

AGRICULTURE NOTES

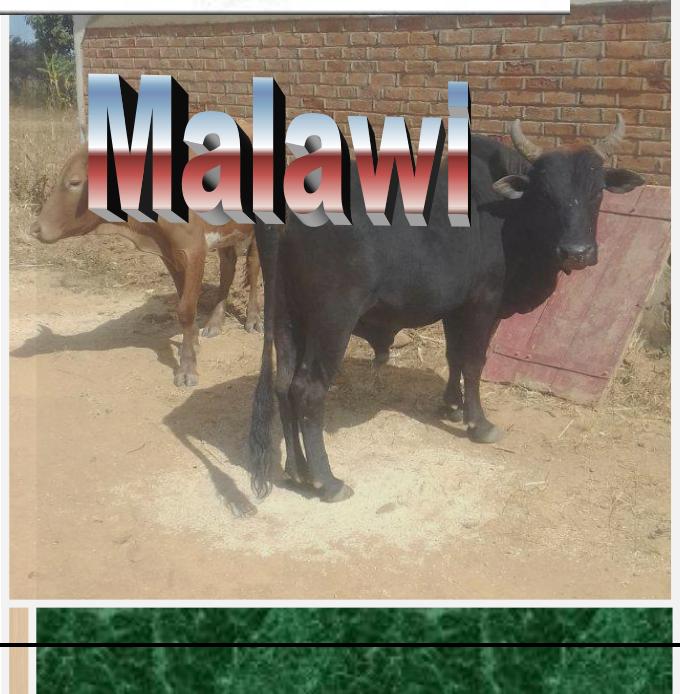
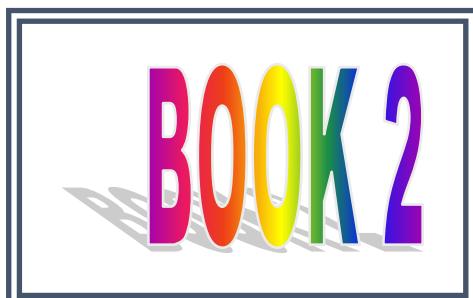
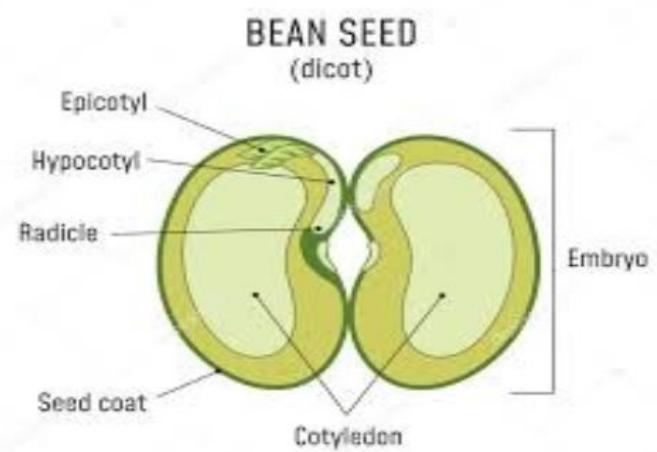
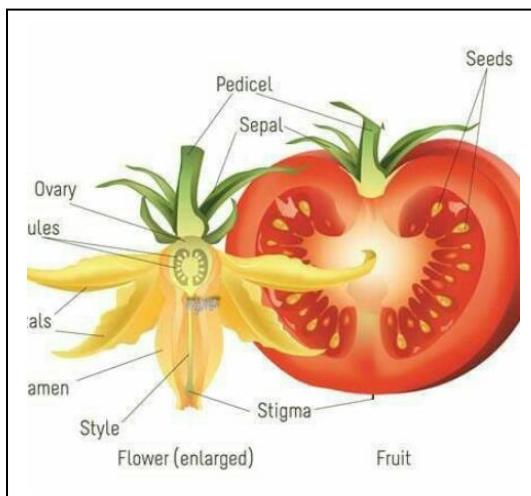


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Topic 1: Agriculture and the Environment

UNIT 1: Soil composition

Soil is made up of five components namely:

- Inorganic constituents; that is, mineral matter
- Organic matter (humus)
- Living organisms
- Soil water (moisture)
- Soil air (gases)

(a) Soil water

Water is a very important constituent of soil. Its functions include the following:

- ✓ It acts as a major component of the cell protoplasm. Soil water provides support to the plant. In herbaceous plants, it helps to make the plant cells turgid.
- ✓ Soil water acts as a medium in which plant nutrients are dissolved before being transported up the plant.
- ✓ Water is a raw material of photosynthesis.
- ✓ Loss of soil water by transpiration has a cooling effect on plants.
- ✓ Water is necessary for microbial activities in the soil.
- ✓ Soil water creates suitable conditions for seed germination.

Soil water exists in three forms. They are:

- Superfluous water
- Hygroscopic water
- Capillary water

Superfluous water

This is the soil water found in the large air spaces (macropores) in the soil particles,

It is held together by gravitational forces. Once these spaces are saturated with water, the soil becomes water-logged. This type of soil water is available for plant use.

Hygroscopic water

This is the type of soil water found in form of a thin film on the surface of the soil particles. This water is held together by strong forces and so, it is not available for plant use.

Capillary water

This soil water occupies the micropores in the soil. It is held by strong adhesive and cohesive forces. It is the soil water that is readily available and beneficial to plants.

(b) Soil air

Soil contains air. Air is a mixture of gases. These gases include carbon dioxide, oxygen, nitrogen and inert gases. Air is found in the spaces between the soil particles. The amount of air in the soil is inversely proportional to the amount of water available in that soil. Ploughing increases the amount of air in the soil.

Importance of air in the soil

- *Soil air is necessary for respiration of plant roots and animals in the soil.*
- *Nitrogen in the soil is used during nitrogen fixation, whereby it is converted to nitrates.*
- *Good aeration increases microbial activities in the soil.*
- *Good air circulation in the soil is necessary because it removes excess carbon dioxide that may be poisonous to plants.*

(c) Organic matter

This is an important component of the soil. It is derived from the remains of animals and plants. Organic matter undergoes decomposition to release nutrients and humus. Humus binds the soil particles together thus improving the soil structure. It is dark in colour hence it helps raise the soil temperature.

(d) Inorganic matter

These are inorganic compounds which arise from disintegration of rocks. They form the skeleton or framework of the soil. Apart from anchorage of plants, they also provide minerals necessary for proper growth of the plants. Examples are calcium, sulphur and potassium. Mineral matter consists of sand, silt and clay which are referred to as fractions. The fractions vary in size and are classified according to their diameters.

Separation of mineral matter

- ☞ *Mineral matter is made up of particles of different sizes. These can be separated by two methods:*

1. The sieve method
2. The sedimentation method

(e) Living organisms

Living organisms in the soil include rodents, worms, insects and micro-organisms. They play an important role in soil formation. Arthropods break down organic matter as they feed. Also, as the organisms burrow into the soil, they mix up soil particles thus accelerating soil formation.

Micro-organisms, for example bacteria and fungi, bring about putrefaction and decomposition thus helping add organic matter into the soil. Bacteria, like Rhizobium spp. and Azotobacter spp. carry out nitrogen fixation hence add nitrates into the soil. Nematodes, however, are parasitic to plants. Some nematodes, for example, Meloidogyne, attack Irish potatoes hence greatly lowering the yields.

All living things respire. During respiration, carbon dioxide is produced as one of the by-products. It is therefore expected that if the soil has micro-organisms, carbon dioxide will be produced. Carbon dioxide is tested using lime water; carbon dioxide turns lime water milky.

SOIL PROFILE

Soil profile refers to the vertical arrangement of different layers of soil from the ground surface to the bedrock. These layers are also called horizons and are very distinct, especially where the soil forming process has taken place over a long period of time.

The soil profile is made up of four layers (horizons) namely:

- Topsoil (Horizon A)
- Subsoil (Horizon B)
- Weathered rocks (Horizon C)
- Parent or Bedrock (Horizon D)

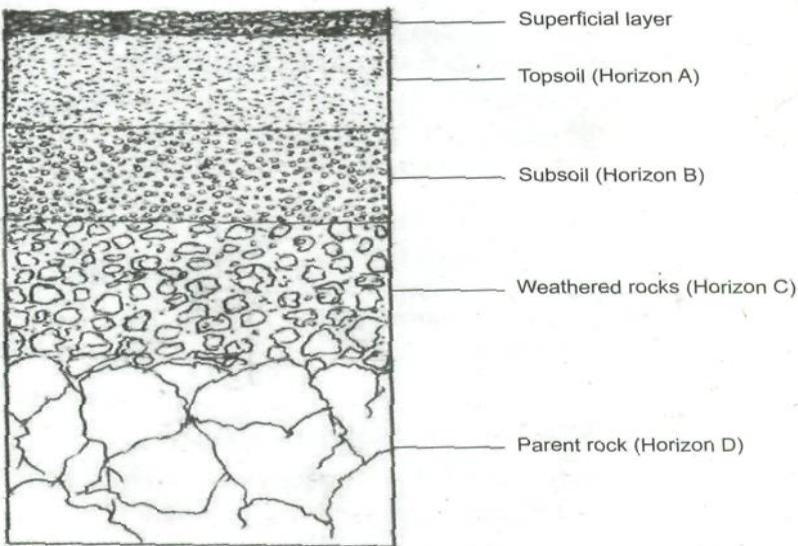


Fig. 1.5: Soil profile

(a) Topsoil

This is the first layer of the soil found on the surface. The topmost part of the topsoil is made up of decomposed and decomposing organic matter. During land preparation, these materials are ploughed into the soil adding organic matter to the soil.

The topsoil has a dark colour due to the presence of humus. It is rich in nutrients and is also well-aerated. It is however subject to leaching, that is, the downward movement of dissolved minerals. It is very thick in some areas but thin in others. Micro organisms are also found here since the layer is well-aerated. Most plant roots are found here.

(b) Subsoil

This is the layer beneath the topsoil. It is more compact and less aerated than the topsoil. Mineral salts carried down from topsoil through leaching are deposited in this zone; giving it the name "layer of accumulation". Some deep rooted crops will have their roots growing up to this region. The layer is composed of larger soil particles and is lighter in colour than the topsoil. Where the subsoil is not well cultivated, or if it is cultivated when wet using heavy machinery, hard pans can be formed in it. (Hard pans are hard impermeable layers that cannot be broken down during land preparation unless subsoiling is done.)

(c) Weathered rocks

This is the third layer from the top. It is composed of weathered rocks broken down from parent rock material. Rocks in this zone are at various levels of disintegration. Most of the materials found in this zone originate from the

bedrock itself. As one moves down the zone, rock particles become larger in size as they are less exposed to agents of weathering.

(d) Parent rock

This layer is also referred to as the substratum or bedrock. The zone exists as a solid mass. The rocks are still intact, that is, unweathered. It is called parent rock because it is the source of the inorganic matter of the soil. The water table is on the surface of this rock. The nutrient content of soil depends on the mineral constitution of the parent rock. The colour of the soil is also determined by the parent rock.

Effects of soil profile on crop production

The characteristics of the soil profile vary from one area to the other. These variant characteristics affect crop production in a number of ways.

(a) Soil depth: *This is the distance from the topsoil to the parent rock. Soil depth influences the soil capacity to hold water and minerals. Deep soils have more room for water and minerals compared to shallow soils. The depth of the soil will also determine the crop to be grown. Deep-rooted crops can only do well in deep soils but in shallow soils, they may not be well-anchored.*

Deep soils are less prone to soil erosion because they have room for more water hence reducing surface run off as most of the water infiltrates into the soil.

(b) Compactness of the soil: *This influences aeration, drainage and root penetration. Compact soils have poor drainage, aeration and they also limit root penetration and tuber enlargement. Loosely packed soils will ensure good aeration, good drainage, good root penetration and tuber expansion. Hence loosely packed soils are appropriate for growing tuber crops.*

(c) Composition of the parent rock: *This influences the type of minerals present in the soil. A soil formed in situ will largely supply those minerals that were present in the parent rock from which the soil was formed. If the parent rock was rich in particular minerals, the soil will also be rich in the same minerals. If the parent rock lacked some minerals, they will also be absent in the soil.*

UNIT 2 :SOIL FERTILITY

- ❖ This is the ability of the soil to provide and sustain high crop yields indefinitely.

A fertile soil should provide all necessary conditions for proper growth of crops and consequently give high crop yields of high quality.

Maintenance of soil fertility

A soil that is no longer productive, or that which is less productive, can be made more productive through various practices. They include the following:

- ❖ Application of organic and inorganic fertilisers
- ❖ Practising crop rotation
- ❖ Regulation of soil pH
- ❖ Controlling soil erosion
- ❖ Ensuring proper drainage
- ❖ Timely weed control
- ❖ Practising minimum tillage
- ❖ Practising inter-cropping

(a) Application of organic and inorganic fertilisers.

These will replenish the nutrients lost from the soil. Organic manure also releases humus that binds the soil particles thus improving soil structure. They also help to buffer the soil pH, thus preventing rapid changes in soil pH. Organic manure acts as food and shelter to soil organisms thus increasing microbial activity.

(b) Practising crop rotation

This is the practice of growing different types of crops on the same piece of land following a definite succession. This improves soil fertility in the following ways,

- ✓ Controls specific soil-borne pests and diseases.
- ✓ Ensures maximum utilisation of soil minerals from all horizons.
- ✓ Legumes included in the cycle add nitrates through nitrogen fixation.
- ✓ Controls specific crop weeds such as witch weed (*Strigga spp.*)

(c) Regulation of soil pH

Soil pH is the degree of acidity or alkalinity in a soil solution. pH can be regulated through:

- ✓ Use of organic manures.

- ✓ Use of acidic fertilisers
- ✓ Use of agricultural lime.

Good soil pH has the following benefits.

- i. Ensures availability of crop nutrients.
- ii. Increases the population and activity of soil organisms.
- iii. Determines the type of crop to be grown.

(d) Controlling soil erosion

Soil erosion leads to the loss of top fertile soil making the soil less productive. There are a number practices that a farmer can carry out to reduce soil erosion. These include mulching, growing cover crops, strip cropping, contour farming, terracing and use of cut-off drains.

(e) Ensuring proper drainage

Water-logged soils are not suitable for crop production apart from paddy rice and coco yams. Water-logging can be caused by a number of factors and ways of dealing with it also vary. They may include:

- i. Draining excess water.
- ii. Application of organic manure.
- iii. Breaking hard pans if present.

