Manual

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Soil Fertility and Nutrient Management (NRM-121)

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Introduction to soil fertility and productivity

Soil Fertility: It is defined as the inherent capacity of a soil to supply available nutrients to plants in an adequate amount and in suitable proportions to maintain growth and development. It is measure of nutrient status of soil which decides growth and yield of corp.

Factors affecting soil fertility:

I. Natural factors or Pedogenic factors: are those which influence the formation of the soil.

These include: a. Parent material b. Climate and vegetation c. Topography and age of soil

a. Parent material:

Rocks and minerals are the parent materials, act as very important raw materials for the formation of any soils. If the parent material is rich in plant nutrients, the soils formed from it are usually quite fertile. The property of soil depends on the property of parent rock.

Ex: a. Sandy loam soils (Red), formed from granite and granite gneiss are low to medium in fertility.

b. Lime stone and Basalt rock which are easily weathered results fine textured, very fertile and dark colored (black) soil.

c. Soils derived from calcareous rock contain more P than the soil derived from granite.

d. Sand stone-leads to coarse textured, sandy soil of low fertility.

e. Shale- forms clayey soil, but not very fertile.

b. Climate and vegetation:

They are interrelated factors as the amount and type of vegetation in an area depends on climate especially rainfall and temperature. These two factors in turn influence the type of soil fertility. Under heavy rainfall of humid region, the natural vegetation is forest, which develops more fertile soils due to accumulation of forest litter and organic matter.

On the other hand temperate soils are not very fertile compared to tropical soils because of the lesser decomposition of organic matter in soil due to very low temperature. The tropical soils are more fertile soils due to constant high temperature which helps in faster rate of disintegration and decomposition of organic matter in the tropics than in temperate regions.

In semi arid conditions the natural vegetation is grass which leads to more accumulation of organic matter in soil surface layer due to fibrous root system, and good soil aggregation. These soils are hence more fertile than the area under forest vegetation.

c. Topography and Age of soil:

The soils of hilly tracts are usually poor because of excessive leaching and erosion of the top soil. In sloppy land, the soils of low lying areas are usually richer because of the transportation and accumulation of soil and plant nutrients. Similarly, old soils are less fertile due to excessive weathering, leaching and continuous cultivation.

II. Edaphic factors or Soil management factors: Includes the entire soil conditions and their management practices that are concerned with addition or removal of plant nutrients.

1. Physical conditions of soil

a. Texture of soil: Fine textured soils (clay rich) are having greater surface area, greater CEC and so better soil fertility than the coarse textured soils (sand rich).

b. Structure of soil: Well aggregated soils are more productive compared to non aggregated soils or loose soils.

c. Soil water: Clayey soil store more water than sandy soils, hence they are more productive

d. Soil aeration: Soil air containing oxygen is essential for root respiration, decomposition of soil organic matter and uptake of nutrients by plants. Higher CO2 content in the soil restrict the uptake of nutrients. Soil aeration decides oxidation and reduction process of soils.

e. Soil temperature: It is required for metabolic activity of plants, microbial activity and decomposition process. Temperature variations also affect the nutrient absorption and nutrient conversions in soil and ultimately plant growth.

f. Soil compaction and tillage operations: Compactness will decide the aeration status of soil and root penetration. It has direct effect on the ability of plant roots to absorb both nutrients and moisture from the soil. Tillage operations using heavy implements will destroy the good soil structure, make more compact soil which intern affect the soil fertility status.

g. Soil reaction (pH): Availability of nutrients in soils is greatly influenced by increase or decrease in soil pH. The neutral pH of 6.5-7.5 is optimum for good productive soils.

h. Microorganisms: Soil microorganisms improve the soil fertility as they help in decomposition of organic matter and nutrient mineralization in soil. They also involve in nutrients cycling by mineralization, fixation, absorption and solubilization of nutrients in soils.

2. Root growth and extension: Root performs absorption of water and nutrients needed for the plant. Root metabolism creates a nutrient demand. Dense and extensive root system helps better nutrient availability to plants.

3. Organic matter content of the soil: Higher the organic matter status higher will be the fertility status. Organic matter increases humus content hence, more CEC of soils. It acts as store house of various nutrients; it improves the physical properties of soil like structure, good aggregation of soil particles, aeration, and water holding capacity, solubility of the minerals and supplies "energy" for the growth and development of microorganisms.

4. Cropping system: Cultivation of same crop continuously in the same field without replenishment decreases the soil fertility. Thus, inclusion of various crops and cropping systems like double, mixed , relay, multiple cropping and crop rotation increases the soil fertility.

5. Soil erosion: Erosion is the physical removal of top soil by water and wind. As such it decreases the soil fertility and promotes soil degradation due to nutrients are being lost by erosion continuously along with soil.

Importance of Soil fertility

1. Soil fertility is a key factor for successful crop production and it is a measure of capacity of soil to supply plant nutrients. Soil fertility and fertilizers are very much closely related terms. Soil fertility acts as a 'SINK' where in plants can draw nutrients for maximum yield, where as fertilizer, acts as a 'SOURCE' wherein we can draw continuously different nutrients and also add to the sink. The importance of soil fertility and fertilizer management is being increasingly recognized in all countries recently to meet the demand for food and other agricultural raw materials.

2. Intensive use of fertilizer, intensive cropping with high yielding varieties have no doubt increased the food production and reduced the food shortage but it has also brought in numerous problems of soil fertility, soil and water pollution. On the other hand, fast depletion of nutrients due to over exploitation, a wide spread deficiency of N, P, K and S coupled with micro nutrients deficiencies especially Zn and boron has been noticed in many soils.

3. Further deforestation, shifting cultivation, burning of trees, bushes, grasses and cow dung, soil erosion, soil degradation, nutrient losses, excessive fertilizer application, leaching losses etc., have aggravated the depletion of soil fertility status. It is being realized that the future of Indian agriculture is closely related to scientific management of soil fertility along with judicious and efficient use of fertilizers.

4. Soil fertility problems cannot be solved by mere supply of plant food nutrients, but their efficient management is also very important aspect since the fertilizer is one of the costliest inputs. It requires a well balanced scheduling of fertilizers to get maximum returns with minimum investment. Apart from fertilizers, due to lack of biomass resources, farmers are not in a position to apply sufficient organic manures also.

5. So with all these conditions soils become deficient and very "hungry" for the need of nutrients day by day. It is therefore, imperative that sound soil and crop management practices, Judicious use of fertilizers and Integrated nutrient management practices must be adapted to improve and maintain good soil fertility and better soil physical condition for the purpose of sustained crop production.

Soil Productivity? Soil productivity means the crop producing capacity of a soil which is measured in terms of yield (bio-mass). Productivity is a very broad term and fertility is only one of the factors that determine the crop yields. Soil, climate, pests, disease, genetic potential of crop and man's management are the main factors governing land productivity, as measured by the yield of crop. To be productive, soil must contain all the 17 essential nutrients required by the plants.

The total quantity of nutrients is not only being sufficient but they should also be present in an easily "available" form and in "balanced" proportions. Over and above fertility, there are other factors deciding productivity.

"All the productive soils are fertile but not all fertile soils are productive"

Factors affecting Soil Productivity

The factors affecting soil productivity include all those which affect the physical, chemical and biological conditions of the soil environment in which plants grow. They include all the practices that affect fertility, the water and air relationships and the activity of the biological agents such as insects, pests, diseases and microorganisms.

I. Internal factors: may be called as genetic or hereditary factors which cannot be manipulated such as soil type, texture etc.

II. External factors: may be regulated to certain extent, They include

a. Climatic factors: like precipitation (rain fall), solar radiation, atmospheric gases (CO_2, NO_2, N_2O, O_2), wind velocity etc.

b. Edaphic or Soil factors: Soil moisture, soil air, soil temperature, soil mineral matter, inorganic and organic components, microorganisms, soil reaction.

c. Biotic factors:

i. Plants: have competitive and complementary nature, competition between weeds and crop plants, plants growing as parasites.

ii. Bacteria of symbionts, free living.

d. Animals: earth worms, small and large animals

e. Physiographic factors: geological strata (parent materials), topography (altitude, steepness of slope)

f. Anthropogenic factors: human factors including skill and efficiency of cultivation by man.

Difference between soil fertility and productivity

SOIL FERTILITY	SOIL PRODUCTIVITY
It is an index of available nutrients to plants	It is broader term used to indicate yields
It is one of the factors for crop production	It is interaction of all the factors that determine the magnitude of yields
It can be analyzed in the laboratory	It can be assessed in the filed under particular climatic condition.
It is potential status of the soil to produce crops	It is the resultant of various factors influencing soil management.
It is an inherent property of soil	It is not the inherent property of soil
All fertile soils are not productive	All productive soil are fertile
Influenced by physical, chemical and biological factors of soil	Depends upon soil fertility and location
It is status of soil	It is capacity of soil

Essential plant nutrient elements, function, deficiency symptoms, transformations and availability

Nutrient: Nutrients are substances required by an organism for their normal growth and reproduction.

Plant Nutrient: Plant nutrients are the chemical elements that are essential to the nourishment of plant health.

Plant nutrition: It is the study of the chemical elements and compounds necessary for plant growth, plant metabolism and their external supply. In 1972, Emanuel Epstein defined two criteria for an element to be essential for plant growth:

1. Absence of the element plant is unable to complete a normal life cycle.
2. That element is part of some essential plant constituent or metabolite.

Criteria of Essentiality of Nutrients:

This concept was propounded by Arnon and Stout (1939) and they considered 16 elements essential for plant nutrition. For an element be regarded as an essential nutrient, it must satisfy the following criteria;

1. A deficiency of an essential nutrient element makes it impossible for the plant to complete the vegetative or reproductive stage of its life cycle.
2. The deficiency of an element is very specific to the element in question and deficiency can be corrected /prevented only by supplying that particular element.
3. The element must directly be involved in the nutrition and metabolism of the plant and have a direct influence on plant apart from its possible effects in correcting some micro-biological or chemical conditions of the soil or other culture medium.

Types of nutrient elements: Plant nutrient elements are broadly grouped in to two types.

A. Essential Nutrients/ Elements

B. Beneficial Nutrients/Elements

A. Essential Nutrients/elements: The elements needed by the plant without which the plant is not able to survive and complete its life cycle are called essential nutrient. or

An essential nutrient element is the one which is required for the normal life cycle of an organism and where functions cannot be substituted by any other chemical compound.

Plants absorb or utilize more than 90 nutrient elements from the soil and other sources during their growth and development and about 64 nutrients have been identified in plants by their tissue analysis. But all are not essential for their growth and development. **They require only 17 elements/nutrients. These 17 have been recognized as essential elements. They are;**

1. Carbon (C)
2. Hydrogen (H)
3. Oxygen (O)
4. Nitrogen (N)
5. Phosphorous (P)
6. Potassium (K)
7. Calcium (Ca)
8. Magnesium (Mg),
9. Sulphur (S)
10. Iron (Fe)
11. Manganese (Mn)
12. Zinc(Zn)
13. Copper (Cu)
14. Boron(B)
15. Molybdenum (Mo)
16. Chlorine (Cl)
17. Nickel (Ni)

Of these element C,H,O together constitute 95-96% (C-45%, O-45%,H-6%). Subsequently N, P and K constitute 2.7% in plants. The other elements constitute only 1.3-1.4%. But all have definite roles to play in the growth and development. Among these Nickel is the latest nutrient addition to the list in 1987.

Classification of essential nutrients

Essential nutrients are classified in to two major groups based on relative utilization or absorption by the plants and also based on their biochemical behavior and physiological functions.

I. Based on relative utilization or absorption by the plants;

A. Macro or Major Nutrients:

Further Macronutrients are classified into two types

1. Primary Nutrient: Nitrogen, Phosphorus and Potassium. These three elements are also called as fertilizer elements.

2. Secondary Nutrients: Calcium, Magnesium and Sulphur.

B. Micro nutrients: These include Fe, Mn, Zn, Cu, B, Mo, Cl and Ni.

II. Classification based on their biochemical behavior and physiological functions.

Group	Nutrient elements	Biochemical Functions
Group I	C,H,O, Ca	**They are basic structural elements.** They are Major constituent of plants (carbohydrates, proteins and fats) and organic matter. These elements are also involved in enzymes process. They provide energy for growth and development by oxidative break down.
Group-II	N,P & S	**Accessory structural elements** of the more active and vital living tissues. Essential component of metabolically active compounds like amino acids, proteins, enzymes and non-proteinaceous compounds. They involve in energy storage (ATP & ADP) and transfer (Phosphate esters).
Group-III	K, Ca, Mg	**Regulators & carriers** for the most part of plant metabolism. They involve in synthesis and translocation of carbohydrates, maintain ionic charge balance and induce enzyme activation.
Group-IV	Fe, Mn, Zn, Cu, B, Mo, Cl.	**Catalysts and activators**. These elements Involve in oxidation-reduction reactions, chlorophyll synthesis and also exists in organic combinations.

Beneficial elements: Beneficial elements are the mineral elements which stimulate the growth and have beneficial effects even at very low concentration. They are not essential or essential only for certain plant species under specific conditions. They are also known as 'potential micro-nutrients'.

These elements have been found to affect the uptake, translocation and utilization of other essential elements, help in production of essential metabolite by activating enzymatic system/action and also counteract the toxic effects of some other elements or anti metabolites.

Eg: Silicon (Si) for rice, Sodium (Na), Aluminum (Al), Cobalt (Co), Selenium (Se), Iodine (I), Gallium (Ga) and Vanadium (Va).

Definitions of Primary and secondary nutrient:

Macro or Major Nutrients: They are the nutrients utilized by the plants in relatively large amounts (quantity) for their growth and development.

Eg: C, H. O. N, P, K, Ca, Mg and S (C, H and O are abundantly present in the atmosphere and need not be applied through fertilizers).

Primary nutrients: are those nutrients required relatively in large quantities by the plants for their growth and development. These are also designated as 'fertilizer elements' because, deficiency of these elements is corrected by application through fertilizers.

Eg: N, P and K

Secondary nutrients: are those nutrients which are required by plants in moderate amounts. They are called secondary because they are unknowingly supplied through fertilizers and other amendments. However their role in nutrition is not secondary but they are given secondary importance in its supply and management.

Eg: Ca, Mg & S

Ex: When SSP is applied as a fertilizer for P it supply Ca and S

Dolomite applied as a liming material supply Ca and Mg.

Ammonium Sulphate added as N fertilizer will supply S

Micronutrients: The nutrients which are required by plants in relatively smaller quantities for their growth and development, but these are equally important and essential to plants as macronutrients. They are also called as trace/rare/nano elements.

These include Fe, Mn, Zn, Cu, B, Mo, Cl and Ni.

Terminology

Deficient: When an essential element is at a low concentration in plant that severely limits the plant growth and produces more or less distinct deficiency symptoms on plants. Under such conditions the yield of crop will be low / the quality of produce will be inferior.

Insufficient: When the level of an essential nutrient is below their actual content in plant or available in an inadequate amounts that also affect the plant growth and development.

Toxic: When the concentration of an element in plants is very high this affects the plant growth severely and produces toxicity symptoms on plants.

Excessive: When the concentration of an essential nutrient is sufficiently high but not toxic. It results in a corresponding shortage of other nutrients.

Functions of Carbon, Hydrogen & Oxygen

Carbon, Hydrogen and Oxygen form about 95% of the dry weight of plants and are obtained from CO_2 and H_2O. They are converted in to simple carbohydrates by photosynthesis and ultimately elaborated into complex amino acids, proteins and protoplasm. These are the major components of carbohydrates, proteins and fats.

Functions:

1. They play a dominant role in the process of photosynthesis and respiration in plants.,

2. They are involved in the formation of simple as well as complex organic compounds like carbohydrates, starch proteins etc.

3. Maintaining the structure of the plant cells.

4. They provide 'energy' required for the growth and development of plant by oxidative break down of carbohydrates, proteins and fats during their cellular respiration.

Functions and deficiency symptoms of Nitrogen

Nitrogen plays a key role in the nutrition of plants. It is one of the principal growth promoting nutrient elements. Green plants are more markedly influenced by the deficiency of nitrogen than by any other element. It is absorbed by plants in the ionic form of NO_3^-, by most of the plants. Some plants require NH_4^+ form (rice). When applied as foliar nutrition, NH_2 (amide from) is also absorbed. It has got most recognized role in the plant metabolism as it performs the following vital functions. **In the N sufficient plants its concentration varies from 1 to 5%**

Functions of Nitrogen in plants

1. The Nitrogen is mainly involved in Photosynthesis of plants as it is essential constituent of chlorophyll, a green pigment essential in photosynthesis.

2. It is very basic constituent of plant life, because, it forms essential constituent of proteins, nucleotides phosphatides, alkaloids, enzymes, hormones, vitamins etc.,

3. It promotes better Vegetative growth and adequate supply of nitrogen promotes rapid early growth and imparts dark green color to plants, improves quality and succulence of leafy vegetables and fodder crops.

4. It stimulates the formation of fruit buds; increases fruit set, and improve quality of fruits.

5. It govern the better utilization of Potassium, Phosphorus & other elements.

Deficiency symptoms of Nitrogen in plants: Nitrogen is highly mobile element in plants and so deficiency is exhibited in older/ bottom leaves. The striking deficiency symptoms are

¥ Yellowing of older leaves due to inhibition of chloroplasts and chlorophyll synthesis. As the deficiency of Nitrogen becomes severe "Chlorosis" of leaves is observed.

¥ Plants become dwarfed or stunted growth.

¥ Tends to advance the time of flower bud formation and reduce yield.

¥ Fruits become hard, small, low bearing capacity of trees,

¥ Reduces fertilization, premature dropping and fruits may become seed less.

¥ Severe deficiency leads to Necrosis of plant leaves (complete death of leaf)

¥ Excessive N in plants leads to more vegetative growth. Leaves become more succulent and more susceptible to pest and disease attack. Lodging of plants may occur. Reduces the sugar content of plant, storage and keeping quality of fruits or leaves and prolong the growing period and delay the reproductive phase of plant and crop maturity.

Functions and deficiency symptoms of Phosphorus

Phosphorous is a constituent of essential cell components such as phytins, phosphoproteins, phospholipids, nucleic acids (DNA, RNA), co-enzymes (NAD & NADP), ATP and other high energy compounds. It is also a structural component of cell membrane, chloroplasts, mitochondria and meristematic tissues. Plants absorb the Phosphorus as $H_2PO_4^-$ and HPO_4^{2-} ionic form. Phosphate compounds act as "energy currency" within plants. It is highly mobile in plants but immobile in soils. **P-content varies from 0.1% to 0.4 % by weight which is 1/5th to 1/10th of N or K content.**

Functions

1. **Involved in Energy storage and transfer. Also carry various metabolic processes in plants.**

2. Involved in cell division and development of meristematic tissue and thus it improves better vegetative growth of plants.

3. **Important for root development and stimulates root growth**.

4. Helps in primordial development, flowering, seed formation, ripening of fruits germination of seeds and also early maturity of crops.

5. It is essential for formation of starch, proteins, nucleic acids, photosynthesis, nitrogen-metabolism, carbohydrate metabolism, glycolysis, respiration and fatty acid synthesis.

Deficiency symptoms of Phosphorus in plants

¥Deficiency symptoms of P appear first on the older leaves.

¥ Stunted and slow growth of plants due to its effects on cell division and meristematic tissue development.

¥ Leaves are small and defoliation starts from the older leaves and premature leaf fall.

¥ **Purplish discoloration of foliage due to anthocyanin pigment. Plants develop dead necrotic areas on the leaves, petioles or fruits.**

¥ Slender and woody stem with under developed roots are characteristics symptoms.

¥ Delay in flowering and ripening of fruits, inferior quality, shedding of blossom, inflorescence becomes small and premature fruit falling.

¥ Inhibit the sugar synthesis or abnormally high sugar levels in plant.

Functions and deficiency symptoms of Potassium

Potassium is indispensable in the plant nutrition and needs to be supplied in relatively large quantities to fruit crops and field crops. Plants absorb K from the soil as K^+ ion and it is mobile in nature in plants. Potassium does not enter in to the composition of any of the constituents of the plant cells such as proteins, chlorophyll, fats and carbohydrates. It primarily occurs as soluble inorganic salts and occasionally as salts of organic acids. It is abundant cation in the cytoplasm, meristematic regions, cell sap. It is considered as Quality element for many crops. **Its concentration in healthy plant tissues varies from 1% to 5%.**

Functions

1. Potassium is responsible for osmoregulation and controls cell turger pressure.
2. It has important role in pH stabilization, enzyme activation, protein synthesis, stomata movement (closing and opening), cell extension and photosynthesis.
3. Impart drought/heat/frost resistance to plants as it regulates transpiration and water conditions in the plant cell. It improves water use efficiency
4. Impart pest and disease resistance to plants
5. Required for ATP synthesis and better N use efficiency by favoring the protein formation.
6. Plants become strong and stiff; thus it reduces lodging of plants.
7. Essential in the formation and transfer of starch and sugars especially in potato, sweet potato, turnip, banana, tapioca.
8. It increase root growth and improves drought tolerance.
9. It enhances the crop quality. High concentration of available K improve physical qualities and shelf life of fruits and vegetables.

Deficiency symptoms

1. Deficiency symptoms of K appear first on the older leaves.

2. Weakening of stem and Lodging of crops and easy susceptibility to pest and diseases.
3. Scorching of leaves and burning appearance of leaf margins and tip
4. Poor keeping quality of fruits. The quality of fruits and vegetables decreased.
5. Marginal necrosis and burning of leaf tips.

6. Stunted growth, shortening of internodes.

7. It causes great disturbance in the water economy of plants and more water is lost per unit dry matter.

8. Poor sprouting of vines.

9. Severe attack of the grapes with Botrytis cinerea due to K deficiency.

Functions and deficiency symptoms of Calcium (Ca)

It is immobile in plants and exists as deposits of calcium oxalate, calcium pectate in the middle lamella of cell wall and $CaCO_3$ and $CaPO_4$ in cell vacuoles. Although calcium is present in plants in relatively higher proportion as compared with other elements, its actual requirement by plants is not much higher than that of a primary nutrient. **Calcium in ca-sufficient plants ranges between 0.2 to 1.0%. Among all the nutrients Ca is most abundant in plant available forms in the soil.**

Functions

1. It is a constituent of the cell wall and promotes early root development.

2. It is required for cell divisions and chromosome stability, cell wall construction, cell elongation of the shoot and root.

3. Stabilizing the pectin of the middle lamella in the cell wall by forming calcium pectate. Thus Ca brings resistance against diseases.

4. Effect on fruit quality and increases in the firmness of the fruit.

5. Indirectly influences many enzyme systems and maintain cation- anion balance (by acting as a counter ion).

Deficiency

• Deficiency is first observed on the young leaves and growing tips (immobile in plants).

• Leaves become small, distorted, cup shaped, crinkled and malformation of leaves (It resembles boron deficiencies)

• Terminal buds may deteriorate and die in fruits trees. Root growth is impaired.

• Destruction of cell well structure results in disturbance of nuclear and cell division.

• Fruit quality is reduced, loss of fruit fleshy, sometimes rotting of fruits and susceptible to fungal disease.

• Blossom end rot on a tomato (hyper link)

Magnesium (Mg) Mg is a constituent of the chlorophyll molecule and located at its centre, without which photosynthesis by plants would not occur. It is a mobile element and plant absorb as Mg^{2+} ionic form. **Its concentration in Mg- sufficient plants varies from 0.1 to 0.4%.**

Functions:

• Very much essential for photosynthesis.

• It is involved in the regulation of cellular pH, cation-anion balance and turgur regulation of cells.

• Necessary for protein synthesis.

• Activator of enzymes in carbohydrate and ATP metabolism.

• Essential for the formation of oils and fats

• It is required for stabilization of cell membranes.

Deficiency:

¥ **Interveinal chlorosis of lower leaves and in extreme cases becomes necrotic**.

¥ Leaves remain in small and brittle even in final stages.

¥ Twigs may become weak and premature dropping of leaves results in heavy loss of fruit crops.

¥ Inhibits nitrate reduction and the production of photo hormones.

¥ Stalk necrosis or stem 'Die back' in a Vine plant.

Excess of Mg absorption becomes poisonous leads to browning of roots as a result growth is ceased and death of roots and leaves. It can be counteracted by CO_2 antagonistic action.

Sulphur

It is abundant in plant, particularly in the leaves. Plant absorbs as sulphate (SO_4^{2-}) form. It does not easily translocated in plants. **Its concentration in S- sufficient plants varies from 0.1 to 0.4%.**

Functions:

1. Required for synthesis of the S-containing amino acids like cystine, cysteine and methionine, which are important for protein synthesis.
2. Role in photosynthesis by involving in structural formation of chlorophyll in leaves.
3. It is a constituent of proteins and volatile compounds responsible for the characteristic taste & smell of plants in the mustard and onion families.
4. It enhances oil synthesis in crops
5. It is a vital part of Ferrodoxins (Non Heme iron, sulfur protein), S- adenosyl methionine.

Deficiency :

1. Pale yellow or light green leaves in younger leaves (Deficiencies resemble those of nitrogen)
2. Stalks are short & slender, growth is retarded.
3. Fruits often do not mature fully & remain light green in colour.
4. In Brassica species, leaves shows cupping & curling.
5. Cell division is retarded & fruit development is suppressed.
6. Disrupts N metabolism, reduces protein quality & induces starch (carbohydrate) accumulation.

S- Toxicity: Sulphide injury, necrosis of the leaves.

Functions and deficiency symptoms of Fe

It is the first micronutrient to be discovered as an essential element for plant life. Iron present in chloroplasts as a "ferrodoxin" compound. Plants obtain as Fe^{2+} and Fe^{3+} forms and also as chelated Fe form. **Its concentration in the range of 100-500 mg/kg in mature leaf tissues is regarded sufficient for optimum crop production**. Immobile element within the plant; as such iron deficiency is noticeable in younger leaves at the growing region.

Functions:

1. Involved in biosynthesis of chlorophyll and in the synthesis of chloroplast proteins
2. Activates several enzymes involved in respiration.
3. It brings about oxidation-reduction reactions in the plant.
4. It regulates respiration, photosynthesis, reduction of nitrates and sulphates.

Deficiency symptoms:

1. **Interveinal chlorosis of younger leaves with leaf margins and veins remaining green and generally called as "Iron chlorosis" or lime induced chlorosis. On severe deficiency leaves become "Pale white".**
2. Reddish-brown necrotic spots along the leaf margins of young shoots in tree crops.
3. In Brassica necrotic terminal buds at early seedling stage.

Functions and deficiency symptoms of Mn

It is absorbed by plants as Mn^{2+} form from the soil. It is translocated to the different plant parts where it is most needed. **Healthy Mn- sufficient mature plants contaion 20 o 300 ppm of Mn**.

Functions:

1. Involved in oxidation-reduction reactions and electron transport in photosystem II
2. It is directly or indirectly involved in chloroplast formation and their multiplication.
3. It activates large number of enzymes and acts as a co-factor and catalyses most of the enzymes
4. It helps in movement of Iron.

Deficiency symptoms:

1. Interveinal chlorosis on younger leaves similar to Iron chlorosis.
2. Speckled yellow of sugarbeet-leaves develop interveinal yellowish green chlorotic mottling and leaf margins role upwards.
3. Depresses inflorescence and fructification and results in stunted leaf and root development.

Functions and deficiency symptoms of Cu. Copper (Cu): Minute quantities of copper are necessary for normal growth of plants. **The concentration of Cu in Cu-sufficient plants varies from 5 to 30 ppm.** Copper salts are poisonous even in exceedingly small concentrations. It is absorbed as cupric ion (Cu^{2+}). Its function is almost similar to those of Fe. It is immobile element in plants.

Functions:

1. It acts as electron carriers in enzymes which bring about oxidation-reduction reaction in plants.

2. Helps in utilization of iron in chlorophyll synthesis.

3. Influence on cell wall permeability and nitrate reduction.

4. Play a role in the biosynthesis & activity of ethylene in ripening fruit.

5. Promote the formation of vitamin-A in plants.

6. Influence on pollen formation & fertilization.

7. It enhances the fertility of male flowers.

Deficiency:

1. Narrow, twisted leaves and pale white tips. interveinal chlorotic mottling of leaves.

2. In fruit trees "die-back" (terminal bud wither and die) is most common.

3. It affects fruit formation much more than vegetative growth.

4. The critical stage of Cu deficiency induces pollen sterility in microsporogenesis.

5. Reduced fruit set and number of flowers.

6. **Male flowers sterility, delayed flowering and senescence are the most important effects of Cu-deficiency.**

Functions and deficiency symptoms of Boron

Boron is present especially at the growing points and in the conducting tissue. **Normal boron sufficient pants have B-contents ranging from 10 to 20 ppm.** This element being a non metal doesn't appear to be a part of any enzyme system. Plants absorb B as $H_3BO_3^-$, $B_4O_7^{2-}$, $H_2BO_3^-$, and HBO_2^{-3} & BO_3^{2-}. It is immobile element in plants.

Function:

1. Essential for cell division in the meristematic tissues.

2. Involved in proper pollination, pollen formation, pollen tube growth/ flowering and fruit or seed set.

3. Important role in the fertilizing process of plants and during blossom period its requirement is high.

4. It influences carbohydrates and N-metabolism and also Ca.

5. Translocation of sugars through cellular membranes and prevents the polymerization of sugars.

6. It enhances rooting of cutting through oxidation process.

7. It has role in hormone movement and action.

8. It gives resistance for pest and disease infection, e.g.: virus, fungi & insects.

9. Role in water relations i.e., prevents hydration of root tips & thus strengthens the plant roots

10. Acts as a regulator of potassium/calcium ratio in the plant. Solubility & mobility of Ca increases.

Deficiencies:

1. Young leaves may be deformed, appear like a “rosette”, cracking and cork formation in stems, stalks and fruits, thickening of stems and leaves, reduced buds, flowers and seed production. 2. Premature seed or fruit drop.

3. ‘Hen and Chicken disease’ in grapes bunches i.e. fruits of vine with small & long berries.

4. Deformed fruits of papaya tree.

5. Vine plant with thickened internodes. Poor fructification and development of the berries. In mango, leaves become pale green distorted & brittle leaves.

6. Browning or hollow stem of cauliflower.

7. Heart rot disease’ in fruits of the sweet melon (Cucumis melo), sugar beet & marigold.

8. Interruption in cell wall formation and differentiation and then necrosis.

9. Flowers wilt, die and persist on the tree. This phenomenon is called “Blossom Blast”.

10. Tissue break down and preventing sugar and starch accumulation in the leaves.

11. Excessive formation and accumulation of phenolics.

12. Bitter orange fruits with thickened peels or rinds & blackish discoloration.

• **B Toxcity-** yellowing of the leaf tip and leaf margin which spreads towards the midrib leaves become scorched and may drop early.

Functions and deficiency symptoms of Molybdenum

Required by plants in small quantity, plant absorb as MoO_4^{2-} form. It is structural components of Nitrogenase enzyme and constituent of nitrate reductase. **A healthy Mo-sufficient plant contains 0.1 to 2 ppm of Mo.**

Functions:

1. Essential role in iron absorption and translocation in plants, protein synthesis and N- Fixation in legumes.

2. Brings oxidation and reduction reactions especially in the reduction of NO_3 to NH_4.

3. It acts as a bridge or link in transferring electrons.

4. Role in phosphate system and ascorbic acid synthesis.

5. Mo affects the formation and viability of pollens and development of anthers.

Deficiency:

1. Reddish or purplish discoloration of leaves, chlorosis and marginal necrosis of leaves.

2. Marginal scorching and rolling or cupping of leaves, “Yellow spot” disease of citrus and “Whiptail” in cauliflower is commonly associated.

3. NO_3 accumulation in plants thus inhibits the utilization of N for protein synthesis.

Mo Deficiency (Bright yellow mottling between veins; leaves wither, curl and margins collapse; leaves distorted and narrow; older leaves affecter first. Rare deficiency).

Functions and deficiency symptoms of Cl

Chlorine is readily taken up by plants and its mobility in short and long distance transport is high. It does not form constituents of organic substance but act only in ionic form. The plant requirement for chlorine is rather quite high as compared to other micronutrients. **Normal healthy plants have Cl-content ranging from 100-500 ppm.** The exact role of Cl in plant metabolism is still obscure.

Functions:

1. Involved in the evolution of "Oxygen" by chloroplasts in photo system-II.
2. Associated with turgor production in the guard cells by the osmotic pressure exerted by K^+ ions
3. Role in stomata regulation (opening & closing).
4. Water splitting in photo system-II.
5. Act as a bridging ligand for stabilization of the oxidized state of Mn.

Deficiency :

1. Chlorosis and burning of tips and margin of leaves. In tomato, leaves become chlorotic and later bronzed.
2. Over wilting effect and leaf fall, yielding ability decreases.

Chloride toxicity on many crops- Bronze or yellow colors of leaves with brown or scorched leaf margins.

Functions and deficiency symptoms of Zn

Zinc is having limited mobility in plants and immobile in soil and plant absorb as Zn^{2+} form. **Zinc-sufficient plants contain 27 to 150 ppm Zn in mature tissue.**

Functions:

1. Zn is a constituent of several enzymes systems which regulate various metabolic reactions in the plant.
2. Influences the formation of some growth hormones in the plant like IAA, and Auxin.
3. Helpful in reproduction of certain plants.
4. Role in photosynthesis and involved in chlorophyll synthesis, protein synthesis.
5. Involved in alcohol dehydrogenase activity in fruit trees.

Deficiency:

1. Chlorotic and Brown rusty spots on leaves.
2. Lower Auxin level.
3. Drastic decrease in leaf area and leaf deformation (Rosetting), stunted growth (shortage of internodes).
4. Under severe deficiency the shoot apices die (dieback) and diffusive or mottled leaf
5. The rate of protein synthesis is drastically reduced and amino acids and amides accumulate.

Functions and deficiency symptoms of nickel:

Nickel is absorbed by plants as nickel ions Ni^{2+}. **Its concentration in Ni-sufficient plants varies from 0.1 to 10 ppm.**

Functions:

1. Nickel is required by plants for proper seed germination.

2. It is beneficial for N metabolism in legumes and other plants in which ureides (compounds derived from urea) are important in metabolism .

3. Ni is the metal component in urease, an enzyme that catalyzes the conversion of urea to ammonium.

Deficiency:

1. Though Ni deficiency symptoms are not well documented.

2. Symptoms include chlorosis and interveinal chlorosis in young leaves that progress to plant tissue necrosis.

3. Other symptoms include poor seed germination and decreased crop yield.

Luxury consumption?

It is the tendency of some crops to absorb and accumulate nutrients far in excess of their actual needs if it is present in sufficiently large quantities in the soil. Potassium is one of the nutrient elements which is subjected to luxury consumption.

The absorption pattern of different nutrients by plants is varies greatly among the plant species and also their age and growth stages.

Nutrient interactions in plants and soils

1. Interaction can be defined as the influence of an element upon another in relation to growth and crop yield. There may be positive or negative interaction of nutrients occurs either in soil or plant. The positive interaction of nutrients gives higher crop yield and such interactions should be exploited in increasing the crop production. Conversely, all negative interactions will lead to decline in crop yield and should be avoided in formulating agronomic packages for a crop.

2. The knowledge about interactions occurring in soils or plants or both is basic to help develop appropriate and efficient technologies. Further this will help to refine the existing ones to increase agricultural production.

3. There are mainly two types of interactions effect viz. antagonistic and synergistic effects. Antagonistic effect means an increase in concentration of any nutrient element will decrease the activity of another nutrient (negative effect). While synergistic effects means an increase of concentration of any one nutrient element will influence the activity of another nutrient element (Positive effect). One must understand how the negative or positive interaction takes place within or outside the plant.

The following antagonistic effects have been well established on the uptake of micronutrients by crops:

1. Excess of P adversely affects utilization of Zn, Fe and Cu
2. Excess of Fe adversely affects utilization of Zn and Mn
3. Excess of Zn, Mn, and Cu induces Fe-deficiency in crops
4. Excess of S and Cu induces Mo-deficiency in crops
5. Excess of Lime induces deficiency of all micronutrients.
6. Presence of carbonate and bicarbonate ions in soil due to sodicity or over liming reduces the availability of micronutrient cations to crops which suffer most iron deficiency.
7. Lime X P, Lime X Mo, Mo X P, and Na X K are common negative interactions.
8. Excess of Ca may induce P deficiency

N- Transformation and availability in soils

N- Availability in soil.

Dynamics and transformation of nitrogen in soil is very important with respect to plant nutrition. A bulk of total N is present in the organic form (98%) and only about 2% in inorganic form. However there are continuous transformations between these two pools. The crops utilize nitrogen in the inorganic forms only such as NO_3^-N and NH_4^-N. The inorganic form of N is also liable to undergo different types of loses like runoff, ammonia volatilization, leaching, denitrification and fixation by clay minerals.

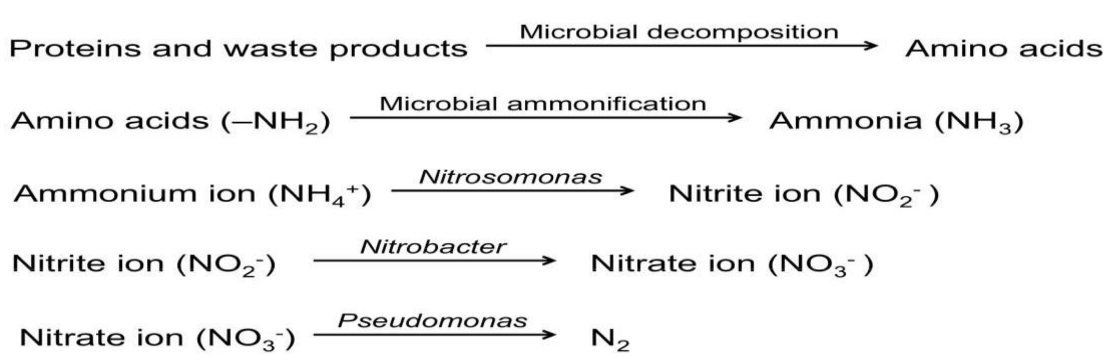
N- Transformation in soils

The Nitrogen cycle mainly includes transformations such as

1. Nitrogen mineralization : In which N containing organic complexes are decomposed and converted into inorganic compounds for use by plants

2. N immobilization : In which N containing inorganic compounds are assimilated

N_2 is acted on by certain micro organism sometimes in symbiosis with a higher plant, which can use it is as a N source for growth. The process of nitrogen fixation, results in the accumulation of new organic compounds in the cells of responsible micro organisms. The N_2 thus fixed reenters general circulation when the newly formed cells are inturn mineralized. By means of these reactions the subterranean microflora regulates the supply and governs the availability and chemical nature of N in soil.



I. Nitrogen mineralization

The conversion of organic N to the more mobile, inorganic state is known as nitrogen mineralization. As a consequence of mineralization, ammonium and nitrate are generated and organic N disappears. This takes place in three distinct microbiological steps.

