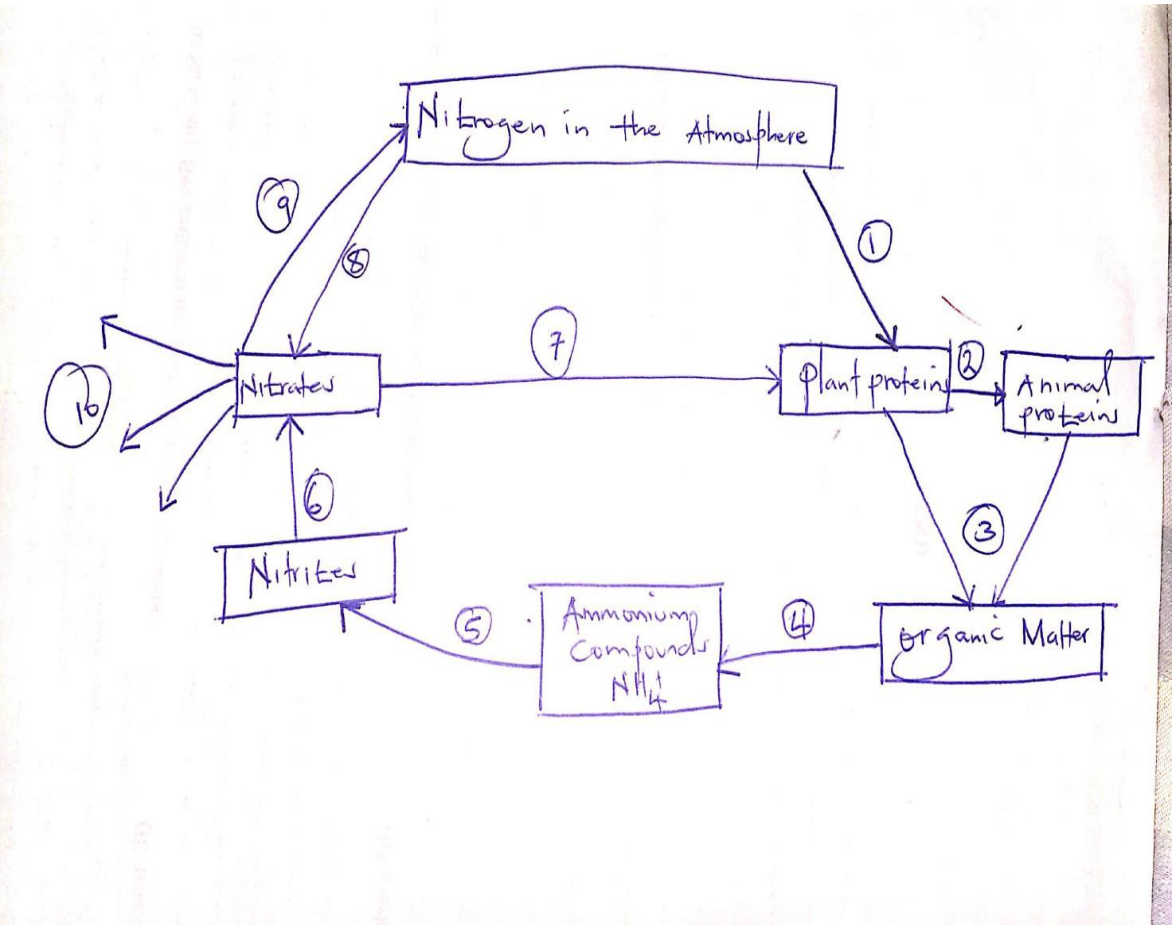
Fate /loss of nitrogen from the soil

- Crop removal during harvesting
- Soil erosion.
- Through leaching
- Burning of crop residues
- Volatilization

THE NITROGEN CYCLE



1.Symbiotic nitrogen fixation
2.Feeding by animals
3.Death and decay
4.Ammonification
5.Nitrification by Nitrosomonas
6.Nitrification by Nitrobacter
7.Absorption by plants
8.Direct nitrogen fixation by free living bacteria
9.Denitrification

10.Nitrogen loss

Symbiotic Nitrogen Fixation

This is brought about by the bacteria e.g rhizobium species in the root nodules of leguminous plants.The bacteria enter the roots through the root hairs and cause irritation to the plant and this leads to formation of galls(nodules)in which the bacteria live

The plant provides carbohydrates for energy to the bacteria which the bacteria uses to fix nitrogen into amino,Ammonia and Amide forms that are used by plants.