(f) Timely weed control

Weeds compete with cultivated crops for various resources such as water, air, minerals and space. Some weeds are alternative hosts of crop pests and diseases. These consequently lead to poor crop yields. Weeds should be controlled and at the right time before serious damage is done. There are several methods a farmer can employ to control weeds. Such methods can be put into five categories namely:

- Legislative
- Cultural
- Mechanical
- Biological
- Chemical

(g) Practising minimum tillage

Over cultivation destroys the soil structure. A farmer should therefore reduce the tillage Operations as much as possible. Minimum tillage improves soil fertility in the following ways;

- *Maintains the soil structure.*
- *Conserves the soil moisture.*
- *Reduces root damage and disturbance.* • *Reduces soil erosion.*

(h) Practising inter-cropping

This is (he practice of growing different types of crops on the same piece of land at the same time. This helps to maintain soil fertility in the following ways.

- *Ensuring maximum utilisation of the soil minerals.*
- *Legumes included among the crops add nitrates through nitrogen fixation.*
- *Providing better ground cover hence controlling soil erosion and smootlicring weeds.*

Classification of fertilisers

Fertilisers are classified into two categories: .

- *Organic fertilisers.*
- *Inorganic fertilisers*

1. Organic manures

Organic manures, also known as organic fertilisers are substances that are prepared from animal and plant remains. They are added to the soil to supply plant nutrients.

Characteristics of organic fertilisers

- *They have low nutrient value per unit volume.*
- *They release nutrients very slowly.*
- *They are rich in many plant nutrients.*
- *They are bulky and hence cumbersome to transport and apply.*
- *They have few negative effects even if used over a long period of time.*

Classification of organic fertilisers

There are three types of organic fertilisers. These are:

- *Green manure*
- *Farmyard manure*
- *Compost manure*

(i) Green manure

This type of manure is made from green plants. The plants are grown for the sole purpose of being incorporated into the soil to decompose and improve

soil fertility. Examples of crops used to make green manure are maize, sorghum, wild sunflower, beans, clovers and lucerne. Legumes have an added advantage in that they are able to supply nitrates to the soil.

Establishment of the crops: All of the above mentioned crops are planted in the field. They are allowed to grow up to the flowering stage, then ploughed back into the soil and allowed to decompose. Sufficient time must be allowed for the material to decompose well before planting.

Qualities of crops to be used as green manure

Crops grown for green manure should have the following desirable characteristics.

- They should be able to grow rapidly.
- They should be highly leafy or vegetative.
- They should have high nutrient content and preferably leguminous.
- They should be capable of fast decomposition.
- They should be short for ease of ploughing into the soil.
- They should have the ability to grow on poor soils.

Reasons why green manure is not commonly used

- Proper timing of the correct stage for ploughing into the soil is necessary.
- There is inadequate land space to grow the green manure crops.
- The release of nutrients by green manure crops is slow. Thus, it takes a long time to completely decompose and release nutrients for crop use.
- Most of the green manure crops are food crops therefore farmers are unwilling to destroy them especially where land is limited.
- They absorb available soil moisture and nutrients at the expense of the incoming crops.

(ii) Farmyard manure (FYM)

This type of organic manure is also known as muck or pen manure. It is a mixture of animal wastes and animal bedding which are completely rotten.

Preparation of farmyard manure

Animal wastes and bedding are taken from the animals' house (yards) and are then heaped under rain-proof sheds where they are left to decompose.

Constant turning-over or mixing is done to ensure uniform decomposition.

Water may also be sprinkled if dry to speed up decomposition by the micro-organisms.

When completely decomposed, the manure becomes dry. If farmyard manure is used when it is not completely decomposed, it may cause fungal disease. For example, black scurf in Irish potatoes. When the manure is dry and finely broken down, it is then ready for use.

Fresh animal waste should not be applied to the seedbed because the bacteria which breaks it down to release nutrients will fix available soil nutrients making them unavailable for plant use.

When farmyard manure is exposed to the open, there is loss of nutrients due to:

- Volatilisation of nitrates (its conversion into ammonia gas).
- Leaching and washing away by rainfall.

Therefore, it is important to prepare the manure under a shed.

The nutritional value and quality of farmyard manure depends on:

- The type of animal producing the manure: Different types of animals provide varying qualities of farmyard manure depending on their nutrition and nutrient requirements. Below is the order of nutrient richness of various animal manure from the highest to the lowest.
 - Poultry manure
 - Sheep manure
 - Pig manure
 - Horses manure
 - Cattle manure
- The quality of the feed given to the animal: For instance, livestock fed on feeds rich in nutrients will result in farmyard manure rich in the same nutrients.
- Type of litter: The best type of litter is that of high urine absorption capacity and which is easy to decompose such as straw. Litter with a high level of nutrients produces high quality manure.
- Method of storage: Proper storage is necessary to prevent volatilisation, washing away of nutrients by rain and leaching. Hence, a rain-proof structure is necessary in the preparation of farmyard manure. A concrete floor is necessary to prevent leaching during manure preparation.
- Age of the manure: Well rotten manure is rich in nutrients and releases them fast into the soil.

- *Age of the animal:* Young animals produce inferior quality manure while older animals give higher quality manure. This is because young animals use most of the nutrients for growth.

Advantages of farmyard manure

- It is cheaper than the commercial fertilisers.
- It does not require high technical skills to make.
- It uses locally available raw materials and therefore minimises wastage while maximising utilisation of resources.
- It improves the soil structure.
- It is a cheaper way of maintaining a clean environment. That is, accumulation and scattering of livestock waste in animal housing and the surrounding is avoided.

Disadvantages of farmyard manure

- It is bulky, hence difficult to prepare, transport and apply.
- It releases nutrients slowly.
- If poorly stored, soluble nutrients are easily leached and volatilisation can take place.
- If used before it is completely rotten, it can cause fungal infection or scorch the plants.
- It can introduce weeds in the seedbed through litter infested with weed seeds.

(iii) Compost manure

This is manure prepared from organic materials like soft hedge cuttings, grass, and kitchen wastes. Compost is prepared by piling plant residues in a heap or a pit. The material should be turned over at regular intervals to facilitate a uniform rate of decay. If the material is of low nitrogen content, ammonium sulphate may be added to improve the nitrogen content of the manure. If the material is dry, it can be moistened by sprinkling water

Note: Protect the compost from direct sun and rain,

Some quantities of old compost organic manure should be added to introduce micro-organisms necessary for decomposition. Refer to the methods of preparing compost manure in your Junior Agriculture textbook.

Advantages of compost manure

- One does not have to own livestock in order to prepare it.

- A lot of manure can be produced within a short time. However, quantities produced depend on the amount of vegetative matter available.
- A variety of materials can be used in its preparation.
- Use of organic compost manure improves soil aeration.
- Locally available materials can be used making it cheaper than the artificial fertilisers.
- It improves the soil structure

Disadvantages of compost manure

- It releases nutrients slowly into the soil.
- Large quantities of compost manure are required to supply enough plant nutrients.
- Its preparation is labour intensive.
- It may induce soil-borne pests, such as, nematodes.

Advantages and disadvantages of organic fertilisers

Advantages of organic fertilisers

- They are cheap because they are made from locally available materials.
- They bind the soil particles together thus improving soil structure.
- They improve the water holding capacity of the soil.
- They supply a variety of essential nutrients.
- They have a long residue effect, they can supply nutrients for a long period after application.
- They encourage activities of soil micro-organisms because they provide food and shelter to the organisms,
- They help to buffer soil pH.
- They help to moderate soil temperature.
- They do not require special skills to prepare or apply.

Disadvantages of organic fertilisers

- They are bulky, hence expensive to apply and transport.
- They have a low level of nutrients per unit weight,
- They take long to release the nutrients as they must undergo complete decomposition.
- They can introduce weeds to the field.

- They can cause fungal infections or scorch the plants if not well-decomposed.
- They require a lot of labour to prepare.

2. Inorganic fertilisers

Classification of inorganic fertilisers

Inorganic fertilisers can be classified on the basis of the following:

- ❖ Nutrient composition
- ❖ Reaction with the soil

(a) **Nutrient composition**

Fertilisers are classified as straight or compound fertilisers on the basis of their nutrient composition.

(i) Straight fertilisers

These are fertilisers which contain only one of the three primary macro-nutrients. The nutrient can be nitrogen(N), phosphorous(P) potassium(K). The different categories of straight fertilisers are nitrogenous ,phosphatic andpotassic fertilisers.

(ii) Compound fertilisers

These contain two or three of the primary macro-nutrients. When the compound

fertilisers contain only two primary elements, they are referred to as incomplete compound fertilisers. Examples are Diammonium Phosphate (DAP) contains 18-47-0, 20-20-0 and 23:21:0.

If the fertiliser contains all the three primary elements (N,P,K), it is referred to as a complete compound fertilizer. Examples include 20-10-10, 17-17-17, 15-15-15 and 2:18:15.

(b) **Reaction with the soil**

Fertilisers can also be classified on the basis of their reaction with soil. They can either be acidic, basic or neutral. Acidic fertilisers are those which increase the acidity (lower the pH) of the soil. For example Sulphate of Ammonia.

Basic fertilisers are those which reduce the acidity (raise the pH) of the soil.

Neutral fertilisers neither raise nor lower the soil pH; they do not affect the acidity of the soil.

Identification and properties of inorganic fertilisers

(i) Straight fertilisers

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Nitrogenous fertilisers

Nitrogenous fertilisers have the following properties.

- They are readily soluble in water.
- They have short residual effects on the soil.
- They scorch or burn the plant body upon contact. Therefore, they should not be put into contact with any part of the plant except when applied as foliar treatment.
- They are highly volatile; change into gaseous form when applied to dry soil. A typical example is Sulphate of Ammonia.
- They are highly leached especially when rainfall is high. The nitrate forms leach more than the ammonium forms. Leaching is most prevalent in high rainfall areas. Application should be done when plant roots are fully developed.
- They are hygroscopic, (have the tendency to absorb moisture from the atmosphere). This causes them to stick together in lumps (to "cake") easily. Therefore, they should be stored under dry conditions and for shorter periods.
- Most nitrogenous fertilisers tend to corrode the skin and should therefore not be handled with bare hands.

In shallow-rooted perennial crops, such as bananas, it is advisable to apply the fertiliser in small dosages (known as splits) several times, rather than in one large dosage. The application of nitrogenous fertilisers in splits is important owing to their high solubility and high leaching rate. Applying the recommended rate all at once may result in leaching, and consequently deprive the plant of the much needed fertiliser nutrients.

Application of excess nitrogenous fertiliser may have the following adverse consequences.

- An increased incidence of certain leaf diseases such as in rice blast.
- Poor malting in barley.
- Poor combustibility in tobacco.
- Lodging of cereal crops.
- Excessive vegetative growth at the expense of tuber formation in root crops.
- Failure to form tubers in root crops. For example, Irish potatoes.

Examples of nitrogenous fertilisers

(a) Sulphate of Ammonia (SA), $(NH_4)_2SO_4$

It is a straight fertiliser containing 21% N. Nitrogen is present in the ammonium form and is converted to nitrate form by the action of soil bacteria. This happens faster in warm soils. Sulphate of ammonia also contains 26% Sulphur in sulphate form. It has a white, crystalline appearance and is highly volatile. It is an acid-inducing fertiliser.

(b) Ammonium Nitrate (AN). NH_4NO_3

This is a straight fertiliser containing 34-35 %N in ammonium and nitrate forms on equal proportions. Ammonium nitrate has a white crystalline appearance and is highly explosive in a refined state, As a result, the fertiliser is usually coated and packaged in moisture-proof materials. Conditioning agents are used to reduce the explosiveness of ammonium nitrate.

(c) Ammonium Sulphate Nitrate (A.S.N.), $(NH_4)_2SO_4 \cdot NH_4NO_3$

It is a mixture of Sulphate of Ammonia and Ammonium Nitrate. It is usually yellow or orange in colour and granular Typically, ASN contains 26%N (6.5% in nitrate form and 19.5% in ammonium form) and 13.5% S. The fertiliser is acidic and hygroscopic in nature. It has a scorching effect on plants.

(d) Calcium Ammonium Nitrate (C.A.N.), $NH_4NO_3 + CaCO_3$

It consists of ammonium nitrate and calcium carbonate. It is also referred to as , niro chalk. It is a straight nitrogenous fertiliser containing 21% N (10% in ammonium form and 11% in nitrate form). It also contains 10-20% quick lime (calcium oxide). It is granular and greyish in colour and hygroscopic in nature. CAN is a neutral fertiliser owing to the presence of calcium.

(e) Urea, $CO(NH_2)_2$

This is the most concentrated form of nitrogenous fertiliser. It contains 45-48% N, all in ammonium form. It is granular, white, slightly acidic and extremely soluble in water. Urea is highly hygroscopic, easily leached, and volatilises quickly. It is applied as a foliar feed (sprayed on the foliage) to crops such as coffee and pineapple. The fertiliser is also used in the processing of livestock feed.

Other nitrogenous fertilisers are potassium ammonium nitrate and sodium nitrate. It is important to note that only part of the nitrogen in nitrogenous fertilisers applied to the crops will be absorbed by the plant. For example, when urea is applied to crops, less than half of its nitrogen content is

absorbed by the plant. In general, only 50% of the water-soluble nitrogen will be absorbed by the crop. The rest is likely to be lost through leaching, erosion, volatilisation, immobilisation, or to be taken up by weeds.

Immobilisation is the process by which a certain quantity of nitrogen is assimilated into the soil micro-organism tissue during the decomposition of plant residues in the soil.

Phosphatic fertilisers

Most soils contain fairly large amounts of phosphorous though much of it is available in the form which is not absorbable by plants. Phosphorous forms insoluble compounds with other soil minerals.

Phosphatic fertilisers have the following properties.

- They are not readily leached.
- They are slightly soluble in water.
- In acidic soils, much of the fertiliser is converted into insoluble compounds, and thus becomes fixed. Due to this fixation, phosphate fertilisers must be placed in the root range of growing plants.. For example, by drilling or mixing with the soil in the planting hole.
- Phosphatic fertilisers have a long residual effect on the soil and can be available to plants long after its application (in some cases, up to 4 years).
- Unlike nitrogenous and potassic fertilisers, phosphatic fertilisers have a slight scorching effect.

Examples of phosphatic fertilisers

(a) Single Superphosphate (S.S.P), $\text{Ca}(\text{H}_2\text{PQJ}_2 \cdot \text{CaSO}_4)$

It contains 18-21% P_2O_5 . It also contains sulphur which distinguishes it from double or triple super phosphate, which have very little or no sulphur. It is granular, creamy-white, and much whiter than the double and triple superphosphate due to its high lime content. When applied to the soil, most of the P_2O_5 diffuses out in calcium phosphate form. It can remain in an undissolved state for several months. It is a neutral fertiliser.

(b) Double and Triple Super Phosphate (D. S.P.orT.S.P.)

They are usually granular grey in appearance. They contain about 40-49 % P_2O_5 .

(c) Soda phosphate

It contains up to 20% P_2O_5 and may contain other elements for example 30% CaO , 30% FeO and small amounts of Mg , Cu , Zn , CO , MO and B . It is good for soils lacking trace elements. It is grey and powdery.