1. Aminization

It is a process of enzymatic digestion by non-specific heterotrophic bacteria, actinomycetes and fungi by which protein and proteinous compounds are decomposed into amino acids or amines.

$$\text{Protein} \xrightarrow[\text{Heterogeneous soil microbs}]{\text{Enzymatic reaction}} \text{Polypeptides} \xrightarrow[\text{hydrolysis}]{} \text{amino acid} + CO_2 + \text{energy}$$

2. Ammonification

It is the process of mineralization in which proteins, nucleic acids and other organic components are degraded by micro organism with the eventual liberation of ammonia. This is called ammonification. A part of the liberated ammonia is assimilated by the micro organism themselves. The first step in ammonication process is the hydrolysis of proteins, nucleic acids and other organic nitrogenous compounds into amino acids (proteolysis). The amino compounds are then deaminated to yield ammonia. Ammonification usually occurs under aerobic conditions while under anerobic conditions protein decomposition leads to conversion of ammonia into amines and related compounds (eg) clostridium. The anaerobic decomposition of protein called as putrefaction. These amines are subsequently oxidized in the presence of O2 to release ammonia.

Break down of nitrogenous substance is brought about by the activity of a multitude of microbial species.

Almost all bacteria, actinomycetes and fungi can bring about proteolysis and the amino acids produced are utilized for the growth of these organisms.

(3) Nitrification

The biological oxidation of ammonium salts (in soil) to nitrites and the subsequent oxidation of nitrites to nitrates is called as nitrification. i.e. the biological convention of N in soil from a reduced to a more oxidized state, called nitrification.

Nitrification occurs in two steps;

First ammonia is oxidized to nitrite.

$2\ NH_3 + 1½\ \ H_2O_2 \rightarrow NO_2^- + 2H{+}H_2O$-Nitrosofication

This change is brought about by chemoautotrophic bacteria of the genera *Nitrosomonas*, *Nitrosolobus, Nitrosococus, Nitrosospira*. These bacteria obtain their energy requirement by the oxidation of NH_4^+ to NO^-_2. Among the nitrifiers *Nitrosomonas* are most important in soils.

Some heteotrophs involved; *Streptomyces, Nocardia*

Second step

Nitrite is further oxidized to nitrate

$HNO_2 + ½\ O_2 \rightarrow HNO_3$.

Organisms: *Nitrobacter*, *Aspergillus*, *Penicillium*, *Cephalosporium*.

Factors influencing the growth of nitrifying bacteria in soil

Levels of ammonia and nitrite, aeration, moisture, temperature, pH and organic matter. In acid soils – nitrification is poor. Waterlogged soils – deficient in O_2 – not congenial for nitrification.

4. Denitrification

The convention of nitrate and nitrite into molecular N_2 or nitrous oxide through microbial processes is known as denitrification. Certain bacteria are capable of using nitrate as the terminal electron acceptor under anaerobic conditions. This is called **nitrate respiration**. As a consequence of nitrate respiration, NO_3 is reduced to N_2 gas or nitrous oxide. Denitirifcation leads to the loss of N from the soil. It depletes N, and therefore it is not a desirable reaction.

The escape of molecular N into the atmosphere is also known as **volatalization**.

Denitirfication occur mostly in waterlogged anaerobic soils with a high organic matter contents. Denitrification of bound nitrogen to gaseous N is mediated by numerous species of bacteria, which normally use O_2 as hydrogen acceptor (aerobically) and, also use nitrates and nitrites (anerobically).

Anaerbic convertion of nitrate into molecular nitrogen is known as nitrate respiration.

Bacterial genera which bring about denitirfication *Pseudomonas, Achromobacter, Bacillus, Micrococcus*

$2NO^-_3 + 10\ H \rightarrow N_2 + 4H_2O + 2OH^-$ (or)

$2NO^-_2 + 6\ H \rightarrow N_2 + 2H_2O + 2OH^-$ (or)

$N_2O + 2H \rightarrow N_2 + H_2O$

Since nitrates are used as a source of electron acceptor, there is a net loss of N from soil. This process is termed also as **dissimilatory nitrate reduction**. Many soil bacteria like.

Thiobacillus denitrificans

Oxidize S (chemoautotrophically) and also reduce nitrate to nitrogen

$5S + 6\ KNO_3 + 2\ H_2O \rightarrow 3N_2 + K_2SO_4 + 4KHSO_4$ (or)

$5\ K_2S_2O_3 + 8\ KNO_3 + H_2O \rightarrow 4N_2 + 9\ K_2SO_4 + H_2SO_4$

General pathway of denitrification

Nitrate is first reduced to nitrite, which is then transformed to nitrous oxide (NO). The nitrous oxide is converted to N_2 with N_2O as an intermediate.

$$2\ HNO_3 \xrightarrow{1} 2HNO_2 \xrightarrow{2} 2\ NO \xrightarrow{3} N_2O \xrightarrow{4} N_2$$

The enzymes involved

1. Nitrate reductase
2. Nitrite reductase
3. Nitric oxide reductase
4. Nitrous oxide reductase

- Fallow soils flooded with water are more congenial for denitrification than well drained and continuously cropped soils.
- Though it is a undesirable reaction in point of view of plant nutrition, but have ecological importance. Because with out denitrification the supply of N on the earth world have got depleted and NO_3 would have accumulated.
- High concentration of NO_3 are toxic, denitrification is a mechanism by which some of the N is released back to the atmosphere.

5. Nitrate reduction

The reverse of nitrification process. That is the reduction of nitrate to nitrite and then ammonia. Since organisms are able to obtain cellular N^{th} ammonia assimilation, the process is called as assimilatory nitrate reduction.

$HNO_3 + 4H_2 \rightarrow NH_3 + 3H_2O$

II. Nitrogen immobilization

The process of microbial assimilation of inorganic nitrogen is referred as immobilization. In contrast to mineralization, microbial immobilization leads to the biosynthesis of the complex molecules of microbial protoplasm from ammonium and nitrate. Immobilization results in a marked depression of nitrogen uptake by the plant.

The mineralization of organic N and the microbial assimilation of inorganic ions proceeds simultaneously.Both mineralization and immobilization take place regardless of the % of N in the organic N in organic matter. On the death of micro organism, the immobilized N is however released through mineralization. It is also a loss of nitrogen. NO_3 when accumulated in microbial protoplasm it is referred as assimilatory NO_3 reduction.

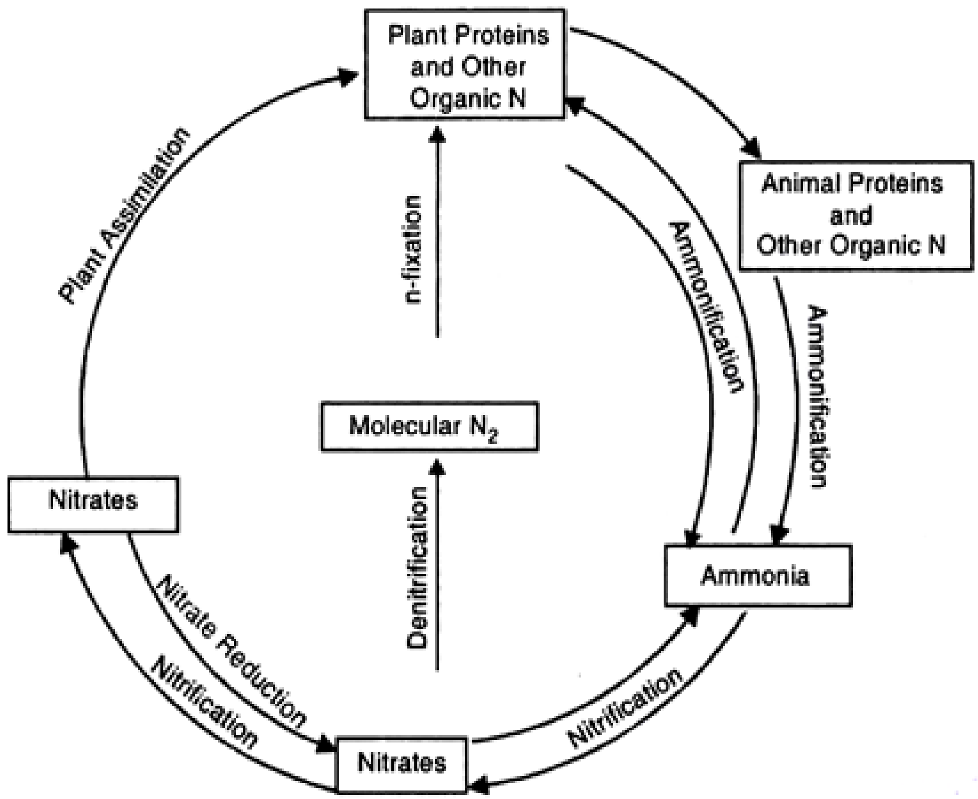


Fig. 12.11. Nitrogen cycle in ecosystem.

P- transformation in soil

Soil P exists in various chemical forms including inorganic P (Pi) and organic P (Po). These P forms differ in their behavior and fate in soils. Pi usually accounts for 35% to 70% of total P in soil. Primary P minerals including apatites, strengite, and variscite are very stable, and the release of available P from these minerals by weathering is generally too slow to meet the crop demand though direct application of phosphate rocks (i.e. apatites) has proved relatively efficient for crop growth in acidic soils. In contrast, secondary P minerals including calcium (Ca), iron (Fe), and aluminum (Al) phosphates vary in their dissolution rates, depending on size of mineral particles and soil pH. With increasing soil pH, solubility of Fe and Al phosphates increases but solubility of Ca phosphate decreases, except for pH values above 8. The P adsorbed on various clays and Al/Fe oxides can be released by desorption reactions. All these P forms exist in complex equilibria with each other, representing from very stable, sparingly available, to plant-available P pools such as labile P and solution P.

Key Points

- Phosphorus in phytin, phospholipids and nucleic acids is found as phosphates
- Phytin is the calcium – magnesium salt of phytic acid
- Phospholipids are compounds in which phosphate is combined with a lipid, contained 10% of cell phosphorus.
- Inorganic polyphosphates are quite abundant in certain fungi
- In soil, from15-85% of the total P is organic. Soils rich in organic matter contain abundant organic P.
- Ratios of organic C to P of 100 to 300:1 N: organic P = 5 to 20: 1

In cultivated soil P present in abundant about 1100 kg/ha but most of them as not available to plants; only about 1% of the total P is in available form.

PO_4^{3-} in rocks and in cells

$$\text{Insoluble } PO_4^{3-} \xrightarrow{\text{Acid}} \text{Soluble } PO_4^{3-}$$

- Acid from *Thiobacillus*

$$\text{Soluble } PO_4^{3-} \xrightarrow{\text{Bird guano}} \text{Insoluble } PO_4^{3-}$$

Microorganisms bring about a number of transformations of the element.

1. Altering the solubility of inorganic compounds of P
2. Mineralization of organic compounds with the release of inorganic phosphate
3. Converting the inorganic, available anion into cell components, an immobilization process (analogous to that occurring with N)
4. Bringing about an oxidation or reduction of inorganic P compounds

Particularly, important to P cycle are the microbial mineralization and immobilization reactions.

(1) Solubilization of inorganic phosphorus

Insoluble inorganic compounds of P are largely unavailable to plants, but many micro organisms can bring the PO_4 into solution. P solubilizing are 10^5 to 10^7 / g soil.

Eg: *Pseudomonas striata*, Microoccus *Bacillus sp*., Fusarium, *pergillus* sp, Solubilises calcium salts, iron, aluminum, magnesium manganese phosphate.

- P is solubilized by the production of organic acids. The acids convert $Ca_3 (PO_4)_2$ to di and monobasic phosphates and releases P to plants.
- Solubilization of phosphates by plant roots & micro organism is dependent on soil pH. In neutrals and alkaline soils having a content of calcium, precipitation of $CaPO_4$ takes place. Micro organism and plant root readily dissolve such PO_4 and make them available to plants.
- On contrary, acid soils are generally poor in Ca ions and phosphates and precipitated in the form of ferric or aluminum compounds which are not soluble. There, it is solubilized by the addition of PO_4 solublizing micro organism.
- Phosphorus exists mainly as apatides, with the basic formula $M_{10} (PO_4)_6 X_2$.

Commonly the mineral (M) is Ca, less often Al or Fe. The anion (X) is either F^- or Cl^- or OH^- or $CO^{2-}{}_3$. Diverse combinations of M and X results in 200 forms of P.

(2) Mineralization of organic phosphorus

Organic form of P is the larger reservoir of P in soil. By the action of bacteria, fungi and actinomycetes, bound element in remains of the vegetation and in soil organic matter is made available to succeeding generations of plants.

Among the organic phosphours compounds, lecithin, nucleic acids and phytin occupy a prominent place. Lecithin contains 9.39 % P_2O_5, 1.6% N and 65.36% C.

It is a process of convention of organic forms of phosphorus into inorganic available forms of P a highly significant correlation is observed between the rates of N and P convention to inorganic forms.

- Mineralization is favoured by warm temperature, with the thermophilic range being more favourable than mesophilic range.
- Neutral pH increases PO_4 release, which favours microbial metabolism
- Quantity of substrate ie presence of organic P. If more P, more of mineralization

- Mineralization is mediated by the enzymes called phosphatases. These enzymes cleave phosphorus from more frequently encountered organic substrates.
- Phytases liberates PO_4 from phytic acid or its Ca-Mg, Salt, Phytin. They remove PO_4-s, one at a time, yield penta – tetra, di- and mono PO_4 and then finally free inositol.
- *Bacillus, Pseudomonas, Aspergillus, Penicillium, Rhizopus* can synthesize this enzyme. Mycorrhizal (fungi) are also able to mineralize the organic forms of P and increases P uptake by the plants.

(3) Immobilization

Process of assimilation of P into microbial nucleic acids, phospholipids or other protoplasmic substances is called immobilization. It leads to the accumulation of non utilizable forms of the element.

P accounts for 0.5-1.0% of fungus mycelium and 1.0 to 3.0% of the dry weight of the bacteria and actinomycetes.

(4) Oxidation reduction reactions

Biological oxidation of reduced phosphorus compounds into oxidized state.

Phosphite ($HPO_3^=$) is oxidized to phosphate. A number of hetertrophic (bacteria), (fungi) & (actinomycetes) utilize phosphite as sole P source. Hypophosphites ($HPO_2^=$) can also be oxidized to phosphate by heterotrophs.

$HPO_3^= \rightarrow HPO_4^=$

$HPO_2^= \rightarrow HPO_4^=$

Reductive process, reductive pathway has also been functioned. PO_4 is reduced to phosphite and hypophosphite.$H_3PO_4 \rightarrow H_3PO_3 \rightarrow H_3PO_2$

Clostridium butyricum, *E. coli* form phosphite and hypophosphite from orthophosphate. It is biochemically analogue to the process of denitirification. Only little information is available about this process.

P exist in an organic form in the protoplasm on the death of living organism, this (P) is changed to inorganic phosphoric acid. This is soon converted into insoluble salts of Ca, Fe, Mg and Al. Phosphorus thus alternates between organic and inorganic, and soluble and insoluble forms. In soluble P is solubilized by various acids produced by micro organism.

Microbial activities involved in the cycling of C, N and P are absolutely essential for maintenance of soil fertility.

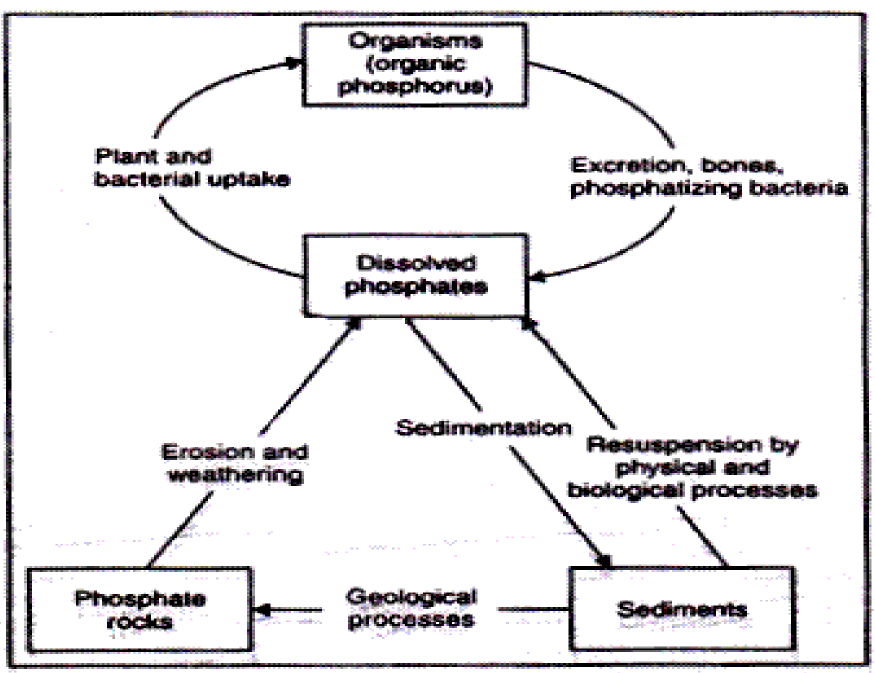
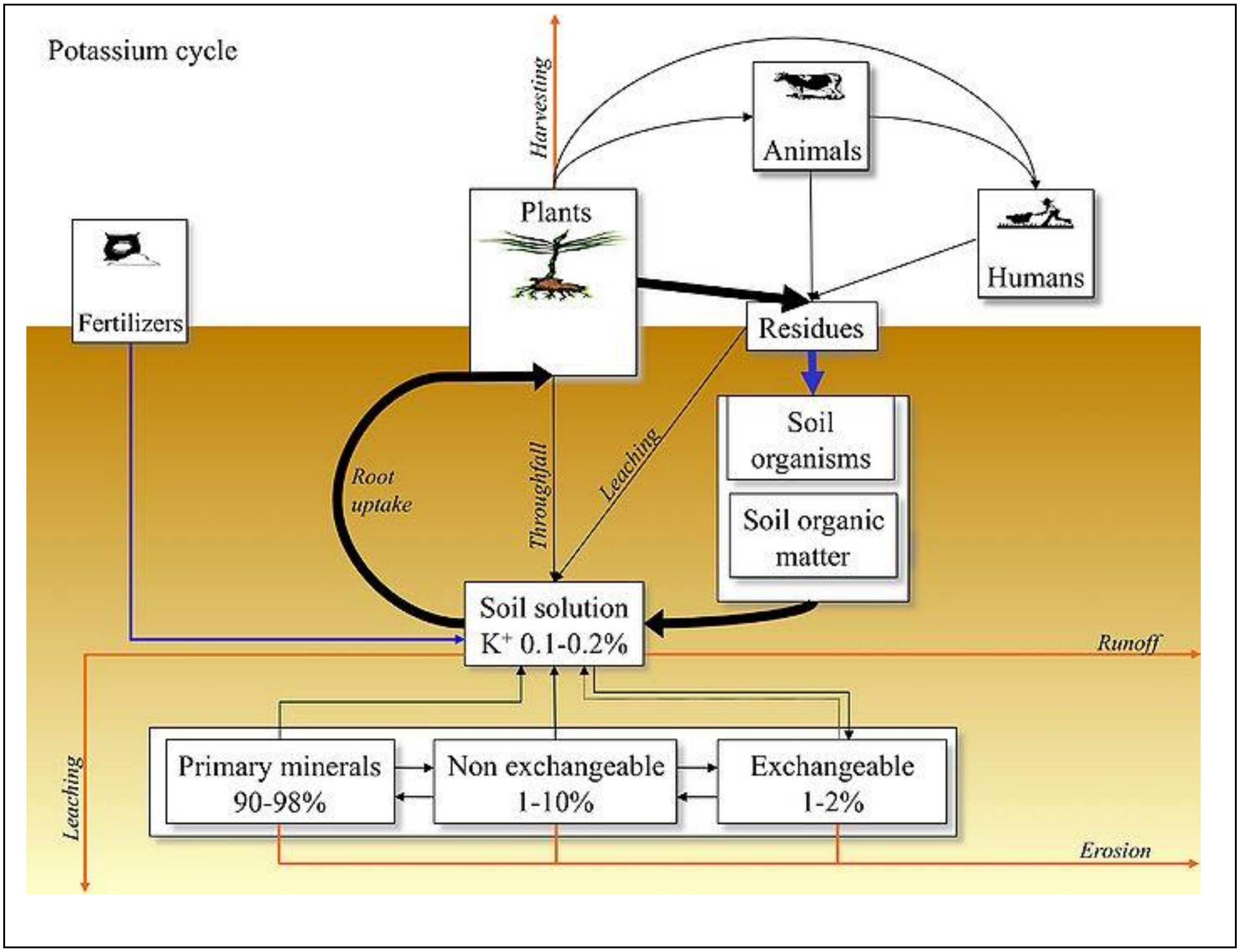


Fig. 5.9. A simplified diagram of the phosphorus cycle. (after E.P. Odum, 1993)

K-transformations & availability in soils

K- Availability in soil

Potassum is present in soil solution as K^+ ion which is readily available to plants. But this form is in dynamic equilibrium with exchangeable K which intern with fixed K. Fixed K is in equilibrium with mineral K. The available K is the solution-K and Exchangeable K which can be easily absorbed by plants.



Calcium and Magnesium availability in soils

Ca &Mg availability in soils:

Ca and Mg are the most abundant cations occupying the exchange sites of the soil colloids of both inorganic (clay) and organic (humus). Soil Ca and Mg mainly come from the weathering of rocks and minerals (Calcite and Apatite). Thus most soils contain enough Ca and Mg except highly weathered leached acid soils and alkali soils. Deficiencies of Ca and Mg most commonly occur in coarse textured soils, acidic soils of high rainfall area due to leaching losses. In soil solution occurs as cations and also adsorbed cation on the clay and humus surfaces and involved in exchange process. The critical limits of exchangeable Ca and Mg vary widely among soils. However average value of <2.0 m.eq/100g for exchangeable Ca and < 0.5 m.eq/ 100g for exchangeable Mg are considered critical limits for availability.

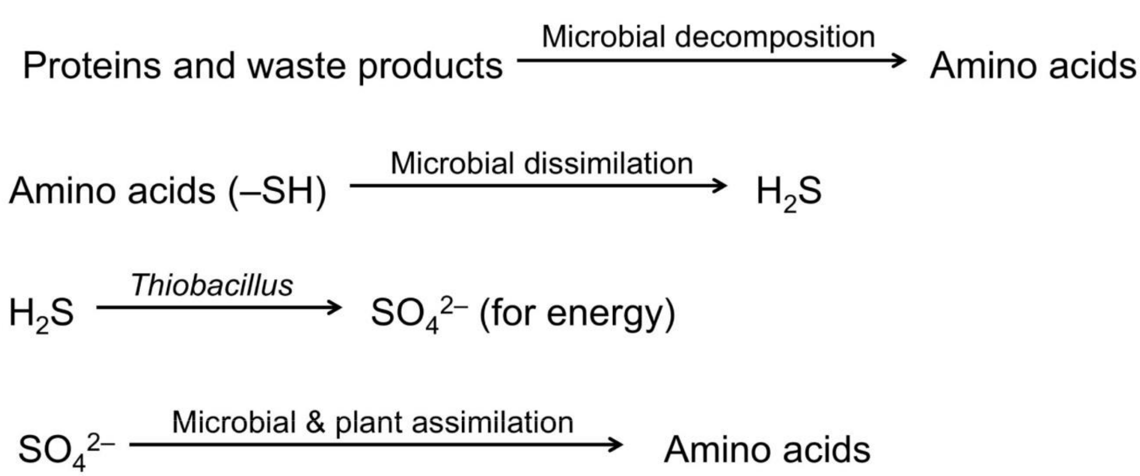
Ca & Mg Transformations:

Ca and Mg occupying the exchange sites of the soil colloids (clay & humus) are subjected to cation exchange reactions with other monovalent and divalent cations then released into soil solution for plants absorption or adsorbed on the clay and organic matter surfaces. Soils usually contain less Mg than Ca because Mg^{2+} ions are not adsorbed as strongly by clay and organic matter as Ca^{2+} ions and further Mg^{2+} ions are more susceptible to leaching than Ca^{2+}ions. The solution Ca and Mg is subjected to leaching/erosion losses and crop uptake, thus it may deplete the Ca and Mg content soil.

S transformation and cycle:

Four distinct transformations are recognized

1. **Decomposition/Mineralization** of larger organic S compounds to smaller units and their conversion into inorganic compounds
2. **Oxidation of inorganic ions and compounds** such as sulphides,thiosulphates, sulphates
3. **Reduction** of Sulphates abd other sulphides
4. Microbial associated **immobilization**



Mineralization

Conversion of organic bound S into inorganic state, mediated through M.O. The released S in either absorbed by plants or escaped into atmosphere in the form of oxides

Oxidation

- Occurs both in aerobic and anaerobic condition
- Bacteria
- Nonfilamentous forms- Thiobacillus
- Filamentous forms – Beggiatoa,Thiothrix and Thioloca
- Fungi and actinomycets
- Aspergillus, Penecillium and Microsporium

Sulphate reduction

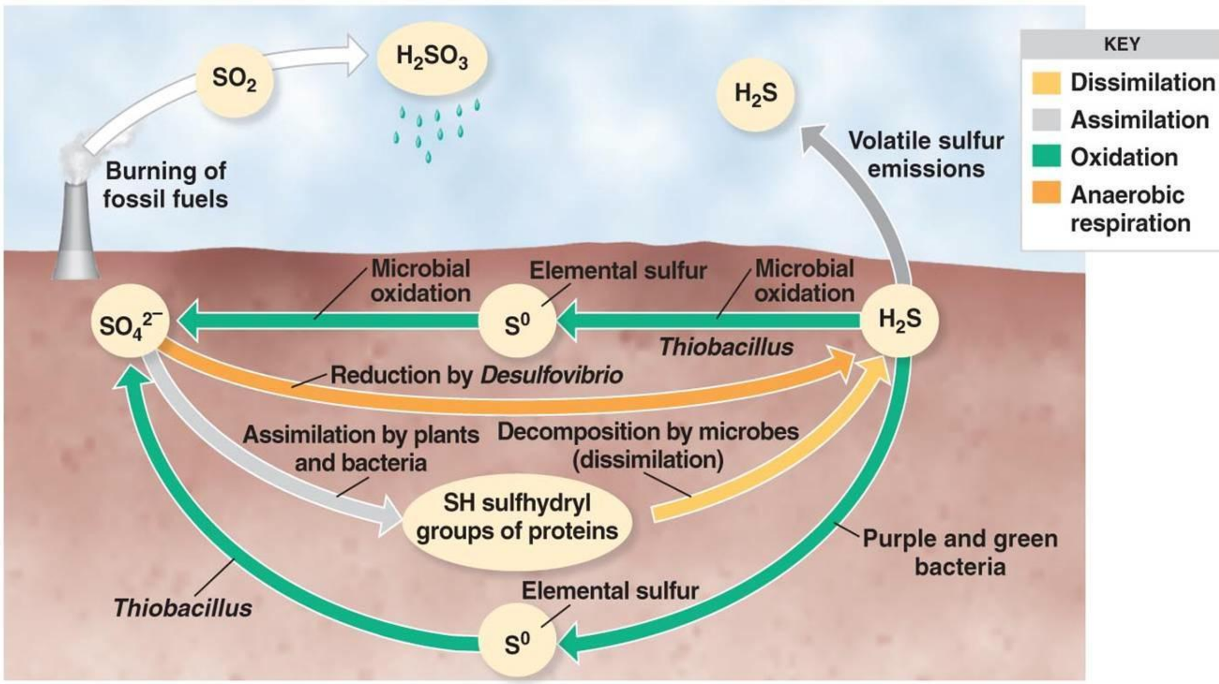
Reduces inorganic sulphate into Hydrogen sulphide –reduces the availability of S for plant nutrition. *Desulphovibrio desulphricans –anaerobe*

Immobilization: Conversion of inorganic S to organic S by microorganism.

Importance of Thiobacillus

Produces Sulphuric acid ,lower down the soil pH – Hence used in controlling plant disease

- Apple and Potato scab –*Streptomyces scabis* ,Sweet potato rot – *S. ipomea*
- *S+ Thiobacillus* application is used for the control
- Remediation of alkali soil
- Increases the solubilization of other nutrients (P,K,Ca,Mn,Al and Mg)
- Preparation of biosuper- Rock phosphate + T.thiooxidans and S--- Australia
- Lipman’s process- Compost preparation
- Soil + manure + elemental S + rock phosphate



KEY
Dissimilation
Assimilation
Oxidation
Anaerobic respiration
SO2
H2SO3
H2S
Burning of fossil fuels
Volatile sulfur emissions
Microbial oxidation
Elemental sulfur
Microbial oxidation
SO4 2−
S0
H2S
Thiobacillus
Reduction by Desulfovibrio
Assimilation by plants and bacteria
Decomposition by microbes (dissimilation)
SH sulfhydryl groups of proteins
Purple and green bacteria
Thiobacillus
Elemental sulfur
S0

Micronutrients and their Transformations in soil

Micro or trace elements in soil are derived from the parent materials and natural deposition from the atmosphere, organic manures and fertilizers. Trace elements are largely bound in mineral lattices, to be released by weathering. Iron, Cu, Mn, Zn, Co, Mo, Ni and Cr occur in ferromagnesian minerals common in ultrabasic and basic igneous rock.

The total content of Fe, Mn, Zn, Cu, Co, Cl & B varies considerably in different soils. Except Zn, Cu and B, all other micronutrients (Fe, Mn, Cl, Mo) are present in Indian soils in sufficient amounts to sustain agricultural productivity. Zn and Boron deficiency is found in all the soils of agro ecological regions of the country. The availability of micronutrient cations in soil is highly affected by inorganic ions in soil solution, soil solid constituents like free oxides of Fe & Al, soil organic matter, fertilizers and amendments applied to soil.

Nutritional disorder

Disease due to calcium deficiency:

1. Blossom end rot in peppers and tomato.
2. Bitter pit in apple
3. Internal brown spot in potato.
4. Black heat in peanuts, cleary.
5. Cavity spots in carrots.

Disease due to Mn deficiency:

1. Grey speck of oats.
2. Speckled yellow of sugarbeet.
3. Marsh spot of peas.
4. Pahala blight of sugarcane
5. Frenching of tung trees.

Disease due to Mn toxicity:

1. Crinkle leaf of cotton

Disease due to Zn deficiency:

1. Khaira in rice
2. White bud of maize.
3. Mottle leaf (little leaf) or frenching of citrus.
4. Little leaf of cotton.

Disease due to Cu deficiency:

1. Reclamation disease

Disease due to Mo deficiency:

1. Whip-tail in cauliflower

Disease due to B deficiency:

1. Heart rot of sugarbeet and mangold.
2. Browning or hollow stem of cauliflower.
3. Top sickness of tobacco.
4. Internal cork of apple.

Soil Reaction

Method of expressing acidity and alkalinity: **When an acid is dissolved in water, it releases hydrogen ions (H^+) which make the solution acidic. When an alkali is dissolved in water, it releases hydroxyl ions (OH^-), which make the solution alkaline**. Equivalent quantities, of all acids or alkalis contain the same number of total hydrogen or hydroxyl ions respectively, but when they are dissolved in water they do not ionize to the same extent. The amount of acid and alkali ionized depends upon their contain free H and OH ions. Same is true of water also. and microorganisms than the weaker acids or alkalis. This is due to greater number of hydrogen ions or hydroxyl ions in strong acid or alkali respectively. Titration determines both the ionized and unionized hydrogen and hydroxyl ions.

Scale of acidity or alkalinity (pH scale): Instead of stating in a vague manner that a solution is weakly acidic or alkaline or is strongly acidic or alkaline or is neutral, the acidity or alkalinity of a soil solution (or even a pure solution) can be expressed on the scale of acidity and alkalinity in the same way as temperature is expressed on a thermometer scale. The scale of acidity or alkalinity is called pH scale. The units of this scale are called pH values. This scale runs from 0 to 14 pH values. The neutral point in this scale is at pH 7.0. All values above pH 7.0 represents alkalinity and values below 7.0 denote acidity. The degree of alkalinity increases as values go above pH 7.0 and the degree of acidity increases as the pH decreases below 7.0.

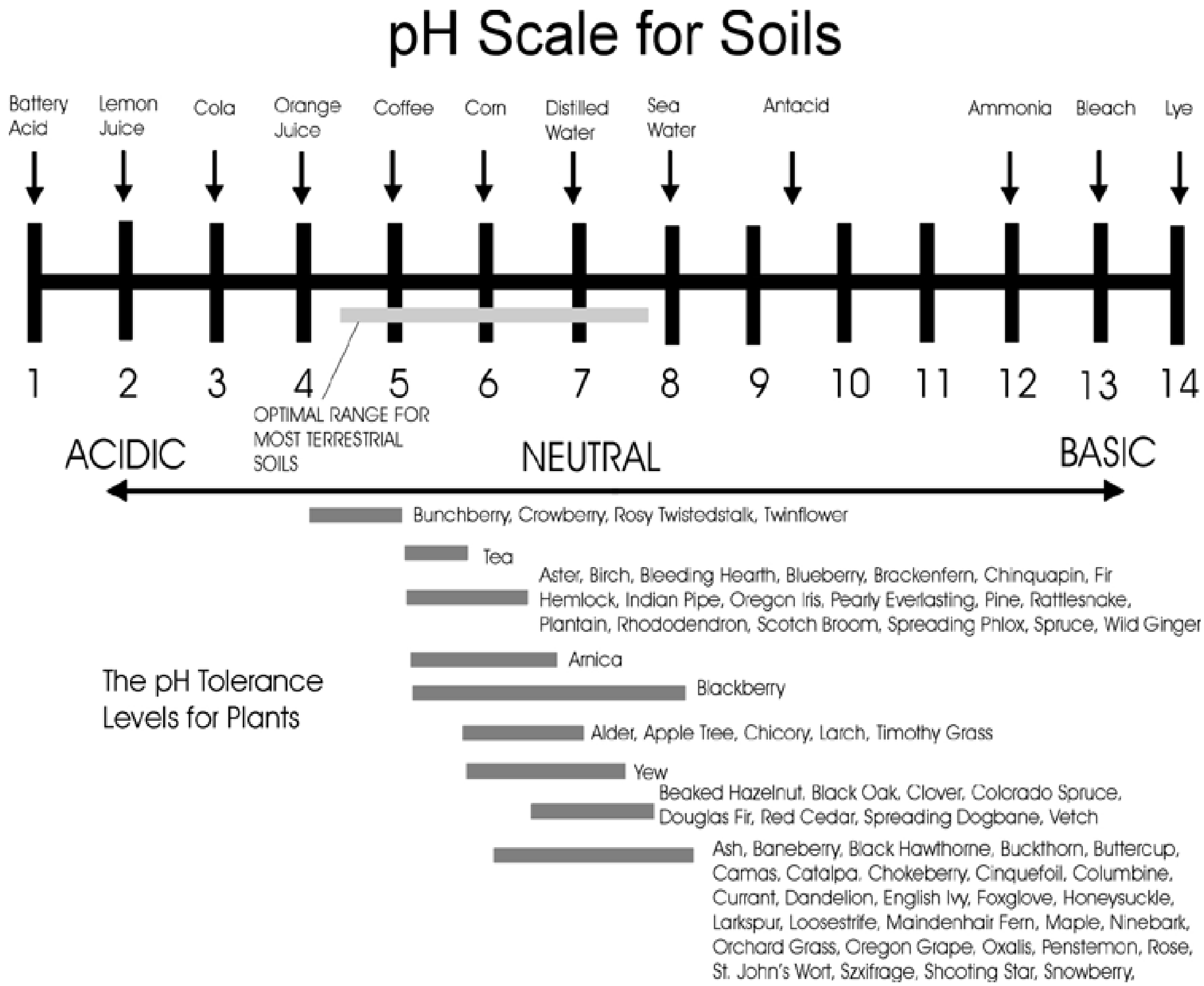
Soil pH: The reaction of an aqueous solution represents the degree of acidity or basicity caused by the relative concentration or activity of hydrogen (H^+) or hydroxyl (OH^-) ions present in it. Acidity is due to the excess of H ions over OH ions, and alkalinity to the excess OH ions over H ions. A neutral reaction is produced by an equal activity of H and OH ions. According to the theory of dissociation, the activity is due to the dissociation or ionization of compounds into ions. Even pure water which is neutral in reaction dissociates into H and OH ions, $H_2O \rightarrow H^+ + OH^-$, as it shows a very slight but definite conductivity. Only one mole in about ten million is dissociated into ions. Hence the concentration of each ion in pure water is extremely small, being of the order of 1×10^{-7} when expressed in mols per litre. The product of dissociation of the two ions is a constant as represented by the equation:

$$K_w = [H^+] \times [OH^-] = 10^{-14}$$

or, taking the logarithm of the reciprocals:

$$\log 1/K_w = \log 1/[H^+] + \log 1/[OH^-] = 14$$

where K_w represents the ionization constant for pure water at 22^0C. If the concentration of one kind of ion is increased, that of the other must correspondingly decrease. Hence the measurement of one type of ion, viz., H^+ ions, is sufficient to tell us whether a solution is acid or alkaline.



In 1909 Sorensen, a Danish scientist, introduced the idea of representing the degree of acidity or alkalinity of a solution in terms of its pH value, i.e., its active hydrogen ion content. The pH value of a solution may be defined as the logarithm of the reciprocal (or the negative logarithm) of hydrogen ion activity or concentration and is expressed as:

$$pH = \log 1/[H^+] = -\log [H^+]$$

The pH value, therefore, represents the amount of free or active acidity and not the total quantity of potential or combined acidity. In other words, it represents the intensity of acidity of a solution. In this scale, the pH value ranges from 0 to 14, where pH 0 represents the highest limit of active acidity, and pH 14 the highest degree of basicity. At neutrality, pH = pOH = 7; therefore the pH 7 represents a neutral reaction. As the pH is logarithmic, a solution with pH 5.0 is ten times as acid as one having pH 6.0, and one-tenth as acid as that having pH 4.0. As the pH values move up or down by geometric progression, a relatively small change in pH represents a comparatively large change in reaction.

For practical purposes, soils having pH ranging from 6.5 to 7.5 are considered neutral as the very slight acidity or alkalinity indicated by this range is of no consequence as far as crop growth is concerned. Soils having pH between 6.5 to 6.0 are considered slightly acid, those between 6.0 and 5.0 are considered moderately acid, those between 5.0 and 4.0 are strongly acid, while those having pH less than 4.0 are extremely acid. There are very few cases of soils having pH less than 3.0. Such soils are usually barren as no plant is able to tolerate such a high acidity.

Similarly, soil having pH between 7.5 and 8.0 are considered slightly alkaline. Those between 8.0 and 9.0 are moderately alkaline, those between 9.0 and 10.0 strongly alkaline, while those having pH greater than 10.0 are extremely alkaline. Crop growth is practically impossible in such soils.

