6. Plant Nutrition

Recall a little

1. Any living thing requires food (nutrition) for their growth, development and maintenance.
2. The food of plant is composed of certain chemical elements which are referred to as essential nutrients.
3. These elements are absorbed by plant roots principally as inorganic ions derived mostly form mineral constituents of the soil.
4. Depending upon the availability of the nutrients in soil, the nutrients content in a plant could be deficient, insufficient, sufficient, excess or toxic.

6.1 Essential elements

6.1.1 Definition

The elements needed by the plant for their growth, development and completion of life cycle, without which plant will not be able to survive are called as essential elements.

Remember this

Dr. Daniel Israel Arnon
14 Nov 1910 to
20 Dec 1994

Polish born American plant physiologist whose research led to greater insights into the operation of photosynthesis in plants. He was awarded national medal of science in 1973. He suggested criteria of essentiality in 'plant nutrition, (1954).

6.1.2 Criteria of essentiality

For an element to be regarded as an essential nutrient the following three criteria have been suggested by the scientist Arnon (1954).

1. The plant may be unable to grow normally or complete its life cycle in the absence of the element.
2. The element is specific and can not be replaced by any other element.
3. The element plays a direct role in the process of metabolism.

The following elements are recognized as essential (major) for plant growth. They are Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo) and Chlorine (Cl).

Now a days sodium (Na), Cobalt (Co), Silicon (Si) and some other elements are also being added to this list as supporting ones (minor).

6.1.3 Sources of elements

The deficiency symptoms of an element can be corrected by the application of that element. (see table 6.1)

Can you tell?

1. Can we consume variety of food items in our daily life i.e. vegetables, fruits, rice, milk, salt, etc. in equal quantity?
2. What is the food of plants?
3. Whether the plants require all nutrients in equal quantity?

Table 6.1 : Sources of elements

Natural Source	Nutrient	Usable form by plant	Specific source
Air	Carbon (C), Oxygen (O)		CO_2, O_2
Water	Oxygen (O) Hydrogen (H)		H_2O and O_2 H_2O
Soil	Nitrogen (N)	NO_3^- (Nitrate - anian) NH_4^+ (Ammonium - cation)	Fertilizers, manures and also atmospheric N-Fixation
	Phosphorus (P)	$H_2PO_4^-$ (Monophosphate - anian) HPO_4^{-2} (Diphosphate - anian)	Apatite Rock Phosphate
	Potassium (K)	K^+ (K-cation)	Feldspar, Mica, Illite
	Calcium (Ca)	Ca^{+2} (Ca-Cation)	Calcite, Dolomite, Gypsum
	Magnesium (Mg)	Mg^{+2} (Mg-cation)	Dolomite, Sandstone
	Sulphur (S)	SO_4^{-2} (Sulphate - anion) SO_3^{-2} (Sulphite - anion)	Iron pyrite, Gypsum
	Zinc (Zn)	Zn^{+2} (Zn-cation)	Sphalerite Smithsonite
	Copper (Cu)	Cu^{+2} (Cu-cation)	Chalcocite, Cuprite
	Iron (Fe)	Fe^{+2} (Ferous cation) Fe^{+3} (Ferric cation)	Haematite, Pyrite, Olivine
	Manganese (Mn)	Mn^{+2} (Mn-cation))	Magnetite, Pyrolusite
	Boron (B)	$H_3BO^{-2}_3$ (Metaborate - anian) BO^{-3}_3 (Borate - anian)	Borax Tourmaline
	Molybdenum (Mo)	$HMoO_4^-$ (Moybdate - anian)	Molybdenite, Ferrimolybdate
	Chlorine (Cl)	Cl^- (Cl-anion)	Muriate of Potash, Sodium Chloride

6.2 Classification of essential elements

On the basis of quantity required by plants, the elements are classified as follows.

1. Major or macronutients

Major or macronutrients, are required by plants in large quantity. These include C, H, O, N, P, K, Ca, Mg and S. These are further subdivided as follows.

(a) Basic nutrients - C, O, H

Carbon, oxygen and hydrogen constitute about 95% weight of plant. Field crops obtain most of their carbon and oxygen directly from the air. Hydrogen is derived either directly or indirectly from the soil water.

(b) Primary nutrients -

Nitrogen, Phosphorus and Potassium are termed as primary nutrients as they are required in large amount by the plants. Their wide spread deficiencies can be corrected by the application of chemical fertilizers. Hence they are some times designated as 'fertilizer elements'.

(c) Secondary nutrients -

Calcium, Magnesium and Sulphur are termed as secondary nutrients because they are required in moderate amount by the plants. Secondary nutrients are as significant as primary nutrients in plants but they are needed in moderate quantity.

Deficiency of secondary nutrients can be corrected through application of Calcium nitrate, Magnesium sulphate, Sulphur, etc. and fertilizers containing primary nutrients e.g. single super phosphate contains both Ca and S, likewise ammonium sulphate, a nitrogenous fertilizer also supply S.

2. Minor or micronutrients (Trace elements)

The nutrient that are required relatively in smaller quantities are termed as 'micronutrients'. These include Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo) and Chlorine (Cl). The micronutrients are subdivided into micronutrients cations and anions depending upon the form in which plants absorb them.

(a) Micronutrient cations - Fe, Mn, Zn and Cu

(b) Micronutrient anions - B, Mo and Cl

The sources used to supply micro nutrients are called micronutrient fertilizers. They are supplied through inorganic salts e.g. Ferrous Sulphate, Zinc Sulphate, Borax, etc.