(d) Basic slag

It contains 15-16% P_2O_5 and 40-50% lime: It is therefore suitable for heavily acidic soils such as clay. Basic slag contains small traces of S , Mn , Mg , Fe , CO , Cu and MO . It is highly basic, and should not be mixed with another fertiliser. It is grey and powdery.

Potassic fertilisers

Potassic fertilisers have a moderate scorching effect and are fairly soluble (more soluble than phosphatic fertilisers but less soluble than nitrogenous fertilisers). Sources of potassium include: crude salts, seaweeds, wood ashes and potassium-containing rocks. It can also be produced as a by-product in the manufacture of cement. Should only be applied where soil tests show potassium deficiency.

Examples of potassic fertilisers

(a) Muriate of potash (potassium chloride)

It is a crystalline, whitish - red, fertiliser containing up to 48-62% K_2O . It contains impurities of calcium, magnesium, sulphur as well as some trace elements. It is hygroscopic and water-soluble, with no residual effect on the soil.

(b) Potassium sulphate (sulphate of potash)

It is a crystalline yellow, water-soluble fertiliser containing about 42-52% K_2O . It is manufactured by combining Muriate of potash with sulphuric acid. It also contains some trace elements. Unlike the Muriate of potash, potassium sulphate is not widely used as a fertiliser.

(c) Wood ashes

They vary in the amount of potassium they contain. Thoroughly leached ashes are of little or no value as potassic fertilisers. Hardwood ashes are generally richer in potassium than soft woods. Wood burnt at high temperatures produces ashes much lower in potassium than that burnt at low temperatures.

(ii) Compound fertilisers

These fertilisers contain two or three of the primary macronutrients (nitrogen, phosphorus and potassium). Complete compound fertilisers have all the three primary macronutrients, whereas incomplete compound fertilisers lack one of the primary macronutrients. In a compound fertiliser, the elements are

expressed in percentage forms of N, P₂O₅ and K₂O, respectively. For example, 20-20-0 has 20% N, 20% P₂O₅ and 0% K₂O, also 23:21:0 has 23%N, 21% P₂O₅ and 0% K₂O.

In areas where soils are rich in potassium, most compound fertilisers do not contain K₂O. In compound fertilisers, nitrogen is found in its element form, phosphorus in phosphorouspentoxide (P₂O₅) and potassium in its potassium oxide (K₂O) form.

Advantages of compound fertilisers

- They are cheaper and more convenient to apply thereby saving on cost, time and labour.
- They are easy to store as they do not form lumps when stored over a long period of time.

Disadvantages of compound fertilisers

- They can be uneconomical considering that their nitrogen component may not be utilised where the plant roots are not developed at the time of fertiliser application.
- They are expensive to buy.

Advantages of inorganic fertilisers

- They are less bulky hence cheap to apply and transport.
- They can contain high levels of nutrients per unit weight.
- They readily release nutrients once applied.

Disadvantages of inorganic fertilisers

- They are expensive to buy.
- They only supply particular nutrients.
- They have a short residual effect.
- They require special skills to store and handle.
- They may alter soil pH if applied for a long time.
- May be harmful to crops if applied in excess.
- Some may inhibit the activities of soil micro organisms.

UNIT 3: Agriculture and Climate Change

Meaning of Climate Change

- Climate refers to all weather elements of an area observed over a long period of time usually over 30 years. Such weather elements include:
- Rainfall/ precipitation
- Temperature
- Wind
- Relative humidity
- Light

Different parts of the world are classified into climatic zones depending on their climate. This has over the years changed and we are observing areas that used to be suitable for growing a particular crop, then the crop no longer performs well. Climate change is the gradual change in the weather elements of a particular place.

Comments like "we are nowadays experiencing long dry spells" or "in the old days the land was very fertile that we produced a lot without the use of fertilisers" or in the past we never experienced malaria attack in this region" are very common. All these are impacts of climate change.

Various climates of the world today differ considerably from those experienced in the past. Malawi is one of the most vulnerable countries to climate change as it relies on rain fed agriculture for economic survival. Malawi also lies within the tropics where impacts of climate change are likely to be more severe. Being a developing country it has a low capacity to adapt to and mitigate against climate change.

To show how acute the issue of climate change is, several specialised institutions and organisations have been established both at the international and national level to research on climate change, its impact and propose responses and mitigation to reduce the rate of change. The most influential of these is the intergovernmental panel on climate change (IPCC), established in 1988 by two United Nations organisations namely the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).

Causes of climate change

Factors that lead to climate change can be put into two categories:

- Natural processes.

➤ *Human activities.*

(a) *Natural causes*

The earth's climate can be influenced by natural factors outside the climate system. Such factors include:

- *Volcanic eruptions.*
- *Change in earth's orbit around the sun.*
- *Changes in solar radiation.*

These natural factors have very little significance in climate change.

(b) *Human causes*

- *Production of greenhouse gases (GHG's). These are gases such as carbon dioxide, methane, nitrous oxide and fluorocarbons. They raise the global temperature,*

(a) *Carbon dioxide:* *This is the most significant human-induced cause of climate change. It is released in large quantities from burning fossil fuels such as petroleum, coal and natural gases. Carbon dioxide leads to significant raising of the global temperature.*

(b) *Methane:* *The most significant source of methane is decomposition of organic matter such as in landfills and in agriculture. Digestion in ruminant animals also produces significant amounts of methane.*

(c) *Nitrous oxide:* *This is a very powerful greenhouse gas produced through production and use of organic fertiliser and burning of fossil fuels.*

(d) *Chlorofluorocarbons (CFCs):* *These are produced for industrial use as refrigerating and as air conditioning compounds.*

Note: *The overall effect of greenhouse gases has raised the earth's average temperature from 15.50°C to 16.20°C in the last 100 years.*

- *Aerosols: Some human activities lead to an increase in the amount of aerosols in the atmosphere. They include the following.*

(a) *Aerosols absorb solar and infrared radiations hence raising the global temperature.*

(b) *Dust released into the atmosphere by tilling land when very dry.*

(c) *Burning of biomass leads to production of soot particles.*

(d) *Industrial processes produce a variety of aerosols.*

(e) *Exhaust fumes from engines also produce aerosols.*

- *Deforestation: This is the indiscriminate clearing of forest cover which leads to changes of the land surface. Removal of land surface cover leads to changes in the amount of light reflected from the earth's surface back to space.*

Effects of climate change

Climate change impacts on agriculture and peoples' livelihoods in different ways.

(a) Impact on land

- *Erratic rainfall due to indiscriminate deforestation. The ever increasing need for more arable land and need for fuel energy has aggravated deforestation.*
- *Seasonal droughts that gradually give way to aridity leading to loss of arable land.*
- *Floods which lead to serious land degradation by forming of large gullies and consequently loss of arable land*
- *Changing woodlands. Here due to changing temperatures, trees adapted to a particular temperature, as the condition changes, the habitat becomes unsuitable for the trees.*
- *Landslides and mudslides degrading the land for agricultural activities.*

(b) Impact on crops

- *Increase in crop pests: Warm climate increases reproduction and rate of growth of crop pests hence increasing their population. This lowers the crop yield.*
- *High carbon dioxide concentration stimulates growth of certain crops thereby increasing their yield. However, the crop produce may be of low quality.*
- *Erratic rainfall and drought leads to total crop failure lowering the expected yield.*
- *Flooding makes the land water-logged damaging the crops already grown lowering crop yield.*
- *Strong winds cause breakages of tree crops and lodging of annual crops affecting the expected yield.*
- *Landslides and mudslides may destroy crops already growing in the field.*

- Increased hailstorms may cause serious damage to crops in the field, such as tea, lowering the output of the crop.
- Flash floods and intense rainfall lead to loss of the top fertile soil. This reduces the potential of the land to produce high crop yield.
- Unpredictable weather patterns leave the farmers unable to make appropriate decisions such as time for land preparation and time for planting annual crops. Early or delayed planting considerably lowers the expected yield.

(c) Impacts on livestock

- Increased temperature may induce heat stress in animals in areas that were initially cooler.
- Low rainfall and drought will lead to low quantity fodder for livestock lowering livestock growth and output.
- Increased temperature leads to faster multiplication and growth of livestock parasites, such as ticks and tsetse flies. This subsequently leads to increased vector-borne diseases negatively affecting the livestock industry
- Low water levels lead to low fish stocks. Some water-bodies even dry completely, such as Lake Chilwa in 1995, resulting to total loss of biodiversity. Some of which are endemic to Malawi,
- Temperature changes will influence the distribution of livestock as areas that were previously cool become warmer with time.

(d) Impact on livelihood

- Increased food insecurity which leads to malnutrition and hunger. This results in reduced farm labour and chronic food deficits.
- Floods lead to water pollution lowering the quantity of pure water. This may result in outbreaks of water-borne diseases such as dysentery and cholera.
- Low water levels in rivers and dams have impacted negatively on hydroelectric power generation such as river Shire. This forces people to use alternative sources of fuel such as biomass leading to further deforestation.
- Spread of malaria and other vector-borne diseases in areas previously too cold for the vectors to survive.

- Floods also lead to siltation of dams and other water bodies lowering their capacity for storing water. The floods may also damage water pipes compounding the problem of clean water shortage.
- Low water supply impacts negatively on industries as they do not get adequate water. This may lead to loss of the highly needed employment for sustainable livelihood.
- Floods are responsible for the destruction of fish ponds leading to loss of livelihoods for the fish farmers.
- Forest fires are more prevalent during the dry season. Such fires lead to loss of seedlings and biodiversity of a given region.
- In the rural communities, drought means women have to travel for long distances in search of water for domestic use. This translates to less meaningful work done in the crop fields bearing in mind that women are the major providers of labour in small scale farming.

Topic 2: Agricultural Research and Technology

UNIT 4 : IRRIGATION

➤ Irrigation is the artificial application of water into the soil so as to provide adequate moisture for plant growth. Irrigation is practised mainly in areas where rainfall is inadequate or unreliable,

Importance of irrigation

Irrigation has the following importance.

1. It enables growing of crops during dry seasons when there is no rain.
2. It is used to supplement inadequate rainfall so as to grow crops.
3. It is a method of land reclamation in arid and semi arid areas.
4. It enables growing of crops in special structures such as green houses,
5. It enables one to grow crops that require high amount of water such as paddy rice.
6. It is a source of employment where it is used intensively.
7. It promotes crop production for export market earning revenue to the country,
8. Overhead irrigation helps control some crop pests such as aphids.

Systems of irrigation

There are basically three systems of irrigation namely:

1. Surface
2. Overhead
3. Drip

(a) Surface irrigation

This is a system of irrigation where water reaches fields to be irrigated through canals or furrows.

Conditions necessary for surface irrigation

- (i) Topography: The land must be fairly level (gentle sloping) for the water to flow by gravity.
- (ii) Amount of water supply: Plenty of water is required due to high wastage through seepage and evaporation.
- (iii) Soil type: The soil must be able to hold water for a long period of time and should preferably be clay soil

Types of surface irrigation system

Surface irrigation can be practised in three ways. These are.

- *Flood irrigation*
- *Furrow irrigation*
- *Basin irrigation*

(i) Flood irrigation

In this type of irrigation, water is allowed to flow into the field through furrows or canals. It is then directed to various parts of the farm by opening of sluice gates in the field. Flood irrigation requires that land be as near flat as possible. This type of irrigation is best used in growing paddy rice which requires flooded fields.

Advantages and disadvantages of flood irrigation

- *It is relatively cheap to establish,*
- *It requires less skill.*

Disadvantages

- *A lot of water is used.*
- *Water is unevenly distributed causing water-logging in some areas while other parts do not get enough water.*
- *Siltation of the canals is prevalent.*
- *It can only be practised in soils with high water retention capacity.*
- *It can only be practised in flat areas,*

(ii) Furrow irrigation

This is used on land with gentle slopes of 1% gradient. Water flows through open gates into furrows. The furrows are dug along the contours to reduce soil erosion. As water flows along the furrows, it wets the soil on the ridge. Crops are planted on the ridges of the furrows. The spacing of the furrows depends on the spacing of the crop. The furrows are maintained by repairing embankments when eroded or worn out, and by removal of weeds and accumulated silt

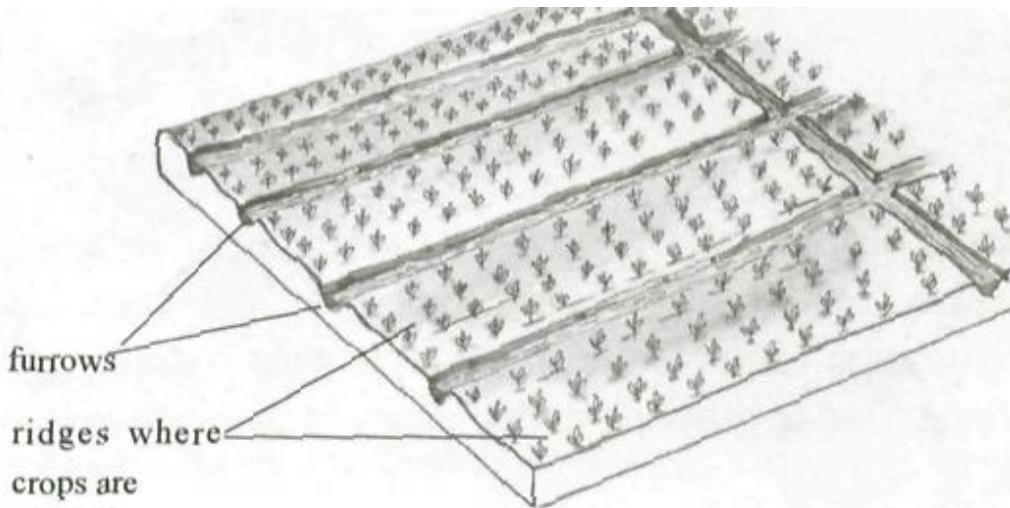


Fig 4.2: Furrow irrigation

Advantages and disadvantages of furrow irrigation

Advantages

- Reduces incidences of fungal diseases, such as leaf blight, because the leaves do not come into contact with water.
- Relatively cheap to establish and maintain.
- Requires less skills.

Disadvantages

A lot of water is wasted.

Soil erosion may occur if the design is not well done. If water is saline, it may affect plant roots.

- It is not easy to maintain a uniform flow of water in the furrows from the source to the end.

(Hi) Basin irrigation

It is the flooding of an entire area enclosed by earth embankments known as dykes or levees. The depth of the water is controlled by the dykes or levees. The ground should be levelled and a dyke or levee constructed around each levelled ground. Levelled ground surrounded by dykes is called a level basin. Water is allowed into each level basin through an inlet. Sometimes, fruits and trees are grown in basins where a basin is created for each crop. The difference between flood irrigation and basin irrigation is that, in flood irrigation the surface is always flooded with water while in basin, water is only allowed to flow in when needed.

