SAC 301 SOIL FERTILITY , FERTILISERS AND MANURES 2+1

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“Soil fertility is the ability of the soil to supply essential plant nutrients during growth period of the plants, without toxic concentration of any nutrients”. i..e. **“the capacity of soil to supply nutrient in available form to crop”.**

1) Soil productivity

“Soil productivity is ability of soil to produce a particular crop or sequence of crops under a specified mgt system” i.e the crop producing of soil”.

All the productive soils are fertile but many of the fertile soils are unproductive, because they are subjected to drought or other unsatisfactory growth factors or management practices.

Soil Management

1. Excess elements may be toxic eg. Mo, Cu, Fe.
2. Excess of one element may cause deficiency of other elements.
    a. Excess of N may cause K deficiency
    b. Excess of K may cause Mn deficiency
    c. Excess of P may cause Zn deficiency
    d. Excess of Ca may cause Fe deficiency

Imbalanced fertigation will not help in increases the yield but it increases only the cost of production. This may lead to **Luxury consumption.**

2) LUXURY CONSUMPTION

“Luxury consumption is defined as the nutrient concentration range in which added nutrient will not increases yield but can increases nutrient concentration”.

History of development of soil fertility

Francis Bacon (1591- 1624) suggested that the principle nourishment of plants was water and the main purpose of the soil was to keep plants erect and to protect from heat and cold.

Jan Baptiste **Van Helmant** (1577 – 1644) was reported that water was sole nutrient of plants.

Rober Boyle (1627 – 1691) an England scientist confirmed the findings of Van Helmant and proved that plant synthesis salts, spirits and oil etc from H_2O.

Anthur young (1741 – 1820) an English agriculturist conducted pot experiment using Barley as a test crop under sand culture condition. He added charcoal, train oil, poultry dung, spirits of wine, oster shells and numerous other materials and he conduced that some of the materials were produced higher plant growth.

Priestly (1800) established the essentiality of O_2 for the plant growth.

J.B. Boussingault (1802-1882) French chemist conducted field experiment and maintained balance sheet. He was first scientist to conduct field experiment. He is considered as **father of field experiments.**

Justus Van Liebig (1835) suggested that

a. Most of the carbon in plants comes from the CO_2 of the atmosphere.
b. Hydrogen and O_2 comes from H_2O.
c. Alkaline metals are needed for neutralization of acids formed by plants as a result of their metabolic activities.
d. Phosphorus is necessary for seed formation.
e. Plant absorb every thing from the soil but excrete from their roots those materials that are not essential.

The field may contain some nutrient in excess, some in optimum and some in least, but the limiting factor for growth is the least available nutrient. **The law of Mn**, stated by **Liebig in 1862**, is a simple but logical guide for predicting crop response to fertilization. This law states that, "the level of plant production cannot be grater than that allowed by the most limiting of the essential plant growth factors". The contributions made by Liebig to the advancement of agriculture were monumental and he is recognized as the **father of Agricultural chemistry.**

J.B. Lawes and J. H. Gilbert (1843) established **permanent manurial experiment** at Rothemsted Agricultural experiment station at England. They conducted field experiments for twelve years and their findings were

a. Crop requires both P and K, but the composition of the plant ash is no measure of the amounts of these constituents required by the plant.
b. No legume crop require N. without this element, no growth will be obtained regardless of the quantities of P and K present. The amount of ammonium contributed by the atmosphere is insufficient for the needs of the crop.
c. Soil fertility can be maintained for some years by chemical fertilizers.
d. The beneficial effect of fallow lies in the increases in the available N compounds in the soil.

Robert Warrington England showed that the nitrification could be supported by carbon disulphide and chloroform and that it would be stopped by adding a small amount of unsterilized soil. He demonstrated that the reaction was two step phenomenon. First NH_3 being converted to nitrites and the nitrites to nitrites.

Essentiality of the elements established by

Carbon : Priestly (1800)
Nitrogen : Theodore De saussure (1804)
Ca, Mg, K, S : Carl sprengel (1839)
Phosphorus : Von Liebig (1844)
Iron (Fe) : E. Greiss (1844)
Mn : J.S. Hargue (1922)
Zn : Sommer and Lipman (1926)
Cu : Sommer, Lipman and Mc Kenny (1931)
Mo : Arnon and Stout (1939)
Na : Brownell and wood (1957)
Co : Ahamed and Evans (1959)
B : Warring ton (1923)
Cl : Broyer (1954)

Essential elements

"A mineral element is considered to plant growth and development if the element is involved in plant metabolic functions and the plant cannot complete its life cycle without the element".

Major Nutrients or Macro elements

The plant/ plants require comparatively larger quantity of nutrients for complete the life cycle they are

C, H, O, N, P, K, Ca, Mg and S.

Minor elements of Micronutrients

The plants require comparatively small or very trace quantity of nutrients for complete the life cycle.

Fe, Zn, Cu, Mn, B, Mo, Cl, Na, Va, Si, Co and Ni

Criteria of essentiality – Arnon and stout 1939.

a. The plant must be unable to grow normally or complete its life cycle in the absence of the element.
b. The element is specific and cannot be replaced by other.
c. The element plays a direct role in the metabolism of the plant.

Until the middle of 19th century, the scientist did not have experimental technique to distinguish essential and non essential elements. With the development of **"Solution Culture"** technique the scientist established the essentiality of nutrients.

SOIL FERTILITY EVALUATION

Optimum productivity of any cropping systems depends on an adequate supply of nutrients. Although one or more nutrients are commonly applied to most crops, the quantity of nutrient removed in the harvested crop is much grater than the quantity added.

The proper rate of plant nutrient is determined by knowing the nutrients requirement of the crop supply is power of the soil.

Diagnostic techniques, including identification of deficiency symptoms are helpful in determining specific nutrient stress and the quantity of nutrients needed to eliminate the stress.

Several techniques are commonly employed to asses the fertility status of a soil.

1. Nutrient deficiency symptoms of a plant.
2. Analysis of tissue from the plants growing in the soil.
3. Biological tests in which the growth of either higher plants or certain micro organism is used as measure of soil fertility.
4. Soil analysis.

Nutrient deficiency symptoms

It can be classified as

a. Complete crop failure at the seedling stage.
b. Severe **stunting** of plants.
c. Specific leaf symptoms appearing at varying times during the season.

d. Internal abnormalities such as clogged conductive tissues.
e. Delayed abnormal maturity.
f. Obvious yield differences.
g. Poor quality of crops including difference in protein, oil or starch.

Hidden hunger

"It refers to a situation in which a crop needs more of a given nutrient yet has shown no deficiency symptoms". The nutrient content is above the deficiency symptom zone but still considerably below that needed for optimum crop production.

Hidden Hunger is term used to described a plant that shows no obvious symptoms, yet the nutrient content is not sufficient to give the top profitable yield.

Seasonal effects

Nutrient shortages in the soil may be caused by abnormal weather conditions. Nutrient may be present in sufficient quantities when conditions are ideal, but in drought, excessive moisture. Unusual temperature conditions plant may not be able to obtain an adequate supply.

Nutrient uptake is generally reduced by

1. Mass flow of nutrients is reduced by decreases growth rate and transpiration.
2. Nutrient diffusion rate decreases with declining temperature and lower concentration gradient.
3. Mineralisaton of nutrients complexed with organic matter is reduced.

Plant analysis

Two types of plant analysis

1. Tissue test on fresh tissue in the field.
2. Tissue analysis performed in the laboratory.

Plant analysis are based on the premise that the amt of a given nutrient in a plant is directly related to the availability of the nutrient in soil. Since shortage of nutrient will affect the growth others may accumulate in the cell sap regardless of their supply.

Tissue test and plant analysis are made for

1. To aid in determining the nutrient supplying power of the soil.
2. To help identify deficiency symptoms and to determine nutrient shortages before they appear as symptoms.
3. To aid in determining the effect of fertility treatment on the nutrient supply in the plant.
4. To study the relationship between the nutrient status of the plant and crop performance.

Tissue test

The plant root absorbs the nutrient from the soil and these nutrients are transported to other port of the plant where they are needed. The concentration of the nutrients in the cell sap is usually a good indication of how the plant is supply at the time of testing. It is possible to anticipate certain problems of deficiency of nutrients.

1. **In general the tissue test methods employed are**
    1. The intensity of the colour developed is compared with **standards** and used as a measure of the supply of nutrient.
    2. In plant sap, the colour developing reagents were added, and the resulting colour intensity is compared with standard chart, that indicates very low, low medium and high nutrient content.

2. **Plant parts to be tested**

It is essential to test the part of the plant that will give the best indication of the nutritional status. In general, the recently matured leaf is used for testing and the immature leaf in the top of the plants are avoided.

3. **Time of testing**

In general, most critical stages for tissue testing is a bloom to the early fruiting stage.

Total analysis

Total analysis is performed on the plants or on plant parts. After sampling, the plant material is dried, ground and the nutrient content determined by digesting or ashing of the plant materials. With total analysis, the content of all descents, essential or non essential can be determined.

Critical nutrient range

Critical nutrient range is that range of nutrient concentration at a specified growth stage above which the crop is amply supplied and below which the crop is deficient.

Diagnosis and recommendations integrated system (DRIS)

DRIS is a system that identifies all the nutrimental factors limiting crop production and thus increases the chance of obtaining high crop yields by improving fertilizer recommendations.

Index value

Index value that measure how for particular nutrients in the leaf or plant are from the optimum are used in the calibration of classify yield factors.

Biological tests

It involves in the field test, strip tests and in the laboratory green house tests. The nutrients was assessed by using higher plants and micro organisms.

1. Mitscherlich pot culture method.

Mitscherlich predicted the plant nutrient reserved (native fertility) as the percentage of increases in the yield expected from the addition of a given quantity of fertilizers.

2. Jenny pot culture tests

He grouped the plants into 3 categories viz., (a) definite deficiency (b) probable deficiency and uncertain deficiency based on the percentage of yield.

3. Neubauer seedling method

It is based on the uptake of nutrient by a large no. of plants grown an a small amount of soil. The roots thoroughly penetrate the soil, exhausting the available nutrient supply within a short time. The total nutrients removed are quantified and tables are established to give the Mn value of macro and micro nutrients available for satisfactory yields of various crops.

4. Sunflower pot culture techniques for boron

Deficiency is classified as marked deficiency Moderate deficiency and not or little deficiency based upon the no of days after which boron deficiency is observed.

5. A value technique

Fried and Dean (1952) calculated the avail nutrient in the soil be using Radio active isotopes.

A value is defined as that amt of nutrients in soil, which behaves in a similar way as the applied fertilizers nutrient doses.

$$A = B\left(\frac{1 - y}{y}\right)$$

where, A = Avail soil nutrient
B = Amount of fertility nutrient applied.
Y = Fraction of the nutrients derived from the fertilizers contained in the plant.

Soil testing

Analysis of soil is essential for determining the nutrient requirement of a crop and nutrient supplying power of the soil.

Objective of soil testing

1. To provide an index of nutrient available or supply in a given soil.
2. To predict the probability of obtaining a profitable response to lime and fertilizer.
3. To provide a basis for recommendations on the amount of lime and fertilizer to apply.
4. To evaluate the fertility status of soils on a country soil area, state wise basis by the use of soil test summaries.
5. It helps to predict the amt of nutrients needed to supplement the supply in the soil.

Soil analysis

Soil sampling includes.

a. Areas of sample
b. No. of sites to sample composite
c. Depth of sampling.
d. Time of sampling.

Laboratory characteristics

Determination of p^H, soluble salts, calcium carbonate, organic carbon, available nutrients were done.

Grouping of soils in different classes based upon the soil test values. The different classes were very low, low medium, high and very high.

1) Nitrogen

The cheap source of N is the crop residues in temperate region the soil N occurs at 2.6 tonnes / ha. In acid tropical soils, the N content is 0.03-0.1 %. Rainfall is also source of N at 4.6 kg of N / ha is received ha^{-1} yr^{-1}. It is converted to NO_3 during lighting addition of organic matter and fertilizer is other major sources.

Functions of N :

a] N is an essential constituent of proteins and is present in many other compounds of great physiological importance in plant metabolism
b] N is an integral part of chlorophyll, which is primary observer of light energy needed for photosynthesis.
c] N also imparts vigorous vegetative growth and dark green colour to plants.
d] It produces early green and delay in maturity to plants
e] It governs the utilization of K, P and other elements

Deficiency of N:

1. Plants are stunted and yellow in appearance.
2. The loss of protein N from chloroplasts. In older leaves produces the yellowing or chlorosis. It appears first on the lower leaves, the upper leaves remain green, while under severe N deficiency lower leaves will turn brown and die.
3. The necrosis begins at the leaf tip and progress along the midrib until the leaf is dead.

