5. FERTILISERS AND MANURES

MANURES

Definition: “Materials which are organic in origin, bulky and concentrated in nature and capable of supplying plant nutrients to soil is called manures.” Manures help to improve soil physical environment having no definite chemical composition with low analytical value produced from organic, plant and other organic wastes and by products. Organic manures include well rotten farm yard manures (FYM), compost, green manures etc.

CLASSIFICATION OF MANURES

The organic manures may be classified into two groups

(i) Bulky organic manures and

(ii) Concentrated organic manures.

Bulky organic manures generally contain less amount of plant nutrients as compared to concentrated organic manures. Concentrated organic manures are mainly derived from raw materials of animal or plant origin. No definite composition of NPK and other micronutrients.

EFFECT OF BULKY ORGANIC MANURES ON SOIL

Organic manure contain two components i.e. plant nutrient and organic matter, when it is applied into the soil it will act as follows.

(i) Manure when added to soil increase the organic matter content and improve physical condition of the soil. Such as soil structure, aeration, water holding capacity etc.
(ii) They add plant nutrients in small percentage and increase the fertility of the soil. Besides N, P, K they also add micronutrients which are very essential for plant growth in an available form.

(iii) It also stimulates the activity of different soil microorganism through the supply of energy.

(iv) It improves the buffering and exchange capacities of the soil and also influences the solubility of soil minerals as well as mineral nutrients in soil.

(v) It also forms chelates and helps for the nutrition of plants.

FARM YARD MANURES

“Farm yard manure is a mixture of cattle dung, urine, litter or bedding material, portion of fodder not consumed by cattle and other domestic wastes like ashes etc. collected and dumped into a pit or heap in corner of the back yard”. It is allow remaining there and rotting till it take out and applied to field. Composition of manure is variable depending upon the nature of material. But on an average well-totted FYM contain 0.5 % N, 0.2 % P$_2$O$_5$ and 0.5 % K$_2$O.

Factors affecting the composition of farm yard manure:

1. **Source of manure**- Dung and urine voided by the different animals varies considerably in quality. The dung and urine of sheep is richer than dung and urine of cow and bullock. The quality also depends on the proportion of urine present in the FYM. Urine of cattle and horses is nearly two and half time richer in nitrogen content than the dung but in case of pig it is not so. Sheep and goat dung is richer in P$_2$O$_5$.

2. **Food of the animal**- This is one of the most important factors that determines the manure quality. e.g. The richer the food in proteins, the richer will be the manure in nitrogen.

3. **Age and condition of the animal**- Young animals need more protein to build of their body. The manure obtained from them is poorer in nitrogen than from old animals. A sick animal will not digest food properly and its dung is reacher than that of healty animal.

4. **Function of the animal**- The quality of dung from cow in milk will differ from a bullock doing hard work and a dry cow. The cow will need more proteins mwhile bullock will need more carbohydrates. The dung from cow in milk will be poorer in N, P, K than the dung from bullock.
5. **Nature and proportion of litter**- The most common litter in FYM are wheat, paddy, straw, jowar, bajri and maize kadbi (stalks).

6. **Species of animals**- The composition of nutrients varies with the ruminant and non-ruminant animals.

7. **Handling and storage of manures**- potassium is lost from manure if drainage is allowed to escape from the manure heap. Therefore improper handling and storage leads to losses of plant nutrients from the manures.

**Losses during handling and storage of FYM**

**A) Losses during handling:** The FYM consists of two original components
   (i) The solid or dung and
   (ii) The liquid or urine. Both the component contains N, P₂O₅ and K₂O.

   To conserve N, P and K it is most essential that both the parts of cattle manure are properly handled and stored.

1. **Loss of liquid portion or urine:** The floor of the cattle is uncemented or kachha. As such, the urine passed by animals during night gets soaked into the kachha floor. When the animals are in field the urine is soaked in the soil of field but at the time of night large amount of urine are lost in the kachha floor. Large quantity of nitrogen is lost through the formation of gaseous ammonia.

2. **Loss of solid portion or dung:** The most serious loss of dung is through cakes for burning or for use as fuel. Secondly, when milk animals go out for grazing the dung dropped by them is not collected and large amount is lost.