Maintenance of surface irrigation

In surface irrigation, the following maintenance operations are necessary:

Repair of levees if broken.

- *Removal of weeds in the canals, basin inlet and outlet.*

De-silting of canals.

Repair of sluice gates.

Advantages and disadvantages of surface irrigation

Advantages

- *It is cheap to establish and maintain. It does not require a lot of skills.*

Disadvantages

It results in accumulation of a lot of salts in the soil. It cannot be used in sloppy areas.

- *Floods may destroy the basins during heavy rains. A lot of water is wasted.*

There may be high incidences of water-borne diseases such as bilharzia and malaria.

(b) Overhead irrigation

This is a means of supplying water to growing crops from above in form of fine droplets.

Overhead irrigation can be practised in three ways.

- (i) *Use of hose pipes. This is also appropriate for small scale farming. Fig. 4.4(a)*
- (ii) *Use of sprinklers. This is where the water is forced through pipes and out through the sprinklers. The water must be under high pressure for the system to work effectively. Fig.4.4 (b)*
- (iii) *Use of watering cans -suitable for watering seedlings in a nursery bed but only at small scale. Fig.4.4 (c)*



(a) Hose pipe irrigation



(b) Sprinkler irrigation



(c) Irrigation using watering can

Fig 4.4: Methods of overhead irrigation

Overhead irrigation using sprinklers

In overhead irrigation, water is supplied to the crops in form of fine droplets from above,

The system is made up of the following components as shown in Fig. 4.5

- A water pump Main pipes Lateral pipes Riser pipes Sprinklers

Irrigation pipes are mostly made of aluminium.

(a) Pump

This provides a mechanical force that pushes water through pipes and out through sprinklers.

There are different types of pumps that may be used. They include:

- Hydraulic pump Reciprocating pumps Centrifugal pumps

The pump could either use electricity, petroleum products or animals as a source of power or be connected to the tractor power take off shaft.

(b) Main pipes

This delivers water from the pump into the field. The pipes could be plastic or aluminium. If the main line is permanent, the pipes are buried into the soil and the most suitable material is plastic. However, if the main line is portable, the pipes should be made of aluminium as it is light hence easy to shift from one place to another.

(c) Lateral pipes

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Connected to the main pipe at definite intervals, through a manually operated valve. They are made of aluminium for ease of carrying from one point to another. The bore of the lateral pipe is narrower compared to that of the main pipe so as to sustain high water pressure.

(d) Riser pipes

As per their name, they are vertical to the ground and are fitted at definite intervals from the lateral pipe. Their main pipe bore is narrow than that of the laterals. They hold the sprinklers at the top.

(e) Sprinklers

Sprinklers release water under pressure in form of fine droplets. There are two types of sprinklers.

Continuous rotating sprinklers; appropriate for small scale farming.

- *Spring loaded sprinklers, suitable for large scale irrigation.*

The sprinklers are arranged in such a way that the circles irrigated by individual sprinklers overlap. This ensures that there are no spots left unirrigated.

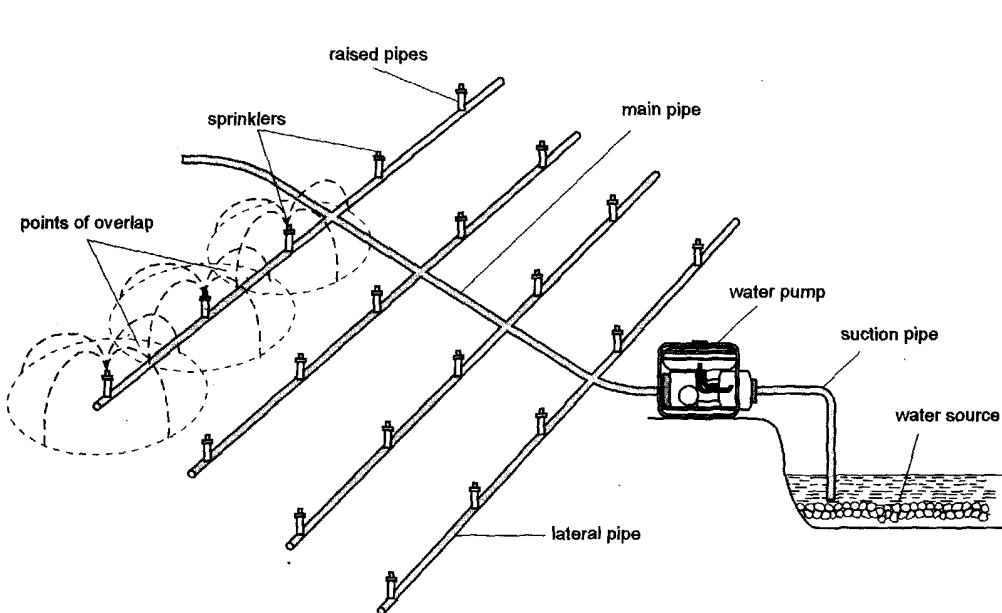


Fig 4.5: Sprinkler irrigation

The period of time the sprinkler remains in operation in one point depends on:

- *Soil type*
- *Crop being irrigated*
- *Topography*

Soil moisture content The working pressure should be suitable for the crop being irrigated. For instance:

- Low pressure for vegetable crops
- Medium pressure for field crops
- High pressure for perennial crops such as coffee

Advantages and disadvantages of overhead irrigation

Advantages

- Does not require levelling of the land, can be practised even on sloppy areas.
- Water is evenly distributed in the required area.
- The method is the most ideal for sandy soils.
- It is water economical compared to surface irrigation.
- Soluble fertilisers and herbicides can be mixed with the irrigation water and applied so.
- It is easy to move the sprinklers from one point to another.
- Soil erosion is minimised.

- It does not require special skills.

Disadvantages

- It is expensive to start.
- May destroy the soil structure due to impact of water drops.
- The method may require the establishment of wind breaks.
- It increases incidences of fungal diseases on the crop.
- It can lead to soil erosion if not well-controlled.
- The water must be under pressure.
- The water must be free from solid impurities otherwise the sprinkler nozzles will be blocked.

(c) Drip irrigation

In this system of irrigation, the water is applied at the root zone of the crop in form of drops. The system is also known as trickle irrigation. Polythene pipes with nozzles at specific intervals are used to deliver the water to the crop as shown below.

How drip irrigation works

- Drip irrigation supplies water at the base of the crop drop by drop.

- *The system is made up of a series of pipes with nozzles at specific intervals.*
- *The pipes are made up of plastic and laid along the crop rows.*
- *The nozzles allow water to flow out drop by drop, though the speed varies.*
- *Some nozzles are able to trap and hold any solid particles that may be in the water, thus preventing blockage of the nozzle.*
- *The distance from one nozzle to the other depends on the spacing of the crops to be irrigated.*

Advantages and disadvantages of drip irrigation

Advantages

1. *It uses most water economically hence suitable for dry areas.*
2. *Does not encourage fungal diseases on the crop.*
3. *Does not encourage growth of weeds between the rows.*
4. *Water even at low pressure can still be used.*

Disadvantages

1. *It is quite expensive to install.*
2. *It requires high levels of skills.*
3. *The water must be free from solid impurities to prevent blockage of nozzles.*

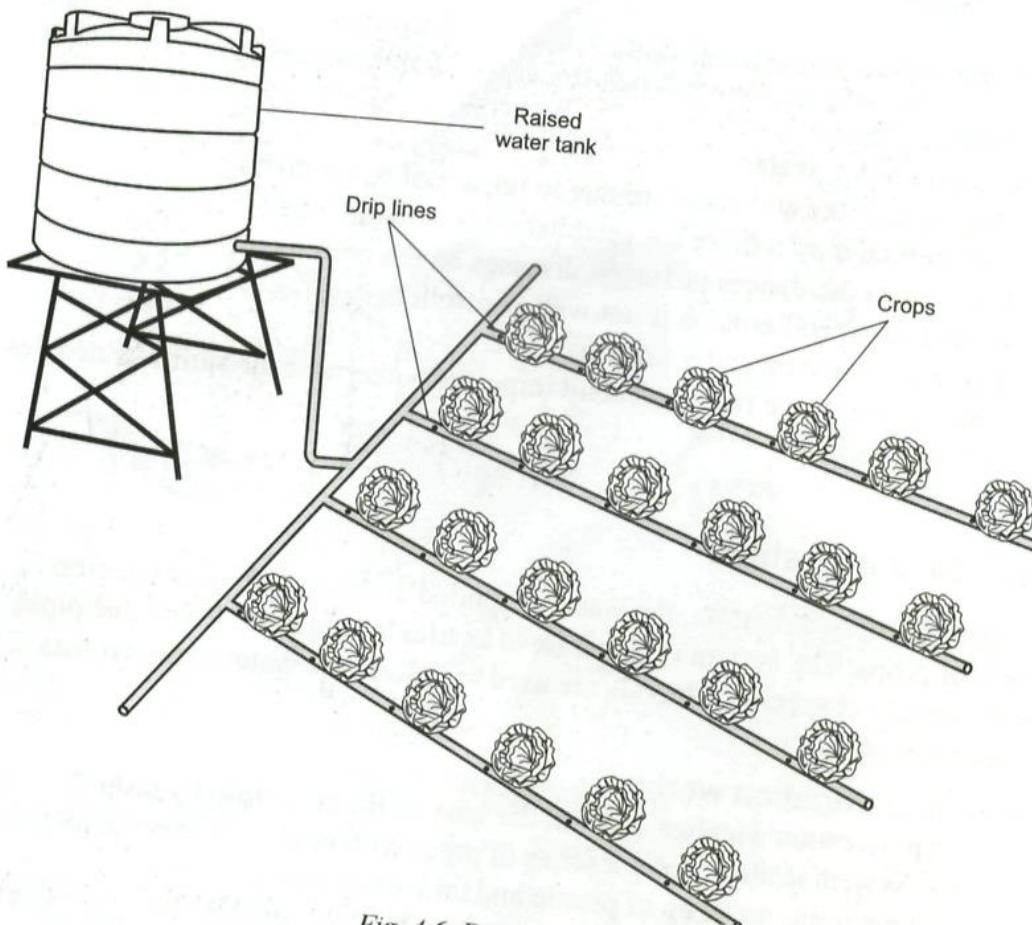


Fig. 4.6: Drip nozzles

Factors that influence the frequency and time of irrigation

How often a crop should be irrigated and also the duration of water application will depend on a number of factors.

Some of these factors include:

- (i) **Type of soil:** Soils with free drainage, such as sand soil, tend to lose water fast through seepage. Such soils require to be irrigated more frequently compared to soils with low drainage such as clayey soils.
- (ii) **Type of crop:** Some crops require more water than others thus they should be irrigated more frequently and for a longer duration Such as paddy rice and vegetable crops,
- (iii) **Weather conditions:** During hot and dry weather, the rate of evapotranspiration ration is high. Thus crops and the soil tend to lose water faster. This calls for more irrigation water than when it is cool,
- (iv) **Moisture content of the soil:** If an area has recently received rainfall, the soil is still having some moisture and if one is to irrigate, only a small amount of irrigation water will be required.

(v) **Presence of mulch:** Mulching conserves soil moisture by reducing its rate of evaporation. This calls for low frequency of watering the crops.

(vi) **Stage of plant growth:** Some crops require more water in certain stages of their growth than other stages. Maize requires more water during the silking and rilling stage of its growth.

How to irrigate vegetables in a school garden

Step I

Decide on the method of irrigation to use. This may be influenced mainly by:

- (i) Type of crop to be irrigated. Sprinkler irrigation is not appropriate for crops like tomatoes, that are susceptible to fungal diseases,
- (ii) Available capital. Some methods are more expensive. Use of hose pipes and watering cans are the cheapest,
- (iii) Skills available. Drip irrigation requires specialised skills.

Step II

Gather the required equipment such as hose pipe, watering can and sprinkler.

Step III

Irrigate the crop as follows.

(a) Using a hose pipe

Connect one end of the hose pipe to a water tap.

Open the water tap for water to flow out through the hose pipe.

Hold the other end of the hose pipe.

Direct the hose pipe to the crop to be irrigated.

Create pressure by partially blocking the opening of the hose pipe for water to reach the crops that are some distance away.

Ensure all crops get adequate water

(b) Using a watering can

- Fetch water into the watering can
- Carry the water to the vegetable garden.
- Apply water to the crops by slanting the can for water to come out through the nose.
- Ensure all crops get adequate water.

(c) Using the hose pipe and sprinkler

- Connect one end of a hose pipe to a water tap.
- Connect a sprinkler to the other end of the pipe.

- Place the sprinkler in an appropriate position in the garden.
- Open the tap for water to flow through the pipe and out through the sprinkler.
- Check that the crops have received adequate water.
- Shift the sprinkler to another location so as to water other crops.
- The position of the sprinkler should be such that the circular areas irrigated should overlap to ensure that no crop is left unwatered.

Step IV

- Gather the equipment used
- Clean the equipment
- Store them properly

Selection of an irrigation system

There are several irrigation systems a farmer can choose from. The choice of such is influenced by several factors such as:

- Topography
- Source of water .
- Type of crop
- Value of crop Capital available
- Type of soil
- Technical knowhow

(a) Topography

Surface irrigation requires a relatively flat area where water can flow slowly with little or no soil erosion. Piped irrigations can be practised in any topography as there is no risk of erosion.

(b) Source of water

Surface irrigation requires large water sources such as a river, a dam or a fresh water lake since it requires large amounts of water. Piped irrigations are more water economical and thus water from streams may be adequate.

(c) Type of crop

Paddy rice can only be grown under flood irrigation because it requires that the field remains covered with water. For crops that are highly susceptible to fungal diseases, overhead irrigation should be avoided as it increases the incidence of the diseases.

(d) Value of crop

Some systems of irrigation are very expensive to install; for example drip irrigation. The farmer should only choose drip irrigation in case the crop to be grown has a very high profit margin. It would be uneconomical to grow maize under drip irrigation. High value vegetables however can be grown under drip irrigation.

(e) Capital

Surface irrigation is relatively inexpensive to establish compared to piped irrigation. A farmer with little capital may not afford to install piped irrigation.

(f) Soil type

Soil water holding capacity and drainage influences the system of irrigation a farmer is to practise.

Surface irrigation requires soil with poor drainage and high water holding capacity, otherwise a lot of water would be lost through infiltration. Piped irrigation can be practised on any soil type because the water flows inside pipes.

(g) Technical knowhow

The skills required and technological advancements also influences the system of irrigation to be used. Drip irrigation requires high technological knowhow compared to surface irrigation.

Establishing an irrigation unit

An irrigation unit is a set-up that provides water to the crops automatically. The set-up could be for drip irrigation or sprinkler irrigation.