In cauliflower	- young leaves turn pale yellow and old leaves become orange.
In coffee	- Veins becomes yellow and new leaves are very small.
Tomato	- Stem become purple and hard. Flower buds become yellow and flower dropping rate also increases

C. Excess of Nitrogen (Toxicity off nitrogen)

a. Causes excess vegetative growth, dark green leaves, lodging, maturity is delayed with increases susceptibility to pest and disease.
b. In cotton, weak fibre are resulted. In rice, lodging is common.
c. Lengthening of crop duration and narrow leaf.
d. Slender shoot, profuse vegetation, thick peel and skin will be rough and leathery in the case of citrus.
e. Excess N in coffee plant, interferes the K uptake causing imbalance between N and K.

Forms of soil nitrogen

Inorganic forms	Organic forms of soil N
1. Ammonium NH_4^+	Amide form (NH_2)
2. Nitrite NO_2^-	Plant absorbs N as both NH_4^-, NO_3^-.
3. Nitrate NO_3^-	
4. Elemental N (No)	

Losses of Nitrogen

1. Crop removal
2. Leaching (or) drainage (11-18% loss)
3. Gaseous losses as NH_4 or elemental N_2
4. Volatilization.
5. Erosion (8 – 15 kg $ha^{-1}yr^{-1}$).
6. Ammonia fixation by clays
7. Immobilization in organic materials.

N transformations in soils

a. N Mineralisation
b. Aminisation
c. Conversation of urea
d. N Immobilization.
e. N factor
f. Ammonification.
g. Nitrification
h. Denitrification
i. Organic fixation
j. Elemental N loss.
k. Nitrogen cycle.

Phosphorus

Phosphorus occurs in most plants in concentrations between 0.1 and 0.4%. Plants absorb either $H_2Po_4^-$ or $H +$ PO_4^{2-} ortho PO_4 ions Absorption of $H_2PO_4^-$ is greatest at low pH values, where as uptake of HPO_4^{2-} is greater at higher values of soil pH, plant uptake of HPO_4^- is much slower than $H_2PO_4^-$.

Functions of P

1. It has a greater role in energy storage and transfer.
2. It is a constituent of nucleic acid, phytin and phospholipids
3. It is essential for cell division and development
4. P compounds act as energy currency within plants. The most common P energy currency is that found in ADP and ATP. Transfer of the energy rich PO_4 molecules from ATP to energy requiring substances in the plant is known as **“Phosphorylation”**
5. It stimulates early root development and growth and there by helps to establish seedlings quickly.
6. It gives rapid and vigorous start to plants strengthen’s straw and decreasess lodging tendency.
7. It is essential for seed formation because larger quantities of P is found in seed and fruit-phytic acid is the principle storage from of phosphorus in seeds.
8. It increases the activity of Rhizobia and increases the formation of root nodules.

Deficiency symptoms

P is mobile in plants and when a deficiency occurs it is translocated from older tissues to the active meristematic regions.

1. It arrests metabolism resulting in reduction of total N of plants.
2. Reduced sugar content.

3. Premature leaf fall.
4. Develops necrotic area on the leaf petiole and in the fruit
5. Leaves will show characteristic bluish green colour.

Toxicity of phosphorus

a. Profuse root growth i.e. lateral and fibrous root lets.
b. It develops normal growth having green leaf colour.
c. It may cause in some cases trace elements deficiencies i.e. **Zinc and Iron.**

Soil P its origin and Nature

Soil P exists in many primary and secondary compounds. The **apatite** group of primary mineral is the original source i.e. 55% of soil P.

a) Aluminium and Iron Phosphates

In the initial stages of acid weathering Po_4 becomes increasingly bound to Fe^{3+} and Al^{3+} ions released from silicate minerals by replacing OH^- from **hydroxyl minerals** or oxygen from **oxide minerals.** $FePO_4$ and $ZnPO_4$ has been found in H_2O logged or poorly drained soils, sand and silt fraction of some soils.

Calcium phosphates

The group of compounds form an important category in the young soils and the matured soils of **neutral** to **alkaline** pH ranges. The $CaPO_4$ found either in **stable** or **metastable** state in the soil fertilizer reaction zones.

Eg. Fluorapatite - $Ca_{10}(PO_4)_3$ Fe
Carbonate apatite - $Ca_{10}(PO_4)_3$ Co_3
Dlcalcium Po_4 - Ca HPO_4 $2H_2O$
Monocalcium Po_4 - CaH_2PO_4 H_2O.

Organic phosphates

It is derived secondarily by the addition of organic matter to the soil through the growth of plants and the deposition of plant residues. The soil micro organic synthesize organic PO_4 compounds and accumulate in the soil mixed with derived from plant tissues. It constitute 20 – 30% of total soil P. The major classes of organic compounds in soils are

a. Phospholipids (0.6 – 0.9%)
b. Phospho proteins of nucleic acid (0.6 – 2.4%)
c. Phosphorylated sugar
d. Phytin and Inositol PO_4

The ideal C : N : P : S ratio in soils are

a. Calcarious 113 : 10 : 1.3 : 1.3
b. Non calcarious 147 : 10 : 2.5 : 1.4
c. Indian soils 144 : 10 : 1.4 : 1.8

Potassium

The potassium ion (K^+) is actively taken up soil solution by plant roots. The concentration of K^+ in vegetative tissue ranges from 1 to 4% on dry matter basis.

Functions of potassium

1. Essential for photosynthesis, development of chlorophyll.
2. It improves vigour of the plants to enable to with stand adverse climatic conditions.
3. Reduces lodging in cereal crops.
4. It regulates stomata opening and closing.
5. It regulates the movement of ions with in the plants and hence it is called **traffic policeman** of the plant.
6. Activation of enzymes, enzyme synthesis, peptide bonds synthesis.
7. Regulates H_2O imbalance within the plant.

Deficiency symptoms

1. Plant becomes stunted in growth with shortening of internodes and busy in appearance.
2. K deficiency in plants show reduced rate of photosynthesis.
3. Chlorosis, yellowing of leafs and leaf scarch in case of fruits trees.

Rice : The leave tips will dark brown in colour and blades will blueish green, chlorotic and necrotic are seen.

Banana : Deficiency is seen in the margin and bottom of leaves.
Grapes : Leaves are yellow with brown spots which are necrotic, brittle with uneven ripening.

Sources of K

The micas and fieldspars constitute the major K bearing mincreasesals which on weathering slowly release K to the soil.
(Muscovite and biotite) (Orthoclase and microcline)

Forms of potassium in soils

a. H_2O soluble K.
b. Readily exchangeable K.
c. Fixed K.
d. Lattice or increasest reserve K.

The different forms are in **dynamic equilibrium** with one another and represented as follows.

$$\begin{tikzcd} \text{Fixed K} \arrow[r, shift left] & \text{slow} \quad \text{Readily exchange} \quad \text{fast} \arrow[l, shift left] \arrow[r, shift left] & H_2O \text{ soluble K} \arrow[l, shift left] \\ & \text{Lattice Reserve K} \arrow[u] \arrow[ur] & \end{tikzcd}$$

H_2O soluble K

The Concentration of H_2O soluble K in soil depends on (a) type of day (b) H_2O content (c) Intensity of leaching (d) Amount of exchange K (e) Kind and concentration of other ions.

The dilution of the soil, increasess the concentration of H_2O soluble K and drying decreasess it. The uptake of K is influenced by the presence of other cations, ie Ca^{2+} and Mg^{2+} of Al^{3+} (acidic soils) and Na^{+} in salt affected soils.

The activity ratio $(Are^{K}) = \dfrac{\text{Activity of } K^{\pm}}{\sqrt{\text{activity of } Ca^{2+} \text{ and } Mg^{2+}}}$ (or)

$$= \frac{ak}{\sqrt{{}^{a}Ca - Mg}}$$

2. Exchange K

The K adsorbed on soil clay complex and replaceable with neutral salts in relatively short time. The Cl reacts with soil Ca and form Ca Cl_2 which is leached by high rainfall. Hence **K is called** as **Decalcifier**

3. Fixed K

Added K which is firmly bound by the soil and not immediately replaceable with neutral salts.

4. Lattice K or Mincreasesal K

Muscovite, biotite and K feldspar. The capacity of soils to release lattice K by weathering depends on the content of K mincreasesals and soil texture.

Potassium fixation

The important of K fixation is to regulate the supply of the soil a for the plants and protects it against loss through leaching.

In the dynamics of soil Potassium, the phenomenon of fixation of exchange K and the liberation of non exchange K play an important role. K ions are relatively small to enter the silica sheets where they are held firmly by **electrostatic forces**. The presence of K^+ ions can block the release of fixed NH_4^+ and vice visa.

Calcium

Calcium is absorbed by plants as Ca^{2+} and its concentration ranges from 0.2 to 1.0% and it is supplied through mass flow method.

Functions of calcium

1. It is immobile in plants and hence the deficiency is observed in younger leaves.
2. It is a constituent of cell wall and increases in stiffness of plants.
3. Promotes root development and growth of plants, root elongation and cell division.
4. Helps to translocate the sugar in the plants.
5. It involves chromosome stability and that it is a constituent of chromosome structure.
6. Affects translocation of CHO in plants.
7. Encourages seed production.
8. Activates enzyme phosphate and kinease.
9. Accumulated protein during respiration by mitochondria and it increases their protein content.
10. It binds DNA to protein molecules.

Deficiency of calcium

a. Young leaves of terminal buds dieback at the tip and margins.
b. Normal growth in affected.
c. Root may become short, stubby and brown.
d. Causes acidity of soil.
e. Cell may become rigid and brittle.
f. Young leaves of cereals remain folded.

Sources of soil calcium

Earth crust contains about 3.64%. The important source of calcium is **anorthite** ($Ca\ Al_2$, Si_2O_3). Generally arid region soils contain high amount of Ca regard less of texture, low rainfall and little leaching.

In arid and semiarid regions Calcite ($CaCo_3$)
Dolomite ($Ca, Mg, (Co_3)_2$)
Gypsum ($CaSo_4, 2H_2O$)

In humid regions, even the soils formed from lime stone are frequently acid in the surface layers because of the removal of Ca and other cations by leaching.

Factors affecting Ca^{2+} availability

1. Total Ca supply : Sandy acidic soils with low CEC having less Ca.
2. Soil pH : In acid soils Ca is not readily available to plants at low cane.
3. CEC : Soils having low CEC might will supply more Ca^{2+}.
4. % Ca saturation : High Ca^{2+} saturation indicates favourable pH for pt growth and microbial activity.
5. Type of soil colloid : 2 : 1 type require higher Ca saturation than 1: 1 type.
6. Ratio of Ca^{2+} to other catians : Increaseeasing the Al^{3+} cane in soil solution reduces Ca uptake in pt.

Magnesium

Magnesium is absorbed as Mg^{2+} and the concentration in crop varies between 0.1 and 0.6%. It was taken by plant by **Mass flow and diffusion.**

Functions of Mg

1. Primary constituent of chlorophyll
2. Imports dark green colour in leaves.
3. Serves as a structural components in ribosomes and stabilizing the ribosome configuration for protein synthesis.
4. Involves numbers of physiological and biochemical function.
5. Activates phosphorylating enzymes in CHO metabolism.
6. Act as a cofactor for certain enzymes other than Po_4 transfer enzyme.
7. Increases in the oil content of oil seed crops.
8. Regulates the uptake of other nutrients.

Deficiency of Magnesium

1. Interveinal chlorosis of the leaf in which only the leave veins remain green.
2. Stiff brittle, twisted leaves, wrinkled and distortion of leaves.
3. cotton –lower leaves may develop a reddish purple finally nicrotic (Redding of leaves)
4. In brassica, Chlorosis with interveinal mottling uniformly distributed in older leaves while the other vascular tissues remain green. This condition is called **"Puckering".**

Sources of soil Magnesium

It constitutes 1.93% of earth crust

Primarily mincreasesals (a) Biotite (b) Dolomite (c) Hornblende (d) olivine (e) serpentine.

Secondary mincreasesals (a) Chlorite (b) Juite (c) Montmorillonite.

In arid region subotantial amount of Mg present as **Epsomite** (Mg So_4 $7H_2O$)

Functions of Mg in the soil

1. It occurs predominately as exchange and solution mg.
2. Coarse text soil exhibits the greatest potential for Mg deficiencies.
3. Competition bet NH_4^+ and Mg^{2+} also lower the Mg^{2+} availability to crops.

Losses of Mg

It is leached by soils and it depends on the Mg content, rate of weathering, intensity of weathering and uptake of plants.

Sulphur

Sulphur is absorbed by plant roots as So_4^{2-} ions. Concentration of S in plants range between 0.1 and 0.4%.

