K. T. S. P. Mandal's

Hutatma Rajguru Mahavidyalaya, Rajgurunagar

Tal. Khed Dist. Pune

T. Y. B. Sc. Chemistry

Term- 1st Sem. 3rd

Agricultural Chemistry

Pramod Kulkarni

Syllabus : 2013 Pattern

Chapter No. 5

Chapter Name : Fertilizers and Manures

Fertilizers and Manures

Fertilizers supply plant food and help to increase the yield of different crops through improvement of soil fertility. Manures not only supply nutrients, but also improves the soil physical environment influencing plant growth.Manures consist of animal waste mixed with straw or hay from barnyards through it may be a pure animal waste. This waste is collected and spread onto fields.When it decays it releases important nutrients that enrich the soil and aid plant growth. Manure also losers the soil and improves its ability to absorb moisture. A special kind of manure, green manure is obtained from plants that are ploughed into soil and allowed to decay.

The content of animal manure varies widely depending on the kind of manure and whether it is fresh, dried or partially decayed. Most animal manures from farms come from the waste of cattles, chickens, horses, pigs and sheeps. Animal manures are an excellent source of organic matter for the soil, but it is low in such important nutrients Viz. N, P and K. In general, it takes about 900kgs of manures to supply as much of these three elements as 45 kgs of commercial fertilizers.

(A) Fertilizers

Def. Fertilizers are those substances which must be added to the soil to improve the deficiency of essential elements required for plant growth. Farmers use various kinds of fertilizers to produce abundant crops.

Classification of fertilizers

Classification according to their agrochemical nature

a. Direct fertilizers

b. Indirect fertilizers

a. Direct fertilizers: plants which directly absorb fertilizers are called direct fertilizers. They may or may not be a source of all the vital elements for plants. Ex. Phosphatic, nitrogenous, potash, magnesium.

Direct fertilizers are further classified according to the nutrient elements present in them.

I. Simple fertilizers: They contain only one nutrient element such as phosphorus, nitrogen, and potassium.

II. Double or triple fertilizers: They contain two or three elements respectively. The triple fertilizers are also called complete fertilizers, because they contain all the principle nutrient elements nitrogen, phosphorus and potassium.

III. Micro fertilizers: They contain the elements such as boron, manganese, zinc and copper. These fertilizers are required in very small amounts to stimulate the plant growth.

IV. Mixed fertilizers: They contain several nutrient elements and obtained by mechanical mixing of various fertilizers.

b. Indirect fertilizers: The substances which are added to the soil in order to improve its chemical, mechanical or biological properties. For example, ground dolomite and limestone are used to decrease soil acidity and gypsum used to improve the properties of soils with a high salt content. Thus, these substances keep the soil pH value suitable for plant growth.

B. Classification According to their solubility in the moisture in the soil

1. Water soluble fertilizers: All nitrogenous and potash fertilizers are Soluble in water. These fertilizers are readily assimilated by plants, but they are quickly washed out of the soil by surface water.
2. Soluble in soil acid fertilizers: Most phosphates are the fertilizers soluble in soil acids. They are dissolved much slower, but are retained in the soil much slower, but are retained in the soil much longer.

Classification According to their physical properties

A. Powder form: They are more hygroscopic and form cake during storage. They are not retained by the soil for a longer time, that is they are washed out quickly by rains. They can add to the soil manually.

B. Granulated form: They are less hygroscopic and do not form cake during storage. They are retained by the soil for a long time that is they are not washed out quickly by rains. They can be added to the soil using fertilizer machines or seed drills.

Source of Fertilizers:

a. Plant matter: Oil cakes from cottonseed meal, linseed, and castor cake. They contain 7%, 5.5%, and 6% nitrogen respectively.

b. FYM: It consists of cow dung, sheep dung, human excreta.

c. Animal matter: powdered dry fish and red dry blood from slaughter houses are important nitrogenous fertilizers.

d. Guano: It is a mixture of birds excreta fish refuse and fish bones. It is a complete fertilizer.

Importance of Fertilizers:

Green plant produces the food by means of the process of photosynthesis. This process requires large amounts of carbon, hydrogen, oxygen, phosphorus, potassium nitrogen, sulphur, calcium and magnesium. It also requires smaller amounts of several other elements like boron, copper, iron, managense, chlorine, molybdenum and zinc.

Air and water provide most of the carbon, hydrogen and oxygen needed by green plants for growth. The other elements must chiefly come from the soil. Decaying Plants, animal matter and dissolved minerals normally provide these elements. But sometimes soil does not have enough of these substances resulting bin a need for fertilizers. The harvesting crops remove plants from the soil before they die and decay, thus the soil does not receive the mineral elements contained in the crops, so fertilizers must be added to supply them with the nutrients. N, P and K are the elements in which soil is most frequently deficient pores of soil and enables the free circulation of water. Another important factor is the action of carbon dioxide on the material in the soil. Carbon dioxide dissolves 8n water to form carbonic acid, which has high solvent power for $CaCO_3$, $MgCO_3$, Fe_2O_3 and MnO_2 which are insoluble in pure water. Carbonic acid helps water to circulate many fertilizers in the soil, which are otherwise hardly available. Substances which are added to soil to improve soil texture are called soil improvers while substances which are added to correct unfavourable conditions like acidity or high concentration of certain substances are called soil amendments. Example lime and gypsum.

Fertility of soil

Virgin soil: It may be regarded as the portion of soil or land on which plants have not been grown for a long time. Since plants as food have not used up the elements present in it, it is always fertile and making use of it may yield good crop.

Exhausted soil: It is an unproductive soil and may be regarded as the soil on which crop of same variety have been raised for a long time. As a result the elements of soil have been absorbed and the soil becomes impoverished.

There are three factors which affect fertility of soil

1. Amount of fixed nitrogen
2. N, P, K and other mineral salts
3. pH values of soil

pH value

It is the most important factors in the fertility, although the latter is also influenced by the number and type of soil microorganisms, the existence of these microbial flora depends on temperature, moisture, aeration structure and composition of soil. The optimum pH value of soil must be between 7 to 8 which means neutral or slightly alkaline. Any soil between between pH 8.5 and 10 is said to be non-saline. If pH is less than 8.5 then it is called saline soil. During the cultivation of soil calcium, magnesium and other base forming minerals are taken up by plants which results in the decrease of pH value. The increase in the acidity of the soil is corrected by adding a small amount of base like lime whereby acid gets neutralized. If the soil has pH value <3, no cultivation is possible. The ammonium compounds when applied to soil decrease the pH of the soil in two different ways

a) They undergo hydrolysis with water in the soil.