Requirements

1. A timer that could be battery operated.
2. Pressure regulator.
3. Garden hose of appropriate length.
4. Hose thread adaptors.
5. Main drip lines a quarter inch plastic tubing.
6. Assortment of connectors T-shaped, L-shaped and below joints.
7. Emitter lines 1/8 plastic tubing.
8. Emitters.
9. Tape measure.

Procedure

1. Determine the water source, either a tank or an outdoor faucet.

2. Lay the main drip line and the emmitter line under the sun to soften the plastic, so that its easier to work with.
3. Fix the emmiters or nozzles at appropriate intervals, according to the crop spacing along the emmitter lines.
4. Have enough emmitter lines for all the crop rows in the field.
5. Cut the main line with a pair of scissors and push the ends into the T-shaped connectors.
6. Connect each emmitter line to a T-shaped connector already fitted on the main line.
7. Connect the timer to the tap of the water tank followed by hose thread adaptor, garden hose and another hose thread adaptor.
8. Connect the main drip irrigation line to the final hose thread adaptor.
9. Set the timer on manual and then set it on, turn on the tap.
10. Water will be seen spouting from the emitters, adjust the amount of water flowing using the tap.
11. Check for leakages along the whole unit, and if any seal them appropriately.
12. Set the timer, time duration for watering the type of crop to be irrigated and also the amount of moisture already in the soil.

Maintaining an irrigation unit

Maintenance of an irrigation unit depends on the system of irrigation being practised; whether surface irrigation or piped irrigation.

(a) Surface irrigation

In surface irrigation, water is brought to a crop field from its source through canals

or furrows. This method of irrigation allows water to flow or to be directed along channels.

Surface irrigation units can be maintained in the following ways.

- Repairing levels if broken.
- Removal of weeds in the canals, basins inlet and outlet.
- De-silting of canals.
- Repairing of sluice gates.

(b) Piped irrigation

This is where the water is conveyed through pipes to reach the field. The water must be under pressure hence the need of some mechanical forces. Maintenance practices of a piped irrigation unit include:

- *Repairing broken components such as pumps.*
- *Replacing broken pipes, sprinklers among others.*
- *Occasionally flush the pipes with phosphoric acid to remove salts especially where saline water is used.*
- *Replacing faulty parts such as emmitters or nozzles. Unblock the sprinkler nozzles in case they are blocked.*

Unit 5

Experimental Design

Experimentation is a type of research design that deliberately imposes the treatment on a group of objects or subjects in the interest of observing their response. Experimentation differs from observational study where data is collected and analysed without changing the existing conditions. In an experiment, all factors are held constant except the treatment; that is the independent variable. Usually, an experiment is carried out under highly controlled settings. An experimental design is the way in which a particular experiment is planned out. A good experimental design should give reliable results.

Two experimental designs are discussed in this section.

- Randomised block design
- Latin square design

(a) Randomised block design

Blocking is the practice of putting similar test subjects or objects together. These test subjects or objects are then known as a block.

Each block then will be made up of subjects or objects that are similar hence a homogenous block.

Each homogenous block is then given similar treatment levels of the primary factor in a random manner.

The main idea is that variability within each block is less than the variability of the entire sample. This gives more accurate and hence more reliable results than in a situation where there was no blocking.

Factors that may be considered when blocking the subjects or objects of a given study may include:

- Sex, age and breed of livestock. A livestock researcher may decide to block the subjects of study (livestock) in terms of their age. Thus young ones, middle aged and old ones.
- Light and temperature for crops in a greenhouse and variety of crop in crop production.

(b) Latin square design

This is a specialised experimental design for experiments with highly variable experimental units. If blocking was done in conducting such experiments, each block would typically have only one experimental unit.

Latin square design allows for two blocking factors. That is, it can be used to simultaneously control or eliminate two sources of nuisance variability in an experiment.

The Latin square design (LSD) can be visualised as a square, with rows and columns to form blocks, and treatments represented with Latin letters A, B, C and D these are the treatments factor level.

The number of rows and columns have to correspond with the number of treatment levels.

In this case the number of rows and columns is equal to four and similarly the number of treatment levels is also equal to four.

Rows/ columns	1	2	3	4
1	C	A	D	B
2	D	C	B	A
3	A	B	C	D
4	B	D	A	C

Each treatment level appears in each row and each column. Each treatment, A, B, C and D, appears in every row and every column. This ensures each treatment under all the blocking conditions is tested in the experiment. Use of Latin letters to represent the treatment factor levels gives the experimental design its name.

Designing an experiment

(i) *The first thing to do when designing an experiment is coming up with a hypothesis. A hypothesis is an educated guess about a particular problem or idea.*

(ii) *Identifying the variables to be used. Variables or factors are measurable aspects of an experiment. There are two types of variables.*

- **Independent variables:** *These are the variables that can be manipulated by a researcher. Thus they can be administered at different intensities. These intensities are known as levels of a variable.*

For example in fertiliser application, quantities applied may be varied in different subjects. In maize plants, it may be varied for example 50 kg per ha, 75 kg per ha, 100 kg per ha, 125 kg per ha among others.

- **Dependent variables:** *These are variables that change depending on how the independent variable is being manipulated. As the fertiliser levels are*

increased, the output of maize is expected to change. The dependent variable, which is the maize output, therefore provides data for the experiment.

- (iii) *Selecting the experimental unit.*
- (iv) *Administering a treatment to an experimental unit.*
- (v) *Establish a control experiment. This is similar to the experiment units but lacks the treatment.*
- (vi) *Observing or measuring results,*
- (vii) *Recording data results,*
- (viii) *Making conclusions,*
- (ix) *Reporting on errors*

Factors to consider when laying out experiments

The following factors need to be considered when laying out experimental designs:

- *Treatment*
- *Randomisation*
- *Replication*

(a) Treatment

A treatment is anything a researcher deliberately imposes on experimental units. Treatments are carried out with a view of solving a hypothesis. A farmer can plant hybrid maize at different time intervals in the rainy seasons so as to determine the most suitable time for planting. In this case, different time intervals are the treatment given to each experimental unit.

Treatments are administered to experimental units in levels; that is, the amount or magnitude of the treatment. In the example above; if planting was done at intervals of one week, and the experimental units were four, then the first was planted at 1 week, 2nd at 2 weeks, 3rd at 3 weeks and the 4th at 4 weeks. These would be the four levels of treatment.

(b) Randomisation

This is the practice of assigning objects of study to an experimental unit by chance. Randomisation is the true way of creating homogenous treatment units which helps to eliminate any form of potential bias from the researcher. There are several methods of randomising experimental designs.

- (i) ***Completely randomised design.*** *This is where all the objects or subjects of study are assigned to groups completely at random.*

(ii) **Randomised block designs.** This is where the subjects or objects are first divided into homogenous units, known as blocks, before they are randomly assigned to treatment groups.

(c) Replication

This is the second principle of experimental designs. Replication involves repetition of the basic experiment. Variations in an experiment may arise from the fact that, the experimental units such as land or individual livestock cannot be physically identical. The experiment is therefore performed more than once, each repetition is referred to as a replicate. Replication has the following benefits:

- Secures more accurate estimates of the experimental error.
- Decreases experimental errors thus increasing precision.
- Obtains a more precise estimate of the mean effect of a treatment.

Randomisation of treatments

Randomisation is a key principle in statistical theory and more so in experimental designs.

There are various techniques of randomisation that can be employed. Some are outright manual and others are automated.

Manual methods of randomisation include:

- Shuffling of playing cards.
- Drawing pieces of paper from a bag.
- Throwing a dice.
- Tossing a coin.

(i) Tossing a coin

A farmer intends to test the performance of two maize varieties within his ecological area.

He intends to have two replicas, thus four plots of equal size are prepared.

How does the farmer decide which variety of crop to plant in a particular plot?

Assign variety of Maize A, heads, and variety of maize B, tails.

Toss the coin and if tails come first, assign variety B on the 1st plot on the left and variety A on the plot on the right.

1st Replica	B	A
2nd Replica	A	B

Allocations on the replica are done such that none of the experimental units appear twice on each row.

(ii) Using a dice

A dice is six-faced with each face having a specific value from 1-6.

(iii) Using pieces of paper

Get six blank pieces of paper of the same size. Write on each paper a number from 1-6.

Put the pieces of paper in a container or hat. Pick a paper without looking at them.

Allocate the number you have picked on the first column on the left. Repeat the process until the first row is filled.

In any of the above techniques, previous outcomes do not give even the slightest clue to the future outcomes. This is because the two, the previous outcome and the future outcome, are truly random events.

(iv) Use of random number tables

This entails using a table of numbers generated in an unpredictable, haphazard sequence.

It could be a manually done table. However, today random numbers can be generated by a computer.

Randomisation involves randomly allocating the experimental units across the treatment group.

Conducting an Agricultural Research

The following should be put into consideration when carrying out an agricultural research.

- Applying treatments
- Collecting data
- Recording data
- Analysing data
- Evaluating data

(a) Applying treatments

Treatments to the selected subject should be done randomly; this is known as random assignment. It refers to the process of deciding which subject gets which treatment.

The treatment should be the only practise carried out on the subject different from the rest of the population.

(b) Collecting data

Data is anything given as a fact on which research conclusions will be based. Data is the end result of a research procedure. Tools used in data collection include:

- *Observation*
- *Questionnaires*
- *Interviews*
- *Document analysis*

Observation is the most commonly used technique of data collection in agricultural research. It involves the use of all senses to perceive and understand any experience of interest in the research. In collecting data ensure the following.

- *Collect accurate data.*
- *Record the data in a book to serve as reference.*
- *Use proper tools for carrying out measurements such as weight, height and length.*

(c) Recording data

Collected data must be represented in the result section of a research report. Data can be recorded in various ways. These are:

- *Tables*
- *Graphs*
- *Figures*

(I) Tables

Used to record precise numerical data. A good table should have the following:

- *Table number*
- *Title*
- *Column headings*
- *Row headings*
- *Body of the table*
- *Foot notes*

A table should be self-explanatory and clearly show the main points. Units of measurement should be well indicated such as cm, kg and tonnes. Figures

should be rounded off to two significant figures such as 8.27 cm rather than 8.2568 cm.

(ii) Graphs

These are used for illustrating trends and relationships among sets of variables. There are different types of graphs such as:

- **Line graphs** - show relationship among data.
- **Bars and histograms** - used to compare quantities.
- **Pie charts** - show proportions of a whole component as wedges of a circle. A percentage must be assigned to the segment or wedge.
- **Flow charts** - shows the process of a complex system

Example

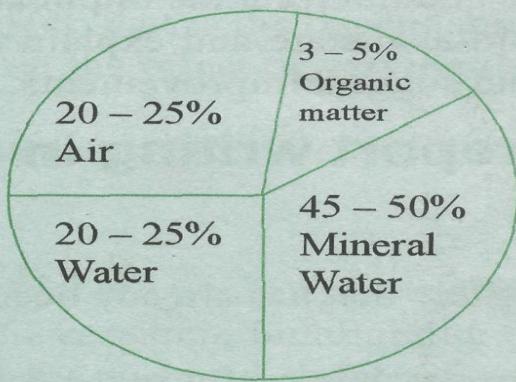


Fig. 5.1: Composition of soil

(iii) Figures

These are used to show vivid evidence of research findings. They include line drawings and photographs.

(d) Analysing data

This deals with the organisation, interpretation and *presentation of collected data. Data analysis involves separation of data into constituent elements and evaluating it to distinguish its component elements separately or in relation to the whole data.

Techniques of data analysis

There are two techniques of analysing quantitative data. These are:

- *Descriptive*
- *Inferential*

(i) Descriptive analysis

This involves the use or measures of;

- Central tendencies such as mean, median and mode. Such describe how close a measure is to the central measure.
- Dispersions such as range, quartile deviation and standard deviation, to describe a group of subjects. Such describe how far a measure is from the central measure.

This technique of analysis is mostly used when the researcher does not want to generate the finding of the experiment beyond the sample.

(ii) Inferential analysis

This is where statistics are used to draw conclusions about the population from which the sample was taken.

(e) Evaluating data

This is the discussion of the results and describing the implications of the findings. The researcher mainly identifies and interprets the major findings; the ones that relate directly to the study objectives.

The researcher should evaluate and interpret the implications of the study to the original hypothesis. One should also state and explain how the study helps to resolve the original problem and suggest improvements.

Importance of report writing in agricultural research

What it a research report?

This is a detailed account of a study that has already been concluded. It presents the results of the research.

Report writing in agricultural research is useful in the following ways:

(I). Provides a means of presenting ones findings after the research is concluded. This makes the researcher to have self-satisfaction that his work is available for other people to read.

(ii) Outline the significance of the findings.

(iii) Give recommendations, this is a possible source of further research.

(iv) Allows other scientists to assess work and criticise it.

(v) Allows other scientists to replicate your work and either approve or disapprove it.

(vi) Are important to those who financed the research because it enables them to see what their money was put into.

(vii) Research reports can be used in decision and policy making with an aim of improving agricultural production, viii. Reports provide reliable permanent information that can be available over a long period of time.

Format for report writing

A scientific agricultural research report should have the following sub titles:

- *Title*
- *Introduction*
- *Aim*
- *Objectives*
- *Material and methods*
- *Design of the experiment*
- *Results*
- *Discussion of the results*
- *Conclusion*
- *Recommendation*

(a) Title

This is a statement that describes what is being investigated.

The title appears on the first page of the report.

A good title gives a summary of the main idea of the research in a simplified and clear way.

It should have a clear subject; that is the dependable variable.

An example is "A report on the effect of varying depth of planting on the yield of maize".

The subject of the study is the maize yield and the dependable variable is depth of planting.

(b) Introduction

Introduction is usually the first chapter in a report. It provides the basis of the study. It gives an overview of the research, highlighting the background information, statement of the problem being analysed, the significance and scope of the research.

(c) Aim

This is also referred to as the purpose of the research. It simply gives the general intention of the research. It elaborates on the information mentioned in the title by giving a quick overview of the study.

The aim should be as brief as possible. An example is "the purpose of this study is to explore the effect of varying depth of planting on the total yield of maize using experimental design."

(d) Objectives

These are the specific aims of the study. They show specific outcomes that specify more directly what the research is going to do.

Objectives are a breakdown of the purpose into small user friendly units.

A good research objective should be:

- (a) Specific
 - (b) Measurable
 - (c) Attainable
 - (d) Realistic
 - (e) Time bound

(f) Clearly indicate the variables to be investigated and their relationship such as:

- Determining the relationship between depth of planting maize seeds and the yield of maize in Balaka District in Malawi.
 - Establishing the effect of deep seed placement to the yield of maize in Balaka District in Malawi.
 - Establishing the effect of shallow planting of maize seeds to the yield of maize seeds in Balaka District in Malawi.

