leads to micro and secondary nutrient deficiencies.

Non-application of micronutrients: Farmers are excessively applying N, P and K fertilizers, ignoring the requirement of micro and secondary nutrients.

Crop rotation: Monocropping of same crop without adopting crop rotation mines the nutrients from the same depth in the soil leading to nutrient depletion. Deep rooted crops like redgram, cotton, sunflower etc., should rotated with crops like rice, maize and jowar whose root system will be in the surface layers

SOIL PRODUCTIVITY denotes the capacity of the soil to produce crops. Productivity depends on various other factors in addition to soil fertility. Few factors that influence productivity are as mentioned below.

Soil pH: When the soils have neutral pH the availability of many nutrients will be in optimum. A decrease or increase in pH will affect the nutrient availability and make them either deficient or toxic.

Soil Texture: Nutrient and moisture retentive capacity of a soil mainly depends on soil texture. In light textured soils nitrogen is lost through leaching and becomes unavailable to plants, similarly in heavy textured soils nutrients become unavailable due to fixation and adsorption by clay.

Soil structure: The proportion of macro and micropores of the soils mainly influence the plant growth and in turn the productivity. A good structured soil provides good aeration and congenial conditions for microbial growth, which will hasten up the physical, chemical and biological reactions in the soil. As a result of these reactions the organic matter is converted in to stable humus and increases the CEC of the soil and in turn the nutrient availability to plants will be increased.

Soil aeration: Root growth, nutrient availability, microbial population, and mineralization are mainly influenced by the soil aeration.

Soil drainage: Under improper or ill drained conditions of soils, immobilization of nutrients takes place and plant roots cannot absorb nutrients.

Soil microbes & C: N ratio: Growth of soil microbes, decomposition of organic matter, conversion of humus are influenced by carbon nitrogen ratio and in turn they affect the productivity.

Organic manures: The utilization of applied fertilizers can be improved through application of organics.

Problematic soils: When the soils have constraints like salinity, alkalinity, acidity, improper drainage and very shallow depth, they cannot supply plant nutrients in optimum proportions, as a result the productivity of the soils is affected.

DIFFERENCES BETWEEN THE SOIL FERTILITY AND SOIL PRODUCTIVITY

Soil fertility		**Soil productivity**
1	It is the inherent capacity of the soil to provide essential chemical elements for plant growth	Soil productivity emphasizes the capacity of soil to produce crops and is expressed in terms of yield.
2	A combination of soil properties and an aspect of soil – plant relationships.	An economic concept and not a property of soil
3	Soil fertility is vital to a productive soil. But a fertile soil is not necessarily be a productive soil. Many factors can limit production, even when fertility is adequate. For eg., soils in arid region may be fertile but not productive.	Soil fertility is one factor among all the external factors that control plant growth like air heat (temp.), light, mechanical support, soil fertility and water. Plant depends on soil for all these factors except for light.
4	Organic matter in the soil improves soil fertility by mineralization of nutrients.	Organic matter also improves soil productivity by improving soil porosity, aggregation and physical condition of soil thus modifying the soil environment for crop growth.

Lecture 2. : Definitions, Differences and classification of Manures & Fertilizers

The word "Manure" is originated from the French word "MANOEUVRER" which refers to "work with soil". The word Manure has also origination from Latin word "Manu" (hand) and operate (to work).

Manure:

Manures are the substances which are organic in nature, capable of supplying plant nutrients in available form , bulky in nature having low analytical value and having no definite composition and most of them are obtained from animal and plant waste products. Manuring is the process of increasing the productive capacity of land by adding plant foods to the soil in different forms.

Fertilizer:

A fertilizer can be defined as a mined or manufactured material containing one or more essential plant nutrients in potentially available forms in commercially valuable amounts.

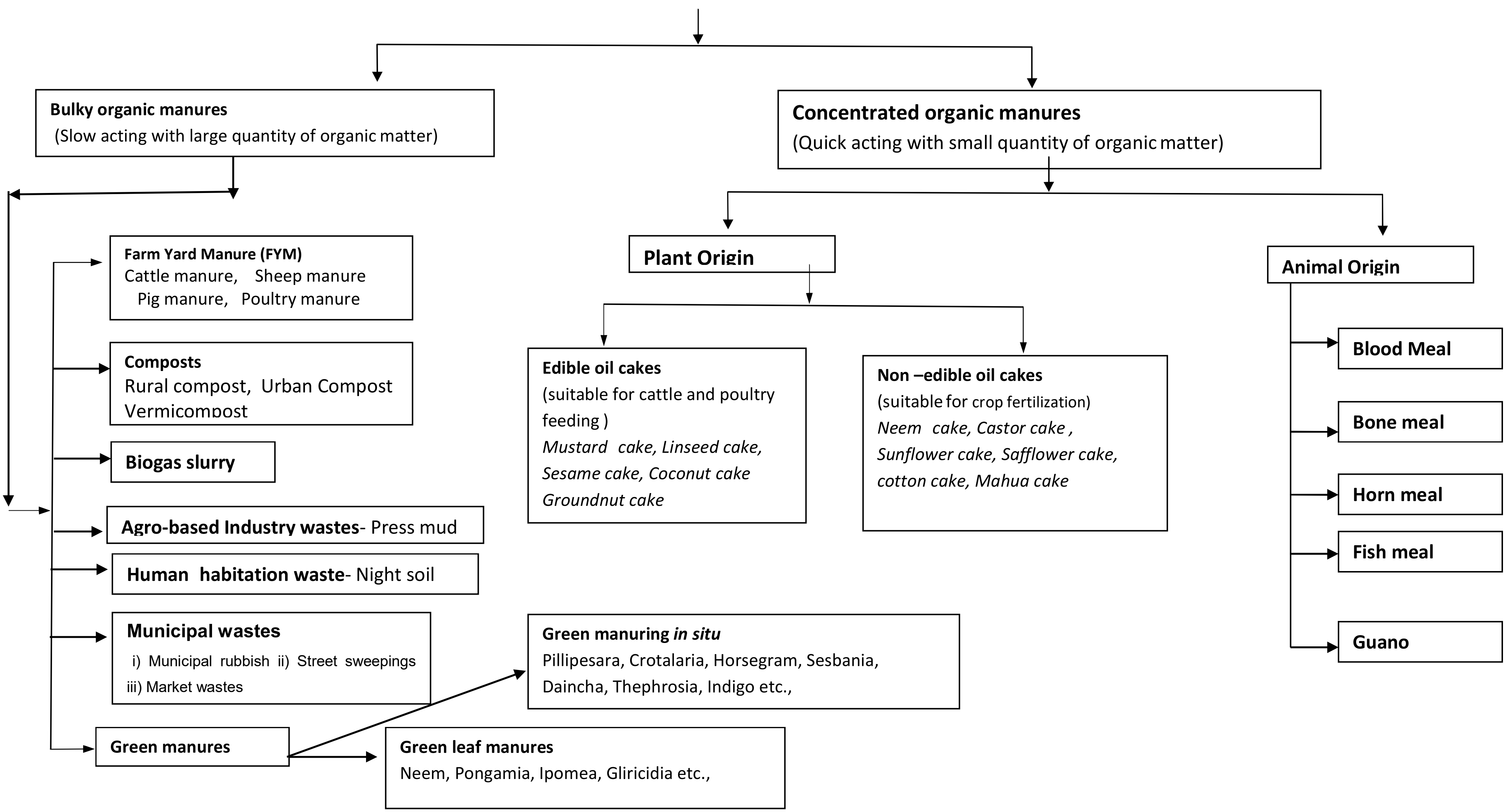
Differences between manures and Fertilizers:

MANURES	FERTILIZERS
Organic in nature	Inorganic in nature
Slow acting	Quick acting
Having low analytical value	Having high analytical value
Having no definite chemical composition	Having definite chemical composition
Obtained from plant , animal and human resources	Mined or manufactured
Improves physical properties of soils	Don't improve the physical properties of soils
Supply almost all major, minor and micronutrients.	Supply one or very few plant nutrients.
Derived from French word 'MANOEUVRER' to work with soil	Derived from Latin word Fertil means Fertile
Bulky in nature	Non-bulky in nature

Basically there are three categories of Manures & Fertilizers

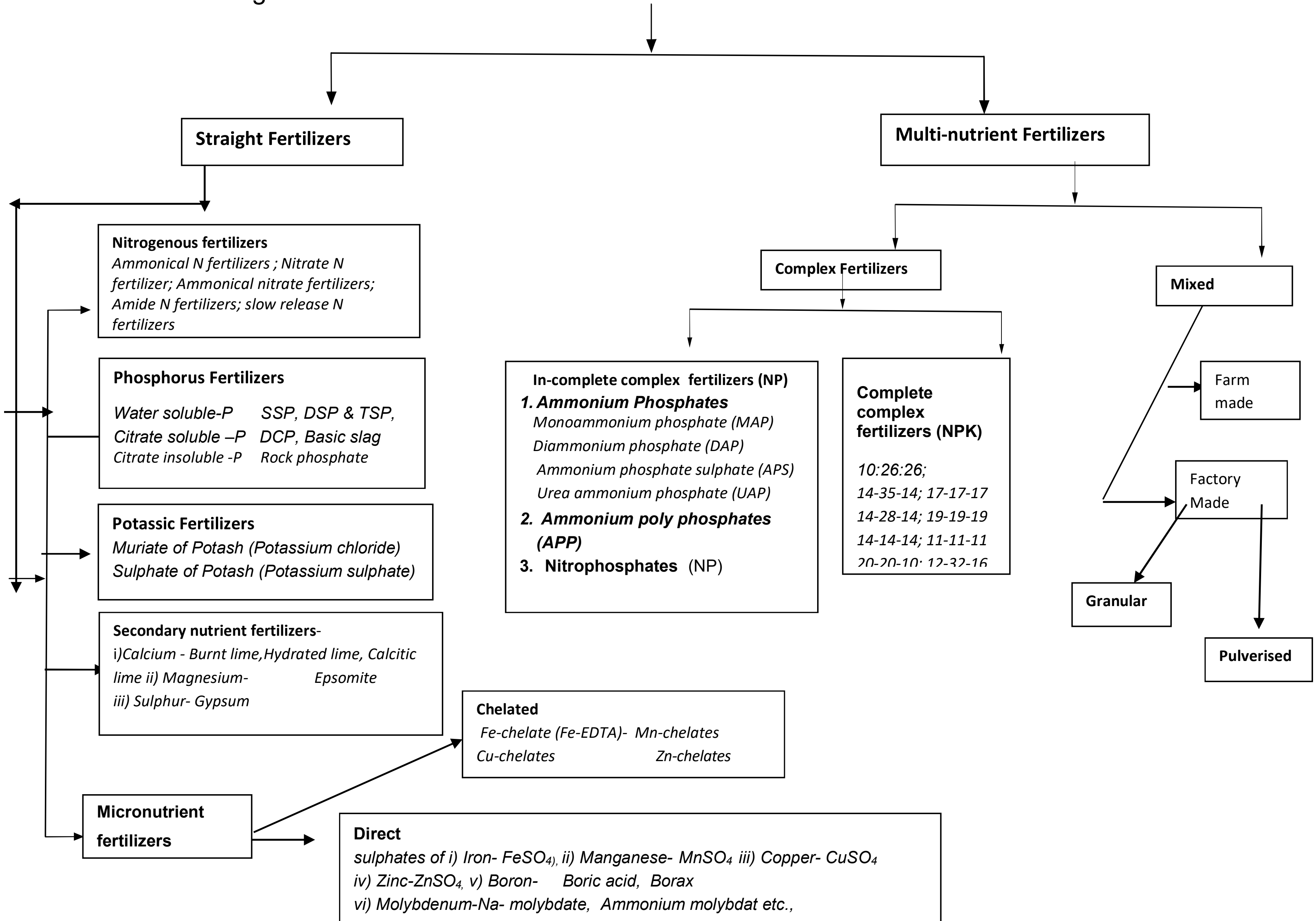
- I. Organic manures
- II. Inorganic/Chemical Fertilizers
- III. Bio-fertilizers

I. Classification of Organic Manures : **ORGANIC MANURES**

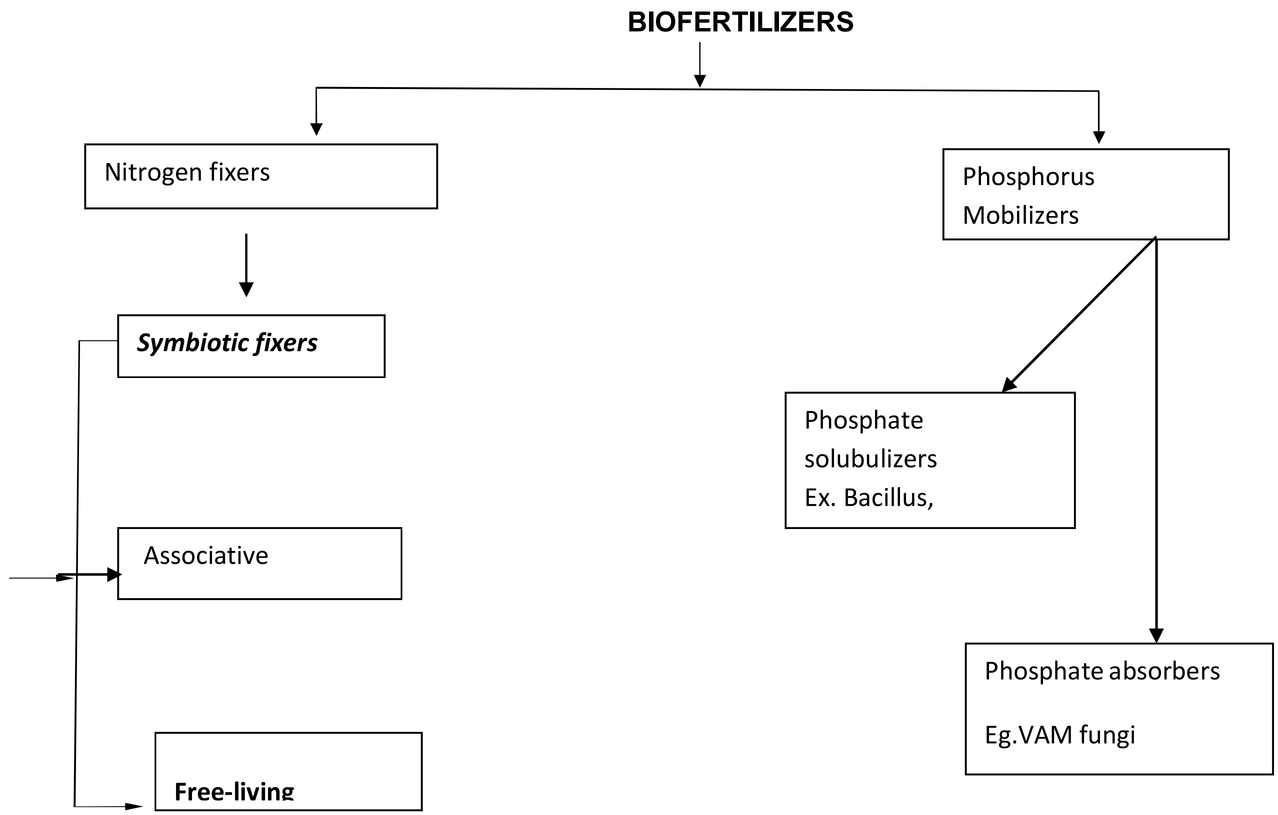


II. Classification of Inorganic Fertilizers:

INORGANIC FERTILIZERS



III. Classification of Biofertilizers



Lecture 3: Bulky Organic manures- Preparation of FYM- Heap method, Pit method and Covered pit method

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MANURES

A. Bulky organic manures:

Bulky organic manures are those materials of plant and /or animal origin, which when added to the soil have tendency to decrease bulk density and to increase soil volume, thus providing better physical conditions for plant growth especially in coarse textured soils and also provide essential nutrients in smaller quantities than the chemical fertilizers .

CHARACTERISTICS OF BULKY ORGANIC MANURES:

1. Organic materials are relatively poorer in concentration of plant nutrients
2. These materials possess wider C:N ratio and C:S ratios and so supply energy needed for microorganisms
3. The mineral nutrients that are available in the organic materials become available to plants after mineralization.
4. Judicious combination of organic and inorganic manures is quite essential to maintain fertility status.

   Ex. FYM, Composts, Green manures, Sewage sludge Biogas slurry, Molasses and Vermicompost. Of the various bulky organic manures FYM, Compost and Green manures are widely used

ADVANTAGES OF BULKY ORGANIC MANURES

- Bulky organic manures increase organic matter and humus content and hence improve the physical properties of soil viz.,
  - ✓ Improvement of soil structure,
  - ✓ Improvement of water holding capacity,
  - ✓ Improvement of soil aeration,
  - ✓ Reduction of soil loss through erosion,
  - ✓ Reduction in bulk density of soil.