**B) Loss during storage:**

The manure remains exposed to the sun and rain. During such type of storage, leaching and volatilization lose nutrients. Due to leaching and volatilization, the FYM loses half its fertility if exposed to the weather during storage.

**IMPROVED METHODS OF HANDLING FYM**

**1) Trench method of preparing FYM:**

C.N. Acharya has recommended trench method of preparing FYM according to which trenches of suitable size, say 6 m long, 1.5 m broad and 1 m deep are constructed. All available dry litter and bedding and other material from the farm is heaped near the cattle shed. A portion of this is spread on the floor of the cattle shed in the evening for absorption
of urine. Each morning the urine soaked litter and dung is well mixed and taken to manure trench. A section of one-meter length of the trench from one end is taken up for filling with the daily collection of dung mixed with urine soaked litter. When the section is filled up to a height of 45-60 cms above ground level, the top of the heap is made dome shaped and plastered over with cow dung earth slurry, after which next one meter length of the trench is taken up for filling.

When an entire trench is filled up, second trench is taken up for filling. The manure in the first trench is completely decomposed and ready for use in field. The empty trench can be used again for manure preparation. Two such trenches would normally be sufficient for a farmer with about 4 to 5 cattles. If the numbers of cattles are more, then increase the length of trench. The manure is friable, moist and contains more quantity of nitrogen.

(2) Use of Gober Gas – Compost plant:

More than 50% of cow dung available in the country is made into cakes and burnt as a fuel for cooking purpose by the cultivators. The use of cow dung gas plant to produce a combustible gas called methane is an improved method of handling FYM.

Construction of gober gas plant is very simple. It has mainly two parts, the digester and gas container. The gas digester is a type of well which is dung and built below the ground level having a depth of 370 to 610 cm. With 120 to 610 cm diameter depending upon the capacity.

![Fig. Gober gas plant](image-url)
This digester has a partition wall in the center dividing it into two semi-circular compartments. It has two slanting cement pipes serving as inlet and outlet pipes. Fresh dung mixed with water flows into the digester through the inlet pipe and after decomposing for nearly a month, it comes out in the form of slurry through the outlet pipe and stored in the manure pits. After drying the slurry could be used as manure in the farms. During the decomposition process, methane which is produced is stored in the gas container, which is a drum constructed of mild steel sheets. There is supply pipe fitted on the top of the drum, which carries methane gas for cooking to the desired place - the kitchen or gas lamp. The gas produced is a mixture of 50-60% methane, 30 to 40% carbon dioxide and about 10% hydrogen.

**Advantages of gober gas:**

(i) Methane gas produced by these gas can be used for heating, lighting and motive power. It requires burners and lamps which are different types of appliances from the ones required by coal and indane.

(ii) The methane gas can be used for running oil engine and generators.

(iii) The manure which comes out from the plant after decomposition is quite rich in nitrogen (1.2 to 1.5%). It also contains phosphorus, potash and number of many other micronutrients like zinc, sulphur and iron.

(iv) Gober gas plant is extremely cheap and is made by locally available material. Therefore it is set in villages, which can’t afford chemical fertilizers.

(v) The prolonged use of organic manures maintains as well as builds the fertility of the soil. Which can be lossed by inorganic fertilizers.

**Human excreta (Night soil):**

Night soil is human excrement- soild and liquid. In china, it has been directly used to the land for more than two thousand years and this practice has been one of the chief factors in maintenance of soil fertility in china. In India, it is not applied directly to the soil, except in villages where there are no sanitary arrangements or public latrines and villagers go to the field and cover night soil with earth. In big villages night soil compost is being prepared and has been found to the most continent method of disposal of night soil. In some villages, night soil is dehydrated by mixing it with suitable material such as dry soil, wood ash or limes. Such a preparation is called poudrette.
Mixing of night soil with an equal volume of ash and 10% powdered charcoal produces an odourless material containing 1.3% nitrogen, 2.8% phosphoric acid, 4.1% potash and 24.2% lime.

Human urine contains 1% N, 0.1 to 0.2% P\(_2\)O\(_5\) and 0.2 to 0.3% K\(_2\)O. it is usually mixed with night soil and used as manure. The liquid may also be used as manure.

**SEWAGE AND SLUDGE**

In the modern system of sanitation adopted in cities, water is used for the removal of human excreta another wastes. This called the sewage system of sanitation. In this system, there is considerable dilution of the material in solution and in dispersion. In fact water is the main constituent of sewage, amounting often to 99.0%.