$(NH_4)_2SO_4 + 2H_2O \longrightarrow 2NH_4OH + H_2SO_4$

$NH_4NO_3 + H_2O \longrightarrow NH_4OH + HNO_3$

b) The nitrification process activated by nitrifying bacteria

$2NH_4^+ + 4O_2 \longrightarrow 2NO_3^- + 4H^+ + 2H_2O$

Because the low pH of the soil is not conducive to plant growth, the adverse acidifying effect is compensated by adding lime to the soil. Lime not only eliminates effectively the acids, but also precipitates the toxic material without affecting the structure of the soil. The harmful high pH effects are removed by treatment with aluminium sulphate, ammonium sulfate through graded acidification of the soil by hydrolysis.

Nitrogenous fertilizers

These are the most widely used fertilizers produced from ammonia gas. Ammonia is used in making liquid fertilizers as anhydrous ammonia and aq. Ammonia, $(NH_4)_2SO_4(s)$, NH_4NO_3 (s), $(NH_4)_3PO_4(s)$, and urea (s). Each of these fertilizers provides soil with large amount of nitrogen. Soil takes up nitrogen in the form of NH_4^+ or nitrate ions and forms amino acids with carbon compounds in the complex chemical system. These amino acids with carbon compounds in the complex chemical system. These amino acids are converted into proteins and enzymes. Proteins thus formed make part of protoplasm while enzymes act as catalysts for various reactions taking place in the plant. Nitrogen is also a special constituent of chlorophyll without which photosynthesis is not possible. Nitrogen makes up 16 to 18% of the plants protein and constituents 1-4% of the weight of plants and is required in large amounts in any of the plant nutrients. The main sources of nitrogen are fertilizers, organic nitrogen compounds formed in the soil by recurring natural processes and atmosphere.

Classification of Nitrogenous Fertilizers

These have been classified into four categories depending on the form of nitrogen present in them.

Class	Fertilizer	%N	Remark
Nitrate N_2	1. Sodium nitrate 2. Calcium nitrate	16.00 15.50	Basic Basic
Ammoniacal Nitrogen	1. Ammonium Sulphate 2. Ammonium chloride 3. Anhydrous Ammonia	20 24-26 83	Acid forming Acid forming Acid forming
Both nitrate and ammoniacal Nitrogen	1. Ammonium nitrate 2. Calcium Ammonium nitrate	33-34 20	Acid forming Neutral
Amide	1. Urea 2. Calcium Cynamide	46 21	Acid forming Basic

Action of ammonium sulphate in soil

Ammonium sulphate is acidic in nature and nitrogen is present in cationic form ammonium ion which is retained by the soil colloids. It is headed by soil by forming complex,

$Ca[soil\ colloids] + (NH_4)_2SO_4 \longrightarrow NH_4^+ + CaSO_4$

Soil colloids. Soluble (leaching)

Calcium sulfate may be lasting in drainage water by leaching and the soil loses Ca^{2+} ion. The ammonium ion on the soil colloid may be taken up directly by the plants it is nitrified as

NH_4^+ NO_3^-

N and H^+ ions are formed during nitrification due to which soil becomes acidic and the soil pH lowers.

Therefore, it is suitable for calcareous, alkaline, neutral and alkaline soils. In calcareous soil, lots of ammonia is lost through volatilisation.

$(NH_4)_2SO_4 + CaCO_3 + 2H_2O \longrightarrow CaSO_4.2H_2O + (NH_4)_2CO_3$

$(NH_4)_2CO_3 \longrightarrow 2NH_3 + CO_2 + H_2O$

Ammonium sulphate may be applied before sowing along with the seed or can be top-dressed to the standing crop. It should be applied very close to seed to avoid the bad effects on seed germination.

Reaction of Urea

Urea is first hydrolyzed by soil water to ammonia and carbon dioxide. Then nitrosofication of ammonia takes place by the nitrosomonas and nitrosoccus bacteria and nitrites are formed. Nitrobacters convert nitrites to nitrates.

$CO(NH_4)_2 + H_2O \longrightarrow CO_2 + 2NH_3$

Bacteria

$2NH_3 + 3O_2 \longrightarrow 2NO_2^- + 2H_2O + 2H^+ + Energy$

$2NO_2^- + O_2 \longrightarrow 2NO_3^- + Energy$

About 75% Ammonia is used as a fertilizer directly. Urea should be applied 3-4 days before sowing because the conversion takes about a week for completion.

Nitrolim fertilizers

- It is a mixture of calcium Cynamide and carbon; when applied to the soil, it gets hydrolyzed to calcium hydroxide and urea in the presence of soil catalyst and or micro organisms.

$$Ca(CN)_2 + 4H_2O \longrightarrow Ca(OH)_2 + (NH_2)_2CO + H_2O$$

$$Ca(CN)_2 + 3H_2O \longrightarrow Ca(OH)_2 + (NH_2)_2CO$$

$$(NH_2)_2CO + H_2O \xrightarrow[\text{Urease}]{\text{Enzyme}} CO_2 + 2NH_3$$

$$2NH_3 + 3O_2 \xrightarrow{\text{Bacteria}} NO_3^- + H_2O$$

The principle nitrogen solution is a mixture of ammonium nitrate, urea and water in the ratio of 80 (NH_4NO_3 + urea): 20 water. The highest concentration of this nitrogen solution can be further increased by the addition of formamide.

Phosphatic fertilizers

These are also called phosphates. These are made from the mineral appetite or rock phosphate, which can be applied, directly in the finely powdered form. Appetite when treated with sulphuric acid or phosphoric acid make liquid super phosphate. These fertilizers are required in lesser amounts than nitrogen. Most soils contain phosphate in the form of complex calcium phosphate, iron and aluminium complex and organic compounds. Such sources are insoluble so plants can make very little use of them. It is supplied in two major forms to plants as calcium phosphate or ammonium phosphate.

Classification of Phosphatic fertilizers

They are divided into three groups

1. Water soluble orho or mono calcium phosphate
2. Citric acid soluble dicalciumphosphate
3. Insoluble phosphate fertilizers.

Dicalcium phosphate is the principle constituents in two major fertilizers Viz. Ammonium phosphate obtained as a product of the neutralization of phosphate ore and nitric acid ammonia. The resulting product is dried and granulated. The other is ammoniacal superphosphate. $Ca(H_2PO_4)_2$ is formed when mono calcium phosphate in super phosphate is treated with ammonia. Some basic phosphate is also formed along with it. For phosphate of low solubility

best result is obtained with finely divided material on acid soil. Polyphosphates are also used as fertilizers.