- Bulky organic manures help in improvement of soil chemical properties through
  - ✓ Supply of essential plant nutrients in balanced ratio
  - ✓ Besides the major nutrients, they also contain traces of micro-nutrients
  - ✓ Slow release of nutrients
  - ✓ High residual value
  - ✓ Improvement in buffering capacity
  - ✓ Increase the use efficiency of applied nutrients
  - ✓ Improvement in the CEC of the soils
  - ✓ Promotion of mineralization, release and retention of nutrients
- Bulky organic manures provide food for soil microorganisms. This increases the activity of microbes through stimulation of soil fauna and flora which in turn help to convert unavailable plant nutrients into available form.

FARM YARD MANURE (CATTLE MANURE)

Farm Yard Manure /Cattle manure is slow acting, bulky organic and a low analysis fertilizer, obtained from dung and urine of farm animals mixed with litter and other miscellaneous farm wastes.

Quality and composition of FYM:

The quality of manure and chemical composition in particular is highly variable as the following factors affect the product.

1. Kind of animal
2. Age and condition of the individual animal
3. Quality and quantity of feed consumed
4. Kind of litter used
5. Collection and
6. Storage of manure

1) Kind of animal:

The quality of manure depends on the class of manure .viz., cattle, horse manure. Within the same class, quality varies according to the kind of animal, such as milch cattle, dry cattle, work cattle ,breeding bulls etc., By and large the dung and urine from animals, which assimilates less (little) for their maintenance and production will provide better quality manure .

2) **Age and condition and individual animal:**

Growing animals ,milch cattle, pregnant or carrying cattle utilize much of the ingredients in the feeds for building up their growing bodies ,milk production and for the development of the embryo[calf] .Old or adult animals kept on light work or no work utilize little from feeds and as such, most of nitrogen is voided through urine and dung. Eventually, the adult old cattle provide better manure.

3) **Quality and quantity of feed consumed:**

Nutritious and protein rich feeds like oil cakes enriches the nitrogen content to the resulting manure than the bulky feeds like straw and green grass. Animals fed on concentrated feeds yield better quality manure.

4) **Kind of litter used:**

The quality of manure depends to a considerable extent on the nature of litter used. Remnants of leguminous hays (*Bhusa*) give richer manure than usual straws.

5) **Collection of manure:**

The method adopted for collection of dung, urine and litter primarily decide the quality of manure as the loss of nutrients particularly nitrogen occurs from the time urine and dung are voided by cattle .The quality of manure depends upon the methods of collection viz., Byre, Lose box and Dry earth systems

6) **Storage of Manure:**

Method of storage of manure influences the quality of manure to a large extent. During storage the manure undergoes fermentative changes, decomposition which leads to losing its original structure and shape. The manure stored under shade and plastered pit will have better quality

There are three methods of FYM preparation viz., pit method and heap method and covered pit method.

A. Heap method (Above the ground level) :

- ✓ This is the most common method adopted in Indian villages
- ✓ . Manure is heaped on the ground preferably under the shade of a tree.
- ✓ Ideal procedure is to dump the dung first and to cover it with litter soaked urine .This is further covered with a layer of litter/ /ash / earth to prevent the loss of moisture and to avoid direct exposure to sun.It is also desirable to put up a small bund around the base of the heap to protect against surface run-off washing out the manurial ingredients.
- ✓ It is beneficial to cover the exposed portion of the heap with Palmyra leaves or any other available material.

Disadvantages

- ✓ The maximum losses of nutrients occur in this method of storage, resulting in poor quality manure.
- ✓ Direct exposure to the vagaries of climate such as sunshine and rainfall causes looseness and dryness of manure, which hasten the losses of nutrients and rapid oxidation of organic matter.

B. Pit method (Below ground level) :

- ✓ In this method, the manure is stored in a pit with non –absorbent bottom and sides.
- ✓ The pit is provided with a bund at the rim of the pit to prevent the surface run-off of waters during rainy season.
- ✓ The dimensions of the pit can be variable depending on the quantity of dung ,urine and litter produced on the farm per day .
- ✓ A pit with a depth of 3 feet is convenient to handle
- ✓ The filling of the pit should be from one side and upon filling of 1/3rd of pit, a layer of good soil should be added followed by animal dung and litter until the pit is filled to half meter above the ground level. Then the pit should be

plastered with mud and dung.

- ✓ Two pits are sufficient to prepare manure from a farm with two cattle pairs. About 5-6 tonnes of good quality manure can be obtained from each animal per annum
- ✓ The losses also occur in this method due to exposure to sun and rain, but it is relatively a better method than the heap method.

C. Covered pit method:

- ✓ Of all the methods described, it is the best method.
- ✓ In this method, the bottom and sides of the pit are made non-absorbent by granite stone lining.
- ✓ The pit is also provided with a bund of 1½ feet height to prevent surface flow of water (Rain water) and a suitable cover by way of roofing with locally available materials like Palmyra or phoenix leaves etc.,
- ✓ Organic matter and nutrient losses can be effectively controlled in this method of storage in order to obtain better quality manure [FYM: 0.68 % N- 0.5%P – 1 % K].
- ✓ Application of single super phosphate to the pit will improve the quality of manure

Lecture 4: Compost - Different methods of composting – Factors affecting Composting & advantages

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Composting: Composting is a process of converting organic matter in to manure in a short time by accelerating fermentation process under controlled conditions is called composting.

The organic material that is usually handled for composting are waste vegetative material such as spoiled straw, peanut hulls, saw dust, dried leaves etc., stubbles, plants, cotton stalks, tobacco stems, weeds, municipal rubbish etc., according to availability.

The word compost is derived from the Latin word "COMPONERE" to mean put together.

Compost: Compost is a product of decomposition of plant and animal wastes with various additives .The compost had the largest variation of all organic material ranging from neglected garbage dumps to carefully composted and treated substances with high fertility.

PURPOSE & ADVANTAGES OF COMPOSTING

- ✓ The purpose of composting is to convert organic matter/ wastes into growth promoting substances, for sustained soil improvement and crop production.
- ✓ It does not require any skill and accumulation of garbage in the cities and towns can be reduced
- ✓ Spread of diseases due to harmful microbes that develop on garbage can be avoided.
- ✓ C: N of the residues and waste material can be effectively reduced and be used as sources of valuable nutrients.
- ✓ As weed seeds gets decomposed during the process of composting, spread of weeds can be arrested.
- ✓ Space occupied by garbage/residues can be saved.

FACTORS AFFECTING COMPOSTING

- ✓ Physical and chemical properties of organic waste
- ✓ Aeration in the compost pit
- ✓ Moisture content in the compost pit- care should be taken to maintain optimum moisture
- ✓ Temperature in the compost pit.
- ✓ pH in the compost pit.
- ✓ Time taken for composting
- ✓ Yeast sludge can be used to hasten the process of composting

Bacteria like

Bacillus brewis, Bacillus circulans, Bacillus coagulans, Bacillus subtilis:

Actinomycetes like

Nocardia, Streptometes rectus, and Thermoactinomycetes vulgalris and Thermonospora.

Fungi like

Mucor, Chetomium, Thermophylum, Pencilium and Aspergillus are involved in composting

Lecture 5: Compost - Preparation of Composts from agricultural Wastes (Rural Compost) & Urban Compost

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TYPES OF COMPOSTS

1. Rural compost
2. Urban Compost

RURAL COMPOST

Compost prepared using farm organic wastes and fresh dung and /or urine soaked earth as starter is called as Rural Compost. This is within the reach of farmers, as they can individually prepare the compost in their farm sheds.

Composting can be done in a pit size of 12 x 50 x 6 feet size located on an elevated place. Even length and width are adjustable depending upon the raw material available.

Keep the sides of the pit slanting. When a number of pits are dug, keep 12 feet gap between the pits for facilitating turnings .Locate the compost pits away from the civilians areas.

Basic raw material:

1) Green succulent, non-woody and non-fibrous material, food wastes, other wastes generated in the villages
2) Dry materials like sugarcane trash, cotton stubbles etc., (3" thick), crop residues, and animal shed waste

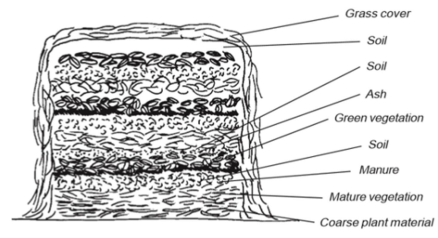
Starter : Dung and water

Neutralizing agents for organic acids: Bone meal is preferred to ash as it provides Ca and also phosphate, which are desirable constituents in the final product.

Procedure:

The organic material is spread in layers .The thickness depends upon compostability of materials. Green succulent non-woody materials can be laid in 12 " layer while tough woody materials like sugarcane trash and stubbles are spread in 3" layer.

Bone meal or ash is sprinkled in a thin layer over the material to provide the base for neutralizing organic acids produced during the decomposition. Dung and water is then sprinkled over the layer. Dung functions as starter while the water provides the moisture. The layers are thus built up to a height of one foot above the ground level. It is desirable to cover the surface of the heap with a layer of earth. Periodically watering is done.



The layers of a compost heap

Precautions:

- ✓ Over watering creates anaerobic decomposition.
- ✓ Turnings are necessary to hasten the aerobic decomposition
- ✓ After turning the compost must be re-heaped and covered
- ✓ Use the compost immediately
- ✓ It is to be preserved by providing suitable cover
- ✓ The compost will be ready by three months to one year depending upon material (Sugarcane trash –late)

URBAN COMPOST

Compost prepared by local bodies, municipalities, corporations etc., with their out Put of street sweepings, municipal rubbish etc., as organic matter using night soil as starter is called urban compost

Methods of urban composting:

This process composting is taken up at least 1.5 km away from the residential areas/townships. Town refuse is heaped into a pit of dimensions of 8 x 4 x 4 feet .A groove measuring 6 x1 x 1 feet is made at the top in the centre and is filled up with night soil and covered over with refuse. Heap is moistened daily with sullage water and racked up once a week. For six weeks by which the decomposition process would be complete and the product would be ready for use as manure.

Sprinkling of copper sulphate powder between layers will put down the offensive odour due putrefactive fermentation of the material

The various systems of urban composting are

1. ADCO process (Agricultural Development Company)
2. Activated compost process
3. Indore process
4. Bangalore process
5. Coimbatore process

The raw material and starters /catalysts used vary with various methods. Lime, Ammonium Sulphate, Bone meal, Urea, Oilcakes and charcoal are used hasten up the process. The decomposition/ composting will be completed in 3-4 months and is fit for application to the field.

Comparison between rural and urban composts

Rural compost	**Urban compost**
Prepared by farmers in the villages near their farms and cattle sheds	Prepared by local government bodies at least 1.5 km away from the residential areas/townships
Raw materials are green succulent, non-woody and non-fibrous material, food wastes, other wastes generated in the villages and farms like sugarcane trash, cotton stubbles, crop residues, animal shed waste etc.,	Raw material is Street sweepings, municipal rubbish etc.,
Starter material is dung	Starter material is night soil
Moisture is provided with water	Moisture is provided with sullage water
Bone meal or ash is sprinkled in a thin layer over the material to provide the base for neutralizing organic acids	Lime, Ammonium Sulphate, Bone meal, Urea, Oilcakes and charcoal are used hasten up the process.
Compost will be ready by three months to one year	Composting will be completed in 3-4 months

Benefits of composting

- ✓ Enables clean environment
- ✓ Absorbs odors, degrade toxic substances and heavy metals
- ✓ Avoids un-necessary dumping of wastes
- ✓ Supply valuable organic manure

General Properties of Commercially Accepted Compost:

Color	Brown Black
Nitrogen (%)	>2
P (%)	0.15-1.5
C: N	<20
Odor	Earthy
Ash %	10-20
Water Holding Capacity (%)	150-200
Moisture %	10-20
CEC (Meq 100 g^{-1})	75-100

Lecture 6: Biogas- Plant construction-Precautions to be taken-management –Advantages

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Use of animal waste as manure is an age old practice. However, the animal dung is very good source of energy and produces very high heat. The German scientists have identified that when dung or any other organic materials is fermented in absence of air, the combustible gas methane is produced and that gas can be used as source of energy and the left out slurry can be used as manure to agricultural lands. This has led to concept of development of Biogas. This concept has helped in a very good development of villages and the biogas unit is popularly called as Gruha Lakshmi.

Construction of Biogas Plant:

The major components of the unit are Mixing plant, Digester/Fermenter, An iron drum and connecting pipes.

Digester/Fermenter

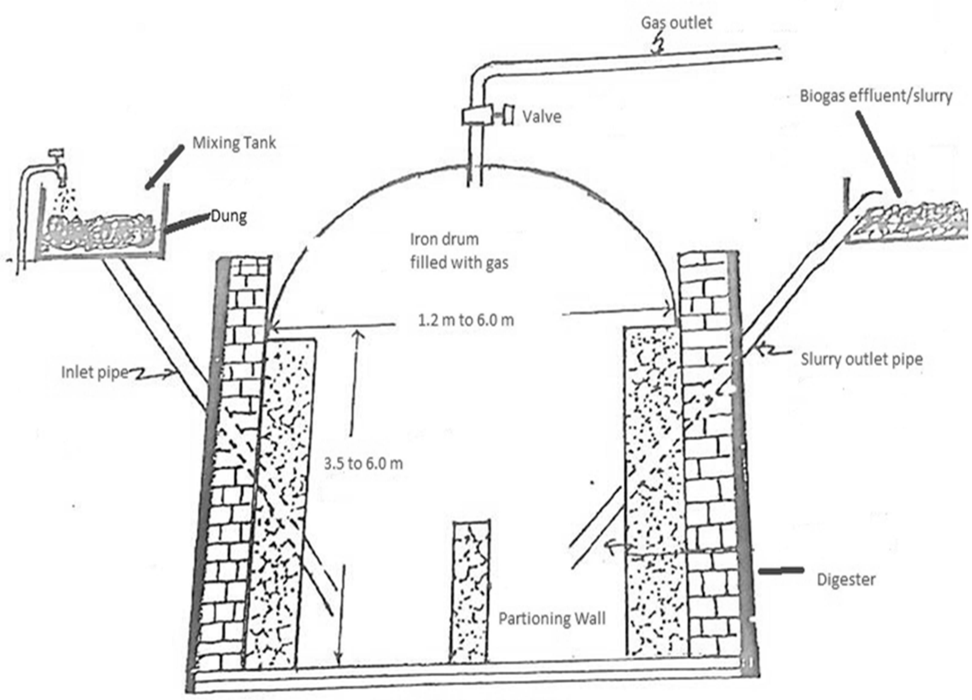
In biogas plant, the fermentation is carried out in a brick lined well like concrete structure called digester/fermenter. The size of the structure/well depends on the quantity of biogas to be produced. Generally, the well is built with depth of 3.5 to 6.0 m depth and with diameter of 1.2 to 6.0 m. Performance biogas unit depends on the digester. Internally, the digester is separated in to two compartments, on one side it is filled with dung made in to liquid slurry with water. The other partition of the well is used for filling of digested slurry. On one side, the digester is connected to the mixing tank and on the other side an outlet is provided for passage of digested effluent/biogas slurry. The slurry will be generally routed to the compost pit.

Mixing tank/plant

Adjacent to digester, a tank is constructed to mix dung and water (in 4:5 ratio). A cement pipe is arranged connecting the digester and the mixing tank through which the mixed slurry is passed into the digester.

The digester is covered with an iron drum introduced upside down in the well which serves to cut off air and provide the necessary conditions for fermentation. The methane gas is produced in the form of bubbles inside the drum which gradually fills up and begins to float and rise. The gas is then taken through a wheel cock on the top of the drum and led to the kitchen by pipes and burned through suitable burners.

The gas production is maintained by adding 50 kg fresh dung daily through a funnel pipe which carries the slurry to the bottom of the well.



BIOGAS PLANT

Precautions to be taken while setting up a gas plant

1. A minimum of 45 kg dung should be available to operate the gas plant of

60 cubic feet (2 m^3) capacity. Medium size cow, buffalo or bullock yield 10 kg fresh dung and roughly 5 animals are needed.

2. Night soil can also be used. Sixty (60) adults are needed for the above plant. This is normally possible in case of hotels, hostels, public lavatories etc.,
3. Besides cattle dung and night soil, piggery and poultry droppings if available in sufficient quantities can also be utilized.
4. The gas plant should be located in open space in order to receive maximum possible sunshine to ensure better fermentation and gas production.
5. Normally the distance between gas plant and place where gas is to be used should be within 20 meters (Kitchen to gas plant).

Advantages of Biogas Plant:

1. The cow dung when processed through the gas plant yields enough gas (combustible gas) for cooking, lightening and good quality methane free manure.
2. Biogas slurry is also used as bulky organic manure. The manure obtained from biogas plants has higher content of nitrogen (1.5%) as against 0.7% found in FYM.
3. The thermal efficiency of cow dung bunt for fuel in usual manner is around 11 per cent while it is 60 per cent when burnt in properly designed burners.
4. Biogas digest is very rich in humus content
5. The manure is free from offensive odour
6. It helps in improving the sanitation by preventing fly and mosquito breeding.

Lecture 7 & 8: Vermicompost – Preparation of vermicompost beds and suitable earthworm *sps* for vermicomposting- Advantages of vermicompost & precautions

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Vermicomposting is a method of making compost, with the use of earthworms, which generally live in soil, eat biomass and excrete it in digested form. This compost is generally called as vermicompost or Wormicompost. It Is an emerging technology for recycling of crop residues and other organic solid wastes.