6.3 Functions and deficiency symptoms

The essential elements play an important but different role/functions in plants. The better known important functions of the essential elements are :

1. They act as structural constituents and support the frame work of the plant body.
2. They are components of cell constituents and metabolically active compounds of the cell.
3. They help in maintenance of cellular organisation.
4. They help in energy transformation and enzyme action.

When the quantity of nutrients is low/ deficient in the growing medium, such nutrients limit the growth of plants. This deficiency produces specific symptoms on the plant. The deficiency symptoms are characteristic to the specific nutrient.

Remember this

1. Nutrient content is considered **deficient** when it is so low that it severely limits the growth and produces deficiency symptoms on plants.
2. Nutrient content when associated with only growth reduction and not by appearance of deficiency symptoms are termed as **insufficient**.
3. Range of nutrient content in plant associated with optimum crop yields is called as **sufficient**.
4. When the concentration of a nutrient element rises too high to cause significant growth reductions, it is termed as **toxic**.

Do you know ?

1. How healthy plant is different from sick plant?
2. Morphological difference between normal plant and abnormal plant in respect of appearance, height, growth, modification, etc.

The general functions of the specific elements carried out in the plant body as well as the specific symptoms exhibited on plant when that element is dificient in the soil are given in short in the following table.

Table 6.2 : Functions and deficiency symptoms of nutrients.

Element	Functions	Deficiency Symptoms
Macronutrients		
Carbon (C)	(i) Carbon forms backbone of most of the plant biomolecules including ptotein, starch and cellulose. (ii) Carbon forms the skeleton of the plant	--
Hydrogen (H)	(i) It is necessary for building sugars in plant. (ii) It maintains turgour rigidity (iii) It helps for electron transport chain in photosynthesis and for respiration.	--
Oxygen (O)	(i) It is component of many organic and inorganic molecules within the plant. (ii) It is required for aerobic cellular respiration and breakdown of glucose to produce ATP	--
Nitrogen (N)	(i) It is a constituent of chlorophyll (ii) Nitrogen imparts dark green colour to plant. (iii) It increases vegetative growth (iv) It is required for formation of amino acids, proteins and nucleic acid. (v) It increases acceleration, utilization of the constituents.	It's deficiency causes (i) Stunted growth (ii) Restricted foliage (iii) Pale yellow or light green colour to leaves (iv) Low yields of crops (v) Shedding of leaves and fruits
Phosphorus (P)	(i) It is constituent of nucleic acid, co-enzymes, phospho proteins and phospholipids (ii) It increases root nodule formation on roots of pulses (iii) Increases tillers and ratio of grain to straw in crops (iv) It induces early maturity (v) It makes plant tolerant to drought, cold, pests and diseases (vi) It increases root growth	(i) Restricts growth of plant shoots and roots (ii) Imparts bluish green or dark green colour to older leaves (iii) It suppresses growth of lateral buds (iv) Delays maturity of crops (v) Potato tubers show rusty brown lesions in the flesh

Potassium (K)	(i) It increases leaf efficiency in manufacturing sugar and starch (ii) It controlls the stomatal movement (iii) It plays catalytic role in activating number of enzymes (iv) It is required for maintenance of cellular organisation (v) It increases resistance to diseases, heat and moisture stress (vi) It improves quality of fruits (colour, flavour and size, etc.)	(i) Deficiency causes stunted and bushy plant growth. (ii) Leaf margins turn brown (iii) It causes shortening of internodes and drying of shoot (iv) Deficiency causes blackening of potato tubers and damage in storage
Calcium (Ca)	(i) It is a constituent of cell wall (ii) It is required for mitotic activities (iii) It activates enzymes phospholipase and ATPase, etc. (iv) It plays primary role as soil amendmend (v) It helps to translocate the sugar in the plants (vi) It neutralises organic acid which may become poisonous to plants	(i) It affects the meristimatic portions of root and terminal buds of plant die. (ii) Root growth is stunted (iii) Marginal chlorosis occurs in younger leaves (iv) Premature falling of flowers and fruits in leguminous crops
Magnesium (Mg)	(i) It is a part of chlorophyll molecules (ii) It is required by enzymes involved in carbohydrate metabolism (iii) It is essential for activity of enzymes (iv) It is usually needed by plants for synthesis of oils and fats (v) Increases crop resistance to drought and diseases	(i) It increases chlorosis between the veins of older leaves and they may turn brown (ii) It may causes necrosis in severe deficiency.
Sulphur (S)	(i) It is a constituent of amino acid and vitamins involved in synthesis of chlorophyll (ii) It is required for the activities of enzymes (iii) Pungent odour of onion and garlic is due to sulphur compounds' (iv) It stimulates seed formation	(i) It causes chlorosis (ii) It develops antho-cyanine pigmentation (which is first in younger leaves) (iii) Fruit becomes abnormal-shaped, thick skinned and less juicy
Iron (Fe)	(i) It takes part for chlorophyll synthesis (ii) It has a catalytic role in activities of many enzymes (iii) It is active in biological oxidation	(i) It causes interveinal chlorosis which first appear in younger leaves (ii) Leaves become dry and papery latter turn brown and necrotic (iii) Chlorosis and mottle leaf in sugarcane