Importance: Soil reaction is of great importance as it influences **crop growth** both directly and indirectly. Higher plants as well as microorganisms respond markedly to their environment of which soil reaction is an important contributory factor. Most plants do well in neutral soils. Many of them fail to grow properly if the reaction becomes very acidic or alkaline. On the other hand, there are some species of plants that require an acid or alkaline reaction for their best performance. **The availability of many plant nutrients depends to a large extent on the prevailing soil reaction. Iron, manganese, zinc, copper, etc., are available more in acid than in alkaline soils. Phosphorus becomes less available or completely unavailable depending upon the reaction of the soil.**

The kind of phosphate ion present in the solution depends upon the pH of the soil solution. When the soil is acidic (pH 5.5) the $H_2PO_4^-$ ion is dominant, while as the pH value increases HPO_4^{2-} ions are in excess and in distinctly alkaline soils (pH 7.5) PO_4^{3-} ions are present in excess. Moreover, at low pH values iron, manganese, titanium, etc., become more soluble which form insoluble phosphates of iron, manganese, aluminium and titanium and thus render the phosphate insoluble by fixing them. For this reason the pH of the soil which favors a mixture of $H_2PO_4^-$ and HPO_4^{2-} ions is most commonly preferred. Such fixation of phosphorus is most serious at pH 5.0 or below it.

On the other hand pH values above 7.5 or 8.0 disturb the nutrition of higher plants and microorganisms in another way. If the pH is above 7.0 and lime is abundant calcium forms complex calcium phosphates which range in increasing insolubility from oxy-apatite [$3Ca_3(PO_4)_2CaO$] to the most insoluble phosphate the flour-apatites [$3Ca_3(PO_4)_2CaF_2$] which may be formed in the presence of fluorine. Thus, when the pH of the soil is above 8.5 the solubility of both native and added phosphates may be impaired seriously.

However, soil pH above 7.0 affects in other ways. If lime is in excess, excess calcium hinders in the translocation of phosphate ions through the cell walls of root hairs. Even if ions are once absorbed, it may interfere in its metabolism. At pH between 6.0 and 7.0 fixation is least and so availability of phosphorus is maximum.

The reaction of the soil also exerts an important influence on **soil structure**. Soil pH is governed by the nature of cations held by colloidal particles. The cations, in turn, control the aggregation of colloidal clay, and hence soil reaction indirectly influences soil structure.

Soil reaction also influences the activity of **microorganisms** which in turn influence plant growth and crop production. Most microorganisms are very active in neutral or slightly alkaline soils. The decomposition of organic matter and the release of nutrients like nitrogen, phosphorus, sulphur, etc., in available form depend, therefore, on soil reaction. The nitrogen-fixing bacteria, both symbiotic and nonsymbiotic, require neutral or slightly alkaline soils for their best activity.

Soil reaction influences the **need of fertilizers**. The availability of phosphorus in superphosphate is much less in acid soils, and thus a higher application of the fertilizer is needed. In calcareous and alkaline soils, the availability of potassium, phosphorus, iron and many minor elements is reduced, and hence the application of fertilizers carrying these elements is necessary for such soils.

Soil reaction affects the **quality of crop** also. The quality of tobacco grown in more acid conditions is greatly impaired. It influences the incidence of plant diseases especially those that are soil-borne. Acid soils favor the development of diseases like the Panama disease of banana and others. On the other hand, a certain degree of soil acidity helps to keep certain diseases, e.g., potato scab, in control. A high favors the incidence of black root disease in tobacco and the damping-off disease of some plant species. Calcareous alkaline soils are responsible for inducing chlorosis in a number of crops. Soil reaction, therefore, plays a very important role in governing the relation between soil condition and crop production.

Measurement of Soil pH values: There two principal techniques have been proposed for measuring soil pH: (1) colorimetric method (2) electrometric method. There are several variations of the electrometric method known according to the type of electrode used: (a) quinhydrone method (b) hydrogen electrode method (c) glass electrode method and (d) antimony electrode method.

Buffering of Soil:

Buffering is defined as the tolerance to change in pH of a solution. This is due to the fact that weak acid radicals such as carbonates, bicarbonates and phosphates present in soils behave as buffers. The most important form of the viewpoint of this phenomenon are specially those of the colloidal complex with associated cations which act as a strong buffering agent. Many weak organic acids are produced in soil due to microbial activity. These provide excellent buffering agents. Briefly it can be said that an average soil is colloidally buffered by humus and clay present in it.

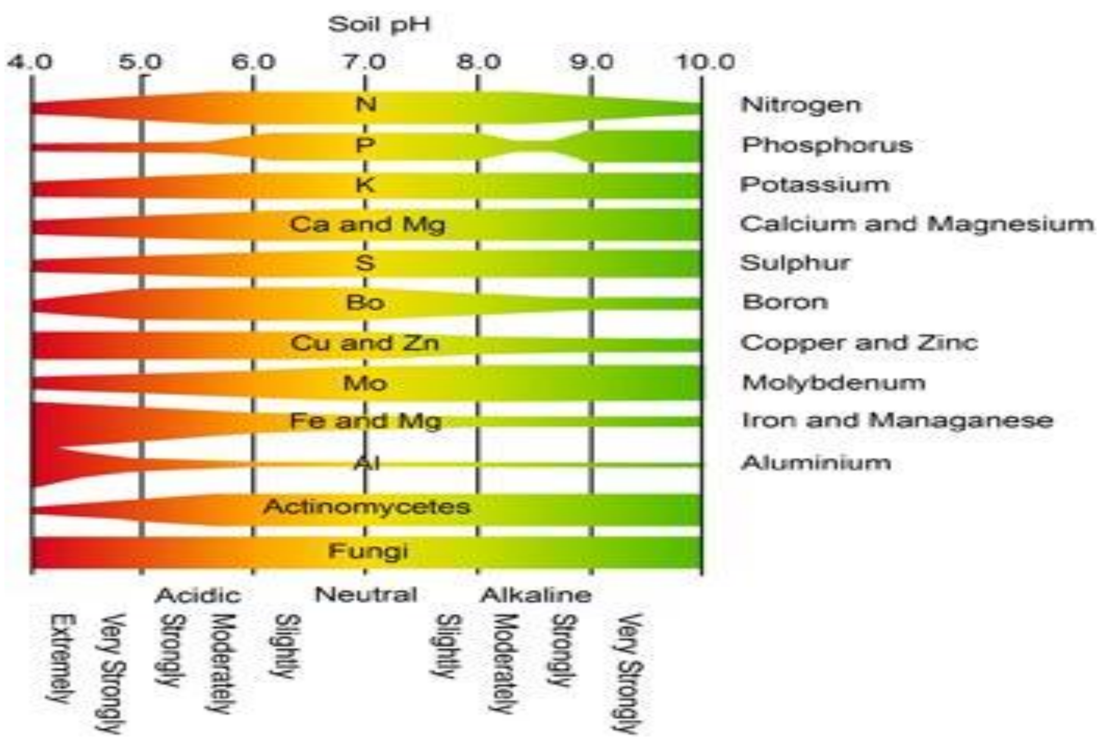
In soil there is always equilibrium established between adsorbed hydrogen ions (which give the potential or reserve acidity) and hydrogen ions of the soil solution (which give active acidity).

Adsorbed H^+ === Soil Solution H^+

(potential or reserve acidity) (active acidity)

If lime is added to neutralize the hydrogen ions of the soil solution some more adsorbed hydrogen ions give hydrogen ions to the soil solution. Hence apparently there appears no change in soil pH. However, if some acid is added, some hydrogen ions of soil solution get adsorbed and in this way the pH of the soil solution is not affected markedly.

Buffering capacity of the soil varies with its cation exchange capacity. The greater the CEC, the greater will be its buffering capacity. It follows, therefore, that the heavier the texture and the greater the organic matter content of a soil, the greater the amount of acid or alkaline material require to change its pH.



Acid Soils

Acid Soils: The soils with pH less than 6.5 and which respond to liming may be considered as acidic soils.

Soil acidity is more common in all regions where rainfall is of such magnitude so as to leach appreciable amounts of calcium and magnesium from the surface layer soils. If these metallic cations are active they tend to reduce the hydrogen ion concentration of the soil solution. As a matter of fact the controls of soil pH lies in the soil colloidal complex which according to its nature and conditions exerts a dominating equilibrium, restrain and regulation upon the reaction of the soil solution. **A low percentage of base saturation means acidity.**

(a) Reasons for Acidity:

(i) Humus decomposition results in release of large amounts of acids. There by lowering the pH.

(ii) Rainfall: In areas with more than 100 cm rainfall associated with high relative humidity., Ca, Mg is dissolved in water and leached out due to this base saturation of soil decreases.

(iii) Application of elemental sulphur under goes reactions resulting in formation of H_2SO_4.

(iv) Continuous application of acid forming fertilizers like ammonium sulphates or ammonium chlorides results in depletion of Ca by CEC (cation exchange capacity) phenomenon.

v) Parent Material: Generally rocks are considered as acidic, which contain large amount of silica (SiO_2) when this combined with water, acidity increases.

Classification of Soil Acidity

A Active acidity;- It may be defined as the acidity developed due to concentration of hydrogen and aluminum ions in the soil solution.

B Exchangeable acidity- It may be defined as the acidity developed due to adsorbed hydrogen and aluminum ions on soil colloids.

C Reserve acidity- It may be defined as the acidity developed due to the aluminum hydroxi ion, hydrogen ion and aluminum ins present in non exchangeable form with organic matter and clay content.

The magnitude of the reserve acidity may be 1000 times greater than the active acidity in case of sandy soils and 50000 or even 100000 times greater for a clay soil rich in organic matter.

(b) Characteristics:

(i) pH is less than 6.5

(ii) These soils are open textured with high massive Structure.

iii) Low in Ca, Mg with negligible amount of soluble salts.

(iv) These soils appear as brown or reddish brown, sandy loams or sands.

(c) Injury to Crops:

(i) Direct Affects:

(1) Plant root system does not grow normally due to toxic hydrogen ions.

(2) Permeability of plant membranes are adversely affected due to soil acidity.

(3) Enzyme actions may be altered, since they are sensitive to pH changes.

(ii) Indirect Affects:

1) Deficiency of Ca and Mg occur by leaching.

(2) Al, Mn and Fe available in toxic amounts.

(3) All the micro nutrients except molybdenum are available. So 'Mo' deficiency has been identified in leguminous crops.

(4) Phosphorous gets immobilized and its availability is reduced.

(iii) Effect on Activity of Microorganisms:

(1) Most of the activities of beneficial organisms like Azotobacter and nodule forming bacteria of legumes are adversely affected as acidity increases

(e) Amelioration:

(i) Lime as reclaiming agent: Lime is added to neutralize acidity and to increase the pH, so that the availability of nutrients will be increased.

(ii) Basic slag obtained from Iron and steel industry can be substituted for lime. It contains about 48-54 per cent of CaO and 3-4 per cent MgO.

(iii) Ammonium sulphate and Ammonium chloride should not be applied to acid soils but urea can be applied.

(iv) Calcium Ammonium Nitrate (CAN) is suitable to acidic soils.

(v) Any citrate soluble phosphate fertilizer is good source of phosphorous for acidic soils.

(vi) Eg. Dicalcium phosphate (DCP), Tricalcium phosphate (TCP) Potassium sulphate is a suitable source of 'K' for acidic soils. But MOP is better than K_2SO_4 because Cl^- of MOP replaces -OH ions, their by release of -OH ions tends to increase the pH.

Use of acid resistant crop- Lucern, berseem, sweet clover, barley,soybean, wheat, maize, rice, and potato etc.

Calcareous Soils- A calcareous soil is a soil that has high levels of both magnesium carbonate and calcium that reduce acidity in the soil. They are relatively widespread in the drier areas of the earth.

Arid regions usually contain accumulations of lime at some point in the profile. When the zone of lime accumulation coincides with the depth of high root concentration, it may be an important factor in plant nutrition. Many soils are formed from limestone or marl parent materials. Often the calcium carbonate has not been leached from these soils to any appreciable degree. Such soils are typically calcareous throughout the profile. The content of calcium and magnesium carbonates may be as high as 60 to 70 per cent of the total soil mass.

Calcium carbonate occurs in sand, silt, and clay size fractions of calcareous soils. The proportion in each fraction varies greatly. Calcareous soils encompass special problems that seem associated with the alkaline pH (8), free calcium and magnesium carbonates, reactions with plant nutrients, and interaction with plant roots.

In general, the pH of calcareous soils rises as the proportion of water to soil is increased.

$$CaCO_3 + H_2O \rightarrow \quad Ca^{2+} + HCO_3^- + OH^-$$

Soils high in lime are frequently productive for many ordinary field crops, including most forage crops, corn, cotton, sugar beets, potatoes, and tomatoes. Some other crops including berries, deciduous and citrus fruits, many flowers and ornamental shrubs, sorghums, and, to a lesser extent, peas and beans, suffer from acute iron deficiency on certain high-lime soils. The typical yellowing of leaves under these conditions is termed lime-induced chlorosis and is characterized by iron deficiencies in the plant leaves.

Saline and Alkali Soils

Characteristics of Saline and Alkali Soils - Saline and alkali soils are distinguished into three groups:

1. Saline
2. Saline alkali
3. Non saline alkali

Saline Soils: **Saline soils are those soils for which the electrical conductivity of the saturation extract is more than 4 mmhos/cm at 25^{0}C and the exchangeable sodium percentage is less than 15. The pH of such soil is ordinarily less than 8.5. Hilgard called these soils as 'white alkali' soils and Soviet scientists called it as 'Solonchaks'. Saline soils have deposits of white crusts of salts on the surface.** Such salts may be found either in soils with well developed soil profile or in undifferentiated soil material such as alluvium.

(a) Reasons for Salinity:

In arid and semi arid areas salts formed during weathering are not fully leached. During the periods of higher rainfall the soluble salts are leached from the more permeable high laying areas to low laying areas and where ever the drainage is restricted, salts accumulate on the soil surface, as water evaporates.

(i) The excessive irrigation of uplands containing salts results in the accumulation of salts in the valleys.

(ii) In areas having salt layer at lower depths in the profile, seasonal irrigation may favour the upward movement of salts.

(iii) Salinity is also caused if the soils are irrigated with saline water.

(iv) In coastal areas the ingress of sea water induces salinity in the soil.

(b) Characteristics:

(i) Saline soil has soil pH of less than 8.5

(ii) EC is more than 4.0 dS/m

(iii) ESP (exchangeable sodium per cent) is less than 15

(iv) Dominated by sulphate and chloride ions and low in exchangeable sodium

(v) Flocculation due to excess soluble salts.

(vi) High osmotic pressure of soil solution

(vii) Presence of white crust

(viii) It has white colour that why it is also called as White alkali

(c) Injury to Crops:

(i) High osmotic pressure decreases the water availability to plants hence retardation of growth rate.

(ii) As a result of retarded growth rate, leaves and stems of affected plants are stunted.

(iii) Development of thicker layer of surface wax imparts bluish green tinge on leaves during to high EC germination per cent of seeds is reduced.

(d) Crops Suitable for Cultivation in Saline Soils:

(i) Barley, Sugar beet, Cotton, Sugarcane, Mustard, Rice, Maize, Red gram, Green gram, Sunflower, Linseed, Sesame, Bajra, Sorghum, Tomato, Cabbage, Cauliflower, Cucumber, Pumpkin, Bitter guard. Beetroot, Guava, Asparagus, Banana, Spinach, Coconut, Grape, Date palm, Pomegranate.

(e) Amelioration:

(i) The salts are to be leached below the root zone and not allowed to come up. However this practice is somewhat difficult in deep and fine textured soils containing more salts in the lower layers. Under these conditions, a provision of some kind of sub-surface drains becomes important.

(ii) The required area is to be made into smaller plots and each plot should be bounded to hold irrigation water.

(iii) Separate irrigation and drainage channels are to be provided for each plot.

(iv) Plots are to be flooded with good quality water up to 15 – 20 cms and puddled.

(v) Thus, soluble salts will be dissolved in the water.

(vi) The excess water with dissolved salts is to be removed into the drainage channels.

(vii) Flooding and drainage are to be repeated 5 or 6 times, till the soluble salts are leached from the soil to a safer limit

(viii) Green manure crops like Daincha can be grown up to flowering stage and incorporated into the soil. Paddy straw can also be used.

(ix) Super phosphate. Ammonium sulphate or Urea can be applied in the last puddle. MOP and Ammonium chlorides should not be used.

(x) Scrape the salt layer on the surface of the soil with spade.

(xi) Grow salt tolerant crops like sugar beet, tomato, beet root, barley etc. Before sowing, the seeds are to be treated by soaking the seeds in 0.1 per cent salt solution for 2 to 3 hours.

Saline Alkali Soils: **The term saline alkali soil is used to denote such soils whose conductivity of the saturation extract is greater than 4 mmhos/cm at 25^{0}C and the exchangeable sodium percentage is more than 15. The pH values of these soils are seldom above 8.5, due to excess of soluble salts. These soils are formed due to the combined process of salinisation and alkalization.** The properties of these soils are usually similar to saline soils in the presence of excess soluble salts. After soluble salts are leached, the concentration of the salts in the soil solution is lowered and some of the exchangeable sodium hydrolyses and forms sodium hydroxide. Sodium hydroxide absorbs carbon dioxide from the atmosphere and is converted to sodium carbonate. Thus after leaching, the soil becomes strongly alkaline and the pH may increase over 8.5. Under such conditions the soil particles disperse and the soil becomes unfavourable for water percolation and tillage. Therefore, the management of saline alkali soils is very difficult. The excess salts and the exchangeable sodium both should be removed from the root zone from such soils to establish a favourable physical condition of soil.

Sometimes saline-alkali soils contain gypsum and when such soils are leached, calcium dissolves and replaces exchangeable sodium with the removal of excess salts.

Non Saline Alkali Soils (**Sodic Soil**): **The term non saline alkali soil is used to denote such soils whose exchangeable sodium percentage is more than 15, and the conductivity of the saturation extract is less than 4 mmhos/cm at 25^{0}C. The pH of these soils usually range between 8.5 and 10.0. These soils are the Hilgard's 'black alkali' and Russian 'Solonetz' soils. These soils are found in arid and semi arid regions in small irregular areas called 'slick spots'.** The exchangeable sodium markedly influences the physical and chemical properties of the non saline alkali soils. With the increase of exchangeable sodium percentage, the soil becomes more dispersed. The pH value may go up as high as 10. The soil solution of such soils contain calcium and magnesium as the cation and chloride sulphate, bicarbonate and small amounts of carbonate as the anions. Some soils may contain large amounts of exchangeable and soluble potassium.

Some soil having exchangeable sodium percentage more than 15 have surprisingly low pH values, as low as 6. Thses soils have been referred by De Sigmond (1938) as **degraded alkali soils**, because these occur in the absence of lime and low pH value is due to exchangeable hydrogen. But the physical properties are dominated by the exchangeable sodium and are typically those of a non saline alkali soils.

(a) Reasons for Alkalinity:

The excessive irrigation of uplands containing Na salts results in the accumulation of salts in the valleys.

(i) In arid and semi arid areas salt formed during weathering are not fully leached.

(ii) In coastal areas if the soil contains carbonates the ingression of sea water leads to the formation of alkali soils due to formation of sodium carbonates.

(iii) Irrigated soils with poor drainage.

(b) Characteristics:

(i) Alkali soil has soil pH of more than 8.5

(ii) EC is less than 4.0 dS/m

(iii) ESP (exchangeable sodium per cent) is more than 15

(iv) It has black colour that why it is also called as Black alkali

(c) Injury to Crops:

(i) High exchangeable sodium decreases the availability of calcium, magnesium to plants.

(ii) Dispersion of soil particles due to high exchangeable 'Na' leads to poor physical condition of soil, low permeability to water and air, tends to be sticky when wet and becomes hard on drying.

(iii) Toxicity due to excess hydroxyl and carbonate ions.

(iv) Growth of plant gets affected mainly due to nutritional imbalance.

(v) Restricted root system and delay in flowering in sensitive varieties.

(vi) Typical leaf burn in annuals and woody plants due to excess of chloride and sodium.

(vii) Bronzing of leaves in citrus.

(viii) It affects the solubility of zinc (Zn).

(d) Crops Suitable for Cultivation in Alkaline Soils:

(i) Barley, Sugar beet, Cotton, Sugarcane, Mustard, Rice, Maize, Red gram, Green gram, Sunflower, Linseed, Sesame, Bajra, Sorghum, Tomato, Cabbage, Cauliflower, Cucumber, Pumpkin, Bitter guard. Beetroot, Guava, Asparagus, Banana, Spinach, Coconut, Grape, Date palm, Pomegranate.

(e) Amelioration:

(i) The process of amelioration consists of two steps:

(1) To convert exchangeable sodium into water soluble form.

(2) To leach out the soluble sodium from the field. Amendments used for reclamation of Alkali soils.

(ii) Gypsum:

(1) It is slightly soluble in water. So it should be applied well in advance.

(2) For every 1 m.e. of exchangeable Na per 100 gm of soil, 1.7 tones of Gypsum/acre is to be added.

(iii) Use of Pyrites (FeS_2) .

(iv) Sulphur present in pyrites causes decrease in pH of soil due to formation of H_2SO_4.

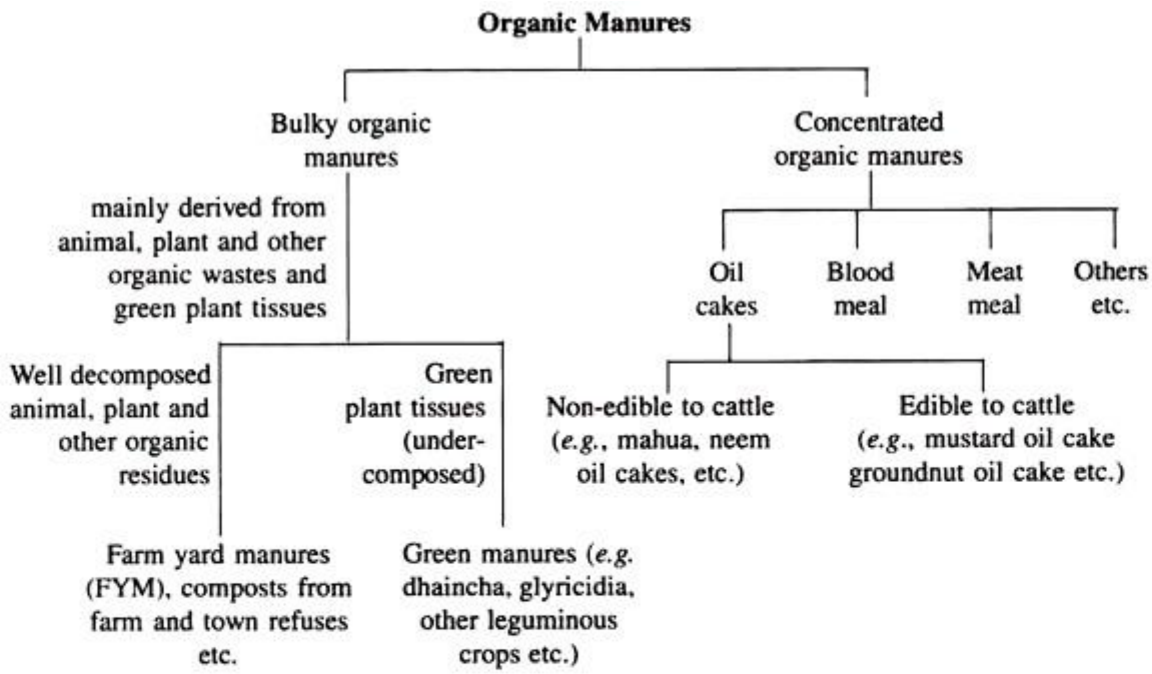
(v) Application of sulphur.

(vi) Application of molasses.

(vii) Drainage channels must be arranged around the field.

(viii) Growing the green manure crops and incorporates in the field.

CLASSIFICATION OF MANURES



Manures are broadly classified as-

1. Bulky organic manures

2. Concentrated organic manures

1. Bulky organic manures- These are voluminous in nature and contain small concentrations of plant nutrients and large quantity of organic matter. Ex- FYM, Compost, Green manure and Crop residues, etc.

2. Concentrated organic manures- these manures contain higher concentration of nutrient than bulky organic manure. They are plant or animal origin. Ex – oil cakes, blood meal, fish meal, meat meal etc.

1. Bulky organic manures-

a. FYM- It is the decomposed product of dung, urine, litter and leaf-over fodder fed to the cattle. It is prepared either in pits or trenches or heaps having an ideal of 6m x 2m x 1m. The FYM becomes ready for use in 4-6 months and on an average contain 0.5% N, P_2O_5 0.2% and K_2O 0.5%. 10 tonnes FYM to the soil gives 50 kg N, 20 kg P_2O_5 and 50 kg K_2O. Out of this 30% of N, 60-70% of P_2O_5 and 75% of K_2O is available to the crop in first year of application and the rest of the nutrients are available in subsequent years.

b. Compost- Composting is the process of converting organic residues of plant and animal origin into organic manure, rich in humus and plant nutrients by a variety of microbes in a warm, moist, aerobic or anerobic environment. It is a biological process in which organic matter decomposed by aerobic or anaerobic microbes and reduces the C/N ration of substrate used. The final product formed is an amotphous, brown to dark brown, humified material known as compost. It is more stable and nutrient rich than FYM. Well decomposed compost should have a neutral pH, C/N ratio < 20 and contain more than 16% C, 0.5 N, 0.5% P_2O_5 and 1% K_2O

Differnts methods of composting-

1. Indore method- aerobic method of composting, developed at Institute of Plant Industry, Indore

2. Bangalore method- anaerobic method of composting developed by Dr. C.N. Acharya in 1939 at IiS, Bangalore.

3. NADEP composting- aerobic method of composting, developed by Shri Narayan Deorao Pandharipande.

c. Vermicomposting- Compost prepared using earthworms is called vermicompost. The efficient species of earthworms are Eisenis foetida, Pheritima elongate, Eudrilus eugeniae and Perionyx excavtus. The average nutrient content if vermicomost is 0.6-1.2% N, 0.13-0.22% P_2O_5, 0.4-0.7% K_2O, 0.4% CaO and 0.15% MgO

d. Green Manuring: Green manuring can be defined as a practice of ploughing or turning into the soil un-decomposed green plant tissues for the purpose of improving soil physical chemical and biological environments.

Kinds of Green Manuring:

The practice of green manuring is performed in different ways according to suitable soil and climatic conditions of particular area. Broadly the practice of green manuring in India can be divided into two types

1. Green manuring in situ

2. Green leaf manuring

i. Green Manuring in Situ:

It can be defined as a system by which green manure crops are grown and incorporated into the soil of the same field that is to be green manured, either as a pure crop or an intercrop with the main crop. Common green manure crops in this system sun hemp (*crotolaria juncea*) dhaincha (*sesbania aculeata* and *sesbania rostrata*), guar (*cyamopsis tetragonoloba*), etc.

ii. Green leaf Manuring –

It refers to turning into the soil green leaves and tender green twigs collected from outside the field to be green manured. The common green manure crops, are Glyricidia (*Glyricidia maculata*), Karanja (*Pongamia pinnata*) etc.

2. Concentrated organic manures- These manures contain higher concentration of nutrient than bulky organic manure. They are plant or animal origin. Ex – oil cakes, blood meal, fish meal, meat meal etc. The average nutrient content of some concentrated organic manures is presented in table-

Table 15.1. Average nutrient content in concentrated organic manures

Product	N (%)	P_2O_5 (%)	K_2O (%)
Plant origin			
Edible oil cakes			
Safflower (decorticated)	7.9	2.2	1.9
Groundnut	7.3	1.5	1.3
Sesame	6.2	2.0	1.2
Rapeseed/ mustard	5.2	1.8	1.2
Linseed	4.9	1.4	1.3
Non edible oil cakes			
Neem	5.2	1.0	1.4
Castor	4.3	1.8	1.3
Karanj	3.9	0.9	1.2
Cottonseed (undecorticated)	3.9	1.8	1.6
Mahua	2.5	0.8	1.8
Animal origin			
Blood meal	10-12	1.0-2.0	0.6-0.8
Meat meal	10-11	2.0-2.5	0.7-1.0
Fish meal	5-8	3.0-6.0	0.3-1.5
Guano	7-8	11-14	2.0-3.0
Slaughter house waste	8-10	3.0	-
Bone meal (raw)	3.0	20.0 (8% citrate soluble P_2O_5)	-
Bone meal (steamed)	-	22.0 (16% citrate soluble P_2O_5)	-
Wool waste	4-7	-	1.0-5.0
Miscellaneous			
Press mud	1.0-1.5	4.0-5.0	2.0-7.0

Biofertilizers

A bio-fertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces, 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 (Vessey, 2003).

Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilising phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. Bio-fertilizers can be expected to reduce the use of chemical fertilizers and pesticides. The microorganisms in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter.

Classification of Biofertilizers: There are three type of Biofertilizers –

A Nitrogen fixing

B Phosphate Solubilizing

C Organic matter decomposer

A Nitrogen Fixing Biofertilizers:- The nitrogen fixing bacteria work under two conditions, Symbiotically and as free living bacteria (non-symbiotic).

The symbiotic bacteria make an association with crop plants through forming nodules in their roots. Example- **Rhizobium (fast growing) and Brady Rhizobium (Slow growing)**

The free living bacteria do not form any association but live freely and fix atmospheric nitrogen. Example- ***Azotobacter chrococcum, Azospirillum, Clostridium Etc***

Rhizobium- This is the most common biofertilizer as stated earlier. Rhizobium lives in the root hairs of the legumes by forming nodules. First time, Beijirinck from Holland isolated this bacterium from nodules of a legume in 1888. A new classification has been established for Rhizobium. That is 'slow growing rhizobia' known as Bradyrhizobium and the other group is 'fast growing rhizobia' called Rhizobium.

Rhizobium Cross Inoculation Groups

Rhizobium Spp.	**Cross Inoculation Grouping**	**Legume Types**
R. Leguminosarum	**Pea group**	**Pisum, Visia, Lens**
R. phaseoli	**Bean group**	**Phaseolus**
R. trifoli	**Clover group**	**Trifolium**
R. meliloti	**Alfalfa group**	**Melilotus, Medicago, Trigonella**
R. lupine	**Lupine group**	**Lupinus, Orinthopus**
Bradyrhizobium japonicum	**Soybean group**	**Glycine**
Rhizobium spp.	**Cowpea group**	**Vigina, Arachis**

Rhizobium - Legume Symbiosis- Rhizobia are soil bacteria. They have an ability to fix atmospheric nitrogen. They make a symbiotic association with legumes and some non-legumes like Parasponia. Rhizobium bacteria enter into the roots through root hairs. They release certain.stimulatory root exudates and form nodules. Inside the root, rhizobia invade expanded cells of cortex, and then differentiate into nitrogen-fixing "bacteroids". Neither the plant nor the bacteria can fix nitrogen when live separately. The nodules filled with pink sap(leghaemoglobin pigment) are called the effective nodules. This pigment maintains the rhythm of oxygen supply to the bacteria and helps the activity of nitrogenase enzyme. The nitrogenase is responsible for reduction of nitrogen to ammonia in the process of nitrogen fixation.

Azotobactor

Azotobactor is a heterotrophic free living nitrogen fixing bacteria present in alkaline and neutral soils. *Azotobactor chrococcum* is the most commonly occurring species in arable soils of India. Apart from its ability to fix' atmospheric nitrogen in soils, it can also synthesize growth promoting substances viz., auxins, and gibberellins and also to some extent the vitamins. Many strains of *Azotobactor* also exhibit fungicidal properties against certain species of fungus. Response of *Azotobactor* has been seen in rice, maize, cotton, sugarcane, pearl millet, vegetable and some plantation crops. Its population is very low in uncultivated lands. Presence of organic matter in the soil promotes its multiplication and nitrogen fixing capacity. *Azotobacter* inoculation curtails the requirement of nitrogenous fertilizers by 10 to 20% under normal field conditions.

Azospirillum

This is a free living or non -symbiotic bacteria (does not form nodules but makes association by living in the rhizosphere). *Azospirillum* species establish an association with many plants particularly with C, plants such as maize, sorghum, sugarcane, etc. It is the most common organism and can form associative symbiosis on a large variety of plants. They fix nitrogen from 10 to 40 kg/ha. The *Azospirillum* inoculation helps better vegetative growth of the plants, saving nitrogenous fertilizers by 25-30%. So far only four species of *Azospirillum* have been identified. They are *A. lipoferum*, *A. brasilense,* A. *amazonense*, *A. iraquense.* In Indian soils *A. brasilense(in* C_3 *plant Rice, Whaet, Oat etc)* and *A. lipoferum* (in C_4 plant Maize, Sorghum)are very common.

Acetobactor

Acetobactor diazotrophicus is a newly discovered nitrogen fixing bacteria associated with sugarcane crop. This bacterium belongs to the alpha group of proteobacteria. It is an acid and high salt tolerant and sucrose loving bacteria which can fix up to 200 kg nitrogen per hectare. Under field condition, the yield of sugarcane increased after its inoculation.

Frankia

Frankia is actinomycetes which also fixes atmospheric nitrogen. It forms a symbiotic association by forming root nodules in some non-leguminous trees such as Casuarina and Alnus.

Blue Green Algae (BGA) (*Cynobecteria*)-

The Blue-Green Alga (*Anabaena azollae*) forms a symbiotic relationship with Azolla (aquatic fern) and fixes atmospheric nitrogen. Individuaily B,G A and Azolla can also be used in paddy fields. BGA are capable of performing photosynthetic activity as well as fix the atmospheric nitrogen in flooded rice ecosystem. They use energy derived from photosynthesis to fix nitrogen, hence, called Autotrophs. BGA fix 20-30 kg N ha^{-1} and Azolla fix 40-60 kg N ha^{-1}.

B Phosphorus Solubilising Microorganisms (PSM)- A group of heterotrophic microorganisms solubilize the fixed phosphorous by producing organic acids and enzymes and make them available to the crops. This group of microorganism is called Phosphorous Solublising Microorganisms .

There are two types of Phosphorus Solubilising Microorganisms-

A **Phospahte solubilizers**- Example *Bacillus, Pseudomonas, Aspergillus, Penicllium* Etc.

B **Phosphate mobilizers-** *AM, Glomus, Gigaspora*

***Vesicular Arbuscular Mycorrhiza* (VAM)-** This is the most fascinating class of fungi giving benefit to plants. The term mycorrhiza was taken from Greek language meaning 'fungus root'. This term was coined by Frank in 1885. As indicated above, the mycorrhiza is a mutualistic association between fungal mycelia and plant roots. VAM is an endotrophic (live inside) mycorrhiza formed by aseptated phycomycetous fungi. **VAM help in nutrient transfer mainly of phosphorus, zinc and sulfur.** They also mobilize different nutrients like Cu(copper), K(potassium), Al(aluminum), Mn(manganese), Fe (iron)and

Mg (magnesium) from the soil to the plant roots. They penetrate into root cortex and forms intracellular obligate fungal endo-symbiont. They posses vesicles (sac like structure) for storage of nutrients and arbuscular for funneling them into root system. Hyphae of VAM fungi do not solubilise the insoluble unavailable phosphorus but -assimilate phosphorus and other nutrients from soil for their own requirement. In addition, help transfer them in different forms to the host roots. It also improves water absorption by the roots.

There are two main recognized groups of mycorrhiza-

(i) Ecto-mycorrhiza

(ii) Endo-mycorrhiza.

In the ecto-mycorrhiza, the hyphae form a cover both outside and within the root in the intercellular spaces of epidermis and cortex. Trees are commonly infected with ectomycorrhiza.

endomycorrhiza have three sub group. Among these VAM are most common. They produce an internal network of hyphae between cortical cells which extend to the soil and absorb nutrients and water. VAM forms an association with many crop plants, whether monocot, dicot, annual or perennial crops.

Mechanism of Action

The VAM forms an association with plant roots. It penetrates in the root cortex and spreads around the roots of the plant. As the name indicates, they posses sac like structure called vesicules which stores phosphorus as phospholipids. The other structure called arbuscule helps bringing the distant nutrients to the vesicules and root.

Actions of Mycorrhiza

1) Enhances the feeding areas of the plant root is as the hyphae spreads around the roots.

2) Mobilizes the nutrients from distantance to root.

3) Stores the nutrients (sp. phosphorus).

4) Removes the toxic chemicals (example : phenolics) which otherwise hinder nutrient availability.

5) Provide protection against other fungi and nematodes.

C Organic matter decomposer- A group of microorganism decompose the organic matter known as organic matter decomposer. There are two types of OMD-

A Cellulolytic- Trichurus, Trichoderma etc.

B Lignolytic- Pleurotus, Agaricus etc.

Methods of Application of Biofertilizers

A Seed Treatment- For treating seed 200g of biofertilizers is suspended in 300-400 ml of water and mixed gently with the seeds (10 kg) using an adhesive like gum acacia, jiggery solution etc. So that the bioinoculants may get energy for their prolonged survival. The seeds are than spread on a clean sheet/ cloth under shade to dry and used immediately for sowing.

Seedling root dip- For rice crop, a bed is made in the filed and filled with water. Recommended biofertilizers are mixed in this water and the roots of seedlings are dipped for 8-10 hr and transplanted.

Soil Treatment- 4 Kg each of the recommended biofertilizers is mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Common Microorganism used as Biofertilizers-

Contributing Plant Nutrients	Microorganisms	Suitable Crops
Nitrogen	1. Symbiotic	
	A Rhizobium (with legume) and its other groups.	Pulse legume: Gram, pea, lentil, arhar, green gram, black gram. Oil, legume: Groundnut, soybean. Fodder legume : Berseem and Lucerne
	B Azola (Fern- Anabaena symbiosis)	Rice
	2. Associative symbiosis (Azospirillum)	Rice, sugarcane, fingermillet, maize
	3. Non- symbiotic	
	A Hetrotrophs (Azotobacter)	Vegetable crops, wheat, rice and other commercial crops.
	B Photo autotrophs (BGA)	Rice
Phosphorus	1 Phosphate solubilizing and mineralizes	For all crops
	A Fungi- Aspergillus, Penicillum B Bacteria- Bacillus, Pseudomonas	
	2 Phosphate absorber (root fungus symbiosis)-VAM A Ecto mycorrhiza: Pisolitthus, Rhizopogon B Endo mycorrhizae- Glomus, Gigaspora	For all crops

Role of bio-fertilizers in agriculture: Some of the important roles of Bio-fertilizers in agriculture are:

– They supplement chemical fertilizers for meeting the integrated nutrient demand of the crops.

– Application of bio-fertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation.

– Some bio-fertilizers (eg, Rhizobium BGA, Azotobacter sp) stimulate production of growth promoting substance like vitamin-B complex, Indole acetic acid (IAA) and Gibberellic acids etc.

– Phosphate mobilizing or phosphorus solubilising bio-fertilizers / microorganisms (bacteria, fungi, mycorrhiza etc.) converts insoluble soil phosphate into soluble forms by secreting several organic acids and under optimum conditions they can solubilise / mobilize about 30-50 kg P2O5/ha due to which crop yield may increase by 10 to20%.

