Manures, Fertilizers and Biofertilizers

Manures

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition.

Organic manures have been the traditional means of maintaining soil fertility. Most organic manures contain many essential nutrients and therefore provide a “balanced” source of nutrients for crops.

The main effects of organic manures are:

- Improvement of physical soil properties
  - ✓ Improvement of soil structure
  - ✓ Improvement of water holding capacity
  - ✓ Improvement in soil serration
  - ✓ Buffering of soil surface temperature
  - ✓ Reduction in soil losses due to erosion
- Improvement in chemical properties
  - ✓ Supply of essential nutrients in balanced ratio
  - ✓ Supply of nutrients
  - ✓ Slow release of nutrients
- Improvement of biological properties
  - ✓ Stimulation of soil flora and fauna

Manures are grouped into Bulky Organic Manures and Concentrated Organic Manures.

Bulky Organic Manures

Bulky organic manure contains small percentage of nutrients and they are applied in large quantities. Examples FYM, Farm Compost, Town Compost, Night Soil, Sludge, Green Manures and other bulky sources of organic matter.

I. Farm Yard Manure (FYM)

Farm Yard Manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle.

Methods of FYM Preparation

i) Pit Method- Commercially adopted by majority of farmers.
ii) Trench Method (Dr. C.N. Acharya method)- FYM prepared by this method generally contain more nutrient than the average nutrient composition
iii) Heap Method- commonly used method by farmers but there is significant loss of nutrients during preparation period in this method.

Response of crops to FYM application

- **Crops which show profitable response**- Vegetable crops, especially Potato, Tomato, Sweet Potato, melons, Radish, Carrot, Cauliflower, Turnip, onion, garlic etc. Rice, Maize, Jute. Fruit crops like orange, banana, apple, guava, mango etc.
- **Crops less responsive**- Cereals like Sorghum, Pearl millet, wheat, barley, oat, oilseed crops like groundnut, linseed, sesamum, castor, coconut, cotton etc.

Rate and Time of Application

- In general, FYM is applied at the rate of 20-25 tonnes/ha for most of the crops but it may go high for vegetables, sugarcane etc.
- FYM should be applied 15-20 before sowing or transplanting and mixed properly by cultivator or country plough.

II. Compost

Compost is manure obtained by decomposition of farm waste or town waste in absence of cow dung or urine which has almost comparable qualities to that of FYM.

Hutchinson and Richard (**1921**) were first scientists who prepared compost from straw at Rothamsted Experimental Station, **England** where disposal of straw became a serious problem.

The compost prepared made from farm waste like sugarcane trash, paddy straw, weed and other plants and other waste is called **Farm compost** while the compost made from town refuses like night soil, street sweepings and dustbin refuse is called **town compost**.

Ordinary compost can be enriched with Nitrogen (N) and Phosphorus (P) through Azotobacter and Superphosphates respectively. When

superphosphates is used during composting, it is called **Supercompost** and compost prepared by using N-fixing bacteria is called **Azo compost**.

Methods of Compost Formation

1. Adco method (suggested by Hutchison and Richards)
2. Activated Composting Method (invented by Fowler and Redge in 1922 at Indian Institute of Science Bangalore)
3. Indore Method
4. Bangalore Method (method was evolved by C.N. Acharya at Indian Institute of Science, Bangalore for composting in Urban areas)
5. Maya Das Method (method was evolved by Dr. Maya Das, Director of Agriculture, UP)

III. Night Soil

Night soil is human excreta, both solid and liquid. It is richer in nutrient composition than farmyard manure and compost.

In India, it is applied to a limited extent directly to the soil in trenches. In these pits, night-soil is deposited and covered with a layer of earth, ash, charcoal and sawdust which dehydrate the night soil and produces a Poudrette. This is known as the "**Poudrette System**".

IV. Sewage and Sludge

In the modern system of sanitation adopted in cities, water is used for the removal of human excreta and other wastes. This is called the sewage system of sanitation.

In general, sewage system has two components, namely, i) Solid portion, known as **Sludge** ii) Liquid portion commonly known as **Sewage-water**.

Sludges are, in general, rich in nitrogen and phosphorus, while they are low in potash. The principal value of sludges as a manure lies in their slowly available nitrogen and phosphorus.

Activated Sludge produced by a **rapid aerobic treatment of sewage** that results in coagulation and settling of suspended materials is used with safety for manuring.

V. Vermicompost

Compost that is prepared with the help of earthworms is called **Vermicompost**. Earthworms consume large quantities of organic matter and excrete soil as **casts**.