Manganese (Mn)	(i) It is the activator of enzymes in respiration and metabolism (ii) It also activates many other enzymes (iii) It helps in synthesis of chlorophyll as it is a part of chlororophyll	(i) It causes interveinal chlorosis of young leaves (ii) The necrotic spots appear on leaves (iii) Causes marsh spots on peas and blight on sugarcane leaves
Zinc (Zn)	(i) It is required in auxin and protein synthesis (ii) It takes part in synthesis of chlorophyll (iii) It is essential for RNA synthesis and seed production	(i) It causes interveinal chlorosis (ii) Chlorosis is followed by necrosis in older leaves (iii) It gives short internodes Khaira disease in rice, 'White bud' in maize. (iv) Plants show rosette apperance
Copper (Cu)	(i) It is required in carbohydrate and protein metabolism (ii) It is activator of enzyme (iii) It is essential for synthesis of vit.-A in plants (iv) It is involved in the respiration of plants	(i) The young leaves become necrotic at tip point (ii) Dead tissue appear on tips of leaves (iii) Multiple bud formation in the leaf axil (iv) Gum formation and dieback in citrus
Boron (B)	(i) It is involved in transportation of carbohydrate in plants (ii) It helps in flower and pollen grain formation (iii) Essential for translocation of sugar in plants	(i) Its deficiency causes death of shoot tips (ii) Causes stunted leaves (iii) Also causes cracking of fruits (iv) Associated with sterility and malformation of reproductive organs
Molybdenum (Mo)	(i) It is essential in symbiotic 'N' fixation and nitrate assimilation (ii) It is the constituent of nitrate reductase enzyme	(i) It causes chlorotic interveinal mottling of the basal leaves which is followed by necrosis. (ii) Its deficiency causes 'Whip tail' in cauliflower. (iii) It reduces activities of nitrogen fixing organisms.
Chlorine (Cl)	(i) It is involved in primary photosynthetic reaction. (ii) It is also involved in cyclic photo phosphorylation	(i) It gives wilted appearance to foliage (ii) It causes stuffy roots with lateral branching

6.3.2 Integrated Nutrient Management (INM)

It is the combined application of chemical fertilizers along with organic resource materials like organic manure, green manures, biofertiliers and other decomposable material for crop production. The basic concept of INM is the adjustment of plant nutrient supply to an optimum level for sustaining the desired crop productivity.

Integrated nutrient management (INM) is the consideration of all the factors responsible for increasing available nutrients in the soil.

Those factors are as follows.

(1) Physical condition of soil – The availability of nutrient depends on the physical condition of soil such as good structure, aeration, etc.

(2) Soil moisture - Plants absorb nutrients from the soil in the form of solution and which require sufficient moisture in the soil.

(3) Soil pH – The nutrients remain generally available in the soil at neutral pH (6.0-7.0).

(4) Manures and nutrient management– Manure provide organic nutrients and moisture in the soil. It improves physical, chemical and biological properties of soil.

(5) Fertilizer and nutrient management- The frtilizers are acidic or basic in nature. Application of fertilizer constantly make the soil acidic or alkaline according to nature of fertilizer used. Fertilizer should be applied on the basis of the soil analysis.

(6) Bio - fertilizer and nutrient management - Bio-fertilizer are the culture of microorganism capable of fixing or solubilizing the nutrients.

Integrated Nutrient Management (INM) is actually the techinical and managerial component which is one of the policy of ICAR. Organic materials are the potential source of major nutrients besides containing fair amounts of micro nutrients. The indirect effects include augmentation of beneficial microbial population, their activities and improvement of soil health. Incorporation of crop residues as well as other organic material like press mud cake, biogas slurry, green manuring, vermicompost, etc. seems to be quite promising for increasing organic matter in the soil.

To achieve the objectives of INM the strategies are-

i. Using fertilizer recommendation based on soil analysis. Use optimum and balanced fertilizers for the cropping system as a whole.

ii. Integrated use of all sources of nutrients as per soil and crop need.

iii. Use of crop rotations involving legumes

iv. Remove deficiencies of nutrients as and when first detected and ameliorate problem soils with appropriate amendments.

v. Encourage farmers to use bio-inoculants, bio-fertilizers, organic manures and promote farmer to evaluate soils for quality, fertility and overall productivity.

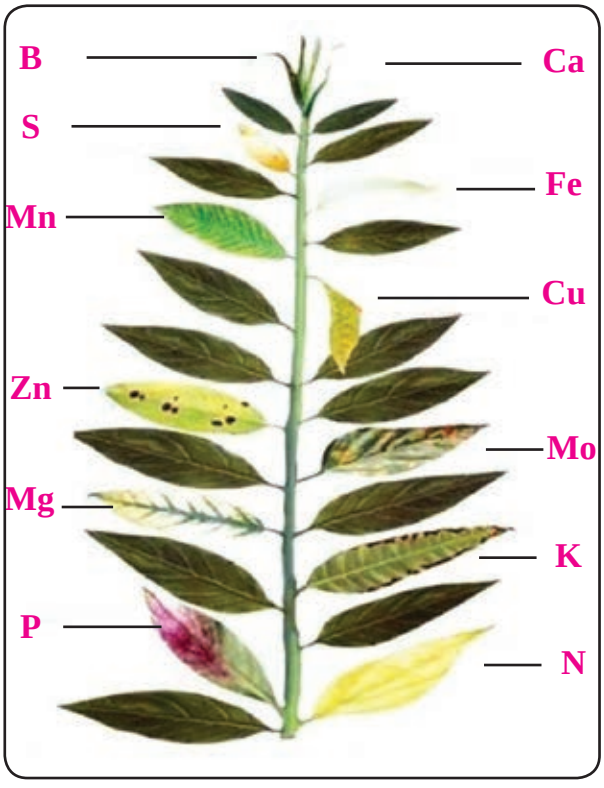


Fig. 6.1 : Deficiency symptoms of nutrients

Can you tell?