(e) Materials and methods

This clearly indicates all the materials and equipment that were used in carrying out the research such as hoes, machetes, garden lines, fertilisers, manure, maize seeds and the variety among others. It also outlines the procedure followed when carrying out the research.

(f) Design of the experiment

This describes the pattern or strategy the researcher has used in conducting the research. There are several designs that can be used depending on the set objectives of study. The researcher should:

- *Identify and name the research design.*
 - *Briefly and in concise terms, describe the design.*
 - *Justify for the use of the design.*
 - *Explain how the design will be used.*

(g) Results

This gives a detailed description of the results obtained after data analysis. The data collected can be presented in form of tables and figures. There are two kinds of data that can be collected in a study:

- Quantitative data
- Qualitative data

(i) **Quantitative data** is got from measurable variables. There can be measured using a scale that shows how much of the characteristic is present. These variables include height of seedling, size of the cob, yield of maize per unit area.

(ii) **Qualitative data** indicates the objects under study and individual differences that a researcher can find in a particular category.

When presenting findings, the research restates each objective and then includes all the findings related to that objective.

The data collected should be analysed using a suitable technique and presented in an acceptable and conventional manner.

(h) Discussion of the results

This involves the interpretation of findings in the research objectives. The following procedure should be followed.

- Give a brief summary of the problem that was being investigated.
- Present the major findings under each objective.
- Discuss the possible reasons why the results occurred that way.
- Make theoretical interpretations of the findings.

(i) Conclusion

This is a result of a reasoned judgement of the issues raised in the research process. The conclusion should be based on the research problem (that is the main hypothesis) and also on the research objectives.

(j) Recommendations

These present the possible solutions to the research hypothesis based on the findings of the research. The recommendations should have a target group (that is what is to be done how and when) Suggestions for further research in the same field should be given.

Unit 6

Gender and gender roles in agricultural production

The term 'gender roles' refers to cultural, or social duties, performed by either male or female members in a given community.

Agriculture can be an important engine for growth and poverty reduction in Malawi. However, more than half of Malawians are women whom about 75% are illiterate. This has greatly affected the participation of women in agricultural development.

Women make up between 60 to 80 % of the agricultural labour force.

The following roles are played by women in Malawi:

- (a) Producing agricultural crops. Women do activities like weeding, harvesting, fertiliser application and other related duties.
- (b) Rearing livestock.
- (c) Processing and preparing food.
- (d) Working for wages in agricultural or other rural enterprises.
- (e) Collecting fuel and water.
- (f) Engaging in trade and marketing.
- (g) Caring for family members and maintaining their homes.

The participation of women in agricultural production is limited by the following:

- (i) **Land ownership:** in customary laws of land ownership, land is owned by men and they have sole rights to decide on the proportions of what is to be produced.
- (ii) **Land use:** Men make decisions on growing of cash crops while women are involved in production of food crops. This includes planting, management practices, harvesting and storage. Men may not be involved in the actual production of the cash crops but they make marketing decisions. Women are involved in management of livestock but can only make decisions on marketing small livestock like chicken. Marketing of the main livestock such as cattle is done by men.
- (in) **Access to credit:** Women have no right over land ownership and hence cannot use it as a form of security to get loans. The decisions for loan acquisition are made by men.

- (iv) **Extension and training services:** Although women form majority of farmers in Malawi, they have limited access to extension and training services. This is due to socio-cultural values and low levels of education.
- (v) **Use of farm income:** Although women are involved in cultivation and management of livestock, the decisions on how to use the income upon sale of the produce is left to men. Very little of the income is invested back in the farming or used to improve the living standards of the family.

Equal division of labour in agricultural development

In Malawi, it is clear that there is unequal division of labour in agricultural production.

Women do more of agricultural activities compared to men. Therefore, it is better when both men and women contribute equally towards agricultural production. This will promote agricultural production in the following ways:

- Men and women will be working as a team; hence decisions will be made jointly.
- Men and women will cooperate in all farming activities.
- Work on the farm will be fairly distributed between men and women hence no overworking of one group.
- Men and women will make consultative decisions in income utilisation and investment.

Role of women in making decisions in Agricultural Production

Though women make up the biggest fraction of the labour force in agricultural production, they are rarely involved in making major decisions. Major farming decisions are a preserve of their male companions. This is further compounded by the fact that in most households, men are employed elsewhere; mainly in the urban areas.

Women are involved in making minor decisions in agricultural production and more often, in consultation with their husbands. Such decisions include:

- Time of land preparation
- Time of land planting
- Time of land weeding
- Time of land harvesting
- Time of land applying fertiliser
- Selling of minor produces such as, vegetables, fruits and small stock like chicken and eggs.

- *What food crops to produce.*
- *How much food crops to produce*

Other decisions made by women in consultation with their husbands include.

- *What commercial enterprise to undertake*
- *Marketing of major produce like tea and cotton.*
- *Selling of major livestock such as cattle, pigs and goats.*
- *How to produce; that is the technology to use.*
- *How much to produce; that is the size of each enterprise.*

Impact of gender roles in agricultural production

The following include effects of the existing gender roles:

(a) Inappropriate land preparation

Over 70% of Malawian households are headed by women. They have less labour available for heavy tasks like land preparation because they have fewer male family members. This leads to inadequate and late land preparation.

(b) Late planting

Late land preparation leads to late planting which affects general crop yields.

(c) Low yields

As a result of poor land preparation and late planting, crop yields will always be below average.

(d) Low quality produce

Farmers do not practise timely pest and disease control measures because the pesticides may not be available at appropriate times.

(e) Low household income

Low agricultural output and low quality produce lead to low income to the farmers.

(f) Low adoption of mechanised agriculture

Most farmers being of low levels of education, have a hard time understanding modern agricultural technology. This therefore leads to inefficient agricultural production.

UNIT 7

Farming Systems

Introduction

There are several activities or enterprises that can be found in a farm. These activities or enterprises are organised in various ways depending on:

- *Size of the land Capital available*
- *Labour available*
- *Management skills*

Level of technology available

7.1: Meaning and types of farming systems

A farming system refers to the way a farmer organises and carries out farming activities on his or her farm. There are basically two types of farming systems namely:

- *Intensive*
- *Extensive*

7.2: Intensive farming system

This is a system of farming that is characterised by high capital investment and maximum utilisation of available land.

Methods of farming under intensive farming system

These include:

- *Mixed farming Mixed cropping*
- *Zero grazing*
- *Deep litter poultry rearing systems*
- *Battery cage poultry*
- *No-till cropping/zero tillage*
- *Organic farming*

(i) Mixed farming

A method of farming that involves growing of crops and rearing of livestock on the same piece of land.

Advantages

- *Animals can be used as a source of farm power.*
- *There is mutual benefit between the crops and livestock that is, livestock produce manure for crops and crop remains are used as livestock feed.*

- *There is diversification hence security.*
- *There is maximum utility of land.*
- *Animals waste can be used to produce biogas.*

Disadvantages

- *Requires a lot of labour.*
- *Requires high level of management skills.*
- *Requires high capital investment.*
- *Livestock may damage crops if not well confined.*

(ii) Mixed cropping

This is the growing of two or more crops on the same field but in different sections of the farm at the same time. Acts as an insurance against a crop failure.

(iii) Zero grazing

In this method, animals do not directly feed on the pasture in the field but are confined in a shed or yard where they are fed that is, feed is cut and brought to them in stall.

(iv) Deep litter system

This is a method of rearing poultry where the birds are confined within a big house.

The house usually has no partition and the floor is covered with absorbent litter. It also has feeders, waterers, laying nests and other requirements.

(v) Battery cage system

In this method, birds are confined in wired cages. The number of birds per cage varies from 1 to 4 depending on the size of the cage, size of birds, the environment and a farmer's preference.

The cages are normally in rows called tiers (that is, a row built over another usually 2 to 3 in number). The cages are arranged back to back and are raised 2 to 3 feet above the ground for ease of cleaning the floor.

The cages have a slopping floor to allow easy rolling of eggs to the collecting tray.

There is a watering and a feeding system which is continuous throughout the cages.

A suitable cage for hens should be 1.4 ft high at the back, 1.8 ft high at the front, 1.5 ft deep and 1.2 ft wide.

(vi) No-till cropping

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This is a method of farming where crops are planted season after season without any tillage. It is also known as zero-tillage. The land is usually heavily mulched to prevent weed growth. Alternatively herbicides are used to control weeds.

The seeds are planted by drilling into the soil.

Advantages

- Reduces soil erosion.
- Reduces the cost of crop production.
- Conserves soil moisture.
- Maintains soil structure.
- Promotes timely planting.
- Prevents root damage of cultivated crops.

Disadvantages

- May encourage build-up of soil borne diseases and pests.
- May lead to poor water infiltration.
- May lead to poor aeration.

(vii) Organic farming

This is a method of farming where there is growing of crops and rearing of animals without using agricultural chemicals. Practices such as mulching using organic materials are also used. Crop rotation is used to enhance organic farming.

Advantages

- Environmental friendly and the products do not have any inorganic chemical residues.
- It utilises organic manure to replenish soil nutrients.
- It also improves soil structure and enhances soil water infiltration and retention.
- It also provides food for the soil microbes which help in releasing minerals for crop nutrition.
- Naturally occurring materials such as medicinal plants are used instead of chemicals.

Importance of intensive farming

Intensive farming can support a growing population in the following ways.

- Through intensive farming there is maximum utilisation of available land, hence higher output per unit area to support the ever growing population. The available land is properly utilised through good pest and disease management, water conserving irrigation, conservation tillage and use of genetically improved crop varieties.
- Intensive farming leads to high yields of good quality due to the high level of management skills and use of modern technology. This provides enough food for the growing population.
- Intensive farming can be practised in densely populated areas hence most appropriate in a country where population is growing fast.
- Intensive farming protects the environment because it reduces the amount of land used for agriculture which is in turn exposed to erosive agents. Therefore intensive farming ensures sustainable agriculture for future generations.
- Intensive farming results in high income per unit area hence providing employment to the increasing force.

7.3: Extensive farming system

This is a system of farming that is characterised by low capital investment and is usually carried out on large tracts of land.

Methods of farming under extensive farming system

- Shifting cultivation.
- Ranching.
- Bush fallowing.
- Cut and carry (Visoso or Chitemere).

(I) Shifting cultivation

This is an old method of farming. It involves ploughing a piece of land and growing crops on it until the soil is exhausted. A farmer then moves to an uncleared land and begins the process once again. The method requires large tracts of land and for that reason it has slowly died out.

Advantages

- Land is given time to rest and regain its fertility.
- Pests and diseases die upon shifting.
- The cost of production is low because no fertiliser is used.

Disadvantages

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- *It can only be practised in areas with large tracts of land.*
- *Its continuous use of the land may lead to soil erosion.*
- *It can only be used for growing annual crops and not perennial ones.*
- *It may lead to land fragmentation.*

(ii) Ranching

This is a method of rearing livestock in vast land. The animals, usually beef cattle, are kept in partitioned pastures known as paddocks.

Advantages

- *There is maximum use of available pasture.*
- *Pasture is given time to regenerate because of paddocking.*
- *It allows the farmer time to carry out management practices on the pastures such as top-dressing, topping and re-seeding.*
- *Animal droppings are evenly distributed in the fields.*

Disadvantage

- *It requires large tracts of land. It has low output.*

(iii) Bush fallowing

This is also known as slash and burn agriculture. It is the practice of clearing small plots of land to cultivate for a few years (generally 2 to 5 years) and then leaving the land under natural vegetation for much longer periods usually more than 5 years to restore soil fertility.

(iv) Cut and carry (Visoso or Chitemere)

In this method, crop residues and any forages are cut and carried from communal areas, or other farms, and taken to the fields to feed tethered animals.

Importance of extensive farming

An extensive system of farming has the following benefits.

- *It is cheap due to low capital input.*
- *It requires less labour input.*
- *It ensures proper utilisation of marginal areas which could not have otherwise been utilised.*
- *It does not require a high level of management or skills.*

Unit 8

Financial Agricultural Enterprises

Introduction

There are several activities involved in agricultural production. Such activities require financing. Most farmers lack adequate capital to finance their farm businesses.

8.1: Sources of finance for Agricultural Production

Farmers can acquire capital in various ways. They include the following:

- Credit facilities Personal savings
- Inheritance
- Grants or donations

(a) Credit facilities

Farmers can borrow capital either in cash or in kind (that is in form of farm inputs). Credit may be attained from the following financial service providers:

(i) Commercial banks

There are several commercial banks in Malawi which offer credit services to farmers. The credit is payable with interest. The interest rates vary from one bank to another. Banks however demand security for the loans. The security can be in form of buildings or land title deeds. Most farmers in Malawi do not borrow from commercial banks as they fear indebtedness.

(ii) Non-bank formal service providers

These include insurance companies, pension companies, Malawi stock exchange (MSB) among others.

They offer credit services to farmers, although not very popular.

(iii) Micro-finance providers

These include the financial cooperatives, SACCOs and micro-finance institutions. These finance providers work under the Malawi union of savings and credit cooperative (MUSCO) and Malawi microfinance network (MAMN). The MUSCO and MAMN coordinate and organise the exchange of information and farm inputs to farmers.

(iv) Informal providers

These include rotating savings and credit associations, village savings and loans associations or individual money lenders (also known as katapila).

These informal services are the most utilised forms of finance in rural areas. These katapilas (private individual money lenders) provide short term loans at short notice with relatively high interest rates without necessarily requiring

security or collateral. The loans are payable in one to two months and are repaid in a single installment.

Types of credit

Credit can be classified into two categories depending on:

- *Repayment period*
- *Type of security demanded*

On the basis of repayment period, there are three types of credit. They include:

- **Short term credit:** *Usually repaid within 1 year.*
- **Medium term credit:** *Usually repaid within 2 to 5 years.*
- **Long term credit:** *Repayable within 5 to 15 years.*

Depending on the type of security demanded, there are:

Soft loans: *These are offered with little or no security. **Hard loans:** These are offered against immovable assets as security, such as land.*

(b) Personal savings

A farmer can set aside part of his or her income to accumulate over a period of time. When enough accumulative savings have been made, the farmer uses it to buy capital assets needed for the production process.

(c) Inheritance

One may inherit capital from relatives or close friends.

(d) Grants or donations

Individual farmers or a group of farmers may be awarded grants by sponsors or well wishers.

These donations can assist farmers to start agricultural projects.

8.2: Conditions and terms for borrowing

Different financial institutions stipulate the lending and repayment conditions as well as securities to be offered.