Symbiotic nitrogen fixation would be enhanced if the nitrogen fixing bacteria were artificially introduced to the correct plant species

Factors affecting Symbiotic nitrogen fixation

- PH; The organisms are sensitive to an excess of H^+ and die off easily in acidic conditions.
- Amount of calcium in the soil; Calcium favours formation of nodules and hence nitrogen fixation
- Amount of nitrogen in the soil; The more the nitrogen the less the nodulation and hence the less the nitrogen fixation
- Amount of moisture in the soil; Legumes tent to shed off their leaves during prolonged drought and this slows down the rate of nodulation
- Amount of carbohydrates; Sufficient carbohydrates for the bacteria enhance nitrogen fixation
- Efficient nodulation capacity by the host plant; The higher the capacity ,the greater the nodulation

Requirements for efficient symbiotic nitrogen fixation

- Correct rhizobium species
- Sufficient supply of carbohydrates to the bacteria
- Effective nodulation capacity of the host plant
- Adequate supply of moisture
- Adequate supply of nutrients especially calcium

Non symbiotic nitrogen fixation

This is brought about by the free living bacteria like azotobacter,blue green algae, clostridium etc. that are able to fix nitrogen into the soil directly

Factors/Favourable conditions for non- symbiotic nitrogen fixation

- Soil pH;Different nitrogen fixers require different pH for optimum performance e.g. blue green algae is favoured by acidity but not excessive acidity
- Level of soil nitrogen; Fixation is favoured by low levels of soil nitrogen
- Organic matter content; This is necessary to provide energy for the bacteria
- Light;Some non-symbiotic nitrogen fixers require light because they are autotrophic
- Amount of soil water; Most fixers need some moisture to suvive.A few can survive drought conditions

N.B;All the organisms that fix nitrogen later die off and decompose and release the nitrogen in their bodies into the soil for subsequent use by the plants

MINERALIZATION OF ORGANIC MATTER

The term mineralization describes a whole series of biochemical reactions in which organic matter is decomposed to release simple inorganic ions i.e. Ammonium ions, nitrites and nitrates. It involves the following processes;

Aminization; This is the conversion of more complex proteins to amino acid groups.

Ammonification; This is the conversion of amino acids into ammonium ions.

The fate of ammonium ions in the soil

- They may be converted into nitrites and later nitrates which are utilized by the plants
- They may be absorbed directly by higher plants especially low land rice
- They may be utilized by heterotrophic organisms into further decomposing of organic matter
- May be fixed in a biologically unavailable form by some clay minerals
- May be utilized by microorganisms to build their tissues(immobilization)

NITRIFICATION

This is the biological oxidation of ammonia to nitrates. It is a two phase process which involves conversion of ammonia to nitrites by a group of autotrophic bacteria called nitrosomonas (phase 1).The nitrites are then oxidized to nitrates by a second group of bacteria called nitrobacter (phase2)

N.B;It is very rare to find significant amounts of nitrites in the soil because under normal conditions the second phase follows closely after the first phase so that there is a reasonable accumulation of nitrates. This is desirable because a high nitrite concentration is toxic to plants.

Factors affecting the rate of nitrification

- Aeration; Nitrification is an oxidative process and hence increase in aeration increases the rate of nitrification
- C:N Ratio; An optimum C:N ratio is required for optimum nitrification and mineralization of organic matter by microorganisms
- Temperature; Increase in temperature increases the rate of nitrification.
- Exchangeable bases;Abundance of exchangeable bases like Ca^{2+}increases the rate of nitrification
- Soil moisture content; The rate of nitrification is highest in soils that are continuously moist and low in sols that undergo cycles of wetting and drying

The fate of nitrate nitrogen/Loss of nitrogen

- Leaching
- Immobilization
- Denitrification
- Volatilization
- Crop removal
  Etc.