1. Different materials which supply nutrients to plants
2. Naturally available source and artificial compounds supplying nutrients

6.4 Manures and fertilizers

6.4.1 Meaning

1. Manures

These are the organic substances of plant or animal origin and capable of supplying plant nutrients in small quantity per unit weight as well as provide food for soil micro organism. Examples are FYM, compost, green manure, vermicompost, organic waste, crop residues, etc. (The value of these manures, however, depends on the amount of humus they add to the soil.)

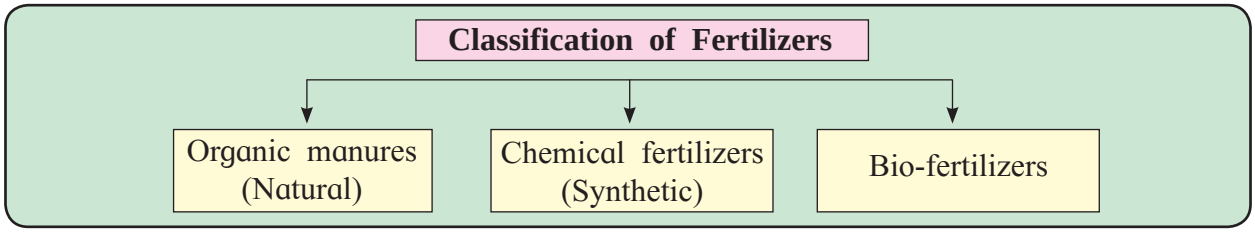
2. Fertilizers

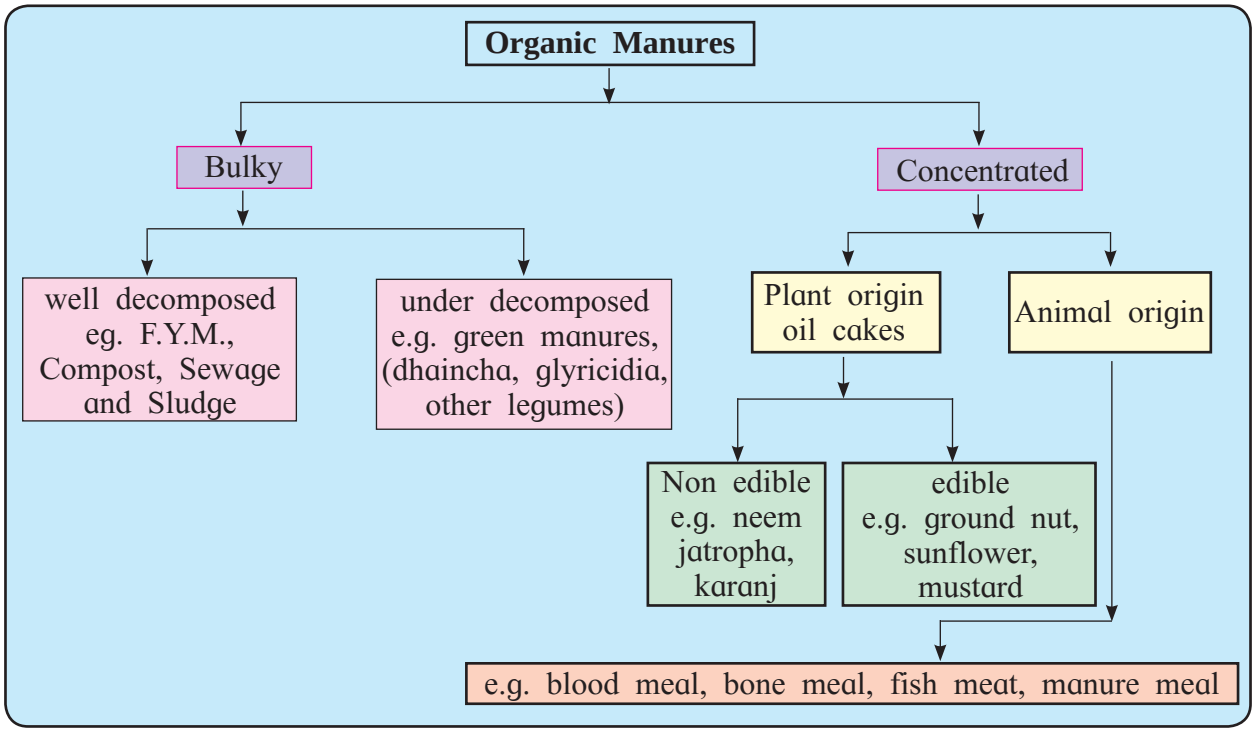
These are the inorganic substances added to soil to supply certain elements essential for crop growth. They contain large amount of nutrients per unit weight and in a definite composition e.g. urea, single super phosphate, muriate of potash, etc.

3. Bio-fertilizers

These are the substances which contains living micro organisms which, when applied to seed, plant surfaces or soil colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. e.g. *Rhizobium, Azotobacter,* Blue green atage (BGA) etc.