Definition of Vermiculture:

Vermiculture means scientific method of breeding and rising earthworms in controlled conditions. The species like

Perionyx excavatus, Eisenia foetida,

Eudrilus eugeniae and Lampito marutii are effective in converting

Vermi technology:

Vermitechnology is the combination of vermiculture and vermicomposting. Thus, earthworms can be used in the following areas.

1. For development of arable soils, turnover of soil, break down of plant organic matter, for improved aeration and drainage
2. For production of useful products like vermifertilizer and worm tissue for animal feed.
3. For maintenance of environmental quality and monitor of the environment for soil fertility, organic and heavy metal non-biodegradable toxic material pollution.

Preparation of vermicompost:

1. Basic raw material : Any organic material generated in the farm like bhusa, leaf fall etc.,
2. Starter : Cow dung, Biogas slurry or urine of cattle
3. Earth worms (Species like *Eisenia foetida*)
4. Favourable conditions of earth worms in the composting material:

A. pH : Range between 6.5 and 7.5

B. Moisture : Waste/residues should have 60-70 % moisture

C. Aeration : 50 % aeration from the total pore space

D. Temperature: Range between 18 ^{0}C to 35 ^{0}C

Procedure:

It is mostly prepared in either pit or heap method. The dimensions either heap or pit are generally 10 x 4 x 2 feet. The length and width can be increased or decreased depending on the availability of material but not the depth because the earthworm's activity is confined to the 2 feet depth only. Shade should be provided above the beds either with thatched roof or net.

Spreading crop residues/ organic waste in layers in a pit of 10 x 4 x 2 feet size

Application of dung slurry as starter

Provision of shade and moisture

The raw material is spread in layers in the pit. The 1st layer is a bedding material of 1" thick with soft leaves/ coir /cane trash, the 2nd layer is 9" thick organic residue layer with finely chaffed material like shed waste, vegetable waste and crop residues while the third 3rd layer is with starter material (dung + water mixture) equal of 2" layer. The waste may be pre-incubated with dung slurry before filling in to the pit.

Continue to add the layers up to pile to ground level protect the worms against natural enemies like ants, lizards, snakes, frogs, toads etc., Maintain proper moisture and temperature by turnings and subsequent staking. After completely filling, worms are introduced in to the pit [$1m^2$=1000 worms or 1kg per tonne of residue]. The pit should be covered with old gunny bags or rice straw and maintained moist by regular sprinkling the water and moisture content of the pit should be maintained at 30-40%. By two months, entire raw material will be turned into the vermicompost. The turnover of the compost is 75 % [the total material accommodated in the pit is 1000 kg; The out turn will be 750 kg]

Harvesting of the vermicompost from the pit:

Stop watering before one week of harvest. All the worms spread across the pit come in close and penetrate each other in the form of ball in 2 or 3 locations. Heap the compost by removing the balls and place them in a bucket, then the material is sieved in 2 mm sieve, the material passed through the sieve is called as vermicompost which is stored in a polythene bags

Conversion rates: 1000 earth worms may convert 5 kg waste material per day

1000 worms weighs about a kilogram

Precautions to be taken

- Vermicomposting is done under thatched roof to protect worms against rain and sun.
- Plastic and glass should be carefully sorted out while adding waste in to pit.
- Vermicompost should be harvested at appropriate time
- Pre-incubated waste may be preferred for filling in to the pit.
- Care and protection should be provided against ants, rats and other natural enemies

Advantages of vermicomposting:

1. There will be no immobilization in compost because of narrow C:N ratio.
2. Vermicompost is rich in nutrients when compared to FYM.

Nutrient composition of vermicompost

S. No.	Nutrient	Content
1	Organic carbon	9.15 to 17.98 %
2	Total nitrogen	1.5 to 2.10 %
3	Total phosphorus	1.0 to 1.50 %
4	Total potassium	0.60-0.80 %
5	Ca and Mg	22.00 to 70.00 m e / 100 g
6	Available S	128 to 548 ppm
7	Copper	100 ppm
8	Iron	1800 ppm
9	Zinc	50 ppm

3. Besides the above nutrients the vermicompost also contains the enzymes like Protease, Lipase, Amylase, Cellulose and other growth promoting hormones.
4. Application is easy, because the compost is humified and have a structure of crumb and granular.
5. It is hygienic; pathogens and weeds seeds are destroyed.
6. No loss of nutrients
7. Provides buffering against soil acidity and alkalinity.
8. It improves physical properties better than compost on soil application and Improves water holding capacity of the soil
9. Quality, fragrance and shelf life flowers and fruits is improved
10. Imparts disease and pest resistance to crops
11. Improves the yield
12. Helps in reducing the environmental pollution and ecologically safe.

Application/dosage

- Vermicompost may be applied @ 1 t/ha for various field crops
- For fruit crops, 5-10 kg/tree is recommended
- For flowering plants in pots, 200g/pot is recommended

Lecture 9: Green manures – Green manuring *in situ* – Criteria for selection of crops – Crops suitable – Nutrient composition.

Green manuring: Green manuring can be defined as growing of a green, nutrient rich, succulent and fast growing crop for the specific purpose of incorporating it into soil while green, or soon after maturity with a view to improve the soil and benefiting subsequent crops or Practice of ploughing or turning in to the soil undecomposed green plant tissues for the purpose of improving physical condition as well as fertility of the soil.

Objectives of green manuring:

i. Increasing organic matter content of soil
ii. Maintain and improve soil structure
iii. Reduce the loss of nutrients, particularly nitrogen
iv. Provide a source of nitrogen for the following crop.
v. Reduce the soil loss by erosion

Suitability criteria of crops for growing as green manure crops

The crops should be

1. Fast growing and should be able to produce more biomass
2. Should be able to grow in all soil types.
3. Leaves should be non fibrous and succulent.
4. Should decompose quickly
5. Should have deep root system and be able to mine nutrients from deeper layers.
6. Should grow quickly to smother the ground and control weeds
7. Preferably a legume crop that can fix nitrogen from atmosphere through symbiosis.

Types of green manuring:

The practice of green manuring is adopted in various ways in different states of India to suit soil and climatic conditions. Broadly speaking, the following two types of green manuring can be differentiated.

1. Green manure in situ
2. Green leaf manuring

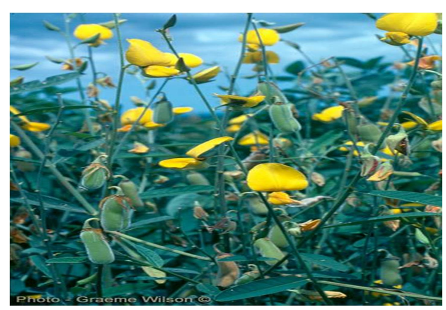
I. Green manuring *in situ*:

In this system, green manure crops are grown and buried in the same field which is to be green-manured, either as a pure crop or as intercrop with the main crop. This is most common green manure crops grown under this system are sunnhemp (Crotalaria juncea), daincha *(Sesabania aculeata*), Pillipesera (*Phaseolus trilobus*) Indigo (Indigofera tinctoria), Wild Indigo *(Thephrosia purpurea)* and guar (*Cyamopsis tetragonoloba*)

The green manure crops are mostly legumes, which are fast growing and yield substantial succulent vegetation. There is little or no preparatory cultivation. Sowing is effected by broad cast adopting a heavy seed rate. Green manuring can be safely adopted for irrigated and irrigated dry crops viz., rice, sugarcane, tuber crops, vegetables and orchards. In case of dry crops it is unsafe because of limiting moisture. But when rains are sufficient and evenly distributed green manuring could be followed even under rain fed conditions when the rain fall is above 900 mm (Application of lime is suggested to neutralize organic acids that are formed during decomposition (Bone meal preferred)

Characters of some green manure crops

1. Sunnhemp (*Crotalaria juncea***) :**



i) It is a unique crop possessing, fiber, fodder and green manurial value with nutrient composition of 2.3 % N, 0.2 % P and 1.4 %K
ii) It can be raised beneficially for irrigated dry conditions
iii) Under high rain fall conditions it is grown in dry lands
iv) Grown in medium fertile soils

v) Seed rate is 45 kg ha $^{-1}$

vi) Green matter yield 9-17 tonnes ha -1

2. Daincha (*Sesbania aculeata*) and (*Sesbania speciosa*)

i. They are erect growing deep rooted crops and useful to open soil and improve drainage in heavy soils.

ii. Nutrient composition(%) [3.5 N,0.3P and 1.0K]

iii. These crops are grown on heavy soils

iv. They are non fodder crops and non palatable

v. They correct sodic soils specially S. speciosa as it is less woody and less fibrous, which gives heavy foliage and easily decomposable

vi. Seed rate 30 kg ha $^{-1}$

vii. Yield 5 tonnes ha $^{-1}$

viii. Seeds require scarification for easy germination (Scarification means lightly pounding with sand).

3. Indigo (*Indigofera tinctoria*):

i) Slow growing, deep rooted drought resistant crop

ii) It is not relished by cattle

iii) Can be grown in fruit gardens and plantations during non –monsoon

iv) Seed rate is 20 kg ha $^{-1}$

v) Yield is 5 tonnes ha $^{-1}$

4. Wild indigo (*Tephrosia purpurea*)

i) It is suited for hard coarse gravelly textured soil and poor soils.

ii) It is used as a green leaf manure also

iii) Self grown crop when sown once

iv) Suitable for unirrigated orchards like mango, sapota

v) Nutrient composition (%) crop: 1.8N , 0.1 P and 0.3 K ; leaf : 3.2 N, 0.1 P and 1.2 K

5. Pillipesara (Phaseolus trilobus)

i) Regular green manure, minor pulse crop and fodder crop (triple purpose crop)

ii) Popular green manure crop for black and alluvial soils

iii) It has good ratooning capacity

iv) The crop could be incorporated in to the soil after two cuttings for fodder

v) Yield : 3-5 tonnes ha^{-1}

vi) Seed rate : 35 kg ha^{-1}

vii) Chemical composition (%): 3 N,0.1 P and 0.3 K

6. Horse gram (*Dolichus biflorus*)

i. It is suitable as green manure crop for poor and hard soils.

ii. It can also withstands drought .

iii. Seed rate is 35 kg ha-1 and yield a green matter of 3.5 tonnes ha^{-1}

Lecture 10: Green manuring *in situ* – Advantages and Limitations– cultivation Techniques

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Advantages of green manuring (*in situ):*

1. Green manure crops can be chosen to suit the soil, season, water facility and cropping pattern
2. Reduces expenditure on collection and transportation of green leaf
3. It is easy to incorporate the green manure crop in right time
4. It reduces the loss of nitrogen from the soil, fixes atmospheric nitrogen(Rhizobium fixes 25-50 kg nitrogen/acre in their root nodules)
5. Improve soil physical conditions and water holding and infiltration capacity.
6. Improves soil organic matter and provides good substrate for growth of microbes and over all soil quality will be improved.
7. Promotes mineralization of nutrients and nutrient availability will be increased.
8. Improves use efficiency of applied nutrients
9. Availability of phosphorus and sulphur will be improved.
10. micronutrients will be high due to formation of chelation.
11. Crops like daincha and sesbania can reclaim the salt affected soils
12. Crops like Crotalaria and Pillipesara are suitable as fodder for cattle

Limitations of green manure crops (in situ)

1. There must be sufficient time available for growing the green manure crop, nearly 2-3 months
2. Extra expenditure has to be incurred for growing green manure crop
3. Some of the green manure crops are of fodder value, they are liable for cattle trespass
4. They are susceptible for pests and diseases as such they may harbour them as alternate hosts.

5. Need timely rainfall or irrigation etc.,
6. Seeds may not be available in time

Method or techniques to be followed for green manuring:

1. Green manuring crop should be sown done immediately or prior to harvesting of main crop. Ex Crotalaria and Pillipesara are sown prior to harvest of rice
2. If moisture is insufficient , should be sown with the start of monsoon
3. If irrigation facilities are available a summer crop may be preferred
4. Time gap available between two long duration crops (like sugarcane-February and rice-June) can be utilized
5. Can be cultivated as intercrop in crops like turmeric, yam and cane and incorporated at the time flowering


6. The crop should be tender and incorporated at the stage of 50% flowering, delay in incorporation will affect the decomposition.
7. More seed rate should be adopted to promote dense and good crop growth.

Lecture 11: Green leaf manuring– Advantages and Limitations– crop suitable-Cultivation Techniques

II. Green leaf manuring:

Green leaf manuring refers to addition of green leaves and tender twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas and turning into the soil. In dry and rainfed areas where green manuring in situ is not possible, it is practicable to go for green leaf manuring 15-20 days prior to sowing of main crop. The common shrubs and trees used are Glyricidia , Sesbania speciosa , Karanj (Pongamia pinnata) etc.,

Plants used as a source of green leaf manure are as follows

1 Azolla pinnata
2 Calotropis gigantea
3 Cassia auriculata
4 Cassia siamea
5 Cyamopsis tetragonoloba
6 Ipomea carnea
7 Gliricidia maculate
8 Leucaena leucocephala
9 Pongamia glabra
10 Sesbania rostrata

Advantages of green leaf manuring

1. All the quantity of green leaf applied is entirely anaddition to soil – neither the moisture nor nutrients are utilized from the soil
2. There is no fear of spread of pests and diseases
3. It can be adopted at any time irrespective of the season

Limitations of green leaf manuring:

1. The green leaf is not available everywhere except in forest regions and waste lands

2. Green leaf whichever is available has to be used without choice
3. Green leaf may not be available sufficient quantity in all seasons
4. Extra expenditure on collection and transport has to be incurred

Method or techniques to be followed for green leaf manuring:

1. Green leaf manuring should be done 15-20 days prior to sowing of main crop.
2. There should be optimum moisture at the time of incorporation.
3. Application single super phosphate will hasten up the process of decomposition.
4. The leaves and twigs should be tender.

Lecture 12: Concentrated organic manures – Plant origin manures – Edible and non-edible oil cakes – Nutritional composition

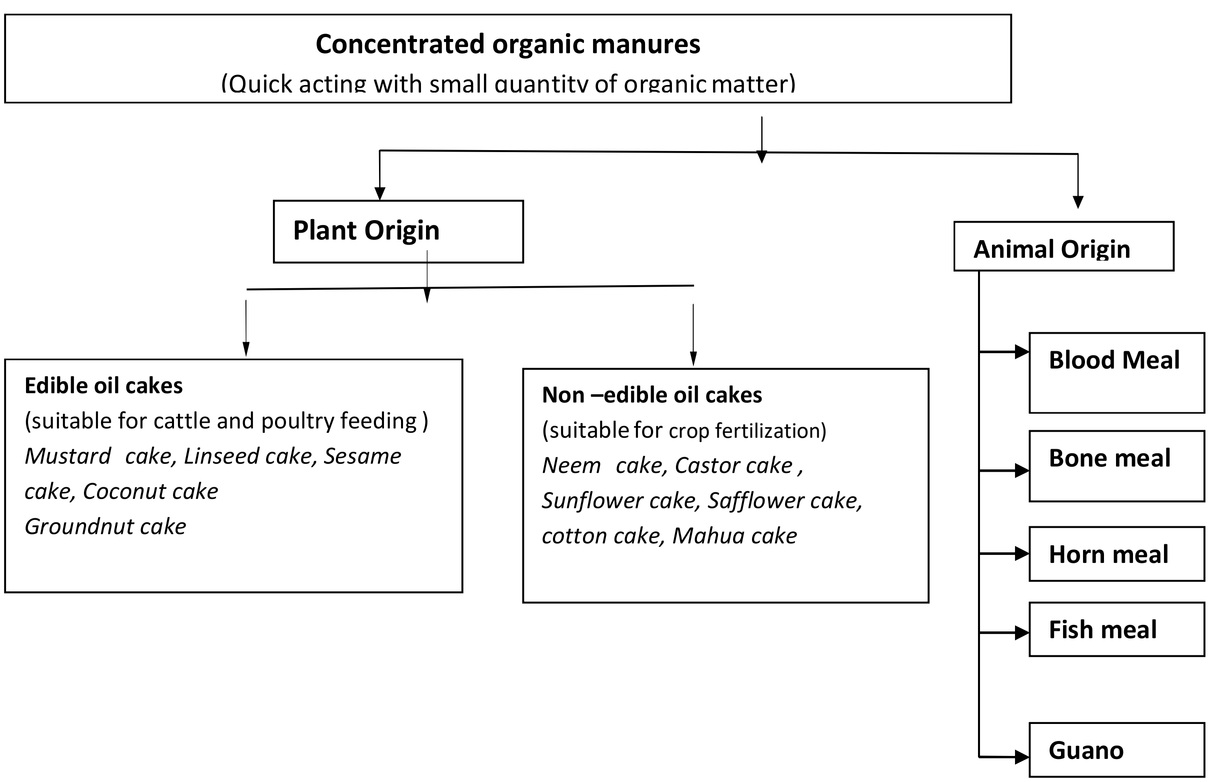
These are the organic manures of plant and animal origin and contain more quantities of major and micro plant nutrients and considerable amount of organic matter.