Vermiculture- It is the cultivation of earthworms, especially in order to use them to convert organic waste into fertilizer. Most commonly reared earthworm species in India are ***Erudilus evgeniae*** **and** ***Eisenia foetida***)

Average Nutrient Composition of Bulky Organic Manures

Bulky Organic Manures	Nitrogen (N) (%)	P_2O_5 (%)	K_2O (%)
Farm Yard Manure (FYM)	0.5	0.2	0.5
Farm Compost	0.5	0.15	0.5
Town Compost	1.4	1.0	1.4
Night Soil	5.5	4.0	2.0
Poudrette	1.32	2.8	4.1
Sludge	1.5-3.5	0.78-4.0	0.3-0.6
Activated Sludge	3-6	2	1
Sheep and Goat Manure	3	1	2
Poultry Manure	3.03	2.63	1.4
Vermicompost	3	1	1.5

- **Hot and Cold Manure**- The manure obtained from the excreta of horses and sheep is called Hot Manure in temperate countries, whereas Pig and Cattle manure is called Cold Manure due to comparatively less vigorous decomposition and less rise in temperature of manure.
- **Short and Long Manure**- Decomposed manure that has lost the structure of the original materials is called short manure while there

fresh manure having pieces of straw and other materials is called long manure.

- **Fire Fanging**- There is profuse fungal growth on the surface of moist manure, giving it an ashy grey appearance. It is called Fire Fanging.

VI. Green Manuring

Green manuring can be defined as the practice of ploughing or turning into the soil undecomposed green plant tissues for the purpose of improving physical structure of soil and soil fertility.

Types of Green Manuring

Broadly speaking green manuring is of two types-

- Green Manuring in situ- In this system, green manure crops are grown and buried in the same field which is to be green-manured. Most common green manure crops grown under this system are sunnhemp (Crotalaria juncea), Dhaincha (Sesbania aculeate), pillipesara, cowpea, Black gram, Clover and Guar.
  Under this turning of green plants is done at their highest foliage stage in soil

- Green-leaf manuring- It refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, wastelands and nearby forest areas. The trees and shrubs used are Glyricidia, Sesbania speciosa, Karanj, etc.

Sesbania rostrata is a stem nodulating green manure crop which is native of West Africa.

Green manuring in situ is common in Northern India while Green-leaf manuring is common in Eastern and Central India.

Sowing of Green Manure Crop

- ✓ Green manure crops are sown much before or at least 35-40 days before onset of monsoon. So that sufficient water should be available at the time of decomposition.
- ✓ Usually One and half times of normal seed rate is used in case of raising green manuring crop. Seed Rate of some green manure crops:

Green Manure Crops	Seed Rate (Kg/ha)
Sunnhemp	**40**
Dhaincha	**30**
Guar	**20**
Cowpea	**50**
Green gram/Black gram	**20-25**

Advantages of Green Manuring

1. It adds organic matter in the soil, which stimulates the activity of soil micro-organisms
2. It improves the structure of the soil
3. It facilitates the penetration of rain water, thus decreasing run-off and erosion
4. When leguminous plants, like sunnhemp and dhaincha are used as green manure crops, they add nitrogen to the soil for the succeeding crops
5. It increases the availability of certain plant nutrients, like phosphorus, calcium, potassium, magnesium and iron.
6. Green manuring helps in reclamation of alkaline soils.
7. Root-knot nematodes can be controlled by green manuring.

List of common Leguminous green-manuring crops

Green Manuring crop	Growing season	Avg. yield of green matter(q/ha)	Nitrogen (% on green weight basis)	Nitrogen added (kg hectare)
Sunnhemp	**Kharif**	**152**	**0.43**	**84.0**
Dhaincha	**kharif**	**144**	**0.42**	**77.1**
Pillipesara	**kharif**	**132**	**1.10**	**55.6**
Green gram	**Kharif/zaid**	**57**	**0.53**	**38.6**

Cowpea	**kharif**	**108**	**0.5**	**56.3**
Guar	**kharif**	**144**	**0.34**	**62.3**
Senji	**Rabi**	**206**	**0.51**	**134.4**
Khesri (Lathyrus)	**Rabi**	**88**	**0.54**	**61.5**
Berseem	**Rabi**	**111**	**0.43**	**60.7**

Important Green Manure crops

i) **Sunnhemp**- It is the most outstanding green manure crop. It is extensively used with sugarcane, potato, garden crops etc.
ii) **Dhaincha**- It occupies the second most import green manure crop after sunnhemp.
iii) **Guar**- It flourishes well in areas of low rainfall and poor fertility. It is the most common green manure crop in Punjab and Rajasthan.