In general, sewage has two components namely (i) solid protein- technically known as sludge. (ii) Liquid portion commonly known as sewage water. Both the component of sewage is used in the increasing crop production, as they contain plant nutrients. However due to high bacterial contamination, untreated sewage should not be used for growing vegetable and other crops to be consumed raw or uncooked by human beings, since these crop also carries bacterial contamination and are a real danger for health.

(1) Sludge: In the modern system of sewage utilization, solid portion or sludge is separated and given a primary treatment before its use as manure. For this purpose sewage is used to stand in a settling or septic tank to settle heavier portion of the solid matter and also to undergo a preliminary fermentation and oxidation of the organic matter in fresh sewage. This reduces the C: N ratio of the sludge.

A number of sludge types are produced by the different methods of sewage treatment. They may be classified as follows.

(i) **Settled sludge**- produced by plain sedimentation.

(ii) **Digested sludge**- Resulting from anaerobic decomposition of sedimented sludge.

(iii) **Activated sludge**- produced by a special rapid aerobic treatment of sewage that results in coagulation and settling of suspended materials.

(iv) **Digested activated sludge**.

(v) **Chemically precipitated sludge**.

**Characteristics:**

(i) Sewage and sludge vary considerably in their plant nutrients, depending on the decomposition of the sewage and method by which it has been prepared.
(ii) On an average, the sewage of Indian cities contains **50 ppm of nitrogen, 15 ppm of phosphorus** and **30 ppm of potassium**. Sludge on an average contains **1.5 to 3.5 % nitrogen, 0.75 to 4.0 % P₂O₅ and 0.3 to 0.6 % K₂O**. Sludge are in general rich in nitrogen and phosphorus, while they are low in potash.

(iii) As a variety of wastes goes into sewage and as urban population consume foods which are often brought from a number of agricultural areas, the sludge may be a good source of micronutrients elements such as boron, manganese, copper, zinc and iron.

(2) Sewage irrigation:

When raw sewages is treated to remove the solid portion or sludge, the water, technically known as treated effluent is used for irrigation purposes. Such a system of irrigation is known as sewage irrigation. The field crops when irrigated with sewage water, receive nitrogen, phosphorus and potash. Sewage water can be used for raising all field crops. It is not advisable to grow vegetables, which are eaten raw or uncooked viz. tomatoes, radish, onion, garlic, carrots, and etc. with sewage water. Sewage water is mixed with river water before using for irrigation.

GREEN MANURING:

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

(1) Types of green manuring:

The practice of green manuring is adopted in various ways in different states of India to suit soil and climatic conditions. Broadly there are two types of green manuring.

1) **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 pure crop or as a intercrop with the main crop. The most common green manure crop grown under this system are sannhemp, dhaincha, pillipesara and guar.

2) **Green leaf manuring**: Green leaf manuring 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 common shrubs and trees used are Glyricidia, sesbania speciosa, karanj, etc.
(2) Advantages of green manuring:

1) It adds organic matter to the soil. This stimulates the activity of soil microorganisms.
2) The green manure crops return to upper top soil, plant nutrients take by the crop from deeper layer.
3) It improves the structure of the soil.
4) It holds plant nutrients otherwise it will be lost by leaching.
5) When leguminous plants, like sannhem and dhanchia are used as green manuring crops, they add nitrogen to the soil for the succeeding crops.
6) It increases the availability of certain plant nutrients like $P_2O_5$, calcium, potassium, Magnesium and iron.

(3) Disadvantages of green manuring:

Green manuring shows some disadvantages, when the proper technique of green manuring is not followed. Some disadvantages are as follows.

1) If insufficient rainfall, there is not proper decomposition of the green manuring and satisfactory germination of the succeeding crop. This generally applies to the wheat region of the India.
2) Since green manuring for wheat means loss of kharif crop, the practice of green manuring may not be always economical. This may be applied to the regions where irrigation facilities are available for raising kharif crop along with easy availability of fertilizers.
3) An increase of diseases, insects and nematodes are possible.

(4) Characteristic of green manuring crops:

A green manuring crop has following characteristics.