These manures should be powdered and applied at the time of land preparation for thorough incorporation in the soil. These decompose quickly than the bulky organic manures and supply nutrients to plants.

Nitrogen content is higher in concentrated organic manures and varied from 2.5 per cent in mahua cake to 7.9 per cent in decorticated safflower cake. since they contain nitrogen in relatively large quantities, they are usually classified as organic nitrogenous manures . By virtue of this high nitrogen content they enrich the nitrogen status of soil.

In addition to nitrogen all the oil cakes contain P_2O_5 (0.8 to 2.9 %) and K_2O (1.2 to 2.2%).

The classification of concentrated organic manures is as given under



PLANT ORIGINATED CONCENTRATED ORGANIC MANURES

OIL CAKES: After removal of oil from seeds, the residue is made in to cakes. Oil cakes are used as organic fertilizers as they are rich source of organic nitrogen in protein form. In addition to N, small amounts of P, K and micronutrients.

Composition of oil cakes is variable. Oil cakes are quick acting organic manures. The decomposability increases with decrease in oil content .They nitrify in about 30-45 days on addition to the soil .The rate of decomposition can be hastened by grinding the oil cakes into fine powder and thorough mixing with the soil .

Oil cakes are classified into two groups viz.,

i) **Edible oil cakes**: Suitable for cattle and poultry feeding and also as a manure/ fertilizer. Edible oil cakes serve as fertilizers, but their use is restricted due to economic reasons. Ex. Groundnut, Coconut, Gingelly cakes etc.,

ii) **Non –Edible oil cakes**: Suitable for crop fertilization. Eg. Castor cake, neem cake, Mahua cake, Cotton seed cake, Mustard cake, Safflower cake etc.,

Castor cake: it is also called as castor pomace. It is a by- product and the ground residue of beans from which oil has been extracted. it is poisonous to animals and used only as fertilizer. It contains 4.4 % N , 1.9 % P_2O_5 and 1.4 % K_2O.

Neem cake: Cake is prepared by crushing the neem seed (with shells) in expellers and oil is separated. Neem cake is useful for cash crops mainly due to insect repellant or insecticidal properties owing to the presence of residual bitter and sulphur. Comparatively it contains higher N. It cannot be used as a cattle feed due to its bitter taste. Neem cake has also been used as coating material over urea super granules as the former is reported to improve the fertilizer efficiency of soil applied urea.

Lecture 13: Animal origin manures – Blood meal, Bone meal, Fish meal, Horn meal and Guano–Nutritional composition

ANIMAL ORIGINATED CONCENTRATED ORGANIC MANURES

BONE MEAL: Bone meal is a white to whitish material produced by treating the bones obtained in abattoirs (Slaughter houses) .The bones are dried, crushed, degreased and cleaned to obtain bone grist. Through steaming or deamination process proteins are removed from the grist and are referred as steamed bone meal. Finely ground, it serves as an organic N- P fertilizer.

Bone meal is a good P-fertilizer of organic origin i.e., it contains $Ca_3(PO_4)_2$. It has 1.0 to 4.0 per cent N and 10-25 per cent P. In general young bones contain less P and more nitrogen than older bones. It is particularly useful for soils high in Fe and Al content (acid soils) and applied along green manures with advantage prior to sowing or planting. It can be used for all crops rather indiscriminately without fear of salt damage (burning) unlike chemical fertilizers.

HORN MEAL: Horn powder, horn grist or horn chips can be obtained depending on the degree of crushing and collectively termed as horn meal .This is a slow acting fertilizer of Nitrogen containing 14 per cent N. About 3-4 kg horn and hoof material can be obtained from each animal.

BLOOD MEAL/ BLOOD POWDER: Blood is collected from abattoirs (slaughter houses) dried and ground. This powder is used as manure. Of all the protein organic manures, dried blood has the highest availability of N it is 80 per cent as efficient as the inorganic N fertilizer in providing the nitrogen to the crop. About 30-40 kg of dried blood is obtained from 100 kg fresh blood.

FISH MEAL: The non-edible fish, fish carcasses and offels (parts of butchered animal) are used to prepare fish meal. Such material are crushed or powdered after drying. The oil is generally removed before the meal is ground and facilitate easy decomposition .It is quick acting fertilizer suitable for all crops on all soils .It contains 4 to 10% N, 3 to 9 % P_2O_5 and 0.3 to 1.5 % K_2O

GUANO: The name Guano is originated in PERU, from the word "HAUNO" to mean manure. GUANO is a product of sea bird (Pelican, Gannets, and Albatrosses) excrement covered over long periods and occurring in natural deposits. These birds live on islands with no rain or vegetation along with the pacific ocean coasts of PERU and CHILE and feed on abundant fish in the sea. These deposits are treated with concentrated sulphuric acid and prepared as manure.

Nutritional Composition of various Organic manures

Organic Manure	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Bulky Organic Manures			
Farm Yard Manure	0.5-1.5	0.3-0.9	0.5-1.9
Poultry manure	3.0	2.0	2.0
Sheep manure	0.5-0.7	0.4-0.6	0.1-3.0
Pig manure	3.75	3.13	2.5
Rural compost	0.5	0.15	0.5
Urban compost	1.4	1.0	1.4
Vermicompost	1.3-3.0	1.5-2.2	1.1-1.75
Biogas slurry	2.0-2.5	1.5	1.0
Green manures			
Crotolaria	0.75	0.12	0.51
Dhanicha	0.62	0.15	0.46
Pillipesara	0.72	0.10	0.53
Cowpea	0.71	0.15	0.58
Concentrated organic manures			
Plant origin - Edible			
Gingelly cake	4.7	2.1	1.3
Coconut cake	3.4	1.5	2.0
Groundnut cake	6.5	1.3	1.5
Plant origin-Non edible			
Neem cake	5.2	1.1	1.5
Castro cake	4.4	1.9	1.4
Safflower cake	7.9	2.2	1.9
Mustard cake	4.8	2.0	1.3
Cotton seed cake	6.9	3.1	1.6
Animal origin			
Bloodmeal	12.0	1.5	0.8
Horn meal	14.0	-	-
Fish meal	4-10	3-9	0.3-1.5
Bone meal	1-4	10-25	--
Guano	8-15	2.3	2.4

Lecture 14: Bio-fertilizers – Classification – Atmospheric nitrogen fixers

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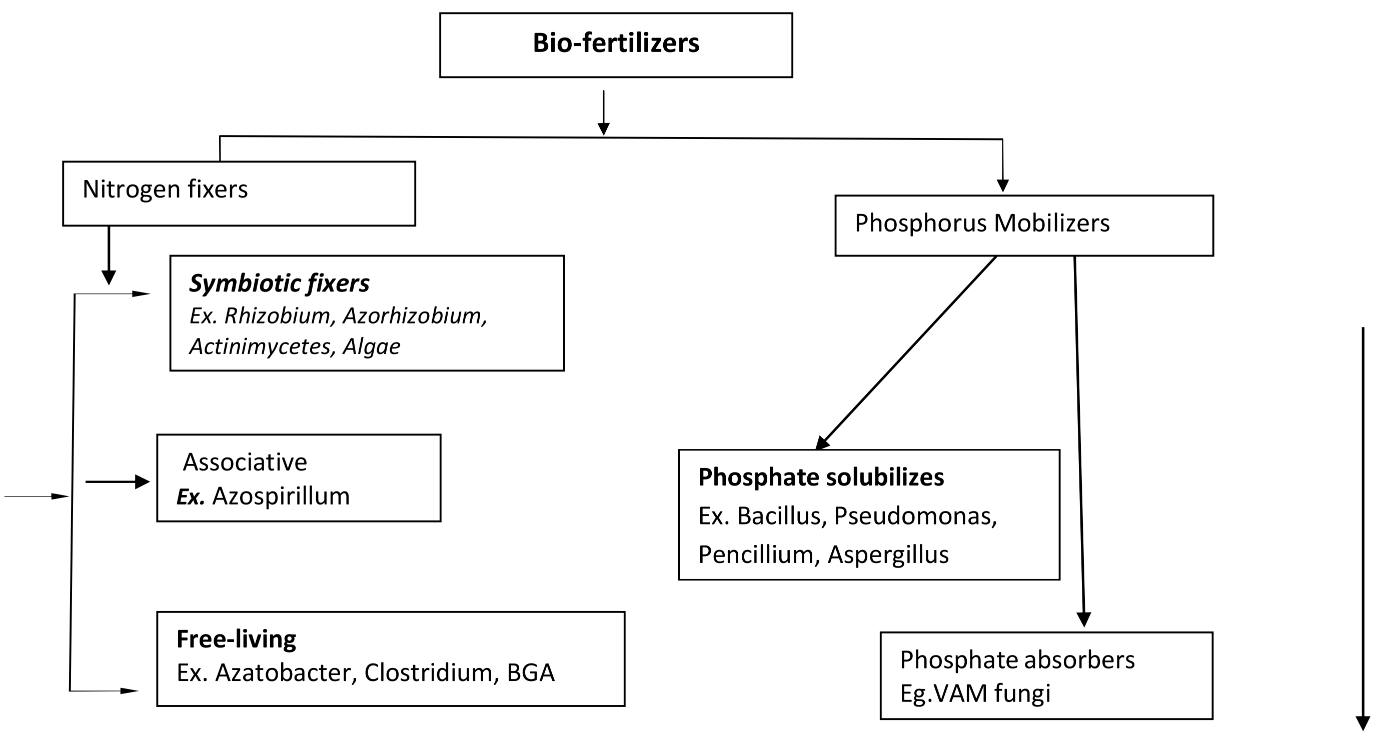
The soil is packed with millions of living organisms which make it a living and a dynamic system. Role of high yielding varieties and use fertilizers is indispensable in Green revolution. However, due to non-availability of organic manures in villages farmers are resorting to excessive and indiscriminate of chemical fertilizers to achieve higher yields. But this is leading to soil, water and environmental pollution and the productive agricultural soils are getting degraded. Under such situations bio-fertilizers are good alternative sources to protect our soil.

Bio-fertilizers or Bio-inoculants are productions containing living organisms such as nitrogen fixers or phosphorus solubilisers which are useful for agricultural production.

Bio-fertilizers play a significant role in improving soil fertility and plant growth

- ✓ by fixing atmospheric nitrogen both in association with plants and without plants
- ✓ by solubilising insoluble soil phosphates into soluble phosphates there by increasing the availability of phosphorus
- ✓ by secreting growth promoting substances and supplies to the inoculated plants.

Classification of Bio-Fertilizers



Nitrogen fixing bio fertilizers

Atmosphere contains nearly 78% of nitrogen in gaseous form, and this is 1.5 times higher than the N content present in urea. Certain group of microbes are capable of fixing the gaseous nitrogen and convert into plant available form. Nitrogen fixation is a biochemical reaction where in the atmospheric gaseous nitrogen (N_2) is reduced to ammonia (NH_4^+) in the presence of nitrogenase enzyme. This ammonia can be utilized by the plants.

A well-developed root system, slightly alkaline soil reaction and availability of sufficient quantities of phosphorus, calcium, sulphur iron and molybdenum in soil are the favourable conditions for nitrogen fixation

Different kinds of nitrogen fixation

Symbiotic nitrogen fixation: This kind of association is primarily seen in leguminous crops. Here microbes live in the roots/stems of plants and absorb their food from plants and in turn they fix the atmospheric nitrogen.

Examples

Bacteria:	*Rhizobium* (on root nodules of legumes) and
	Azorhizobium colidans (On stem nodules of sesbania)
Actinomycetes:	Frankia on Casuarina
Algae:	Anabaena and Azolla in rice

Associative Nitrogen Fixation

In this the microbes will be living in association with plant but there will not be any mutual benefit or inter dependency.

Ex. Azospirillum

Free living nitrogen fixation

In this the microbes will be living freely without any association with plant and fix the atmospheric nitrogen

Ex. Azatobacter, Clostridium, BGA

Lecture 15: Symbiotic nitrogen fixers – Associative nitrogen fixers and free living nitrogen fixers

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Symbiotic nitrogen fixers

***Rhizobium* inoculants:**

Belongs to the family Rhizobiaceae and symbiotic in nature. *Rhizobium* establishes symbiotic relations with pulses and other legumes and can fix 50 to 100 kg N ha^{-1} by which application of chemical nitrogen fertilizers could be reduced and supplemented nearly 80-90 per cent of nitrogen requirement of crop is met by nitrogen fixation in root nodules of legume crops. On average yield increase was 15-30 % due to rhizobium inoculation.

It is used for pulse legume crops like chick pea, red gram, chickpea, lentil, black gram etc., and oil seed legumes like soybean and groundnut and forage legumes like besrseem, lucerne and pillipesara. The rhizobia show host specificity to some extent. In other words rhizobia isolated from ground nut cannot be used for red gram.

Rhizobium sps	Specific Crop
Rhizobium meliloti	Berseem
Rhizobium trifoli	Pillipesara
Rhizobium leguminosarum	Peas& Lathyrus beans
Rhizobium phaseoli	Black gram
Rhizobium japanicum	Soybean
Rhizobium (cowpea group)	Cowpea

Method of preparation:

This biofertilizer is available commercially as carrier based (lignite or peat) biofertilizers. Direct application of rhizobium to seed is the most common form of legume inoculation (seed coat).

However, for groundnut, slurry of peat based inoculam in the seed furrows is recommended as the seeds are fragile. Prepare a solution of jaggery/sugar by dissolving 50g in 1 litre of boiling water and to this solution, after cooling add 200g rhizobium culture and can be used as seed coat. Seed should be shade dried before sowing. 200g of rhizobium is sufficient to coat the seed necessary for one acre.

AZOLLA [Botanical name is ***Azolla pinnata*****] :**

It belongs to the family Azollaceae. Azolla is a water fern. It is considered as aquatic weed commonly found in floating in idle ponds, tanks shallow ditches and canals. Azolla is associated with rice field.

A blue green algae (BGA) *Anabaena azollae l*iving in the epidermal cavity of lower side of the leaf of Azolla. The symbiotic association of *Azolla pinnata* and *Anabaena azollae* is termed as Azolla Anabaena complex. This algae fixes atmospheric nitrogen for Azolla and in exchange, the plant provides shelter and food to the algae. As this complex fixes atmospheric nitrogen, it has great potentiality for use, in agricultural field as biofertilizer and can be used as an alternative to nitrogen fertilizers. It is recommended as green manure because of its large biomass and high N content (4-6%N) for sub merged rice fields, with in maximum temperature of 38^{0}C. The yield increase is 15-20%.

Associative Nitrogen Fixers

In this the microbes will be living in association with plant but there will not be any mutual benefit or dependency.

***Azospirillum* Inoculant :**

It belongs to the family spirillaceae, chemoautotrophic and associative in nature. It is an associative nitrogen fixing organism was found to be beneficial for sorghum, wheat, maize, barley, fodder grasses and minor millets. Yield increase was 15-30 %. By the application of this fertilizer nitrogen saving is 20-30 kg /ha. It also produces growth regulating substances.

Application of this biofertilzer results inIncreased mineral uptake, Increased water up take, good Root development and vegetative growth. Make the plant drought resistant

Freeliving Nitrogen Fixers

***Azotobacter* inoculant**:

Azotobacter belongs to the family Azotobacteriaceae, which is a chemoautotrophic in nature, frees living, non-symbiotic in nature and is recommended for application to non-legume crops. It thrives well in many types of soils, with a minimal dose of phosphorus and carbon compounds. It grows best in neutral to alkaline soils. By the application of Azotobacter to various crops, the amount of recommended doses of nitrogenous fertilizers can be reduced by 10-20%. It produces plant growth promoting substances like vitamins of B group, Indole acetic acid, Gibberellic acid by which plants grow quickly and healthy. Yield increase of 10-15 % was noticed in some millet. This biofertilizer is recommended for rice, wheat, millets and other cereals, vegetables, sunflower, mustard, tobacco, sugarcane, cotton etc., and also fruit crops.

Method of usage: It is carrier based biofertilizer (lignite / peat). Azotobacter can be applied by seed inoculation, seedling inoculation, or by broad casting in the field after mixing with FYM or with well decomposed compost.

Seed inoculation: Seed is treated with Jaggery to make it sticky and then treated with biofertilizer and shade dried. Seedling inoculation: Make slurry of biofertilizer and dip the roots in it. The recommended dose of Azotobacter is 2-3 packets /ha.

Blue green algae or Cyanobacteria:

BGA is phototrophic in nature. These are photosynthetic, prokaryotic microorganisms and capable of fixing molecular nitrogen. BGA are found to grown in a paddy filed and marshland. It is used as biofertilizer for irrigated rice crop.

The rice field ecosystem provides an environment favourable for the growth of BGA with respect to their requirements viz., light, water and temperature. Nitrogen fixation by BGA have been estimated to be 25-30 kg N/ha. Yield increases by 10-15 %. BGA has some species viz., Nostoc, Anabaena, Olocia, Calothrix, Tolipothix etc., They fix nitrogen in the presence of sunlight .They also contain growth promoting substances like auxin, Indole acetic acid and Gibberellic acid.