I. Ortho phosphatic Fertilizers:

The active constituents are mono calcium phosphate (MCP) and phosphoric acid. Superphosphate is formed by dissolving rock salt into sulphuric acid, thus,

$Ca_{10}(PO_4)6F_2 + 7H_2SO_4 + 3H_2O \longrightarrow 3Ca(H_2PO_4)_2.H_2O + 7CaSO_4 + 2HF$

If rock phosphate is reacted with excess of H_2SO_4, H_3PO_4 is produced which then used to dissolve fresh rock phosphate and higher grades of superphosphates are obtained.

$Ca_{10}(PO_4)6F_2 + 14H_3PO_4 + 10H_2O \longrightarrow 2HF + 10Ca(H_2PO_4)_2.H_2O$ (n

Triple super phosphate

Partial neutralization of an acid with ammonia gives multi nutrient fertilizers as mono ammonium phosphate (MAP) and di-ammonium phosphate (DAP). By decreasing the ratio of water to phosphorus pentoxide, phosphoric acid is upgraded to super phosphoric acid, which is a mixture of $H_4P_2O_7$ and higher molecular weight polymers.

Ammoniation of triple poly phosphoric acid produces very soluble fertilizer Viz., ammonium polyphosphates (12% N and 23% P). It is a liquid fertilizer.

SSP contains 16-18% P_2O_5, DSP, 32% P_2O_5 and TSP 46-80% P_2O_5. They contain water soluble P, which is easily available to plants in the form of $H_2PO_4^-$ ions. This fertilizer should be used on neutral to alkaline soil only.

II. Citric Acid Soluble Dicalciumphosphate $CaHPO_4$ or $[Ca(H_2PO_4)_2]$:

Basic slag contains 14-28% phosphorus pentoxide and calcium hydrogen phosphate contain 34-49% phosphorus pentoxide. Because big low pH, these fertilizers are suitable for acidic soils. Being citric acid soluble, they get converted to MCP and phosphate does not get fixed by Fe as and Al as phosphates.

III. Phosphatic fertilizers (Insoluble) $Ca_3(PO_4)_2$ (TCP):

Rock phosphate contains 20-40% P_2O_5, raw bone meal 20-25% P_2O_5 steamed bone meal 22% P_2O_5 are some of the fertilizers of this group. They are suitable for highly acidic soil or organic soil, which require large quantities of phosphoric fertilizers.

Potassic Fertilizers:

Potassium is one of the essential nutrients of the plants. It is obtained from natural deposits e.g., potassium chloride, which occurs in large deposits. It is soluble and readily available to plants. Potassium sulphate, which occurs as double salt $K_2SO_4.2MgSO_4$ (langbainite) is either used as such or treated to remove associated salt. The fertilizers containing N, P, and K are known as NPK fertilizers. Potassium fertilizers are called potash. Being highly reactive metal, it is never found in a free state. It readily oxidizes to K_2O. On exposure to air which combines with water to form KOH. Hence it is never used in elemental form as fertilizer. The common potassic fertilizers are muriate of potash, sulphate of potash K_2SO_4 and potassium nitrate KNO_3. With water these fertilizers liberate K^+ ion which is absorbed by growing plants.

Potassium chloride and potassium sulphate are soluble in water and they release K^+ ions which are absorbed on the soil colloids and are available to plants through cation exchange reactions. When these fertilizers are applied to acidic soils Cl^- ions replace ^-OH ions associated with the free iron oxide therefore it gives greater response than potassium sulphate. It is toxic to plants in alkaline soils. In alkaline soils potassium chloride is always applied along with organic matter.

$$2KCl + SO_3 + H_2O \longrightarrow K_2SO_4 + 2HCl$$

Potassium sulphate is less hygroscopic than KCl therefore is easy to handle. It is preferred source of potassium for crops which are sensitive to high concentration of Cl_2, such as tobacco, potatoes etc. and many vegetables grown in glass houses.

Potassium nitrate is also favoured for tobacco because it contains no chlorides and all nitrogen is present as NO_3^- ion the preferred form of N for this crop.

Complex Fertilizers:

These are the fertilizers, which contain all three primary nutrients (NPK). If only two nutrients are present in any fertilizers, then it is called complete complex fertilizers. e. g. nitrophosphate, mono ammonium phosphate, di-ammonium phosphate. NPK fertilizers are ammonium sulphate phosphate and K_2O combination.

Complex fertilizers have high contents of nutrients, uniform grain size, good physical conditions, noncaking and Mon-hygroscopic. They are cheap as compared to super phosphate or

ammonium sulphate and are preferred by cultivators. The most important grades of nitrophosphate and other commercial complex fertilizer grades are 15:15:15, 20:20:20.

Mixed Fertilizers:

Mixed fertilizers are the mixture of two or more straight fertilizers. It is highly useful for good crop yield and plant growth.

The advantages of mixed fertilizers are

1. They save cost of application of Fertilizers especially in labour scarcity areas.
2. They possess better physical conditions than single fertilizers and hence can be drilled easily. The requirement of these fertilizers is very less.
3. They rectify the residual acidity of certain nitrogenous fertilizers in soil.
4. They supply the balanced amount of nutrients to plants and soil.

There are certain disadvantages of mixed fertilizers:

1. They do not permit the application of individual nutrients, which may suit the need of a crop of specific times.
2. The unit cost of plant nutrients in the mixture is usually higher than those in straight fertilizers.
3. Farmers do not mix the Fertilizers in proper proportion.
4. Differential application of fertilizer mixture is not possible.
5. In mixing chemical compatibility results in reduction in availability of some nutrients.
6. A chemical reaction between fertilizers may cause loss of nutrients.

Time and Method of Fertilizer Application:

To obtain the maximum benefit from fertilizers it must be applied at proper place and in proper proportion. The application of fertilizer depends on-

1. The nature of fertilizer
2. The type of soil
3. The type and nature of field crop.

Selection of time for application of fertilizer depends on the stage of the plant growth. Plants require less nitrogen in the early stages growth and harvest time, but the maximum during its grand growth period, thus nitrogen is required by plants throughout their life time, therefore, nitrogenous fertilizers would be applied in split doses throughout the growth period so as to remove nitrogen deficiency.

The more amount of phosphorus is required during early growth period. Phosphatic fertilizers bare slow realizing therefore they must be applied as superphosphates before regular operation of this extra labour is needed.