1) It should yield a large quantity of green material within a short period.
2) It should be quickly growing especially in the beginning, so as to suppress weeds.
3) It should be have more leafy growth than woody growth, so that its decomposition will be rapid.
4) It should preferably be a legume, so that atmospheric will be fixed.
5) It should have deep and fibrous root system so that it will absorb nutrients from lower zone and add them to the surface soil and also improve soil structure.
6) It should be able to grow even on poor soils.
FERTILISERS

Definition: “Fertilisers are defined as materials having definite chemical composition with a higher analytical value and capable of supply plant nutrients in available form.” Fertilizers are now regarded as one of the major inputs in intensive cultivation programme.

Essential requirements of good fertilizers:
Every compound containing nitrogen and phosphorus or calcium etc. can’t be used as a fertilizer.
(i) The elements present in the compound must be easily available to the plants.
(ii) The substances must be soluble in water.
(iii) It should be stable, so that it may be available to the plant for a long time.
(iv) It should not be very costly.
(v) It should maintain pH of the soil in the vicinity of 7 to 8.
(vi) It should be a poison for plant.

CLASSIFICATION OF FERTILISERS:
Fertilizers are usually classified according to their mode of operation on the soil.
1) Complete fertilizers: Those fertilizers which provide all the essential elements such as NPK etc. required for plant growth. Guano is the example of complete fertilizers.
2) Incomplete fertilizers: Those fertilizers which contain only one primary or major nutrient element. e.g. ammonium sulphate \((\text{NH}_4)_2\text{SO}_4\), Urea \(\text{CO(NH}_2\text{)}_2\).
3) Straight fertilizers: Chemical fertilizers, which contain only one primary or major nutrient elements produced by mixing or by the process of chemical reactions. e.g. 10:20:20, DAP (diammonium phosphate) etc.

There are generally three types of chemical fertilizers available in the market namely nitrogenous, phosphatic and potassic fertilizers.

NITROGENOUS FERTILIZERS

CLASSIFICATION OF NITROGENOUS FERTILISERS:
Nitrogen fertilizers can be classified into four classes on the basis of forms of N present in straight nitrogenous fertilizers as given in table.
### Fertilizers and Manures

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Class</th>
<th>Fertilizers</th>
<th>% N</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nitrate nitrogen</td>
<td>(i) sodium nitrate</td>
<td>16.00</td>
<td>Basic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) calcium nitrate</td>
<td>15.50</td>
<td>Basic</td>
</tr>
<tr>
<td>2</td>
<td>Ammoniacal nitrogen</td>
<td>(i) Ammonium sulphate</td>
<td>20.00</td>
<td>Acid forming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Ammonium chloride</td>
<td>24-26</td>
<td>Acid forming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Unhydrous ammonia</td>
<td>82.00</td>
<td>Acid forming</td>
</tr>
<tr>
<td>3</td>
<td>Both nitrate and ammoniacal</td>
<td>(i) Ammonium nitrate</td>
<td>33-34</td>
<td>Acid forming</td>
</tr>
<tr>
<td></td>
<td>nitrogen</td>
<td>(ii) Calcium ammonium nitrate</td>
<td>20.00</td>
<td>Neutral</td>
</tr>
<tr>
<td>4</td>
<td>Amide nitrogen</td>
<td>(i) Urea</td>
<td>46.00</td>
<td>Acid forming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Calcium cyanamide</td>
<td>21.00</td>
<td>Basic</td>
</tr>
</tbody>
</table>

The most important and widely used nitrogenous fertilizers are ammonium sulphate and urea.

**Action of ammonium sulphate as fertilizer in soils:**

The solution of ammonium sulphate is acidic to litmus. Nitrogen is present in cationic form $\text{NH}_4^+$. So this form of nitrogen is retained by soil colloids. Though it is soluble in water it is not lost from the soil as the exchange complex holds ammonium ions.

$$\text{Ca-soil colloids} + (\text{NH}_4)_2\text{SO}_4 \leftrightarrow (\text{NH}_4)_2\text{- soil colloids} + \text{CaSO}_4 \downarrow$$

Calcium sulphate so formed may be leached and lost in drainage water. In this way the loss of soil calcium ($\text{Ca}^{2+}$) takes place due application of ammonium sulphate fertilizers. The ammonium ions on the soil is directly taken by the plants. Continuous use of $(\text{NH}_4)_2\text{SO}_4$ will lower the pH of the soil therefore this fertilizers is suitable for neutral, calcareous, saline and alkaline soils.