PHOSPHOROUS

USES

- Encourages root formation and development
- It is necessary for the formation of fruits and seeds.
- It is needed for cell division and in the production of fats and proteins.
- It helps to break down carbohydrates during respiration.
- It gives resistance to the plants against certain diseases.
- It improves crop quality especially in vegetables.
- It is needed during seed germination flowering, seeding and fruiting of crops.
- It prevents lodging by strengthening stems of crops especially in cereals.

Sources of phosphorous in the soil

- From decomposition of organic matter
- Artificial fertilizers

- From phosphorous containing rocks e.g. rock phosphate

DEFICIENCY SYMPTOMS OF PHOSPHOROUS

- ✓ Purple colouration of the leaves especially along the leaf margins e.g.in maize.
- ✓ Low yields of grain, fruit and root crops.
- ✓ Slow growth rate resulting in late maturing of the crop.
- ✓ Poor branching in roots and stems.
- ✓ The axillary buds fail to grow/become dormant
- ✓ The leaves and fruits may develop dead patches

FACTORS AFFECTING THE AVAILABILITY OF PHOSPHOROUS TO PLANTS

- Soil PH;Phosphorous is available at a PH of 6-7 and not available at extremes
- Availability of soluble iron, Manganese and aluminium;These react with phosphates making them insoluble and consequently unavailable for plant uptake
- Presence of calcium and calcium minerals; Calcium minerals cause precipitation of phosphates in alkaline soils e.g. if a soil contains calcium carbonate, The available phosphates will react with both the calcium ions and its carbonates forming insoluble compounds
- Amount and decomposition of organic matter; Organic matter contains phospholipids that supply phosphorous to the soil
- Activities of microorganisms; Rapid decomposition of organic matter and high microbial populations results into a temporary tying up of inorganic phosphates in microbial tissues. Humus and lignin also help to release phosphorous after been fixed as basic ion phosphate

- Types of silicate clays present in the soil; Some silicate clays fix more phosphorous than others and therefore make it unavailable

POTASSIUM

The potassium content of soils varies widely and is dependent on the parent material.

Compared with other nutrients, the amount of potassium in soils are usually high especially in newly opened soils. Potassium is a sparingly soluble macronutrient.

IMPORTANCE OF POTASSIUM

- It is needed in the formation and transfer of carbohydrates during photosynthesis in plants.
- It increases resistance to certain diseases.
- It is essential for chlorophyll formation
- It is needed for Nitrogen metabolism and protein synthesis.
- It encourages root growth and development.
- It reduces lodging in plants by strengthening the cellulose in the cell walls.
- It controls the opening and closing of stomata and therefore water loss.

Deficiency Symptoms of potassium

- Retarded/Stunted growth
- Plants are easily attacked by disease / susceptible to diseases.
- Leave dry out at the edges.
- Leave may curl at edges and develop spots.
- Premature loss of leaves.
- Stems and branches of plants are weakened and after fall off before maturity is reached.

- Roots and tubers of some crops e.g. yams, carrots and sweet potatoes will develop poorly.

Sources of phosphorous

- crop residues

Cereal residue may be left /incorporated into the soil or burned.Bush burning leads to the accumulation of potassium on the soil surface.

- Artificial fertilizers

Farm yard manure adds potassium to the soil although it is mainly rich in Nitrogen – Artificial (in organic fertilizers) such as muriate of potash supplies potassium in the soil.

Loss of potassium from the soil

- Leaching. Especially in areas where there is a lot of rain.
- Crop removal. More potassium is taken up by plants than any other nutrient except Nitrogen. This is because plants generally take up more soluble potassium than what they actually need as longer as it is available.

The excess uptake which often does not lead to any increase in yield is termed as luxury consumption.

For this reason and because of leaching, potassium fertilizers often have low residual effects especially in course textured soils.