Some of the general terms and conditions include the following:

- (a) *Repayment period must be clearly stated.*
- (b) *Interest rates have to be specified.*
- (c) *Default. This specifies what happens in case one fails to pay on time.*
- (d) *Loans are negotiated between applicant and financing institution.*
- (e) *Before receiving the loan the applicant must sign the contract forms.*
- (f) *Some financial institutions give credit against immovable assets.*

Base interest rates

This is the minimum interest rate that investors will accept for investing in a non-treasury security. It is set and published by commercial banks. It is also known as the minimum interest rate or benchmark interest rate.

Effective interest rate

This is also known as effective annual interest, annual equivalent rate (AER), market interest rate discount rate or the annual percentage rate (APR). It is the interest rate on a loan restated from the nominal interest rate as an interest rate with annual compound interest payable. It attempts to describe the full cost of borrowing. It takes into account the effect of compounding interest which is left out on the nominal or stated interest rates. For example, a loan may have 10% interest because more interest is accumulated each month.

Calculation of effective interest rate on borrowed money

Determine stated interest rate and number of compounding periods for the loan.

The stated interest rate will be expressed as a percentage.

The compounding periods will generally be monthly, quarterly, annually or continuously. (This refers to how often interest is applied.)

The effective interest rate is calculated through a simple formula.

$$r = (1 + i/n)n - 1$$

where r is effective annual rate

i is the nominal interest rate

n is number of compounding periods per year

Example 1

A loan with a stated interest rate of 5 % that is compounded monthly, using the formula

$$r = (1 + 0.05 / 12) - 1$$

12

$$= 5.12\%$$

Note: Effective interest rate will always be greater than the stated rate.

If interest is compounded continuously, you should calculate the effective interest rate using a different formula.

$$r = e^l - 1$$

Where r is effective interest rate

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i is the stated interest rate

e is the constant = 2.718

Example 2

Consider a loan with a nominal interest rate of 9% compounded continuously.

The above yields:

$$r = 2.718^{0.09} - 1$$

$$= 9.417\%$$

Example of calculated effective interest rates

Nominal rate	Semi-annually	Quarterly	Monthly	Daily	Continuous
1%	1.002%	1.004%	1.005%	1.005%	1.005%
5%	5.062%	1.005%	5.116%	5.127%	5.127%
10%	10.250%	5.095%	10.471%	10.516%	10.517%
15%	15.562%	15.562%	16.075%	16.180%	16.183%
20%	21.000%	21.551%	21.939%	22.134%	22.140%
25%	26.563%	27.443%	28.073%	28.392%	28.403%
30%	32.250%	33.547%	34.489%	34.489%	34.986%

Calculating effective interest rate is actually calculating the cost of borrowing money.

Example

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If a farmer borrowed a loan of Mk 100,000 at an interest rate of 18% to be repaid within one year.

(a) Calculate the total amount of money the farmer will have paid by the end of the year. Firstly calculate the effective interest rate. Thus:

$$r = (+6.18)2 - 1$$

12

$$= 19.561 \%$$

Then calculate the amount of effective interest rate. Thus:

$$= \frac{19.561}{100,000} \times 100,000$$

$$= \text{Mk } 19,561$$

Unit 9

Crop Husbandry practices

9.1: Land preparation

Land preparation involves the practices carried out on a particular piece of land to create a suitable soil tilth in readiness for planting. The size of soil clods, the soil depth and the looseness of the soil must be appropriate in order to facilitate the germination and establishment of the crops. Timely land preparation and deep ploughing creates favourable conditions for easy management of subsequent field practices, such as, weeding and pest control. Land which has been prepared for the purpose of growing crops is called a seedbed.

Importance of land preparation

- To remove vegetation cover which may interfere with the subsequent operations.
- To bury organic matter into the soil which later decomposes. This helps in binding soil particles as well as adding nutrients into the soil.
- To kill pests and disease causing micro-organisms. This is by exposing the soil-borne pests and disease causing organisms to harsh environmental conditions on the soil surface, thus killing them.
- To kill perennial weeds, like couch grass, which would otherwise compete with the crops.'
- To improve the physical condition of the soil by loosening soil making it suitable for root development that is root penetration. This facilitates proper anchorage of plants.
- To improve infiltration of water into the soil.

- To try to bring up to the surface the nutrients which are present within the subsoil section of the soil for the benefit of crops grown later.

Operations in land preparation

Land preparation involves a number of operations. These operations can be grouped into four categories:

- Land clearing
- Primary cultivation
- Secondary cultivation
- Tertiary operations.

(a) Land clearing

Land clearing can be defined as the removal of vegetation cover from the surface before ploughing. The vegetation could be trees, the previous season's crop remains, weeds, grasses, shrubs, "among others. It involves the following activities:

- Felling of trees and removal of tree stumps.
- Slashing or cutting of tall grass or shrubs or bushes.
- Burning of vegetation. This is not recommended as it destroys the soil structure and kills useful soil micro-organisms. Fire can also spread to an area where it was not intended, and this may lead to destruction of property, forest or already established crops in nearby farms.

Land clearing can be done manually (hand method), using chemicals or it can be mechanised (using machinery).

(i) Hand method

It involves the use of hand tools like machetes and slashers. The use of these tools is slow and therefore only a few hectares of land can be cleared over a long period of time. This method leads to delay in seedbed preparation and may result in late planting, and consequently, poor crop yields. This method of land clearing is commonly used by small scale farmers.

(ii) Chemical method

It involves the use of chemicals called herbicides which kill weeds. For example Roundup, Gramoxone, Atrazine, among others.

(iii) Mechanised method

This involves the use of tractor-mounted implements for example tractors with a chain to fell trees in a forest and bulldozers to remove stumps. This method is commonly used by large scale farmers.

Advantages

- It is efficient in land clearing.
- It has a low labour requirement.
- Large areas can be cleared within a short time. Limitation: The cost of purchasing and maintaining the machines is high.

Importance of land clearing

- It makes subsequent land preparation operations, such as, ploughing, easier and efficient.
- It helps in the eradication of pests and diseases. Certain crop diseases, such as the Armillaria root-rot, which affects tea bushes, can be prevented by removal and destruction of stumps. Pests and animals, such as squirrels, mice, and monkeys, which destroy crops inhabit bushy lands.
- It helps open up virgin land. Forest land or bushy areas cannot be cultivated unless first cleared of the bushes or forest trees. However, forests are water catchment areas and should be avoided for cultivation purposes.
- It is a land reclamation method, especially in warm humid bushy lands. These areas are prone to tsetse fly infestation and are not suitable for human settlement and livestock keeping. Therefore, land clearing in such areas makes them become habitable by people and livestock.

(b) Primary cultivation

This is the initial opening of land either after clearing the bush or after a previous season of cropping.

Primary cultivation can be carried out using hand tools or mechanically using various tractor-drawn or ox-drawn ploughs.

Importance of primary cultivation

- It makes subsequent operations easier.
- It facilitates aeration and water infiltration in the soil.
- It controls weeds, such as rhizomatous weeds, by burying or uprooting them.
- It buries crop residues to decompose and add nutrients into the soil.
- It eases the penetration of the crop roots.
- It controls pests and diseases. This is achieved when one exposes them to the scorching sun or to predators. For example earthworms can be eaten by birds.

Tools used in primary cultivation

Hand method: Small scale farmers use hand tools such as hoes, fork hoes, ox-ploughs among others.

Mechanised method: This is mainly used by large scale farmers. It involves use of disc ploughs, chisel ploughs, mould board ploughs, rotary cultivators (rotavators) among others. Initial capital and maintenance cost in this method is high.

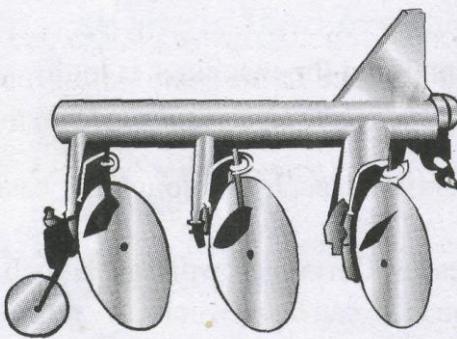


Fig. 9.1 (a): Disc plough

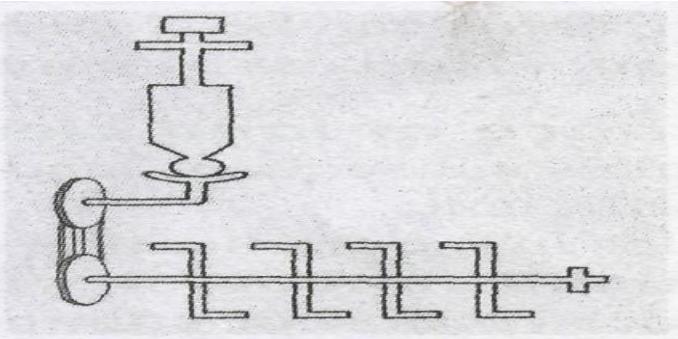


Fig. 9.1 (b): Rotavator

Factors that influence the choice of the tools and equipment used in primary cultivation

- (i) **Type of tilth required:** This will depend on the size of seeds to be planted for example small seeds need fine tilth hence many tools are used.
- (ii) **Cultivation depth:** Deep rooted crops require a tool that will plough deep into the soil.
- (iii) **Type of soil:** Heavy tools are required when ploughing heavy soils.
- (iv) **Soil moisture content:** A forked hoe may be more suitable than a regular hoe in wet soils.
- (v) **Size of the land:** There is need for heavy mechanical implements when dealing with large parcels of land.
- (vi) **Availability of capital:** One may not choose a tractor-drawn plough due to the high costs of purchase and maintenance. The farmer may instead opt for an ox-drawn plough because it is cheaper and can do the same work.
- (Vii) **Topography.** In steep areas animal-drawn implements may be used but tractor drawn implements cannot be used.

Timing of primary cultivation

The best time to prepare the seedbed is during the dry season so that the weeds can be scorched to dry by the sun. A seedbed, which was previously cropped is best prepared immediately after harvesting. Early land preparation enables the farmer to plant early.

(c) Secondary cultivation

These are the subsequent land preparation operations which follow primary cultivation. It involves seedbed refinement practises, that is breaking large soil clods. It is also referred to as harrowing.

Factors determining the number of times secondary cultivation is done

The number of harrowings can be one, two, or more, depending on the following factors:

- (i) **Initial condition of the seedbed:** A roughly prepared seedbed during primary cultivation or opening up of virgin land may necessitate more secondary cultivations.
- (ii) **Size of planting materials'.** Crops that have small-sized seeds require a finer soil tilth and therefore more secondary cultivation operations are necessary.
- (iii) **Slope of the land:** It is advisable to reduce the frequency of harrowing where land is too steep. This is because it pulverises the soil and makes it more prone to soil erosion.
- (iv) **Moisture content of the soil:** Wet soils require more secondary operations. Dry soils require less operations in order to conserve moisture.
- (v) **Type of implement used during primary cultivation:** Some implements are more effective than others. For example, in a land ploughed using a disc plough, the soil clods tend to be larger and a lot of trash and fresh vegetation remain unburied. This hence requires more secondary operations.

Importance of secondary cultivation

- To break large soil clods into finer particles.
- To destroy weeds which may have grown after primary cultivation.
- To create a suitable tilth ready to receive seeds or other planting materials.
- To incorporate organic materials, such as crop residues, into the soil effectively for faster decomposition.
- To level the seedbed so as to facilitate uniform depth of planting and subsequent uniform establishment of crops in the field.
- To help in mixing organic manure, such as compost and farmyard manure, in order to accelerate the release of nutrients into the soil.
- To further help in exposing the soil-borne pests so that they may be destroyed by desiccation.

Tools used in secondary cultivation

For a small scale farmer, simple hand tools like the forked hoe, rakes, regular hoes, ox-plough can be used.

For a large scale farmer, disc harrows, spike tooth harrows, spring tine harrows and cultivators (rotavators) can be used.

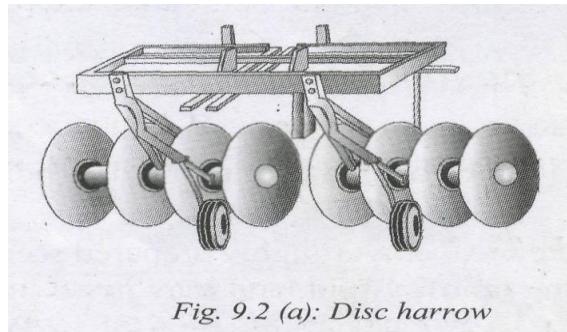


Fig. 9.2 (a): Disc harrow

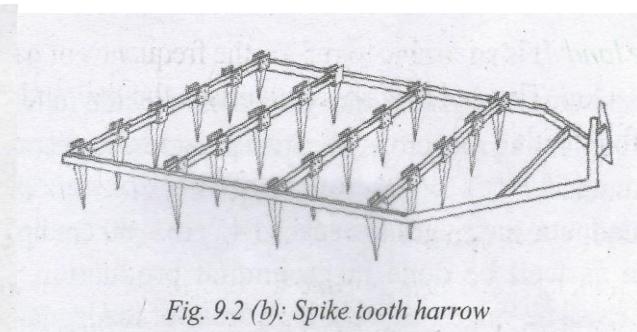


Fig. 9.2 (b): Spike tooth harrow

Mechanised secondary cultivation has the following benefits:

- The rate of work is faster thereby facilitating timely land preparation.
- It is effective in burying weeds.
- It is less laborious.

Table 9.1: Comparison of the hand method and mechanisation

Mechanised method	Hand method
• The rate of work is faster.	• The rate of work is slower.
• The rate of work is faster.	• Inefficient in burying weeds.
• The rate of work is faster.	• Very tiring.
• Facilitates timely land preparation.	• May delay land preparation.

Relating final tilth to the intended planting material

If a farmer intends to plant small seeds, the seedbed should be of very fine tilth, whereas big seeds require medium tilth. Large soil clods have a tendency of covering the seeds inappropriately, thus hindering their emergence

The tilth of a seedbed is important in that, if small seeds are planted in a rough seedbed, the germination rate will be poor, and hence the planting of seeds will be difficult.

When using vegetative planting materials, the tilth of the seedbed is not an important consideration since they can do well in seedbeds of any tilth. The condition of the seedbed influences the ease of operations, such as weeding.

(d) Tertiary operations

These are operations done on the seedbed which are necessitated by the growing of certain crops. They follow secondary cultivation and they are also referred to as miscellaneous operations (that is, the extra operations which may or may not be done depending on a particular crop production need). The most common tertiary operation is ridging.

Ridging

Here soil is dug in a continuous line and heaped on the side to form a ridge. Ridges are good for planting root crops like Irish potatoes, sweet potatoes, cassava as well as groundnuts.

For planting groundnuts, the ridges are spaced 45 cm - 80 cm apart.

Box ridging can as well be done in groundnut production. This involves establishment of cross tie ridges, especially in areas of inadequate rainfall.