The ammonium carbonate is unstable and decomposes easily to give $\text{NH}_3$, $\text{CO}_2$ and $\text{H}_2\text{O}$. The losses of nitrogen from ammonium sulphate applied as broadcast in calcareous soils may be appreciable. It should not be applied very close to seed to avoid bad effects on seed germination.

**Reaction of Urea as fertilizer in soil:**

It is a white solid fertilizer containing 46% nitrogen.

$$\text{NH}_2\text{-CO-NH}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{N-COONH}_4$$

Ammonium carbamate (unstable)
H₂N-COONH₄ → 2NH₃ + CO₂

Ammonium carbamate Ammonia

It is hygroscopic in nature and therefore unstable compound known as ammonium carbamate. This NH₃ is converted to NH₄⁺ ions by accepting one proton (H⁺) from proton donor and forms NH₄OH or any other NH₄⁺ ion compounds depending on the nature of the donor.

\[
\text{NH}_2\text{-CO-NH}_2 + \text{H}_2\text{O} \xrightarrow{\text{Enzymatic hydrolysis by urease}} (\text{NH}_4)_2\text{CO}_3
\]

\[
(\text{NH}_4)_2\text{CO}_3 + 3\text{O}_2 \xrightarrow{\text{Microbial oxidation}} 2\text{HNO}_2 + 3\text{H}_2\text{O} + \text{CO}_2
\]

\[
2\text{HNO}_2 + 2\text{O}_2 \xrightarrow{\text{Microbial oxidation}} 2\text{HNO}_3
\]

Urea is applied in soils rich in organic matter so that ammonium ions can be held by the soil colloids. In high concentration of urea, there is combined toxic effect of NH₃ and NO₂ (nitrite). Due to higher concentration of ammonia, the conversion of NH₄ → NO₂ will increase.

Conversion of urea into ammonical and nitrate forms is complete in about a week. As such it is advisable to apply urea three to four days before sowing of any field crop.

**PHOSPHATIC FERTILIZERS**

The plant nutrient content of all phosphatic fertilizers is expressed in terms of percentage of phosphorus pentoxide (P₂O₅). All crops absorbs phosphorus in the form of negatively charged ions as HPO₄²⁻ or H₂PO₄⁻. The three replaceable ions of phosphoric acid combines with Ca²⁺ to form three different combined salts, of calcium and phosphorus resulting different classes of phosphatic fertilizers.

**Classification of phosphatic fertilizers:**

Phosphatic fertilizers can be classified into three groups on the basis of forms in which orthophosphoric (H₃PO₄) acid combines with calcium.

1) **Water soluble, monocalcium phosphate** [Ca(H₂PO₄)₂] Example- superphosphate
   1. **Single superphosphate** (SSP) 16-18 % P₂O₅,
   2. **Double superphosphate** (DSP) 32 % P₂O₅,
   3. **Triple superphosphate** (TSP) 46-48 % P₂O₅.
They contain water-soluble phosphorus and can easily available to plants as H$_2$PO$_4^-$ ions. This class of fertilizers is rapidly transformed in the soil into water insoluble form. These fertilizers should be used on neutral to alkaline soils but not on acidic soils. Under acidic conditions, water-soluble phosphoric acid gets converted into unavailable iron and aluminium phosphates.

(2) Citric acid soluble, dicalcium phosphate [CaH$_2$(PO$_4$)$_2$ or CaHPO$_4$]

Example- Basic slag (14-18 % P$_2$O$_5$), Dicalcium phosphate (34 – 39 % P$_2$O$_5$)

The fertilizers of this group are particularly suitable for the acidic soils because with low pH, citrate soluble phosphoric acid gets converted into monocalcium phosphate or water soluble phosphate and there is less chances of phosphatic getting fixed on iron and aluminium phosphate.

(3) Phosphatic fertilizers not soluble in water or citric acid:

Tricalcium phosphate [Ca$_3$(PO$_4$)$_2$] Example-

1. Rock phosphate (20-40 % P$_2$O$_5$),
2. Raw bone metal (20-25 % P$_2$O$_5$),
3. Steamed bone metal (22 % P$_2$O$_5$).

These fertilizers are well suitable for strongly acidic soils or organic soils, which require large quantities of phosphatic fertilizers to raise the soil fertility. In India, the most important phosphatic fertilizers are used by farmers are superphosphate and rock phosphate.