Potash is an intermediate fertilizer between nitrogen and phosphorus. It should also be applied during sowing time. Sandy soils require more frequent applications of all types of Fertilizers to avoid the loss of nutrients through leaching.

Correct method of fertilizer application:

Nitrogenous fertilizers being highly soluble reach the plant roots easily and rapidly, therefore they are broadcasted on the soil surface just before sowing. To overcome the deficiency of nitrogen at latter stages of plant growth, it is top dressed and side dressed.

Phosphorus is a slow releasing fertilizer therefore it is placed near the seeds or seedling roots for three reasons. Some important points are

1. Restricted contact of fertilizers with the soil lessens their fixation of phosphate.
2. Necessary plant food is placed within easy reach of the plant roots. The possibility of injurious concentrations is minimized if the placement is accurately controlled and
3. The fertilizer placed in a side band along the row doses does not readily furnish nutrients to weeds growing between the grows.

Potassic fertilizers should also be placed near the root zones, as they are mobile.

(I) Methods of applying fertilizers: (Solid form)

A. Broadcasting
B. Placement
C. Localized placement form

(II) Methods of applying fertilizers (Liquid form)

Starter solutions

Foliar applications or spray fertilizers

Direct application to the soil

Application through irrigation water

(I) Application of fertilizer in solid form

(a) **Broadcasting**: In order to distribute fertilizer evenly and uniformly it is spread over the entire soil before being ploughed or immediately before planting or while the crop is standing. Broadcasting is of two types.

1. **Broadcasting at planting**:

The main objectives of this type of broadcasting are:

a. To distribute fertilizer evenly and to incorporate it with part of or throughout the plough layer.

b. To apply large quantities that can be safely applied at the time of planting with a seed and fertilizer drill. Suitable nitrogenous fertilizers are ammonium sulphate, ammonium nitrate and conc. Organic manure, phosphatic fertilizers are basic slag, DCP and potassium fertilizers are KCl and K_2SO_4.

2. **Top dressing**:

In order to supply available nitrogen to growing plants like paddy and wheat, Nitrogenous fertilizers like ammonium nitrate, sodium nitrate, calcium ammonium nitrate etc are applied to soil. A top dressing of phosphorus and potassium is done only on pasture lands. Top dressing is not done when the leaves are wet, as they may get burnt by nitrogenous or potassic fertilizers.

(b) Placement

Fertilizers are placed in the soil irrespective of the position of the seed, seedling or growing plants before sowing the crop. It is done by the following methods:

I. **Plough sole placement**: During the process of ploughing the fertilizers is placed in a continuous band at the bottom of the furrow. Each band is covered as the next furrow is turned. Seeds can be sown anywhere on the bands. This method is recommended for places having heavy clay soil and dry soil in such a way that moist soil becomes available to growing plants during the dry season. In this method less fixation of phosphorus and potassium takes place.

II. **Deep placement of nitrogenous fertilizers**: In this method ammoniacal nitrogenous like ammonium sulfate, urea, etc. Is placed in the reduction zone, where it remains in the form of

ammonia and is available to crop during active vegetative period. This also ensures better distribution of root zone and prevents any loss by surface drain off.

III. **Subsoil placement**: Fertilizer is placed in the subsoil, which is highly acidic and nutrient deficient. It is applied in humid and sub humid regions. Phosphatic and potassic fertilizers are placed in the subsoil for better root development.

C. **Localized placement**: It is used when a very small quantity of fertilizer is required by soil. In this method fertilizer is placed near to or along with seeds or plants in bands or pockets, so as to promote the rapid early growth of plantss. It controls weeds and reduces fixation of phosphorus and potassium.

The various methods used are:

1. **Contact placement or combined drilling or drill placement**: In this method seeds and fertilizers are drilled together while sowing by placing them in the same row. It is very useful for applying the phosphatic and potassic fertilizers to wheat, barley, jawar, bajraragi, cotton and grasses. Due to excessive concentration of soluble salts germination may get affected. So only small quantities of fertilizers should be drilled. It is not good for pulses and legumes.
2. **Row placement**: Here the nitrogenous fertilizers is mixed with the soil in the form of pelset 2.5 to 5 cm deep between the rows of paddy crop in the ratio of 1:10.
3. **Side dressing**: In this method fertilizers are spread in between the rows and around the plants by any of the following methods:
   I. To give additional dose of N fertilizers to the broad row crops of maize, sugarcane, tobacco etc the fertilizers are spread by hand.
   II. Application of mixed or straight fertilizers around the base of the fruit trees like papaya, banana, grape, apple, orange, etc. This is done once, twice or thrice a year depending on the age of fruit trees. This is also known as Hill application.
4. **Band placement**: The fertilizers are placed in continuous or discontinuous bands close to seeds or transplanted plants by two methods:

a. **Hill placement**: When the plants are spaced 90 cm or more on both sides, fertilizers are placed close to the plant in bands on one or both sides of the plant. This is known as Hill Placement. The size of the band varies with species of plant and the amount of fertilizer. It is used for nitrogenous and phosphatic fertilizers to grow fruits and vegetables like orange, papaya.

b. **Row placement**: The fertilizers are placed in a continuous band when the seeds are sown close together in a row. It is used for sugarcane, potato, maize, tobacco, cotton, cereals and vegetable crops.

2. **Application of Liquid Fertilizer**:

(a) Starter solution: These generally consist of nitrogen, phosphorus pentoxide, potassium oxide in the ratio of 1:2:1 and 1:1:2 and are applied to young vegetable plants at the time of transplanting. They are used in small quantities and they replace water. These solutions have two advantages:

a. The nutrients reach the plant roots immediately.

b. The solution is sufficiently diluted so that it does not inhibit growth.

The disadvantages of this method are

a. If watering is not a part of the regular operation, extra labour is needed.

b. Fixation of phosphate may be greater.

B. **Foliar application**: In this method leaves of growing plants is sprayed with suitable fertilizer solution in low concentration to supply nutrient or combination of nutrients to plants. Its effect is same as that of soil application. So fertilizers are not saved by this method. Foliars may be applied when

a. Competitive crop or soil conditions make nutrients from soil dressing unavailable.

b. An accurate, timely response to fertilizers is required.

c. Routine applications of insecticidal herbicidal sprays to which nutrients can be added are made.

d. The growth of the crop prevents application of fertilizers to the soil, but permits it's application to the leaves from a high clearance sprayer.

The difficulties associated with the foliar application of nutrients are-

1. Strong solution burn leaves.
2. Solutions of low concentration provide only small quantities of nutrients in a single spray.
3. Several applications are needed for moderate to high fertilizer rate.
4. It is costly as compared to soil application unless combined with other spraying operations taken up for weed, insect or disease control.