Regions not suitable for Green manuring

- The use of green manures in dry farming res in arid and semi-arid regions receiving less than 62.5 cm of rainfall is, as a rule is impracticable.
- On very fertile soils in good physical conditions, it is not advisable to use green manures as part of regular rotations.
- In areas where rabi crops are raised on conserved soil moisture due to lack of irrigation facilities, it is not practicable to adopt green manuring.

Concentrated Organic Manure

Concentrated organic manures are those that are organic in nature and contain higher percentage of major plant nutrients like N, P, K, compared to bulky organic manures.

Important Concentrate Organic manures are:

I. Oilcakes

After oil is extracted from Oilseeds, the remaining solid portion is dried as cake which can be used as manure. The oilcakes are of two types:

- Edible Oilcakes- suitable for feeding livestocks e.g. groundnut cake, coconut cake etc.
- Non-edible Oilcakes- not suitable for feeding livestocks e.g. castor cake, neem cake, mahua cake etc.

Both edible and non-edible oilcakes can be used as manures. However, edible oilcakes are fed to cattle and non-edible oilcakes are used as manures especially for Horticultural crops and long duration crops like sugarcane and tapioca.

Oilcakes are the quick acting organic manures. Though insoluble in water, their nitrogen becomes quickly available to plants in about 7 to 10 days after application.

Oilcakes are well powdered before application for even distribution and quicker decomposition.

Average nutrient contents of Oilcakes

Non-Edible Oilcakes			
Oilcakes	**Nutrient Content (%)**		
	Nitrogen (N)	**P_2O_5**	**K_2O**
Castor Cake	**4.3**	**1.8**	**1.3**
Cotton seed cake undecorticated	**3.9**	**1.8**	**1.6**
Karanj or Honge cake	**3.9**	**0.9**	**1.2**
Mahua or ippi cake	**2.5**	**0.8**	**1.8**
Neem cake	**5.2**	**1.0**	**1.4**
Safflower cake, undecorticated	**4.9**	**1.4**	**1.2**
Undi or Punna cake	**3.6**	**1.5**	**2.0**

Edible Oilcakes			
Oilcakes	Nutrient Content (%)		
	Nitrogen (N)	P_2O_5	K_2O
Coconut cake	3.0	1.9	1.8
Cotton seed cake decorticated	6.4	2.9	2.2
Groundnut cake	7.3	1.5	1.3
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rapeseed cake	5.2	1.8	1.2
Safflower cake decorticated	7.9	2.2	1.9
Sunflower cake decorticated	7.9		
Sesame or Til cake	6.2	2.0	1.2

II. Other Concentrated Organic Manures

Concentrated Manure	Nutrient Content (%)		
	Nitrogen (N)	P_2O_5	K_2O
Blood Meal	10-12	1-2	1.0
Meat Meal	10.5	2.5	0.5
Fish Meal	4-10	3-9	0.3-1.5
Horn and Hoof Meal	10-15 (avg. 13)	1.0	-
Bone Meal	3-4	20	-
Bone Meal (steamed)	1-2	22	-
Bird Guano	7-8	11-14	2-3

Fertilizers

Fertilizers are materials either natural or manufactured, containing nutrients essential for normal growth and developments of plants.

Or

Fertilizers are industrially manufactured chemicals containing plant nutrients.

Or

Fertilizers are materials having definite chemical composition with a higher analytical value and capable of supplying plant nutrients in available forms.

History of Fertilizers in India

- In India the use of artificial fertilizers was first initiated in 1896 when imported Chilean nitrate was used as a fertilizer.
- The manufacture of Ammonium sulphate in India was started at Bellegola in Mysore in 1938 on a small scale.
- In 1951 Govt. of India set up Fertilizer factory at Sindri, Jharkhand.

Status of Fertilizers in India

- In India the most widely used fertilizer in the Nitrogenous category is Urea, DAP (Diammonium phosphate) and MOP for Phosphorus and Potassium respectively.
- India is the 3rd largest producer and consumer of fertilizers.
- The actual production of all the Fertilizers during the year 2016-17 was 414.41 LMT. The estimated production of all the Fertilizers during the year 2017-18 is expected to be 462.20 LMT.
- India Produce 80% of its urea requirement in country while from rest 20% maximum urea is imported from Oman.
- India mainly import DAP from China and MoP (Muriate of Potash) from Canada.
- Government is making available fertilizers, namely Urea and 21 grades of P&K fertilizers to farmers at subsidized prices through fertilizer manufacturers/importers. The subsidy on P&K fertilizers is being governed by Nutrient Based Subsidy (NBS) Scheme w.e.f 01.04.2010.