- Mycorrhiza or VA-mycorrhiza (VAM fungi) when used as bio-fertilizers enhance uptake of P, Zn, S and water, leading to uniform crop growth and increased yield and also enhance resistance to root diseases and improve hardiness of transplant stock.

– They liberate growth promoting substances and vitamins and help to maintain soil fertility.

– They act as antagonists and suppress the incidence of soil borne plant pathogens and thus, help in the biocontrol of diseases.

– Nitrogen fixing, phosphate mobilizing and cellulolytic microorganisms in bio-fertilizer enhance the availability of plant nutrients in the soil and thus, sustain the agricultural production and farming system.

– They are cheaper, pollution free and renewable energy sources

– They improve physical properties of soil, soil tilth and soil health in general.

– They improve soil fertility and soil productivity.

– Blue green algae like Nostoc, Anabaena and Scytonema are often employed in the reclamation of alkaline soils.

– Bio-inoculants containing cellulolytic and lignolytic microorganisms enhance the degradation/ decomposition of organic matter in soil, as well as enhance the rate of decomposition in compost pit.

– BGA plays a vital role in the nitrogen economy of rice fields in tropical regions.

– Azotobacter inoculants when applied to many non leguminous crop plants, promote seed germination and initial vigour of plants by producing growth promoting substances.

– Azolla-Anabaena grows profusely as a floating plant in the flooded rice fields and can fix 100-150 kg N/ ha /year in approximately 40-60 tones of biomass produced,

– Plays important role in the recycling of plant nutrients.

Liquid bio-fertilizers: A preparation comprising requirements to preserve organisms and deliver them to the target regions to improve their biological activity.

Benefits:

The advantages of liquid bio-fertilizer over conventional carrier based bio-fertilizers are listed below:

– Longer shelf-life -12-24 months.

– No contamination.

– No loss of properties due to storage up to 45ºC.

– Greater potentials to fight with native population.

– Easy identification by typical fermented smell.

– Better survival on seeds and soil.

– Very much easy to use by the farmer.

– High commercial revenues.

– High export potential

Important terms:-

Symbiosis- Symbiosis is defined as a mutually beneficial relationship between two organisms.

Autotroph- Organisms that uses carbon dioxide as the sole carbon source.

Heterotrophic- Organisms dependent on exogenous organic source for their metabolism and growth.

Integrated Nutrient Management

Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.

Concept of IPNMS

The basic concept of IPNMS is the promotion and maintenance of soil fertility for sustaining crop productivity through optimum use of all possible sources of nutrients like organic, inorganic and biological in an integrated manner appropriate to each farming situation. Improvement of soil fertility and productivity on sustainable basis through appropriate use of fertilizers and organic manures is the key principle and their scientific management for optimum growth and yield of crops in a specific agro ecological conditions.

The three main components of INMS as defined by

FAO, 1998 are:

1. Maintain or enhance soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients

2. Improve the stock of plant nutrients in the soils

3. Improve the efficiency of plant nutrients, thus, limiting losses to the environment.

Thus, integrated nutrient supply/management (INS) aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner (Roy and Ange, 1991).

Main objectives of IPNMS or INM

1. To reduce the dependence on chemical fertilizers.

2. To maintain productivity on sustainable basis without affecting soil health.

3. To conserve locally available resources & utilize them judiciously.

4. To reduce the gap between nutrients used & nutrients harvested by the crop.

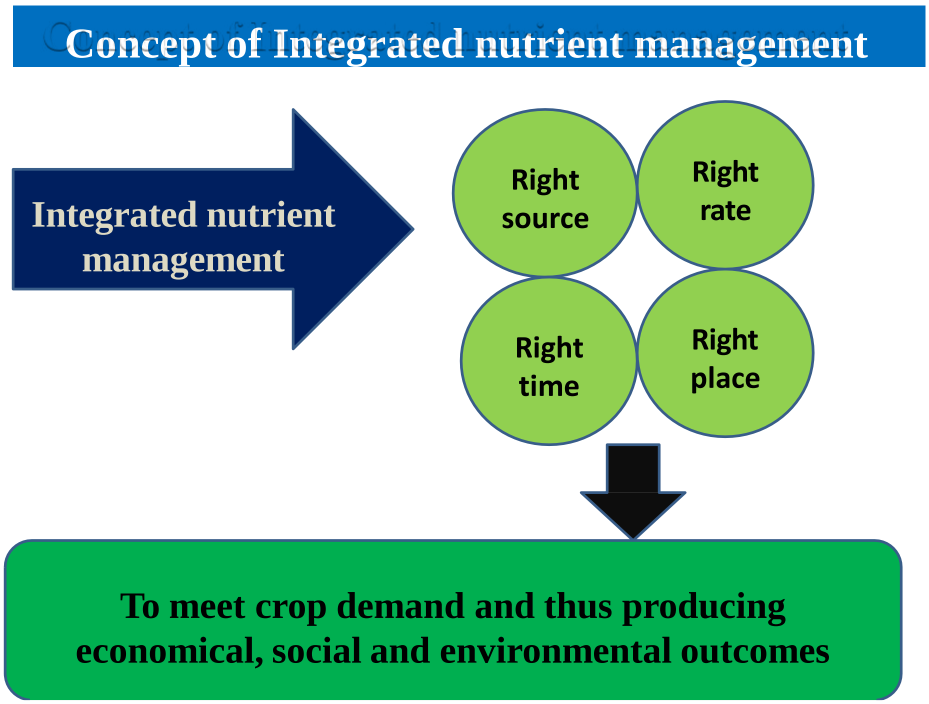
5. To improve physical, chemical & biological properties of soil.

6. To make soil healthy by providing balanced nutrients through different nutrient sources.

7. To overcome or reduce the ill effects of continuous use of only inorganic chemical fertilizers.

8. To improve economical status of farmers.

9. To increase the fertilizer use efficiency (FUE).



Approach/components in INM

Besides inorganic fertilizers as the major component, others include organic manures, green manure, crop residues, crop rotation and biofertilizers.

1 Balanced fertilization- Improved crop nutrition aims at maintenance of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of various plant nutrients in an integrated manner. Balanced dose of N, P and K is usually applied to the soil in the ratio of 2:1:1 or 3:1:1 ($N:P_2O_5:K_2O$).

2 Organic manures- Compost or organic manure is a rich source of **organic** matter. Soil **organic** matter plays an**important role** in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. Use of organic manures like FYM, compost, vermicompost, biogas, slurry, poultry manure, bio-compost, press mud cakes, phosphocompost.

3 Green Manure- Green manuring is the practice of growing a short duration, succulent and leafy legume crop and ploughing the plants in the same field before they form seeds. The use of green manure results in increased levels of key plant **nutrients**. Leguminous green manures (e.g. clover, alfalfa, vetch) have the ability to fix nitrogen from the air and add it into the soil, where this key nutrient promotes a healthy growth of crops. Example – Leguminous green manure crops- cowpea, Cassia and Non Leguminous green manure crops-Sesbania, Crotalaria etc.

4 Crop Residues- Recycling of crop residues serve as effective source of plant nutrients and humus in soil. SOM plays an important role in maintaining proper rhizosphere for better growth of the plants.

5 Biofertilizers- Utilization of Bio fertilizers.

6 Crop Rotation- Crop rotation is a very important tool in sustaining nutrient supply. Legumes in rotation restore soil fertility in more than one way viz. some of the N fixed is left in the soil after harvest, improvement in soil properties, lesser pest and disease problem and better weed control.

Advantages of INM

1 Enhance the availability of applied as well as native soil nutrient.

2 Synchronizes the nutrient demand with the native supply from native and applied sources

3 Provide balanced nutrition to the crops.

4 Improves and sustain physical, chemical and biological properties of soil.

5 Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration.

6 Reducing nutrient losses to ground surface water bodies and atmosphere.

Common Constraints of INM:

1. Non-availability of FYM.

2. Difficulties in growing green manure crops.

3. Non-availability of bio-fertilizers.

4. Non-availability of soil testing facilities.

5. High cost of chemical fertilizers.

6. Non-availability of water.

7. Lack of knowledge and poor advisory services.

8. Non-availability of improved seeds.

NUTRIENT USE EFFICIENCY AND MANAGEMENT

Nutrient/ Fertilizer Use Efficiency- Nutrient use efficiency defined as the amount of dry matter produced per unit of nutrient applied. Nutrient use efficiency of primary nutrients i.e. N, P and K are 40%, 20% and 50 % respectively. The nutrient use efficiency of micro nutrients are 2% which is very low.

Management Practices for Enhancing Nutrient Use Efficiency

1. Adopt Resource Conservation Technologies

Avoiding excessive fertilizer applications to cropland can reduce farmers' operating costs. A number of resource conserving practices such as zero tillage, mulching, ssnm, crop rotation placement of fertilizers etc. and technologies are available to increase the efficiency of fertilizer use and reduce N_2O emissions.

2. Smart Soil Management Practices

Good soil management can help to achieve maximum nutrient efficiency and it regulates emissions of three key greenhouse gases viz., carbon dioxide, methane and nitrous oxide from agricultural land. Good soil management practices include management of soil physical and chemical properties, adopt site-specific nutrient management and integrated nutrient management practice are generally still advantageous due to the wider production and environmental benefits gained in the climate changing era.

3. Nutrient Management

Best nutrient management strategies are based on the ‘4 R’ principle of right source, at the right rate, at the right time and at right placement to improve the nutrient use efficiency of crops, thereby reducing fertilizer requirement and associated GHGs emissions.

According to the Roberts (2006) the following are guiding principles for fertilizer management. **Right source:** Balanced fertilization is one of the keys to increasing nutrient use efficiency. **Right rate:** Appropriate amount of fertilizer applied to the crop needs. Too much fertilizer leads to leaching and other losses to the environment and too little results in lower yields and crop quality and less residue to protect and build the soil. Realistic yield goals, soil testing, omission plots, crop nutrient budgets, tissue testing, plant analysis, applicator calibration, variable rate technology, crop scouting, record keeping and nutrient management planning are the best management practices that will help determine the right rate of fertilizer to apply.

Right time: Make nutrients available when the crop needs them. Nutrients are used most efficiently when their availability is synchronized with crop demand. Application timing (pre-plant or split applications), controlled release technologies, stabilizers, inhibitors and product choice are examples of best management practices that influence the timing of nutrient availability. Advanced tools such as SPAD meter and leaf colour chart to be used to meet out the crop demands at right time.

Right place: Place and keep nutrients where crops can use them. Application method is critical for efficient fertilizer use. Crop, cropping system and soil properties dictate the most appropriate method of application, but incorporation is usually the best option to keep nutrients in place and increase their efficiency. Conservation tillage, buffer strips, cover crops and irrigation management are other best management practices that will help keep fertilizer nutrients where they were placed and accessible to growing crops.

4. Crop varieties and cropping systems

5. Agronomic management

- **Timely sowing/transplanting:**
- **Plant population:**
- **Weed Control:**
- **Water management:**

6. Fertilizer materials

Fertilizer materials are responsive for increase or decrease of nutrient use efficiency. In fertilizer materials nitrogen fertilizers are highly soluble and this leads to considerable leaching losses under upland conditions and de-nitrification losses under low-land situations. There are 3 kinds of nitrogen fertilizers are developed for improve nutrient use efficiency these are as follows:-

1 Slow released fertilizers for examples Urea super granules, Urea formaldehyde, Isobutylidene diurea and Crotonylidene diurea.

2 Controlled-release fertilizers – These are coated or encapsulated fertilizers. Examples are S-coated urea, Polymer-coated urea etc.

3 Stabilized nitrogen fertilizers- Treated with nitrification and urease inhibitors.

7. Integrated Plant Nutrient Supply System (IPNS)

8. Breeding for Nutrient Use Efficiency

Exploiting Genetic Potential to Enhance Nutrient Use Efficiency

Nutrient efficient genotypes are adapted to environments with low nutrient availability. It is useful to screen and exploit the genetic variability present across crop species to enhance nutrient use efficiency.

Decomposition of Soil Organic Matter and Humus Formation

Decomposition of SOM

Definition:

Breakdown of dead plant and animal material and release of inorganic nutrients

or

Decomposition is a biological breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (Juma, 1998).

The organic materials (plant and animal residues) incorporated in the soil are attacked by a variety of microbes, worms and insects in the soil if the soil is moist. Some of the constituents are decomposed very rapidly, some less readily, and others very slowly. The list of constituents in terms of ease of decomposition:

1. Sugars, starches and simple proteins Rapid Decomposition

2. Crude proteins

3. Hemicelluloses

4. Cellulose

5. Fats, waxes, resins

6. Lignins Very slow Decomposition

Decomposition Process

•Three Main Processes:

1)Assimilation Conversion of substrates materials into protoplasmic materials. E.g. OM carbon to microbial carbon. E.g. protein to microbial protein

2) Mineralization Conversion of organic substance to inorganic form. E.g. protein from OM will be converted to inorganic nitrogen in the soil.

3) Immobilization Conversion of inorganic form into organic. E.g. inorganic nitrogen from the soil converted into microbial protein.

The organic matter is also classified on the basis of their rate of decomposition

Rapidly decomposed: Sugars, starches, proteins etc

Less rapidly decomposed: Hemicelluloses, celluloses etc

Very slowly decomposed: Fats, waxes, resins, lignins etc

A. Decomposition of soluble substances: When glucose is decomposed under aerobic conditions the reaction is as under:

Sugar + Oxygen ————> CO_2 + H_2O

Under partially oxidized conditions,

Sugar + Oxygen ————> Aliphatic acids

(Acetic, formic etc.) or Hydroxy acids

(Citric, lactic etc.) or Alcohols (ethyl alcohol etc.)

Some of the reactions invoiced may be represented as under:

$C_6H_{12}O_6$ + $2O_2$ ————-> 2 CH_3.COOH + $2CO_2$ + $2H_2O$

$2C_6H_{12}O_6$ + $3O_2$ ————> 2 $C_6H_8O_7$ + 4 H_2O

$C_6H_{12}O_6$ + $2O_2$ ————-> $2C_2H_5OH$ + 2 CO_2

i) Ammonification: The transformation of organic nitrogenous compounds (amino acids, amides, ammonium compounds, nitrates etc.) into ammonia is called ammonification. This process occurs as a result of hydrolytic and oxidative enzymatic reaction under aerobic conditions by heterotrophic microbes.

ii)Nitrification: The process of conversion of ammonia to nitrites (NO_2) and then to nitrate (NO_3) is known as nitrification. It is an aerobic process by autotrophic bacteria.

Nitrosomonas Nitrobacter

NH_3 ———————> NO_2 —————-> NO_3

Ammonia Nitrite Nitrate

The net reactions are as follows:

NH_4 + O_2 —————-> NO2 + 2H+ + H2O + energy

NO_2 + O_2 ————— - >NO_3 + energy

iii) Denitrification: The process, which involves conversion of soil nitrate into gaseous nitrogen or nitrous oxide, is called Denitrification. Water logging and high pH will increase N loss by Denitrification.

Pseudomonas / Bacillus

Nitrate ———————————————> Nitrogen Gas

B. Decomposition of Insoluble Substances

i) Breakdown of Protein: During the course of decomposition of plant materials, the proteins are first hydrolyzed to a number of intermediate products and may be represented as under:

Hydrolysis Proteases Aas

Proteins ————> Peptones ———> Amides ——> Ammonia Peptides

Aminization Ammonification

Aminization: The process of conversion of proteins to aminoacids.

Ammonification: The process of conversion of aminoacids and amides to ammonia.

ii) Breakdown of cellulose: The decomposition of the most abundant carbohydrates is as follows:

hydrolysis hydrolysis

Cellulose ————> Cellobiose —————-> Glucose

(cellulase) (cellobiase)

oxidation

—————> Organic acids ————-> $CO_2 + H_2O$

This reaction proceeds more slowly in acid soils than in neutral and alkaline soils. It is quite rapid in well aerated soils and comparatively slow in poorly aerated soils.

iii) Breakdown of Hemicellulose: Decompose faster than cellulose and are first hydrolyzed to their components sugars and uronic acids. Sugars are attacked by microbes and are converted to organic acids, alcohols, carbon dioxide and water. The uronic acids are broken down to pentose and CO_2. The newly synthesized hemicelluloses thus form a part of the humus.

iv) Breakdown of Starch: It is chemically a glucose polymer and is first hydrolyzed to maltose by the action of amylases. Maltose is next converted to glucose by maltase. The process is represented as under:

$(C_6H_{10}O_5)n + nH_2O$ ————-> $(C_6H_{12}O_6)$

C. Decomposition of ether soluble substances:

Fats————————> glycerol + fatty acids

Glycerol ——————-> CO_2 + water

D. Decomposition of lignin: Lignin decomposes slowly, much slower than cellulose. Complete oxidation gives rise to CO_2 and H_2O.

Role of organic matter:

1. Organic matter creates a granular condition of soil which maintains favorable condition dof aeration and permeability.
2. Water holding capacity of soil is increased and surface runoff, erosion etc., are reduced as there is good infiltration due to the addition of organic matter.
3. Surface mulching with coarse organic matter lowers wind erosion and lowers soil temperatures in the summer and keeps the soil warmer in winter.
4. Organic matter serves as a source of energy for the microbes and as a reservoir of nutrients that are essential for plant growth and also hormones, antibiotics.
5. Fresh organic matter supplies food for earthworms, ants and rodents and makes soil P readily available in acid soils.
6. Organic acids released from decomposing organic matter help to reduce alkalinity in soils; organic acids along with released CO_2 dissolve minerals and make them more available.
7. Humus (a highly decomposed organic matter) provides a storehouse for the exchangeable and available cations.
8. It act as a buffering agent which checks rapid chemical changes in pH and soil reaction.. It also acts as an oxidation-reduction buffer
9. Humus is an important source of nutrients for higher plants.
10. Although humus is transitional and does not remain in the soil for ever, it has a certain permanency and disappears from the soil only slowly.

Humus – Fractionation of organic matter

HUMUS

Humus is a complex and rather resistant mixture of brown or dark brown amorphous and colloidal organic substance that results from microbial decomposition and synthesis and has chemical and physical properties of great significance to soils and plants. Humus is a product of the decomposition of plant and animal residues. It covers a wide variety of substances derived from the dead and decomposing bodies of all kinds of animals and plants. It is thus likely to include almost every known type of organic compound. It differs from the original plant and animal materials from which it was produced as it no longer possesses their structural form and other characteristics. It is one of the important components of all cultivated soils and is responsible to a very great extent in controlling the relations between soil condition and plant growth.

Organic matter in soil one must clearly distinguish between two main groups of organic substances which differ vitally from one another: (1) reserve organic matter or that part of soil organic matter which is still undecomposed and which, through continued biochemical influences, is gradually changed into humus, and (2) humus, i.e., that part which is fully decomposed to the colloidal state and which is able to fulfill the important functions.

Humus Formation

The humus compounds have resulted from two general types of biochemical reactions: Decomposition and Synthesis.

1. Decomposition: a) Chemicals in the plant residues are broken down by soil microbes including lignin. b) Other simpler organic compounds that result from the breakdown take part immediately in the second of the humus-forming processes, biochemical synthesis. c) These simpler chemicals are metabolized into new compounds in the body tissue of soil microbes. d) The new compounds are subject to further modification and synthesis as the microbial tissue is subsequently attacked by other soil microbes.

2. Synthesis: Involved such breakdown products of lignin as the phenols and quinines. a) These monomers undergo polymerization by which polyphenols and plyquinones are formed. b) These high molecular weight compounds interact with N-containing amino compounds and forms a significant component of resistant humus. c) Colloidal clays encourage formation of these polymers. d) Generally two groups of compounds that collectively make up humus, the humic group and the nonhumic group.

Soil Organic Matter Fraction

- Humic matter
- Non humic matter
- When soil is extracted with alkali the humic substances go into solution. The insoluble portion forms the non humic matter.

Humic Group

- This group makes up about 60 – 80 % of the soil organic matter.
- They are most complex. They are most resistant to microbial attack.
- Humic substances have aromatic ring type structures.
- These include polyphenols and poly quinines.
- These are formed by decomposition, synthesis and polymerization.

The humic substances are classified based on resistance to degradation and solubility in acids and alkalis into

- **Fulvic Acid:** Fulvic acid lowest in molecular weight and light in color. Soluble in both acid and alkali. Most susceptible to microbial attack.
- **Humic Acid:** Medium in molecular weight and color. Soluble in alkali but insoluble in acid .It is intermediate in resistance to degradation.
- **Humin:** Highest in molecular weight, darkest in color, insoluble in both acid and alkali. Most resistant to microbial attack.

Non Humic Group

- This group makes upto 20 – 30% of the organic matter in soil.

- These are less complex and less resistant to microbial attack as compared to humic substances.
- They are polysaccharides, polymers having sugar like structures and polyuronides.
- These include proteins, carbohydrates, lignins, fats, waxes, resins, tannins and some compounds of low molecular weight.

Properties of Humus

1. The tiny colloidal particles are composed of C, H and O2.
2. The colloidal particles are negatively charged (-OH, -COOH or phenolic groups)has very high surface area, higher CEC (150 – 300 cmol/kg), 4 – 5 times higher WHC than that of silicate clays.
3. Humus has a very favorable effect on aggregate formation and stability.
4. Impart dark brown to black colour to soils.

Cation exchange reactions are similar to those occurring with silicate clays.

Clay -------- Humus Complex

5. It has a great water absorbing and water holding capacity. One hundred parts of humus, by weight nearly 181 parts of water against 70 for clay and 25 for sand.
6. It possesses the power of adhesion and cohesion. Humus is however, much less adhesive and cohesive than clay. It is because of this property that it acts as a cementing agent in crumb formation.
7. It has a high ion adsorbing capacity, nearly four to six times that of clay. The adsorbed cations undergo base exchange as they do in the case of colloidal clay. Hence it has a high base exchange capacity. Because of the highly heterogenous nature of the material, its cation exchange capacity varies very widely, from 30 to 350 meq. per cent.
8. It is insoluble in water. It dissolves readily in dilute alkali giving a dark coloured liquid. It is re-precipitated to a large extent when the alkaline solution is neutralized with acid.
9. It behaves like a weak acid and forms salts with bases. With alkalis it forms soluble salts such as sodium and potassium humates, while with alkaline earths it forms insoluble salts. Humus is electronegative like clay acid. It is usually present in the soil in combination with bases mainly calcium forming calcium nitrate.

A simple fractionation scheme for soil organic matter or humus is depicted below

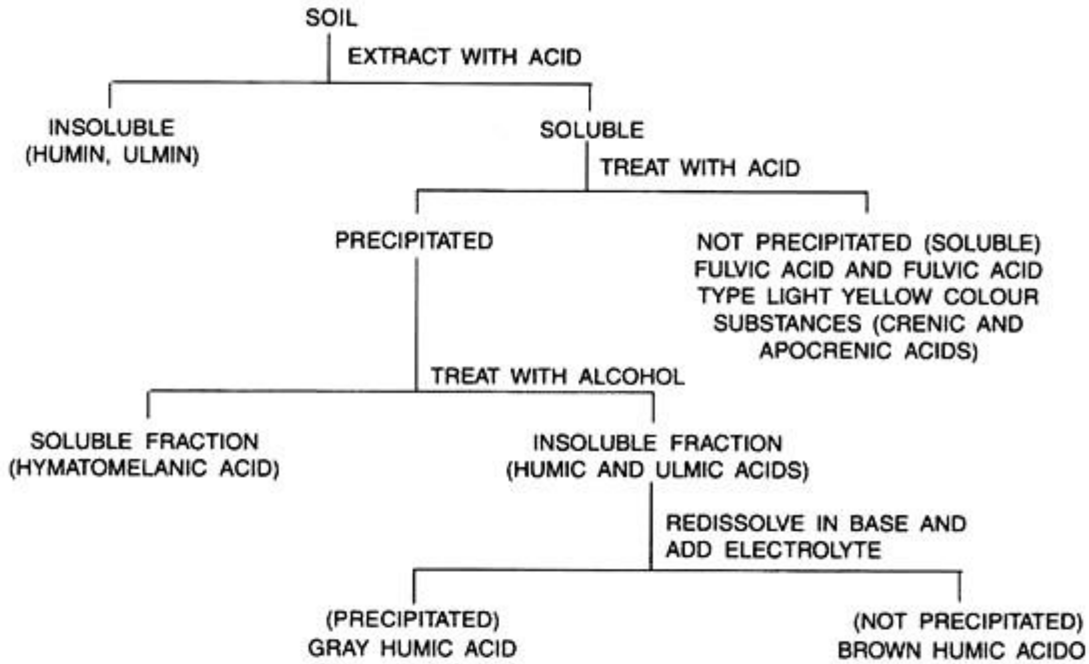


Fig. 19.5. Fractionation Scheme of Soil Organic Matter.

Soil fertility evaluation?

Soil Fertility Evaluation; The diagnosis of the nutrient status of the soil by using different techniques or methods is known as soil fertility evaluation.

Methods of soil fertility evaluation

There are various diagnostic techniques that are commonly used to evaluate fertility of the soils. They are;

I. Nutrient deficiency symptoms on plants

II. Plant analysis

III. Biological tests

IV. Soil testing

V. Modern approaches of soil fertility evaluation and fertilizer recommendation

I. Nutrient deficiency symptoms of plants

It is a qualitative measurement of availability of plant nutrients. It is the visual method of evaluating soil fertility and diagnosing the malady affecting the plant. An abnormal appearance of the growing plant may be caused by a deficiency of one or more nutrient elements. The appearance of deficiency symptoms on plants has been commonly used as an index of soil fertility evaluation.

If a plant is lacking in a particular element, more or less characteristics symptoms may appear. This visual method of soil fertility evaluation is very simple, not expensive and does not require elaborate equipments but it becomes difficult to judge the deficiency symptoms if many nutrients are involved. In such cases it requires experienced person to make proper judgment.

The common deficiency symptoms are

1. Complete crop failure at seedling stage

2. Retarded/stunted growth

3. Abnormal color pattern. E.g.: Chlorosis (yellowing), necrosis (dying of tissue)

4. Malformation of different plant parts. E.g.: rosette appearance of leaves

5. Delayed maturity

6. Poor quality of crops like low protein, oil, starch content, keeping/ storage quality reduced.

7. Internal abnormality like Hidden hunger (It is a situation in which a crop needs more of a given element, yet has been shown no deficiency symptoms).

II. Plant Analysis

It is a valuable supplement to soil testing in the task of soil fertility evaluation. Plant analysis indicates the actual removal of nutrients from the soil and identifies nutrient status of plant and deficiency of nutrient element. It is a direct reflection of nutrient status of soil.

Advantages of plant analysis are

a. Diagnosing or confirming the diagnosis of visible symptoms

b. Identifying hidden hunger

c. Locating areas of incipient (early stage) deficiencies.

d. Indicating whether the applied nutrients have entered the plant

e. Indicating interactions or antagonisms among nutrient elements.

Plant analysis consists of two methods

Rapid tissue tests: It is a rapid test and qualitative or semi quantitative method. Fresh plant tissue or sap from ruptured cells is tested for unassimilated N, P, K and other nutrients. The cell sap is added with certain reagents to develop color. Based on intensity of color low, medium and high color is categorized which indicates the deficiency, adequate and high nutrients in the plants respectively. It is mainly used for predicting deficiencies of nutrients and it is possible to forecast certain production problems.

Total analysis: It is a quantitative method and performed on whole plant or on plant parts. The dried plant material is digested with acid mixtures and tested for different nutrients quantitatively by different methods. The determination gives both assimilated and unassimilated nutrients such as nitrogen, phosphorus, potassium calcium, magnesium, suphur, iron, manganese, copper, boron, molybdenum, cobalt, chlorine, silicon, zinc, aluminum etc., in plants. Recently matured plant material is preferable for accurate analysis.

III. Biological methods

It is conducted for calibrating the crop responses to added nutrients. Different methods are adopted for evaluating fertility status of soil.

Field tests:

Field tests are conducted on different fertilizers and crops with treatments impositions in replications. The treatment which gives highest yield will be selected. These experiments are helpful for making general recommendations of fertilizer to each crop and soil and we can also choose right type and quantity of fertilizer for various crops. It is laborious, time consuming, expensive but most reliable method. They are used in conjunction with laboratory and greenhouse studies as final proving technology and in the calibration of soil and plant tests. Thy widely used by experiment stations.

Indicator plants:

These are plants that are more susceptible to the deficiency of specific nutrients and develop clear deficiency symptoms if grown in that nutrient deficient soil. Hence these are called as indicator plants.

Some indicator plants are;

Nutrients	Indicator plants
N, Ca	Cabbage, Cauliflower
P	Rape
K, Mg	Potato
Fe	Cauliflower, cabbage, potato, oats
Zn	Maize
Na, B	Sugar beet
Mn	Sugarbeet, oats, potato
Mo	Lucerne
Cu	Wheat

3. Microbiological test:

By using various cultures of microorganisms soil fertility can be evaluated. These methods are simple, rapid and need little space. Winogradsky was one of the first to observe in the absence of mineral elements certain microorganisms exhibited a behavior similar to that of higher plants.

Microorganisms are sensitive to deficiency of nutrients and could be used to detect the deficiency of any nutrient. A soil is treated with suitable nutrient solutions and cultures of various microbial species (bacteria, fungi) and incubated for a few days. Then observing the growth and development of organisms in terms of weight or diameter of the mycelia pad, the amount of nutrient present in the soil is estimated.

Ex: a. Azotobactor method for Ca, P and K.

b. Aspergillus niger test for P and K

c. Mehlich's Cunninghamella (Fungus)- plaque method for phosphorus

d. Sackett and Stewart techniques (Azotobacter culture) to find out P and K status in the soil.

4. Laboratory and Green house Tests:

These are simple and more rapid biological techniques for soil fertility evaluation. Here, higher plants and small amounts of soils are used for testing. All these techniques are based on the uptake of nutrients by a large number of plants grown on a small amount of soil. It is used to assess availability of several nutrients and they are quantitatively determined by chemical analysis of the entire plant and soil. Some common methods are;

E.g.: a. Mitscherlich pot culture method for testing N,P, K status in oat

b. Jenny's pot culture test using lettuce crop with NPK nutrients

c. Neubauer seedling method for NPK d. Sunflower pot-culture technique for boron

IV. Soil Testing

A soil test is a chemical method for estimating the nutrient supplying power of a soil. It is much more rapid and has the added advantage over other methods of soil fertility evaluation. One can determine the needs of the soil before the crop is planted. A soil test measures a part of the total nutrient supply in the soil.

Soil testing plays a key role in today's modern and intensive agriculture production system as it involves continuous use and misuse of soil without proper care and management. Soil analysis is helpful for better understanding of the soils to increase the crop production and obtaining sustainable yield. Soil testing is an indispensable tool in soil fertility management for sustained soil productivity.

Objective of soil testing

a. To evaluate fertility status of soil by measuring available nutrient status

b. To prescribe or recommend soil amendments like lime and gypsum and fertilizers for each crop

c. To assess nutrient deficiencies, imbalances or toxicities in soil and crop

d. To test the suitability of soil for cultivation or gardening or orchard making

e. To know acidity, alkalinity and salinity problems

f. To know morphology, genesis and classification of soil

g. To find out the effect of irrigation on soil properties.
h. To prepare a soil fertility map of an area (village, taluk, district, state)

In the soil testing programme, “soil sampling” is most important step to be followed for getting accurate results. Soil sampling is a process by which a true representative sample of an area or orcahrd can be obtained. The soil sampling must be done scientifically by adopting appropriate time and depth of sampling given for each crop for accurate analysis of soils.

Interpretation of soil test results and critical levels of nutrients in soils.

Nutrients	Low	Medium	High
Avail. Nitrogen(Kg/ha)	280	280-580	>580
Avail.Phosphorus(P2O5 Kg/ha)	22.5	22.5-55	>55
Avail. Potassium(K2OKg/ha)	125	125-300	>300
Organic carbon (%)	0.5	0.5-0.75	>0.75
pH	<6.5 = Acidic 6.5-7.5 =Normal/Neutral 7.5-8.5 = Saline >8.5 =Alkaline		
EC(dSm^{-1})	<0.80 = Normal 0.8-1.60 = Critical for some crops 1.6-2.5 = Critical for salt tolerant crops >2.5 = Injurious to all crops		
Ca	<50% of CEC		
Mg	<4% of CEC		
S	<10ppm		
Zn	<0.6 ppm (0.5-1.2ppm)		
Fe	2.5-4.5 ppm		
Mn	<2 ppm		
Cu	<0.2 ppm		

B	<0.5 ppm(WS)
Mo	<0.2 ppm
Cl	<2 ppm(WS)

V. Modern approaches of soil fertility evaluation and fertilizer recommendation

1) Soil Test Crop Response (STCR)/Targeted Yield Concept
2) Diagnosis and Recommendation Integrated System (DRIS) Approach

1) **SOIL TEST CROP RESPONSE (STCR)**

After introduction of high yielding varieties and hybrid crops, the need for systematic soil test crop response research in different soil agro-climatic regions become evident. ICAR established the AICRP on STCR in 1967 and the STCR concept was developed by Ramamoorthy, in 1987. STCR provides the relationship between a soil test value and crop yield.

The soil test values are needed to be correlated with actual crop response obtained under field conditions. Separate calibration charts are needed for each crop and soil. Fertility gradient and regression approach and targeted yield concepts were evolved. This is also called as "rationalized fertilizer prescription approach" in which inherent soil fertility and yield level of the crop are taken in to account while recommending the fertilizer doses.

Objective of STCR

To prescribe fertilizer doses for a given crop based on soil test values to achieve the "Targeted yields" in a specific soil agro-climatic region under irrigation or protective irrigation conditions by using mathematical equations for different crops and different soil agro-climatic zones separately.

This takes in to consideration-the efficiency of utilization of soil and added fertilizer nutrient by the crops and its nutrient requirements for a "desired yield level".

Concept of STCR

STCR approach is aiming at obtaining a basis for precise quantitative adjustment of fertilizer doses under varying soil test values and response conditions of the farmers and for targeted levels of crop production. These are tested in follow up verification by field trials to back up soil testing laboratories for their advisory purpose under specific soil, crop, and agro climatic conditions. The fertilizers are recommended based on the following criterias.

• Fertilizer recommendations based on regression analysis approach

• Recommendations for certain % of maximum yield

STCR methodology takes in to account the three factors;

Nutrient requirement (NR) in kg/ quintal of the produce
Percentage contribution from soil available nutrients (SE)
Percentage contribution from added fertilizers towards making effective fertilizer prescriptions for specific yields.

i) Nutrient Requirement (NR) (in kg for producing 1 Quintals of grain)

$$\text{NR} = \frac{\text{Total nutrient uptake (grain+straw) kg/ha}}{\text{Yield of grain (q/ha)}}$$

ii) Fertilizer Efficiency (FE in %)

$$\text{FE} = \frac{\text{Total nutrient uptake (kg/ha)-soil test value in treated Plot (kg/ha) X soil nutrient efficiency (\%) X 100}}{\text{Fertilizer dose applied (kg/ha)}}$$

iii) Soil Efficiency (SE in %)

$$\text{SE} = \frac{\text{Total nutrient uptake in control kg/ha X 100}}{\text{Soil test value in control kg/ha}}$$

With the help of above parameters, adjustment equations have been developed for a number of crops in various soils.
E.g.: For Rice crop.
a. Fertilizer N = 4.39 T -0.6723 Soil N
b. Fertilizer P_2O_5 = 2.83 T – 6.110 Soil P
c. Fertilizer K_2O = 1.41 T – 0.329 Soil K
Where T= Targeted yield of rice

Advantages

1) Efficient and profitable site specific fertilizer recommendation for increased crop production and for maintenance of soil fertility.

2) Aims to provide balanced, efficient and profitable nutrient application rates for pre- set yield targets giving due consideration to basic fertility status of soil

Targeted yield concepts:

These are soil test based recommendations but given for different yield goals and not for a single optimum yield level. A large variety of fertilizer prescription have been made available by putting soil test values in to certain mathematical equations and finding out the amounts of nutrients needed for a given yield target.

Soil Microrganisms

Soil biology is the study of microbial and faunal activity and ecology in soil. These organisms include earthworms, nematodes, protozoa, fungi, bacteria, Soil biology plays a vital role in determining many soil characteristics yet, being a relatively new science, much remains unknown about soil biology and its effect on soil ecosystems.

Distribution of various microorganisms in soil ecosystem

Organisms in Soil- Organisms presents in soil are classified into two main groups-

Soil Flora- Belonging to plant kingdom.

Soil Fauna- Belonging to animal kingdom

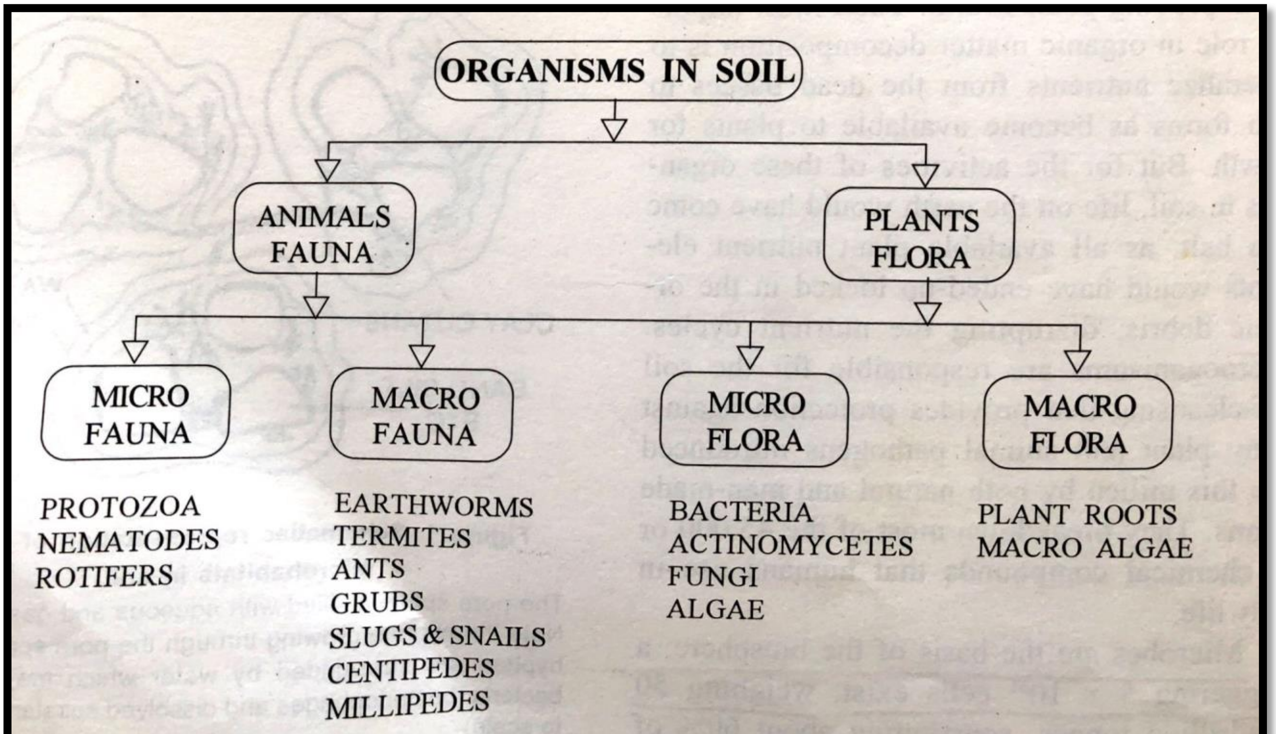


Figure 2. Important groups of organisms commonly present in soil

Classification of Microbes

A Based on the ability to grow in the presence or absence of molecular oxygen microbes are of two categories.