Reactions of superphosphate as fertilizer in soils:

When superphosphate is applied to a moist soil or to a dry soil before rainfall or irrigation, the monocalcium phosphate gets dissolved in the soil moisture. The roots of growing plants easily take up this form of phosphoric acid. In the mean while, within a very short period, the solution of monocalcium phosphate is precipitated in the soil pores. Depending on the soil pH, different phosphate compounds are formed. These new compounds are not soluble in water and thus superphosphate is not leached from the soil by rain.
POTASSIC FERTILIZERS

Potash fertilizers are applied to the soil to supply the potassium to plants, which is one of the essential for the plant growth. The potassium in fertilizer is expressed as K₂O and is commonly referred to as potash.

Potassium is a soft, gray metal that reacts vigorously with water and so it is never found in free state. On exposure to the air, it rapidly oxides to K₂O. This combines with water to form potassium hydroxide. For this purpose potassium is not used in the elemental form as fertilizers, it is used in the combined form. The most common potassium fertilizer is potassium chloride (muriate of potash), potassium sulphate and potassium nitrate. These salts of potassium are easily dissolves in water and split up into potassium ions and appropriate ions.

Classification of potassic fertilizers:
(i) Fertilizers having K in the chloride form e.g. muriate of potash (KCl)
(ii) Fertilizers having K in the non-chloride form e.g. sulphate of potash (K₂SO₄), Potassium nitrate (KNO₃).

Reactions of potash fertilizers in soil:
Potassium chloride and potassium sulphate in soil ionizes into K⁺, Cl⁻, SO₄²⁻ ions. The released potassium ions from the fertilizers get absorbed on the soil colloids and also available to the plants through cation exchange reactions. When potassic fertilizers are applied to acidic soils, chloride ion replaces the OH- ions associated with the free iron oxides and therefore in such soils, muriate of potash is likely to give a greater response than K₂SO₄.

In alkaline soils, when muriate of potash is applied, then accumulation of chloride ions create toxic to plants. So in potash deficient soils with alkaline reactions, it should be applied along with organic matter.

COMPLEX FERTILIZERS

Complex fertilizers may be defined as a material containing all three primary nutrients (NPK) and it is also designated as complete complex fertilizers, while a fertilizer material containing only two of the primary nutrient elements (N and P or P and K etc.) are known as incomplete complex fertilizers. e.g. Nitrophosphate, monoammonium phosphate 10:52:0, Diammonium phosphate (DAP) 18:46:0 or 20:48:0.
Chief characteristics of complex fertilizers:

(i) They usually have high content of plant Nutrients.

(ii) They usually have a uniform grain size and good physical conditions.

(iii) They supply N and P in an available form to the soil in one operation.

(iv) Manufacture cost of it is high but they cheaper to the cultivator when the cost is worked out on the basis of per kg of plant nutrient.

(v) They are non caking and non hygroscopic, thus safer for storage.

In India, different types of nitophosphates are manufactured and marketed as their different grades and commercial names. The most important grades of nitrophosphates is 20:20:0, besides these, there are various other commercially produced complex fertilizers- suphala of different grades- 15:15:15, 20:20:20 etc.

MIXED FERTILIZERS

A mixture of two or more straight fertilizers materials is referred to as fertilizer mixture (Mixed fertilizers). Sometimes complex fertilizers containing two plant nutrients are also used in formulating fertilizer mixtures. Balanced nutrition is the key to successful agriculture. Fertilizer mixtures achieve it. However, mixing of proper proportion of straight fertilizer is very important. Mixing depends upon the climate, storage conditions, properties of fertilizers and reactions that occur between the fertilizers.

Advantages of mixed fertilizers:

(i) They save the cost of application of fertilizers.

(ii) It possess better physical conditions and can be drilled more easily than the single fertilizers, specially if the mixture is granular.

(iii) The application of nutrients required in small amounts is possible in a more evenly manner when mixed with other fertilizers rather than when applied single.

(iv) The application of fertilizer mixture ensures the balanced use of nutrients.