Functions of sulphur

1. Essential for synthesis of sulphur containing aminoacids cystine, cysteine and methionine.
2. Essential for synthesis of other metabolites including Co-enzyme A., Biotin, Thiamin of vitamin B and Glutothione.
3. Synthesis of chlorophyll.
4. It is a vital part of ferredoxins i.e Fe – S – protein occurring in the chloroplasts.
5. Responsible for the characteristic smell or odor and taste of mustard, onion and Garlies. (Puncy smell)
6. Enhances the oil formation in crops (Soyabean)
7. Increaseeasing root growth.
8. Stimulate seed formation.
9. Promote nodule formation – Leguminous species.

Deficiency of sulphur

a. Stunted growth pale green to yellow colour.
b. Immobile in plants and plants symptoms start first at younger leaves.
c. Poor seed set in rapeseed.
d. Tea –Tea yellows.

Sources of sulphur

1. Amount has <0.05 ppm in the form of So_2.
2. Earth crust contains 0.06 to 0.10%.
3. Sulphur bearing mincreasesals Gypsum - $CaSo_4$ 2 H_2O.
   Epsomite - $MgSo_4$, $7H_2O$
   Mirabilite - Na_2So_4, 10 H_2O.
   Pyrite - FeS_2.
4. Silicate min contains <0.01 % S.
5. Igneous rocks 0.02 to 0.07%
   Sedimentary rocks 0.02 to 0.22%

Forms of sulphur in soil

Present both organic (90%) and Inorganic forms.

The inorganic forms are

1. Solution So_4^{2-}.
2. Adsorbed $So_4^{=}$ Readily available fraction.
3. Insoluble $So_4^{=}$
4. Reduced inorganic compounds.

Iron

Fe is absorbed by plants roots as Fe2+, Fe3+ and chelected irons. Sufficiency range of Fe in plant tissue is 50-250 ppm.

Functions of Iron

1. It helps in the synthesis of chlorophyll.
2. Structural component of porphyrin molecules like cytochromes, hematin, hemes, ferrichrome and hemoglobin. These substance are involved in oxidation-reduction reactors in respiration and photosynthesis.
3. Structural component of non hemine compounds like ferredoxins.
4. Constituent of enzyme systems Egl cytochrome oxidase, catalase, nitrogenase reaction in plants.
5. Component of flavoprotein like
   FMN = Flavin mono nucleotides
   FAD = Flavin Adinosine Dinudeotide.

Deficiency symptoms

1. Deficiency symptoms occurs in younger leaves since Fe is immobile element within plant.
2. It occurs in soils of calcareous or alkaline soils and poorly drained H_2O logged soils.
3. Younger leaves develop interveinal chlorosis with progresses rapidly over the entire leaf. Severe cases entire leaf turns yellow colour.

Sources of iron

Earth crust contains about 5%

Primary and secondary mincreasesals such as 1. Olivene, 2. Pyrite
3. Hematite, 4. Goethite, 5. Magrulite and limestone

Forms of iron (Fe cycle)

Fe occurs in Four major forms in soil.

1. Primary and secondary mincreasesal Fe
2. Adsorbed Fe
3. Organic Fe and
4. Solution Fe.

Soil solution Fe

It occurs primarily as $Fe(OH)^{+}{}_2$, Fe^{3+} concentration In solution is very low. In well drained, oxidized soils, the solution Fe^{2+} concentration is less than that of the dominant Fe^{3+} in solution. The pH dependent relationship for Fe^{3+} is described as

$$Fe\ (OH)_3\ (Soil) + 3H^+ \leftrightarrow Fe^{3+} + 3H_2O$$

For every increases in pH, Fe^{3+} concentration decreases 1000 fold. Oxidation - redn reactions, the result of change in O_2 partial pressure, exert considerable influence on the amount of soluble Fe in the soil solution. The insoluble Fe^{3+} form predominates in well drained soils, while levels of soluble Fe2+ increases significantly when soils become H_2O logged. In general, lowering Redox increases Fe^{2+} solubility, 10 fold for each unit decreases. in pH.

Over the normal pH range in soils, total solution Fe is not sufficient to meet plant requirements for Fe even in acid soils, where Fe deficiency Occur less frequently than in high pH and calcareous soils.

"Is a term derived from a Greek and meaning "Claw".

Chelates are soluble organic compounds that bond with metals such as Fe, Zn, Cu and Mn increasing their solubility and their supply to plant roots.

"Natural organic chelates in soils are products of microbial activity and degradation of soil organic matter and plant residues. Root exudates are capable complexing nutrients substantial quantities of organic completed. Fe can be cycled through crop residue and compounds of citric acid and oxalic acids have chelating properties.

MANGANESE

Mn concentration in plant ranges from 20 to 500 ppm

Functions of Mn

1. Helps in chlorophyll formation
2. Involves in photosynthesis, particularly in evolution of O_2.
3. Involves in oxidation - reduction - process in decarboxylation and hydrolysis reactions.
4. Involves in enzyme systems and various enzyme reactions in the citric acid cycle.
5. It is a substitute for Mg^{2+} in many of the phosphorylating and group transfer reactions.

Deficiency of Mn

1. Immobile in plant and def. starts in the younger leaves.
2. Interveinal chlorosis occur
   Oats - Gray specks / streaks
   Peas - Marsh spot
   Sugarbeet - speckled yellow
   Sugar cane - Pahala blight - midrib pale green and white.
3. Deficiency increasess asparatic acid and decreases glutamine
4. Increases respiration
5. Accumulation N compounds mainly as amines.

Sources of Mn

Earth crust contains 1000 ppm. Various oxides and hydroxides.
Manganite MnO (OH)
Braunite Mn_2O_3

Factors affecting Mn availability

1. Soil pH and carbonates

Liming to acid soils decreases solution and exch. Mn^{2+} due to precipitation Mn^{2+} as MnO_2.

2. Excessive H_2O and poor aeration

H_2O logging will reduce O_2 and lower redox potential will increases soluble Mn^{2+}. Poor aeration increases Mn availability.

3. Organic matter

Increases solution and exchangeable Mn.

4. Climatic factor

Increases soil temp during the growing season improves Mn uptake, because of greater plant growth and root activity.

5. Soil micro org

Deficiency caused by soil organisms oxidizing Mn^{2+} to Mn^{4+}.

Forms of Mn

i. Solution Mn^{2+}
ii. Exchange Mn^{2+}
iii. Organic bound Mn
iv. Mn Mineral

ZINC

Normal concentration in plant 25 to 150 ppm
Deficiency level is < 20 ppm
Toxic level is > 400 ppm

Zn is present in all parts of the plants. In general root contain more zinc than fruits.

Cereals : 27.8 ppm
Pulses : 34.8 ppm
Vegetables : 28.2 ppm
Fruits : 36.6 ppm

Functions of Zn

1. Essential too formation of growth harmones
2. Helps in reproduction of certain plants.
3. Stabilise rhibosomal fractions
4. Influence the activity of dehydrogenase enzymes
5. Involves in auxin metabolism like tryptophan synthetase.

Deficiency of Zn

1. Light yellow or white areas bet the veins of leaves particularly older leaves.
2. Death of tissue, discolored
3. Mal formation of fruits
4. Reduced growth hormone production.

Cotton : White bud (or) little leaf
Citrus : Mottle leaf
Potato : Fern leaf
Fruit trees : Rosette (Upnormal growth)
Paddy : Khaira
Foliar spray : 0.2 to 0.5% $ZnSO_4$.

Sources of zinc

Soil : 10-300 ppm
Igneous rock : >10 ppm
Sedimentary : > 95 ppm

Forms of soil Zn

1. Solution Zn^{2+}
2. Adsorbed Zn^{2+}
3. Organically completed Zn^{2+}

Factors affecting Zn availability

1. Soil pH : Avail of Zn decrease with increase soil pH Zn def occur in neutral and calcareous soil. At soil pH, Zn precipitates as insoluble amorphous soil Zn, which reduces Zn^{2+} in soil.

    Al and Fe oxides, OM and $CaCO_3$ increase with increasing pH.
2. Organic matter
3. Interaction with other nutrients

    SO_4 and N can increase the Zn uptake in plants.

    Higher the soil pH, poor aeration greater the Zn deficiency

COPPER

Copper is absorbed by plants as cupric ion Cu^{2+}

Normal concentration in plants 5-20 ppm.

Functions of copper

1. Essential for the synthesis of vitamin A
2. Act as a catalyst in respiration
3. Act as a "electron carrier" in enzyme which bring about oxidation reduction reactions in plants.
4. Constituent of chlorophyll.

Deficiency of copper

1. Chlorosis, withering and distortion of terminal buds.
2. Dead tissue appears along the tips and edges of leaves.
3. Multiple bud formation in the leaf axil and mal formation of leaves.
4. Guava - cracking of fruits and terminal bud die back.
5. Heavy liming, excessive application of N and P - induces Cu deficiency

Sources of copper

1. Igneous rock 10-100 ppm of Cu.
2. Sedimentary rock 4-45 ppm
3. Primary minerals contains
    1. Chalcopyrite
    2. Chalcocite
    3. Bornite
4. Sedimentary minerals

    Oxides, Carbonates, Silicates, Sulphates and Chlorides.

Forms of soil copper

1. Soil solution - ionic and completed
2. Cation exchange sites of clay and organic matter
3. Occluded and co-precipitated in soil oxide material.
4. Specific adsorption sites
5. Inorganic matter and living organisms

Factors affecting Cu availability

1. Soil texture
2. pH
3. CEE
4. Org matter content
5. Hydrous oxides

Soil texture

Sandy soils contain lower amounts of Cu than silt and clay soils.

pH

The concentration of Cu in soil solution decreases with increase in pH.

Interaction with other nutrients

Application of NPK fertilizer induce Cu deficiency

Increase N supply to crops reduce mobility of Cu in plants

High concentration of Zn, Fe and P in soil solution also can depress Cu absorption by plant roots.

BORON

B concentration in mono cotyledons and dicotyledons (20-60 ppm) varies between 6 and 18 ppm.

It is absorbed by plants as undissociated boric acid (H_3BO_3).

Functions of boron

1. New cell development in meristematic tissue.
2. Pollination, fruit / seed set.
3. Translocation of sugars, starches, N and P
4. Synthesis of proteins and amino acids.
5. Nodule formation in legumes
6. Regulation of CHO metabolism.

Deficiencies of Boron

1. Since it is immobile, deficiency Symptoms occurs in terminal bud growth.
2. Flowering and fruit development are restricted.
3. Sterility and mal formation of reproductive organs.
4. Thickened and curled leaves.
5. Discoloration, cracking or rotting of fruit, tubers or roots

Apple - Internal cracking.

Break down of internal tissue in root crops given rise to darkened areas referred to Brown heart / black heart : cotton - weeping disease.

Sources of boron

1. Non metal among the micronutrient
2. Low concentration in earth crust igneous rocks (<10 ppm)
3. Tourmaline and borosilicate contains B.

Forms of boron (Boron cycle)

B exists in 4 forms in soil.

1. Rocks and minerals.

2. Adsorbed on clay surface, Fe and Al oxides combined with O.M.
3. Boric acid (H_3BO_3) and 4 B $(OH)^-_4$ in soil solution.

MOLYBDENUM

Non metal anion absorbed as molybdate (MoO_4). It is weak acid and form complex poly anions such as phosphomdybdate. Plant contains <1 ppm Mo.

Functions of Mo

1. Essential component of enzyme NO3 reductase, which catalyses NO_3^- to NO_2^-.
2. Structural component of nitrogenase enzyme - involved in N fixation.
3. Essential for absorption and translocation of Fe in plant 6.

Deficiency of Mo

1. Inhibits flower formation
2. Imbalances various Amino Acids in plants.
3. Reduce activity of symbiotic and non symbiotic N fixation.

Cauliflower - Whip tail.

Sources of Mo

Earth crust 2 ppm : and range from 0.2 to 5 ppm.

Forms of Mo

1. Non exchangeable Mo in primary and secondary minerals.
2. Exchangeable Mo held by Fe and Al oxides.
3. Mo in soil solution
4. Organically bound Mo.

Mo in solution occurs mainly as $Mo_4^=$, $HMoO_4^-$, H_2MoO4^o.

Factors affecting Mo availability

1. Soil pH and liming

Mo availability increases with increasing pH. Liming to correct acidity will increase Mo avail. Mo avail decrease with application of acid forming fertilizer $(NH_4)_2SO_4$.

2. Reaction with Fe and Al

Strongly absorbed by Fe and Al oxides.