Classification of Fertilizers

Classification of fertilizers on the basis of nutrient composition

- **Complete Fertilizers**- Complete fertilizer is referred to a fertilizer material which contains all three major nutrients, N, P and K.
- **Incomplete Fertilizers**- This fertilizer is referred to a fertilizer material which lacks any one of three major nutrient elements (N, P, and K).
- **Straight fertilizers**: Straight fertilizers are those which supply only one primary plant nutrient, namely nitrogen or phosphorus or potassium. E.g. Urea, ammonium sulphate, potassium chloride and potassium sulphate.
- **Binary fertilizers**: Fertilizers which contains two major nutrients e.g. KNO_3.
- **Ternary fertilizers**: Fertilizers which contains three major nutrients e.g. Ammonium potassium phosphate.
- **Complex fertilizers**: Complex fertilizers contain two or three primary plant nutrients of which two primary nutrients are in chemical combination. These fertilisers are usually produced in granular form. E.g. Diammonium phosphate, nitrophosphates and ammonium phosphate.
- **Mixed fertilizers**: are physical mixtures of straight fertilizers. They contain two or three primary plant nutrients. Mixed fertilizers are made by thoroughly mixing the ingredients either mechanically or manually.
- **High analysis fertilizers**- Fertilizers that have more than 25% total available nutrients are called high analysis fertilizers.
- **Low analysis fertilizers**- Fertilizers with less than 25% total available nutrients are called low analysis fertilizers.

Classification of fertilizers on the basis of physical forms:

- **Solid fertilizers** are in several forms viz.
  - ✓ **Powder** (single superphosphate)
  - ✓ **Crystals** (ammonium sulphate)
  - ✓ **Prills** (urea, diammonium phosphate, superphosphate),
  - ✓ **Granules** (Holland granules),
  - ✓ **Supergranules** (urea supergranules) and
  - ✓ **Briquettes** (urea briquettes).
- **Liquid fertilizers:**
  - ✓ Liquid form fertilizers are applied with irrigation water or for direct application.
  - ✓ Ease of handling, less labour requirement and possibility of mixing with herbicides has made the liquid fertilisers more acceptable to farmers.

Nitrogenous Fertilizers

Fertilizers which contain nitrogen as primary nutrient are called nitrogenous fertilizers.

Classification of Nitrogenous fertilizers

Nitrogenous fertilizers may be classified into four groups on the basis of the chemical form in which nitrogen is combined with other elements within a fertilizer.

I. Nitrate fertilizers

In nitrate fertilizers nitrogen is combined as NO_3^- or nitrate with other elements. Such fertilizers are

Nitrate Fertilizers	Nitrogen (%)
Sodium Nitrate or Chilean Nitrate ($NaNO_3$)	16
Calcium nitrate [$Ca(NO_3)_2$]	15.5

II. Ammonium Fertilizers

In these fertilizers, nitrogen is combined in ammonium (NH_4^+) with other elements. Such fertilizers are:

Ammonium Fertilizers	Nutrient (%)
Ammonium sulphate [$(NH_4)_2SO_4$]	20.6% or 21% N+ 24% S
Ammonium phosphate ($NH_4H_2PO_4$)	20%N+ 20% P_2O_5 or 16%N+ 20% P_2O_5
Ammonium chloride (NH_4Cl)	26% N
Anhydrous ammonia	82% N
Ammonia solution	20 to 25%

III. Nitrate and Ammonium Fertilizers

These fertilizers contain nitrogen in the form of both Nitrate and Ammonium. Such fertilizers are

Nitrate and Ammonium fertilizers	Nitrogen (%)
Ammonium Nitrate (NH_4NO_3)	33
Calcium ammonium nitrate	25
Ammonium sulphate nitrate	26

IV. Amide Fertilizers

These fertilizers contain nitrogen in amide form. Such fertilizers are:

Amide Fertilizers	Nitrogen (%)
Urea [$CO(NH_2)_2$]	46
Calcium cynamide (CaNCN)	21

Important points- Nitrogenous Fertilizers

- **Nitrate fertilizers**
  - ✓ These are quickly dissociated in soil solution, releasing the nitrate ion for plant absorption.
  - ✓ **Most of the plants except Paddy, in the early stages of their growth take up nitrogen in nitrate form**.
  - ✓ Nitrate fertilizers are often used as top and side dressings, nitrogen reach root zone very quickly.
  - ✓ There is also increased **danger of leaching** of these fertilizers.
  - ✓ On dry soils, nitrate fertilizers are superior to other forms of nitrogenous fertilizers.
  - ✓ All nitrate fertilizers are **basic in their residual effect**.