1 Aerobs- Azotobacter, Rhizobium

2 Anaerobs- Clostridium

Facultative aerobs- Those which generally grow and develop in the presence of oxygen but can also adopt themselves to grow under an oxygen depleted environment. Ex- Staphylococcus spp., Streptococcus spp., Escherichia coli

B Based on Temprature

Psychrophiles- Those which grow at temperature below 10^0C

Mesophiles- Those which grow between 20^0C to 40^0C. e.g., E. coli, Salmonella spp., and Lactobacillus spp.

Thermophiles- Those which grow above 45^0C.

C Based on the energy and carbon requirements for cell synthesis-

Heterotrophs- The heterotrophs derive their energy from oxidation of complex organic compounds which also serve as sources of carbon. Ex- Azotobacter, Rhizobium

Autotrophs- The autotrophs utilize carbon from CO_2. Ex Cynobacteria

Chemoautotrophs- Which drive their energy from oxidation of simple inorganic compounds.Ex - Nitrosomonas, Methanogens

Photoautotrophs- Which derive their energy from sunlight. Ex- BGA

Soil MicroFlora (Soil microorganism)- Soil microorganisms can be classified as bacteria, actinomycetes, fungi, algae and protozoa. Each of these groups has characteristics that define them and their functions in soil.

1 Bacteria- Bacteria are the smallest and most numerous of the organisms present in soil. They are single cell organisms and their size is approximately 1 micron in diameter and up to 10 micron in length. The bacteria in soil are of different shapes. Those with spherical cells are called cocci, rod- shaped cells are termed as bacilli and long spiral- shaped are termed as spirilla.

The different bacterial genera commonly occurring in diverse soils are : Pseudomonas, Arthrobacter, Clostridium, Bacillus, Achromobacter, Micrococcus and Agrobacterium. The genus Bacillus has largest representation in soils in terms of species.

2 Actinomycetes- Taxonomically actinomycetes are like bacteria which possess aerial hyphae like fungi. These organisms share characteristics of both bacteria(cell size, structure and mode of multiplication) and fungi (branching). They are next to bacteria in numbers and are fairly widely distributed in soils. They are more common in dry soils and in undisturbed pastures and grasslands. Like bacteria, they are more common in neutral to slightly alkaline soils. They are aerobic organisms. The species more commonly encountered in soils belong to the genera Streptomyces, Micro- monospora, Nocardia and Thermo-actinomyces.

3 Fungi- Fungi are filamentous organisms with much larger cell width than actinomycetes. The filaments are called hyphae and the network of hyphae collectively is termed mycelium. They are heterotrophs devoid of chlorophyll and are primarily responsible for organic matter decomposition. Soil fungi can grow in a wide range of soil pH, but their population is more under acidic condition. A majority of fungi are aerobic and prefer to grow at optimum soil moisture. Example- Pythium, Rhizopous, Mucor, Aspergillus, Penicillium , VAM Etc.

4 Alage- Soil alage are chlorophyll containing organism. They are autotrophic and therefore, their development is not restricted by organic carbon supply. Soil alage are classified on the basis of the colour (pigments) as:

1 Cyanophyta (blue green)

2 Chlorophyta (grass green)

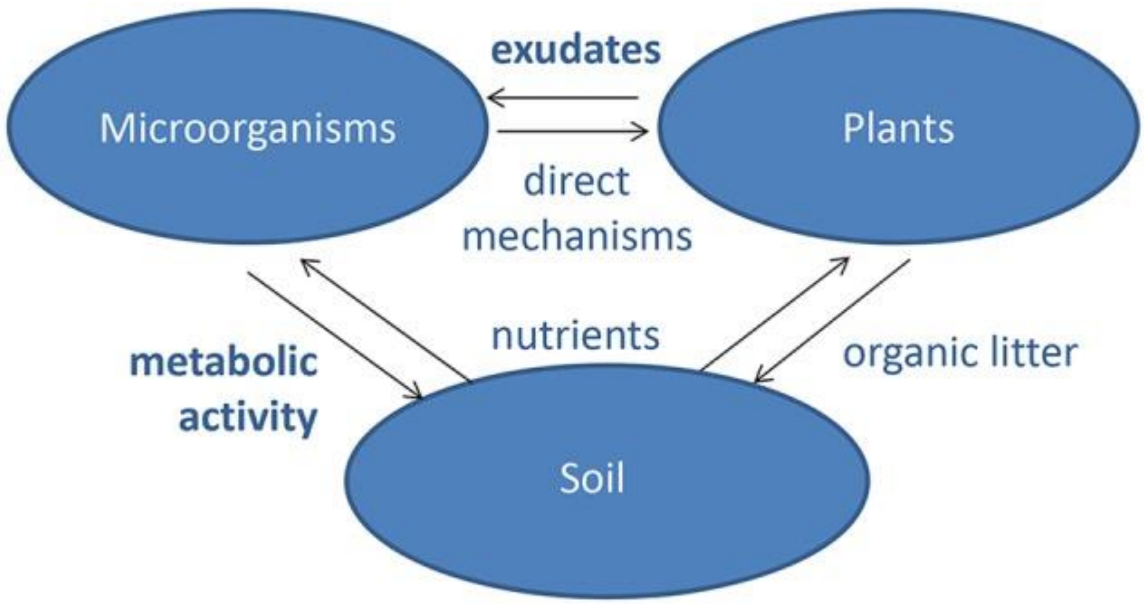
3 Xanthophyta (yellow green)

4 Bacilliriophyta (golden brown)

Blue green alage also known as Cyanobacteria are most important from the agricultural point of view because they fix atmospheric nitrogen. Some other examples- Anabaena, Nostoc etc.

5 Protozoa- Soil protozoa are single cell organisms belong to animal kingdom and larger in size than most microorganisms found in the soils.

Interactions



Interactions between plants, microbiota, and soil. Both plants and microorganisms obtain their nutrients from soil and change soil properties by organic litter deposition and metabolic activities, respectively. Microorganisms have a range of direct effects on plants through, e.g., manipulation of hormone signaling and protection against pathogens. Plants communicate with the microorganisms through metabolites exuded by the roots.

Role of microorganism in soil fertility

1 Microbes can make nutrients and minerals in the soil available to plants, produce hormones that spur growth, stimulate the plant immune system and trigger or

dampen stress responses. In general a more diverse soil microbiome results in fewer plant diseases and higher yield.

2 The group of bacteria called rhizobia live inside the roots of legumes and fix nitrogen from the air into a biologically useful form.

3 Mycorrhizae or root fungi form a dense network of thin filaments that reach far into the soil, acting as extensions of the plant roots they live on or in. These fungi facilitate the uptake of water and a wide range of nutrients.

4 Stenotrophomonas rhizophila increases drought tolerance in crops such as sugar beets and maize. The microbe excretes molecules that help plants withstand stress, including osmoprotectants, which prevent the catastrophic outflux of water from plants in salty environments.

5 Soil microorganisms are very important as almost every chemical transformation taking place in soil involves active contributions from soil microorganisms.

6 Soil microorganisms are responsible for the decomposition of the organic matter entering the soil (e.g. plant litter) and therefore in the recycling of nutrients in soil.

7 Soil microorganisms produce compounds that stimulate the natural defense mechanisms of the plant and improve its resistance to pathogens. Collectively, these soil microorganisms have been termed 'biopesticides' and represent an emerging and important alternative (i.e. biological control) to the use of chemical pesticides for the protection of crops against certain pathogens and pests.

Rhizosphere and Phylosphere

The rhizosphere is the narrow region of soil that is directly influenced by root secretions and associated soil microorganisms. The rhizosphere contains many bacteria and other microorganisms that feed on sloughed-off plant cells, termed rhizodeposition, and the proteins and sugars released by roots.

The active root zone of the plant contact with the soil is termed as ‘rhizosphere’ which play an important role in maintaining of plant-microbe relationship.

The microbial population of rhizosphere has an important influence on the growth of the plant. The interaction of plant root and rhizosphere microorganisms are based largely on interactive modification of the chemical soil environment by processes such as, water up take by plant system , release of organic chemicals to the soil by plant roots, microbial production of plant factors and microbial mediated availability of mineral nutrients.

Microbial population in the rhizosphere soil may benefit to the plant various ways, including removal of H2S, toxic to the roots, increased solubilization of mineral nutrients, synthesis of vitamin, amino acids, auxins and gibberellins which stimulate the plant growth and antagonism with potential plant pathogen through competition and development of a mensal relationships based on production of antibiotics.

The Phyllosphere: The stem, leaves and fruits of a plant provided suitable habitats for some microbial populations such as, heterotrophic and cyanobacteria, fungi, lichens and some algae which are occurring in the aerial plant surface. Such type of growing plants are called 'epiphytes'. The habitat in the leaf surface is known as 'phyllosphere' to denote leaf surface environment. The name was coined by Last (1955) and Ruinen (1956) independently. The term phyllosphere and phylloplane are interchangeably used in literature. Phylloplane is a natural habitat on leaf surface which support heterogeneous population both pathogen and non-pathogens. The phylloplane microbes cover a wide variety of microorganisms including yeast, filamentous fungi, bacteria, actinomycetes, blue green algae etc. The phylloplane mycofiora is of special interest from various view point because some of them have antagonistic action against fungal pathogen, degrade plant surface wax and cuticles and produce plant hormones as well as activate plants to produce phytoalexinins.

EFFECT OF POTENTIAL TOXIC ELEMENTS IN SOIL PRODCTIVITY

Defination- Potentially toxic elements are the elements with high density and high relative atomic weight, showing metallic properties as ductility, malleability, conductivity, ligand specificity.

Contamination of soils by potentially toxic elements due to different anthropogenic activities is one of the factors which influence the life in soils. There are four major pathways by which potentially toxic elements enter in the soils: (i) atmosphere to soils, (ii) sewage to soils, (iii) solid waste to soil, and (iv) agricultural supplies to soils.

Some potentially toxic elements such as Co, Cu, Fe, Mn, Mo, Ni, and Zn are beneficial to the biological system when present in permissible amount but damage the biological system if present in excess. Soil potentially toxic elements such as Pb, Cd, Hg and As (a metalloid but generally referred to as a potentially toxic element) are harmful to crops, humans, and animals. Potentially toxic elements are added to the soil naturally and by anthropogenic activities; metals Cd, Pb, Zn and Ni are also originated from heavy traffic on roads and causes soil pollution. The annual estimate of potentially toxic elements release from all sources in worldwide is around 22,000 metric ton of Cd; 939,000 of Cu; 783,000 of Pb and 1,350,000 of Zn.

Impact of potentially toxic elements on plant growth In soils, plants can uptake potentially toxic elements which are water-soluble or get easily solubilized by roots. As potentially toxic elements cannot be degraded, when their concentrations within the plant exceed permissible limit they adversely affect the plant directly and indirectly.

Direct effect- In direct effect toxicity of element causes leaf chlorosis, disturbed water balance, and reduced stomatal opening, inhibition of cytoplasmic enzymes and damage to cell structures due to oxidative stress.

Indirect effect- Some time potentially toxic element replaces essential nutrients at cation exchange sites of plants it is one of the examples of indirect toxic effect. High metal concentration may lead to decrease in organic matter decomposition, the decline in soil nutrients, decrease in enzymatic activities useful for plant metabolism lead to a decline in plant growth which sometimes results in the death of plant.

Effects of potentially toxic elements on soil microbial activity

Soil biochemical processes are the tools for maintaining soil quality; formation of soil organic matter; decomposition of harmful substances; formation of soil structure and biochemical cycles. Contamination of soils by toxic metals decreases soil microbial properties such as soil respiration, enzymatic activities. Soil microbial properties depend on soil pH, organic matter and other chemical properties. Severe potentially toxic element pollution can inhibit soil microbial activity and seriously threaten the soil ecosystem function.

Potentially toxic elements immobilize soil bacteria, while microbial metabolites enhanced the mobility of potentially toxic elements. Potentially toxic elements in different quantities and forms in soils cause changes in the counts of microorganisms, microbial biomass and microbial activity via inhibiting microbial community diversity, particularly that of fungal groups i.e., Ascomycota and Chytridiomycota) in the large-size fractions, which mainly depends on heterogeneous SOC availability across the PSFs. Potentially toxic elements create abiotic stresses by inducing disorders in the metabolism of the microorganism.

Many researchers have reported that when potentially toxic elements are present in the excessive amount in the soil the microbial count and diversity of microorganisms' decreases.

Effects of potentially toxic elements on soil microbial composition Potentially toxic elements when accumulated in soil beyond their permissible limit they firstly influence the quality and quantity of soil bacteria, fungi, actinomycetes, and other microbial population. Potentially toxic element contamination in soil not only produces different microbial community patterns but also change the chemical and biological properties of the soil. In the soils which are polluted by potentially toxic elements for a long time, those soil microorganisms which can specifically be adapted exist. The efficiency of microbial populations in organic mineralization is inversely correlated with the soil organic carbon content, an indicator of the impact of potentially toxic element pollution. Microbial communities in soils are very important as they are helpful in nutrient cycling, plant symbiosis, and the detoxification of noxious chemicals (used to control plant pests and plant growth). When metal enriched sewage sludge is added to soils microbial biomass leads to a decrease in functional diversity and changes in microbial community structure. However, metal exposure may also lead to the development of metal-tolerant microbial population.

Effects of potentially toxic elements on soil enzyme activities The biological activity of soils is an essential parameter of their ecological status. The potentially toxic elements present in the soil due to anthropogenic activities disturb the normal functioning of soil biota and, hence, the entire soil system. As the concentration of potentially toxic elements increases, the activity of most enzymes is significantly reduced and may be caused directly by the interaction between the enzyme and the potentially toxic elements, which is not associated with a reduction in microbes. Potentially toxic elements influence the enzymatic activity, by destroying the spatial structure of the active groups of the enzyme, by inhibiting the growth and reproduction of microorganisms which reduces the synthesis and metabolism of the microbial enzymes. Soil microbes and soil enzymatic activities are significantly correlated. Some enzymes secreted by microorganisms participate in soil ecosystems and energy together. Potentially toxic elements in enzymes play a triple function: catalytic, structural and regulatory. Zinc is an integral part of the number of enzymes and number of intracellular enzymes viz., carbon anhydrase, carboxypeptidase, thermolysin, alkaline phosphatase, dehydrogenases (glyceraldehyde-3-phosphate, alcohol, glutamine), fructo-diphosphate aldolases, superoxide dismutase, DNA and RNA polymerase, tRNA transferase need zinc for proper functioning. When potentially toxic elements are present in excess the natural functions of metals are distorted.

Effects of potentially toxic elements on soil physicochemical properties water holding capacity, soil bulk density, porosity, permeability, infiltration besides other factors also depends on the concentration of potentially toxic elements. Soil chemical properties depend on soil pH which affects the availability of soil nutrients and form of potentially toxic elements. The amount of plant available organic matter is also influenced by the concentration of potentially toxic elements. Clay content and soil pH were non-significantly negatively correlated with soil total potentially toxic element’s concentration. Organic carbon, cation exchange capacity, total nitrogen, phosphorous, calcium, potassium, sodium were positively significantly correlated with soil chromium, zinc and lead content, while no significant correlation with copper and nickel content.

Fertilizer and application methodology

Definition of Fertilizer

Fertilizers are defined as materials having definite chemical composition with a high analytical value that supply essential plant nutrients in available form. They are usually manufactured by industries and sold with a trade name. They are commonly synthetic in nature and also called as chemical fertilizers/inorganic fertilizers/commercial fertilizers other than lime and gypsum.

- Most of the chemical fertilizers are inorganic in nature. The only exception to this is urea and calcium cyanamide ($CaCN_2$), the solid organic N fertilizer.
- In India the use of artificial fertilizers was first initiated in 1896 when imported Chilean nitrate was used as a fertilizer.
- Presently fertilizers have become an integral part of agricultural economy as they increase the fertility of soils and enable them to support high yields. About 50% of the increase in crop production during recent times has been attributed to fertilizer use; though the fertilizer use efficiency is very poor.

Classification of inorganic fertilizers

- **A. Based on number of nutrients present**
- 1. Straight fertilizers
- 2. Complex fertilizers
- 3. Mixed Fertilisers Or Fertiliser Mixtures
- **B. Classification of fertilizers based on particular plant nutrient element**
- 1. Nitrogenous fertilizers
- 2 Phosphatic fertilizers Primary nutrient fertilizers
- 3. Potassic fertilizers
- 4. Secondary nutrient fertilizers
- 5. Micronutrient fertilizers.

A. Based on number of nutrients present

1. Straight fertilizers

Are those fertilizers containing or supplying only one plant nutrient element at a time. For e.g., Urea, Ammonium Sulphate (NH_4SO_4), Ammonium nitrate(NH_4NO_3), Single super phosphate (SSP), Muriate of potash(MOP- KCl).

2. Complex fertilizers

Fertilizers containing at least 2 or more of the primary essential nutrients (NPK). They are chemical mixtures, granular and free flowing and easy to apply. There are two types of complex fertilizers;

a. Complete or compound fertilizer: They are the chemical mixtures of three or more primary or major nutrient elements (NPK) in one compound or mixture. They are usually in granular form and easy to apply.

Ex: 10-26-26, 17:17:17, 19:19:19

b. Incomplete complex fertilizers: A fertilizer material lacking any one of three major nutrients or containing only two of the primary nutrients like N, P and K

Ex: N-P complex fertilizer : -Nitro-phosphate(Suphala:-15-15-0,20:20:0, -Diammonium phosphate: 18-46-0

Characteristics of complex fertilizers (CF)

1. They usually have a high content of plant nutrients. As such they are also called high analysis fertilizers.

2. They usually have a uniform grain size, granular form and good physical condition during storage.

Advantage of complex fertilizers

1. In one application we can supply more nutrients and need not apply separately.
2. Balanced nutrition can be achieved.
3. Less cost is involved in transportation and application.
4. They are available in different grades according to need of the soils and crops.
5. Being granular, it is easy to apply by broadcasting.
6. Some complex fertilizers also provides some micronutrients to soil.
7. Transport and distribution is easy

8. They are non-caking and non- hygroscopic, thus safer for storage

3. Mixed Fertilisers Or Fertiliser Mixtures

A mechanical/physical mixture of two or more straight fertilizer materials in suitable proportion is referred to as fertilizer mixture or mixed fertilizers. Sometimes, complex fertilizers containing two plant nutrients are also used in formulating fertilizer mixtures. Specific fertilizer grades are recommended for specific crops depending upon the soil and climatic conditions of the region.

The mixed fertilizers are usually in powder form or sometimes granular form. Fertilizer mixture (FM) are free flowing and easy to apply. The mixed fertilizers can be made according to the need of the crop and there is wide scope for adjusting the fertilizer ratio..

Guide for mixing fertilizers

Some fertilizers cannot be mixed with other fertilizers. Mixing of incompatible fertilizer leads to a loss of some of the nutrients in the form of gas, converting soluble nutrients into insoluble form or caking. Certain fundamental principles are to be followed in mixing fertilizers are.

1. Ammonium sulphate, ammonium chloride and other ammonical fertilizers and nitrogenous organic manures should not be mixed with lime
2. Urea should not be mixed with Super phosphate(SP)
3. Calcium cyanamide, basic slag, quick lime slaked lime should not be mixed with N in NH4-N form.
4. Super phosphate should not be mixed with lime or $CaCO_3$ or wood ashes.
5. $NaNO_3$ or KNO_3 should not be mixed with Super phosphate.
6. Ammonium sulphate, nitrate should not be mixed with lime.
7. Nitrochalk should not be mixed with SP or lime.

The commonest fertilizer mixture can be made from SSP, Ammonium sulphate, SOP, Bonemeal, and MOP.

Advantages of fertilizer mixtures

1. Less labour is required to apply fertilizer mixture to soil. Individual crop wise fertilizer mixture can be made.
2. Balanced nutrition can be achieved.

3. The residual acidity of fertilizers can be effectively controlled by adding liming materials in the mixtures.

4. Micronutrients can be incorporated in fertilizer mixtures.

5. They have a better physical condition and more easily applied.

6. There is no need of purchasing straight fertilizers separately.

Disadvantages of fertilizer mixtures

1. Does not permit application of individual nutrients according to the needs of crops during specific times.

2. The unit cost of plant nutrients is higher than of straight fertilizer.

3. Lack of knowledge about proper mixing and their use.

4. Fertilizer mixture of particular grade suitable for particular crop cannot be applied for all crops.

B. Classification of fertilizers based on particular plant nutrient element

The element forms their principal constituent in the fertilizer.

1. Nitrogenous fertilizers

2 Phosphatic fertilizers

3. Potasic fertilizers

4. Secondary nutrient fertilizers

5. Micronutrient fertilizers.

I. Nitrogenous fertilizers

There are 6 groups.

a. Ammonium fertilizers

i. Ammonium sulphate $(NH_4)2\ SO_4$ – 20% N

ii. Ammonium chloride : NH_4Cl_2 -24-26%

iii. Ammonium phosphate : $NH_4H_2\ PO_4$ -20%N + 20% P_2O_5 or 16% N and 20% P_2O_5

iv. Anhydrous ammonium (82%N)

v. Ammonium solution- 20-25%N

vi. Ammonium carbonate- 21-24%N

vii. Ammonium bicarbonate- 17%N

b. Nitrate fertilizers

i. Sodium nitrate or Chilean nitrate : $NaNO_3$ – 16%N

ii. Calcium nitrate: $CaNO_3$ – 15.5% N

iii. Nitrophosphate

c. Both Ammonium and nitrate fertilizers

i. Ammonium nitrate: NH_4NO_3- 33-34%N

ii. Calcium ammonium nitrate (CAN) – 25, 26 and 28% N

iii. Ammonium sulphate nitrate (ASN) – 26%N

d. Amide fertilizers

i. Urea – 46% N

ii. Calcium cyanamide- 21 %N

iii. Urea phosphate

iv. Urea sulphate

e. Nitrogen solutions

i. Anhydrous ammonia

ii. Aqueous ammonia

iii. Solution containing one or more of the following urea, ammonium nitrate, ammonia

f. Slowly available nitrogenous fertilizers

i. Urea formaldehyde compounds

ii. Neem Cake coated Urea NCU

iii. Lac Coated Urea(LCU)

iv. Sulphur Coated Urea(SCU)

v. Urea super granules (USG)

vi. Prilled urea (PU)

II. Phosphatic fertilizers

They are broadly classified into 3 major groups on the basis of their solubility either in water or in citrate or citric acid.

a. Water soluble phosphatic fertilizers (Contain phosphoric acid or mono calcium phosphate.)

1. Single Super phosphate (SSP)- 16-18 % P_2O_5
2. Triple super phosphate (TSP) – 46-48 % P_2O_5
3. Double super phosphate (DSP)- 32% P_2O_5

4. Di-Ammonium phosphate (DAP)- 18%N and 46% P containing dicalcium phosphate

b. Citric acid soluble phosphatic fertilizers

1. Dicalcium phosphate (DCP) - 34-39% P_2O_5

2. Rhenamia phosphate- 23-26% P_2O_5

3. Basic slag- 14-18% P_2O_5

4. Raw or steamed bone meal- part of P_2O_5 soluble in citric acid.

5. Fused calcium magnesium phosphate- 16.5% P_2O_5

c. Water insoluble or citric acid insoluble phosphatic fertilizers. Containing tricalcium phosphate [(Ca_3 (PO4)$_2$]

Ex: Rock phosphate- 20-40% P_2O_5

Raw bone meal- 20-25% P_2O_5

Steamed bone meal- 22% P_2O_5

Pyrophos - 17% P_2O_5

III. Potassic Fertilizers

A. Fertilizers having K in the Chloride form

1. Muriate of Potash (MOP) – KCl- 60-62 % K_2O

B. Fertilizers having K in Non-chloride form

1. Sulphate of potash (SOP) -K_2SO_4: 48-52% K_2O

2. Potassium nitrateKNO_3 - 44% K_2O

IV. Secondary Nutrient Fertilizers

Secondary elements are as important as primary elements because they help in uptake of primary elements by plants. They are required in very little quantity as compared to primary elements. The most important secondary nutrients are Ca, Mg and S. The fertilizers carrying secondary nutrients are;

1. Calcium cyanamide(39.57% Ca)

2. Calcium Ammonium Nitrate (8.0% Ca & 4.5% Mg)

3. Calcium nitrate (1.5% Mg)

4. Super phosphate (20.0% Ca)

5. Bone meal (23.1% Ca)

6 Limestone (32.58% Ca)

7. Dolomite (20.0% Mg)

8 Gypsum (29.40% Ca & 21.0% S)

9. Potassium sulphate18.5% S & 0.6 to 0.9% Mg)

10. Ammonium sulphate (24% S)

V. Micronutrient Fertilizers

Micronutrients are those which required by plants in very minute quantities by plants but they have equal role as that of primary nutrients. They govern most of the physiological as well as biochemical reactions of plant growth and development.

The most important micronutrients are iron, manganese, zinc, copper, molybdenum, chlorine, boron and nickel. The fertilizers carrying micronutrients are;

Fe carrying fertilizers

1. Ferrous sulphate(19.0% Fe)
2. Ferric sulpahte(23.0% Fe)
3. Ferrous ammonium sulphate(29.0%Fe)
4. Ferric and ferrous oxide70.0 and 77.0% Fe)

Boron carrying fertilizers

1. Borax(11.0% B)
2. Boric acid(17.0% B)
3. Sodium tetra borate(14.0% B)
4. Borosite(21.0% B)

Manganese carrying fertilizers

1. Manganese sulphate (20.0 to 28.0% Mn)
2. Manganese carbonate (31.0% Mn)
3. Manganese chloride(17.0% Mn)

Zinc carrying fertilizers

1. Zinc sulphate (55.0% Zn)
2. Zinc oxide (67.0% Zn)
3. Zinc sulphide (67.0% Zn)
4. Zinc ammonium sulphate(33.5% Zn)

Molybdenum carrying fertilizers

1. Sodium molybdate (39.0% Mo)
2. Ammonium molybdate (54.0% Mo)

Copper carrying fertilizers: Copper sulphate.

Methods of Fertilizer Application

Fertilizer recovery is greatly influenced by method of its application. Method of application varies according to the spacing of crop, type of fertilizer material, time of application, etc. A brief account of these points could be explained as under:

A. Method of application of solid fertilizer materials

Solid materials may be applied in following ways:

1. Broadcasting

Even and uniform spreading of dry solid fertilizers by hand or spreader over the entire field before or after sowing of the crop is termed as broadcasting. Well decomposed FYM, compost, oil cake, bone meal, urea, superphosphate and lime are applied by this method.

Advantages

This method is easy, less time taking, cheap and more convenient to the farmers. This method proves effective-

- When the crops have a dense stand
- When the plant roots absorb nutrient from whole volume of soil
- When soil is rich in fertility
- When large amount of material is to be used
- When potassic fertilizers are to be used on light soils, etc.

Disadvantages

- It is not advantageous because it encourages weed growth all over the field.
- Most of the material remains on the soil surface and does not reach to the root zone for uptake by plants.
- There is greater loss of fertilizer nutrients due to washing, run-off, volatilization, etc. Hence the recovery (extent of fertilizer used by plants) ranges between 25 to 45 per cent or even less.

Broadcasting may be done in following ways:

a. Basal application Spreading of fertilizers before sowing or planting of the crops and mixing them by cultivating the soil during seed bed preparation is termed as basal application through broadcasting.

b. Top dressing and side dressing

Spreading of fertilizer in standing crops without considering the crop rows is termed as top dressing. But when the crop rows are taken into account and the material is dropped on the ground surface near the crop rows then it is called as side dressing.

2. Placement

This refers to applying fertilizers into the soil from where the crop roots can take them easily.

Advantages

- Maximum portion of the material can be used by plants.
- Losses through uptake by weeds, washing, run-off, volatilization etc. could be eliminated to the greatest extent.

Disadvantage

- Is not suitable for bulky manures.

Placement could be done in following ways:

a. Plough sole placement When the fertilizers are applied in open furrows at plough sole level while ploughing then it is termed as plough sole placement. Such furrows are covered immediately during the next run of the plough.

b. Deep placement

The method is adopted in dry land condition where the fertilizers are placed deeper than plough sole level then it is called as deep placement.

c. Sub-soil placement

When fertilizers are placed still deeper than the seeding or planting depth and also deeper than the previous two methods the method is termed as sub-soil placement.

3. Localized placement

There is distinction between placement and localized placement. The former refers to applying fertilizer into the soil without special reference to the location of seed or plant while the latter implies the application of fertilizer into the soil close to the seed or plant.

Advantages

Localized placement of fertilizers have many advantages over broadcasting method of application such as-

- Relatively lesser quantity is required for production of an ideal crop

- Weed growth is suppressed
- Fertilizer losses are reduced
- Fertilizers are placed in moist zone where they remain available to plants for longer period of time
- Fertilizers come in easy reach of crop roots
- Fertilizer recovery and response of crops to applied doses is increased.

Disadvantages

- The method is very technical and needs special precaution.
- Besides, it is very expensive.

The method could be adopted in following ways:

a. Contact placement/combine drilling

When fertilizer is placed along with seed then it is called as contact placement. This is done by using seed-cum-fertilizer drill. Sometimes fertilizer is drilled by implement and seed is sown in the same furrow.

b. Band placement

This is a localized placement of fertilizers by the side of plants or seeds (about 5 cm apart). This may be of two types as the bands may be continuous or discontinuous:

i. Hill placement (discontinuous band)

In the hill for widely spaced plants like cotton, castor and cucurbits fertilizers are placed on either of both sides of plants along or across the row but not along the entire row. This method is also termed as discontinuous band application.

ii. Row placement (continuous band)

Along the entire rows of closely spaced crops like cereals, minor millets, potato and tobacco fertilizers are applied continuously at 2-2.5 cm depth. This method has a definite relationship of fertilizers with seedlings or seed as the fertilizer is placed to the side of seedlings or seeds some distance away from them or at the level of the seed, above or below or by the side of the seed level. When the soil surface is dry, this method gives very promising results.

iii. Ring placement (continuous band)

Fertilizer is applied in a circle around individual plant or hill base at a depth of about 2.5-5 cm.

c. Pocket/spot placement

When fertilizers are placed at a fixed spot by the help of a bamboo peg having a hole at the bottom in case of very widely spaced crops then the method is termed as pocket/spot placement method. Fertilizers are placed deeper into the pocket (dibble) and seeds are sown in the same pocket about 5 cm above the fertilizers.

d. Pellet placement

This method is adopted specially in case of deep water rice cultivation where it is difficult to apply fertilizers in normal methods as the fertilizer granules get dissolved in water before reaching to the ground level. In this method fertilizers (specially nitrogenous ones) are mixed with clay soil in the ratio of one part of fertilizer into 10-15 parts of soil. The fertilizer is well mixed with soil after slight moistening then filled in gunny bags and stored for two-three days. Now small mud bolls are prepared and these boll or pellets are dropped near the crop rows in rice Jr jute under deep water conditions.

B. Method of application of liquid fertilizers

Use of liquid fertilizers is not very common practice but in advanced countries this is the most common method. It is the most suitable method under dry land agriculture and in the areas which are prone to erosion problems. Liquid fertilizers may be applied in following ways:

1. Use of starter solution

Starter solutions usually contain N, P, K in 1: 2: 1 or 1: 1: 2. This method is used for transplanted crops where in place of irrigation water this solution is applied just to wet the field so that the seedlings may establish quickly.

2. Application through irrigation water (Fertigation)

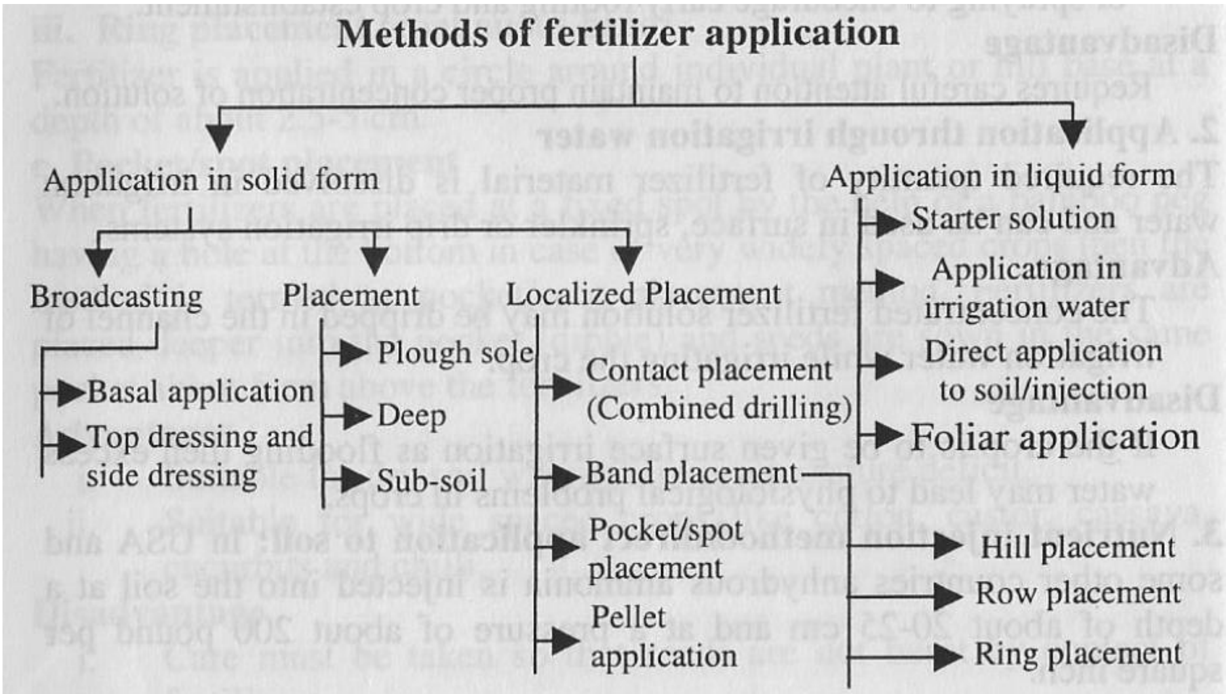
The required quantity of fertilizer material is dissolved in irrigation water and can be used in surface, sprinkler or drip irrigation systems. This process known as fertigation

3. Nutrient injection method/direct application to soil

In USA and some other countries anhydrous ammonia is injected into the soil at a depth of about 20-25 cm and at a pressure of about 200 pound per square inch.

4. Foliar spraying of nutrient solutions

In this method of fertilizer application urea, micro nutrients and other required materials are dissolved in water, filtered and sprayed over the crop foliage by the help of a suitable sprayer.



Critical limits of plant nutrient elements and hunger signs

Table.1 Soil fertility categories for organic carbon and available NPK

S. No.	Soil Nutrients	Soil fertility ratings		
		Low	Medium	High
1.	Organic carbon as a measure of available Nitrogen (%)	< 0.5	0.5-0.75	>0.75
2.	Available N as per alkaline permanganate method (kg/ha)	< 280	280-560	>560
3.	Available P by Olsen's method (kg/ha) in Alkaline soil	< 10	10-24.6	>24.6
4.	Available K by Neutral N, ammonia acetate method (kg/ha)	< 108	108-280	>280

(Source: Muhr *et al.,* 1965)

Table.2 Critical level of micro nutrients in soils

Micronutrient	Indices	Range of Critical level (ppm)
B	Hot water soluble	0.5 – 1.0
Cu	Mehlich No.1	0.1 – 10.0
	DTPA + $CaCl_2$ (pH 7.3)	0.2 – 0.5
	1 N NH_4OAc (pH 4.8)	0.2
Fe	DTPA + $CaCl_2$ (pH 7.3)	2.5 – 5.8
	1 N NH_4OAc (pH 4.8)	2
Mn	Mehlich No.1	4.0 – 8.0
	DTPA + $CaCl_2$ (pH 7.3)	1.0 – 2.0
	0.03 M H_3PO_4	0-20.0
	1 N NH_4OAc (pH 7)	3-4
Mo	$(NH_4)_2C_2O_4$ (pH 3.3)	0.05 – 0.2
Zn	0.1 N HCl	1.0 – 5.0
	1 N NH_4OAc (pH 4.6)	0.2 – 0.5
	DTPA + $CaCl_2$ (pH 7.3)	0.5 – 1.0
	0.05 N HCl	1

No.11-3/83-STU
Government of India
Ministry of Agriculture and Rural Development
(Department of Agriculture and Cooperation)
New Delhi, dated 25th September 1985

THE FERTILISER (CONTROL) ORDER 1985

ORDER

G.S.R. 758 (E). In exercise of the powers conferred by section 3 of the Essential Commodities Act, 1955 (10 of 1955), the Central Government hereby makes the following Order, namely

1. Short title and commencement

1. This Order may be called the Fertiliser (Control) Order, 1985.

2. It shall come into force on the date of its publication in the Official Gazette.

2. Definitions

In this Order, unless the context otherwise requires:

(a) "Act" means the Essential Commodities Act, 1955 (10 of 1955).

(aa). Biofertiliser means the product containing carrier based (solid or liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilisation or nutrient mobilization, to increase the productivity of the soil and/or crop/ ;

(b) "certificate of source" means a certificate given by a State Government, Commodity Board, manufacturer, importer, pool handling agency or as the case may be, wholesale dealer indicating therein the source from which fertiliser for purpose of sale is obtained.

(c) "Commodity Board" means the Coffee Board constituted under section 4 of the Coffee Act, 1942 (7 of 1942) or the Rubber Board constituted under section 4 of the

Rubber Act, 1947 (24 of 1947), or the Tea Board constituted under section 4 of the Tea Act, 1953 (29 of .1953), or as the case may be, the Cardamom Board constituted under section 4 of the Cardamom Act, 1965 (42 of 1965).

(d) "compound or complex fertiliser" means a fertilizer containing two or more nutrients during the production of which chemical reaction takes place

(e) "controller" means the person appointed as Controller of Fertilisers by the Central Government and includes any other person empowered by the Central Government to exercise or perform all or any of the powers, or as the case may be, functions of the Controller under this Order.

(ee) “Customised fertiliser” means the fertilizer specified under clause 20 B;

(f) "Dealer" means a person carrying on the business of selling fertilisers whether wholesale or retail or industrial use and includes a manufacturer, Importer, and a pool handling agency carrying on such business and the agents of such person, manufacturer, importer or pool handling agency

(g) Clause 'g' deleted vide S.O. 725 (E) dated 28.7.88.

(h) "fertliser" means any substance used or intended to be used as a fertiliser of the soil and/or crop and specified in Part A of Schedule I and includes a mixture of fertilizer and special mixture of ferti1isers provisional fertiliser ,customised fertilizer, Bio-fertilizers specified in Schedule III and Organic fertilizers specified in Schedule IV;

(i) "Form" means a form appended to this Order.