MAGNESIUM

Uses

- Helps in translocation of carbohydrates and proteins
- It influences seedling formation
- It helps to make cell walls stronger thus reduces lodging of plants

- It is a constituent of the chlorophyll molecule
- It helps in activation of enzymes

Deficiency symptoms

- Interveinal chlorosis
- In maize, stripes appear on the leaves
- Stunted growth
- In some crops e.g. cotton, the leaves on the lower surface may develop a reddish purple colour
- The leaf tissues become uniformly pale yellow and then turn to brown and finally die
- The leaves get scorched from the margin inwards

SULPHUR

It is very important in legumes which require high quantities with in thin tissues. In some tropical soils, it is normally deficient due to bush burning which causes volatilization

Uses of sulphur

- It plays a major role in the synthesis of lipids and proteins e.g.in groundnuts
- It helps to activate respiration of acetyl co-enzyme A enzymes in plants
- It is a component of the cell sap(cytoplasm)
- Essential in formation of some vitamins e.g. B-complex

Deficiency symptoms

- Uniform yellowing of leaves
- Slow growth of roots which may lead to lack of nodules in legumes
- Delayed maturity of fruits and seeds in some plants

- Development of a reddish colour on the underside of the leaves e.g. in cabbages

CALCIUM

Uses of calcium

- Strengthening of plant stems
- Essential in synthesis of plant proteins
- It raises soil PH thereby providing ideal conditions for nitrifying bacteria
- It promotes availability of Mg and K to plants
- Helps in the formation of middle lamella of leaves and strengthening of stems

Deficiency symptoms

- Poor growth and development of terminal buds
- Premature drying of leaves
- Weak stems
- Curling of leaves

IRON

It is very abundant in tropical soils.In very acidic solution,Iron becomes more soluble and available but in alkaline soils it is less available especially in calcerous soils.

Poorly aerated soils have very low levels of iron as its presence is affected by excess Mn,Cu and Zinc

Uses of iron

- It is a part of the chlorophyll molecule
- It helps to activate respiratory enzymes to a smaller extent
- It is involved in metabolic functions such as photosynthesis

Deficiency symptoms of iron

The deficiency symptoms of iron show up first in young leaves. The young leaves develop interveinal chlorosis which progresses rapidly over the entire leaf. This may eventually make the leaves to turn to white colour especially under severe cases of iron deficiency

ZINC

It is important during chlorophyll synthesis, Stem elongation or meristematic growth and normal root development.

Deficiency symptoms

- Light green yellow of white area between the veins of leaves particularly the older low leaves
- Shortening of stem internodes resulting in a rosette appearance of leaves
- White bud formation/Young leaves are almost without chlorophyll

FERTILIZERS AND MANURES

These are substances which are either organic or inorganic that add fertility to the soil once applied.

There are two types of manures /fertilizers i.e. organic manures and inorganic manures.

Inorganic manures/fertilizers are chemical substances which are manufactured artificially to supply the chemical elements required for growth and reproduction of the plant.

Characteristics of a good fertilizer

- Easy to apply
- Easy to handle and store
- Should supply the required plant nutrients to the soil
- Should be affordable

- Should not be toxic

ORGANIC MANURES

These are substances derived from plants or animals products/remains that will add fertility to the soil once applied.

Examples of organic manures:-

Farm yard manure
Green manure
Compost manure
Organic mulches

Importance of organic manures:

- They increase nitrogen content in soils after decomposition
- They increase the availability of plant nutrients like potassium, calcium, magnesium, and phosphorus.
- They increase the humus content in the soil after their decomposition.
- They improve the soil structure more especially in sandy soils.
- It increases the population of microbes in the soil by acting as food for such living organisms.
- They buffer the pH of the soil

Advantages of using organic fertilizers

- They supply a variety of plant nutrients
- They are cheaper to purchase
- They have a long lasting effect in the soil
- They do not require special skills to apply
- They are readily available in rural areas

Disadvantages of organic fertilizers

- They require more storage space
- They are bulky making transportation to the field difficult
- Exposure to elements of weather may cause a severe loss of nutrients
- Crop residues may transfer pests and diseases to the field
- They release nutrients slowly
- They may be a health hazard to humans and animals if not properly treated before use

Characteristics of organic manures

i. They are derived from plant and animal materials

ii. Contain much lower amounts of plant nutrients
iii. They improve soil structure
iv. They stimulate the rate of microbial activities
v. They are not leached easily due their low solubility in water
vi. Have no residual effects on crops and soil organisms

COMPOST MANURE:

This is a mixture of decomposed crop remains, vegetable matter, weeds and kitchen refuse.