- **Ammonium fertilizers**
  - ✓ Ammonium fertilizers are readily soluble in water and as such readily available. However, they are less rapidly utilized by growing plants than nitrate nitrogen, as ammonium has to be nitrified to form nitrate form before it can be absorbed by the plant.
  - ✓ **Paddy** is an exception and **prefers the ammonium form in the early stage.**

- ✓ Ammonium fertilizers are **much resistant to loss by leaching**, since they are readily absorbed on the colloidal complex of the soil.
- ✓ All ammonium fertilizers are **acidic in their residual effect** on the soils.

- **Nitrate and Ammonium Fertilizers**
  - ✓ Fertilizers of this group are readily soluble in water.
  - ✓ These fertilizers are **acidic in their residual effect**.

- **Amide Fertilizers**
  - ✓ Amide fertilizers **Urea and Calcium cynamide** are carbon compounds and classified as **organic compounds or fertilizers**.
  - ✓ These fertilizers are readily soluble in water and easily decomposed by microorganisms in the soil.
  - ✓ In the soil they quickly changed into ammonical form and then to nitrate form.

Important Nitrogenous fertilizers

1. **Ammonium sulphate [$(NH_4)_2SO_4$]**
   - ✓ Crystalline salt, stable and soluble in water
   - ✓ Good storage quality
   - ✓ It is physiologically acidic in nature
   - ✓ Nitrogen %- 20.6% or 21%
   - ✓ It is manufactured by **Gypsum process**, **Direct neutralization**, **Recovery from coke-ovens or by product of Coal and steel industry**, and **Byproduct from caprolactum** (the starting material for Nylon- 6) **plant**.

2. **Ammonium chloride (NH_4Cl) 26% N**
   - ✓ This is sometimes called **nitrate of ammonia**.
   - ✓ white, crystalline salt
   - ✓ This is physiologically acidic fertilizer.
   - ✓ It is commercially prepared by combining ammonia with HCl and the resultant product.
   - ✓ This fertilizer is also obtained as a byproduct of the Solvay process of making $(Na)_2CO_3$.

3. **Ammonium nitrate ($NH_4 NO_3$) – 33% N**
   - ✓ It white crystalline salt.

- ✓ It is highly hygroscopic and explosive and thus requires careful handling.

4. Urea

- ✓ Urea is an organic fertilizer
- ✓ It is white crystalline salt and completely soluble in soil solution.
- ✓ Urea is manufactured by reacting anhydrous ammonia and carbon dioxide gas under very high pressure in the presence of suitable catalyst.
- ✓ Urea was first produced at Sindri, Jharkhand in 1960-61.

Phosphatic fertilizers

Phosphorus content of fertilizers is expressed in oxidized form (P_2O_5), while its content in soil and plant is expressed in elemental form.

Classification of Phosphatic fertilizers

Phosphatic fertilizers can be classified into three groups based on their availability to crops and solubility.

I. Phosphetic fertilizers containing water soluble Phosphoric acid or Monocalcium phosphate, $Ca(H_2PO_4)_2$

- ✓ These phosphatic fertilizer are water soluble, thus Phosphorus is easily available to plants from these fertilizers.
- ✓ These fertilizers are **most suitable for neutral and alkaline soils**.
- ✓ They form insoluble iron and aluminium phosphates in acid soils, which are immobilized form thus not suitable in acidic soils.
- ✓ These fertilizers are used when crop requires quick start and for short duration crops like wheat, sorghum, pulses etc.
- ✓ Phosphatic fertilizers of this group are:

Water soluble Phosphatic acid containing Phosphatic Fertilizers or Monocalcium phosphate, $Ca(H_2PO_4)_2$	**P_2O_5 (%)**
Single superphosphate	**16-18**
Double superphosphate	**32**
Triple superphosphate	**46-48**
Ammonium phosphate	**20**