(j) "Grade" means the nutrient element contents in the fertilizer expressed in percentage;

(k) "Granulated mixture" means a mixture of fertilisers made by intimately mixing two or more fertilisers with or without inert material, and granulating them together, without involving any chemical reaction;

(kk)“importer" means a person who imports fertiliser in accordance with the Export and Import Policy of the Central Government, as amended from time to time.

(l) "inspector" means an Inspector of Fertilisers appointed under clause 27.

(ll) "industrial dealer" means a dealer who sells fertilisers for industrial purposes.

(lll) "industrial purposes" means the use of fertiliser for purposes other than fertilisation of soil and Increasing productivity of crops.

(m)"manufacturer" means a person who produces fertlllsers or mixtures of fertilisers and the expression "manufacture" with its grammatical variations shall be construed accordingly.

(n) "mixture of fertilisers" means a mixture of fertllisers made by physical mixing two or more fertilisers with or without inert material in physical or granular form and includes a mixture of NPK fertilisers, a mixture of micronutrient fertilisers and a mixture of NPK with micronutrient fertilizers;

(nn)“Notified Authority ”means an authority appointed under clause 26 A;

(o) "offer for sale" includes a reference to an intimation by a person of a proposal by him for the sale of any fertiliser, made by publication of a price list, by exposing the fertilizer for sale indicating the price, by furnishing of a quotation or otherwise howsoever;

(oo)”Organic fertilizer” means substances made up of one or more unprocessed material (s) of a biological nature (plant/animal) and may include unprocessed mineral materials that have been altered through microbiological decomposition process;

(p) ‘physical mixture" means a mixture of fertilisers made by physically mixing two or more fertilisers with or without inert material necessary to make a required grade, without involving any chemical reaction;

(pp) “Provisional fertilizer” means fertilizer specified under clause 20 A’.

(q) "prescribed standard" means:-

(i) in relation to a fertiliser included in column 1 of Part A of Schedule-I, the standard set out in the corresponding entry in column 2, subject to the limits of permissible variation as specified in Part B of that Schedule; and

(ii) in relation to a mixture of fertilisers, the standard set out in respect of that mixture under sub-clause (1) of clause 13 by the Central Government, subject to the limits of permissible variation as specified in Part B of Schedule-I

(iii) in relation to mixture of fertilisers, standard set out in respect of that mixture under sub-clause (2) of clause 13 by the State Government, subject to limits of permissible variation as specified in Part B of Schedule-I.

(iv) in relation to a Biofertiliser included in column 1 of Part A of Schedule-III, the standard set out in the corresponding entry in column 2, subject to the limits of permissible variation as specified in Part B of that Schedule;

(v) in relation to a Organic fertiliser included in column 1 of Part A of Schedule-IV, the standard set out in the corresponding entry in column 2, subject to the limits of permissible variation as specified in Part B of that Schedule.

(r) "pool handling agency" means an agency entrusted by the Central Government with functions relating to handling and distribution of imported fertilisers.

(s) "registering authority" means a registering authority appointed under clause 26 in respect of mixture of fertilizers and special mixture of fertilizers

(t) "retail dealer" means a dealer who sells fertilisers to farmers or plantations for **agricultural use such as for fertilisation of soil and increasing productivity of crops.

(u) "Schedule" means a Schedule appended to this Order.

(v) "special mixture of fertilisers" means any mixture of fertilisers prepared for experimental purposes in pursuance of a requisition made by any person (including a person engaged in the cultivation of tea, coffee or rubber) for sale to that person in such quantity and within such period as may be specified in such requisition; and.

(w) "wholesale dealer" means a dealer who sells fertilisers otherwise than in retail-for agricultural use such as for fertilisation of soil and increasing productivity of crops.

II. PRICE CONTROL

3. Fixation of prices of fertilisers

1. The Central Government may, with a view to regulating equitable distribution of fertilisers and making fertilisers available at fair prices, by notification in the Official Gazette, fix the maximum prices or rates at which any fertiliser may be sold by a dealer, manufacturer, importer or a pool handling agency.
2. The Central Government may having regard to the local conditions of any area, the period of storage of fertilisers and other relevant circumstances, fix different prices or rates for fertilisers having different periods of storage or for different areas or for different classes of consumers.
3. No dealer, manufacturer importer or pool handling agency shall sell or offer for sale any fertiliser at a price exceeding the maximum price or rate fixed under this clause.

4. Display of stock position and price list of fertilisers

Every dealer, who makes or offers to make a retail sale of any fertilisers, shall prominently display in his place of business:-

(a) the quantities of opening stock of different fertilisers held by him on each day;
Explanation -The actual stocks at any point of time during the day may be different from that of the displayed opening stocks to the extent of sale and receipt of such fertilisers upto the time of inspection during that day

(b) a list of prices or rates of such fertilisers fixed under clause 3 and for the time being in force.

5. Issue of cash/credit memorandum

a. Every dealer shall issue a cash or credit memorandum to a purchaser of a fertiliser in Form M.

III. CONTROL ON DISTRIBUTION OF FERTILISERS BY MANUFACTURER/ IMPORTER

6. Allocation of fertilisers to various States

The Central Government may, with a view to securing equitable distribution and availability of fertilisers to the farmers in time, by notification in the Official Gazette, direct any manufacturer/importer to sell the fertilisers produced by him in such quantities and In such State or States and within such period as may be specified in the said notification.

IV. AUTHORISATION OR REGISTRATION OF DEALERS"

7. Registration of Industrial dealers and authorization of other dealers

No person shall sell, offer for sale or carry on the business of selling of fertilizer at any place as wholesale dealer or retail dealer except under and in accordance with clause8:Provided that a State Government may, if it considers it necessary or expedient, by notification in the Official Gazette, exempt from the provisions of this clause any person selling fertilizer to farmers in such areas and subject to such conditions as may be specified in that notification.

8. Application for intimation or registration

1. Every person intending to sell or offer for sale or carrying on the business of selling of fertilizer as Industrial Dealer shall obtain a certificate of registration from the controller by making an application in Form A together with the fee prescribed under clause 36 and a Certificate of source in Form O.

2. Every person including a manufacturer, an importer, a pool handling agency, wholesaler and a retail dealer intending to sell or offer for sale or carrying on the business of selling of fertilizer shall make a Memorandum

of Intimation to the Notified Authority, in Form A1 duly filled in, in duplicate, together with the fee prescribed under clause 36 and certificate of source in Form O.

3. On receipt of a Memorandum of Intimation, complete in all respects, the Notified Authority shall issue an acknowledgement of receipt in Form A2 and it shall be deemed to be an authorization letter granted and the concerned person as authorised dealer for the purposes of this Order.

Provided that a certificate of registration granted before the commencement of the Fertiliser (Control) Amendment Order, 2003, shall be deemed to be an authorization letter granted under the provisions of this Order:

Provided further that where the applicant is a State Government, a manufacturer or an importer or a pool-handling agency, it shall not be necessary for it or him to submit Form O.

Provided also that a separate Memorandum of Intimation shall be submitted by an applicant for whole sale business or retail dealership, as the case may be:

Provided also that where fertilizers are obtained for sale from different sources,a certificate of source from each such source shall be furnished in Form O."

Provided also that where the manufacturer of organic fertilizer is a State Government or municipality, it shall not be necessary for it to obtain the authorisation letter:

Provided also that where the manufacturer of vermi-compost, other than a State Government or municipality, has annual production capacity less than 50 metric tonnes, it shall not be necessary for him to obtain the authorisation letter.

9. Grant or refusal of certificate of registration

The Controller, shall grant a certificate of registration in Form 'B' within thirty days of the receipt of application to any person who applies for it under clause 8;

Provided that no certificate of registration shall be granted to a person: -

(a) if his previous certificate of registration is under suspension; or

(b) if his previous certificate of registration has been cancelled within a period of one year immediately preceding the date of application; or

(c) if he has been convicted of an offence under the Act, or any Order made there under within three years immediately preceding the date of making the.

(d) if he fails to enclose with the application a certificate of source ; or

(e) if the application is incomplete in any respect; or

(f) if he makes an application for obtaining the certificate of registration for industrial dealer and, excepting if he is a manufacturer , importer or pool handling agency, holds [an authorization letter] for wholesale dealer or retail dealer or both, and as the case may be, the vice-versa.

10. Period of validity of certificate of registration and letter of authorization

Every certificate of registration granted under clause 9 and every authorization letter issued under clause 8 shall, unless renewed, suspended or cancelled, be valid for a period of three years from the date of its issue.

11. Renewal of certificates of registration and authorization letters

(1) Every holder of a certificate of registration granted under clause 9 or authorization letter granted or deemed to have been granted under clause 8, desiring to renew such certificate or authorization letter shall, before the date of expiry of such certificate of registration or authorization letter, as the case may be, make an application for renewal to the Controller, in Form C, or to the Notified Authority in Form A1, respectively, in duplicate, together with the fee prescribed under clause 36 for such renewal and a certificate of source as required under clause 8.

(2) On receipt of an application under sub-clause (1), together with such fee and certificate of source, the controller may renew the certificate of registration or the

Notified Authority, as the case may be shall issue acknowledgement receipt of renewal in form A 2. Provided that a certificate of registration shall not be renewed if the holder of the same did not sell any fertiliser during the period of one year immediately preceding the date of expiry of the period of validity.

(3) If any application for renewal is not made before the expiry of the period of validity of the certificate of registration or, as the case may be, the authorization letter but is made within one month from the date of such expiry, the certificate of registration or, as the case may be, the authorization letter shall be dealt as provided in sub-clause (2) on payment of such additional fee as may be prescribed under clause 36 in addition to the fee for renewal.

(4) Where the application for renewal of certificate of registration is made within the time specified in sub-clause (1) or sub-clause (3), the applicant shall be deemed to have held a valid certificate of registration until such date as the controller passes orders on the application for renewal

(5) If an application for renewal of a certificate of registration or authorization letter is not made within one month from the date of expiry of their period of validity ,the same shall be deemed to have lapsed on the date on which its validity expired and any business carried on after that date shall be deemed to have been carried on in contravention of clause 7."

V. MANUFACTURE OF MIXTURES OF FERTlLIZERS, ORGANIC FERTILISER AND BIO- FERTILISER

12. Restriction on preparation of mixtures of fertilizer

No person shall carry on the business of preparing any mixture of fertilisers. or special mixture of fertilizers, Bio-fertilizers or Organic fertilisers except under and in accordance with the terms and conditions of a certificate of manufacture granted to him under clauses 15 or 16.

13. Standards of mixtures of Fertilisers

(1) Subject to the other provisions of the order

(a) no person shall manufacture any mixture of fertilisers whether of solid or liquid fertilizers specified in Part A of schedule I unless such mixture conforms to the standards set out in the notification to be issued by the Central Government in the Official Gazette;

(b) no person shall manufacture any biofertiliser unless such biofertiliser conforms to the standards set out in the part A of Schedule – III.

(c) no person shall manufacture any Organic fertilizer unless such organic fertilizer conforms to the standards set out in the part A of Schedule IV.

(2)Subject to the other provisions of this order, no person shall manufacture any "mixture of fertilisers unless such mixture conforms to the standards set out in the notification to be issued by the State Government in the Official Gazette; Explanation- For the purposes of this sub-clause, mixture of fertilizers shall not include liquid fertilizers and 100% water soluble fertilizers, containing N,P,K.

(3)[omitted]

(4) No Certificate of manufacture shall be granted in respect of any fertiliser which does not conform to the standards set out in the notification referred in sub- clause (1) or (2);

(5) Nothing in this clause shall apply to special mixtures of fertilisers

14. Application for certificate of manufacture of mixtures of fertillsers

(1)Every person desiring to obtain a certificate of manufacture for preparation of any mixture of fertilisers or special mixture of fertilisers shall possess such mixture, *and possess the minimum laboratory facility as specified in clause 21A of this Order.

(2) An applicant for a certificate of manufacture for preparation of mixture of fertilisers or special mixture of fertilisers shall make an application to the registering authority

(a) if he is an applicant for a certificate of manufacture for any mixture of fertilisers in Form D, in duplicate, together with the fee prescribed there for under clause36;or ;

(b) if he is an applicant for a certificate of manufacture for any special mixture, in Form E, in duplicate, together with the fee prescribed there for under the said clause 36 and an attested copy of the requisition of the purchaser.

(3) Every person desiring to obtain a Certificate of Manufacture for preparation or organic fertilizer or biofertiliser shall make an application in Form D, in duplicate, together with a fee prescribed therefore under clause 36, to Registering authority.

"Provided that where the manufacturer of organic fertilizer is a State Government or a municipality, it shall not be necessary for it to obtain the Certificate of Manufacture:

Provided further that where the manufacturer of vermi-compost, other than a State Government or municipality, has annual production capacity less than fifty metric tonnes, it shall not be necessary for him to obtain the Certificate of Manufacture for preparation of vermi-compost."

15. Grant or refusal of certificate of manufacture for preparation of mixtures of fertilizers, Biofertilisers or Organic fertilizer.

(1) On receipt of an application under clause 14, the registering authority shall, by order in writing, either grant or refuse to grant the certificate of manufacture in respect of any mixture of fertilizer, Biofertiliser, Organic fertiliser or special mixture of fertilizer and shall, within forty-five days from the date of receipt of the application, furnish to the applicant a copy of the order so passed;

(2) Where an application for a certificate of manufacture for mixture of fertilizers, Biofertiliser, Organic fertiliser is not refused under sub-clause (1), the registering authority shall grant a certificate of manufacture in Form F and where an application for a certificate of manufacture for a special mixture is not refused under that sub-clause, *[such authority shall within forty five dates from the date of receipt of the application,]grant a certificate of manufacture to the applicant in Form G

16. Conditions for grant of certificate of manufacture in respect of special mixture of fertilisers and period of validity of such certificate

(1) No certificate of manufacture in respect of any special mixture of fertilisers shall be granted to an applicant unless he holds a valid certificate of manufacture under this Order for any mixture of fertilisers.

(2) Every certificate of manufacture granted in respect of any special mixture of fertilisers shall be valid for a period of [sixmonths] from the date of its issue; Provided that the registering authority may, if it is satisfied that it is necessary so to do, extend the said period to such further period or periods as it may deem fit, so however, that the total period or periods so extended shall not exceed [twelve months]

17. Period of validity of a certificate of manufacture for preparation of mixtures of fertilizers, Biofertilisers or Organic fertilizer.

Every certificate of manufacture granted under clause 15 for preparation of a mixture of fertilizers, Biofertiliser or Organic fertilizers shall, unless suspended or cancelled, be valid for a period of three years from the date of issue.

18. Renewal of certificate of manufacture for preparation of mixtures of fertilizers, Biofertiliser or Organic fertiliser

(1) Every holder of a certificate of manufacture for preparation of a mixture of fertilizers, Biofertiliser, Organic fertiliser desiring to renew the certificate, shall, before the date of expiry of the said certificate of manufacture make an application to the registering authority in Form D in duplicate, together with the fee prescribed for this purpose under clause 36.

(2) On receipt of an application for renewal as provided in sub-clause (1), and keeping in view the performance of the applicant and other relevant circum- stances, the registering authority may, if he so decides, renew the [certificate of manufacture by endorsement on Form F and in case the certificate of registration is not renewed, the registering authority shall record in writing his reasons for not renewing the certificate of manufacture.

(3) If an application for renewal is not made before the expiry of the certificate of manufacture but is made within one month from the date of expiry of the [certificate of manufacture, the certificate of manufacture] may be renewed on payment of such additional fee as may be prescribed by the State Government for this purpose.

(4) Where the application for renewal is made within the time specified in sub- clause (1) or sub-clause (3), the applicant shall be deemed to have held a valid [certificate of

manufacture] until such date as the registering authority passes order on the application for renewal.

(5) f an application for renewal of a certificate of manufacture is not made within the period stipulated under sub-clause (1) or, as the case may be, under sub-clause (3), the certificate of manufacture shall be deemed to have expired immediately on the expiry of its validity period, and any business carried on after that date shall be deemed to have been carried on in contravention of clause 12.

VI. RESTRICTIONS ON MANUFACTURE/ IMPORT, SALE, ETC. OF FERTILISER

19. Restriction on manufacture/import, sale and distribution of fertilisers

No person shall himself or by any other person on his behalf:-

(a) manufacture/import for sale, sell, offer for sale, stock or exhibit for sale or distribute any fertlliser which Is not of prescribed standard;

(b) manufacture/Import for sale, sell, offer for sale, stock or exhibit for sale, or distribute any mixture of fertl11sers, which is not of prescribed standard** (subject to such limits of permissible variation as may be specified from time to time by the Central Government) or special mixture of fertilisers which does not conform to the particulars specified In the certificate of manufacture granted to him under this Order in respect of such special mixture.

(c) sell, offer for sale, stock or exhibit for sale or distribute:-

(i) any fertiliser the container whereof is not packed and marked in the manner laid down In this Order

(ii) any fertiliser which is an [imitation of or] a substitute for another fertiliser under the name of which It Is sold;

(iii) Any fertilizer which is adulterated;

Explanation:- A fertiliser shall be deemed to be adulterated, If It contains any substance the addition of which is likely to eliminate or decrease Its nutrient contents or make the fertiliser not conforming to the prescribed standard.

(iv) any fertiliser the label or container whereof bears the name of any individual firm or company purporting to be manufacturer/Importer of the fertiliser, which individual, firm or company Is fictitious or does not exsist.

(v) any fertiliser, the label or container whereof or anything accompanying therewith bears any statement which makes a false claim for the fertiliser of which s false or misleading in any material particular.

(vi) any substance as a fertiliser which substance is not, in fact, a fertiliser; or

(vii) any fertilizer without exhibiting the minimum guaranteed percentage by weight of plant nutrient.

Provided that specifications of city compost in Schedule IV shall, in case of municipalities, be applicable only when it is traded in packaged form for use in agriculture:

Provided further that the specifications of vermi-compost in Schedule IV shall be applicable only in such cases where it is sold in packaged form and for agricultural purposes.

20. Specifications In respect of imported fertilisers

Notwithstanding anything contained in this Order, the Central Government may by an order, published in the Official Gazette, fix separate specifications in respect of imported fertilisers.

20 A. Specification in respect of provisional fertilizer

Notwithstanding anything contained in this Order, the Central Government may, by order published in the Official Gazette, notify specifications, valid for a period not exceeding three years, in respect of fertilizers to be manufactured by any manufacturing unit for conducting commercial trials.

20B. Specifications in respect of customized fertilizers. - Notwithstanding anything contained in this Order, the Central Government may by order published in the Official Gazette, notify specification, valid for a period not exceeding three years in respect of customized fertiliser to be manufactured by any manufacturing unit.

21. Manufacturers/Importers pool handling agencies to comply with certain requirements in regard to packing and marking, etc.2

Every manufacturer/importer and pool handling agency shall, in regard to packing and marking of containers of fertilisers, Biofertiliser or Organic fertiliser comply with the following requirements, namely:-

(a) Every container in which any fertiliser is packed shall conspicuously be superscribed with the word “FERTILISER” and shall bear only such particulars and unless otherwise required under any law nothing else, as may from time to time, be specified by the Controller in this behalf, and;]

(aa) Every container in which any Biofertiliser or Organic fertilizer is packed shall conspicuously be superscribed with the word “BIO-FERTILISER/ ORGANIC FERTILISER” and shall bear only such particulars and unless otherwise required under any law nothing else, as may from time to time, be specified by the Controller in this behalf,

Provided that in case of containers the gross weight of which is 5 kg or less, no such printing of superscription and other particular shall be necessary if such super superscription and other particulars are printed on a separate label which is securely affixed to such container.

(b) Every container shall be so packed and sealed that the contents thereof cannot be tampered with without breaking the seal;

Provided that where fertilizer manufactured in India are packed in bags stitched on hand, such bags shall bear lead seals, so that the contents thereof cannot be tampered with without breaking the seals;

Provided further that lead sealing shall not be necessary:-

(i) if such bags are machine stitched in such a manner that contents thereof cannot be tampered with without a visible break in the stitching; and
(ii) in the case of fertilizers imported from abroad and packed a in bags stitched in hand, in such a manner that the contents thereof cannot be tampered with without visible break in the stitching.

Provided also that in case fertilizer bags are in cut, torn or damaged condition during transportation or mishandling during loading or unloading operation, the manufacturer of such fertilizer may, under intimation to the State Government and the Central Government, repack he fertilizer in new bags or restandardise the quantity in terms of declared weight.

(c). Every fertiliser bag in which any fertiliser is packed for sale shall be of such weight and size as may be specified by the Central Government from time to time in this behalf

21 A. Manufacturers to comply with certain requirements for laboratory facilities:-

Every manufacturer shall, in order to ensure quality of their product, possess minimum laboratory facility, as may be specified from time to time by the Controller.

22. Bulk sale of fertillsers

Notwithstanding anything contained In this Order:-

(a) a retail dealer may retain at any time one bag or container of each variety of fertiliser in an open and unsealed condition for the purpose of sale;
(b) a manufacturer/importer may sell the fertillser manufactured/imported by him in bulk to a manufacturer of mixture of fertilisers, compound / complex fertilisers or special mixture of fertilisers; and
(c) the Central Government may by notification published in the Official Gazette in this behalf authorise a manufacturer/importer to sell any fertiliser manufactured/ imported by him In bulk also direct to farmers for such period as may be specified in that notification:Provided that a certificate indicating the minimum guaranteed percentage of plant nutrients is issued by the manufacturer/importer to each farmer at the time of such sale.

23. Disposal of non-standard fertilisers

(1) Notwithstanding anything contained In this Order, a person may sell, offer for sale, stock or exhibit for sale or distribute, any fertillser except any fertillser imported by the Central Government which, not being an adulterated fertiliser, does not conform to the prescribed standard (hereinafter in this Order referred to as non-standard fertiliser) subject to the conditions that:-

(a) the container of such non-standard fertilizer is conspicuously superscribed in red colour with the words "non-standard" and also with the sign "X"; and

(b) an application forthe disposal of non-standard fertilisers in Form H is submitted to the [Notified authority] to grant a certificate of authorisation for sale of such fertilisers and a certificate of authorisation with regard to their disposal and price is obtained in Form I.

(c) such non-standard fertiliser shall be sold only to the manufacturers of mixtures of fertilisers or special mixtures of fertilisers or research farms of Government or Universities or such bodies.

(2) The price per unit of the non-standard fertiliser shall be fixed by the notified authority after satisfying itself that the sample taken is a representative one, and after considering the nutrient contents in the sample determined on the basis of a chemical analysis of the non-standard fertilizer.

(3)The Central Government may, by notification in the official Gazette and subject to the conditions, if any, laid down in that notification, and subject to guidelines issued in this regard by the Central Government exempt such pool handling agencies, as it deems fit, from complying with conditions laid down in paragraphs (a) and (b) of the sub-clause (1)

(4) Where any fertiliser imported by the Central Government is found to be of non-standard and the Central Government decides that the fertilizer cannot be permitted for direct use in agriculture, it may permit the use of such fertiliser by manufacturers of complex fertilisers, mixture of fertilisers or special mixture of fertilisers to be sold at such price as may be fixed by the Central Government.

(5)If a manufacture or importer detects or as reasonable doubt about the standard of the fertilizer manufactured or imported by him, and dispatched for sale as deteriorated in quality during transit due to natural calamity and is not of the prescribed standards, he may, within fifteen days from the date of dispatch from factory or port, apply with detailed justifications to the Central Government for obtaining permission for reprocessing the same in a factory to meet the prescribed standards and the Central Government may, after considering the facts, permit the re-processing of such fertilizer on the terms and conditions as may be notified by the Central Government in this behalf.

Provided that no such application for permission to reprocess the fertilizer by the manufacturer or importer shall be accepted by the Central Government after the expiry of the said period of fifteen days.

24. Manufacturers/Pool handling agencies to appoint officers responsible with compliance of the Order

Every manufacturing organization, ***importer and pool handling agency shall appoint in that organization and in consultation with the Central Government, an officer, who shall be responsible for compliance with the provisions of this Order .

25. Restriction on sale/use of fertilisers

(1) No person shall, except with the prior permission of the Central Government and subject to such terms and conditions as may be imposed by such Government, sell or use fertiliser, for purposes other than fertilisation of soils and increasing productivity of crops.

Provided that the price of fertilisers permitted for sale for industrial use shall be no profit no loss price, excluding all subsidies at the production, import, handling or on sale for agricultural consumers;

Provided further that wherever customs or excise duties are chargeable, these may be added to the price so fixed.

Provided also that in the case of non-standard fertilisers, reductions shall be made from the no profit no loss price, indicated above, proportionate to the loss of nutrient contents.

(2)Notwithstanding anything contained in sub-clause (1), no prior permission for use of fertiliser for industrial purposes shall be necessary when the fertiliser for such purposes is purchased from the Industrial dealer possessing a valid certificate of registration granted under clause 9.

(3) Any person possessing a valid certificate of registration for Industrial dealer, unless such person is a State Government, a manufacturer/importer or a pool handling

agency, shall not carry on the business of selling fertilisers foragricultural purposes, including a wholesale dealer or a retail dealer. However, in case of a State Government, a manufacturer or a importer or a pool handling agency possessing a valid certificate of registration for sale of fertiliser for industrial use, and also for sale of fertiliser for agricultural use, whether in wholesale or retail or both, shall not carryon the business of selling fertilisers both for Industrial use and agricultural use In the same premises.

VII. ENFORCEMENT AUTHORITIES

26. Appointment of registering authority The State Government may, by notification in the Official Gazette, appoint such number of persons, as it thinks necessary, to be registering authorities for the purpose of this Order [$]for industrial dealers, and may, in any such notification define the limits of local area within which each such registering authority shall exercise his jurisdiction.

26A. Notified Authority- The State Government may, by notification in the Official Gazette, appoint such number of persons, as it thinks necessary, to be Notified Authorities for the purpose of this Order and define the local limits within which each such Notified Authority shall exercise his jurisdiction.

27. Appointment of inspectors

The State Government, or the Central Government may, by notification in the Official Gazette appoint such number of persons, as it thinks necessary, to be inspectors of fertilisers for the purpose of this Order, and may, in any such notification, define the limits of local area within which each such inspector shall exercise his jurisdictions.

27A. Qualifications for appointment of fertiliser Inspectors

No person shall be eligible for appointment as Fertiliser Inspector under this Order unless he possesses the following qualifications, namely:-

(1) Graduate In agriculture or science with chemistry as one of the subjects, from a recognlsed university; and

(2) Training or experience in the quality control of fertilisers and working in the State or Central Government Department of Agriculture.

27B. **Qualifications for appointment of fertiliser Inspectors for Biofertiliser and Organic Fertiliser.**

No person shall be eligible for appointment as inspector of biofertiliser and Organic fertilizer under this Order unless he may possess the following qualifications, namely:-

(1) Graduate in agriculture or science with chemistry/microbiology as one of the subject; and

(2) Training or experience in the field of quality control of biofertilisers/organic fertilizers.

28. Powers of Inspectors

(1) An inspector may, with a view to securing compliance with this Order:-

(a) require any manufacturer, +importer, pool handling agency, wholesale dealer or retail dealer to give any information in his possession with respect to the manufacture, storage and disposal of any fertilizer manufactured or, in any manner handled by him

(b) draw samples of any fertiliser in accordance with the procedure of drawal of samples laid down in Schedule II. Provided that the inspector shall prepare the sampling details in duplicate In Form J, and hand over one copy of the same to the dealer or his representative from whom the sample has been drawn;

(ba) draw samples of any biofertilisers in accordance with the procedure of drawl of samples laid down in schedule III.

(bb) draw samples of any organic fertilisers in accordance with the procedure of drawl of samples laid down in schedule IV.

(c) enter upon and search any premises where any fertiliser is manufactured/ Imported or stored or exhibited for sale, if he has reason to believe that any fertiliser has been or is being manufactured/imported, sold, offered for sale, stored, exhibited for sale or distributed contrary to the provisions of this Order;

(d) seize or detain any fertiliser in respect of which he has reason to believe that a contravention of this Order has been or is being or is [attempted] to be committed;

(e) seize any books of accounts or documents relating to manufacture, storage or sale of fertilisers, etc. in respect of which he has reason to believe that any contravention of this Order has been or is being or is about to be committed;

Provided that the Inspector shall give a receipt for such fertilisers or books of accounts or documents so seized to the person from whom the same have been seized;

Provided further that the books of accounts or documents so seized shall be returned to the person from whom they were seized after copies thereof or extracts thereform as certified by such person, have been taken.

(2) Subject to the proviso to paragraphs (d) and (e) of sub-clause (1), the provisions of the Code of Criminal Procedure, 1973 (2 of 1974) relating to search and seizure shall, so far as may be, apply to searches and seizures under this clause.

Provided also that the inspector shall give the stop sale notice in writing to the person whose stocks have been detained and initiate appropriate action as per the provisions of this order within a period of twenty one days. If no action has been initiated by the inspector within the said period of twenty one days from the date of issue of the said notice, the notice of stop sale shall be deemed to have been revoked.

(3) Where any fertiliser is seized by an inspector under this clause, he shall forthwith report the fact of such seizure to the collector whereupon the provisions of sections 6A, 6B, 6C, 6D and 6E of the Act, shall apply to the custody, disposal and confiscation of such fertilisers.

(4)Every person, if so required by an inspector, shall be bound to afford all necessary facilities to him for the purpose of enabling him to exercise his powers under sub-clause (1).

VIII. ANALYSIS OF SAMPLES

29. Laboratory for analysis

1. A fertiliser samples, drawn by an inspector, shall be analyzed in accordance with the instructions contained in Schedule II in the -Central Fertiliser Quality Control and Training Institute, **Faridabad or Regional Fertiliser Control Laboratories at Bombay, Madras or Kalyani (Calcutta) or in any other laboratory notified for this purpose by the State Government [with the prior approval of the Central Government.

(1A) Biofertiliser samples, drawn by an inspector, shall be analyzed in accordance with the instructions contained in Schedule III in the –National Centres of Organic Farming, Ghaziabad or Regional Centres of Organic Farming at Bangalore, Bhubaneshwar, Hissar, Imphal, Jabalpur and Nagpur or in any other laboratory notified by the Central or State Government.

(1B) Organic fertiliser samples, drawn by an inspector, shall be analyzed in accordance with the instructions contained in Schedule IV in the –National Centres of Organic Farming, Ghaziabad or Regional Centres of Organic Farming at Bangalore, Bhubaneshwar, Hissar, Imphal, Jabalpur and Nagpur or in any other laboratory notified by the Central or State Government.

(2) Every laboratory referred to in sub-clause (1) shall, in order to ensure accurate analysis, of fertiliser samples, possess minimum equipment and other laboratory facilities, as may be specified from time to time by the Controller in this behalf

29A. Qualifications for appointment of fertiliser analyst in the ferti1ser control laboratories

No person shall be eligible for appointment as fertiliser analyst for analysis of fertiliser samples in the laboratories notified under clause 29 of the Order, unless he possesses the following qualifications, namely:-

(1) graduate in Agriculture or Science with chemistry as one of the subjects from a recognised university; and

(2) training In fertiliser quality control and analysis at Central Fertlllzer Quality Control and Training Institute, Faridabad.

Provided that the fertiliser analysts appointed before the commencement of this Order, who do not possess the requisite training, shall undergo prescribed training, within a period of three years, in the Central Fertiliser Quality Control " and Training Institute, Faridabad from the date of commencement of this Order.

29B Laboratories for refree analysis

(1) Every laboratory referred to in sub-clause (1) of clause 29 shall be designated as referee laboratory for the purpose of analysis of any sample of fertiliser :

Provided that no such laboratory which carried out the first analysis of the fertiliser sample shall be so designated in respect of that sample:

Provided further that in respect of any sample the analysis of which has been challenged, may be sent for referee analysis to any one of the other laboratories except those which are located in the State or where the first analysis has been done.

Provided also that the Central Fertiliser Quality Control and Training Institute and Regional laboratories shall be considered as one group of laboratories and a sample first analysed by any one of them, shall not be sent for referee analysis to any other in that group, but only to any other laboratory notified by a State Government.

(2) Notwithstanding anything contained in this Order, the Appellate Authority as specified under paragraph (b) of sub-clause (1) or paragraph (b) of sub-clause(2) of clause 32, in case of sample analyzed by the State Government laboratory, or the Controller, in case of samples analyzed by Central Fertiliser Quality Control and Training Institute, Faridabad or its Regional Fertiliser Control Laboratories, as the case may be, shall decide and send, one of the two

remaining samples, for reference analysis as provided under sub-clause (1).

30. TIme lImit for analysis, and communication of result

(1) Where sample of a fertlliser has been drawn, the same shall be dispatched alongwith a memorandum in Form K and in case of Organic fertilizers and Biofertilisers in Form KI to the laboratory for analysis within a period of seven days from the date of Its drawal.

(2) The laboratory shall analyse the sample and forward the analysis report in Form L and in case of Organic fertilizer and Biofertiliser in Form LI within [30 days] from the date of receipt of the sample in the laboratory to the authority specified in the said memorandum.

(3) The authority to whom the analysis report is sent under sub-clause (2) shall communicate the result of the analysis to the dealer/manufacturer/Importer/pool handling agency from whom the sample was drawn within [15 days] from the date of receipt of the analysis report of the laboratory.

IX. MISCELLANEOUS

31 Suspension, Cancellation Or Debarment

(1) A Notified Authority, registering authority, or as the case may be, the controller may, after giving the authorized dealer or the holder of certificate of registration or certificate of manufacture or any other certificate granted under this Order, an opportunity of being heard, suspend such authorization letter or certificate or debar the dealer from carrying on the business of fertilizer on one or more of the following grounds, namely:-

(a) that the authorization letter or certificate of registration or certificate of manufacture, as the case may be, has been obtained by wilful suppression of material facts or by misrepresentation of relevant particulars:

(b) that any of the provisions of this Order or any terms and condition of the Memorandum of Intimation or certificate of registration or the certificate of manufacture, as the case may be, has been contravened or not fulfilled:

Provided that while debarring from carrying on the business of fertiliser or canceling the certificate, the dealer or the certificate holder thereof may be allowed for a period of thirty days to dispose of the balance stock of fertilizers, if any, held by him:

Provided further that the stock of fertilizer lying with the dealer after the expiry of the said period of thirty days shall be confiscated.

(2) Where the contravention alleged to have been committed by a person is such as would, on being proved, justify his debarment from carrying on the business of selling of fertilizer or, cancellation of authorization letter or certificate of registration or certificate of manufacture or any other certificate granted under this Order to such person the Notified Authority or registering authority or, as the case may be, the controller may, without any notice, suspend such certificate, authorization letter, as an interim measure:

Provided that the registering authority, Notified Authority or, as the case may be, the controller shall immediately furnish to the affected person details and the nature of contravention alleged to have been committed by such person and, after giving him an opportunity of being heard, pass final orders either revoking the order of suspension or debarment within fifteen days from the date of issue of the order of suspension:

Provided further that where no final order is passed within the period as specified above, the order of interim suspension shall be deemed to have been revoked without prejudice, however, to any further action which the registering authority, Notified Authority or, as the case may be, the controller may take against the affected person under sub-clause (1).

(3) Wherever an authorization letter or certificate is suspended, cancelled or the person is debarred from carrying on the business of fertiliser, the Notified Authority, registering authority, or as the case may be, the Controller shall record a brief statement of the reasons for such suspension or, as the case may be, cancellation or debarment and furnish a copy thereof to the person whose certificate or authorization letter has been suspended or cancelled or business has been debarred.

(4) Wherever the person alleged to have committed the contravention is an industrial dealer, the Notified Authority may take action against the holder of such certificate of registration under sub-clause (1) and sub-clause (2):

Provided that where such certificate is suspended or cancelled, the Notified Authority shall, within a period of fifteen days from the date of issue of such order of suspension or cancellation, furnish to the controller also, besides sending the same to the person whose certificate has been suspended or cancelled, a detailed report about the nature of contravention committed and a brief statement of the reasons for such suspension or, as the case may be, cancellation:

Provided further that the controller, shall, in case of the order for suspension passed by the Notified Authority, on receipt of the detailed report and after giving the person an opportunity of being heard, pass final order either revoking the order of suspension or canceling the certificate of registration, within fifteen days from the date of receipt of the detailed report from the Notified Authority, failing which the order of interim suspension passed by the Notified Authority shall be deemed to have been revoked, without prejudice however, to further action which the controller may take against the holder of certificate under sub-clause (1):

Provided also that the order of cancellation passed by the Notified Authority shall remain effective as if it had been passed by the controller till such time the Controller, on receipt of the detailed report from the Notified Authority, and if deemed necessary, after giving the person a fresh opportunity of being heard, pass the final order either revoking or confirming the order of cancellation.

32. Appeals at Central Government level

(1) In any State, where the fertiliser allocation is made by the Central Government under this Order and if the suspension or cancellation of authorization letter of the manufacturer and or pool handling agency or debarment of business, in any way, has an effect of dislocating the said allocation and if the Central Government is of the opinion that it is necessary or expedient so to do for maintaining the supplies, may direct the concerned State Government to furnish detailed report about the nature of

contravention and a brief statement of the reasons for such suspension or cancellation and pass such order as it may think fit, confirming, modifying or annulling the order of State Government

Provided that if the report called by the Central Government is not received from the State Government within a period of fifteen days from the date of issue of the communication, the Central Government may decide the case without the report, on merit.

(2) Any person aggrieved by the analysis report of Central Fertiliser Quality Control and Training Institute or its regional laboratories may appeal to the Controller for referee analysis of such sample within a period of 30 days from the receipt of analysis report.

Provided that the Controller may entertain an appeal after the expiry of said period of 30 days if it is satisfied that there was sufficient cause for not filling it within that period.

32A. Appeal at the State Government level

(1) The State Government shall, by notification in the Official Gazette, specify such authority as the Appellate authority before whom the appeals may be filed within 30 days from the date of the order appealed against by any person, except by an industrial dealer, aggrieved by any of the following Orders or action of registering authority or a Notified Authority, namely:-

(i) Refusing to grant a certificate of manufacture for preparation of mixture of fertilisers or special mixture of fertilizers;or

(ii) Suspending or canceling a certificate of manufacture; or

(iii) Suspending or canceling authorization letter or debarring from carrying on the business of selling of fertilizer, or

(iv) non-issuance of certificate of manufacture within the stipulated period; or

(v) non-issuance of amendment in authorization letter within the stipulated period.

(2) Any person aggrieved by analysis report of fertilizer Testing laboratories notified by the State Government may

appeal to the appellate authority appointed under sub-clause (1) for reference analysis of such sample within thirty days from the date of receipt of analysis report.

33. Grant of duplicate copies of [authorization letter or Certificate of manufacture] certificate of registrations, etc.

Where authorization letter or a certificate of registration or a certificate of manufacture or any other certificate granted or, as the case may be, renewed under this Order is lost or defaced, the notified authority registering authority or, as the case may be, the Controller may, on an_application made in this behalf, together with the fee prescribed for this purpose under clause 36, grant a duplicate copy of such certificate.