D. **Direct application of liquid fertilizer to soil**:

With the help of special equipment, anhydrous ammonia and nitrogen solutions are directly applied to soils to prevent plant injury and wastage of ammonia. Medium textured soils have the widest range of moisture and are the best places for the application of anhydrous ammonia. Losses occur in sandy or clayey soils that are either too dry or too wet.

E. **Application of liquid fertilizers through irrigation water**: The nutrients required by plants are served through the mixing of straight and mixed fertilizers containing N, P, and K with irrigation stream. Generally nitrogenous fertilizers are applied through irrigation water. This is an inexpensive method.

Factors affecting Efficiency of Fertilizers:

Fertilizer efficiency is defined as the percentage of added fertilizer that is actually used by the plants. The fertilizer efficiencies are approximately 30-70% of added nitrogen, 5-30% of added phosphorus, 50-60% of added potassium. The values can be lower or higher depending on various factors like:

1. Type of soil and its fertility.
2. Cropping history.
3. A season in which the crop is grown.
4. Nature of crop, variety and its growth habit.
5. Sowing time, plant population.
6. Type, quantity, time and method of fertilizer applied.
7. The method, quantity and frequency of irrigation.
8. How the soil moisture is conserved in case of rain fed or unirrigated crops.
9. The extent and manner in which the weeds, the pests and the diseases are controlled.

By manipulation of the above factors, it is possible to substantially increase the per hectare yield of crops from a given rate of fertilizer application in a farmers field.

Vermicompost:

Earthworm composts or vermi compost is the best manure because earthworm looses the soil and improves the texture, thus increasing the quality and quantity of trees.

Preparation of vermicompost:

Vermicompost, or vermicultural means the scientific growing of earthworms. Vermicompost can be done by either of the following methods

1. Indoor or small scale culturing
2. Outdoor culturing technique

The method I Indoor or small scale culturing technique

For Indoor culturing

a. The culture containers should be made of either plastic or wood or tin so that they can be transported from one place to another.

b. They should be nonporous, so that they are able to retain moisture.

c. The boxes should be about 50cm X 35cmX15-20cm with a few holes of 500 mm in diameter at the bottom.

d. Bottom of the box is covered with a plastic window screen which is covered with burlap or jute cloth to prevent the sticking of culture medium and escape of earthworms through holes. It permits the drainage of excess water.

e. Generally, plastic tubes are used for vermiculture because they are more durable and can be easily packed over each other in vertical rows. Top of the box is covered with burlap or jute cloth frame before inoculation of medium and earthworms.

f. A mixture of 1/3 soil and 2/3 organic matter is used for culture purpose. A layer of 2-4cm thick sand is spread in the plastic boxes. This layer is covered with 2-4cm thick soil layer. The organic matter is placed on one side of the container. Water is sprinkled on the culture medium so as to make it 25-30% moist. For indoor process temperature of the building is maintained between 10-20°C. Water should be sprinkled regularly in limited quantity. Sufficient amount of organic material should be added to the culture medium to avoid sogging.

g. Low wattage of light should be applied to avoid crawling out of earthworm boxes.

Method II: Outdoor culturing technique

(a) For outdoor cultures at low temperature places, boxes must be covered with suitable insulation material, e.g. wheat straw, dry hay or weeds etc. to maintain the required temperature.

(b) Large vermiculture beds are made on the wasteland with a bottom layer of 10 cm high gravel over which plastic window is placed with its edges raised up to 20mm height.

(c) The bottom is covered with 2-4cm thick sand layer which is covered with a mixture of 1/3 soil and 2/3 organic matter in the form of conical heap, to avoid accumulation of excess water during rains.

(d) The bottom layers of gravel and sand also helps to maintain the water content in culture.

(e) The window screen prevents the escape of worms.

Effect of vermicompost on soil fertility:

Vermicompost deals with the application of earthworms for production of

1. Rich biofertilizer which break down organics into plant available nutrients.
2. Animal feed for livestock.
3. Treatment of industrial wastes and effluents.
4. It increases the biotic component of soil processes.
5. It keeps the soil aerated.

Nitrogen content in soil is very little and the crops need nitrogen very much. The atmosphere contains 78% nitrogen. However, certain soil organisms can convert and fix the atmospheric nitrogen into ammonia and make it available. The vermicompost produced by earthworm make the soil reach in nitrogen content and increase crop yield.

Therefore, as compared to organic fertilizers vermicompost is most useful and inexpensive.

Synthetic fertilizers are man made inorganic compounds usually derived from byproducts of the petroleum industry. Example ammonium nitrate, ammonium phosphate, superphosphate and potassium sulphate.

Comparison of organic fertilizers and Synthetic fertilizers

	Organic fertilizers	**Synthetic Fertilizers**
1.	These are materials derived from plant and animal parts or residues. Example Blood, meal, compost, manure, Bat-guano, Seaweed and worm castings.	These are Man made inorganic compounds usually derived from products of the petroleum industry. Ammonium sulfate, ammonium phosphate, super phosphate, potassium sulphate.
2	Organic fertilizers support microbiological life in the soil by introducing beneficial microorganisms.	Synthetic fertilizers do not support microbiological life in the soil, kills a significant % of beneficial microorganisms.

3	Organic fertilizers are dilute source of nutrients, creating top growth and root growth simultaneously.	Synthetic fertilizers can release nutrients too quickly, creating a great deal of top growth before the roots are able to catch up.
4	Organic fertilizers are not dissolved easily, hence plants can use them for longer time.	Synthetic fertilizers dissolve easily and release nutrients faster than plants use them.
5	Organic fertilizers are builders of soils and it is the soils that are feeding the plants.	Synthetic fertilizers cause damage to soil nutrient cycling as well as promotes rash of pest problems.
6	Since it is a dilute source of nitrogen, fungi population does not occur.	Sudden increase or decrease in soluble nitrogen can increase the fungi population that attack and weaken the plant.

Environmental effects of synthetic fertilizers:

1. **Effects on soil**:

I. Synthetic fertilizers kill a large % of a soil's naturally occurring microorganisms which normally break down organic matter into a plant usable form.

II. Other useful soil bacteria are disease organisms which keep cut worms, chinch bugs, grubs and other paracides in check, it takes almost six weeks for soil to partially recover biologically from a poisoning by synthetic fertilizers.

III. Soil that is derived of its microorganisms undergoes a rapid decline in soil structure and it loses its essential ability to retain water, air and nutrients.