Advantages of compost manure

- It really releases nutrients for plant growth.
- It promotes the conservation of soil moisture by lowering the rate of evaporation of water from the soil.
- Fully mature compost manure is black therefore helps in absorbing the sun's heat.
- It improves on soil structure more especially in sandy soils.
- It promotes the activity of microbes in the soil by providing food for them.
- It enhances the creation of neutral reaction in the soil.

Limitations of compost (disadvantages)

- If used immediately after making, it can heat up and burn crop roots.
- It requires a lot of Labour to prepare it.
- Big volumes of compost are needed to be applied in order to obtain the required nutrients.
- There should be a good source of composting materials in order for a framer to make enough which is not always easy.
- It requires large volumes of water during processing to keep the temperatures at optimum.

METHODS OF COMPOSTING

There are two main methods i.e. Heap method and pit method.

PIT METHOD/INDORE METHOD

This is when composting is done in pits dug in the ground. It is mainly applied in areas with low rainfall.

Procedure of making compost

i. Pits measuring up to 180cm in length, 120cm width and 60cm in depth are dug. Materials are arranged in the pit as follows;

ii. Dry hedge cuttings/ maize stalks are placed at the bottom of the pit to form a foundation and promote proper air circulation

iii. Fresh grasses, leaves and kitchen refuse

iv. Some FYM is added to provide microorganisms that breakdown the fresh materials

v. A layer of wood ash or artificial fertilizers is added to improve on the nutrient content

vi. Top soil is added to add microorganisms to the manure

vii. If the pit is not full, The order above is repeated until the pit is full

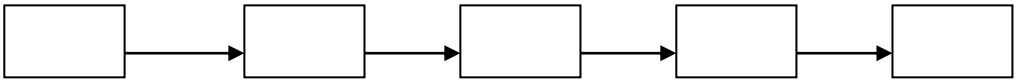
viii. Put plant leaves at the top of the pit to facilitate proper air circulation

ix. Add about 0.5 kg of ammonium Sulphate at any 0.3m height to increase nitrogen content of the compost manure.

x. Place a stick long enough to reach to reach the bottom to monitor the temperatures

xi. Sprinkle water to the pit when the temperatures are high to maintain it at optimum

xii. Turning of the material in pits should be done every after 2 to 3 weeks to enhance complete decomposition as follows;



xiii. Materials in pit A are put in pit B and pit A filled with fresh materials after 3-4 weeks

xiv. After 2 to 3 weeks materials in B are transferred to pit C and replaced with that in pit A

xv. Materials are changed every after 2 to 3 weeks in the order until there is complete decomposition
xvi. This type of sequence ensures continuous supply of manure to the garden

Precautions to take when preparing compost manure/Conditions

i. Make stacks/ heaps that are neither too small nor too big to avoid incomplete decomposition
ii. Ensure free air supply to the compost container for proper decomposition
iii. Avoid putting sticks and plastics in compost materials since they reduce quality
iv. Sprinkle enough water to maintain temperature good for proper decomposition
v. Occasionally turn the materials to ensure proper decomposition
vi. Add thin layers of farm yard manure to improve the quality of compost manure
vii. Do not trap flies in compost material during composting since it may lower quality
viii. Place compost pit or heaps in areas sheltered from sun's heat and wind.

Signs/Characteristics of ready compost manure

- The materials reduce in volume
- The temperature of the compost reduces
- The materials develop a sharp smell
- The materials easily break into pieces
- Fungi grows on the materials

Factors affecting the quality of compost manure

- Degree of wetting; Adequate wetting ensure speedy decomposition
- Degree of turning; The better the turning, the better the decomposition uniformity
- Amount of additives added; These increase the nutrient content hence better quality compost e.g. ash, fertilizers
- Degree of rotting
- Degree of protection from the sun
- Plant materials used

GREEN MANURE

This is the manure made by incorporating green and vigorously growing plants into the soil.