34. Amendment of certificate of registration

The Notified Authority, registering or controller, as the case may be, may, on application being made by the holder of an authorization letter, a certificate of registration or certificate of manufacture, together with the fee prescribed for the purpose under clause 36, amend an entry in such authorization letter, certificate of registration or certificate of manufacture as the case may be.

35. Maintenance of records and submission of returns, etc.

(1) The controller may by an order made in writing direct the dealers. manufacturers/ importers, and pool handling agencies:-

(a) to maintain such books of accounts, records, etc. relating to their business in Form 'N'. and
(b) to submit to such authority, returns and statements in such form and containing such information relating to their business and within such time as may be specified in that order.

(2) Where a person holds certificates of registration for retail sale and wholesale sale of fertilisers, he shall maintain separate books of accounts for these two types of sales made by him.

(3) Where a State Government, a manufacturer, an importer and a pool handling agency holds valid certificates of registration for sale of fertilisers in, wholesale or retail or both and also for sale for industrial use, he shall maintain

separate books of accounts for these two or three types of sales made by him.

(4) Every importer shall inform the Director of Agriculture of the State in which he intends to discharge the imported fertilizer, under intimation to the Central Government, before the import is made orwithin a period of fifteen days after an indent for import is placed, the following details, namely ;-

(i) name of fertiliser

(ii) name of country of import.

(iii) name of manufacturer.

(iv) quantity to be imported

(v) date of arrival of the consignment.

(vi) name of the discharge port.

(vii) other information

36. Fees

(1) The fees payable for grant, amendment or renewal of a[n authorization letter] or certificate of registration or certificate of manufacture a duplicate of such certificates or, renewal thereof under this Order shall be such as the State Government may, from time to time fix, subject to the maximum fees fixed for different purposes by the Central Government and different fees may be fixed for different purposes or for different classes of dealers or for different types of mixtures of fertiliser or special mixture.

(2) The authority to whom and the manner in which the fee fixed under sub-clause (1) shall be paid, shall be such as may be specified by the State Government by notification in the Official Gazette.

(3) Any fee paid under sub-clause (1) shall not be refundable unless the grant or renewal of any certificate of registration or certificate of manufacture or duplicate copy of such certificate or renewal under this Order has been refused.

(4) The fees payable for grant, amendment, renewal or duplicate copy of certificate of registration for industrial dealer and the authority to whom and the manner in which such fee shall be paid, shall be such as may be specified by the Controller from time to time by notification in the Official Gazette.

37. Service of orders and directions

Any order or direction made or issued by the controller or by any other authority under this order shall be served in the same manner as provided in sub-section (5) of section 3 of the Act.

38. Advisory Committee

1. The Central Government may by notification in the Official Gazette and on such terms and conditions as may be specified in such notification, constitute a Committee called the Central Fertiliser Committee consisting of a Chairman and not more than ten other persons having experience or knowledge in the field, who shall be members of the Committee, to advise the Central Government regarding:-

(i) inclusion of a new fertiliser, under this Order;

(ii) specifications of various fertilisers;

(iii) grades/formulations of physical/granulated mixtures of fertilisers that can be allowed to be prepared in a State;

(iv) requirements of laboratory facilities in a manufacturing unit, including a unit manufacturing physical/granulated mixtures of fertilisers;

(v) methods of drawal and analysis of samples.

(vi) any other matter referred by the Central Government to the Committee.

(2) The Committee may, subject to the previous approval of the Central Government, make bye-laws fixing the quorum and regulating its own procedure and the conduct of all business to be transacted by it.

(3) The Committee may co-opt such number of experts and for such purposes or periods as it may deem fit, but any expert so co-opted shall not have the right to vote.

(4)The Committee may appoint one or more sub-committees, consisting wholly of members of the Committee or or partly of the members of the Committee and partly of co-opted members as it thinks fit, for the purpose of discharging such of its functions as may be delegated to such sub-committee or sub-committees by the Central Fertiliser Committee.

(5)The State Government may by notification in the Official Gazette and on such terms and conditions as may be specified in such notification, constitute a Committee called the State Fertiliser Committee consisting of a Chairman and not more than .4 other members, having experience or knowledge in the field, including a representative from State Agricultural University, the Fertiliser Industry and Indian Micro Fertilisers Manufacturers Association to advise the State Government regarding the grades/formulations of *mixture or of fertilisers.

39. Repeal and saving

(1) The Fertiliser Control) Order, 1957 is hereby repealed except as respects things done or omitted to be done under the said Order before the commencement of this Order.

(2) Notwithstanding such repeal, an order made by any authority, which is in force immediately before the commencement of this Order and which is consistent with this Order, shall continue in force and all appointments made, prices fixed, certificates granted and directions issued under repealed Order and in force immediately before such commencement shall likewise continue in force and be deemed to be made, fixed, granted or issued in pursuance of this Order till revoked.

SCHEDULE I
[See Clause 2(h) & (q)]
PART-A
SPECIFICATIONS OF FERTILISERS*

1(a). STRAIGHT NITROGENOUS FERTILISERS

1. Ammonium Sulphate

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Ammoniacal nitrogen per cent by weight, minimum	20.6
(iii)	Free acidity (as H_2SO_4.) per cent by weight, maximum (0.04 for material obtained from by-product ammonia and by-product gypsum)	0.025
(iv)	Arsenic as (As_2O_3) per cent by weight, maximum	0.01
(v)	Sulphur (as S) ,per cent by weight, minimum	23.0

2. Urea (46% N) (While free flowing)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total nitrogen, per cent by weight, (on dry basis) minimum	46.00
(iii)	Biuret per cent by weight, maximum	1.5
(iv)	Particle size—Not less than 90 per cent of the material shall pass through 2.8 mm IS sieve and not less than 80 per cent by weight shall be retained on 1 mm IS sieve	

3. Urea (coated) (45% N) (While free flowing)

(i)	Moisture per cent by weight, maximum	0.5
(ii)	Total nitrogen per cent by weight, content with coating, minimum	45.0
(iii)	Biuret per cent by weight maximum	1.5
(iv)	Particle size- Not less than 90 per cent of the material shall pass through 2.8 mm IS sieve an not less than 80 per cent by weight shall be retained on 1 mm IS sieve.	

4. Ammonium Chloride

(i)	Moisture per cent by weight, maximum	2.0
(ii)	Ammoniacal nitrogen per cent by weight, minimum	25.0

(iii)	Chloride other than ammonium chloride (as NaCl) per cent by weight, (on dry basis) maximum	2.0
(iv)	Omitted	

5. Calcium Ammonium Nitrate (25% N)

(i)	Moisture per cent by weight, maximum	1.00
(ii)	Total ammoniacal and nitrate nitrogen per cent by weight, minimum	25.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	12.5
(iv)	Calcium nitrate per cent by weight, maximum	0.5
(v)	Particle size –Not less than 80 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 10 per cent shall be below 1 mm IS sieve	

6. Calcium Ammonium Nitrate (26% N)

(i)	Moisture per cent by weight, maximum	1.00
(ii)	Total ammoniacal and nitrate nitrogen per cent by weight, minimum	26.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	13.0
(iv)	Calcium nitrate per cent by weight, maximum	0.5
(v)	Particle size -—Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve	

7. Anhydrous Ammonia

(i)	Ammonia per cent by weight, minimum	99.0
(ii)	Water per cent by weight, maximum	1.0
(iii)	Oil content by weight, maximum	20 ppm

8. Urea Super Granulated

(i)	Moisture, per cent by weight, maximum	1.00
(ii)	Total nitrogen, per cent by weight (on dry basis), minimum	46.00
(iii)	Biuret per cent by weight, maximum	1.5
(iv)	Particle size- —Not less than 90 per cent of the material shall pass through 13.2 mm IS sieve and not less than 80 per cent by weight shall be retained on 9.5 mm IS sieve.	

9. Urea (Granular)

(i)	Moisture, per cent by weight, maximum	1.00
(ii)	Total nitrogen, per rent by weight (on dry basis), minimum	46.00
(iii)	Biuret per cent by weight, maximum	1.5
(iv)	Particle size -—Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 2 mm IS sieve. Not more than 5 per cent shall be below 2 mm IS sieve."	

10. Urea Ammonium Nitrate (32%) (liquid)

(i)	Total Nitrogen, percent by weight, minimum	32.0
(ii)	Urea Nitrogen, percent weight maximum	16.6
(iii)	Am monical Nitrogen, percent by weight, minimum	7.7

(iv)	Nitrate Nitrogen, percent by weight, minimum	7.7
(v)	Specify gravity (at 150 C)	1.32
(vi)	Free ammonia (as NH_3) percent by weight, maximum	0.10

1 (b). STRAIGHT PHOSPHATIC FERTIUSERS

1. Single Superphosphate (16% P 205 Powdered)

(i)	Moisture per cent by weight, maximum	12.0
(ii)	Free phosphoric acid (as $P_2 0_5$) per cent by weight, maximum	4.0
(iii)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	16.0
(iv)	Sulphur (as S),percent by weight, minimum.	11.0

2. SIngle Superphosphate (14% P 205 Powdered)

(i)	Moisture per cent by weight, maximum	12.0
(ii)	Free phosphoric acid (as $P_2 0_5$) per cent by weight, maximum	4.0
(iii)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, min	14.0
(iv)	Sulphur (as S),percent by weight, minimum.	11.0

3. Triple Superphosphate

(i)	Moisture per cent by weight, maximum	12.0
(ii)	Free phosphoric acid (as $P_2 0_5$) per cent by weight, maximum	3.0
(iii)	Total phosphates (as $P_2 0_5$) per cent by weight, minimum	46.0

(iv)	Water soluble phosphates (as P_2O_5) per cent by weight, minimum	42.5

4. Bone meal, Raw

(i)	Moisture per cent by weight, maximum	8.0
(ii)	Acid insoluble matter per cent by weight, maximum	12.0
(iii)	Total phosphates (as P_2O_5) per cent by weight, minimum	20.0
(iv)	2 per cent citric acid soluble phosphates (as P_2O_5) per cent by weight, minimum	8.0
(v)	Nitrogen content of water insoluble portion per cent by weight, minimum	3.0
(vi)	Particle size-The material shall pass wholly through 2.36 mm IS sieve of which not more than 30 percent shall be retained on 0.85 mm ISsieve.	

5. Bone meal, Steamed

(i)	Moisture per cent by weight, maximum	7.0
(ii)	Total phosphates (as P_2O_5) per cent by weight, (on dry basis) minimum	22.0
(iii)	2 per cent citric acid soluble phosphates (as P_2O_5) per cent by weight, (on dry basis) minimum	16.0
(iv)	Particle size -Not less than 90 per cent of the material shall pass through 1.18 mm is sieve.	

6. Rock phosphate

(i)	Particle size-Minimum 90 per cent of the material shall pass through 0.15 mm IS sieve and the balance 10 per cent of material shall pass through 0.25 mm IS sieve.	

(ii)	Total Phosphate (as P_2O_5) per cent by weight. minimum	18.0
	7. Single Superphosphate (16% P2O5 Granulated)	
(i)	Moisture per cent by weight, maximum	5.0
(ii)	Free phosphoric acid (as P_2O_5.) per cent by weight, maximum	4.0
(iii)	Water soluble phosphates (as P_2O_5.) per cent by weight, minimum	16.0
(iv)	Particle size -Not less than 90 per cent of the material shall pass through 4 mm IS sieve and shall be retained on 1 mm IS sieve. Not more than 5 per cent shall pass through 1 mm IS sieve.	
(v)	Sulphur (as S),percent by weight, minimum.	11.0
	8.Superphosphoric Acid (70%) P2O5 (liquid)	
(i)	Total phosphate (asP_2O_5)per cent by weight, minimum	70.0
(ii)	Polyphosphate (asP_2O_5)percent by weight, minimum	18.9
(iii)	Methanol Insoluble matter, percent weight, maximum	1.0
(iv)	Magnesium) as Mg0), percent by weight, maximum	0.5
(v)	Specific gravity (at 24*c)	1.96

1(c) STRAIGHT POTASSIC FERTIUSERS

	1.Potassium Chloride (Muriate of Potash)	
(i)	Moisture per cent by weight, maximum	0.5
(ii)	Water soluble potash content (as K_2O) per cent by weight, minimum	6O.0
(iii)	Sodium as NaCI per cent by weight (on dry basis) maximum	3.5

(iv)	Particle size -—minimum 65 cent of the material shall pass through 1.7 mm IS sieve and be retained on 0.25 mm IS sieve.	

2.Potassium Sulphate

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Potash content (as K_2O) per cent by weight, minimum	50.00
(iii)	Total chlorides (as CI) per cent by weight, (on dry basis) maximum	2.5
(iv)	Sodium as NaCI per cent by weight, (on dry basis) maximum	2.0
(v)	Sulphur (as S),percent by weight, minimum.	17.5

3. Potassium Schoenite

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Potash content (as K_2O) per cent by weight (on dry basis), minimum	23.00
(iii)	Magnesium oxide (as MgO) per cent by weight, maximum	11.0
(iv)	Sodium (as NaCI) (on dry basis) per cent by weight, maximum	1.5

4. Potassium Chloride (Muriate of Potash) (Granular)

(i)	Moisture per cent by weight, maximum	0.5
(ii)	Water soluble potash (as K_2O) per cent by weight, minimum	60.00
(iii)	Sodium (as NaCI), per cent by weight, maximum	3.5
(iv)	Magnesium (as $MgCI_2$), per cent by weight, maximum	1.0
	Particle size – not less than 90 per cent of the material shall	

pass through 3.35 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve

5. **Potash derived from molasses**

(i)	Moisture, per cent by weight, maximum	4.79
(ii)	Total nitrogen, per cent by weight,minimum	1.66
(iii)	Neutral ammonium citrate soluble phosphate (as P_2O_5),per cent by weight, minimum	0.39
(iv)	Water soluble potash (as K_2O), per cent by weight, minimum	14.70.

1(cc). Straight Sulphur Fertilisers

1.**Sulphur 90% (powder)**

(i)	Moisture per cent by weight, maximum	1.00
(ii)	Total sulphur (as S) per cent by weight, minimum	90.00

2.**Sulphur (granular)**

(i)	Moisture per cent by weight, maximum	0.5
(ii)	Total Sulphur (as S) per cent by weight, minimum	90.00
(iii)	Particle size – not less than 90 per cent of the material shall pass through 4.0 mm IS sieve and be retained on 1 mm IS sieve and not more than 5% shall be below 1 mm IS sieve.	

(Note : the product may contain inert filler marerial as Bentonite etc. up to the extent of 10 percent by weight , maximum)

1(d). N.P.[COMPLEX] FERTILISERS

1.Deleted vide S.O. 377(E) dt. 29.5.1992

2. Diammonium Phosphate (18-46-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	18.0
(iii)	Ammonical nitrogen form per cent by weight, minimum	15.5
(iv)	Total nitrogen in the form of urea per cent by weight, maximum	2.5
(v)	Neutral ammonium citrate soluble phosphates (as P_20_5) per cent by weight, minimum	46.0
(vi)	Water soluble phosphates (as P_20_5) per cent by weight, minimum	41.0
(vii)	Particle size -– not less than90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below than 1 mm size.	

3. Ammonium Phosphate Sulphate (16-20-0)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total ammoniacal nitrogen per cent by weight, minimum	16.0
(iii)	Neutral ammonium citrate soluble phosphates (as P 205) per cent by weight, minimum	20.0

(iv)	Water soluble phosphates (as P_2O_5) per cent by weight, minimum	19.5
(i)	Particle size-– not less than90 per cent of the material shall pass through 4 mm IS sieve and shall be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	
(ii)	Sulphur (as S),percent by weight, minimum.	11.0

4. Ammonium Phosphate Sulphate (20-20-0)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total nitrogen per cent by weight, minimum	20.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	18.0
(iv)	Nitrogen in the form of urea per cent by weight, maximum	2.0
(v)	Neutral ammonium citrate soluble phosphates (as P_2O_5) per cent by weight, minimum	20.0
(vi)	Water soluble phosphates (as P_2O_5) per cent by weight, minimum	17.0
(vii)	Particle size –not less than90 per cent of the material shall pass through 4 mm IS sieve and shall be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve	
(viii)	Sulphur (as S),percent by weight, minimum.	13.0

5. Ammonium Phosphate Sulphate Nitrate (20-20-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	20.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	17.0

(iv)	Nitrate nitrogen per cent by weight, maximum	3.0
(v)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$} per cent by weight, minimum	20.0
(vi)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	17.0
(vii)	Particle size--- not less than 90 per cent of the material shall pass through 4 mm IS sieve and shall be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	
(viii)	Sulphur (as S),percent by weight, minimum.	13.0

6. Ammonium Phosphate Sulphate (18-9-0)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Ammoniacal nitrogen per cent by weight, minimum	18.0
(iii)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	9.0
(iv)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, .minimum	8.5
(v)	Particle size -90 per cent of the material shall pass through	
(vi)	4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

7. Nitro Phosphate (20-20-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	20.0
(iii)	Nitrogen in ammoniacal form per cent by weight, minimum	10.0

(iv)	Nitrogen in nitrate form per cent by weight, maximum	10.0
(v)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	20.0
(vi)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	12.0
(v)	Calcium nitrate, per cent by weight, maximum	1.0
(vi)	Particle size – not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

8. Urea Ammonium Phosphate (28-28-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	28.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	9.0
(iv)	Neutral ammonium citrate soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	28.0
(v)	Water soluble phosphates (as P 205) per rent by weight, minimum	25.2
(vi)	Particle size – not less than 90 per cent of the matenal shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

9. Urea Ammonium Phosphate (24-24-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	24.0

(iii)	Ammonical nitrogen per cent by weight, minimum	7.5
(iv)	Nitrogen in the form of urea per cent by weight, maximum	16.5
(v)	Neutral ammonnium citrate soluble phosphates (as P 205) per cent by weight, minimum	24.0
(vi)	Water soluble phosphates (as P 205) per cent by weight, minimum	20.4
(vii)	Particle size – not less than90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

(Note: This product contains inert filler material such as sand or dolomite to the extent of 20% by weight, maximum)

10. Urea Ammonium Phosphates (20-20-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	20.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	6.4
(iv)	Neutral ammonical citrate soluble phosphates (as P 205) per cent by weight, minimum	20.0
(v)	Water soluble phosphates (as P 205) per cent by weight, minimum	17.0
(vi)	Particle size- 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

(Note: This product contains filler material (inert soil) to the extent of 30 % by weight)

11. Mono Ammonium Phosphate (11-52-0)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total nitrogen all in ammoniacal form per cent by weight, minimum	11.0
(iii)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	52.0
(iv)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	44.2
(v)	Particle size-not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve.Not more than 5 per cent shall be below 1 mm IS sieve .	

12. NItrophosphate (23-23-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	23.0
(iii)	Nitrogen in ammoniacal form per cent by weight, minimum	11.5
(iv)	Nitrogen in nitrate form per cent by weight, maximum	11.5
(v)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	23.0
(vi)	Water soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	18.5
(vii)	Calcium nitrate, per cent by weight, maximum	1.0

(viii)	Particle size- Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

13. Ammonium Nitrate Phosphate (23-23-0)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	23.0
(iii)	Nitrogen in ammoniacal form per cent by weight,minimum	13.0
(iv)	Nitrogen in nitrate form per cent by weight, maximum	10.0
(v)	Neutral ammonium citrate soluble phosphate (as P_20_5) per cent by weight, minimum	23.0
(vi)	Water soluble phosphates (as P_20_5) per cent by weight, minimum	20.5
(vii)	Particle size- Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

14. Ammonium Poly-phosphate (10-34-0)(Liquid)

(i)	Total Nitrogen (all as Ammoniacal Nitrogen), percent by weight, minimum	10.0
(ii)	Total Phosphate (as P_2O_5) percent by weight minimum	34.0
(iii)	Poly-phosphate) as P_2O_5) percent by weight minimum	22.1
(iv)	Magnesium (as Mg0), percent by weight, maximum	0.5
(v)	Specific gravity (at 27^oC)	1.4

(vi)	pH	5.8-6.2

15. Ammonium Phosphate

(14-28-0)

(i)	Moisture, per cent by weight, maximum	1.5
(ii)	Total nitrogen, per cent by weight, minimum	14.0
(iii)	Urea nitrogen, per cent by weight, maximum	6.0
(iv)	Ammoniacal nitrogen, per cent by weight, minimum	8.0
(v)	Neutral ammonium citrate soluble phosphates (as P_2O_5), per cent by weight, minimum	28.0
(vi)	Water soluble phosphates (as P_2O_5), per cent by weight, minimum	23.0
(vii)	Particle size – Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

16. 13:33:0:15S

(i)	Ammoniacal nitrogen per cent by weight, maximum	13.0
(ii)	Neutral ammonium citrate soluble phosphates (as P_2O_5), per cent by weight, minimum	33.0
(iii)	Water soluble phosphate (as P2O5), per cent by weight, minimum	30.0
(iv)	Total sulphur as S, per cent by weight, minimum	15.0
(v)	Elemental sulphur as S, per cent by weight, maximum	7.6
(vi)	Sulphate sulphur as S, per cent by weight, minimum	7.4
(vii)	Moisture per cent by weight, maximum	1.0

(viii)	Particle size – Not less than 90 percent of the material shall pass through 4 mm sieve and be retained on 1 mm IS sieve and not more than 5 per cent shall be below 1 mm IS sieve.	

17. Diammonium Phosphate (16:44:0)

(i)	Moisture, percent by weight, maximum	3.0
(ii)	Total nitrogen, per cent by weight, minimum	16.0
(iii)	Ammonical nitrogen, per cent by weight, minimum	14.0
(iv)	Total Nitrogen in the form of urea, per cent by weight maximum	2.0
(v)	Neutral ammonium citrate soluble phosphate (as P_2O_5), per cent by weight, minimum	44.0
	Water soluble phosphate (as P_2O_5) per cent by weight, minimum	37.0
	Particle size: Not less than 90 per cent of the material shall pass through 4 mm IS sieve and shall be retained on 1mm IS sieve. Not more than 5 per cent shall be below 1mm IS sieve".	

1 (e). N.P.K. .[COMPLEX] FERTILISER

1. Nitrophosphate with Potash (15-15-15)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen, minimum	15.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	7.5

(iv)	Nitrate nitrogen per cent by weight, maximum	7.5
(v)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	15.0
(vi)	Water soluble phosphates (as$P_2 0_5$) per cent by weight, minimum	4.0
(vii)	Water soluble potash (as K_2O) per cent by weight minimum	15.0
(viii)	Particle size –[not less than]90 per cent of the material shall pass through4 mm IS sieve and be retained on 1 mm IS sieve	
(ix)	Calcium nitrate, per cent by weight; maximum	1.0

2. N.P.K. (10-26-26)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	10.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	7.0
(iv)	Nitrogen in the form of urea per cent by weight, maximum	3.0
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	26.0
(vi)	Water soluble potash (as K2O) per cent by weight, minimum	26.0
(vii)	Water soluble phosphate (as P 205) per cent by weight, minimum	22.1
(viii)	Particle size- Particle size of the material will be such that 90 per cent of the material will be between 1 mm and 4mm IS sieve and not more than 5 per cent will be below 1 mm size.	

3. N.P.K. (12-32-16)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total nitrogen per cent by weight, minimum	12.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	9.0
(iv)	Nitrogen in the form of urea per cent by weight, maximum	3.0
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	32.0
(vi)	Water soluble potash (as K2O) per cent by weight, minimum	27.2
(vii)	Water soluble phosphate (as P 205) per cent by weight, minimum	16.0
(viii)	Particle size -Particle size of the material will be such that 90 per cent of the material will be between 1 mm and 4 mm IS sieve and not more than 5 per cent will be below 1 mm size.	

4. N.P.K (22-22-11)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	22.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	7.0
(iv)	Urea nitrogen per cent by weight, maximum	15.0
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	22.0
(vi)	Water soluble potash (as K_2O) per cent by weight, minimum	11.0
(vii)	Water soluble phosphates (as P_20_5) per cent by weight, minimum	18.7

(viii)	Particle size – not less than90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

5. N.P.K. (14-35-14)

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Nitrogen in ammoniacal form per cent by weight, minimum	14.0
(iii)	omitted	
(iv)	Neutral ammonium citrate soluble phosphates (as $P_2 0_5$) per cent by weight, minimum	35.0
(v)	Water soluble potash (as K_2O) per cent by weight, minimum	14.0
(vi)	Water soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	29.0
(vii)	Particle size -90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

6. N.P.K. (17-17-17)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	17.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	5.0
(iv)	Urea nitrogen per cent by weight, maximum	12.0
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	17.0
(vi)	Water soluble potash (as K_2O) per cent by weight, minimum	17.0

(vii)	Water soluble phosphate (as P_2O_5) per cent by weight, minimum	14.5
(viii)	Particle size –Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve: Not more than 5 per cent shall be below 1 mm IS sieve.	

7. N.P.K. (14-28-14)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	14.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	8.0
(iv)	Urea nitrogen per cent by weight, maximum	6.0
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	28.0
(vi)	Water soluble potash (as K2O) per cent by weight, minimum	14.0
(vii)	Water soluble phosphate (as P_2O_5) per cent by weight, minimum	23.8
(viii)	Particle size – not less than90 per cent of the material shall pass through 4mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.	

8. N.P.K. (19-19-19)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	19.0
(iii)	Ammoniacal nitrogen per cent by weight, minimum	5.6

(iv)	Urea nitrogen per cent by weight, maximum	10.5
(v)	Neutral ammonium citrate soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	19.0
(vi)	Water soluble potash (as K_2O) per cent by weight, minimum	16.2
(vii)	Water soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	19.0
(viii)	Partide size -– not less than90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 5 per cent shall be below 1mm IS sieve.	

9. N.P.K. (17-17-17)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	17.0
(iii)	Ammonium nitrogen per cent by weight, minimum	8.5
(iv)	Nitrate nitrogen per cent by weight, maximum	8.5
(v)	Neutral ammonium citrate soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	17.0
(vi)	Water soluble potash (as K2O) per cent by weight, minimum	17.0
(vii)	Water soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	13.6
(viii)	Particle size-Not less than 80 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve. Not more than 20 per cent shall be above 4 mm IS sieve.	

10. N.P.K.(20-10—10)

(i)	Moisture per cent by weight, maximum	1.5

(ii)	Total nitrogen per cent by weight, minimum	20.0
(iii)	Urea nitrogen percent by weight, minimum	17.1
(iv)	Ammonical nitrogen percent by weight, minimum	3.9
(v)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	10.0
(vi)	Water soluble potash (as K2O) per cent by weight, minimum	10.0
(vii)	Water soluble phosphate (as P_20_5) per cent by weight, minimum	8.5

11. N.P.K. (15:15:15)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	15.0
(iii)	Ammonical nitrogen percent by weight, minimum	12.0
(iv)	Nitrogen in the form of Urea, per cent by weight, maximum	3.0
(v)	Water soluble phosphate (as P 205) per cent by weight, minimum	12.0
(vi)	Neutral ammonium citrate soluble phosphate (as $P\ _20_5$) per cent by weight, minimum	15.0
(vii)	Water soluble potash (as K_2O) per cent by weight, minimum	15.0
	Partide size -– not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve.	

12. N.P.K. (15:15:15:9(S)

(i)	Moisture per cent by weight, maximum	1.5
(ii)	Total nitrogen per cent by weight, minimum	15.0
(iii)	Ammonical nitrogen percent by weight, minimum	12.0
(iv)	Nitrogen in the form of Urea, per cent by weight, maximum	3.0
(v)	Water soluble phosphate (as $P_2 0_5$) per cent by weight, minimum	12.0
(vi)	Neutral ammonium citrate soluble phosphate (as P 205) per cent by weight, minimum	15.0
(vii)	Water soluble potash (as K2O) per cent by weight, minimum	15.0
(viii)	Sulphur (as S),percent by weight minimum	9.0
	Particle size -– not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve.	

13. N.P.K. (12:11:18 with MgO)

(i) Moisture, per cent by weight,maximum 1.5
(ii)Total nitrogen, per cent by weight, minimum 12.0
(iii) Ammonical nitrogen, per cent by weight, minimum 7.0
(iv) Nitrate nitrogen, per cent by weight, minimum 5.0

(v) Neutral ammonium citrate

soluble phosphate (as P_2O_5) per cent by weight, minimum 11.0

(vi) Water soluble phosphates (as P_2O_5), per cent by weight, minimum 7.7

(vii)Water soluble potash (as K_2O), per cent by weight, minimum 18.0

(vii) Magnesium (as Mg) per cent by weight, minimum 1.20

(viii) Sulphur (as S), per cent by weight, minimum 7.6

(ix)Total Chlorides (as Cl), percent by weight, maximum 1.0

(x)Particle size – Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1 mm IS sieve and not more than 5 per cent shall be below 1 mm IS sieve";

1(f) MICRONUTRIENTS

1. Zinc Sulphate Heptahydrate (ZnSO4.7H2O)

(i)	[OMITTED]	
(ii)	Matter insoluble in water per cent. by weight, maximum	1.0
(iii)	Zinc (as Zn) per cent. by weight, minimum	21.0
(iv)	Lead (as Pb) per cent by weight, maximum	0.003
(v)	Copper (as Cu) per cent by weight, maximum	0.1
(vi)	Magnesium (as Mg) per cent by weight, maximum	0.5
(vii)	pH not less than	4.0
(viii)	Sulphur (asS),percent by weight, minimum	10.0
(ix)	Cadmium (as Cd), percent by weight, maximum	0.0025
(x)	Arsenic (as As),percent by weight,maximum	0.01

2. Manganese Sulphate

(i)	Free flowing form	
(ii)	Matter insoluble in water per cent by weight, maximum	1.2
(iii)	Manganese (as Mn) content per cent by weight, minimum	30.5
(iv)	Lead (as Pb) per cent by weight, maximum	0.003
(v)	Copper (as Cu) per cent by weight, maximum	0.1
(vi)	Magnesium (as Mg) per cent by weight, maximum	2.0
(vii)	pH not less than	4.0
(viii)	Sulphur (asS),percent by weight, minimum	17.0

3. Borax (Sodium Tetraborate)
($Na_2B_4O_7$.10H2O) for soil application

(i)	Content of Boron as (B) per cent by weight, minimum	10.5
(ii)	Matter insoluble in water per cent by weight, maximum	1.0
(iii)	pH	9.0-9.5
(iv)	Lead (as Pb) per cent by weight, maximum	0.003

4.Omitted

5. Copper Sulphate ($CuSO_4$.5H2O)

(i)	Copper (as Cu), percent by weight, minimum	24.0
(ii)	Matter insoluble in water per cent by weight, maximum	1.0
(iii)	Soluble iron and aluminium compounds (expressed as Fe), percent by weight, maximum	0.5
(iv)	Lead (as Pb) percent by weight, maximum	0.003

(v)	pH not less than	3.0
(vi)	Sulphur (asS),percent by weight, minimum	17.0

6. Ferrous Sulphate ($FeSO_4.7H2O$)

(i)	Ferrous iron (as Fe) per rent by weight, minimum	19.0
(ii)	Free Acid (as H_2SO_4), per cent by weight, maximum	1.0
(iii)	Ferric Iron (as Fe), percent by weight, maximum	0.5
(iv)	Matter insoluble in water, percent by weight, maximum	1.0
(v)	pH not less than	3.5
(vi)	Lead (as Pb) per rent by weight, maximum	0.003
(vii)	Sulphur (asS),percent by weight, minimum	10.5

7 .Ammonium Molybdate ($(NH_4)_6MO_7O_{24}.4H2O$)

(i)	Molybdenum (as Mo), per rent by weight, minimum	52.0
(ii)	Matter insoluble in water, per cent by weight, maximum	1.0
(iii)	Lead (as Pb), per rent by weight, maximum	0.003

8. Chelated Zinc as Zn-EDTA

(i)	Appearance -Free flowing crystalline / powder	
(ii)	Zinc content (Expressed as Zn), per cent by weight minimum in the form of Zn-EDTA	2.0
(iii)	Lead (as Pb), per cent by weight maximum	0.003
(iv)	pH	6.0-6.5

9. Chelated Iron as Fe-EDTA

(i)	Appearance -Free flowing crystalline / powder	
(ii)	Iron content (expressed as Fe), per cent by weight	

	minimum in the form of Fe-EDTA	12.0
(iii)	Lead (as Pb) per cent by weight, maximum	0.003
(iv)	pH	5.5-6.5

10. Zinc Sulphate Mono-hydrate (ZnSO4 H2O)

(i)	Free flowing powder form	
(ii)	Matter-insoluble in water, per cent by weight, maximum	1.0
(iii)	Zinc (as Zn). per cent by weight. minimum	33.0
(iv)	Lead (as Pb), per cent by weight, maximum	0.003
(v)	Copper (as Cu), per cent by weight, maximum	0.1
(vi)	Magnesium (as Mg), per cent by weight, maximum	0.5
(vii)	Iron (as Fe), per cent by weight, maximum	1.0
(viii)	pH not less than	4.0
(ix)	Sulphur (asS),percent by weight, minimum	15.0
(x)	Cadmium (asCd),percent by weight, minimum	0.0025
(xi)	Arsenic (as As),percent by weight, minimum	0.01

11. Magnesium Sulphate

(i)	Free flowing -crystalline form	
(ii)	Matter insoluble in water, per cent by weight, maximum.	1.0
(iii)	Magnesium {as Mg), per cent by weight, minimum	9.6
(iv)	Lead (as Pb), percent by weight, maximum.	0.003
(v)	pH (5% solution)	5.0-8.0
(vi)	Sulphur (asS),percent by weight, minimum	12.0

12. Boric Acid (H_3BO_3)

(i)	Boron (as B) per cent weight, minimum	17.0
(ii)	Matter insoluble in water, per cent by weight, maximum	1.0
(iii)	Lead (as Pb) per cent by weight, maximum	0.003

13. Di-Sodium Octa Borate Tetra Hydrate

(i)	Boron (as B) per cent weight, minimum	20.0
(ii)	Matter insoluble in water, per cent by weight, maximum	1.0
(iii)	Lead (as Pb) per cent by weight, maximum	0.003

14. **Di-Sodium Tetra Borate Penta Hydrate**

(i)	Boron (as B) per cent weight, minimum	15.0
(ii)	Matter insoluble in water, per cent by weight, maximum	1.0
(iii)	Lead (as Pb) per cent by weight, maximum	0.003
(iv)	Arsenic (as As), per cent by weight, maximum	0.01

Particle size – Not less than 95% of the material shall pass to 5 mm IS sieve and be retained on 1.4 mm IS sieve.

***1(g) FORTIFIED FERTILISERS**

1. Boronated Single Superphosphate (16% P_2O_5powdered)

(i)	Moisture per cent. by weight, maximum	12.0
(ii)	Free phosphoric acid (as P_20_5) per cent by weight, maximum	4.0

(iii)	Water soluble phosphate (as P_2O_5) per cent by weight, minimum	16.0
(iv)	Boron (as B) per cent by weight	0.15-0.20

2. Zincated Urea

(i)	Moisture per cent by weight, maximum	1.0
(ii)	Total nitrogen per cent by weight, (on dry basis), minimum	43.0
(iii)	Zinc (as Zn), per cent by weight, minimum	2.0
(iv)	Biuret,per cent.by weight, maximum	1.5
(v)	Particle Size- Not less than 90 per cent. of the material shall pass through2.8 mm IS sieve and not less than 80 per cent.by weight shall be retained on 1mmIS sieve	

	3. Zincated Phosphate (suspension)	
(i)	Total phosphate (as P_2O_5), per cent by weight, minimum	12.9
(ii)	Total zinc (Zn), per cent by weight, minimum	19.4
(iii)	Neutral ammonium citrate soluble phosphate as (P_2O_5), per cent by weight, minimum	3.9
(iv)	Lead as Pb), per cent by weight, minimum	0.003
(v)	pH	8 ± 1
	4. NPK Complex fertilizer fortified with boron (10:26:26:0.3)	
(i)	Moisture, percent by weight, maximum	1.0
(ii)	Total nitrogen percent by weight, minimum	10.0
(iii)	Ammoniacal Nitrogen percent by weight, minimum	7.0
(iv)	Urea Nitrogen (as N), percent by	3.0

	weight, maximum	
(v)	Neutral Ammonium Citrate Soluble Phosphate as (P_2O_5), percent by weight, minimum	26.0
(vi)	Water soluble Phosphate as (P_2O_5) percent by weight, minimum	22.1
(vii)	Water Soluble Potash (as K_2O), percent by weight, minimum	26.0
(viii)	Boron (as B) percent by weight, minimum Particle size – Not less than 90 per cent of the material shall be between 1 mm and 4 mm IS sieve and not more than 5 per cent shall be below 1 mm IS sieve.	0.3
	5. NPK Complex Fertiliser Fortified with Boron (12:32:16:0.3)	
(i)	Moisture, per cent by weight, maximum	1.0
(ii)	Total nitrogen, per cent by weight, minimum	12.0
(iii)	Ammoniacal nitrogen, per cent by weight, minimum	9.0
(iv)	Nitrogen in the form of urea, per cent by weight, maximum	3.0
(v)	Neutral ammonium citrate soluble phosphate (as P_2O_5)per cent by weight, minimum	32.0
(vi)	Water soluble phosphates (as P_2O_5), per cent by weight, minimum	27.2
(vii)	Water soluble potash (as K_2O), per cent by weight, minimum	16.0
(viii)	Boron (as B) per cent by weight, minimum	0.3
(ix)	Particle size – Particle size of the material will be such that 90 per cent of the material will be between 1 mm and 4 mm IS sieve and not more than 5 per cent will be below 1 mm IS sieve.	
	6**. Diammonium Phosphate fortified with Boron (18:46:0: 0.3)**	
(i)	Moisture, per cent by weight, maximum	1.5
(ii)	Total nitrogen, per cent by weight, minimum	18.0
(iii)	Ammoniacal nitrogen, per cent by weight, minimum	15.5
(iv)	Nitrogen in the form of urea, per cent by weight, maximum	2.5

(v)	Neutral ammonium citrate soluble phosphate (as P_2O_5) per cent by weight, minimum	46.0
(vi)	Water soluble phosphates (as P_2O_5), per cent by weight, minimum	41.0
(vii)	Boron (as B) per cent by weight, minimum	0.3
(vIII)	Particle size – Not less than 90 per cent of the material shall pass through 4 mm IS sieve and be retained on 1mm IS sieve. Not more than 5 per cent shall be below 1 mm IS sieve.”.	