II. Phosphatic fertilizers containing Citric acid soluble Phosphoric acid or Dicalcium phosphate $Ca_2H_2(PO_4)_2$

- ✓ These fertilizers contain citrate soluble phosphoric acid or dicalcium phosphate.
- ✓ As they are **basic in reaction** and contain calcium they are **suitable for acidic soils.**
- ✓ These fertilizers are used for long duration crops like sugarcane, tapioca, tea, coffee, and also for lowland rice.
- ✓ Phosphatic fertilizers belonging to this group are:

Phosphatic fertilizers containing citric-acid soluble phosphatic acid or Dicalcium phosphate $Ca_2H_2(PO_4)_2$	**P_2O_5 (%)**
Basic Slag	**14-18**
Dicalcium phosphate	**34-39**
Rhenania phosphate	**23-26**

III. Phosphatic fertilizers,containing Phosphoric acid which is not soluble in water or citric acid or containing Insoluble Phosphoric Acid, or Tricalcium phosphate, $Ca_3(PO_4)_2$

- ✓ These fertilizers are **well suited for strongly acidic soils or organic soils** which require larger quantities of phosphatic fertilizers to raise the soil fertility.
- ✓ The availability of such fertilizers is also increased if these are ploughed under with green manuring crop or other organic materials.

Phosphatic fertilizer with Insoluble Phosphoric acid	**P_2O_5 (%)**
Rock Phosphate	**20-40**
Raw Bone Meal	**Min. 20 (20-25)**
Steamed Bone Meal	**Min. 22 (25-30)**

Important Points- Phosphatic Fertilizers

- Single superphosphate is the **oldest artificially produced fertilizer**, and its manufacture dates back to 1842 when **Lawes** prepared it **in England**.
- **Single superphosphate** or **common superphosphate** are greyish granular fertilizers

Single Superphosphate

- Superphosphate should be applied just before sowing.
- Superphosphate is unsuitable for top-dressing due to its slow mobility for short duration crops.
- Single superphosphate is manufactured in both powdered and granular form.
- Modified Single Superphosphate (SSP)
  - **Boronated SSP**- Fortified with borax. Contain 0.18% B+ 16% P_2O_5.
  - **Zincated SSP**- Fortified with Zinc sulphate. Contain 2.5% Zn+ 16% P2O5
- Superphosphate should not be used on soil with pH less than 5.5.
- Single superphosphate also contains 8-11% sulphur and 18-21 % Calcium.
- **Super-digested Compost**- Superphosphate is added to the composting material and they are allowed to undergo changes in the compost pit. The enriched compost with superphoshate is the super-digested compost. In this form, phosphorus is available for longer period without being fixed in the soil.
- **Triple superphosphate (TSP)** is also known as **Concentrated Superphosphate**.
- **Enriched superphosphate** contains 25-35% P_2O_5. "Enriched" superphosphate is essentially a mixture of SSP and TSP, usually made

by acidulation of phosphate rock with a mixture of sulfuric and phosphoric acids.

- TSP is more suitable for maximum yield of short season fast growing crops like high yielding varieties of cereals, potatoes and certain vegetables.
- Basic slag is a greyish black power and a by-product of steel industry.
- Rock phosphate and Bone-meal which contain Insoluble phosphate should be used in strong to extremely acidic soils. They should be used for long duration fruits and plantation crops like tea, coffee, rubber, cocoa, oranges, figs, coconut etc., grown in acidic soils.

Potassic Fertilizers

Potassic or Potash, or Potassium sulphate fertilizers are applied to the soils to supply the plants with potassium (K).

The potassium in fertilizers are expressed as K_2O (Potassium oxide) and is commonly referred to as potash.

Classification of Potassic fertilizers

I. Fertilizers having K in the chloride form

- ✓ Ex.- Muriate of Potash (KCl)

II. Fertilizers having K in the Non-chloride form

- ✓ The potassium fertilizers belong to this group are:
  - Sulphate of Potash (K_2SO_4)
  - Sulphate of Potash-magnesia (double salt of K and Mg)
  - Potassium Nitrate (KNO_3)

Potassic Fertilizers	**K_2O (%)**
Muriate of Potash or Potassium chloride (KCl)	**60**
Potassium sulphate or Sulphate of Potash (K_2SO_4)	**48-52% K_2O + 17.5% S**
Potassium Nitrate (KNO_3)	**44% K_2O + 13%N**
Potassium magnesium sulphate	**Min. 22 (25-30) +11% Mg**

Potassium polyphosphate	**24**

Other Important Fertilizers

Calcium (Ca), Magnesium (Mg) and Sulphur fertilizers (S)

Calcium, Magnesium and Sulphur are supplied to plants incidentally by the application of N P K Fertilizers and as such, such fertilizers are not manufactured to supply these nutrients.