(v) Mixture can be prepared in such a way so as to correct the residual acidity of certain nitrogenous fertilizers in soils.

(vi) If the mixture is prepared on the basis of the soil test data and crop requirement, the soils will have the right proportion of plant nutrients.

(vii) In foreign countries, fertilizer mixtures are so prepared that they include certain essential nutrients
Disadvantages of mixed fertilizers:

(i) Due to use of mixed fertilizers individual fertilizers may not get at a specific period.

(ii) The unit cost of individual plant nutrients in mixtures is usually higher than of those in straight fertilizers.

(iii) Soil testing is not available to every farmers and farmers can add less or more nutrient contents without requirement of plant.

In mixed fertilizers chemical reaction can be formed and composition of fertilizers may be changed. e. g. mixing of ammonium sulphate with lime will result in loss of ammonia. Bone meal can be mixed with all fertilizers and hence it is used extensively in preparing fertilizer mixture.

A variety of mixed fertilizers can be used for different crops. Various state department of agriculture have prepared a list of approved fertilizers with definite composition that can be marketed to the cultivators.

In Maharashtra, some of the following mixtures are approved as shown in table.

Table: composition of mixed fertilizer recommended for crops

<table>
<thead>
<tr>
<th>Type</th>
<th>% N</th>
<th>% P</th>
<th>% K</th>
<th>Crop for which recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>Rice, Wheat, Cotton &amp; other cereal crops</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>05</td>
<td>10</td>
<td>Rice, Wheat, Cotton &amp; other cereal crops</td>
</tr>
<tr>
<td>3</td>
<td>05</td>
<td>10</td>
<td>10</td>
<td>Groundnut</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>Vegetables &amp; Fruits</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>05</td>
<td>05</td>
<td>Sugarcane</td>
</tr>
<tr>
<td>6</td>
<td>09</td>
<td>09</td>
<td>05</td>
<td>Potato, Sugarcane, Fruit crops</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>18</td>
<td>10</td>
<td>High yielding varity of paddy, wheat, hybrid jowar, bajara &amp; maize.</td>
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Mode of application of fertilizers:

Fertilizer can be applied in solid as well as in liquid state.

1) Application of fertilizers in solid form

   a) Broadcast: (i) Broadcasting at planting (ii) Top dressing

   b) Placement: (i) Plough- sole placement (ii) Deep placement (iii) Sub soil placement
c) Localized placement: (i) contact placement, combined drilling or drill placement (ii) Band placement (iii) pellet application (iv) side dressing.

2) Application of fertilizers in liquid form
   a) Starter solution
   b) Foliar application or spray fertilization
   c) Direct application to the soil
   d) Application through irrigation water.

(1) Application of fertilizers in solid form:
   (a) Broadcast: In broadcasting, the fertilizer is spread over the entire soil area to be treated, with the main objective of disturbing the whole quantity of fertilizer evenly and uniformly. This may be done before the land ploughed, immediately before planting or while the crop is standing. Accordingly two types of broadcasting-

   (i) Broadcasting at planting: The main objectives of Broadcasting at planting are-
      (I) To distribute the fertilizers evenly and to incorporate it with part of or throughout the plough layer and (II) To apply large quantities.

   (ii) Top dressing: When crop is closely spaced, like wheat and barley, spreading of fertilizers in the standing crop is known as top-dressing. Nitrogenous fertilizers containing nitrate nitrogen, like sodium nitrate, calcium ammonium nitrate, ammonium sulphate-nitrate and ammonium nitrate are applied as a top dressing to closely spaced crops like paddy and wheat.

      Care must taken in top dressing that the fertilizers are not applied when the leaves of plants are wet; it may burn or scorch the leaves. This injury is greater with nitrogenous and potassic fertilizers than with phosphatic fertilizers.

   (b) Placement: In this method fertilizers are applied at the position of seed, seedling or growing plants before sowing or after sowing the drops. The following methods are most common.

   1) Plough-sole placement: With the plough-sole method, the fertilizer is placed in a continuous band on the bottom of the furrow during the process of ploughing. Each band is covered as the next furrow is turned. This method has been recommended in areas where the soil becomes quite dry up to a few inches below the soil surface during the growing season, and especially with soils having a heavy clay pan a little below the plough-sole. By
this method, fertilizer is placed in moist soil where it can become more available to growing plants during dry seasons.