3. Interaction with other nutrients

Mg and P enhances Mo absorption by plants.
High level SO_4 decrease Mo absorption by plants.
Cu and Mn decrease Mo uptake by plants.
NO_3^-N encourages Mo uptake
NH_4^-N reduces Mo uptake

The beneficial effect of NO_3^- nutrition is related to the release of OH ions.

CHLORINE

Normal concentration in plant is about 0.2-2.0%. Absorbed by plants as Cl^- through roots and aerial parts.

Functions of chloride

1. Essential for biochemical reactions Osmotic cation neutralization reactors.
2. Act as a counter ion during rapid K fluxes.
3. Involves in the evaluation of O_2 in photosynthesis.
4. Creates disease resistant by increase osmotic pressure in cell sap.

Deficiency of Cl

1. Partial wilting and loss of turgidity.
2. Necrosis, leaf bronzing and reduction in growth.

Sources of Cl

i. Igneous and metamorphic rocks
ii. Soluble salts such as NaCl, $CaCl_2$ and $Mgel_2$.
iii. Earth crust 0.02-0.05%.

It is mobile with in the plant it can be rapidly recycled through soil systems.

COBALT

Normal concentration of Co in drymatter - 0.02 - 0.5 ppm.

Functions of cobalt

1. Essential for M.O. fixing atmosphere. N. It forms vit. B12 during growth and development of symbiotic M.O.
2. Improves growth, transpiration and photosynthesis.
3. Take parts in leg hemoglobin metabolism and inibonucliotide reductase.

Deficiency

1. Acidic, highly leached, sandy soils with total Co low.
2. Calcareous and peaty soils.

Factors affecting : Co avail

Soil pH : Avail increase with increase in soil acidity, H_2O logging conditions.
Liming and drainage practices - reduce co avail.
Application $CoSO_4$ rectify the deficiency.

VANADIUM

Low concentration of Vanadium is beneficial for growth of M.O.
Vanadium substitute for Mo in N fixation by Rhizobia.
Involves in Biological - oxidation reduction reactions.

Functions of vanadium

NICKEL

Nickel content in pt 0.1 - 1.0 ppm dry matter basis.
Taken by plant as Ni^{2+}
High levels of Ni may induce Zn or Fe deficiency

1. Ni - metal component of urease that catalyse reaction.

$$CO\,(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2.$$

2. Essential for N metabolism.
3. Stimulates nodule weight and yield of crops.

SODIUM

Functions

1. Essential for maintaining turgor and growth of Plants.
2. Helps oxalic acid accumulation in Plants.
3. Helps in stomatal opening and regulate NO_3^- reductase activity.

Sources of Na

Earth crust 2.8% soils
Minerals.

Forms of Na in soil

Solution, exchangeable Na and in silicate minerals.

In arid and semi arid soils Na exist in silicates, NaCl, Na_2SO_4

Na salts accumulating in poorly drained soils of wild and semi arid regions and causes soil salinity and sodicity.

Effect of Na on soil properties

Dispersing action of Na^+ on clay and organic matter reduces soil aggregation, permeability to air and H_2O, germination and root growth.

Sodium fertilizers

Sod. NO_3 : 25% Na
Rhenonia PO_4 12% NA

Abundant element. in lithosphere and absorbed as monosilicic acid.

Cereals and grass contain 0.2 - 2.0%.

Functions of silica

1. Contributes structure of cell wall.
2. Contributes drought tolerance to crops.
3. Regulates photosynthesis.
4. De activates invertase enzyme activity in sugarcane resulting grater sucrose production.
   Larger amounts of Si are accumulated in intracellular deposits known as ‘plant opals’.
5. Increased available P.
6. Responsible for plant disease resistance.

Sources of silicon

Earth crust : 27.6% Most abundant element in earth crust.
Soils 23-35%
Primary and secondary mineral and quartz - major source.
Quartz is the most common mineral in soil, comprising 90-95% of all sand and silt tractions.

Factors affecting Si availability

1. High H2O content encourages Si uptake
2. Heavy application of N decreases Si concentration
3. Liming decreases Si uptake in plants.
4. Acidification increases Si uptake
5. Fe and Al oxides, influence Uptake of Si by plants.

Si fertilizers

1. Calcium silicate slag ($CaAl_2 Si_2O_4$) - 18.21% Si
2. Calcium silicate ($CaSiO_3$) - 31% Si.
3. Sodium metasilicate $NaSiO_3$ - 23% Si.

Terminology

Straight fertilizer

Synthetically manufactured inorganic fertilizer containing one major plant nutrient exemption urea.

Eg. $(NH_4)_2 SO_4$, $NH_4 No_3$, super, Kcl, K_2So_4

Synthetically manufactured inorganic fertilizer containing two or more plant major nutrients. Each granule contain specified proportion.

Eg. Ammonphos, DAP, MAP, $KN0_3$.

Mixed fertilizer

One with contains two or more plant nutrients obtained by **manual** mixing of two or **more straight** fertilizer. Each granule will not contain specified proportion. Eg. Cotton mix, sugarcane mix, groundnut mix.

Complete Fertilizer

One which would supply all the 3 major plant nutrient element in required. proportions.

Complex Fertilizer

One which usually carries two or more of major nutrient and it is obtained by **mechanical blending** of 2 or more straight fertilizer. Each granule may contain specified proportion of nutrient.

Fertilizer Grade

Refer to Minimum guarantee of the plant nutrient in terms of total N, P_2O_5, K_2O 12: 6: 6.

Fertilizer ratio

Refers to relative % on N : P_2O_5 ; K_2O 2: 1:1.

Fertilizer formula

Refers to expression of quantity and analysis of the material in a mixed fertilizer

Acid forming fertilizer

Acid forming fertilizer is one capable of increasing acidity of the soil which is derived principally from the nitrification of ammonium salts by soil bacteria.

Base Fertilizer

Base fertilizers is one capable decreasing the acidity of the soil

Neutral fertilizer

Neutral fertilizer is one that is guranted to leave neither an acidic nor basic residue in the soil.

Clear liquid fertilizer

Clear liquid fertilizer is one in which the NPK and other materials are completely dissolved.

Production of small quantity of Nitrogenous fertilizer commenced in India (1930) $(NH_4)_2 SO_4$ as a by Product from Coke oven gas of the steel plants of Bengal and Bihar.

MFCL	Production of synthetic ammonia was started in India by Mysore chemicals and fertilizers limited near Mysore (1941). Using electrolysis of H_2O.
FACT	Fertilizers and chemicals travancore Ltd. (FACT) at Alwaye using wood as Raw material for the Production of ammonia.
HCFL	Hindustan chemicals and fertilizers Ltd. (HCFL) was floated to manage Sindri and Nangal plants.
	In 1951- 61 two more fertilizer factories were establish one at Nangal – Govt. of India.
NCJM	Another at Varanasi - New central Jute mills (NCJM) now Hari fertilizers.
FCI	Sindari and Nangal plants were taken by Govt. of India by fertilizer corporation of India during 1961. (FCO)
	Between 1961 – 71, there was a considerable growth in fertilizer Industry in the country. Five New plants in the private sector.
EID	Namely EID –party at Ennore – Madras.
East India Distilleries	
GSFC	Gujarat State Fertilizer Co ltd. (GSFC) – Baroda.
CFL	Coramandal Fertilizer ltd. (CFL) – Visakapatnam.
IEL	India explosives Ltd. (IEL) – Kanpur
SCI	Shriram Chemical Industries (SCi) – Kota.
	The **Coal based** plant at **Talcher** and Ramagungam started production of Urea in November 1980.
TACF	During 1982- 83 Tuticorin Alkali chemicals and fertilizers were commenced.

Phosphatie fertilizers

In India the first unit being EID – Parry – Ranipet in 1906.

Consumption and production of fertilizers during the period. 1971 – 72 to 1983 – 84

Year	**Nutrient**	**Consumption Jan. – Feb.**	**Production Apr. – Mar.**	**Gap. 1000 tonns**
1980 – 81	N	3678	2224	1274
	P	1151	763	388
	K	606	-	606
				2510
1981 – 82	N	4069	3143	926
	P	1322	950	372
	K	676	-	676
				1974
1982 – 83	N	4224	3430	794
	P	1436	984	452
	K	727	--	727
				1973
1983 - 84	N	5336	3485	1751
	P	1757	1055	702
	K	799	-	799
				3252

Technology / Production of Fertilizer Products

Ammonia

It is an intermediate product in the MFE of nitrogenous fertilizers. Besides ammonia finds application in the production of nitric acid, soda ash, cleaning agents. Leather tanning petroleum refining, pulp and paper industry, textiles, refrigeration rubber and synthetic resin industries, explosives, food and beverage industries.

Raw materials

(a) Atmospheric air (b) H_2O, Natural gas, naphtha fuel oil or heavy petroleum fraction, coal and coke oven gas.

Methods of Manufacture

Ammonia is a compound of N and H in the ratio of 3:1. It involves 4 steps namely.

(1) Gasification (2) Conversion of Co (3) Gas Purification and (4) Synthesis

Feed stocks for synthesis of Gas production

	Feed stock	**Process**
1.	Water	Electrolyzing
2.	Natural gas	Steam refining / Partial oxidation
3.	Naphtha	Steam refining / Partial oxidation
4.	Fuel Oil	Partial oxidation
5.	Coal	Partial oxidation
6.	Coke oven gas	Partial oxidation / reforming low temperature separation.

Electrolysis

Chemical components of H_2O is Hydrogen and oxygen. Hydrogen is mixed with required nitrogen from the air and mixed. MFL Nangal has a 300 tpd ammonia plant based electrolysis.

$$H_2O \rightarrow H_2 \, ½ \, O_2$$

$$H_2 + N \rightarrow NH_3$$

NH_3 synthesis

The purified mixture containing N_2 and H_2 in the ratio of 3:1 is reacted at a elevated temperature and pressure of the order of 500° C and 270 – 350 atm. Over a activated **iron oxide** catalyst which activates the reaction.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Schematic reaction of manufacture of NH_3 from fuel oil

Air fractionating

Fuel oil

Low sulphur Heavy stock
Heavy sulphur Heavy stock

N_2 Gasification chamber carbon – eliminated out

Flash gases Comes out
N_2 is added
Desulphurification champer
Unwanted gases are eliminated Eg.HCN elemental S is taken out.

Carbon monoxide Conversion chamber — Unwanted gases are eliminated Co_2 – 98.8% pure form can be utilized for the manufacture.

Flash gases — N_2 is added — Decarbonation champer

Liquid N wash — Fuel gas are also eliminated out.

Compressor

NH_3 synthesis — Hydrated liquid NH_3.

Propertion of ammonia

Colour less, 99.5% purity containing 82% N sp. gr. 0.617 at 15.6°C, Boil point 33.4°C

Specification for an hychous ammonia

a. ammonia % by mass Minimum 99.0
b. Moisture and residue on evaporation % by mass 1.0
c. Oil content - Nil

MFE of Nitric Acid

The raw materials required are NH_3 and air

HNo_3 is produced in NFL - Nangal
HSL - Rourala
RCF - Trombay

$(NH_4)_2 SO_4$

It is produced by (a) Recovery from coke ovens (b) Direct neutralization process (c) Gypsum process.

(a) Recovery from coke ovens

Ammonia gas is absorbed in H_2O and then converted into ammonium carbonate by absorbing Co_2. NH_4 Co_3 is reacted with gypsum to produce Ammonium So_4 and calcium Co_3.

$3H_2 + N_2 \rightarrow 2\ NH_3$
$NH_3 + H_2O \rightarrow NH_4\ OH$
$2NH_4OH + Co_2 \rightarrow (NH_4)_2\ Co_3 + H_2O$,
$(NH_4)_2CO_3 + CaSo_4\ 2\ H_2O \rightarrow (NH_4)_2\ So_4 + CaCo_3 + 2\ H_2O$.
$(NH_4)_2So_4$ is evaporated, crystallised, centrifuged and dried.

Properties

White crystalline compound having 21% N. Sp. gravity : 1.769 and Bulk density : 720 – 1040 kgm^3.

Specification given by FCO

Moisture, % wt. max = 1.0
NH_4 Cal N% by wt min = 20.6
Frequently % by wt. min = 0.025
Application of 100 kg of (NH_4) produces acidity which requires 110 kg of $CaCo_3$ by neutralized.

NH_4NO_3 – 35% N

It is produce by (a) Prilling process (b) Crystallisation process. Ammonia vapour is reacted with acquires HNo_3 in a stainless steel reactor by agitation.

$NH_3 + 2O_2 + H_2O \rightarrow H_2O + HNo_3$
$NH_3 + HNO_3 \rightarrow NH_4\,No_3$

Calcium NH_4No_3

Produced by granulating concentration NH_4No_3 solution with limestone or dolomite in a granulator.