6.4.2 Classification of Manures and Fertilizers





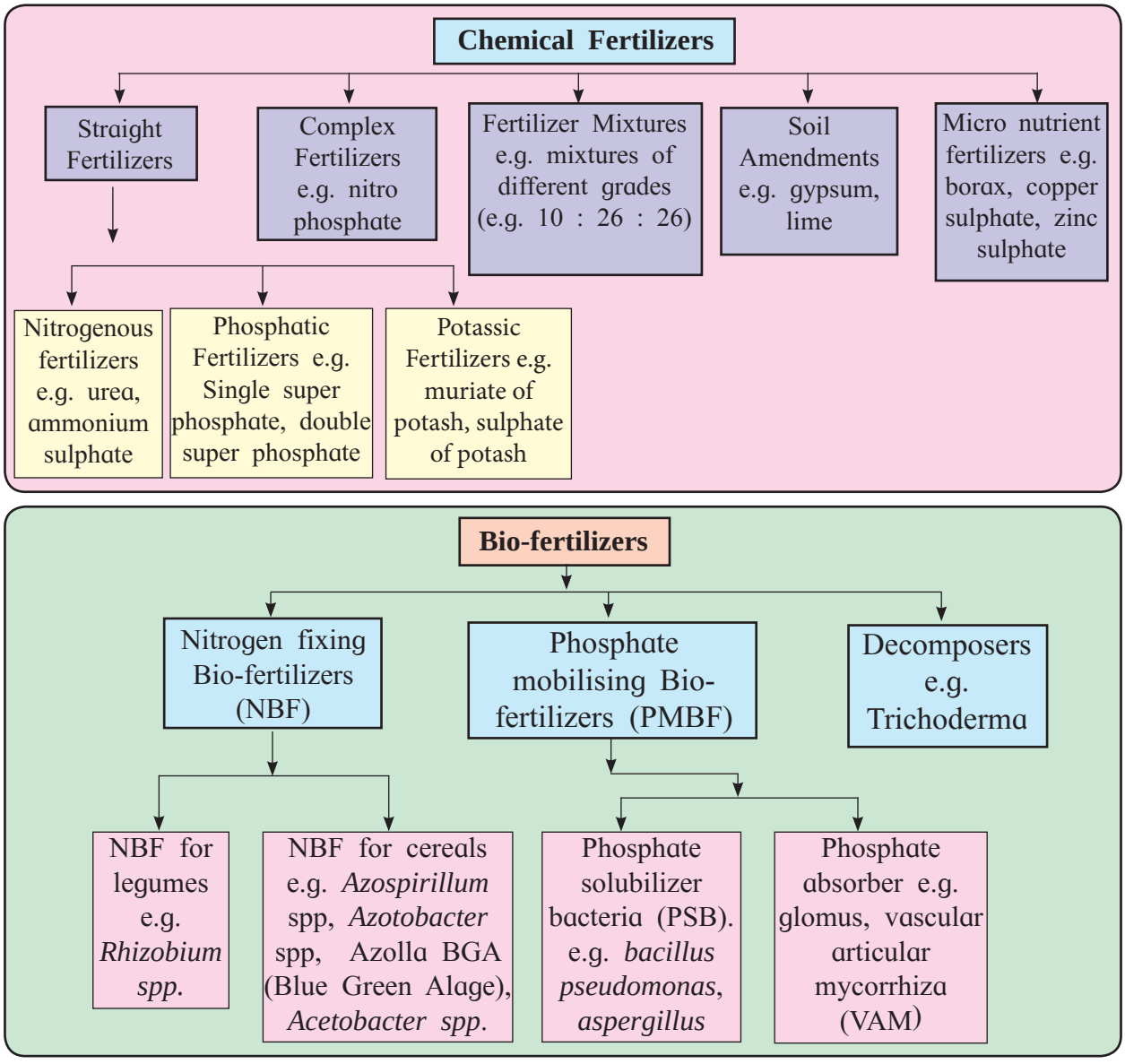


Fig. : 6.2 : Classification of manures and fertilizers

6.4.3 Brief study of Manures and Fertilizers

Bulky Organic Manures

These manures contain plant nutrients in small quantities and organic matter in large quantities.

1. **Farm Yard Manure (FYM) :** It is decomposed mixture of the solid and liquid excreta of farm animals along with litter (e.g. materials used for bedding purpose of cattle) and left over material from fodder fed to the cattle, e.g. cattle manures, sheep penning, poultry manure, etc.
2. **Compost :** This is the bulky organic manure obtained from the decomposition of organic wastes with the help of the action of microorganisms. e.g. rural compost (made from farm waste and house refuses), urban compost (made from town wastes).
3. **Vermicompost** : The compost prepared by using earthworms is called vermicompost.
   (i) Selection of earthworms - *Eisenia foetida* being a most active species hence, commonly used for vermicompost production.

Earthworms which are the native of the local soil can be used.

(ii) Size of pit : 3.0 m long, 1.5 m wide and 0.6 m deep pit may be prepared. The distance between two pits is 0.6 m.

(iii) Preparation of vermibed - At the bottom of the pit 15 cm layer of raw organic material from farm, household refuse, etc. should be placed.

(iv) Organic layering - Compost pit is then layered about 15 cm with partially decomposed cow dung and soil in 3:1 proportion. Moisture level is maintained (without flooding) by spraying of water.

(v) Wet organic layer - Cow dung slurry (or biogas slurry) is to be prepared and spread over it to a thickness of 10 cm and cover the pit with 15 cm organic material (dry and green leaves). After 3-4 days inoculation of earthworm is done.

(vi) Inoculation of earthworm - About 1000-1500 earthworms are introduced as an optimum density into a compost pit.

(vii) Harvesting - At maturation, moisture content is brought down. This ensures drying of compost and migration of worms towards base of the vermibed. Mature compost is removed, sieved, dried and packed.

4. **Sewage and sludge :** (i) Sewage - This is the liquid collected from the closed drains usually contains urine and washings in addition to night soil and other solid ingredients. Sewage has two components.

(a) Solid portion - sludge

(b) Liquid portion - sewage

(ii) Sludge - The settle sewage solid combined with varying amounts of water and dissolved materials removed from sewage by screening, sedimentation, chemical precipitation or bacterial digestion is called sludge.