Multiplication of BGA: Farmers can multiply BGA in their fields by adding 5 kg of culture in well puddled 40m^2 pit duly adding 2 kg of single super phosphate and maintaining 1 inch of water regularly. 250g of carbofuran 3G granules may also be applied to prevent the infestation of other insects. A thick mat of BGA will be developed in 3-4 weeks and can harvested, dried and stored in bags for future use. Regular harvests can be taken at every 20 days interval by adding SSP and carbofuran 3G granules to the trench.

Recommendation: application of 10 kg/ha flakes of BGA. It is applied 10 days after the transplanting of rice crop.

Lecture 16: Phosphorus mobilisers – Method of application – Advantages & Constraints

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Phosphorus mobilisers

Phosphate solubilizing microorganisms

Phosphorus is present in soils in both organic and inorganic forms and most of which is insoluble and unavailable to plants. Several soil bacteria particularly those belonging to the genera ***Pseudomonas*** and ***Bacillus*** and fungi belonging to the genera ***Pencillium* and *Aspergillus*** possess the activity to bring insoluble phosphates in the soil to the soluble forms by secreting organic acids such as acetic acid, propeonic acid etc., These acids lowers the pH and bring about the dissolution of the bound phosphate forms.

Phosphate absorbers

Vesicular Arbuscular Mycorhizae:

Mycorrhizae mean root fungi or VAM. These are obligate symbiotic. They are ubiquitous in nature and with very few exceptions found on a wide range of plant species. They form vesicular –arbuscular –mycorrhizal (VAM) symbiosis. A VAM fungus infects and spreads inside the root by providing an aseptate mycelium. Vesicles which are sac like structure provided by these fungi are known to store phosphorus as phospholipids. Arbuscules formed inside the cortical cells are attributed to help in the exchange of nutrients. Common genera that form VAM associations are **Glomus, Gigaspora , Enterospora etc.,**

Advantages:

1. VAM fungi enhancing the nutrient uptake of P, Zn and S.
2. Enhances the water uptake under drought conditions.
3. Enhances resistance to root damage.
4. Increases the yield.

Method of Application: 1-2 kg of Phosphorus solubilizing bacteria may be mixed with 20 kg of FYM and applied at the time final land preparation. Seed sufficient for one acre may also coated with 200g of culture.

Advantage of Biofertilizers:

1. Absorb nitrogen from the air and make it available to plants –thus reducing the need for nitrogen fertilizer. They can add 20-200 kg N ha^{-1} (by fixation) under optimum conditions.
2. Make inorganic phosphate ad micronutrients soluble and available to plants. They can solubilise/ mobilize 30 -50 kg P_2O_5 ha^{-1}
3. Stimulate plant growth. They liberate growth promoting substances and vitamins and help to maintain soil fertility.
4. They provide physical barriers against pathogens. Thus suppress the incidence of pathogens and control diseases.
5. Enhance plant uptake of P and Zn.
6. Collect and store available nutrients.
7. Decompose organic residues.
8. Increase crop yield by 10-50%
9. They are cheaper, pollution free and based on renewable energy sources.
10. They improve soil physical properties, tilth and soil health in general.

Constraints in usage of biofertilizers

1. Farmers acceptance has been far from satisfaction.
2. Difficult to demonstrate striking increase in yield due to biofertilizers unlike chemical fertilizers.
3. Strains fail to establish if the soil moisture in sufficient in the surface zone.
4. Fungicide treatment is a problem in crops like groundnut.
5. Inoculants manufacturing is far below the requirement.
6. Availability of quality of inoculants is another problem.
7. Seed inoculation is not suitable when seeds are sown on dry soil or when seeds are coated with toxic chemicals and pesticides.
8. Soil containing higher number of ineffective native rhizobia.

9. Seeds have fragile seed coat.

10. When seed coat is toxic to rhizobia. In such situation soil inoculation with granulated inoculants is followed in USA, New Zealand, France etc., Granulated inoculation is prepared using grains of sand, gypsum, peat etc.,

11. Problem like transport form the manufacturing centre.

Lecture 17: Differences between organic manures and chemical fertilizers – Classification of fertilizers

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Organic manures	Chemical fertilizers
Organic in nature- Naturally available plant, human and animal wastes and residues.	Inorganic in nature- Mined or Synthetically manufactured materials and minerals
Supply almost all major, minor and micronutrients but in very low quantities	Prepared to supply one or very few plant nutrients but in higher quantities
Does not have definite chemical composition	Have definite chemical composition
Have low analytical value	Have high analytical value
Slow acting and supplies nutrients for a longer period	Quick acting
Plants cannot absorb nutrients immediately	Releases nutrients immediately
Improves physical properties of soils *viz.*,structure is improved, bulk density is reduced, water infiltration and holding capacity is increased, drainage facility is improved, evaporation is reduced, loss of nutrients and soil through erosion is reduced	Don't improve the physical properties of soils.
Acts as source of food for soil microbes	To some extent provides nutrition to microbes but not completely
Helps in reclamation of problem soils.	Indiscriminate use may affect the soil health. Soils may turn out in to acidic, saline and alkaline with excessive use.
During the process of decomposition organic acids are released and availability of nutrients like phosphorus is increased.	Doesn't help in increasing the native nutrient availability.
Bulky in nature, large quantities (tonnes) are required for application	Non-bulky in nature, smaller quantities (Kilograms) are sufficient to meet the crop nutrient requirements
Should be applied15-20 days well in advance of sowing/planting of the crop and should be incorporated.	Can be applied at the time of planting or sowing.

Lecture 18: Straight fertilizers – Nitrogenous fertilizers – Nitrate, Ammonical, Nitrate – Ammonical and Amide fertilizers.

Plants require both macronutrients (N, P, K, Ca, Mg and S) and micronutrients (Fe , Zn ,Cu ,Mn , Mo, B ,Cl, etc.,). The mineral fertilizers containing these nutrients are produced in plants (Industries or Factories).Chemical fertilizers are also called as commercial fertilizers.

A commercial fertilizer is defined as a material containing at least one of the primary nutrients in assemble or available form to plants in known amounts.

The chemical fertilizers are classified into three groups depending upon the nutrients

1. Straight fertilizers
2. Mixed fertilizers
3. Complex fertilizers

Straight fertilizers

A straight fertilizer may be defined as a chemical fertilizer which contains/supplies only one primary or major nutrient element. These fertilizers are classified into five groups depending upon the nutrients which they supply.

1. Nitrogenous fertilizers
2. Phosphatic fertilizers
3. Potassic fertilizers
4. Secondary nutrient fertilizers
5. Micronutrient fertilizers.

Nitrogenous fertilizers

Nitrogenous fertilizers can be classified into four classes on the basis of form of nitrogen present in that fertilizer:

1. Nitrate fertilizers
2. Ammonical fertilizers
3. Nitrate ammonium fertilizers
4. Amide fertilizers

Nitrate fertilizers

These fertilizers are readily soluble in nature and immediately dissociates in soil solution releasing No_3^- nitrogen. As nitrate nitrogen carriers a negative charge it is not adsorbed onto soil particles and subjected to leaching in to deeper soil layers. Nitrate nitrogen can also be lost to the atmosphere through volatilization. Though plants absorb N in nitrate forms, because of these losses, these fertilizers are not preferred. These fertilizers should not be recommended for irrigated paddy.

Ex: Calcium nitrate (15%)

Sodium nitrate (16%)

Ammonical fertilizers

These fertilizers contain nitrogen in ammonium form (NH_4^+). Due to this positive charge they are adsorbed onto soil particles and leaching of nitrogen does not occur. Hence their use efficiency is more and can be considered as good source of nitrogenous fertilizers.

In due course NH_4^+ is converted in to NO_3^- form. This form of nitrogen is rapidly utilized by the plants. Can be applied as basal dose or as top dressing, but should not be mixed with seed.

Ex: Ammonium sulphate [21% N, 24% S]

Ammonium chloride [25% N]

As these fertilizers are acid producing in nature excessive application of ammonical fertilizers should be discouraged. To neutralize the acidity, for every 100 kg of ammonium sulphate 110 kg of calcium carbonate is required.

Ammonium chloride on application dissociates in to ammonium and chlorine in soil. This chlorine combines with calcium present in the soil and calcium chloride being highly soluble in nature, is lost due to leaching. Hence application of ammonium chloride results in loss of calcium.

Ammonium chloride can be applied in wetlands. However, should not be used in tobacco and potato crops. The chlorine present in the fertilizer, affects quality of leaf in tobacco and shelf life of potato.

Nitrate-Ammonia nitrogen fertilizer

In these fertilizers nitrogen is present in both nitrate and ammonical forms. Under irrigated dry conditions, when these fertilizers are applied nitrate form of nitrogen will be taken by the plants immediately and ammonia form of nitrogen will be available gradually to the plants. Nutrient use efficiency is high for these fertilizers.

Ex: Ammonium nitrate [33%N]

Calcium ammonium nitrate [26%N]

Ammonium Sulphate nitrate [26%N]

Calcium ammonium nitrate is highly hygroscopic in nature, hence should be stored in specialized polythene bags. These fertilizers are neutral in nature,

Amide nitrogen fertilizers

Nitrogen is present in amide form [NH_2] or Cynamide [CN_2] form

Ex. Urea [46%N]

Calcium Cynamide [21%N]

Urea is the most popular amide form of fertilizer. It is highly hygroscopic and forms in to lumps. Slightly acidic in nature. On application in wet lands, nitrogen is lost through leaching and in dry soils it is lost through voltalisation. Hence optimum moisture and though mixing with soil should be ascertained while applying this fertilizer.

As it is soluble in water can be used for foliar spray (2% urea – 20g/l). Higher or excess concentration results in scorching and defoliation.

Urea contains a harmful substance called Biurette, its concentration should be below 1.5% for its use as foliar spray.

Straight nitrogenous fertilizers

S.No.	Chemical Form of Nitrogen	Fertilizer	Chemical formula	N Content (%)
1	Ammonium $[NH_4^+]$	a) Gaseous ammonia	NH_3	82
		b) Ammonia water	NH_3 ,NH_4OH	24
		c) Ammonium sulphate	$(NH_4)_2SO_4$	21
		d) Ammonium Chloride	NH_4Cl	26
2	Nitrate $[NO_3^-]$	a) Calcium nitrate	$Ca(NO_3)_2$	16
		b) Sodium nitrate	$NaNO_3$	16
		c) Potassium nitrate	KNO_3	13
3	Ammonium +Nitrate $[NH_4^+]$ +$[NO_3^-]$	a) Ammonium nitrate	NH_4NO_3	35
		b) Calcium Ammonium Nitrate	NH_4NO_3 +$CaCO_3$	26
		c) Ammonium Sulphate Nitrate	$(NH_4)_2SO_4$+NH_4NO_3	26
4	Amide $[NH_2]$	a) Urea	$CO(NH_2)_2$	46
		b) Calcium cyanamide	$CaCN_2$	22

Lecture 19: Phosphatic fertilizers – Water soluble – Citric acid soluble and insoluble fertilizers – Potassic fertilizers

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Phosphatic fertilizers

Phosphate fertilizers are chemical substances that contain the nutrient element phosphorus in the form of absorbable phosphate ions (anions) or that yield such phosphate anions after conversion.

Phospatic fertilizers were classified based on the form in which orthophosphoric acid/ phospatic acid is combined with calcium and based on relative solubility of phosphate

They are classified into following three types

1. Water soluble phosphorus fertilizers
2. Water Insoluble but citrate soluble phosphorous fertilizers
3. Water and citrate insoluble phosphorus fertilizers

Water soluble phosphorus fertilizers

Phosphorus in these fertilizers is present in water soluble form (H_2PO_4). This form of Phosphorus is generally regarded as the most readily available to plants. P is present in the form of mono calcium phosphate $Ca(H_2PO_4)_2$.

These fertilizers are used in neutral soils and alkaline soils for all crops.

Ex: Single super phosphate (16-18 % P_2O_5)

Double Super Phosphate (32 % P_2O_5)

Triple Super Phosphate (32 % P_2O_5)

Higher content or concentrated super phosphate

Ammonium phosphate (20% N and 20% P_2O_5)

In Single super phosphate, in addition to 16% of phosphorus, 21% of calcium and 12% of sulphur are present, hence this fertilizer is preferred source for oilseed crops like groundnut.

Phosphorus fertilizers should always be applied at the time of sowing as basal fertilizers and by pocketing in 4-8 cm depth at 2-3 cm away from the plant.

Citrate soluble phosphorus fertilizers

Phosphorus is present as dicalcium phosphate $Ca_2H_2(PO_4)_2$ / $CaHPO_4$. This class of fertilizers is not readily soluble in water and hence not readily available to plants. Phosphorus present in these fertilizers is soluble in 2 % ctric acid (or) neutral normal ammonium acetate solution. They should be applied one month before taking up the crop so that insoluble 'P' gets solubilized by the time of sowing of crop.

Ex: Basic slag – 6- 20 % P_2O_5

Bone meal – 20-25 % P_2O_5

Steamed bone meal – 20-25 % P_2O_5

Di calcium phosphate – 34 – 39 % P_2O_5

Water and citrate insoluble phosphorus fertilizers

Phosphorus is present in the form of tri calcium phosphate ($Ca_3(PO_4)_2$) or $(PO_4)^{3-}$. Phosphorus present in the fertilizers is not soluble both in water and citrate solution. In normal conditions these fertilizers is not available to plants. This form of fertilizers are soluble in strongly acidic soils (or) organic soils and hence supplies phosphorus to plants.

Ex: Rock Phosphate – 20- 40 % P_2O_5

Finely grounded phosphorus is used as fertilizer in tea and coffee gardens and in high rainfall mountain areas.

Water soluble single super phosphate can be prepared by chemical reaction of rock phosphate with sulphuric acid(H_2SO_4)

Potassic Fertilizers

The supply of potassium to plants is expressed as K+.

Most important potassic fertilizers are muriate of potash [KCl] ; sulphate of potash [K_2SO_4] ; potassium nitrate [KNO_3].

Muriate of potash contains more per cent of potassium [60% k]. and is quickly soluble in water. This form of potassic fertilizers is available in market with less cost compared to other potassic fertilizers. This form of fertilizers (MOP) is useful for all crops except potato, tobacco, grapes.

Sulphate of potash contains 50% potassium and 18% sulphur. This cost of this fertilizer is more. Sulphate of potash is applied to potato, tobacco and grapes. This fertilizers can be used for foliar application during the periods of rainfall scarcity and drought.

Potassium nitrate contains 45% potassium and 14% nitrogen. This fertilizer can be sprayed for correcting of nitrogen and potassium deficiency.

Lecture 20: Secondary nutrient fertilizers – Micronutrient fertilizers – Different types

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Secondary nutrient fertilizers

Supply of secondary nutrients like calcium, magnesium and sulphur etc., through chemical fertilizers was not needed until 1990s because of application of organic wastes by the farmers and use of straight NPK fertilizers which supply some of these secondary nutrients. With the excessive use of complex fertilizers in place of straight fertilizers coupled with non-application of organic manures and cultivation of high yielding hybrids/ varieties, lead to secondary nutrient deficiencies.

In acidic soils, application of Ca and Mg fertilizers should be practiced every year. Separate application of sulphur is not necessary as fertilizers used for correction of micronutrient deficiencies and chemicals used in prevention of pests and diseases contain some sulphur.

Table: Sources of fertilizers for calcium, magnesium and sulphur:

S. No.	Source	Formula	Ca (%)	Mg (%)	S (%)
1	Burnt lime	CaO	70		
2	Hydrated lime	$Ca(OH)_2$	50		
3	Calcite lime	$CaCO_3$	36		
4	Dolamitic lime	$CaCO_3$ $Mg CO_3$	17	12	
5	Basic slag	$(CaO)_5$ P_2O_5 SiO_2	29		
6	Gypsum	$CaSO_4$ $2H_2O$	22		8
7	Calcium nitrate	$Ca(NO_3)_22H_2O$	20		
8	SingleSuper phosphate	$Ca(H_2PO_4)_2$ $CaSO_4$	20		12
9	Triple super phosphate	$Ca(H_3PO_4)_2$	13		
10	Rock phosphate	$Ca_5(PO_4)_3F$	33		
11	Calcium chloride	$CaCl_2$	36		
12	Magnesium sulphate	$MgSO_4$ $7H_2O$		10.5	13

13	Magnesium oxide	MgO		45	
14	Dolamite	$CaCO_3$ $MgCO_3$	17	12	
15	Ammonium sulphate	$(NH4)_2$ SO_4			23
16	Potassium sulphate	K_2SO_4			18

Of the different sources of Ca, the Gypsum has been gaining importance for crops such as legumes. Global reserves of Ca are considerably large since whole mountain ranges consist of lime stone. Calcium nick named as root developer, which is slightly mobile in plants. Calcium deficiency in plants is rarely caused by shortage of available reserves in the soil, except in acidic soils.

Elemental sulphur is also an important sulphur fertilizer with strong acidifying action. It can be used either directly or as an additive to other solid fertilizers eg sulphur coated urea. The sulphur requirements of plants are approximately 2/3 of their phosphorus requirements and are provided from various sources such as air, rain water,soil and fertilizer .Fields near Industrial zones are supplied with 10-30 kg ha $^{-1}$ per year from SO_2 waste gases .