FCO Specification

Moisture, % by wt. max = 1.0
Total N % by wt. min 25 or 26.0
NH_4 Cal N% by wt min = 12.5 or 13.0
Cal NO_3 % by wt. max = 0.5 or 0.5

NH_4Cl 26% N

$NH_3 \rightarrow NH_4Cl$.

Produced by reacting liquid NH_3 with hydrochloric acid (or) modified solvery process $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)\ CO_3$

$(NH_4)_2\ CO_3 + H_2O + CO_2 \rightarrow 2\ NH_4\ HCO_3$
$(NH_4) + CO_3 + 2\ NaCl \rightarrow NH_4\ Cl + 2\ NaH\ CO_3$.

Sodium Nitrate

It is obtained as a natural product in chile and manufacture from synthetic ammonia. The important impurities are common salt (Nacl), Glaubers salt (NA_2SO_4), Gypsum, Iodates, Borates.

In the process of MFE of $NaNo_3$ synthetically. Gaseous nitrogen obtained from coal gas is combined with it to form NH_3. Thus formed ammonia is oxidized to nitrous oxides in the presence of catalyst. The nitrous oxides are then observed in a solution of Na_2Co_3. The resulting solution is $NaNo_3$. It is evaporated and the solid material is crystallized.

General characteristics

1. Readily soluble in H_2O.
2. It is good for top and side dressing during the growth period.
3. It contains 27% sodium, it has a favourable influence of potassium economy.
4. Field crops benefited by Na application are sugar feet, cotton.
5. It may damage the structure of the soil by reducing flocculation.
6. It is a basic fertilizer 100 kg of $NaNo_3$ reduces the acidity equivalent to 29 Kg of $CaCo_3$.
7. Besides N, Natural $NaNo_3$ contains traces of micro nutrient such as Mg, Mn, B, Cu, Zn.

Other nitrogenous fertilizers

a. Calcium cynamide $CaCN_2$ = 2% N
b. Anhydrous ammonia = 82% N
c. Ammonia solution = 20 – 25% N
d. Ammonium chloride and $CaCo_3$ = 15% N
e. Ammonium Nitrate – Ammonium solution = 37 – 4% N.
f. Calcium Nitrate = 15.5%N
g. Calcium Nitrate Urea = 34% N
i. Urea formalde hyde = 38%N
j. Oxamide = 34% N

Complex fertilisers

Are those which usually carries two and more of major plant nutrients and it is obtained by **mechanical** blending of 2 or more straight fertilizer it self.

Each granule may contain specified proportion of major nutrient elements.

Ammonium sulphate nitrate 26% N.

It is a double salt of Ammonium So_4 and Ammonium No_3. It is also known as **Leuna Salt petre** or **Sulpho nitrate** in Europe. It is a combination of 62.5% $(NH_4)_2 So_4$ and 37.5% NH_3No_3 and has a nitrogen content of 26%.

Specifications of ASN

Moisture % by wt. maximum	=	1.0
Total nitrogen % by wt. minimum	=	26.0
NH_4 Cal N% by wt. minimum	=	19.25
Free acidity % by wt. maximum	=	0.15

It is acidic in nature. Application of 100 kg of ASN makes the soil acidity requires 93kg of $CaCO_3$ to neutralise

2. Ammonium Phosphate sulphate : NH_3N – 16, Total P = 20, H_2O P= 19.5

It contains mainly $(NH_4)_2$ SO_4 (60%) and ammonium Po_4(40%) with a nitrogen content of 16% and P_2O_5 content of 20% in the 16: 20 : 0 grade, 20: 20 : 0 grade – some urea is added to increases the nitrogen content.

Raw materials

NH_3, H_3 Po_4 acid and H_2So_4 acid. It is prepared by **Direct Neutralisation Process**

$H_2So_4 + H_3 Po_4 + NH_3 \rightarrow (NH_4)_2 Po_4 So_4$

FCO specification

	16: 20 : 0	**20: 20 : 0**
Moisture max.	1	1
NH_4 Cal N Min	16	18
Total Po_4 min.	20	20
H_2O soluble P_2O_5 min.	19.5	17

Ammonium Phosphates

Mono Ammoniums Phosphate $_4$(MAP) P_2O_5 =55%, Nitrogen = 11 – 12%

Raw materials :

H_3PO_4 acid and NH_4. vapourized NH_3 is injected into a reactor containing wet process H_3PO_4 acid of 45 – 52% concentration. The NH_3 : H_3Po_4 ratio is maintained at 1:1.

$NH_3 + H_3Po_4 \rightarrow NH_4 H_2 Po_4$

Process: White crystal

pH of 10% solution = 3.5 – 4.0

Bulk density kg per Cupic metre calcium = 348.98

Free flowing. Non hygroscopic material

$(NH_4)_2H_2Po_4$ **Diammanium Phosphate DAP 18 :46 : 0.** High analysis fertilizer containing 18% by weight of NH_4 – N and 46% by weight of P_2O_5 (H_2O soluble P_2O_5).

Five units mfe DAP.
GSFC - Baroda
FACT - Cochin II
MFL - Manali
IFFCO - Kandla
Spic - Tuticorin

Raw materials

1. H_3PO_4 acid of 40 – 54% P_2O_5
2. NH_3

It is produced by reacting 2 moles of ammonia and one mole of H_3PO_4.

$$2Nh_3 + H_3PO_4 \rightarrow (NH_4)_2\ HPO_4.$$

FCO Specification

Nitrogen % = 18
P_2O_5 % = 46
Bulk density Kg Per Calcium max = 993
pH of 10% solution = 7.8
Moist % by weight max = 1
Total N by % weight min. = 18
Total P_2O_5 by % weight min. = 46
H_2O soluble P_2O_5 by % weight min = 41.

Ammonium phosphate sulphate

(Ammophos) 20 : 20: 0. It is MFE by treating the mix of H_3PO_4 and H_3PO_4 andH_2So_4 with NH_3. It contains principally a mixture of amount PO_4 and Ammonium So_4. FACT manufactures this fertilizer.

Ammonium phosphate Nitrate **26 :26: 0**

It is prepared by wet process of H_3PO_4 (54% P_2O_5) and HNo_3 (60%) is neutralised with NH_3 to produce APN.

8:16: 0
15 : 15: 0

Urea ammonium Phosphates (UAP)

MFE by using urea, NH_4 and H_3Po_4 are called UAP urea and H_3Po_4 in the required proportions are reacted in the pre neutralizes. The resulting ammonium Po_4 slurry is pumped into the granulator. N content is increased by adding more NH_3 and solid urea.

	24 : 24	or	28: 28
Total N	24		28
NH_4 N	7.5		9
Citrate solution P_2O_5	24		28
H_2O Solution P_2O_5	20.4		25.2

Ammonium sulphate is manufactured by

1. Gypsum process.
2. By product of coal and steel industries

1. Gypsum process

The raw materials required are (1) Ammonia (2) Pulverised $CaSO_4$
(3) Co_2 (4) H_2O

The process consists of

1. Ammonia by the synthesis of nitrogen and Hydrogen.
2. Ammonia Co_3 by reacting Ammonia with Co_2.
3. Gypsum is reacted with a solution of $Nh_4\ Co_3$ to produce $(NH_4)_2\ SO_4$.

Reactions

1. $3\ H_2 + N_2 \rightarrow 2\ NH_3$
2. $2NH_3 + 2\ H_2O + Co_2 \rightarrow (NH_4)_2\ Co_3 + H_2O$
3. $(NH_4)_2\ Co_3 + CaSO_4 \rightarrow (NH_4)_2\ SO_4 + CaCO_3$.

By this process $(NH_4)_2\ SO_4$ is MFE in India on a large scale at Sindri (Bihar) and Always (Kerala) the production of 1 ton of NH_4SO_4 and required 1.7 four of $CaSO_4$, 0.6 tone of Coke.

2. By product of coal and steel industries

a. Coal → NH_3 (gas) → with H_2O → $(NH_4)_2\ CO_3$.
(destructive + distillation) CO_2 (wash H_2O)

b. $(NH_4)_2\ CO_3 + Ca\ (OH)_2 \rightarrow 2NH_3 + 2H_2O$ m + $CaC0_3$
(or) Wash H_2O (Slaked lime)

c. $2NH_3 + H_2\ SO_4 \rightarrow (NH_4)_2\ SO_4$

Coal contains, on an average 1% N. When coal is distilled in closed evens or reports. A portion of the nitrogen is volatilized as ammonia and ammonium salt retained the ‘Wash water’ Slaked lime is added to this to called ammonia liquid which is distilled, the ammonia produced in absorbed in H_2SO_4. Ammonia and H_2SO_4 combine to give $(NH_4)_2SO_4$.

It is quick acting fertilizer. It is absorbed in the soil colloids, clay and humus, replacing calcium. Resistant to leaching $(NH_4)_2\ SO_4$ Nitrifying NO_3
$\xrightarrow{\text{Bacteria}}$

Urea ($Co(NH_2)_2$)

This organic fertilizer is cheaper per kg of nitrogen than any other solid nitrogenous fertilizers sold in India. Urea is manufactured by reacting an hydrous ammonia and Co_2 gas under very high pressure in the presence of a suitable catalyst.

1. $2NH_3 + Co_2$ $NH_2\ COO\ NH_4$
(Ammonia) an unstable inter mediate product.

2. $NH_2\ COO\ NH_4$ $CO(NH_2)_2 + H_2O$
urea

Urea is a white crystalline salt containing 44 to 46% Nitrogen. It readily absorbs moisture firm adjust.

Specifications of urea as prescribed in the FCO are

a. Moisture % by weight maximum = 1.0
b. Total N % by weight Mn = 46.0
c. Biuret % by weight maximum = 1.5%

Urea is completely soluble in the soil solution, but it is not utilized in amide form by most of the field crops. Under field condition, it under goes hydrolysis in the presence of **increases enzyme** by micro organic and it converted into Ammonia carbonate and then microbial oxidation into ammonia and nitrate, and in there forms in absorbed by plants.

1. $CO(NH_2)_2 + 2H_2O \xrightarrow{\text{increases}} (NH_4)_2CO_3$
2. $(NH_4)_2CO_3 + 3O_2 \rightarrow 2HNO_2 + 3H_2O + CO_2$ Nitrous acid.
3. $2HNO_2 + 2O_2 \rightarrow 2HNO_3$

The conversion of urea into ammonical and nitrate forms in complete in about a week.

Urea is less **acidic** compared to $(NH_4)_2SO_4$ since application of 100 kg of urea leaves acidity which requires 80 Kg of $CaCO_3$ to neutralize.

Sodium Nitrate ($Na\ No_3$)

It is obtained as a natural product in Chile and MFE from synthetic ammonia. The important impurities are common salt (NaCl). Glauber's salt (Na_2SO_4), Gypsum, Iodates, Borates.

In the process MFE $Na\ No_3$ synthetically, Gaseous nitrogen obtained from coal gas is combined with hydrogen to form ammonia. Thus formed ammonia is oxidized to nitrogen oxides in the presence of a suitable catalyst. The nitrogen oxides are then observed in a solution of $Na_2\ CO_3$. The resulting solution of $NaNo_3$ is evaporated and the solid material is cry siding.

General characteristics

1. It is readily soluble in H_2O.
2. It is good for top and side dressing during the growth period.
3. It contains 27% Na. Na has a favourable influence on potassium economy and other phases of plant nutrition.
4. The field crops benefited by Na application are **sugar beet** and **cotton.**
5. It may damage the structure of the soil by reducing flocculation.
6. It is a basic fertilizer 100 kg of $Na\ NO_3$ reduces the acidly equivalent to 29 kg of $CaCO_3$.
7. Besides Nitrogen, Natural $NaNO_3$ contains traces of micro nutrients such as Mg, Mn, Po, Cu and Zn.

NH_4Cl Ammonium chloride

It is produced by treating Nacl with NH_3 and CO_2 to form $NaHCO_3$ and NH_4Cl. The resulting NHCl is then separated from the solution.

$NaCl + Co_2 + NH_3 + H_2O \rightarrow NaHCO_3 + NH_4Cl$.

1. It contains 26% N.
2. It is resistant to reacting loss.
3. It is more acidic compare to $(NH_4)_2SO_4$, 100 kg of Nh_4Cl produces acidity which requires 128 kg of $CaCO_3$ of neutralise.
4. It contains Chlorine, as such it acts as decalcifying fertilizer.

Calcium Ammonium Nitrate (CAN)

H_2O is electrolysed into **hydrogen and O_2.** Air is liquefied into by **Nitrogen and Oxygen.** The nitrogen and hydrogen are then composed and passed over Ammonia catalyst. A part of the Nh_4 is oxidized with oxygen enriched air in the nitric acid plant and absorbed in H_2O to give HNO_3.