5. **Green manuring :** It is the practice of incorporation of green succulent plant material into soil for improving physical structure as well as the fertility of soil. It consists of raising quick growing crops up to flowering stage and incorporate them into the soil by ploughing. There are two types of green manuring.

(i) Green manuring in situ - Green manure crops are grown in situ either as a pure crop or as an intercrop with the main crop and then buried in the same field at flowering stage e.g. sannhemp, dhaincha, cowpea, cluster bean, etc.

(ii) Green leaf manuring - This refers to turning into the soil the green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste land and near by forest area e.g. Glyricidia.

Concentrated organic manures

1. **Plant origin :** These are organic in nature and contain relatively higher percentage of plant nutrients as compared to bulky organic manure. These are generally undecomposed material.

(i) Oil cakes : Richest source of plant nutrients of all organic manures. These are of two type.

(a) Edible oil cakes - These type of oil cakes are generally used for feeding the cattle as concentrates, but low grade ones can be used as manure for crops e.g. groundnut cake, mustard cake, sesame seed cake, linseed cake, etc.

(b) Non edible oil cakes - These types of oil cakes are not suitable for feeding to cattle and mainly used for manuring e.g. neem cake, karanj cake, mahua cake, castor cake, etc.

(ii) **Animal origin - (a) Waste products of slaughter house :** (a) Blood meal Dried blood is a very quick acting manure and is effective for all type of crops and soil.

(b) Bone meal : It is the oldest phosphatic fertilizer as bones contain calcium phosphate. It is more effective with PSB.

(c) Fish meal : This is available either as dried fish or as fish meal or powder where in fish oil is extracted. The residue contains nutrients hence can be used as manure.

Chemical fertilizers

(A) Straight fertilizers : Chemical fertilizers which contains only one primary or macro nutrient are called as straight fertilizers e.g. urea, single super phosphate, MOP, etc.

(B) Compound or complex fertilizers: Fertilizers which contains more than one primary or major nutrient elements and produced by the process of chemical reactions. These fertilizers are usually produced in granular form e.g. diammonium phosphate (DAP), Suphala 15:15:15, 20:20:00:13, Monoamonium phosphate 10:26:26, 12:32:16, etc.

(C) Mixed fertilizers or fertilizer mixtures: These are prepared by physical mixing of two or more fertilizers. Such mixtures can be prepared by mixing two or more straight fertilizers. Usually fertilizer mixtures are prepared to meet specific needs of crop e.g. NPK 10:5:5, 20:20:00, 20:10:10, etc.

(D) Soil amendments : Any material which is used to correct the soil acidity/ alkalinity or any problematic property of soil is called as soil amendment e.g. Gypsum, lime, iron pyrite etc. lime stone is used to correct acidic soil and gypsum to correct alkaline soil.

(E) Micronutrient fertilizers : Micronutrient fertilizers are those which contain micro nutrients. They are the salts like zinc sulphate, ferrous sulphate manganese sulphate, etc.

Bio-fertilizers

(1) Nitrogen fixing bio-fertilizers (NBF)

Atmosphere contains 78 percent nitrogen and 0.03 percent carbon dioxide. Plants are capable to assimilate carbon dioxide through photosynthesis even when carbon dioxide content in air is less, but most of the plants cannot fix atmospheric nitrogen though it is abudant.

NFB bacterias play a very significant role in improving soil fertility by fixing atmospheric nitrogen both in association with plant roots and also without it. e.g. *Rhizobium, Azotobacter, Azospirillium.*

(2) Phosphate mobilising bio-fertilizers (PMBF)

These micro-organisms are mainly bacteria and fungus. They possess the ability to bring insoluble soil phosphates into a soluble forms by secreting several organic acids, under favourable conditions amd also by the biological reactions.

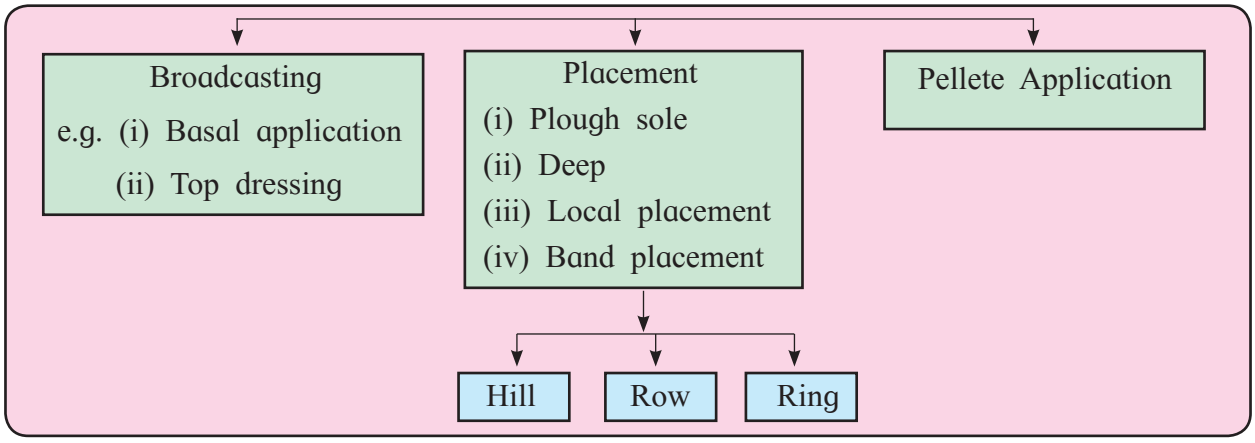
(3) Decomposers

Decomposing bio-fertilizers when added with organic matter increases the rate of decomposition of the organic matter hence, they are used for preperation of compost, FYM and in situ decomposition of organic residuces in field.