IV. Plants grown in such depleted soil are extremely susceptible to damage from diseases; insects and drought.

V. Synthetic fertilizers tend to replenish only nitrogen, phosphorus and potassium; while depleting the other nutrients and minerals that are naturally found in truly fertile soils.

3. **Effects on food and our health**:

I. Organically grown fruits and vegetables have significantly more antioxidant, poly phenols and enzymes that affect our health.

II. A lack of omega-3-oils (nutrient in our body) is known to lead to heart disease, cancers, mental disorders such as attention deficit disorder.

III. Our nutritional deficiencies are due to the fruits and vegetables, which are now being picked prematurely. For example non-organic tomatoes are now being made to look red using synthetic ethylene instead of sunlight.

IV. Laboratory tests prove that the fruits, the vegetables, the grains, the eggs and even the milk and the meats of today are not what they were a few generations ago.

V. Due to existence of rampant obesity. No man of today can eat enough fruits and vegetables to supply his system with the mineral salts he required for perfect health.

Manures

Manure is any substance produced by animal or plants that is used as fertilizer. It is just like the organic matter, consisting of heterogeneous mass of organic compounds, decompose quickly while others decompose slowly and finally change to humus. The application of manure supplies essential ions to the soil.

Classification of Manures:

Manures are classified into two major groups

1. Organic Manure
2. Inorganic Manure

1. **Organic Manure (Bulky Manure)**

These are the materials of plant and animal origin. In this group there are several types of manures Viz.

1. Farm Yard Manure (FYM): Prepared from cow dung, urine and sweeping of farm.
2. Farm composts: Prepared from farm refuse, leaves, trash, sugar6, pachat etc.
3. Town compost: Prepared from town refuse.
4. Vermi compost: It is excreta of earth worms
5. Sheep and goat droppings.
6. Poultry manure: Dropping of poultry birds
7. Night soil: Decomposed human excreta
8. Green manure: Green crop of sanhemp and dhainchs is buried into the soil by ploughing the decompose.

Concentrated organic manures:

Small quantity of the manure contains comparatively more nutrients. These manures are prepared from waste materials of animals and plants origin e. g. Blood meal, bone meal, fish meal, meat meal and waste. These are called oil cakes.

Inorganic manure

These are the commercial chemical compounds, also called chemical fertilizers. They contain nutrient elements in large quantities and are therefore required in small amounts by crop plants. They are grouped as

1. Nitrogenous
2. Phosphatic
3. Potassic
4. Complex fertilizers or mixture of nutrients.

Effect of Bulky organic manures on soil

1. These manures supply plant nutrients in small quantities and organic matter in large quantities
2. They improve physical and biological conditions of soil.
3. They also add micronutrients along with N, P, K which are essential for plant growth in available form.
4. They activate microorganisms by supplying energy.
5. They improve buffering and exchange capabilities of the soil.
6. They influence the solubility of soil minerals as well as mineral nutrients present in soil.
7. They also form chelates, which help in plant nutrition.

Farm Yard Manures

Farm Yard Manure is a mixture of cattle dung, litter or bedding material portion of fodder not consumed by cattle and other domestic wastes like ashes collected and dumped into a pit or heap in the corner of the back yard. It is allowed to rot and then applied to the field. Because of the varied nature of the material, its composition varies widely. Its average composition is 5% N, 2% P_2O_5 and 5% K_2O.

Factors affecting on FYM:

The composition of FYM depends on the following factors:

1. Source of manure: Dung and urine voided by differed animals varies in quality and quantity. Urine of cattle and horses are approximately two and half times richer in nitrogen content than their dung. Sheep and goat dung is richer in phosphorus pentoxide. Pig's dung is richer in potassium oxide.
2. Food of the animal: Richer the food in proteins richer is the manure in nitrogen.
3. Age and condition of the animal: Manure obtained from the excreta of young animals is poor in N, P and K than the dung of labour animals is like bullock, horses.
4. Function of animal: The dung of milch animals is poorer in N, P and K than the dung of labour animals like bullock, horses.
5. Nature and proportion of litter: Most common litter are wheat, paddy, straw, jawar, bajara and maize stacks.
6. Species of animals: The composition of nutrients varies with ruminant and non-ruminant animals.
7. Handling and storage of manure: If drainage escapes from manure heap, potash is lost.

   Improper handling and storage leads, to losses of plant nutrients.

   Losses during handling:

   The major constituents of FYM are solid (dung) and liquid (urine), which contain N, P2O5 and K2O. Generally the floor of the cattle sheds in India, is incremented due to which the urine passed by animals is absorbed by the floor. Except in the summer season, when the cattle's are left in the field, for the remaining 8-9 months, the urine is soaked by the floor of shed this loosing a large quantity of N_2 through the formation of NH_3.

   So that is

   $CO(NH_2)_2$(Urea in urine) + H_2O $\longrightarrow$ $(NH_4)_2CO_3$

   $(NH_4)_2CO_3$ + $2H_2O$ $\longrightarrow$ $2NH_4OH$ + H_2CO_3

   NH_4OH $\longrightarrow$ NH_4 + H_2O

   Most of the solid dung is lost because it is used as domestic fuel. It is also lost when milch animals go out for grazing in pastures

Losses during storage: Dung and farm wastes that are FYM is generally collected in an open place outside the village. It is exposed to direct sunlight and rain, as a result the nutrients are lost by leaching and volatilisation.

FYM is now prepared in the trenches. Trenches of 6m X 1.5m X 1m are constructed. All the farm waste is heaped near the cattle shed. In the evening a portion of this is spread on the floor of the cattle shed for soaking with urine. Each 7ndmorning it is collected and mixed with the dung and put into the trench. When this trench is filled up to a height of 45-60 cms above ground level, the top of the heap is made some shaped and plastered over with cow dung and earth slurry. After this next 1m length of the trench is taken up for filling. It takes a couple of months to fill one trench. Then similar procedure is followed for the second trench gets filled in the manure in the first trench would be ready for the use in the fields. The empty trench is used again for FYM preparation.

This method gives almost double quantity of manure. The manure is friable, moist and contains more quantity of nitrogen because of the aerobic decomposition, which reduces the losses.

Biogas Plant:

In India about 30% of the energy consumed by the public are biological in nature. The gobar gas plant is based on an aerobic fermentation of organic varieties in the absence of air, increasing the heating efficiency of the cattle dung by about 20% and produce an organic manure which is about 43% better than dry cattle dung itself. The manure can also reduce pressure on naphtha based fertilizers. Biogas is produced by degradation of biological matter by anaerobic bacteria in the absence of free oxygen. Natural gas is also a bio-gas, which results after a long time decay of animal and vegetable matter (buried under the earth) brought about by bacteria in the presence of high temperature, high pressure and radioactive rays.