The NH_3 is reacted with the HNO_3 to give NH_4 NO_3. liquor. It is mixed with limestone to form **Nitro limestone** or CAN graceless. It is dried, cooled and coated with suitable coating material to give the final fertilizer material.

Specification by FCO

1. Moist % by weight maximum : 1.0
2. Total Nitrogen % by weight maximum : 25.0
3. Ammonium % by weight maximum : 12.5

$CaCO_3$ combined with Ammonium improves the effeteness of the fertilizer.

1. The explosiveness and hygroscopicity will be reduced.
2. It is neutral in reaction.
3. It forms bigger granules capability easy application.
4. It contains 8.1% calcium (CAN).

Ammonium sulphate Nitrate (ASN)

It is a double Salt of ammonium SO_4 and ammonium NO_3. It is also known as **Leuna** salt petre or sulphonitrate in Europe. It is a combination of 62.5% ammonium SO_4 and 37.5% ammonium NO_3 and has a nitrogen content of 26%.

Specifications of ASN are prescribed FCO 1957 are

1. Moist % by weight, maximum = 1.0
2. Total ammonia and nitrate nitrogen% by weight, Mn = 26.0
3. Amount N% by weight Mn = 19.25
4. Free acidity (as NHo_3) % by weight maximum = 0.15

It is **acidic** in nature. Application of **100 kg of** ASN makes the soil acidity requires 93 kg of$CaCo_3$ to neutralize.

Ammonium Nitrate (NH_4NO_3)

It is MFE by passing NH_3 and oxygen gas with air over a platinum catalyst to firm Nitric acid. This acid is neutralized by ammonia to form Ammonium Nitrate

$NH_3 + 2O_2 \rightarrow H_2O + HNo_3$
$HNo_3 + NH_3 \rightarrow NH_4 \ NO_3$

It is highly hygroscopic and shows a marked tendency to absorb moisture from air to cake.

The following Recommendations have made to minise the explosive hazards of the salt.

1. Do not store Ammonium NO_3 any longer than is absolute necessary.
2. Keep all the bags tightly sealed until ready to use.
3. Keep all the bags indoors in a dry place.
4. Pile the tags not hyper than 6 bags.
5. Chance position of the bags once in a week.

Ammonium NO_3 is 75% and NO_3- N 25%.

It is readily soluble in H_2O. NO_3 N is readily available to plants for rapid growth and NH_4 – N. resists leaching losses.

It is acidic **in their residual effect. Application of 100 kgs of ammonium No_3 produces acidity which requires 60 kg of $CaCO_3$ to neutralize.**

Amide Fertilizer

The amide form of nitrogen for fertilizer use is available as urea ($CO(NH_2)$
Calcium cyanamide ($CaCN_2$)
These materials are carbon compounds and are technically classified as organic compounds.

Theses are readily soluble in H_2O and easily decomposed by micro organism in the soil. They are quickly changed into ammonia cal nitrogen and theneto NO_3 form.

Manufracturing of Ammonium sulphate

It contains 20 – 21% N. It is crystalline salt, soluble and soluble in H_2O.
Specification of $(NH_4)_2 SO_4$ as prescribed by FCO 1957 are

1. Moisture content by weight maximum	=	4.0
2. Ammonium Nitrogen % by weight Min	=	20.6

Nitrophosphates

Raw materials : Rock Po_4, HNo_3 and Ammonia

It is produced by acidulation of Rock PO_4 with HNO_3 acid in a series of reactions. This reactant mass contains $CaNO_3$ and H_3PO_4. The mixture can be coverted into solid granulated fertilizers by 4 methods.

$Ca_{10} (PO_4)_6 F_2 + 20 HNO_3 \rightarrow 6 H_3 PO_4 + 10 Ca (NO_3)_2 + 2HF.$

$Ca_{10}(PO_4)_6 F_2 + 20 HNO_3 + 7 (NH_4)_2 HPO_4 + 10 NH_3 \rightarrow$
$20 NH_4 NO_3 + 4 NH_4 H_2PO_4 + 9 CaHPO_4 + Ca F_2$
Ammonium nitrate MAP DCP

Sulphate recycle process

$Ca(NO_3)_2 + (NH_4)_2SO_4 \rightarrow 2NH_4NO_3 + CaSO_4$.

$CaSO_4 + (NH_4)_2CO_3 \rightarrow (NH_4)_2SO_4 + CaCO_3$.

FCO specification	**20 : 20: 0**	**15 : 15 : 15**
Moist by weight max	1.5	1.5
Total N min	20	15
Citrate soluble min	20	15
H_2O Soluble P_2O_5 min	5.4	4.0

The following recommendations have to minimize explosive hazards of the salt.

a. Do not store NH_4No_3 for longer period.
b. Keep all the bags tidely sealed until ready to use.
c. Keep all the bags indoor in a dry place.
d. Pile the bags not higher than 6 bags.
e. Change position of the bags once in a week.

NH_4 No_3 on oxidation produces 100 kg acidicity equivalent 6 kg of Ca Co_3

Slow release fertilizers

I. Nitrogen inhibitor **II. Chemically modified fertilizer**
III. Coated fertilizers.

I. Nitrogen inhibitor.

"The materials that are used to inhibit the activities of micro organism that are responsible for dentrification process".

NH_4Cal and amide form of N gets oxidized to NO_3 form by biochemical oxidation. The NO_3 can get denitrified into N_2 and N_2O due to low redox potential and get lost into atmosphere.

One of the measures taken, therefore, to avoid denitrification is to control the production of NO_3's. This can be achieved by using nitrogen inhibitors. **Some of the inhibitors are**

a. N serve – 2chloro 6 pyridine

It is toxic to nitrosomonas which oxidizes NH_4 ion to nitrate. It is applied @ 0.2 – 2% of N (0.5 Kg/ha) effective for 22 days only.

b. 2 Amino – 4chloro – 6 methyl pyridine (AM)

It is toxic to nitrosomonas bacteria when applied @ 4 – 10 ppm by mixing with the fertilizer. It is also used as coating material for solid fertilizers using oil as a binder. The effect is only **40 days.**

c. Dicyano Diamide

It is applied @ 5 – 24% on N basis to inhibit nitrification. In winter its effectiveness may go upto 5 months. Higher conc is toxic to plants.

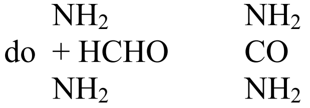
d. Thiourca

It inhibits the nitrification by lengthening the lag period prior to exponential growth of bacteria.

II. Chemically modified fertilizers

The nature of the fertilizer is changed by treating with certain chemicals to reduce its solubility.

a. Urea formal dehyde (38 – 42% N)



$$\begin{matrix} & \mathrm{NH_2} & \mathrm{NH_2} \\ \mathrm{do} & +\,\mathrm{HCHO} & \mathrm{CO} \\ & \mathrm{NH_2} & \mathrm{NH_2} \end{matrix}$$

b. Iso butyli denediurea (IBDU) – condensation product of urea and Iso butylenes in the ratio of 2:1.
c. Urea acetaldehyde = 31.1 % N (Urea + acetaldehyde)
d. Erotonylidene Urea (CDU) = 32.5 % N
e. Glycoluril = 39.4% N (Urea + Glyoxal in the presence of HCl.
f. Difurfuryledene tri Urea = 25% (Urea + Furfural)
g. Guanyl Urea = 7% N.
h. Metal am. Po_4 = 7 – 8 % N.
i. Traiazines = 32 – 66% N

III. Coated fertilizers

Fertilizer granules when coated with any suitable material will release N at slow rate.

a. Sulphur coated Urea

Urea granules are uniformly coated with a layer of sulphur. About 5% coal tar oil is mixed with urea to kill any organism that might break down the coating.

Composition of sca = Urea 80 – 85%
Sulphur 13 – 16%
Wax 2%.

Advantages It releases N at slow rate.
It supplied S which is one of the essential

Release of N depends on

a. Thickness of coating
b. Placement of fertilizer
c. Use of microbicide
d. Temperature
e. Time of Incubation and
f. Redox potential.

b. Lac coated Urea (LUC)

Shallac is well known us surface coating material. The resin required for coating is prepared by mixing **one part** of matter Shallae with **2 part** of resin at 260°C and allowed for 3ornin to complete reaction. This is cooled, solidified and powdered. Urea granules are uniformly smeared with linseed oil at 50±2°C followed by the addition of resin powders. The resin melts and gives coating over urea granules coal tar and soap stone are also added finally the granules are coated with paraffin wax to seal the fine cracks.

Composition		
	Urea 73.7 %	Resin 16.2%
	Linseed oil 3.3%	Soapstone 2.9
	Wax 3.6%	Coal tar 0.3

3. Neem coated Urea

100 kgs of urea is mixed with solution of 1 kg of coal tar in 2 litres of kerosene, 20 kgs of finally powdered neem cake is added in a drum and the contents were thoroughly mixed.

4. Urea super Granules (USG)

For controlling the release of N is to increases the size of the granule to such and extend that it affects its solubility. It is called as "Urea briquettes or super granules".

5. Gypsum coated urea

100kgs of urea + 20Kgs of gypsum. Urea is coated with gypsum of ensure slow release prop. and present losses with the added secondary nutrients calcium, sulphur.

Properties of compound fertilizers.

1. H_2O soluble
2. N and P are easily available to the plants.
3. Acid forming fertilizer.
4. Because of highly soluble in H_2O, P is converted into Fe and Al in the acid soils.
5. Key often it is used for top dressing.

		N	K_2O	P_2O_5
Eg.	KNO_3	13.5%	44%	-
	DAP	18%	-	46
	MAP	16%	-	48
	Ammophos	16%	-	20

Complex fertilizers

Characteristics of complex fertilizers

a. High analysis fertilizer
b. Uniform grain size is ensured.
c. Good physical condition for application.
d. Easy for handling.
e. Nutrients are H_2O soluble form
f. Per unit basis it is comparatively cheaper.
g. Application should be done at a single stroke.
h. Non caking and non hygroscopic fertilizers.

Mixed fertilizer

Raw materials.

Urea
$H_5 Po_4$ + Condition + filler
KCl

4 ingrediants are used for preparing mixed or complex fertilizer.

a. Nutrient element It should be straight of compound fertilizer.

b. conditions Some fertilizer are hygroscopic and calking properties. To over come this conditioners are used.

c. Neutralizing material It is added to neutralize the acidity / basically eg. Lime stone,$CaCo_3$, talc.

d. Filler material is a weight make up materials added to fertilizer materials to produce a mixture of desired grade eg. Clay , sand , saw dust.

Phosphorus

It is present as Apatatites of
1. Chlor apatite $Ca_{10} (PO_4)_6 Cl_2$
2. Fluor apatite $Ca_{10} (PO_4)_6 F_2$
3. Carbonate apatite $Ca_{10} (PO_4)_6 CO_3$
4. Hydroxy apatite $Ca_{10} (PO_4)_6 (OH)_2$

Based on solubility the phosphate fertilizer are grouped into
1. H_2O soluble P_2O_5 : SSP 16%
   : TSP 45%
2. Citrate soluble P_2O_5 : DCP 34%
   : TCP 24%
3. Acid soluble P_2O_5 : Anhydrous R. Po_4 16 – 18%
4. Both H_2O and citrate soluble P_2O_5 : Kottka Po_4 25%
   It is proponed by acidulating Rock PO_4 with H_2SO_4.

Interaction of phosphatic fertilizers with soil

Fertilizer P Plant uptake P

Dissolves in soil Very little P Stays in soil solution Pool of plant avail P H_2Po_4

Fast reaction

Reacts with oxides of Fe, Al, CO_3's etc. Contribute towards

Diffuse away

Reaction products ppt out differ in availability Plant avail P in soil

Phosphatic fertilizer – single super PO_4

Ground rock PO_4 is mixed with H_2SO_4 in a specially designed mixer, which discharge the product on a belt conveyer where the reaction is completed.

$Ca_{10} (PO_4)_2 F_2 + 7 H_2SO_4 \rightarrow 3 Ca H_4 (PO_4)_2 + 7 Ca SO_4 + 2HF$ Hydrofluorine.

The reacted mass is sent to a curing shed where the products is stored for 3 -4 weeks for curing and drying.

Properties It contains 16% H_2O soluble P_2O_5
It contains 4 % free H_3Po_4

FCO specification		**SSP**	**TSP**
Moist % by weight max	:	12.0	12.0

Free H_3PO_4 % by weight max : 4.0 3.0
H_2O soluble P_2O_5% by weight min : 16.0 42.5
16.0 Total P_2O_5 46.0

Triple super PO_4

It is produced by reacting
$Ca_{10}(PO_4)_6F_2 + 14 H_3PO_4 \rightarrow 10 Ca(H_2PO_4)_2 + 2HF$

Dicalcium Phosphate

It is prepared by reacting the ortho H_3Po_4 with Rock PO_4 or CaO.