6.4.4 Methods of fertilizer application

Fertilizers are costlier inputs in agriculture. They need to be applied at proper time and also by correct method to get maximum benefits from this input. Otherwise, the objective of fertilizer application may not be fulfilled. Fertilizers are generally applied in the following two forms.

1. Application of fertilizers in solid form



Types of fertilizer application in solid form

(a) Broadcasting : Even and uniform spreading of manure or fertilizer by hand over the entire surface of field while cultivation or after the sowing in standing crop is termed as broadcasting. Depending upon time of fertilizer application there are two types of broadcasting.

(i) Broadcasting at planting or sowing e.g. concentrated organic manures, potasic fertilizer, citric soluble phosphatic fertilizers, etc.

(ii) Top dressing : Braodcasting fertilizers in standing crop is known as top dressing. Care must be taken that do not apply when leaves are wet e.g. Urea, ammonium nitrate.

Fig 6.2 Broadcasting fertilizer

Disadvantages of broadcasting

(i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.

(ii) The weed growth is stimulated all over the field.

(iii) Nutrients are fixed in the soil as they come in contact with large mass of soil.

(b) Drilling : Granular fertilizers are applied through seed-cum-fertilizer drill at sowing time. The phosphatic and potassic fertilizers are applied to cereal crops and cotton. But this method is not suitable for pulse crops.

(c) Placement or spot application : It is the method of placing fertilizer in the soil before or after sowing the crops. The roots of young plants can get nutrients as per their requirement from the fertilizer applied by this method.

(i) Ring/Circle method : fertilizer application can be done by making circle or ring around the plant trunk with sickle/khurpi and covering it with soil by hand.

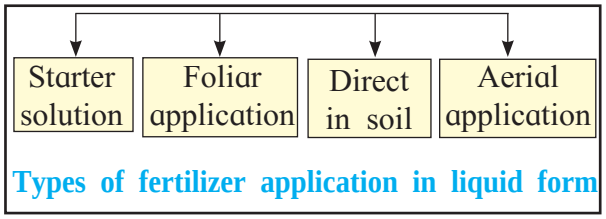
(ii) Band method : fertilizer is placed in bands or hills near the plant (3-5 cm away) and cover with soil.

(iii) Row placement : the fertilizers are placed on one or both sides of the row by hand e.g. potato, sugarcane, etc.

(d) Pellet application : It refers to the placement of nitrogenous fertilizers in

the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop. The fertilizers mixed with the soil in the ratio of 1:10 and small pellets of convenient size are made to deposit.

2. Application of fertilizers in liquid form



Types of fertilizer application in liquid form

(a) Starter solution : Starter solution is prepared by mixing N, P and K fertilizers in the ratio of 1:2:1 or 1:1:2. This is applied to the vegetables seedlings at the time of transplanting and it helps rapid establishment and quick early growth of seedlings.

(b) Foliar application : This is method of spraying leaves of growing plant with suitable fertilizer solution having low concentration. It is effective for micro nutrient fertilizers.

(c) Direct application to the soil : Liquid fertilizers are directly applied to the soil with special injection equipment e.g. unhydrous ammonia, liquid manure such as urine, sewage water and cowshed washings are let into field.

(d) Application through irrigation water (Fertigation) : It refers to the application of water soluble fertilizers through irrigation water generally nitrogenous fertilizers are applied through irrigation.

(e) Aerial application : In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest land, in grass land or in sugarcane field.

3. Application of bio-fertilizers

(a) Seed inoculation method - Bio-fertilizer is mixed in wheat flour with suitable amount of water and then seeds are dipped. Treated seeds are kept in shed for 30 minutes and used for sowing. For 20 kg seed use 200 gm bio-fertilizer and 250 gm wheat flour.

(b) Root inoculation method - Bio-fertilizers mixed in water and roots of clean seedling are dipped in solution for 120 minutes before transplanting. Use 200 gm biofertilizer for 5-6 lit. water.

(c) Soil application - Bio-fertilizer mixed with compost and soil mixture and then spread in field. Use 5 kg biofertilizer for one hectare field and mix it with 25 kg compost and 50 kg soil before spreading.

Precautions adopted in using bio-fertilizers

(i) No other fertilizer or insecticides/ fungicides should be mixed with seed that are treated with bio-fertilizer.

(ii) The seed treatment, if required should be done at least 24 hours before mixing the seeds with bio-fertilizers.

(iii) Organic manures should not be kept in dump place and in bright sun.

(v) The bio-fertilizers should be used before expiry date.

Benefits of bio-fertilizers

There are various benefits in using bio-fertilizers as follows -

(i) It increases the yield of the crop by supplying nitrogen in soil.

(ii) It improves the soil conditionand health through micro-organisms.

(iii) The environment cannot be polluted in any way due to the use of biofertilizers.

(iv) Bio-fertilizers are considered ecofriendly. Bio-fertilizers save the crops primarily form seed, soil and water borne diseases.

(v) It helps in turning the fixed phosphorus to soluble form and increase yield of crops up to 10-30 percent.

(vi) It increases the rate of decomposition in composting process.

Exercise

Q.1 A. Fill in the blanks.