Fertilizers	Nutrient (%)
Calcium nitrate	**19.4% Ca**
Gypsum	**29% Ca + 18.6% S**
Rock phosphate	**33.1% Ca**
SSP	**19.5% Ca**
TSP	**14% Ca**
Epsom salt	**10% Mg**
Copper Sulphate	**11.4% S+ 21% Cu**
Elemental sulphur	**100% S**
Zinc sulphate	**18% S+ 36.4% Zn**
Manganese sulphate	**26% Mn**
Ferrous sulphate	**19% Fe**
Borax	**11% B (Boron)**
Boric acid	**18% B**

Biofertilizers

The term biofertilizers has been coined to embody all such micro-organisms which add, conserve and mobilize the plant nutrients in the soil.

Biofertilizers play a significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilize insoluble soil phosphates and produce plant growth substances.

Classification of Biofertilizers

- **Nitrogen Fixing Biofertilizers for Legumes**
  - Bacteria belonging to the genus Rhizobium (symbiotic bacteria) are capable of fixing atmospheric nitrogen in association with leguminous crops
  - Different species of Rhizobium are used for treating the leguminous crops.
  - Rhizobium species enter the roots of host plants and form nodules on the root surface.
  - The bacterium depends on the host plant for carbohydrates and water while Rhizobium supplies nitrogen to the host.
  - Nitrogen fixed by Rhizobium is translocated through xylem in the form of **Aspergine** and some extent **Glutamine**.
  - Rhizobium species suitable for different species:

***Rhizobium* sp.**	**Crops**
R. leguminosarum	**Peas, Lathyrus, Vicia, Lentil**
R. tripoli	**Berseem**
R. phaseoli	**Kidney bean**
R. lupini	**Lupines, Serrdella**
R. japonicum	**Soybean**
R. meliloti	**Melilotus, Fenugreek, Lucerne**
R. species (Cowpea group)	**Cowpea, Green gram, Black gram, Red gram, Groundnut, Moth bean, Dhaincha, Sunnhemp, Cluster bean etc.**

- Rhizobium is applied as **seed treatment**, **Soil treatment** and **Soil Application**.
- Biological nitrogen fixation by Rhizobium is an anaerobic process.

- **Nitrogen Fixing Biofertilizers for Cereals, millets and Vegetables**
  - The important free living organisms that can fix atmospheric nitrogen are Blue Green Algae (BGA), Azolla, *Azotobacter*, *Azospirillum*, *Rhizospirillum* etc.

  - **Blue Green Algae (BGA)**- Several species of BGA or **Cynobacteria** can fix atmospheric nitrogen. The most important species are *Anabaena* and *Nostoc*. BGA inoculum is applied after **transplantation of rice crop** in the main field.

  - **Azolla**- Azolla is a free floating fresh water fern. It fixes nitrogen due to Anabaena species of BGA present in the lobes of Azolla leaves. Azolla is applied to the main field as a green manure crop or a dual crop in **transplanted rice.**

  - **Azobacter**- It is chemo-heterotropic bacteria, free living or non-symbiotic in nature and fixes nearly 20 to 40 kg N/ha. It is recommended for **Rice, Wheat, Millets, other cereals, Cotton, Vegetables, Sunflower, Mustard and flowers.**

  - **Azospirillum**- It is chemo-heterotropic and associative in nature. It is recommended for Rice, millet, Maize, Wheat, Sorghum, sugarcane and co-inoculants for legumes.

- **Phosphate Solubilizing Micro-organisms**
  Phosphate solubilizing micro-organisms are heterotropic in nature which have ability to solubilize inorganic phosphorus present in soluble sources.
  - These micro-organisms include Bacteria and fungus.
  - Important phosphate solubilizing Bacterial genus are ***Bacillus*** and ***Pseudomonas***
  - Important phosphate solubilizing Fungus genus are ***Aspergillus*** and ***Penicillum***.

- Some **Cynobacteria, VAM (**Glomus fasiculatum**)** and **Actinomyces** also act as phosphate solubilizing organisms.
- It is recommended for all crops

- **<u>Mycorrhiza or Vesicular- Arbusocular Mycorrhizae (VAM)</u>**
  - Mycorhiza is symbiotic association of plant roots and fungus.
  - It is common with majority of agricultural crops under temperate and tropical regions.
  - These are obligate symbiont.
  - VAM promote the plant growth and development by stimulating nutrient uptake and inducing disease resistance in plants. These enhance uptake of P, Zn, S and Water, leading to uniform crop growth and increase yield.
  - Recommended for forest trees, forage grasses, maize, millets, sorghum, barley and leguminous crops.