Cow dung when subjected to the action of various kinds of microorganisms in a closed tank under anaerobic condition undergoes a type of fermentation. As a result dung is converted into gobar gas, which is a mixture of methane, carbon dioxide and minute quantities of other gases. In addition, a slurry rich in combined nitrogen, is also obtained which is used as manure for the fertility of agricultural land. The gas is highly flammable and very useful as a fuel and is used under the name of biogas or gobar gas.

The biogas generator consists of a steel digester dung and set underground by a cement concrete work. The tank is closed once receiving the charge of bacteria and the cow dung. The generator is connected to a pipeline with the gas holder, which is made up of mild steel. The charge consists of cow dung and water in the of slurry. The fermentation is carried out between 35-50° C. About 160 litres of gobar gas are produced per kg of cow dung and the heating value of the gas is 490 kcal. On 160 litres basis. The generated gas is collected in a steel gas holder placed on the top of digestion tank. The plant can digest not only the cattle dung, but also cattle urine, human refuse, poultry sweep etc. The average composition of bio-gas or Gober gas is methane 55%, hydrogen 7.4%, carbon dioxide 35%, nitrogen 2.6% and water in traces. The average gross calorific value is about 5300 kcal/M3. This gas can be carried to distinct places through the pipeline. This gas can be used for heating, lighting and motive power.

The burner and lamps required by it are of different types. It can also be used for running engines and generators by attaching special attachments to the plant.

The manure which is obtained from the plant after the decomposition, is the best and cheap source of replacements of chemical fertilizers.

Limitations:

1. Its production depends on the availability of cattle dung.
2. Gas lamps or burners to be used should be within 10m of the plant.

Use of Chemical There may be loss of nitrogen from FYM which is reduced by the addition of preservatives. The preservatives are directly added to the spread cattle shed, in order to have direct contact with the liquid excreta of animals. The general preservatives used for this purpose are gypsum and superphosphate.

Urea from urine decomposes into ammonium carbonate, which reacts with gypsum to form ammonium sulfate which doesn't liberate ammonia under moist conditions.

$(NH_4)_2CO_3 + CaSO_4 \longrightarrow CaCO_3 + (NH4)2SO4$

Human Waste (Night soil): The soil fertility can be maintained by direct application of human excreta, which consists of the solid portion as faeces and liquid as urine [urine is richer in nitrogen (15%), In big villages night soil compost is prepared by mixing it with dry soil, wood ash or lime. Pits or trenches 10 to 12 ft. Long, 2 to 4 ft. Wide about 1 ft. Deep are made. In these

pits night soil is deposited and covered over on top with a layer of earth or kachra. The material is formed in the above trenches, after they become dry. This preparation is called Poudrette.

A mixture of equal proportions of night soil and ash and 10 percent powdered charcoal produces an odourless material containing 1.3%, 2.8% H_3PO_4, 4.1% KOH and 24.2% calcium carbonate. Human urine contains 1% N, 0.1 to 2% P_2O_5 and 0.2 to 0.3%K_2O. It is mixed with night soil and used as manure. The liquid alone is also used as manure.

Drawbacks of Poudrette system

1. When the night soil starts anaerobic decomposition, various gases like hydrogen sulphide are liberated giving bad smell.
2. It leads to fly breeding.
3. Due to anaerobic condition nitrogen is lost to the greater extent.
4. Due to bad smell, it is difficult to take up field operations with normal class of labourers. Hence special labourers have to be employed.
5. The quantity of manure obtained from Poudrette system is small as compared to the bulk of night soil treated.

Improved method of night soil handling

1. Night soil should be protected from soil and soil breeding.
2. It should be stored in such a way that it does not pollute the supply of drinking water.
3. Pathogens, protozoan cysts worms and eggs should be destroyed before the night soil is applied to land.
4. An attempt should be made to compost the night soil with other refuse in urban areas by town authorities and in rural areas by the farmer himself.

Sewage and Sludge

A. Sewage system: Sewage system of sanitation is the removal of human excreta and other wastes with water. In this system dilution and dispersion of material in solution takes place. Sewage has two component solid or sludge and liquid or sewage water. Both these components are used in increasing the crop production as they contain plant nutrients. It cannot be used for growing vegetables and fruits which are consumed raw or uncooked because they are contaminated with bacteria and are hazardous to health. Both the components can be separated and

given fermentation and oxidation treatments to reduce the bacterial contamination and offensive smell and also to reduce the carbon-nitrogen ratio (10 or 12) of the solid portion. The average composition of sewage is as 6-10% N, 3-4% P_2O_5 and 3.5-4% K_2O

B. Sludge: Solid portion or sludge is separated out and treated before being used as a manure. For this purpose, it is allowed to stand in a septic tank to relieve it of the heavier portion of the solid matter and to undergo fermentation and oxidation of the organic matter in fresh sewage. As a result C:N ratio of sludge is reduced and it is called Activated sludge.

Various types of sludge are produced by different methods of sewage treatment.

Types of Sludges

A. Settled sludge: Produced by plain sedimentation

B. Digested sludge: Due to anaerobic decomposition of sedimented sludge.

C. Activated sludge: produced by a special rapid aerobic treatment of sewage that results in coagulation and settling of suspended materials.

D. Digested activated sludge

E. Chemically Precipitated sludge

Sewage and Sludge are plant nutrients. On an average sewage of Indian cities contains 50 ppm of N, 15 ppm of P, 30 ppm of K and sludge contain 1.5-3.5 of nitrogen, 0.75-4% P_2O_5 and 0.3-0.6% K_2O. They are rich in N and P. They are a good source of micro-nutrients such as B, Mn, Cu, Zn and Fr.

Sewage Irrigation and Uses

The treated effluent of water left after the removal, of sludge is used for irrigation purposes. This is known as sewage irrigation. This effluent is rich in N, P, and K. The effluent from the settling tanks with only anaerobic fermentation treatment still carries a large amount of objectionable colloidal matter. On aerobic it becomes clear, odourless liquid rich in nitrates, free from pathogenic bacterial.

Uses:

1. It can be used for irrigation of field crops only.

2. It cannot be used for growing vegetables like tomatoes, radish onion, garlic, carrots, turnip.
3. It is mixed with river water before being used for field irrigation.
4. Some soaks with high pH develop the sewage sickness by its continued application.
5. It is generally used for raising crops like oats, jawar, maize, sugarcane, cabbage, cauliflower, potato, beans.