(ii) **Deep placement of nitrogenous fertilizers:**
In this method, ammonical fertilizer is placed in the reduction zone, where it remains in ammonia form and is available to the crop during the active vegetative period. This method prevents loss by surface drain-off. Deep placement is done in different ways, depending upon the local cultivation practices.

(iii) **Sub soil placement:** In this method fertilizer are placed with the help of heavy power machinery. This method is recommended in humid and sub-humid region where many sub-soils are strongly acid. Due to acidic solutions, the level of available plant nutrient is extremely low. Especially phosphatic and potassic fertilizers are placed in the sub-soil for better root development.

(c) **Localized placement:** This method is used to apply fertilizers into the soil close to the seed or plant. This method is used when relatively small quantity of fertilizers is applied to the plants. When fertilizers are added near the plant root, roots get it very easily and growth of the plant increases fastly. Various methods are used to place fertilizers close to the seed or plant.

i) **Contact placement, combined drilling or drill placement:**
In this method seed and small quantity of fertilizers are placed in the same row. This method is useful in applying phosphatic and potassic fertilizers to cereals (wheat, barley, jowar, bajra etc.), cotton and grasses. But due to this type of placing sometimes plant may injure or damage due to excessive concentration of soluble salts.

It is not suitable for legumes like gram, peas, beans, soyabean and moong, as even a small dose of fertilizer may damage germination if it is drilled with the seed.

(ii) **Band placement:** In this method, the fertilizer is placed in bands. These bands may be continuous or discontinuous. They are of two types: Hill placement and row placement. Hill placement: when the plants are spaced 90 cm or more on both sides, fertilizers are placed close to the plant in bands in one or both sides of the plant. This is known as hill placement. In India, hill placement is applied for nitrogenous and phosphatic fertilizers to orange, bananas, papaya, apples, pears, and coconut.
Row placement: When the seeds of plants are sown close together in a row, the fertilizer is put in continuous bands on one or both sides of the row by hand or a seed drill. This method of application is known as row placement. This method is applied for sugarcane, potato, maize, tobacco, cotton, cereals and vegetable crops. Row placement is used when quantity of fertilizer is high and row placement is used when small amount of fertilizer is applied

(iii) Pellet application: This localized placement method. Nitrogenous fertilizers are applied 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 into dough. Small pellets of a convenient size are then made and deposited in the soft mud of paddy field.

(iv) Side dressing: In this method, fertilizers are spread in between the rows or around the plants. The common methods, which can be classified in side dressing are:

(a) Application of nitrogenous fertilizers in between the rows by hand to broad row crops like maize, sugarcane, tobacco, jowar, barley, cabbage, tomato, cotton etc. this is applied to supply additional dose to growing plants.

(b) Application of mixed or straight fertilizers around the base of the fruit trees like papaya, banana, orange, grape, apple, mango etc. this is done once, twice or thrice a year, depending on the age of fruit trees.

(2) Application of fertilizers in liquid form: Four primary methods are used.

(i) Starter solution

(ii) Foliar application or spray fertilization

(iii) Direct application to the soil

(iv) Application through irrigation water.

(i) Starter solution: Solution of fertilizers, generally consists of N, P, K in the ratio of 1:2:1 and 1:1:2 are applied to young vegetables at the time of transplanting. This solution is known as starter solution. These are used with the watering to the plants. The starter solution has two advantages:

(a) The nutrients reach the plant roots immediately and

(b) The solution is sufficiently diluted so that it does not inhibit
FACTORS AFFECTING EFFICIENCY OF FERTILIZERS

Fertilizer efficiency is defined as the percentage of added fertilizer that is actually used by the plants.

There are several factors influence fertilizer use efficiency in crop production. This include-

(i) Type of soil and its fertility.
(ii) Cropping history.
(iii) Season in which crop is grown.
(iv) Nature of crop, variety and its growth habit.
(v) Sowing time, plant population.
(vi) Type, quantity, time and method of fertilizer applied.
(vii) The method, quantity and frequency of irrigation.
(viii) How the soil moisture is conserved in case of rain fed or unirrigated crops.
(ix) The extent and the manner in which the weeds, the pests and the diseases are controlled.

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