- **<u>Plant Growth Promoting Rhizobacteria (PGPR)</u>**
  - The group of bacteria that colonize roots or rhizosphere (area surrounding roots) and beneficial to crops are referred to as plant growth promoting rhizobacteria.
  - The PGPR inoculants currently commercialized that seem to promote growth through by at least one of the following mechanisms:
    i) Suppression of plant disease (Bioprotectants)
    ii) Phyto-harmone production (Biostimulants)
    iii) Improved nutrient acquisition (Biofertilizers)

Methods of Fertilizer Application

Soil Application

- **Broadcasting**- Application of Fertilizers uniformly on the soil surface and mixed with the soil is known as broadcasting of fertilizers. It is most widely practiced method in India.

- **Broadcasting and Incorporation**- Fertilizers like Phosphatic and Potassic fertilizers are applied by broadcasting and then incorporated into the soil during field preparation.

- **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.

- **Point Placement**- Placement of fertilizers near the plant either in the hole or in the depression followed by closing or covering with soil is known as point placement of fertilizers. It is adopted for top dressing of nitrogenous fertilizers in widely spaced crops.

- **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.
- **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.

- **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 to place fertilizers close to the seed or plant are as follows:
    - **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.
    - **Side dressing**- It refers to the spread of fertilizer in between the rows and around the plants.

- **Band placement-** If refers to the placement of fertilizer in bands. Band placement is of two types.
    - **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.
    - **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.

- **Sub-soil placement**- It refers to the placement of fertilizers in the sub-soil with the help of high power machinery. This method is recommended in humid and sub-humid regions where sub-soils are acidic.

- **Pellet application-** 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. 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.

- **Fertigation**- Application of fertilizers with irrigation water is known as fertigation.

Application to Plant

- **Root Dipping**- The roots of the seedlings are dipped in nutrient solution before transplanting. In soils deficient in phosphorus, roots of rice seedlings (or young plant) are dipped in phosphorus slurry before transplanting.

- **Foliar Spray**- Application of fertilizers to foliage of the crops as spray solution is known as foliar spray fertilizers. This method is suitable for application of small quantities of fertilizers, especially micro-fertilizers.

Some Terminology

- **Basal Application**- Application of fertilizers before or at the time of sowing is known as basal application.

- **Split application**- Application of recommended dose of fertilizers in two or three splits during crop period is known as split application.

- **Balanced Fertilization**- It refers to application of N, P, K nutrients to the soil in quantities to bring the balance in nutrients in the soil to meet the requirement of any specific crops.

- **Blanket Recommendation**- Fertilizer recommendation based on the fertilizer experiments conducted in different regions with improved varieties. This approach does not consider soil contribution.

Neem Coated Urea

The interim report prepared by **Agricultural Development and Rural Transformation Centre (ADRTC), Bengaluru** has highlighted importance of neem coated urea. These are:

- Improvement in soil health;
- Reduction in costs with respect to plant protection chemicals;
- Reduction in pest and disease attack;
- An increase in yield of paddy, sugarcane, maize, soybean and tur/red gram to an extent of 5.79%, 17.5%, 7.14%, 7.4% and 16.88% respectively;
- Diversion of highly subsidized urea towards non-agricultural purposes negligible among farmers after the introduction of the mandatory policy of production and distribution of only Neem coated urea.
- Due to slow release of Nitrogen, Nitrogen Use Efficiency (NUE) of Neem Coated Urea increases resulting in reduced consumption of NCU as compared to Normal urea.

- The Government, on 24th March, 2015 made mandatory for all the indigenous producers of urea to produce 75% of their total production of subsidized urea as Neem Coated Urea. Subsequently, on 25th May 2015, Department of Fertilizers made it mandatory for all the domestic producers of urea to produce 100% as Neem Coated Urea with an extra MRP of 5%.
- Entire quantity of indigenously produced urea and imported urea is being neem coated w.e.f 1st September, 2015 and 1st December, 2015 respectively.
- 240 LMT of Neem coated urea was produced in our country in 2017-18.

New Urea Policy – 2015

- ✓ **Effective from** 1st June 2015.
- ✓ Objectives: -
  - to maximize indigenous urea production;
  - to promote energy efficiency in the urea units; and
  - to rationalize the subsidy burden on the Government of India