Characteristics of a good green manure plant

- It should be able to grow very fast so as to meet the required purpose in time.
- It should have high nitrogen content.
- It should be leafy or highly vegetative.
- It should be able to rot rapidly and provide manure.
- It should be disease and pest free.
- It should be easy to plough into the soil.

Advantages of green manure

- It supplies Organic matter to the soil which can improve soil structure.
- It adds nitrogen to the soil especially when legumes are used.
- It stimulates bio-chemical activities in the soil
- It assists in conserving and making available plant nutrients.
- It increases yields more especially in maize, by 20% -70%.

Limitations of using green manure

- Potential crops for green manure are food crops therefore its difficult to convince farmers to practice it that way.
- Machinery is needed to incorporate the plant into the soil which may not be readily available.
- Old plants with high fiber content are very difficult to plough into the soil.
- If the crops are left to grow until they are hard and fibrous, they may not decompose easily.

FARM YARD MANURE (MUCK, LIVESTOCK MANURE)

This is manure consisting of fermented dung and urine of animals mixed with rotten vegetable matter/animal beddings

Importance of farm yard manure

- It adds large quantities of organic matter to the soil.
- It provides the soil with essential nutrients like NPK (Nitrogen, Phosphorus & Potassium).
- It can be used to improve the quality of other organic manures such as compost.

Preparation of farm yard manure

- Place dry litter in the animals' pen to act as bedding
- Turn the litter as animals defecate or urinate on it
- Select a flat place with a concrete floor outside the pen
- Remove the dirty litter from the pen and place it on the concrete floor
- Raise a shade over the litter collected from the pen to protect it from rain and sun shine
- Allow the contents to decompose completely while under shade
- Coat the content with a thin layer of top soil to reduce loss of nitrogen
- After six weeks the manure is ready for use

N.B Farm yard manure should be prepared under cover to avoid losses of nitrogen and soluble mineral nutrients.

Factors affecting the quality of farm yard manure:-

1. The type of animals that provides dung; Fattening animals produce dung rich in nutrients than that of lactating animals which extract a lot of phosphorous from the feeds. Also non-ruminants produce better quality manure than ruminants
2. Type of food the animal eats; Feeds that are rich proteins and minerals tend to produce better quality dung for manure.
3. The type of beddings (litter) used by the animals; Cereal straw has a higher capacity of absorbing moisture therefore can make a better raw-material for manure.
4. Method of storage: Manure heaps should be sheltered from direct sunshine and rain since rain leaches away nutrients.
5. Length of time given for complete decomposition; The more time given for complete decomposition, the higher the quality of the manure.
6. Age of the animal; Old animals produce better quality manure than young animals

INORGANIC FERTILIZERS

These are chemical substances which are manufactured artificially to supply the chemical elements required for growth of plants.

TYPES OF INORGANIC MANURES

There are two main types of inorganic fertilizers

i. Straight fertilizers
ii. Mixed /Compound fertilizers.

Straight fertilizers

These supply only one of the primary macro nutrients (nitrogen, phosphorus and potassium) e.g. urea, single super phosphate, double super phosphate, Sulphate of ammonia, calcium-ammonium nitrate and ammonium nitrate.

Mixed/ compound fertilizers

These contain at least two of the primary macro-nutrients (elements) of Nitrogen, Phosphorous and Potassium (NPK). Examples of such fertilizers are N.P.K., Di-ammonium phosphate etc.

Advantages of Compound Fertilizers

- The mixture is usually dried into fine and well-mixed granules which can be applied by hand and through fertilizer drill.
- The mixture is stable and does not cake up to form lumps
- They contain all the major plant nutrients in right proportions.
- They save the farmer's labour of mixing fertilizers during application.

Disadvantages (Limitations)

They are slightly more expensive than straight manures.

They may be unsuitable for most of the soils which lack only one nutrient.