1(h) [100% water soluble Complex Fertiliser]

1.Pottasium Nitrate (13-0-45)

(i)	Omitted	
(ii)	Moisture, percent by weight maximum	0.5
(iii)	Total Nitrogen (all in Nitrate form),percent by weight ,minimum	13,0
(iv)	Water soluble Potash(as K_20),percent by weight ,minimum	1.0
(v)	Sodium (as Na)(On dry basis) percent by weight, maximum.	1.0
(vi)	Total Chloride(as Cl)(On dry basis),percent by weight,maximum.	1.5
(vii)	Matter insoluble in water, per cent by weight , maximum.	0.05

2.Omitted

3. Mono – Potasium Phosphate (0-52-34) (100% water Soluble)

(i)	Moisture percent by weight maximum	0.5
(ii)	Water Soluble Phosphate (as P2 O5)per cent by weight, minimum	52.0
(iii)	Water Soluble Potash (as K_20) per cent by weight, minimum	34.0

(iv)	Sodium(as NaCl) per cent by weight)on dry basis),maximum	0.025

4. Calcium Nitrate

(i)	Total Nitrogen, per cent by weight, minimum	15.5
(ii)	Ammonical Nitrogen percent by weight, maximum.	1.1
(iii)	Nitrate Nitrogen as N percent by weight minimum	14.4.
(iv)	Water soluble Calcium as per cent by weight, minimum	18.8.
(v)	Water insolubles percent by weight maximum	1.5

5. NPK 13:40:13 (100% water soluble)

(i)	Total Nitrogen per cent by weight, minimum	13.0
(ii)	Nitrate nitrogen, per cent by weight, maximum	4.4
(iii)	Ammonical nitrogen per cent by weight , minimum.	8.6
(iv)	Water soluble phosphate(as P_2O_5) per cent by weight, minimum.	40.0
(v)	Water soluble potash as K_2O, per cent by weight, minimum.	13.0
(vi)	Sodium (as NaCl), per cent by weight. on dry basis, maximum.	0.15
(vii)	Matter insoluble in water, per cent by weight, maximum.	0.5

6. NPK 18:18:18 (100% water soluble)

(i)	Total nitrogen, per cent by weight, minimum	18.0
(ii)	Nitrate nitrogen, per cent by weight, maximum.	9.8
(iii)	Ammonical nitrogen, per cent by weight, minimum.	8.2
(iv)	Water Soluble phosphate(as P_2O_5) per cent by weight, minimum.	18.0
(v)	Water soluble potash (as K_2O) per cent by weight, minimum.	18.0
(vi)	Sodium as NaCl, per cent by weight, on dry basis, maximum.	0.25
(vii)	Matter insoluble in water per cent by weight, maximum	0.5

7. NPK 13:5:26 (100% water soluble)

(i)	Total nitrogen per cent by weight, minimum	13.0
(ii)	Nitrate nitrogen per cent by weight, maximum.	7.0
(iii)	Ammoniacal nitrogen, per cent by weight, minimum.	6.0
(iv)	Water soluble phosphate (as P_2O_5) per cent by weight, minimum.	5.0
(v)	Water soluble potash as K_2O per cent by weight, minimum.	26.0
(vi)	Sodium as NaCl ,per cent by weight, on dry basis maximum	0.3
(vii)	Matter insoluble in water per cent by weight, maximum.	0.5

8. NPK 6:12:36 (100% water soluble)

(i)	Total Nitrogen per cent by weight,. minimum	6.0
(ii)	Nitrate nitrogen per cent by weight, maximum.	4.5
(iii)	Ammonical nitrogen per cent by weight minimum.	1.5
(iv)	Water Soluble Phosphate(as P_20_5)per cent by weight., minimum.	12.0
(v)	Water soluble potash, per cent by weight, minimum.	36.0
(vi)	Sodium as NaCl, per cent by weight, maximum	0.5
(vii)	Matter insoluble in water per cent by weight, maximum.	0.5

9 NPK 20:20:20 (100% water soluble)

(i)	Total Nitrogen per cent by weight, minimum	20.0
(ii)	Nitrate nitrogen percent by weight, maximum	4.9
(iii)	Ammonical nitrogen, percent by weight, minimum	3.0
(iv)	Urea nitrogen, percent by weight,maximum	12.1
(v)	Water soluble phosphate (as P_2O_5) per cent by weight, minimum.	20.0
(vi)	Water soluble potash as K_2O, per cent by weight,.minimum.	20.0
(vii)	Sodium as NaCl, per cent by weight on dry basis ,maximum.	0.06
(viii)	Matter insoluble in water per cent by weight, maximum.	0.5.

10 Potassium Magnesium Sulphate

(i)	Moisture per cent by weight, maximum	0.5
(ii)	Potash content (as K_2O) per cent by weight, minimum	22.0
(iii)	Magnesium as MgO, percent by weight ,minimum	18.0
(iv)	total chloride (asCl),percent by weight (on dry basis),maximum	2.5
(v)	Sodium (as NaCl) ,percent by weight(on dry basis),maximum	2.0
(vi)	Sulphur (as S), per cent by weight, minimum	20.0

11. NPK 19 :19:19 (100% water soluble)

(i)	Total Nitrogen per cent by weight, minimum	19.0
(ii)	Nitrate nitrogen, per cent by weight, maximum	4.0
(iii)	Ammonical nitrogen per cent by weight, maximum.	4.5
(iv)	Urea nitrogen,percent by weight,maximum	10.5
(v)	Water soluble Phosphate (as P_2O_5) per cent by weight, minimum.	5.0
(vi)	Water soluble potash (as K_2O) per cent by weight, minimum.	26.0

(vii)	Sodium as NaCl per cent by weight, on dry basis maximum	0.5
(viii)	Matter insoluble in water per cent by weight, maximum.	0.5
(ix)	Moisture, percent by weight,maximum	0.5

12. Mono Ammonium Phosphate 12:61:0 (100% water soluble)

(i)	Moisture, per cent by weight,. maximum	0.5
(ii)	Ammonical nitrogen, per cent by weight minimum.	12.0
(iii)	Water Soluble Phosphate(as P_20_5)per cent by weight., minimum.	61.0
(iv)	Sodium as NaCl per cent by weight, maximum.	0.5
(v)	Matter insoluble in water per cent by weight, maximum	0.5

PART -B

TOLERANCE LIMIT IN PLANT NUTRIENT FOR VARIOUS FERTILISERS

		Nutrients
1	For fertilisers with definite compounds like ammonium sulphate, urea, ammonium chloride, muriate of potash, sulphate of potash, superphosphate, dicalcium phosphate, sulphur powder and Sulphur granular which contain more than 20 percent plant nutrients	0.2
	For those which contain less than 20 per cent plant nutrients	0.1
2.	For calcium ammonium nitrate	0.3
3	For diammonium phosphale	0.5 units each for N & P contents

.

4.For nitrophosphate,ammonium sulphate nitrate,urea ammoniun phosphate, ammonium phosphate sulphate,bonemeal,granulated mixture,compound/complexfertilisers/ 100% water soluble fertilisers/physical mixturesof fertilizers (NPKmixtures),mixtures of NPK with micronutrients	Tolerance varies with nutrient level in fertilizer subjectto maximum of 2 per cent.for all combined nutrients:- Nutrient level (%) — Tolerance level (unit) 15 or less — 0.5 16 to 20 — 0.6 21 or more — 0.7

Note:

(a) In serial number 4, the term nutrient besides NPK also includes Sulphur

(b) The term nutrient in serial number 1,2,3,5,6, 7 and 8 includes N,P,K, S, Ca, Mg, Ge, Mn, Zn, Cu, B & Mo.

(c) In case of fertilizers where "Sulphur' has been specified in the specification under Schedule I Part A, the tolerance limit shall be same as prpescribed under serial number 1,6 and 8 independently for each Nutrient".

5.	For Borax, chelated Zinc-EDTA and Chelated iron-EDTA	0.1
6	For Solubor, copper sulphate, Zinc sulphate, manganese sulphate and ferrous sulphate	0.2
7.	For ammonium molybdate	0.5
8.	For magnesium sulphate	0.1
9.	For mixture of micronutrient fertilizers	

Tolerance varies . with combined nutrient level in fertilizer.

Nutrient Level (%)	Tolerance level (unit)
10 or less	0.1
11 to 20	0.2
21 or more	0.5

10 .	Particle size	3 units
11.	Moisture	0.3 units

“Schedule III
[see clause 2(h) and (q)]
PART – A

SPECIFICATIONS OF BIOFERTILISERS

1. Rhizobium

(i)	Base	=	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	=	CFU minimum $5x10^7$ cell/g of powder, granules or carrier material or $1x10^8$ cell/ml of liquid.
(iii)	Contamination level	=	No contamination at 10^5 dilution
(iv)	pH	=	6.5 – 7.5
(v)	Particle size in case of carrier based material	=	All material shall pass through 0.15-0.212 mm IS sieve
(vi)	Moisture percent by weight, maximum in case of carrier based	=	30-40%
(vii)	Efficiency Character	=	Should show effective nodulation on all the species listed on the packet.

*Type of carrier:
The carrier material such as peat, lignite, peat soil, humus, wood charcoal or similar material favoring growth of the organism.

2. Azotobacter

(i)	Base	=	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	=	CFU minimum $5x10^7$ cell/g of carrier material or $1x\ 10^8$ cell/ml of liquid.
(iii)	Contamination level	=	No contamination at 10^5 dilution
(iv)	pH	=	6.5 – 7.5
(v)	Particle size in case of carrier based material	=	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by	=	30-40%

	weight, maximum		
(vii)	Efficiency character	=	The strain should be capable of fixing at least 10 mg of nitrogen per g of sucrose consumed

*Type of carrier:
The carrier material such as peat, lignite, peat soil, humus, wood charcoal or similar material favoring growth of the organism.

3. *Azospirillum*

(i)	Base	=	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	=	CFU minimum $5x10^7$ cell/g of powder/granules or carrier material or $1 x10^8$ cell/ml of liquid
(iii)	Contamination level	=	No contamination at 10^5 dilution
(iv)	pH	=	6.5 – 7.5
(v)	Particle size in case of carrier based material	=	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based	=	30-40%
(vii)	Efficiency character	=	Formation of white pellicle in semisolid Nitrogen free bromothymol blue media.

*Type of carrier:
The carrier material such as peat, lignite, peat soil, humus, wood charcoal or similar material favoring growth of the organism.

4. *Phosphate Solubilising Bacteria*

(i)	Base	=	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	=	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material.
(iii)	Contamination level	=	No contamination at 10^5 dilution
(iv)	pH	=	6.5-7.5 for moist/dry powder granulated carrier based and 5.0-7.5 for liquid based.
(v)	Particle size in case of	=	All material shall pass through

	carrier based material		0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based	=	30-40%
(vii)	Efficiency Character	=	The strain should have phosphate solubilizing capacity in the range of minimum 30%, when tested spectrophotometrically. In terms of zone formation, minimum 5 mm solubilization zone in prescribed media having at least 3 mm thickness.

*Type of carrier:
The carrier material such as peat, lignite, peat soil, humus, wood charcoal or similar material favoring growth of the organism";

Part – B

TOLERANCE LIMIT Of Biofertilizers

$1x10^7$ CFU/g of carrier material in form of powder or granules or $5x10^7$ CFU/gm of liquid material

PART C

'PROCEDURE FOR DRAWAL OF SAMPLE OF BIOFERTILISERS –

PROCEDURE FOR SAMPLING OF BIOFERTILIZERS', -

"1. General Requirements of Sampling

1.0 In drawing, preparing and handling the samples, the following precautions and directions shall be observed.

1.1 Sampling shall be carried out by a trained and experienced person as it is essential that the sample should be representative of the lot to be examined.

1.2 Samples in their original unopened packets should be drawn and sent to the laboratory to prevent possible contamination of sample during handling and to help in revealing the true condition of the material.

1.3 Intact packets shall be drawn from a protected place not exposed to dampness, air, light, dust or soot."

2. Scale of Sampling

2.1 Lot

All units (containers in a single consignment of type of material belonging to the same batch of manufacture) shall constitute a lot. If a consignment consists of different batches of the manufacture the containers of the same batch shall be separated and shall constitute a separate lot.

2.2 Batch

All inoculant prepared from a batch fermentor or a group of flasks (containers) constitute a batch.

2.3 For ascertaining conformity of the material to the requirements of the specification, samples shall be tested from each lot separately.

2.4 The number of packets to be selected from a lot shall depend on the size of the lot and these packets shall be selected at random and in order to ensure the randomness of selection procedure given in IS 4905 may be followed."

"3. Drawal of Samples

3.1 The Inspector shall take three packets as sample from the same batch. Each sample constitutes a test sample.
3.2 These samples should be sealed in cloth bags and be sealed with the Inspector's seal after putting inside Form P. Identifiable details such as sample number, code number or any other details which enable its identification shall be marked on the cloth bags.
3.3 Out of the three samples collected, one sample so sealed shall be sent to incharge of the laboratory notified by the State Government under clause 29 or to National Centre for Organic Farming or to any of its Regional Centres. Another sample shall be given to the manufacturer or importer or dealer as the case may be. The third sample shall be sent by the inspector to his next higher authority for keeping in safe custody. Any of the latter two samples shall be sent for referee analysis under sub-clause (2) of clause 29B.
3.4 The number of samples to be drawn from the lot

Lot/Batch	**Number of Samples**
Upto 5,000 packets	03

5,001-10,000 packets	04
More than 10,000 packets	05

Schedule – IV
[see clause 2(h) and (q)]
Part – A

PART - A

1. City compost:

(i)	Moisture, per cent by weight	15.0-25.0
(ii)	Colour	Dark brown to black
(iii)	Odour	Absence of foul odour
(iv)	Particle size	Minimum 90% material should pass through 4.0 mm IS sieve
(v)	Bulk density (g/cm^3)	<1.0
(vi)	Total organic carbon, per cent by weight, minimum	12.0
(vii)	Total Nitrogen (as N), per cent by weight, minimum	0.8
(viii)	Total Phosphates (as P_2O_5), per cent by weight, minimum	0.4
(ix)	Total Potash (as K_2O), per cent by weight, minimum	0.4
(x)	C:N ratio	<20
(xi)	pH	6.5 - 7.5
(xii)	Conductivity (as dsm^{-1}), not more than	4.0
(xiii)	Pathogens	Nil
(xiv)	Heavy metal content, (as mg/Kg), maximum	
	Arsenic as (As_2O_3)	10.00
	Cadmium (as Cd)	5.00
	Chromium (as Cr)	50.00
	Copper (as Cu)	300.00
	Mercury (as Hg)	0.15
	Nickel (as Ni)	50.00
	Lead (as Pb)	100.00
	Zinc (as Zn)	1000.00

2. Vermicompost :

(i)	Moisture, per cent by weight	15.0-25.0
(ii)	Colour	Dark brown to black
(iii)	Odour	Absence of foul odour
(iv)	Particle size	Minimum 90% material should pass through 4.0 mm IS sieve
(v)	Bulk density ($g/cm^{3)}$	0.7 -0.9
(vi)	Total organic carbon, per cent by weight, minimum	18.0
(vii)	Total Nitrogen (as N), per cent by weight, minimum	1.0
(viii)	Total Phosphate (as P_2O_5), per cent by weight, minimum	0.8
(ix)	Total Potassium (as K_2O), per cent by weight, minimum	0.8
(x)	Heavy metal content, (as mg/Kg), maximum	
	Cadmium (as Cd)	5.0
	Chromium (as Cr)	50.00
	Nickel (as Ni)	50.00
	Lead (as Pb)	100.00"

(b). in Part B, under the heading 'Tolerance Limit of Organic Fertilisers', for the figures and words "0.1 unit for combined nitrogen, phosphorus and potassium nutrients", the figures and words "A sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5% in City Compost and shall be not less than 2.5% in case of vermicompost", shall be substituted.

Part – B

TOLERANCE LIMIT OF ORGANIC FERTILISER

A sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5% in City Compost and shall be not less than 2.5% in case of vermicompost",

PART D

METHODS OF ANALYSIS OF ORGANIC FERTILISERS

1. Estimation of pH

- Make 25 g of compost into a suspension in 50ml of distitled water and shake on a rotary shaker for 2 hours.

- Filter through Whatman No. 1 or equivalent filter paper under vacuum using a Buchner funnel.

- Determine pH of the filtrate by pH meter.

2. Estimation of Moisture

Method:

Weigh to the nearest mg about 5 gm of the prepared sample in a weighed clean, dry Petri dish. Heat in an oven for about 5 hours at $65^0 \pm 1^0$ C to constant weigh, Cool in a desicator and weigh. Report percentage loss in weight as moisture content.

Calculation

$$\text{Moisture percent by weight} \quad \frac{100\,(B-C)}{B-A}$$

A = Weight of the Petri dish
B= Weight of the Petri dish plus material before drying
C= Weight of the Petri dish plus material after drying

3. Estimation of Bulk density
Requirement

100 ml measuring cylinder	Weighing balance
Rubber pad [1 sq foot; 1 inch thickness]	Hot air oven

Method
- Weigh a dry 100ml cylinder (W 1 gill)
- Cylinder is filled with the sample upto the 100 ml mark. Note the volume (Vl ml)
- Weigh the cylinder along with the sample (W2gm)
- Tap the cylinder for two minutes.
- Measure the compact volume (V2 ml).

Calculation

$$\text{Bulk density} = \frac{\text{Weight of the sample taken (W2 - W1)}}{\text{Volume (Vl – V2)}}$$

4. Estimation of Electrical Conductivity

Requirements:

- 250 ml flask
- 100 ml beaker
- Potassium chloride [AR grade]
- Conductivity meter [With temperature compensation system]
- Funnel [OD - 75 mm]
- Analytical balance
- Filter paper

Method

- Pass fresh sample of organic fertilizer through a 2-4 mm sieve.
- Take 20gm of the sample and add 100ml of distitled water to it to give a ratio of 1:5.
- Stir for about an hour at regular intervals.
- Calibrate the conductivity meter by using 0.01M potassium chloride solution.
- Measure the conductivity of the unfiltered organic fertilizer suspension.

Calculation

Express the results as millimho's or ds/cm at 25^0C specifying the dilution of the organic fertilizer suspension viz., 1:5 organic fertilizer suspension.

5. Estimation of Organic Carbon

Apparatus

(i) Silica/Platinum crucible 25 g cap.
(ii) Muffle Furnace

Procedure

Accurately weigh 10 gm of sample dried in oven at 105^0 C for 6 hrs, in a pre weighed crucible and ignite the material in a Muffle furnace at 650 – 700^oC for 6-8 hrs. Cool to room temperature and keep in Desiccator for 12 hrs.
Weigh the contents with crucible

Calculation

Calculate the total organic carbon by the following formulae:-

$$\text{Total Organic matter \%} = \frac{\text{Initial wt – final wt.}}{\text{wt. of sample taken}} \times 100$$

$$\text{Total C\%} = \frac{\text{total organic matter”}}{1.724}$$

6. Estimation of total Nitrogen

As mentioned under Schedule – II, Part-B, 3 (v) of FCO,1985.

7. Estimation of C: N Ratio

Method

Calculate the C:N ratio by dividing the organic carbon value with the total nitrogen value.

8. Estimation of phosphate

Preparation of sample - Accurately weigh 10 gm oven dried sample in 50 g cap. silica crucible and ignite it to 650^o – 700^oC for 6-8 hrs to obtain ash. Cool and keep in a Dessicator.

Transfer the contents to a 100 ml beaker. Add 30 ml 25% HCl. Wash the crucible with 10 ml 25% HCl twice and transfer the contents to Beaker. Heat over hot plate for 10-15 min. Keep for 4 hrs. Filter through Whatman No.1 filter paper. Wash with distilled water 4-5 times (till acid free).

Make up the volume of filtrate to 250 ml in a volumetric flask.

Estimate total P by gravimetric quinoline molybdate method as described under Schedule – II, Part B, 4(ii) of FCO 1985.

9. Estimation of Potassium

Flame photometry method:- Total Potassium are usually determined by dry ashing at 650-700 Degree Centigrade and dissolving in concentrated hydrochloric acid.

Reagent and Standard curve

(1) Potassium chloride standard solution: Make a stock solution of 1000 ppm K by dissolving 1.909 g. of AR grade potassium chloride (dried at 60 Degree C. for 1 h) in distilled water 1 ; and diluting up to 1 litre. Prepare 100 ppm standard by diluting 100 ml of 1000 ppm stock solution to 1 litre with extracting solution.

(2) Standard curve: Pipette 0,5, 10,15 and 20 ml of 100 ppm solution into 100 ml volumetric flasks and make up the volume upto the mark. The solution contain 0,5, 15 & 20 ppm K respectively.

Procedure:

*Take 5g sample in a porceline crucible and ignite the material to ash at 650-700 C in a muffle furnace.

* Cool it and dissolve in 5 ml concentrated hydrochloric acid, transfer in a 250 ml beaker with several washing of distilled water and heat it. Again transfer it to a 100 ml volumetric flask and make up the volume.

*Filter the solution and dilute the filtrate with distilled water so that the concentration of K in the working solution remains in the range of 0 to20 ppm, if required.
*Determine K by flame photometer using the K- filter after necessary setting and calibration of the instrument.
*Read similarly the different concentration of K of the standard solution in flame photometer and prepare the standard curve by plotting the reading against the different concentration of the K.

Calculation: Potash (K) %by weight = R X 20 X diluting factor, where R= ppm of K in the sample solution (obtained by extra plotting from stand curve).

"10. Estimation of Cadmium, Copper, Chromium, Lead, Nickel and Zinc

Material Required

1. Triacid mixture: Mix 10 parts of HNO_3 (Nitric acid), 1 part of H_2SO_4
   (Sulphuric Acid) and 4 parts of $HClO_3$ (Perchloric Acid)
2. Conical flask, 250ml
3. Hot plate
4. Whatman filter paper No.42
5. Atomic Absorption Spectrophotometer

Processing of sample

Take 5.0 g or suitable quantity of oven dried (105^0C) sample thoroughly ground and sieved through 0.2 mm sieve in a conical flask.

Add 30 ml triacid mixture, cover it with a small glass funnel for refluxing. Digest the sample at 200^0C on a hot plate till the volume is significantly reduced with a whitish residue.
After cooling, filter the sample with Whatman No. 42 filter paper, make up to 100 ml in a volumetric flask.

Preparation of working standards

Cadmium - As mentioned under Schedule – II, Part B, 8(x) of FCO (1985)
Copper - As mentioned under Schedule – II, Part B, 8(iv) of FCO (1985)
Chromium - Dilute 1, 2, 3 and 4 ml of standard 199 ppm Chromium standard solution with doubled distilled water in volumetric flasks and make up the volume to 100 ml to obtain standards having concentrations of 1, 2, 3, 4 ppm

Lead - As mentioned under Schedule – II, Part B, 8(v) of FCO (1985)

Nickel - Dilute 1,2,3 and 4 ml of standard 100 ppm Nickel standard solution with doubled distilled water in volumetric flasks and make up the volume to 100ml to obtain standards having concentrations of 1, 2, 3, 4 ppm

Zinc - As mentioned under Schedule – II, Part B, 8(ii) of FCO (1985)

Measurement of Result

Estimate the metal concentrations of Cd, Cu, Cr, Fe, Pb, Ni, Zn by flaming the standard solution and samples using atomic absorption spectrophotometer (AAS) as per the method given for instrument at recommended wavelength for each element. Run a blank following the same procedure.

Expression of Result

Express the metal concentration as mg/g on oven dry weight basis in 3 decimal units.

(Reference: Manual for Analysis of Municipal Solid Waste (compost): Central Pollution Control Board)."

11. 'Estimation of Mercury

Reagents:

(a) Concentrated Nitric acid (HNO_3)
(b) Concentrated Sulphuric acid (H_2SO_4)
(c) Potassium persulphate (5% solution): Dissolve 50g of $K_2S_2O_8$ in 1 litre of distilled water.
(d) Potassium permagnate (5% solution): Dissolve 50g of $KMnO_4$ in 1 litre of distilled water.
(e) Hydroxylamine sodium chloride solution: Dissolve 120 g of Hydroxyl amine salt and 120 g of sodium chloride (NaCI) in 1 litre distilled water.
(f) Stannous chloride (20%): Dissolve 20 g of $SnCI_2$ in 100 ml distilled water.

Materials required

(a) Water bath
(b) Flameless atomic absorption spectrophotometer or cold vapour mercury analyzer.
(c) BOD bottle , 300 ml

Processing of sample:

(a) Take 5 g (finely ground but not dried) sample in an oven at a temperature of 105^0C for 8 hours for moisture estimation.
(b) Take another 5 g sample (finaly ground but not dried) in a BOD bottle, add to it 2.5 ml of conc. HNO_3, 5ml of cone. H_2SO_4 and 15 ml of 5% $KMnO_4$.
(c) After 15 minutes add 8 ml of 5% $K_2S_2O_8$.
(d) Close the bottle with the lid and digest it on a water bath at 95^0C for 2 hours.
(e) After cooling to room temperature add 5 ml hydroxylamine sodium chloride soln.

Measurement:

Reduction of the digested sample is brought out with 5 ml of 20% $SnC1_2$ immediately before taking the reading, using a cold vapour mercury analyzer.

Expression of results:

Express the mercury concentration as mg/g on oven dry weight basis in 3 decimal units.

(Reference: Manual for Analysis of Municipal Solid Waste (compost). Central Pollution Control Board).

"12. Estimation of Arsenic

Processing of sample – Suspend 10 gm finely ground sample in 30 ml aquaregia (HNO_3 + HCl in a ratio of 1:3) in a beaker. Keep on hot plate till moist black residue is obtained (do not dry). Add 5 ml aquaregia and allow to dry on hot plate till residue is moist. Dissolve the residue in 30 ml conc. HCl and filter through Whatman No.1 filter paper in 100 ml volumetric flask. Wash filter paper 3-4 times with double distilled water. Make up the volume to 100 ml. Take 1 ml of this solution in 100 ml volumetric flask, add 5ml conc. HCl and 2 gm KI and make up the volume to 100 ml.

Prepare standards having concentration of 0.05, 0.1 and 0.2 ppm by diluting 0.05, 0.1 and 0.2 ml, respectively of standard Arsenic solution with double distilled water in volumetric flask and make up the volume to 100 ml

Measurement – Estimate Arsenic using vapour generation assembly attached to Atomic Absorption Spectrophotometer as per the procedure given for the instrument.

13. Pathogenicity Test

Apparatus

1. Samples of Compost

2. Lactose Broth of Single and Double Strength
3. Culture Tubes
4. Durham Tubes
5. Bunsen Burner
6. Sterile Pipettes
7. Incubator, Autoclaves,
8. Petri-Plates
9. Inoculation Loops

Preparation of Culture Media

A. For Presumptive Test

1. Lactose Broth

Beef Extract	: 6.0 g
Peptone	: 10.0 g
Lactose	: 10.0 g
D.W.	: 1000 ml

B. For Confirmative Test

1. Eosine Methylene Blue Agar Media (EMB Media)

Peptone	: 10.0 g
Lactose	: 5.0 g
Sucrose	: 5.0 g
K_2HPO_4	: 2.0 g
Eosine Y	: 0.4 g
Methylene Blue	: 0.06 g
Agar	: 15.0 g
D.W.	: 1000 ml

C. For Completed Test

1. Nutrient Agar

Beef Extract	: 3.0 g
Peptone	: 5.0 g

Procedures

A. Presumptive Test

1. Prepare 12 tubes of lactose broth for each sample and close the tube with cotton plugs/caps and autoclave at 121^{o}C for 20 min.
2. Fill Durham tubes with sterilized distilled water and keep in beaker and autoclave at 121^{o}C for 20 min.
3. Suspend 30 g of compost sample in 270 ml of sterile distilled water and serially dilute upto 10^{-4} dilution as per Schedule III, Part D, serial number 3 of FCO (1985)
4. Suspend 1 ml suspension from 10^{-1} to 10^{-4} in 3 tubes for each dilution
5. Insert distilled water filled Durham tube in inverted position in each tube and close the tube again
6. Inoculate tubes at 36^{o}C for 24h in incubator

Result

Production of gas within 24h - Confirms the presence of coliforms in the sample
Production of gas within 48h - Doubtful Test
No Gas Production - Negative Test

B. Confirmative Test

Confirmative test is for differentiating the coliforms from non-coliforms as well as Gram negative and Gram positive bacteria. In this test, the EMB agar plates are inoculated with sample from positive tubes producing gas. Emergence of small colonies with dark centres confirms the presence of Gram negative, lactose fermenting coliform bacteria. Sometimes some of the non-coliforms also produce gas, therefore, this test is necessary.

1. Prepare EMB agar plates with the composition as per the method at Schedule III, Part D, paragraphs 2.3.3 to 2.3.6
2. Inoculate plates with the help of inoculation loop with streaking of samples showing positive/doubtful tests in the presumptive test
3. Incubate plates at 30± 1^{o}C for 12 h in incubator
4. Dark centred or nucleated colonies appear which may differentiate between *E. coli* and *E. aerogenes* based on size of colonies and metallic sheen

Result

E. coli colonies on this medium are small with metallic sheen, where as *E. aerogenes* colonies are usually large and lack the sheen.

C. Completed Test

This test is required for further confirmation.

Procedure

1. Pick up a single colony from EMB agar plate
2. Inoculate it into lactose broth and streak on a nutrient agar slant
3. Incubate the slants
4. Perform Gram reaction after attaining the growth

Result

Gram-negative nature of bacteria is indicative of a positive completed test.”

GRANT OF PERMISSION FOR USE OF FERTILISIER FOR INDUSTRIAL PURPOSE.

The manufacturer of industrial product who intend to use fertilizer as raw material for manufacturing the product may apply to the Central Government in the Proforma I (appended below)along with the recommendation from the State Government/Central Government/ District Industry Centre of the concern State.

PROFORMA – I

1. Name of the applicant:

2. Postal Address:

3. Location and address where Factory is situated

4. Name of the recommending authority with which the Company is registered i.e. Directorate General Tech. Development/Development Commissioner (Small Scale Industries) Textile Commissioner, Government of India

5. Registration No. and Date

6. Item manufactured

7. Chemical Process of the item for which urea Or other fertilizers are required

8. Installed capacity for each item, requiring use Of Urea or other fertilizer.

9. Production during last 3 years of each item, Requiring use of urea or other fertilizers

10. Last 3 years **consumption** of urea or other Fertilizer (Specify the fertilizer used, each year Supported by a certificate of Chartered Accountant)

11. Quantity of Urea or other fertilizers purchased during the last three years (specify the fertilizer, purchased each year, supported by a certificate of Chartered Accountant).

12. Name of the manufacture/dealer (with complete address from whom Urea or other fertilizer was purchased each year.

13. Whether recommendation of DGTD/DC(SSI),Textile Commissioner on the quantity of fertilizer required has been issued and if so, how much quantity of fertilizers has been recommended.

14. Requirement of urea or other fertilizer for the current year.

15. Whether the requisite certificate from Chartered Accountant is attached with this application.

16. Name of the supplier

Signature of Authorized Signatory

<u>Document to be attached</u>

1. Application in prescribed proforma
2. Certificate from the Chartered Accountant of fertilizer purchase/consume for industrial use.
3. Recommendation from the State Government/ Central Government/ District Industry Centre of the concerned State Government.

4. GRANT OF CERTIFICATE OF REGISTRATION FOR SALE OF FERTILISER FOR INDUSTRIAL PURPOSE-

Under Clause 8 of Fertiliser (Control) Order,1985 for Certificate of Registration is granted for carrying on the business of selling of Fertiliser for industrial purpose.

For this purpose the application is required to be made to Controller of fertilizer in prescribed Form 'A'(appended below) together with fee of Rs. 1500/- and certificate of source in Form 'O' issued by the manufacture of fertilizer .

Currently, the Government of India is granting industrial dealership for sale of Urea only.

FORMS FOR REGISTRATION

FORM 'A'

{ See Clause 8}

FORM OF APPLICATION TO OBTAIN DEALERS'S (INDUSTRIAL)*

CERTIFICATE OF REGISTRATION

To

The *Controller (if the application is for industrial dealer's certificate of registration)

Place__________________ Sate of ______________________

1. Full name and address of the applicant:
   (a) Name of the concern, and postal address:
   (b) Place of business (Please give exact address):
      (i) for safe
      (ii) for storage

2. Is it a proprietary/partnership/limited company/Hindu Undivided family concern?
   Give the name(s) and address(es) of proprietor/partners/ manager/Karta:

(3) In what capacity is this application field.
- (i) Proprietor
- (ii) Partner
- (iii) Manager
- (iv) Karta

(4) Whether the application is for wholesale or retail or **industrial dealership?

(5) Have you ever had a fertilizer dealership registration certificate in the past?
If so, give the following details:
   (i) Registration number
   (ii) Place for which granted
   (iii) Whether wholesale or retail or **industrial dealership.
   (iv) Date of grant of registration certificate
   (v) Whether the registration certificate is still valid?
   (vi) If not, when expired?
   (vii) Reasons for non-renewal
   (viii) If suspended/cancelled and if so, when
   (ix) Quantity of fertilizers handled during last year
   (x) Names of products handled
   (xi) Name of source of supply of fertilizers.

(6) Was the applicant ever convicted under the Essential Commodities Act, 1955 or any Order issued thereunder including the Fertiliser (Control) Order,1957 during the last three years proceeding the date of application? If so give details.

(7) Give the details of the fertilizers to be handled

Sl.No.	Name of Fertiliser	Source of supply

(8) Please attach certificate(s) of source from the supplier(s) indicated under column 3 of Sl.No.7.

(9) I have deposited the registration fee of Rs.______________ vide Challan No.__________ dated ____________ in treasury/Bank *or enclose the Demand Draft No. __________________ dated _____________ for Rs.______________ drawn on ____________________________________ Bank, in favour of _________ payable at ____________________________________ towards registration fee. (Please strike-out whichever is not applicable).

(10) Declaration:-

(a) I/we declare that the information given above is true to the best of my/our knowledge and belief and no part thereof is false.
(b) I/we have carefully read the terms and conditions of the Certificate of Registration given in Form 'B' appended to the Fertiliser (Control) Order,1985 and agree to able by them

(c) *I/we declare that I/we do not possess a certificate of registration for industrial dealer and that I/we shall not sell fertilizers for industrial use. (Applicable in case a person intends to obtain a wholesale dealer or retail dealer certificate of registration, excepting a State Government, a manufacturer or importer or a pool handling agency).

(d) ** I/we declare that I/we do not possess a certificate of registration for wholesale dealer or retail dealer and that I/we shall not sell fertilizers for agricultural use.(Applicable in case a person intends to obtain a industrial dealer certificate of registration, excepting a State Government, a manufacturer, importer or a pool handling agency).

Signature of the
Applicant(s)

Date
Place

Note:

(1) Where the business of selling fertilizers is intended to be carried on at more than one place, a separate application should be made for registration in respect of each such place.
(2) Where a person intends to carry on the business of selling fertilizers both in retail and wholesale, separate applications for retail and wholesale business should be made.
(3) Where a person represents or intends to represent more than one State Government, Commodity Board, Manufacturer/Importer or Wholesale dealer, separate certificate of source from each such source should be enclosed.

For use in Office of *Controller

Date of receipt
Application.

Name and designation of Officer receiving the

Import of 100% Water Soluble Fertilisers for trial purpose.

The fertigation through drip irrigation and sprinkler irrigation has attained special importance in Agriculture. In view of launching of special Horticulture Development Schemes/floriculture programme, the Ministry of Agriculture has been promoting Drip Irrigation System, sprinklers and fertigation, with a view to improve the use and efficiency of both water and fertilizers. The importers have approaching this Ministry for granting permission for importing 100% water soluble fertilizers for trail purpose to establish the efficacy in various crops under field conditions. As per the policy the Government has allowed upto 5 tonnes per grade of micronutrient or mixture of micronutrient and upto 10 tonnes per grade of NPK fertilizers including complexes/mixtures) in prescribed proforma.

<u>Format for import of Fertiliser Product for trails in India</u>

1. **Name of Organization/Company (with full address)**

2. **Name of Chemical/material/fertilizer with Composition to be imported.**

3. **Name of the country from which fertilizer/ Material to be imported**
   (1)Name of organization/company/Manufacturers
   (2)Whether manufactures is authorized to supply the material.

4. **Quantity of chemical material to be imported**

5. **Purpose/objectives**

6. **Experience in the use of material in India or any other Country.**
   To be enclosed with the brief write-up and data

7. **No. of trials and location where Trials are to be conducted.**

8. **Area to be covered under trials**

9. **Experimental programme of trials**

10. **Name of Department/University/Organisation farmers Trials to be conducted along with consent thereof.**

11. **No. of seasons crops for which Fertiliser required for trials**

12. **Name of experienced/qualified Expertise available for Handing the fertilizer experiment**

13. **Cost of imported grades chemicals and who will bear The cost of fertilizer/material for experiment**

14. **For how many seasons trials are proposed to be conducted**

15. **What is the proposal after trial Results are obtained**
16. **Remarks if any**

Signature of authority

DUPLICATE FOR OFFICE RECORD

GOVERNMENT OF INDIA
MINISTRY OF AGRICULTURE
DEPARTMENT OF AGRICULTURE & COOPERATION
NEW DELHI
***

Book No. 2 Registration No. GOI/FCO/1D/_________

Date of Issue ____________________
Valid up to _________________

CERTIFICATE OF REGISTRATION OF CARRY ON THE BUSINESS OF SELLING FERTILISERS AS AN INDUSTRIAL DEALER IN THE STATE OF ______________________________

_______________________________________ hereby granted certificate of registration to carry on the business of selling fertilizers for industrial use at the place specified below in the State of _______________________ subject to the terms and conditions specified below and to the provisions of the Fertiliser (Control) Order, 1985.

Description of the place and type of business:-

Name and style by which the Business is carried on	Location of sale depot	Location of Godown attached to sale depot	Type of Fertiliser	Source of Supply
1	2	3	4	5

Date:
Seal:

Controller

*Form as specified under Fertiliser (Control) Order), 1985

Page 2………

Terms and conditions of certificate of registration:

1. This certificate of registration shall be displayed in a prominent and conspicuous place in a part of business premises open to the public.
2. The holder of certificate shall comply with the provisions of the Fertiliser (Control) Order,1985 and the notification issued thereunder for the time being in force.
3. The certificate of registration shall come into force immediately and be valid upto _______ unless previously cancelled or suspended.
4. The holder of the certificate shall from time to time report to the controller any change in the premises of sale depot and godowns attached to sale depot.
5. xx xx xx (Not applicable for industrial dealer).
6. The industrial dealer shall submit a report to the Central Government by the 15th of April of the preceeding year showing the opening stocks as on 1st of April of the reporting year, source-wise receipts during the year, sale and closing stock of fertilizers alongwith the source-wise purchase/sale price.
7. The wholesale or the retail dealer, except where such dealer is a State Government, a manufacturer or a pool handling agency, shall not sell fertilizers for industrial use and, as the case, may be, an industrial dealer for agricultural use.

Note:

1. The original is ment for the holder of the certificate which will be delivered against his proper and adequate acknowledgement. The original certificate of registration shall be torn off at the place perforated while all duplicates shall be kept intact bound in the registration book by the Controller.
2. Where the business of selling fertilizers is intended to be carried on at more than one place, a separate registration certificate should be obtained in respect of each such place.
3. \where a person intends to carry on the business of selling fertilizers both in retail and wholesale and, as the case may be, a State Government, a manufacturer a pool handling agency, also for industrial use separate registration certificate should be obtained for retail and wholesale business ad for sale for industrial use.