MICRONUTRIENT FERTILIZERS

Higher green plants are known to require seven micronutrients viz., Fe, Mn, Cu, B, Mo, Cl etc. But this number may have to be increased in future.

The need for the micronutrient fertilization has been increasing due to the following reasons:

1. **Change in the plants**: Change in the plant varieties from traditional to high yielding varieties (HYV). HYV have a capacity to remove more nutrients both major and minor. HYV have low mobilizing capacity of micro nutrients from the soils hence they are to be applied through external application.
2. **Changes in soil**: Change in soil condition from acid to alkaline (Increased soil reaction) and aeration cause greater immobilization of most micronutrients except molybdenum (Fe, Zn, Cu and Mn). High acidic nature of the soil induces both calcium and magnesium deficiency.
3. **Changes in fertilization:** Using high doses of NPK in the form of complex

fertilizers, induces deficiencies of secondary and micro nutrients. Antagonistic action due in part to excessive fertilization with NPK Eg. Higher K content in soils affects the uptake of Fe, Mn, and B.

Excess P leads to deficiencies of Zn, Fe, Cu and increases Mo availability. More the sulphate present in the soils, lesser the availability of Mo.

4. **Changes in overall growth conditions**.
   1. Intensive cultivation: Intensive cultivation leads to micro nutrient deficiencies
   2. Non availability and application of organic manure.
   3. Under/ over limed condition.
   4. Parent material: Most of the micronutrients originates from parent material and influences the availability or deficiency of micronutrients to plants
   5. Land levelling and shaping: Most of the micronutrients are concentrated on the surface soil except Molybdenum. Levelling of land and deep tillage operations leads to deficiencies.
   6. Low Si/Mg ratio: Leads to fixation of Zn in soil.
   7. Calcium carbonate: More the $CaCO_3$ in soils lesser the availability of Fe, Cu, Mn, Zn.
   8. Soil texture: Boron availability is more in coarse textured soils and in finer textured soils it gets fixed, unavailable to plants.
   9. Secondary clay minerals: Montmorillonite clay adsorb more of Zn, Cu and leads to deficiency or unavailability to plants.
   10. Soil moisture: Dry conditions of soil fix more of Boran and is released under wet conditions. Presence of more moisture reduces the availability of Mn.
   11. Interaction with macronutrients: Heavy nitrogen interferes with availability of Cu, Mn, Zn and leads to deficiencies in plant.
   12. Liming reduces the availability of Mn, Zn, Fe, Cu.
   13. Seasonal variation: Nutrient deficiencies are more during cold season. Out break of B deficiency is common in dryseasons
   14. Summer drought aggravate Fe chlorosis.
   15. High and low soil temperatures induces Zn deficiency in soils having low zinc.

Lecture 21: Mineral salt and chelated micronutrients-Nutritional composition

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Classification of micronutrient fertilizers

Micronutrient fertilizers are classified into two broad categories :

I. **Inorganic salts**

II. **Chelates**

I. **Inorganic salts:** Supplying micronutrients are salts like Zn SO_4 , Cu SO_4 ,Mn SO_4 Fe SO_4 etc., All these are readily soluble in water and can be used both for soil application and foliar spray.

II. **Chelates :** This is next important category of micronutrient fertilizers .Chelates are metallic molecules of varying sizes and shapes in which the organic part binds the nutrient in a ring like structure . For the chelation of nutrient cation the common chelating agents used in chelating micronutrients as follows.

1. EDTA :Ethylene Diamine Tetra Acetic Acid
2. HEDTA Hydroxy Ethylene Diamine Tetra Acetic Acid
3. EDDHA Ethylene Diamine Dihyroxy Acetic Acid
4. NTA : Nitrilo Tri Acetic Acid
5. DTPA : Diethylene Triamine Penta Acetic Acid

Sources of micronutrients:

S.No.	Micronutrients	Formula	Content (%)
A	**Iron**		
	1.Ferrous sulphate	$FeSO_4$ $7H_2O$	20
	2.Fe-chelate	Fe-EDTA	5
	3.Fe-Chelate	FeEDHA	6
B	**Manganese**		
	1. Manganous sulphate	Mn SO_4 4 H_2O	24
	2.Manganous sulphate(Monohydrate)	Mn SO_4 H_2O	32

	3. Mn -chelate	Mn-EDTA	13
C	**Zinc**		
	1.Zinc sulphate	$ZnSO_4\ 7H_2O$	23
	2.Zinc sulphate (Monohydrate)	$ZnSO_4\ H_2O$	36
	3.Zn-chelate	Zn-EDTA	14
D	**Copper**		
	1.Copper sulphate	$Cu\ SO_4\ 5H_2O$	25
	2.Copper sulphate (Monohydrate)	$Cu\ SO_4\ H_2O$	36
E	**Boron**		
	1. Borax (Na-tetra borate)	$Na_2B_4O_7\ 10H_2O$	11
	2.Borax anhdrous	$Na_2\ B_4O_7$	22
	3.Boric acid	H_3BO_3	18
F	**Molybdenum**		
	1 Sodium molybdate	$Na_2MoO_4\ 2H_2O$	40
	2.Ammonium molybdate	$(NH_4)_6MoO_{24}$	54
	3. Molydenum trioxide	MoO_3	66
	4.Calcium molybdate	$CaMoO_4$	48

Principles involved in micronutrient fertilization

I. Iron fertilization :

Majority of Fe-fertilizers are water soluble .Salts or organic complexes (chelates). They are predominantly applied as foliar sprays, however this requires repeated application. In addition to supplying iron to deficit soils, it is necessary to mobilize iron in the soil itself through acid –N –fertilization .Fe removal amounts to a few kg/ha /year

II. Manganese fertilization :

Manganese sulphate is the best known water soluble fertilizer and is suitable for leaf fertilization .It can also be used as a soil dressing, but is easily fixed in deficit soils when the pH is moreSoil Mn supplies can be improved by

i) Using acid forming fertilizers

ii) Compacting loose soils

iii) Preventing excessive drying

- **iv)** Supply of easily decomposed organic matter ,which on conversion creates reducing conditions and thus Mn released .It is a practical means of Mn supply than to add Mn fertilizer .About ½ to 1.0 kg of Mn /ha/year is removed by crops in general

III. Copper fertilization :

- **i)** Copper sulphate [Blue Vitriol] is the oldest water soluble Cu-fertilizer .It can be applied as soil dressing or foliar nutrient .However; its acidic side effects are likely to cause leaf scorch on foliar application.
- **ii)** Hence less caustic agents like green copper $Cu_2Cl\ (OH)_3$ or Cu-chelates are safe to use
- **iii)** Copper removal by crops in general varies 30-100 g/ha /year
- **iv)** Copper is highly immobile in soil and as such needs thorough mixing with top soil

IV. Zinc fertilization :

- **i)** Zinc sulphate is the simplest form of water soluble fertilizer
- **ii)** It is acidic in reaction and causes leaf scorch on foliar application unless free acidity in neutralized with lime
- **iii)** Improvement of natural zinc sulphate (Soil zinc) can be done by the application of acid forming N -fertilizers to combat Zn-deficiency .Crop removal of Zn varies from 100-400 g /ha /year

V. Boron fertilization :

- **i)** Borax **(**Na –tetra borate) is historically famous water soluble boron fertilizer.
- **ii)** The effectiveness of chile –salt peter was attributed to the presence of borax as natural admixture**.**
- **iii)** It can be applied to soil or foliage
- **iv)** Boron removal by crops is about 50 g / ha /year

VI. Molybdenum fertilization

- **i)** Sodium molybdate and ammonium molybdate are the important Mo fertilizers suitable for soil or foliar application and also for seed treatment
- **ii)** Molybdenum removal by crops varies from 5 to 20 g/ha /year

Lecture 22: Mixed fertilizers – Farm mixtures and Mechanical mixtures

Mixed fertilizers are physical mixtures of straight fertilizers like urea, SSP and MOP. These fertilizers are also called as **bulk blended fertilizers**;

- They contain two or three primary plant nutrients.
- Blending provides a convenient and economical means of mixing dry fertilizer materials to produce specified ratios and grades of varying nutrient percentage depending on the needs of the crops.
- These mixed fertilizers can be made in farmer's level also depending on needs of the crop.
- Mixed fertilizers are made by thoroughly mixing the ingredients either mechanically or manually in small quantities in small factories and can be provided to farmers.

Farm Mixtures: The manually blended fertilizers at farm are called "farm mixtures". Implying that these can be prepared by the farmers themselves based on the crop requirements.

- The chemical fertilizers are spread in layer wise manner (placing bulky materials at the bottom of the floor followed by materials which are less bulky) and turned over number of times with spade to ensure through mixing.
- These farm mixtures can be mixed or prepared at the time of application only to avoid the caking and other chemical reactions.

Farm mixtures preparation at field level

Mechanical mixtures:

These are prepared by mixing large quantities of different fertilizer materials to obtain the required grades or quantities of the product with the help of machines or containers.

While mixing the mechanical mixtures the following precautions may be taken to avoid the caking and other chemical reactions between the fertilizers

- The selected fertilizers for mixing should not react with each other
- Acidic natured fertilizers should not be mixed with alkaline natured fertilizers

  Ex : Ammonium sulphate and basic slag should not be mixed together
- Avoid mixing of high moisture containing or hygroscopic fertilizers

  Ex : Urea, Ammonium nitrate
- In the formulation of mixtures, it is not possible to get exact quantities of major nutrients (NPK) in one tonne of the mixed fertilizers, therefore additional material called fillers and Conditioners are used . These are used to make up weights and to improve the physical conditions of mixed fertilizers, respectively. Ex: Sand, Coal, Corn husks, Dolomite, Ash Lime stone are added
- Conditioners are those materials added to non-granular or granular mixtures to improve their physical condition and to decrease their caking .The actual purpose of adding conditioner is to reduce crystal knitting. Ex: Sand and Silica
- While mixing the mechanical mixtures, concentrated organic manures (oil cakes) or soil amendments (gypsum or lime) can also be added for improving soil health.
- For the purpose of soil amelioration, gypsum and lime can also be used as fillers

Lecture 23: Calculations for preparation of mixed fertilizers

1. How do you prepare one tonne of the fertilizer mixtures of the fertilizer grade **10: 6: 4** [N, P_2O_5, K_2O] by using the following fertilizers and the percent nutrient content against each.

   Required quantity of mixture is 1 tonne = 1000 kg

   a. Ammonium sulphate contains Nitrogen = 20.5 %

   b. Single Super Phosphate contains P_2O_5 = 16 %

   c. Muriate of potash contains K_2O = 60 %

The following are the quantities of individual fertilizers required for preparation of fertilizer grade of 10:6:4

$$\text{Quantity of fertilizer required} = \frac{\text{\% nutrient desired}}{\text{\% nutrient content of the fertilizer}} \times 1000$$

Thus to supply

$$\text{Nitrogen} = \frac{10}{20.5} \times 1000 = 487.80 \text{ kg Ammonium Sulphate}$$

$$\text{Phosphorus} = \frac{6}{16} \times 1000 = 375.00 \text{ kg Single super phosphate}$$

$$\text{Potassium} = \frac{4}{60} \times 1000 = 66.70 \text{ kg Muriate of potash}$$

Sum of the quantities of fertilizers = [487.80 + 375 + 66.70] = 929.50 kg

Required quantity of mixture is = 1000 kg

Balance added filler material = 1000 kg – 929.50 kg

= 70.5 kg

2. Calculate the quantities of different fertilizers required to prepare **one tonne** of the bulk blended fertilizers of the grade **6-4-3.** The fertilizers available and their nutrient contents are given below.

S.No.	Fertilizer	Nutrient content (%)
1.	Neem cake	5.0 %
2.	Urea	46.0%
3.	Basic slag	18.0 %
4.	TSP	45.0%
5.	Sulphate of potash	50%

The fertilizer mixed should also have the following specified ratios

a) Neem cake and urea 1:2

b) Basic slag and TSP 1:3

Total N required for the mixtures: 6 N

Proportion of neem cake: 6 x 1/3 = 2 parts in N fertilizer grade

Proportion of Urea : 6 x 2/3 = 4 parts in N fertilizer grade

Quantity of neem cake required = 2 x 1000/5 = 400 kg

Quantity of urea required = 4 x 1000/46 = 87 kg

Total P_2O_5 required for the mixture = 4 P_2O_5

So through basic slag: 4 x1 /4 = 1 parts in P fertilizer grade

Through TSP = 4 x 3 /4 = 3 parts in P fertilizer grade P_2O_5

Quantity of basic slag required: 1 x 1000/18 = 55.5 kg

Quantity of TSP required: 3 x1000/45 = 66.70 kg

Quantity of SOP required: 3 x 1000/50 = 60 kg

Sum of the quantities of N, P & K = [400 + 87 + 55.5 + 66.67+60] = 669.20

Filler material = [1000-669.20] = 330.80

Total quantity of fertilizer = Sum of the quantities of N, P & K + Filler material = 1000 kg

Lecture 24: Complex fertilizers – Different types – Calculation for nutritional values in fertilizers

Commercial complex fertilizers are those fertilizers which contain at least two or three of the primary essential nutrients. When it contains only two of the primary nutrients (N and P or P and K etc) it is designated as incomplete complex fertilizer. While those contain three nutrients are designated as complete complex fertilizers. They are produced by a process of chemical reaction. Most important complex fertilizers are Nitro phosphates & polyphosphate based fertilizers etc.

Characteristics of complex fertilizers

1. It has high content of plant nutrients more than 30 kg/100 kg of fertilizer, are called high analysis fertilizers.
2. They have uniform grain size and good physical condition so that they can be easily applied in fields
3. Nutrients are equally available to each plant
4. These type of fertilizers are nonhygroscopic, hence application is easy
5. They are cheaper compared to individual fertilizer on the basis of per Kg of nutrient.
6. Transport and distribution cost is reduced on the basis of per kg of nutrients
7. They supply N and P in available form in one application. Nitrogen is present as NO^{-3} and NH^{+4} forms and P as water soluble form upto 50 to 90% of total P_2O_5.
8. They are non-caking and non-hygroscopic, thus safe for storage

The value of complex fertilizers is dependent on the following considerations

a) The content of individual nutrients i.e ., N, P_2O_5, K_2O

b) Their ratio of N to P_2O_5 or K_2O

c) The form in which the individual nutrients are present

d) The resultant acid or basic residual effect

e) The contents of other trace elements

Classification of complex fertilizers:

The complex fertilizers being produced in India can be classified into

A) Incomplete complex fertilizes

B) Complete complex fertilizers

A) Incomplete complex fertilizes: Contain only two major nutrients such as N and P_2O_5 in chemical combination. They are of two types

I. **Ammonium phosphates:** May be present in the combination of mono or diammonium salt or mixture of two. Most of these formulations are in granular form

MAP (Mono Ammonium Phosphate)	11:46
DAP (Di Ammonium Phosphate)	18:46
APS (Ammonium Phosphate Sulphate)	16:20 and
UAP (Urea Ammonium Phosphate)	28:28:0

II. **Nitrophosphates** Ex. 20:20:0, 24:24:0

B) Complete complex fertilizers: Contains all the three major nutrients inchemical combination.

E.g. 14:28:14, 14:35:14, 20:10:10, 15:15:15, 17:17:17 and 19:19: 19

Lecture: 25   Fertilizer use efficiency

Fertilizer use efficiency: it is a measure of the increase in crop yield obtained per unit of fertilizer nutrient applied.

Or

It is expressed as units of yield increased per unit of fertilizer nutrient applied

Important measures/practices for efficient use of organic and chemical fertilizers:

In order to increase the use efficiency of fertilizers, the following measures and cultivation practices will help to achieve maximum agricultural production from each kilogram of nutrients application

1. Site specific and crop based fertilizer recommendations' should be followed.
2. High yielding varieties give higher yields even if chemical fertilizers are not applied: High yielding varieties give higher yields per unit fertilizer applied than indigenous varieties; hence high yielding varieties should be prefered.
3. Selection of fertilizers should be done according to the soil reaction *viz*., acidic fertilizer for alkaline soils and basic fertilizers for acidic soil reactions.
4. In order to get maximum produce from the unit of fertilizer timely sowing or transplanting should be done.
5. For efficient fertilizer use, it is important that there is a synchrony between crop demand and supply. In many field situations upto 50% applied nitrogen is lost because of the lack of synchrony between plant nitrogen demand and supply. Therefore plant need-based fertilizer application is crucial for achieving high yield and fertilizer use efficiency.
6. Spacing and plant density should vary depending on variety of the crop, soil fertility content and weather conditions. Eg: In Kharif paddy, plant spacing is 15 cm between rows to rows and 10 cm between plants (66 tillers per square meter) whereas in Rabi 10 cm X 10 cm (100 bushes per square meter) should be planted.
7. Addition of organic manures leads to mineralization process that in turn

improves the nutrient uptake and also provides all the nutrients in a balanced way to the crop that is being cultivated at any time in any season.