$CaO + H_3PO_4 \rightarrow CaHPO_4 + H_2O$.

In the national lab. Pune, it was prepared on semi commercial scale by reacting R.P. with HCl.

Advantage

40 -44% total P_2O_5 of which 35 – 40% soluble in Neutral ammonium citrate solution. It has got good excellent physical condition and high P_2O_5 content, the over head costs are less.

Tricalcium phosphate

It is prepared by deflourinating the R.P and melting it with silica in a furnace (1) The materials is H_2O insoluble but citrate soluble. (2) It contains 20 – 24% citrate soluble P_2O_5. (3) It has an excellent physical condition and can be stored even openly.

Meta phosphates

(i) Calcium meta PO_4
(ii) Potassium meta PO_4

(i) Calcium meta PO_4

Phosphorus in burnt in a furnace where got and gaseous combustion products pass through the lump. R.PO_4 is packed in the upper part of the furnace. The R. PO_4 and hot vapour are chemically combined to form calcium meta PO_4 which contains 62 – 64% citrate soluble P_2O_5. high grade 'P' fertilizer used for direct soil application and for mixed fertilizer manufacture.

$Ca_{10}(PO_4)_6F_2 + 7 P_2O_5 + H_2O \rightarrow 10 Ca(PO_4)_2 + 2HF$

Potassium Meta PO_4

This material is prepared in the same manner by substituting with KCl instead of Rock PO_4. It contains 60% P_2O_5 of which 57 to 60% citrate soluble.

Bone meal

It is prepared by crushing of bones. Available in 2 form.

	Total P_2O_5	Citrate soluble	Total N
1. Raw Bone Meal	20%	8%	3
2. Steamed Bone Meal	22%	16%	Trace

Finer the size of the bone meal the availability of P_2O_5 in more. Particle side is <2.24mm is considered suitable for fertilizer. Bone meal is produced in our country is 30,000 to 35,000 MT/ Year.

After removal of gelatin. Finer materials are steamed and exported chiefly for feeding live stocks. The coarse particles are used as fertilizers.

Steamed Bone Meal or Bone PO_{4g}

Steamed Bone Meal or Bone Po_4 is white grayish material, powder, light weight.

Method of manufacturing

Young bones are boiled and steamed at high pressure for removing fats that are used for manufacturing of getatin sticks. The bones are then ground for easy handling and distribution. Daring application it should. be mixed with saw dust calcium soil because it is already light in weight.

Chemically it is $\mathbf{Ca_3(PO_4)_2}$ and it is commonly refused as **Bone phosphate of lime.** Generally young bones contain less p and more N than older bones.

Crop Response

a. The availability is superior to Rock PO_4 but slightly lower to basic slag.
b. Liming the soil depress the solubility.
c. Highly suited for home gardens and flower gardens. Since it does not have salt damage.

Basic slag

It contains 3 – 8 and P_2O_5 it can be used for neutralizing soil acidify as it contains **Calcium** as **Calcium silicate** and many trace elements.

Basic slag is mixed with powdered R. $PO_4 + H_2 SO_4$ to produce
'Pelophos' (at Rourkala) containing 17% P_2O_5 of which 16% is citrate soluble.

Mussoorie PO_4

The name **Mussoorie Phosphorus** is derived form the place of its origin **Mussoorrie** Uttar Pradesh, India (dt. Dehradun)

The P_2O_5 content ranges from – Fresh ore : 16 – 25% and weathered ore : 23- 32%

Composition of the blended material is given below

1. Phosphorus as P_2O_5 : 20 – 24 %
2. Calcium as CaO : 37 - 45%
3. Carbondioxide as CO_2 : 15 – 20 %
4. Silica as SiO_2 : 5 – 10 %
5. Magnesium as MgO : 4 – 7 %
6. Total Iron as Fe_2O_3 : 2 – 5%
7. Fluorine as F : 1 – 3%
8. Water as H_2O : 1- 3 %
9. Aluminium as Al_2O_3 : 0.5 – 1.5 %
10. Sulphur as S : 0.5 – 1.0%
11. Potassium as K_2O : 0.1 – 0.5%
12. Vanadium as Va : 250 – 500 PPM

13. Barium as Ba : 400 – 1000 PPM
14. Zinc as Zn : 100 – 150 PPM
15. Chromium as Cr : 40 – 60 PPM
16. Nickel as Ni : 25 – 150 PPM
17. Molybdenum as Mo : 5 – 75 PPM
18. Copper as Cu : 10 – 50 PPM

Classification of K fertilizers

a. K fertilizer carrying chloride - Muriate of potash KCl.
b. K fertilizer without chloride - K_2SO_4, $K NO_3$

For tobacco and potato → K_2So_4 is used to avoid Cl injury.

KCl manufacture

Raw materials → sylvinite mineral. It is mixture of KCl and Nacl. KCl is much more soluble in hot water than in cold H_2O. If solution saturated with both Nacl and Kcl, the concentration Of Nacl decreases is the temperature increases. Kcl is extracted from sylvinite utilizing solubility characteristic Kcl is removed, evaporated crystallized and powdered.

Sources of potash

1. Mineral deposits - Impt. Source of K fertilizers.
2. By product from industry
3. Synthesized K fertilizer --- KNO_3 → 44 – 45 % K_2O.

1. Mincreasesal deposits

a. H_2O soluble mincreasesals

1. Sylvinite KCl : 63 % K_2O (mix of K Cl and NaCl)
2. Carnolite $MgCl_2$ 6 H_2O : 17% K_2O (mix of K Cl and NaCl)
3. Longbeinite K_2SO_4 2 $MgSO_4$: 27% K_2O (mix of K Cl and NaCl)
4. Kyanite Kcl $MgSO_4$ 3 H_2O : 19% K_2O (mix of K Cl and NaCl)

b. Less soluble in H_2O

Poly halite K_2SO_4 $MgSO_4$ 2 $CaSO_4$ 2 H_2O : 15% K_2O

c. Insoluble in H_2O

1. Feldspar KAl Si_3 O_8
2. Mica – Biotite or muscovite
3. Glauconite K Fe SiO_6 2 H_2O.

2. Industrial Bi product

a. Flue dust from - Steel industry = 3 – 18%
- Cement industry = 3 – 13%

b. Pot. Schoentie - obtained from salt pitters
- double salt of K & Mg.
- Very good K fertilizer for acid soil.

Potassium sulphate

Dissolving longibeinite(K_2SO_4. 2 Mg SO_4) in H_2O in which concentration Solution of Kcl is added. Then K_2SO_4 is precipitated, separated and purified.

K_2SO_4 2 Mg SO_4 + 2 Kcl -- 2 K_2SO_4 2 MgCl , 2 Kcl + H_2SO_4 → K_2SO_4 + 2 Hcl.

This reaction is carried out in a special furnace consists of cast iron muffle with rotating ploughs to agitate the reaction mixture. The gaseous HCl is cooled and absorbed inH_2O.

Properties

White crystalline product contains 54% K_2O.
Sp. gravity 2.662
Melting point 1067°C.
Solubility in H_2O= 13%by wt.

Secondary nutrient

Calcium

Sources Dolomite, Calcite, Apatite, Calcium feldspar.

As a general rule, coarse textured, humid region soils formed form rocks low in calcium containing minerals are low in their content of this element. Soils that are fine textured and formed rocks with high in calcium content minerals are much higher in their content both exchange calcium and total calcium

Gypsum $CaCO_4$, $2H_2O$	:	22.3	SSP	:	19.6
Calcium nitrate	:	19.4	TSP	:	14.3

Magnesium

Sources	Earth crust	:	1.93%
	Biotite		
	Dolomite		
	Chlorite		
	Basic slag	:	3.4
	Epsom salt	:	9.6

Organic manures

Farm yard manure

“Consists of decomposed or partly decomposed mixture of dung, urine and the litter. It is a mixture of vegetative refuse from the farm and it mostly consist of the nutrient elements required by the plant.

It is very good source of manure to repliance the deficient of nutrient.

Composition of dung

75 – 80 % is made up of moisture.

20 – 25% is insoluble materials of fodder or food. Chief components of insoluble materials cd be **woody fibre, starch, fats, bile pigments, mucus**. In addition to this it also may contain **skatole and Indole** by product derived from the digestion of food material. It also contain **Fatty acids, Ca, Mg PO_4, Alkaline soap etc.**

Nutrient content of dung %

	Horse	Cattle	Buff	Sheep	Pig	Poultry
H_2O	76.5	80.0	81.0	61.9	80.7	57.0
Organic Mater	21.0	15.2	12.7	33.1	17.0	29.3
Mineral matter	3.3	3.8	5.3	4.7	3.0	5.6
N	0.47	0.30	0.26	.70	.59	1.46
P_2O_5	.38	.18	.18	.51	.46	1.17
K_2O	.30	.18	.17	.29	.43	.62
Lime (CaO)	.17	0.36	.46	.46	.07	

Poultry manure is very rich in nutrient content compare to others. Next to poultry sheep manure is fairly rich, cattle and buffaloe dung is poor in nutrient content.

Urine

It contains 96% H_2O and A% is made up of dissolved substances primarily **urea** derived from the **protein catabolism** in the **blood** and partly from **leucine and tyrosine** as a result of **tryptic digestion** in the intestine. It is also derived as a by product of disintegration in the various organs of the animal body. Other was to subs in urine in addition to urea are **uric** and **Hyppuric** acid.

Inorganic salts
a. sodium chloride – 1%.
b. Sodium hydrogen Po_4
c. Ca and Mg Po_4 } in varying proportions.
d. K and Na So_4

Nearly 50% of N content of FYM comes form **Urine.**

Composition of Urine

	Horse	Cattle	Buff	Sheep	Pig
H_2O	89.6	92.6	81.0	86.3	96.6
Organic Mater	8	4.8	-	9.3	1.5
Mineral matter	8	2.1	-	4.6	1.0
N	1.29	1.21	0.62	1.47	0.38
P_2O_5	.01	.01	Traces	0.05	.10
K_2O	1.39	1.35	1.61	1.96	.99
Lime (CaO)	.45	.01	-	.16	.01

Litter

It is used as a bedding material in foreign country. In Indian condition it refuse to rejects and waste materials. It includes straws of cereals, stalks of sunflower etc. If is used to conserve the loss of NH_3 from urine. If urine is treated with soil (or) soil is soaked with urine (or) matured straws of sorghum, Cumbu, there is a wide range of C : N ratio.

Eg. Sorghum 50 : 1

Characteristics of Farm yard manure

a. Moisture :

75% is made up of moisture. In general moisture content is 50-80% and dry matter 20-50%

b. It is low analysis manure :

one lone of FYM will supply 5 kg N, 2.5 kg P_2O_5 , 5 kg K_2O.

c. Residual effect of FYM

In FYM nutrients are present in complex form as proteins or microbial tissues. During the process of decomposition the microbial tissues are decomposed and farm a source of N. In well decomposed FYM about ½ N, K, 1/6 P readily available to first crop.

Remaining part will left in the soil for the succeeding crops. In well decomposed FYM the C:N ration is 12-15 : Partly decomposed FYM the C:N ration is 20 :. IN such case the residual effect is more for 2 or 3 succeeding crops.

d. Nutrient is unbalanced.

FYM is poor in NPK content is particularly P_2O_5. So it is considered as unbalanced. FYM is mixed with super (or) Rock PO_4 before addition not the field, P_2O_5 content can be increased.

FYM + super → Rein forked. So it is considered us complete manure. It also supplied secondary and micronutrients.

Advantages of farm yard manure

1. It is a complete manure. It supplies major, micro and trace elements.
2. It improves soil fertility.
3. It improves physical, Chemical, Biological and Properties of soils.

Green Manures

Green manure :

Growing the plants i.e. sun hemp and ploughing insitu (or) adding green matter obtained from the field.

Green leaf manure

Addition of green or plant tissues obtained from trees, herbs, shrubs pruning and unwanted weeds.

Green manure	**N**	**P_2O_5**	**K_2O**
Sunhemp	0.5	0.1	0.4
Danicha	**1.1**	**0.2**	**0.4**
Sesbania	0.7	0.1	0.6
Pelli pesera	0.7	0.2	0.4
Cluster bean	0.3	0.1	0.3
Cow pea	0.7	0.2	0.6
Green leaf manure			
Kolungi	0.7	0.1	0.4
Calotropis	0.3	0.1	0.6
Pungam	**1.2**	**0.2**	**0.8**
Glyricidia	0.8	0.1	0.7
Puvarasu	0.8	0.2	0.9

Benefit of Green manure or Green leaf manures

a. Addition of organic matter.
b. Adds Nutrient – Macro, Secondary and micro elements.
c. It improves physical condition of soil.
d. It is useful for the reclamation of problem soils.
e. It act as a cover or catch crop prevent soil erosion, conserves moisture, prevent nutrients, Leaching.
f. When leguminous GM is grown they fix the atmospheric – N by the roots and improves N status of the soil.