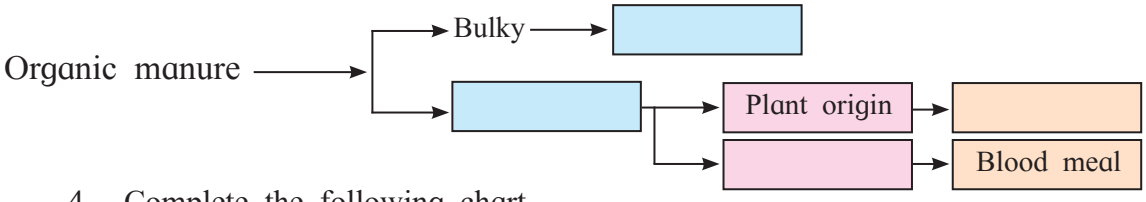
1. The essentiality criteria of element in plant established by .....
2. Nitrogen, phosphorus and potassium are the ..... plant nutrients.
3. Deficiency of ..... plant nutrients causes cracking of fruits.
4. Any material which is used to correct the soil acidity or alkalinity is known as .....
5. BGA is ..... fertilizer.

B. Make the pairs.

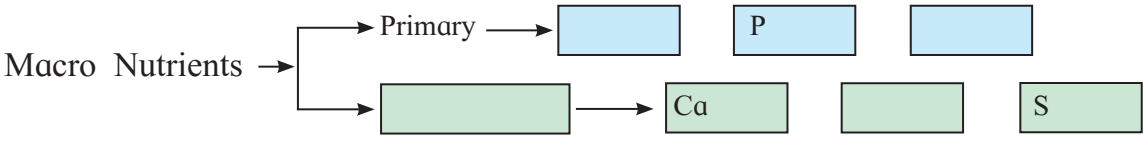
'A' Group	'B' Group
1. Suphala	a. organic manure
2. Azolla	b. soil amendment
3. Neem cake	c. chemical fertilizer
	d. fungicide
	g. biofertilizer

Q.2 Answer in brief.

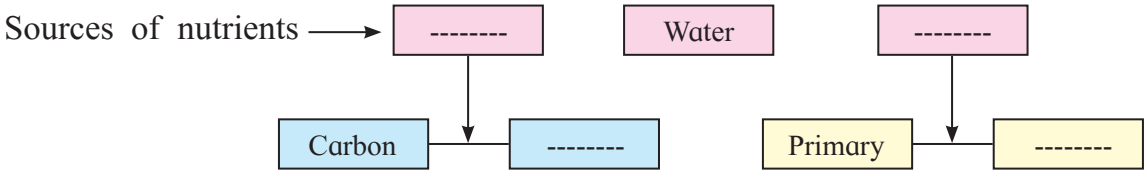
1. Give difference between manure and fertilizer.
2. Write note on biofertilizers.
3. Complete the following chart.



4. Complete the following chart.



5. Complete the following chart.



C. Find the odd out.

1. Rhizobium / suphala / Azolla / BGA / Trichoderma
2. Nitrogen / calcium / magnesium / boron / phosphorus
3. Urea / gypsum / borax / neem cake / suphala
4. Iron / calcium / boron / zinc / chloride
5. Compost / FYM / BGA / Green manure / neem cake

D. State true or false.

1. Straight fertilizer contains only one primary nutrient.
2. Biofertilizers are applied by seed inoculation method.
3. Vermicompost is prepared by using earthworms.
4. Khaira disease in paddy is caused due to deficiency of zinc.
5. Compost is the concentrated organic manure.

Q.3 Answer the following questions.

1. Explain INM.
2. Explain vermicomposting with diagram.
3. Complete table.

Chemical fertilizers ↓				
Straight	---	---	---	Micronutrient Fertilizers
e.g.	Nitro Phosphate	N P K 10 : 26 : 26	Gypsum	---

4. Explain classification of essential nutrients with examples.
5. Complete the table.

Methods of fertilizer application ↓		
Solid form		Bio fertilizers
Braodcasting	Starter solution	
--	--	Root inoculation
Drilling	--	--
--	Fertigation	

Q.4 Answer in detail.

1. Read the given paragraph and answer the following question.

Compost is an organic manure prepared from plant residues and animal waste by decomposition. The process of making compost is known as composting. It is largely a biological process in which aerobic (which requires air or oxygen) and anaerobic (which function in absence of air or free oxygen) microorganism decompose organic matter and lower the Carbon Nitrogen ratio of the refuse. In the aerobic process, the mixed farm residues are collected in the pits of convenient size, say 15' × 5' × 3' (450 × 150 × 90 cm). Each days collection is spread in a thin layer and sprinkled with a mixture of fresh cow dung. Compost manure is reinforced with super phosphate @ 25 kg per ton of manure. When the pit is filled to a height of 1.5 to 2.0 feet (45-60 cm) above ground level the surface is plastered with one inch layer of a mixture of mud and cow dung. The compost becomes ready in about three to four months without any further attention.

1. Define compost.
2. What is the size of compost pit?
3. Explain composting method.
4. Which chemical fertilizer is mixed in pit?
5. What is aerobic decomposition?

2. Complete the given table.

	Nutrient	Usable form by plant	Mineral source
1.	Boron	--	--
2.	--	Ferrous – ion	Haematite
3.	Chlorine	--	Sodium chloride
4.	--	NO_3	--
5.	--	Ca++	--
6.	--	H_2PO4	Apatite
7.	Potassium	--	Feldspar

3. Complete the following table.

	Functions of nitrogen	Functions of calcium	Functions of phosphorus	Functions of boron
1.	....	....	....	....
2.	....	....	....	....
3.	....	....	....	....

4. Write in detail classification of essential element with explination.
5. Explain the different methods of fertilizer application.

Activity :

Apply fertilizers to the crop in the field by different methods.

Courtesy : Rastriya Chemicals and Fertilizers, Mumbai