8. Adequate water (optimum irrigation) should be provided to the crop. If excess irrigation given to crop, the nitrogen and potassium will be leached down into the subsoil. Excess water in the field (water logging situations) causes significant loss of nitrogen in the form of gases. Therefore, when applying chemical fertilizers, care should be taken not to add too much of water at the time of application of fertilizers. This applies especially to urea. Urea should be applied under optimum soil moisture (field capacity) conditions only.

9. The crop yields are more in rabi than kharif with the application of phosphorus fertilizers, hence It is advisable to apply phosphorus fertilizer in rabi as per soil test results.

10. The soil-test based fertilizer recommendation is scientific approach; it indicates the availability of nutrients in the soil. Fertilizer schedule must be based on the soil test values to prevent the nutrient deficiency or luxury consumption.

11. Entire dose of phosphorus and potassium fertilizers are applied at the time of sowing or transplanting (as basal application), but in light textured soils, low content of available K, salt effected soils, high rainfall conditions and long duration crops potassium must be applied in two split basis. Whereas nitrogen fertilizers should be applied in 2-3 split applications depending on the crop requirements and soil moisture condition at different growth stages during the crop season.

12. Phosphorus fertilizers (Water soluble) should be placed 2-5 cm below the soil and 5-6 cm away from the seeds to ensure maximum availability to plants. Insoluble fertilizers should be thoroughly mixed in soil.

13. To prevent the nitrogen loss, one part of urea and 5-10 parts of soft moist soil are mixed properly and incubated for 20-25 hours and applied to the crop, by this method nitrogen use efficiency improved.

14. If soil conditions and weather conditions are not favorable, chemical fertilizers can be applied in the form of foliar application in combination with

pesticides if required.

15. Zinc deficiency is found in many places. Zinc sulphate at the rate of 10 to 50 kg ha^{-1}should be applied at the last ploughing before sowing or transplanting. If deficiency symptoms are seen on standing crops, foliar spray of zinc sulphate @ 2g/l water, 2-3 times in a week should be adopted.
16. Problematic soils must be ameliorated by taking appropriate reclamation methods, in acidic soils lime should be applied and for basic or alkaline soils gypsum should be applied.
17. Remove weeds within 10-15 days of sowing / transplanting, after that first top dressing of fertilizers should be done.
18. Should not apply nitrogen fertilizers in excess dosage, all nutrients can be applied in balanced manner only.
19. Zinc fertilizers should not be mixed with phosphorus fertilizers.
20. Farmers are focusing mostly on the major nutrients like nitrogen, phosphorus and potash fertilizers but they should also focus on micronutrients.

Slow release nitrogen fertilizers:

Nitrogen fertilizers are more soluble in water (especially nitrate form) and are leached down to soil bottom layers and become unavailable to plants, in some cases these fertilizers are converted to gaseous form (volatilization) and lost into the atmosphere.

Measures to reduce the nitrogen losses

To reduce the losses of nitrogen some fertilizers have been developed that are sparingly soluble in water and thus, slowly release nitrogen to the soil solution. They are termed as “Slow release nitrogen fertilizers or slowly available nitrogen fertilizers or controlled release nitrogen fertilizers”. As mentioned above, these fertilizers are characterized by low solubility in water and they maybe of two types

a) Coated urea b) Uncoated urea

Coated urea: Sulphur coated urea (SCU) is an example of this type. Urea is coated with elemental sulphur. As long as urea remains coated with sulphur without its rupture SCU does not dissolve. When added to soils, the sulphur coating ruptures by microbial action. Soil water slowly penetrates into the coated urea slowly and dissolves it. Other materials such as wax, paraffin, acrylic resin, neem, lac etc are sometimes used as coating materials to prepare coated urea fertilizers.

Uncoated urea: most of these are urea-aldehyde condensation products; their solubility in water is very low.

eg: Crotonylidin diurea (CDU)

Isobutylidene diurea (IBDU)

Urea Super Granules: By applying the large sized urea granules of 1-3 g, losses of nitrogen can be reduced

Nitrification Inhibitors: Nitrogen loss is higher from nitrates (NO_3^-) than from ammonia (NH_4^+), hence if nitrate formation (i.e. Nitrification) is inhibited then nitrogen loss will occur from only ammonium (NH_4^+) but not from nitrates (NO_3^-). Consequently nitrogen loss will be reduced; another way to reduce nitrogen loss is inhibiting nitrification.

Nitrification inhibitors are synthetic chemicals or a non-synthetic substance that temporarily inhibits **nitrite (NO_2^-) formation** from ammonium (NH_4^+) or nitrate (NO_3^-) formation from nitrite (NO_2^-). Most of the inhibitors inhibit activity of Nitrosomonas bacteria that oxidizes ammonium to nitrite. some inhibitors inhibit activity of nitrobactor bacteria that oxidizes nitrite to nitrate.

eg: N-Serves, Dicyandiamide (DCD), 2-amino-4-chloro-6-methyl pyrimidine (AM)

neem cake, mahua cake, karanji cake etc.

Urease inhibitors: For hydrolysis of urea, should come in contact with water and urease enzyme should be activated. if the contact is reduced or the enzyme activity is inhibited the rate of urea hydrolysis reduces that slow down ammonium (NH_4^+) formation. Hence, nitrate formation too occurs slowly. Consequently, nitrogen loss by ammonia volatilization and leaching or denitification of nitrate reduces. One way to reduce nitrogen loss is decreasing solubility of urea.

Ex. Hydroxamic acid, Thiourea, Methyl urea etc.

Factors affecting efficient utilization of applied fertilizers

a. **Soil properties**

- Nutrient supplying capacity of the soils.
- Forms of nutrients in the soil and their availability
- Soil texture- on application of fertilizers in light textured soils nitrate leaches down in to lower layers and becomes unavailable.
- In heavy textured soils phosphorus becomes unavailable due to fixation.
- Soil aeration and moisture content- Under ill drained conditions, due to lack of oxygen nutrients become unavailable to plants
- Organic manures should be applied 20-30 days prior to sowing of crops to prevent immobilization.
- Surface application of fertilizers leads losses due to voltalisation
- Bulk density also affects nutrient availability
- Method of fertilizer application also decides the nutrient availability

b. **Crop factors**

- Depending on the type of root system and depth of root penetration the nutrient requirement varies
- Appropriate crop rotations like cereals followed by pulses will help in reducing the nitrogen application.
- Crops with mycorhizal associations also require lesser quantities of nutrient application
- Depending the stage and type of crop the requirement of nutrient varies

c. **Fertilizer properties-management**

- For rainfed and irrigated crops nitrate is the preferred form while ammonia fertilizers are preferred in wetlands.
- SSP should be applied in neutral and alkaline soils and rock phosphate should be preferred in acid soils
- MOP can be applied to all crops except for tobacco and potato. SOP should be applied to these crops

- Micronutrients should preferably be applied in their sulphate forms
- Split of application of nitrogen should be preferred.
- In light textured soils potash should be applied in two splits
- Under drought or moisture conditions foliar application of nitrogen should be adopted
- Slow release fertilizers should be preferred for increased use efficiency.

Lecture 26: Fertilizer applications – Time of fertilizer application

Chemical fertilizers dissolve easily and provide nutrients to plants in quick manner, but the risks of rapid dissolution are also very high (leaching, vaporization etc), so the following points should be kept in mind while applying the chemical fertilizers.

1. Weather conditions in the area eg: season of the crop whether kharif or rabi
2. Soil properties (soil composition, light soils, heavy soils, problematic soils etc.)
3. Fertilizer properties: Solid, liquid, pellets - crushing, moisture absorption, freezing etc.
4. Crop nutrient requirements
5. Crop key phases (for Nutrients) - Key Phase – Importance
6. whether the crop is under irrigated or rainfed conditions

The time of fertilization: The following factors should be taken into consideration to determine the time of application of fertilizers

a) How the plant absorbs nutrients at different crop stages

b) Properties of the soil

c) Properties of fertilizer

d) Carbohydrate exchange in plants

- Generally macro nutrients like nitrogen, phosphorus and potash are taken during the crop growth stages.
- Phosphorus requirement is high in the early stages of crop growth and phosphorus fertilizers are not soluble in water quickly and also phosphorus displacement or movement in soil is very low so phosphorus can be applied either in the last ploughing or at the time of sowing/transplanting.
- The requirement of nitrogen to crop is low at the initial stages, peak or highest at flowering or reproductive stage and again low at harvesting stage of the crop.
- Nitrogen required for the production or synthesis of carbohydrates, fats and

proteins should be determined the doses and applied in split manner.

- The role of potassium in plant growth and food production is significant, the potassium fertilizers can be applied as basal dose only, if the soils are light textured or low content of potassium in soils then it can be applied in split application.
- Potash can be significantly affect the grain productions in grain crops like paddy and maize
- For pulse crops the nitrogen requirement is less as compared to other cereal crops, nitrogen should be apply before formation of root nodules, after formation of root nodules the requirement is less.

Lecture 27: Methods Fertilizer applications – Application of solid fertilizers-Broad casting

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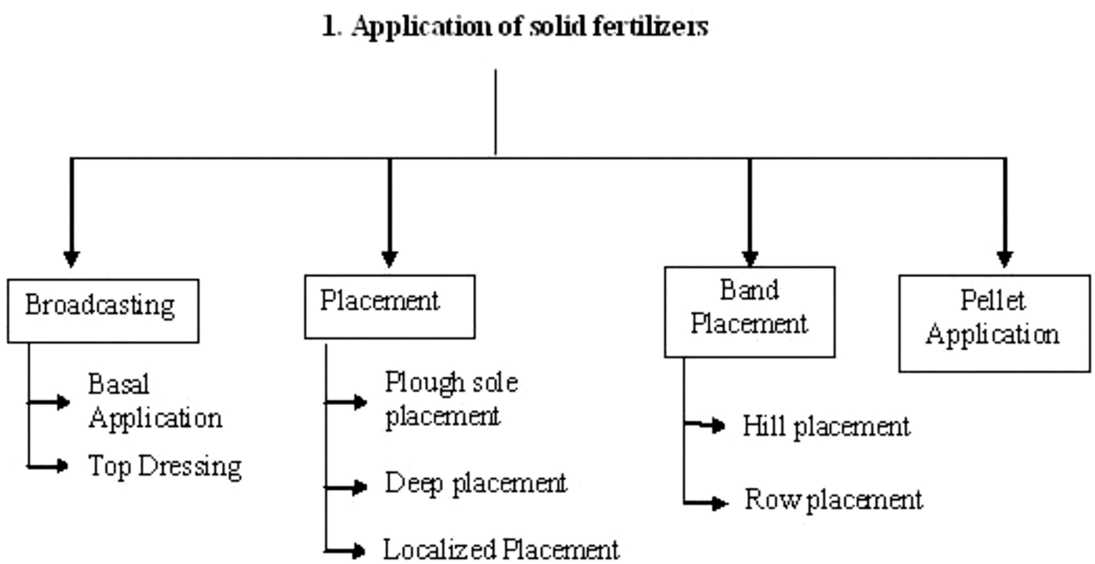
Methods of fertilizer application:

Fertilizers are applied in different ways taking into consideration of type of soils (light textured or heavy textured) and nature of the plant (depth of roots) to ensure timely and regular application of the fertilizers to the plant so that the fertilizer is not wasted and use efficiency can be improved.

The different methods of fertilizer application are as follows:



1. Broadcasting

- It refers to spreading fertilizers uniformly all over the field.
- Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are broadcasted.
- This method/ practice is followed especially in closely planted crops

Broadcasting of fertilizers is of two types.

a) Broadcasting at Sowing or Planting (Basal Application)

The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

b) Top Dressing

It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

Disadvantages of Broadcasting:

The main disadvantages of application of fertilizers through broadcasting are:

- Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
- The weed growth is stimulated all over the field.
- Nutrients are fixed in the soil as they come in contact with a large mass of soil.
- Some of the nutrients like P & K are largely fixed in high fixing soils, because of the increased contact with soil hence a little of them is absorbed by plants.
- it is inefficient to enhance plant uptake of nutrients.
- Losses due to voltalisation are more when broadcasted on dry soil
- Scorching of foliage may occur when leaves moist at the time brosting of fertilizers like urea.

Lecture 28: Methods Fertilizer applications – Placement of fertilizers-Localised placement-Application of liquid fertilizers

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Placement

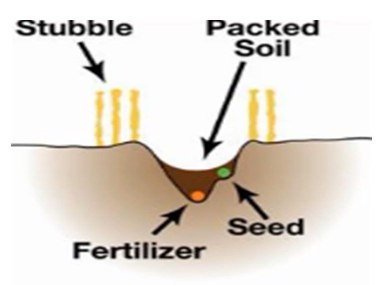
- It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.
- Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soils have a low level of fertility and to apply phosphatic and potassium fertilizers.
- The most common methods of placement are as follows:

i) Plough sole placement

- In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing.
- Every band is covered as the next furrow is turned.
- This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.

ii) Deep Placement

It is the placement of ammoniacal nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.



iii) Localized placement

It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods are

a. Drilling : In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts place fertilizers close to the seed or plant are as follows:

b) Side dressing

It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are like placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

c) Band placement: If refers to the placement of fertilizer in bands. Band placement is of two types.

i) Hill placement

It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

iii) Row placement

When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

d) Pellet application

1. It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop.
2. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

Advantages of placement of fertilizers

The main advantages are as follows:

- ✓ When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced.
- ✓ The weeds all over the field cannot make use of the fertilizers.
- ✓ Residual response of fertilizers is usually higher.
- ✓ Utilization of fertilizers by the plants is higher.
- ✓ Loss of nitrogen by leaching is reduced.
- ✓ Being immobile, phosphates are better utilized when placed.

Foliar Application

1. It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.
2. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.

3. The concentration of the spray solution has to be controlled; otherwise serious damage may result due to scorching of the leaves.

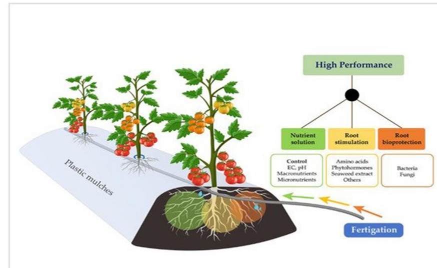
4. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

Application through irrigation water (Fertigation)

1. It refers to the application of water soluble fertilizers through irrigation water.

2. The nutrients are thus carried into the soil in solution.

3. Generally nitrogenous fertilizers are applied through irrigation water.



Lecture 29: Integrated nutrient Management (INM) – Concept- Factors affecting INM – Goals and Components

Integrated Nutrient Management (INM)

Organic farming methods were adopted by our forefathers to maintain soil health and to achieve quality yields. Development of high yielding varieties coupled with the introduction of use of chemical fertilizers helped in meeting the increasing food demand of the growing population of the country. However, indiscriminate of fertilizers coupled with no adoption of use of organics by the farmers due to decreased cattle population and unavailability cattle manure, the soil and environment are getting polluted.

In view of these circumstances and to protect the soil fertility, the researchers and experienced innovative farmers together have introduced a new method of plant nutrition called "Integrated Nutrient Management"

Definition of INM: 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.

Concepts of INM: The main purpose of Integrated nutrient management (INM) is to apply the various nutrients required by the plants through the right amounts of organic and inorganic sources, to achieve higher yields while protecting the environment.

- Regulated nutrient supply for optimum crop growth and higher productivity.
- Improvement and maintenance of soil fertility.
- Zero adverse impact on agro – ecosystem quality by balanced fertilization of organic manures, inorganic fertilizers and bio- inoculants

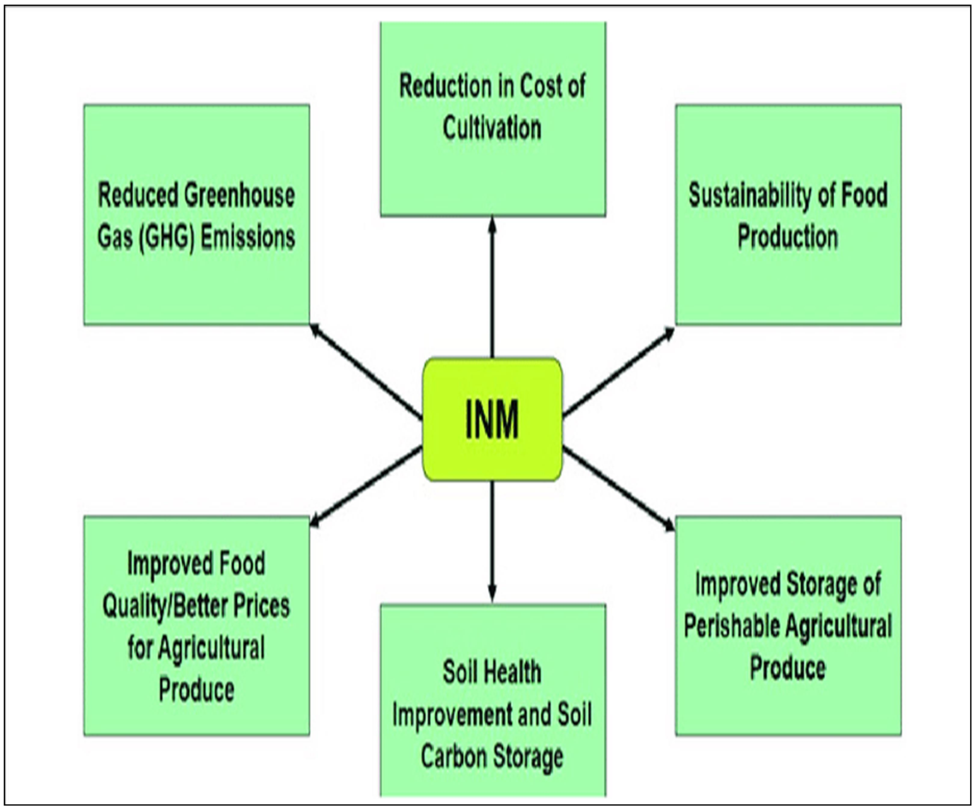
Factors to be considered in integrated nutrient management:

- Nutrient status of the soil
- Nutrients added to organic sources

- ➢ Nutrients added to chemical sources
- ➢ Nutrient loses from the soil and
- ➢ Nutrient requirement of the particular crop

Goals of INM:

- Increasing soil productivity
- Visualizing agriculture as profitable in favorable and adverse climatic conditions also



- Reducing the usage of chemical fertilizers and also other input costs (particularly in chemical fertilizers)
- Efficient utilization of locally available organic manures, green manure and biofertilizers
- Contributing to environmental protection.
- Improving the economic status of farmers without harming natural resources.