Green Manuring

It is mainly used for paddy, irrigated wheat and sugarcane crops. It is of different types depending on the soil and climatic conditions.

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 an inter crop with the main crop. Sanhemp (Crotalaria luncia), dhainch (Sesbonia aculcata), pillipesara(phascolus trilobus) and guar (cyamopsis tetragonoloba) are the most common crops used for green manuring.

Green leaf Manuring:

This refers to turning into soil green leaves and render green twigs collected from shrubs and trees grown on bunds, water lands and nearby forest areas.

Characteristics of good green manuring:

1. It should yield a large quantity of green material within a short period.
2. It should suppress weeds, should be succulent and have more leafy growth.
3. It should preferably be legume, which fixes atmospheric nitrogen.
4. It should have a deep fibrous root system so as to absorb nutrients from lower zones and bring t2jiJJjiJjii8em to surface soil to improve the soil structure.
5. It Should contain large quantities of non fibrous tissues of rapid decomposability containing some percentage of moisture and nitrogen.
6. It should have little water requirements for its own growth and should be capable of making a good stand on poor and exhausted soils.

Advantages of Green Manuring

Green manure

1. It stimulates the activity of soil microorganisms.

2. It adds organic matter to the soil, improves the structure of soil.
3. It improves the fertility of soil.
4. It increases nutrient contents in the soil.
5. It holds plant nutrients that would otherwise be lost by leaching.
6. It facilitates the penetration of rainwater, thus decreasing runoff and soil erosion.
7. The green manure crops nutrients taken by the crop from deep layers and returns to the upper topsoil.
8. When leguminous plants like sanhemp and dhainchs are used as green manure crops they add nitrogen to the soil for the succeeding crops.
9. It increases the availability of certain plant nutrients like phosphorus, calcium, potassium, magnesium and iron.

Disadvantages of green manuring:

1. In case of deficient or scarce rainfall proper decomposition and satisfactory germination of succeeding crop does not take place.
2. It is suitable only for the region's with better irrigation facilities.
3. This manure is more expensive than commercial fertilizer
4. There is possibility of increase of diseases, insects and nematodes.

Biofertilizers:

Biofertilizer is a substance that contains living microorganisms which when applied to seed, plant or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers and nutrients through the natural processes of fixing atmospheric nitrogen, solubilizing phosphorus and stimulating plant growth through the synthesis and stimulating substances.

Classification of biofertilizers:

Depending up their nature and function biofertilizers grouped as follows

Sr. No	Function	Groups	Examples
1	Nitrogen fixing biofertilizers	1. Free living 2. Symbiotic 3. Associative symbiotic	Azotobacter, Nostoc, Rhizobium, Frankia Azospirillum
2	P solubilizing biofertilizers	1. Bacteria 2. Fungi	Bacillus, megaterium van. Phosphatic um Penicillium SP,

			Aspergillus awamori
3	P Mobilizing Biofertilizers	1. Arbuscular mycorrhiza 2. Ectomycorrhiza 3. Orchid mycorrhiza	Glomus SP. Gigaspora Acaulospors SP. Laccaria SP. Amanita Rhizoctonia Solanki
4	Biofertilizers for micronutrients	Silicate and Zinc solubilizers	Bacillus so.
5	Plant growth promoting Rhizobacteria	Psedomonas	Psedomonas fluorescens

Different Types of biofertilizers and their role

1. Rhizobium: This belongs to bacterial group and the classical example is symbiotic nitrogen. It infects the legume root and from root nodules within which they reduce molecular nitrogen to ammonia, which is readily utilized by the plant to produce available proteins, vitamins and other nitrogen containing compounds.
2. Azobacter: It is the most important and we'll known free living nitrogen fixing aerobic bacterium. It is used as a biofertilizer for all non leguminous plants specially rice, cotton, vegetables etc.
3. Azospirillum: It belongs to bacteria and is known to fix the considerable quantity of nitrogen in the range of 20 -40kg N/ha in rhizosphere in non-leguminous plants such as cereals, millets, oilseeds cotton etc. It stimulates growth and imparts green colour which is characteristic of a healthy plant.
4. Azolla: It is a free -floating water fern that floats in water and fixes atmospheric nitrogen in association with nitrogen fixing blue green alga Anabaenaazollae. It is considered to be a potential biofertilizer in terms of nitrogen contribution to rice.
5. Acetobaceter: It is a saccharophillic bacteria and associated with sugarcane, sweet potato and sweet sorghum plants and fixes 30kg/N/ha year. It is commercialized for sugarcane crop. It is known to increase yield by 10-20t/acre and sugar by about 10-15%.

Application of biofertilizers to crop

1. Seeding root dip: This method is applied to the rice crop. A bed of water is spread on the land where the crop has to grow. The seeds of rice are planted in the water and are kept there for 8-10 hours.
2. Seed treatment: In this method the nitrogen and phosphorus fertilizers are mixed together in the water. Then the seeds, dip in this mixture. After the application of this paste to the seeds, the seeds are dried. After they dry out, they have to be sown as soon as possible before they get damaged by harmful microorganisms.
3. Soil treatment: All the biofertilizers along with the compost fertilizers are mixed together. They are kept for one night. Then the next day this mixture is spread on the soil where the seeds have to be sown.

Comparison between Biofertilizers and Chemical fertilizers

Biofertilizers	Chemical fertilizers
They are non-toxic, provide more nitrogen and ensure ecological stability to the soil.	They are toxic and pollute the water and disturb the ecological balance.
They are comparatively cheaper	They are costly and even increasing prices of petroleum products.
Being priced low within the reach of the poor farmers.	Low purchasing power of small farmers.
A concrete tank is sufficient for its production.	Its production requires the setting up of big plants involving huge investment.
They have the capacity to hold water. e.g. blue green algal.	They do not hold water.

Advantages of Biofertilizers:

The advantages of biofertilizers are listed below-

1. Longer shelf life 12-24 months.
2. No contamination.
3. No loss of properties due to storage up to 45ºC.
4. Greater potentials to fight with the native population.
5. Easy identification by typical fermented smell.
6. Better survival by typical fermented small.
7. Very much easy to use by the farmer.

Biofertilizers are however still not popular due to

1. Lack of proper education to the farmer
2. Lack of proper marketing and distribution channels.
3. Lack of quality of guarantee product.

It seems that day is not far off when biofertilizers will replace chemical fertilizers for an era of prosperity and clean environment.

Reference: Text book of Agricultural Chemistry by By Adhav-Date-Shinde-Khot