Characteristics of Green manure

1. It should **have rapid growth.**
   Farmers can fit the GM in the crop rotation because of shorter duration – sun hemp grown very faster than other GM crops with in 45 days it attains 4-5' ht.

2. It should be **abundant and succulent.**
   GM should be heavy yielder and succulent. It contains more of H_2O and less dry matter, decomposition will be rapid and easy.

3. It should have **ability to grow poor soils.**
   Alkaline soil will able to grow **Danicha**

Factor affecting decomposition

a. Organisms present - Bacteria, Fungi, Actinomycetes
Aerobic - Rapid decomposition
Anaerobic - Slow decomposition.

b. Temperature : Optimum temperature for decomposition is **30-35°C** under this condition the growth of organism will be more.

c. Aeration **:** Multiplication of organism is more, aerobic condition decomposition is fast.

d. Moisture : Proper decomposition and growth of organism H_2O is needed.

e. Soil factors : Physical chemical and biological clay soil decomposition is slow.

f. Nature of GM : If it is succulent - quick decomposition
Non- succulent - slow decomposition

Concentrated organics

1. Oil cakes
2. Various meals is Blood meal, Fish meal, Bone meal, Salughter house.
3. Sullage : It contains waste waters received from. Bath room and kitchen waste H_2O only.
   Sewage : Night soil with water.

Sludge : Solid portions of Night soil. It is allowed for fermentation.

Oil cakes

In India about 2m.t. of oil cakes are produced / year. Out of this only 85% is edible and 15% is non edible portion. The nutrient present in the oil cakes are insoluble in H_2O but which are readily available to the plants. (with in 10 days). The **Mahuva** cake takes 1- 1 ½ month time for perfect mineralization. The nutrient content of the oil cake.

N = 2.5 - 8.0 %
P_2O_5 = 1.0 - 3.0%
K_2O = 1.0 - 2.0%

Benefits of organic manures

1. It increases the yield of crop through the supply of nutrient.
2. It improves soil fertility through promoting the physical chemical and biological properties.
3. It corrects the deficiency of secondary and micro elements.
4. Oil cakes and various meals are equally or slightly even better than inorganic fertilizers.
5. Slow acting. It may not be completely decomposed state. So the loss of nutrients are minimized.
6. Quality of crops are improved particularly fruit and vegetable.

Factors affecting the efficient use of fertilizers and manures

I. Soil factors

a. Total nutrient content
b. Availability of nutrient
c. Soil reaction
d. Soil Erosion
e. Soil texture
f. Soil drainage
g. Soil management practices
h. Presence of impermeable layers

II. Climatic and environmental factors

a. Temperature
b. Rainfall
c. Irrigation
d. Evaporation
e. Length of growing season
f. Intensity of sunlight
g. Duration of sunlight.

III. Crop factor

1. Nutrient requirement of crops
2. Crop sequence
3. Crop adaptability to soil factors
4. Crop production practices
5. Crop residues

IV. Systems of farming

V. Fertilizer characters

Compost (or) Artificial FYM
(or) Synthetic FYM

"Dark coloured powdered material derived from decomposition of plant refuse by the microbes in the presence of little amount of soluble nitrogen".

History

During 1921, Rotham Stead, **Hutchinson and Richards** they produce the material called as **synthetic FYM** from straws. They mix the straw with soluble N, P, Ash and allow to decompose under aerobic condition. The Organism which is responsible is **"Cytophaga hutchinsoni"**. Finally they got a manure which is closely resemble to FYM which is called **Artificial or synthetic FYM.**

Principles in compost making

a. Composition of refuse material

It consists of

(a) Cellulose or Hemi cellulose	:	60 – 80%
(b) Lignin	:	15 – 20%
(c) H_2O soluble material	:	5 – 12%
(d) Protein	:	2 -3 %

b. Mechanism of the decomposition brought out by micro organic.
c. The knowledge of the metabolism of the micro organic involved.

Factors affecting the compost

1. Refuse materials - Obtained from farm, straw leaves, Garbage, street sweeping materials.
2. Suitable starter / inoculum's - Which will provided fungi or bacteria for efficient decomposition.
3. Soluble N - Which increases the bacterial activity.
4. Aeration
5. Moisture
6. Temperature

Methods of compost making

a. ADCO process	-	Hutchin son and Richards
b. Activated process	-	Fowler and Rege.
c. Indore Process	-	Howard and ward.
d. Bangalore Method	-	C.N. Acharya.
e. Coimbatore Method	-	AC & RI.

a. ADCO process

Agriculture Development Company – ADCO. They use ADCO powder for rapid decomposition. The plant refuse (or) which can not fed to cattle is used. The refuse material is spread uniformly on the floor to a thickness of 9 – 12". Then the adco powder is sprinkled @ 7% ie. 7kg/ 100 kg of material.

Adco powder contains soluble N, AM SO_4, AM – CO_3 certain amounts of P_2 K, lime, rock PO_4, Ash, KCl. This material is moistened. This can be repeated normally 6 layers. Periodically moistened for quick decomposition. It can be allowed for 3 – 4 months. It is **aerobic** and **Heap method.** For proper decomposition this material is turned or moistened and restate in the form of heap.

b. Activated process

In this method, instead of adco powder, we use some inoculum or activator to decompose the material quickly. It is a **heap system** and turning is given. The starter should be **dung urine, Urine mixed earth, sewage** and **sludge** etc. The straw is uniformly spread and moistened and added sewage sludge. This can start the reaction. This must be respected and after moistened, the level was maintained and periodical turning is given. After 3 – 4 months, the entire mass is converted into Brown colour. They called it as **Starter**. 1/3 of it is used for compost making.

Composting of sugar cane Thrash

Raw materials

1. Trash	: 100 kg / one tonne
2. Pleurotus	: 3 bottles
3. Trichoderma viridi	: 20 grams
4. Urea	: 5Kg

Final compost contains

N = 0.70 %
P_2O_5 = 0.25%
K_2O = 0.70%

→ 20 kg dugongs 60 lit H_2O
→ 100 kg S. trash
→ 100 g Trash derma
→ 100 g S. trash
→ 1 kg urea
→ 100 kg S. trash
→ 1 bottle pleurotus
→ S. Trash - 100 kg

- Composting is done in trenches. The size of the trench will be 5 x 3 m.
- S. trash was cut into small spices and spread uniformly on the floor under shade.
- As in figure.
- Like wise 10 layers may prepared and finally covered with 250 Kg of clay soil or Red soil for compacting the beds Sprinkle the H_2O once in a week.

Long term and permanent manorial experiments to monitor soil fertility, sol productivity and sustainability

PME will provide valuable information on the impact of long term adoption of nutrient management systems with varying sources, types and combinations of plant nutrient inputs on soil fertility and productivity.

The world's oldest long term agricultural field experiments were begun between 1843 and 1856 by Lawes and Gillbert at Rothamsted in England. Eight of this experiments still continue. All these experiments were started as Agronomic experiment to determine the nutrient requirements of agriculture crops.

In Tamil Nadu

Eleven PME are being conducted in various locations, viz.,

TNAU - Coimbatore
AC & RI - Madurai
AC & RI - Killikulam
ARS - Kovilapatti
ARS - Vamban
IRRI - Aduthurai
SWMRS - Thanjavur.
SRS - Cudallore.
ORS - Tindivanam
RRS - Paiyur
TRS - Yethapur

These experiment represent different soil conditions and cropping systems and are most valuable because the data generated from them provide the basis for drawing conclusions on soil sustainability under continuous maintenance with deficient nutrient input systems both under rainfed and irrigated conditions.

The old permanent manorial experiment started in Red soil, on the lines of Rothamsted manurial experiment has been in progress this institute since 1909. So far 140 crops have been raised and the results shown that the higher yields could be obtained by the combined application of NPK. The cattle manure plots maintained the soil fertility. The O.C. content increased upto 30cm depth and decreased thereafter.

In 1925, a New PME was started with the same treatments under irrigated conditions. So far 126 crop have been completed. Results revealed that application of NPK, MP and cattle manure are recorded higher yield over other treatments.

Fertilizer control order – 1957

Essential commodities Act – 1955

Objective

The main of this FCO is to regulate equitable distribution of fertilizers and making fertilizers available at fair prices to the consumers.

Essential features of the order

a. No manufacture or dealer shall sell any fertilizer at a price exceeding the max- price fixed by the central government.
b. Every manufacture or dealer shall give a cash or bill memorandum to a purchases.
c. No person shall carry on the business of selling fertilizer at any place except under and in accordance with the terms and conditions of the license granted to him under this order.
d. The State Government may appoint such number of persons as it thinks necessary to be inspectors of fertilizers.
e. No person shall export or attempt to export of any fertilizer from any state.
f. Any Inspector of fertilizers appointed under FCO can enter and search any place, Seize any fertilizer in respect of which he has reason to believe that nay prevision of this order is being controversial along with the packages, coverings.

g. Every manufacture of manure mixture and straight fertilizers shall legibly mark on the containers of such fertilizers the following particulars namely,

A. On the containers of manure mixtures

1. Register number if any, brand and name of the manure mixture.
2. The N, Total P_2O_5, H_2O Soluble P_2O_5 and K_2O contents denoted by the letters N, P(T), P(S) and K respectively.
3. Registered name of the firm and trade mark, if any.
4. The crop or crops for which the manure mixture is suitable and in the case of general mixture for all crops that expression "All crops"

B. On the containers of straight fertilizers

1. Name of the manufacture.
2. Trade mark if any
3. Name of the fertilizer
4. percentage by wt of N/P/K.
5. Gross and Net content by weight in kilograms.

8. As per this order, a dealer may retain at any time one bag or containers of each variety of fertilizer in an open unsealed condition for the purpose of retail sale.
9. Every containers shall be so sealed that the content, there of cannot be tampered with, with out breaking the seal. For fertilizer manufactured in India, if packed in bags and stitched in hand shall bear "Lead" seals and lead seals are not necessary of such bags are machine stitched.
10. The fertilizer inspector can draw samples of fertilizer for analysis in accordance with the procedure of drawal of samples and send them to state fertilizer laboratories for testing in accordance with the procedure prescribed in this order.

As per this order, there is strict specification for each and every fertilizer for their nutrient content moisture and ingredient if any.

Tolerance or permissible limits

a. Fertilizer with definite compounds like $(NH_4)_2$ SOA, Urea, super (or) potash up to 0.2 unit of the nutrient content is above 20%. 0.1 unit of the nutrient content is below 20%.
b. CAN : 0.3 unit, C. DAP, ASN, Mixture and complex = 0.5unit

The Improvement feature of this FCO is in sampling of the fertilizer so in **drawing samples, the following measures and precautions shall be observed.**

a. Samples shall not be taken at a place exposed to weather.
b. Sampling instruments shall be clean and dry when used.
c. The material being sampled, the sampling instruments and the containers for samples shall be well protected from contamination.
d. To draw a representative sample, the contents of each containers selected for sapling shall be mixed as thoroughly as possible by suitable means.
e. The sample shall be placed in suitable, clean, dry and air tight glass or other suitable containers
f. The sample containers shall be in such size that are almost completely filled by the sample.

g. Each sample containers shall be sealed air tight after filling and marked with full details of sampling, date of sampling etc.
h. Sample shall be stored in cool places.

	Lot size	**Number**	**Containers to be selected**	
1.	2 – 8	2	101 – 300	6
2.	9 – 27	3	301 – 500	7
3.	28 – 64	4	501 – 800	8
4.	65 – 100	5	801 – 1300	9
			> 1301	10

Concepts / approaches for soil test based fertilizer Recommendations

“Soil testing is a phase where the basic research in soil chemistry culminates and applied research on soil fertility begins. the combined research efforts on soil chemist and soil fertility expert, are reflected in an translated to farmers as fertilizer recommendations”.

(Goswami, 1982)

1. General / Blanket Recommendation
2. Soil Test rating and fertilizer adjustment
3. Agronomic approach
4. Critical soil test level approach (Cate and Nelson 1965)
5. Foliar diagnosis
6. Liebig’s model
7. FR for certain percentage of yield maximum
8. Deductive approach
9. Inductive approach
10. Targeted yield approach/ prescription procedure.
11. Integrated STCR correlation approach
12. Soil fertility cum soil survey.