Components of INM:

1) Organic manures

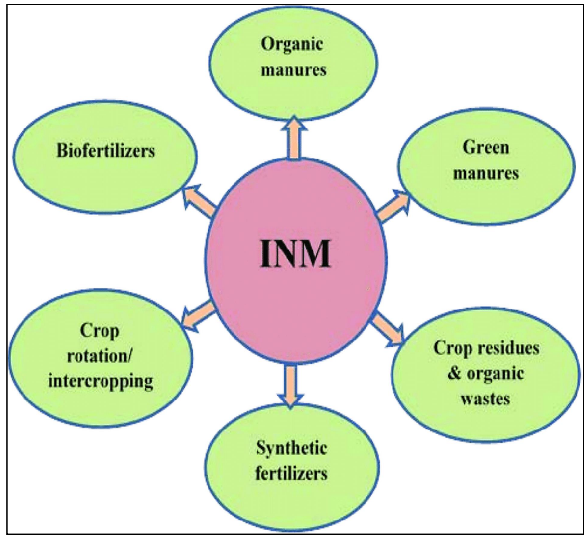
2) Crop residues

3) Biofertilizers

4) Chemical Fertilizers

5) Green manures

6) Crop rotation/intercroppping



Organic manures: all the possible organic manures mostly farm yard manure (FYM), compost and other concentrated organic manures (animal originated concentrated organic manures like blood meal, bone meal, horn meal etc.) may be used

Green manures like Diancha, Pillipesara and green leaf manures like Gliricidia, Sesbania, Pongamia are good sources. Inclusion of legumes in crop rotations or crop sequences is also a good INM practice.

Crop residues: After harvesting of the crop the left over crop residues like stalks and stubble, sugarcane trash ext, mostly low C:N ratio residues may be used.

Bio fertilizers: Nitrogen fixing bio fertilizers like Rhizobium, Azotobacter, Azospirillum and Clostridium, Phosphorus solubilizing bacteria like Pseudomonas, Bacillus species and fungi are Asperzillus, pencilium etc.

Chemical Fertilizers: chemical fertilizers to supply nitrogen, phosphorus, potassium and other secondary and micronutrient etc.

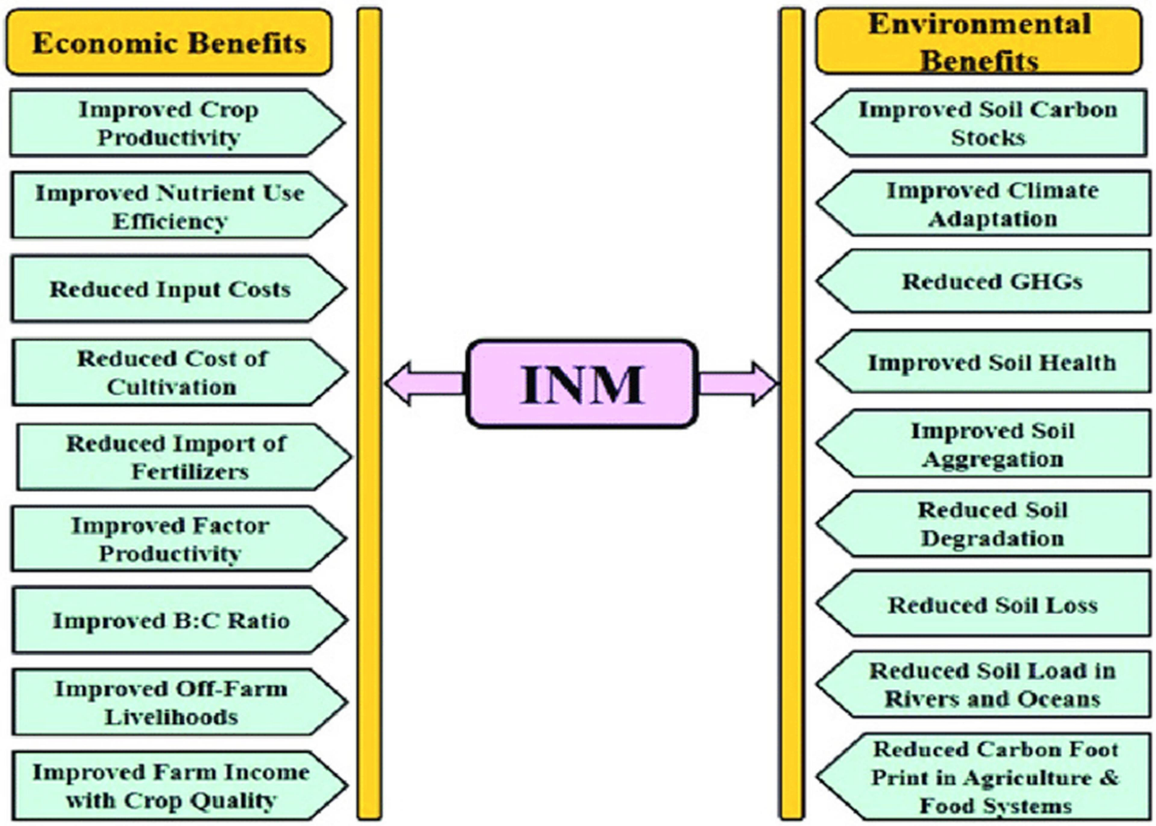
Lecture 30: Integrated nutrient Management (INM) – Advantages and Constraints

Advantages of Integrated Nutrient Management:

The combined application of organic manures and chemical fertilizers generally produces higher crop yields than when each is applied alone. This increase in crop productivity may be due to the combined effect of nutrient supply, synergism and improvement in soil physical and biological properties. It nurtures the soil rather than just a particulars crop. So the advantages of INM can be visualized through

- Increased soil fertility and productivity
- Improved soil physical, chemical and biological properties
- Enhanced infiltration rate and water holding capacity and improvesd soil drainage facility
- Increased mineralization of nutrients and ion exchange capacity
- Increased buffering capacity of the soil
- Increased fertilizer use efficiency
- Reduced investment in chemical fertilizers up to 30 per cent
- Reduced soil and ground water pollution.

Some of the economic and environmental benefits through INM practices



Constraints in INM:

- Availability of organic manures like FYM / Compost in sufficient quantity is less due to decrease in the cattle population with farming community
- Application of bulky organic manures involves high labour and transport cost thus involving high expenditure.
- Availability of green manure seeds in time.
- Growing green manure crop for in situ application involves both time and money apart from the loss of cropping season. In addition it requires optimum moisture at the time of incorporation.
- The bio-fertilizers may not be available in time.
- Lack of knowledge among the farming community regarding the benefits / usage of bio-fertilizers

- Farmers are not having proper understanding of importance of balanced nutrition and sound knowledge on fertilizer use efficiency.
- Lack of soil test base fertilizer applications
- Increasing cost of the chemical fertilizers
- Scarcity of ground water resources
- Problematic soils

Lecture 31: Organic farming – Definition – Methods of cultivation – Merits and demerits

Agriculture was the profession for our ancestors and livestock was reared as integral part. The manure generated from these cattle was used in their fields to increase the soil fertility and produce quality crops.

We have achieved the green revolution due to the development of high yielding varieties and the use of chemical fertilizers; but on other side indiscriminate use of chemical fertilizers and pesticides lead to development of new health problems to mankind which pose a threat to human survival. To avert this menace and help human survival scientists, farmers and governments are once again welcoming our pre-traditional agriculture. For a healthier life - Healthy Food, Healthy Crop – Healthy soil is needed. Realisation of this fact is the beginning of organic farming.

Definition of organic farming by FAO : "Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem's health, including biodiversity, biological cycles, and soil biological activity."

'it is based on minimal use of off-farm inputs and rely on management practices that restore, maintain and enhance ecological harmony".

Organic Farming - Practices to be adopted:

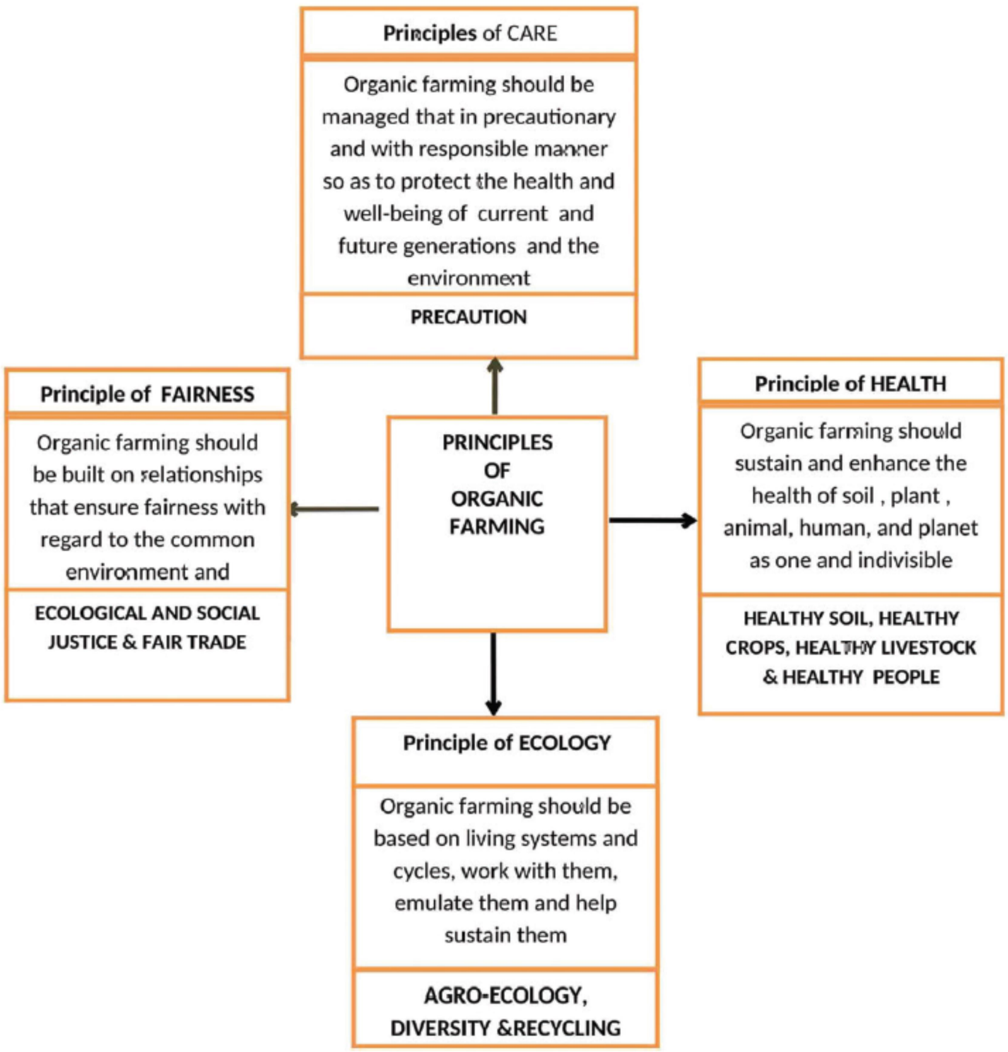
1. Plough the soil only to the extent required - reduce soil erosion.
2. Agriculture means Crop and livestock – keeping this in mind, priority should be given to dairy farming along with the crop production.
3. All plant and animal wastes should be converted into organic manures.
4. Timely inter-cultivation should be done to remove weeds and ensure adequate supply of nutrients to the crop.
5. Awareness should be created on the importance of bio-fertilizers.
6. The government should also increase the production of bio-fertilizers and provide them to the farmers.

7. Appropriate farming practices should be adopted to utilize water resources efficiently and conserve soil moisture

8. Bio-pesticides should be used for plant protection.

8. Plant protection should be given priority to biological control methods.

9. Utilize natural resources without reducing crop yields and deteriorating quality



Benefits of Organic Farming

1. The soil is perfectly healthy.
2. Increases "humus" reserves in the soil and provides all the nutrients to the crops.
3. Soil Physical, chemical and biological properties will be improved

4. Increases water and nutrient retention properties of soil.
5. Water storage capacity and soil drainage facilities will be improved
6. Soil pollution will be reduced and quality will be increased
7. Contributes to the prevention of groundwater pollution.
8. Increases buffering capacity of the soil
9. Reduces pest & disease infestation
10. Helps in the development of earthworms in soil
11. Contributes to ecological balance
12. Provides quality safe food. .
13. Quality and storage quality will be increase.
14. It is the source of sustainable agriculture, farmer mental development and national progress.

Barriers in organic farming:

1. It may be difficult to collect the required organic matter for the entire cultivable land.
2. Due to the change in the lifestyle of the farmers, they are not willing to produce organic matter.
3. Impact of Organic manures on plant growth is slow as compared to chemical fertilizers so farmers are turning to chemical fertilizers only.
4. Tenant farmers do not pay attention to organic sources fertilizers
5. High yielding varieties and hybrids may not produce the expected results through the use of organic fertilizers
6. Though quality is increased with organics, yields can be increased by the use chemical fertilizers.
7. Collection of organic manures in dryland areas is quite difficult so makes organic farming difficult and not remunerative to farmers

Lecture 32: Awareness on Fertilizer Control Order (FCO)

Objectives: Laws and regulations governing the manufacture and sale of fertilizers are imperative in order to check

1. Spurious standards and adulterated fertilizers entering in to the market.
2. To ensure quantity of nutrients and quality of carriers present in the fertilizer
3. To ensure quantity of nutrients and quality of carriers present in the fertilizer
4. To eliminate black marketers off the market
5. The total N ,P_2O_5 and K_2O must be guaranteed in terms of percentage of each

   of these nutrients in a given fertilizer.

By considering the above said objectives, the government of India passed The **FERTILIZER CONTROL ORDER [FCO] on 28th of April, 1957** in exercise of the power conferred by the section **III of the essential commodities act of 1955**. This order is intended to regulate the manufacture, distribution and supply of the fertilizers in India at a control cost. This has been effective from May 18th 1957. It is **revised in 1985 with effect from 25-9-1985.** The Government of India has delegated to powers to state Governments to implement the order The Government of India (G O I) also passed the Fertilizer Movement Order (FMO) on 31st December, 1960 in order to regulate the interstate movement of fertilizers and the export of fertilizers which came into force with effect from 1-1-1961

FERTILIZER CONTROL ORDER [FCO] REGULATIONS:

1. All the fertilizer manufacturers should obtain license from the Commissioner of Agriculture, state Government concerned for the manufacture of fertilizer and mixed fertilizers
2. The fertilizer dealers should on renewable basis, register their dealership with the Assistant Director of the Agriculture (ADA) Regular of the division concerned in a state.
3. The terms and conditions of manufacture, distribution and sales imposed by the government should be followed

4. Duties of inspecting officers and the dealers are specified
5. Fertilizer specifications and kind of package are stated
6. Method of drawing fertilizer samples for analysis in the fertilizer testing laboratories is stated
7. Powers are vested with the FCO enforcing officials to book the cases against the fraudulent manufacturers, distributors and dealers of fertilizers.

Specifications and standards for important fertilizers [As per FCO, 1957]

1. Urea Moisture per cent by weight - Maximum1.0

Total nitrogen per cent by weight –minimum 44.0

Biuret per cent by weight -maximum1.50

Particle size: In the form of granule the material shall pass through 2.8mm and not less than 80% by weight shall be retained on 1mm

2. SSP: Moisture per cent by weight, maximum 12

Free phosphates as (P_2O_5) percent by weight 4.0

Water soluble phosphates (as P_2O_5) by weight maximum 16.0

3. MOP Moisture per cent by weight -maximum 12.00

Water soluble potassium per cent by weight- minimum 60

4. DAP Moisture per cent by weight 1.0

Total nitrogen per cent by weight minimum 18

Total phosphates (as P_2O_5) per cent by weight minimum 46.0

Water soluble phosphates (as P_2O_5) per cent by weight 41.6