Fertilizer Efficiency

This refers to the percentage of the added fertilizers that is actually used by the plants

Factors affecting fertilizer efficiency

- Soil properties e.g. pH,Structure
- Time of application
- Soil moisture content
- Weed control
- Age of the crop

- Type of crop
- Ambient temperature

Ways of improving fertilizer efficiency

- Testing of the soil before applying fertilizers
- Use of slow release fertilizers to avoid nutrient losses
- Proper timing of application
- Application of fertilizers together with irrigation water
- Mulching to minimize water runoff
- Ensuring a correct plant population in the field
- Applying only the recommended fertilizers

Fertilizer Grade

This refers to the guaranteed minimum analysis in whole numbers of the percentage of nitrogen, phosphorous and potassium in a fertilizer material

Factors influencing (determining) the use of manures/fertilizers by farmers:

- Soil analysis: This is important because it expresses the need and type of fertilizers
- The types of fertilizers available; Different crops require specific nutrients and therefore the fertilizers available in shops should meet the above.
- Price of a fertilizer, increases use of fertilizers by farmers is determined by the prices and the expected profits after use.
- Management; The farmer's follow-up of the right application method and period of application affects the results achieved after use.
- Knowledge and skills of the farmer; Farmers more informed about fertilizers can use more of it
- Crop value; growing low value crops may not encourage the use of fertilizers since the cost may be higher than the yield expected
-

Principles of fertilizer application

- Use the right form and amount of fertilizers because different crops respond differently to different forms and amounts of fertilizers

- Apply the fertilizer at the right time because the nutrient requirement for the plants is not constant over the growing period. Also the nutrients are not static after application e.g. Others may be fixed, leached or even volatilized
- Apply the fertilizer at the right place. This is because the nutrients are mobile and also suffer displacement. The placement should also allow movement of nutrients through the soil to the rooting zones

Methods of inorganic fertilizer application

- Broadcasting ,fertilizers are randomly scattered by hand over the field
- Drilling , fertilizers are placed in the soil as near the seed as possible at the time of planting
- Top dressing , fertilizers are placed at the soil surface after the crop has established
- Side dressing ,fertilizer placed on the side of the plant
- Band application., fertilizer is placed by hand along the crop rows a few centimeters from a crop plant
- Plough sole method ,fertilizer is placed in the furrow at ploughing time
- Ring placement, fertilizer is placed in a ring form around the plant
- Foliar application, fertilizer is sprayed on the leaves of crops
- Fertigation, fertilizers mixed with irrigation water and applied together
- Injection method, fertilizer is directly injected into the plant

Factors that influence the method of fertilizer application

- Weather conditions; In hot weather nitrogenous fertilizers should not be applied on the soil surface since they are easily volatilized
- Toxicity of the fertilizer; The toxic fertilizers should not be applied close to the seedlings because they can easily scorch them
- Stage of development of the crop; Fertilizers intended to be utilized by young plants are placed close to the plant since their roots are less widespread to utilize he nutrients in the fertilizer
- Mobility of the fertilizer; Nitrogenous fertilizers may be applied by broadcasting since their nutrients are mobile in the soil
- Ease of fixation;Phosphatic fertilizers are applied by band method in view of the fact that they are easily fixed in soil colloids like clay and humus

Factors that affect response of crops to fertilizers

- Amount of fertilizer applied .too much/little affect crop growth
- Fertility level of the soil. The crop will not use the fertilizer effectively if fertilizers supplied in the soil is already fertile
- Soil moisture; the response to fertilizer is high in the soil with adequate moisture
- Type of soil ; the crop may not benefit much from fertilizers in more porous soil
- Type of crop ;crops respond differently to different fertilizers
- Weed infestation ;weeds compete with crops for nutrients
- Leading to poor response of the fertilizers applied
- Plant population; optimum plant population ensures that plants get adequate nutrients
- Stage of plant growth ;if a fertilizer is applied at the correct stage of plant growth response will be good
- Nature /form of fertilizer ;crops respond faster to fertilizer which is more solid
- Type /kind of fertilizer ;crops respond differently to different types of fertilizers
- Method of placement; crops will respond well to fertilizers applied correctly
- Pests and diseases; affected plants will respond poorly to fertilizer applied
- Soil pH ; suitable soil pH encourages good response to fertilizers applied