Reasons for ridging

- To encourage free expansion of tubers as well as high yielding of groundnuts.
- To make harvesting easy.
- The furrows made in between the ridges helps conserve soil and water.
- Facilitates drainage in waterlogged soils.

9.2: Crop varieties

Maize and groundnuts are the most important cereal and legume crops respectively grown in Malawi.

(a) Common maize varieties

SC403

Takes 90 - 110 days to mature, hence an early maturing variety.

- It is drought tolerant.
- It is resistant to maize streak virus.
- It does well in dry areas under irrigation.
- Under good management, it can yield 3-6 tonnes per hectare

SC407

This is an early maturing variety taking 90-100 days to mature. It is resistant to maize streak virus and grey leaf spot disease. Under good management it can yield 3-7 tonnes per hectare.

SC5/3

This is an early to middle maturing variety taking about 115 days to mature.

- It is a drought resistant variety.
- It is also resistant to grey leaf spot disease.
- Under good management, it can yield 6-10 tonnes per hectare.

SC627

This is a middle maturing variety taking 125-135 days to mature.

- It is resistant to grey leaf spot and maize streak virus.
- It is a high yielding variety, giving 7-10 tonnes per hectare.

SC 709

This is an extremely late maturing variety, taking 130-150 days to mature.

- It is resistant to grey leaf spot disease.
- It is a high yielding variety, giving 11 tonnes per hectare.

SC7/5

This is an extremely late maturing variety, taking 130-150 days to mature. It shows resistance to grey leaf spot disease and maize streak virus. It is a high yielding variety, giving 11 tonnes per hectare.

SC7I7

This is an extremely late maturing variety, also taking 130-150 days to mature.

- It shows resistance to grey leaf spot disease.
- It yields long ears averaging 13 tonnes per hectare.

Note: SC denotes Seed Company which is the largest private seed provider in Malawi.

ZM309

This is an early maturing variety, commonly referred to as Mkawa Sala.

- It is drought resistant variety, which does well in infertile soils.
- It is resistant to maize streak virus, grey leaf spot and other diseases.

ZM523

This is a drought tolerant variety which does well in infertile soils.

DK802I

This is an early maturing variety taking 110-115 days to mature.

- It has a strong resistance to grey leaf spot disease.
- Under good management it can yield 6-8 tonnes per hectare.

DK 8033

This is middle maturing variety taking 115 - 130 days to mature.

- *It is adaptable to a wide range of areas.*
- *It produces two ears, giving a high yield of about 8-9 tonnes per hectare.*

DK805I

This is a middle maturing variety, taking 130-135 days to mature. It has a high milling suitability.

DK807I

This is an extremely late maturing variety, taking 140-145 days to mature.

- *It is also resistant to grey leaf spot disease.*
- *It has high yield giving 9-11 tonnes per hectare.*

Note:

- *DK is the identification code given to hybrids developed by DEKALB (US).*
- *There are new varieties of maize and other crops that are being recommended and released after careful research.*

(b) Common groundnut varieties

CG7 or Red skins

This is a new variety in Malawi commonly found in Thyolo, Balaka and Mchinji districts.

The nuts have a deep red skin and are very uniform in size and distribution.

- *It is suitable for confectionery, oil extraction and peanut butter manufacture.*

Chalimbana

The nuts are light to dark tan in colour.

They have a rich full flavour and are ideal for confectionery and for cooking oil.

Manipintar

This is a runner variety with seeds which are variegated red and white, their size and shapes are irregular.

Other varieties include Chalimbana 2005, Baka, RGI and Nsinjiro.

9.3: Planting

Planting is putting seeds or planting materials into the ground to grow. It is a cultural practice which follows land preparation.

Before planting is done, the seedbed must be prepared to the appropriate tilth depending on the size of seeds to be used.

Timely planting is essential for optimum crop yield especially when growing annual crops such as maize and groundnuts.

The most appropriate time for planting is at the on-set of rains.

Benefits of timely planting

Timely planting has the following advantages.

- (a) *It ensures that the crop makes maximum use of the season's rain.*
- (b) *The crop is able to escape serious attacks by pests such as aphids and maize stalk borer.*
- (c) *The crop is able to effectively compete with weeds.*
- (d) *The crop benefits from nitrogen flush.*
- (e) *It leads to early harvesting enabling farmers to take advantage of high market prices.*

Table 9.2: The effect of delayed planting on maize yield.

Time for planting	Approximate yield (kg/ha)	Maize shelling percentage
Dry planting	1940	62%
4 days after rains	1530	54%
7 days after rains	1150	49%

Selection of planting materials

A planting material from a strong healthy and high yielding parent is more likely to produce an equally strong healthy and high yielding new plant in contrast to one taken from a small diseased and low yielding parent plant.

Young plants from healthy planting materials resemble their parent plants in appearance as well as in genetic makeup such as the ability to resist disease and withstand unfavourable conditions, the ability to ripe early, the ability to yield well and the quality of the produce.

Thus the selection of planting materials should be carefully carried out.

Qualities of good seeds for planting

1. Suitability to the ecological conditions:

The selected planting materials should be well adapted to the environmental conditions of the area, such as; altitude, rainfall, soil type For example, maize variety SC403, SC 407,SC513, ZM309 and DK 8021 are early maturing and can do well in areas with short rains.

2. Certified seeds are those that have been tested and carefully selected based on the following qualities

- High quality and potentiality for high yields

The seeds are selected from parent crops which are high yielding and of high quality.

- Disease resistance

Healthy, strong and disease resistance plant varieties are highly favoured for certification, For example, Maize variety ZM309 is resistant to Maize streak

- Purity

Planting materials should be pure and not mixed with contaminants such as weeds, seeds of different variety or off types.

- Germination percentage

Select seeds with a high germination percentage.

- Free from physical damage

The selected seeds should be free from physical damage.

(a) Planting maize

Maize can be planted either manually or mechanically by use of seed planters. Manual planting is common with small scale holders. Row planting is the most appropriate method of planting maize. The recommended spacing is 90-100 cm x 25-30 cm. The spacing however depends on:

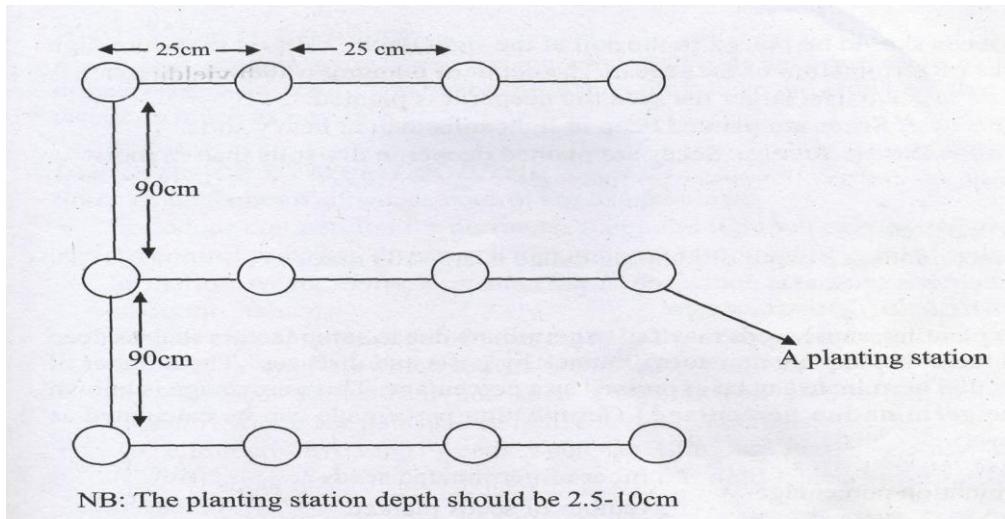
- Number of seeds per hole.
- The cultivated variety (cultivar) grown.
- Soil fertility.
- Rainfall amount of the area.
- Intended use of the crop.

Marking out planting stations

When planting maize manually use a marked planting string to measure out the distance between the planting stations.

The use of a string ensures that the rows are straight and appropriate spacing is adhered to.

For example, mark out the planting stations as shown in the figure below:



The recommended seed rate for maize is 22-30 kg per ha, that is, planting 1-2 seeds per hole. However, it may vary depending on:

- The spacing.
- Number of seeds per hole.
- Intended use of the crop.
- Soil moisture content.

The number of seeds to be planted in a given area of land can be calculated as follows:

$$\text{Number of seeds} = \frac{\text{Size of land} \times \text{Number of seeds per hole}}{\text{Spacing of crop}}$$

Note: spacing of crop is ridge or row spacing x plant spacing

Example I

Given that maize is planted 2 seeds per hole at a spacing of 100 x 30 cm in a plot of land measuring 40 x 30 m, calculate the number of seeds required.

$$\begin{aligned} \text{Number of seeds} &= \frac{4000 \text{ cm} \times 3000 \text{ cm} \times 2}{100 \text{ cm} \times 30 \text{ cm}} \\ &= 8000 \text{ maize seeds.} \end{aligned}$$

The seeds should be placed in the soil at the right depth. This is to ensure high degree of germination of the seeds. The depth of planting is influenced by:

- Size of seed: The larger the seed the deeper it is planted.
- Soil type: Seeds are planted deep in light soils than in heavy soils.
- Soil moisture content: Seeds are planted deeper in dry soils than in moist soils

Planting depth

The recommended depth of planting maize is 2.5 -10 cm.

Germination percentage

After planting, some seeds may fail to germinate due to some factors such as deep placement, inadequate moisture or attack by pests and diseases. The number of seeds that germinate can be expressed as a percentage. This percentage is known as the germination percentage. **Germination percentage** can be calculated as follows:

$$\text{Germination percentage} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds planted}} \times 100$$

(b) Groundnuts

Seedbed preparation

Prepare the soil to medium tilth.

Time sowing: Plant as early as possible. In areas with long wet seasons delay sowing so that harvesting coincides with dry weather to minimise losses of the crop.

Sowing: Seeds should be sown 5 to 10 cm deep.

Spacing: Spacing has an important effect on the prevalence of ground nut rosette, a viral disease transmitted by aphids. In close spacing with complete soil cover, aphids are discouraged from landing and hence low rosette incidences. In wide spacing with uncovered soil, aphids land more readily and hence high

The recommended spacing for erect bunch variety is 45 to 60 cm x 10 cm and for spreading variety a spacing of 60 cm x 10 cm.

Fertilisers and manures

Apply 125 to 250 kg per ha single super phosphate for high yields. Farmyard manure application usually gives good results.

9.4: Weed control

A weed is a plant growing where it is not wanted. Weeds have numerous negative effects on growing crops and hence the farmer must keep the crop field free from weeds as much as possible.

Importance of weed control

Some of the benefits of weeds control are listed below:

- To reduce competition for nutrients, water and light with cultivated crops.

- To control pests and diseases which may be harboured by some weeds such as mallow weed, *Malva neglecta* (*Kapanthi*) which acts as an alternate host of cotton stainer.
- To prevent contamination of farm produce for example, by wild oats, *Avena fatua* (*Nansongole*) which lowers the quality of wheat.
- To eliminate parasitic weeds such as witchweed and *Striga densiflora* (*Kaufiti*) which are parasites of maize and other cereals.
- To eliminate irritating weeds such as Stinging nettle, *Urtica dioica* (*Chilikumwambd*) that irritate farmers on the field hence lowering labour
- To prevent blockage of irrigation channels by aquatic weed. For example, *Salvinia spp.*
- To eliminate allelopathic weeds such as witchweed and *Striga densiflora* (*Kaufiti*) which produce chemical compounds that suppress or inhibit germination of seed crops.

Timely weed control

Weeds should be controlled at the right time. The following are guidelines that a farmer may consider when controlling weeds:

- Control the weeds as soon as they appear.
- In leguminous crops, weeding should be done before flowering. This is because they are mainly self-pollinated and hence disturbance of the plants during flowering may lead to low yielding.
- Weeds should be controlled early before they set seeds and fruits.
- Weed control should be carried out when soil is moist to reduce incidences of damage on the plants.
- Use of herbicides in weed control should be done when the weeds are actively growing.

The frequency of weeding, that is, how often weeding is done will depend on:

Type of crop grown: Some crops are able to smother weeds and hence may require only one weeding.

Climate of the area: Some climatic factors favour fast growth of weeds hence higher frequency of weeding.

Type of weeds : Some weeds are fast growing and require regular weeding.

Soil fertility: Soils rich in nutrients support faster growth of weeds.

Weeding in groundnuts

Clear weeds during early stages of growth.

Weeding after flowering should be discouraged or simply hand pull the weeds otherwise it may interfere with the growth of the pegs.

Weeding in maize

First weeding is done when maize is about 15 cm tall. Subsequent weeding is carried out at appropriate intervals until the maize plants establish a good cover. Hand weeding is done in small scale production. In large scale maize production, however, herbicides may be used.

Note: All precautions should be observed when handling chemicals. Read the labels on the containers for effective use of chemicals.

9.5: Fertiliser application

There are different types of fertilisers. They are applied at different stages of growth of a crop depending on the nutrients they supply. Some fertilisers are applied at planting time, such as double super phosphate (DSP). This is because phosphorous is not highly soluble in water hence less prone to leaching. Phosphorous is required for root growth and development.

Other fertilisers are applied on already established crops in the fields. This is known as top dressing. Nitrogenous and potassic fertilisers are commonly top dressed. This is because they are more soluble in water and hence easily leached. Nitrogenous fertilisers should be applied when soils are moist (to prevent volatilisation) but not when it is raining heavily (to reduce leaching).

Application methods of chemical fertilisers and inorganic manures

(a) Broadcasting: This is the random spreading of the inorganic fertiliser over the seedbed. It is then later incorporated into the soil. The spreading can be done by hand, in small scale farming, or by use of fertiliser spreaders in large scale farming.

(b) Drilling: This is the direct placement of fertiliser in the planting hole or furrows. The fertiliser is then thoroughly mixed with the soil before planting. Drilling is done at the time of planting using the dibbling method in small-scale farming, and by use of planters in large-scale farming. This method is also known as hole placement, or dollop method.

(c) Side dressing or Banding: This is the placement of fertiliser in continuous or discontinuous patterns beside the crop. It is commonly done in perennial crops because they have extensive root systems. The method is also called side-dressing when the fertiliser is placed one or two spots beside the crop and ring application when the fertiliser is placed in a circle around the plant.

Banding is used when top-dressing crops with nitrogenous or potassic fertilisers. Row planted crops can also be side-dressed.

(d) Foliar application: This is the spraying of fertiliser in solution form on the leaves of the crops. It is used in applying urea and micro-nutrients. The response is usually quick as the fertiliser is absorbed through the leaf surface.

(e) Injection into the soil: This is used in specialised cases such as in green houses. In this method, fertilisers, in liquid forms are injected into the soil under pressure.

(f) Irrigation method: In this method, the fertiliser is mixed and applied with the irrigation water. It is also called fertigation.

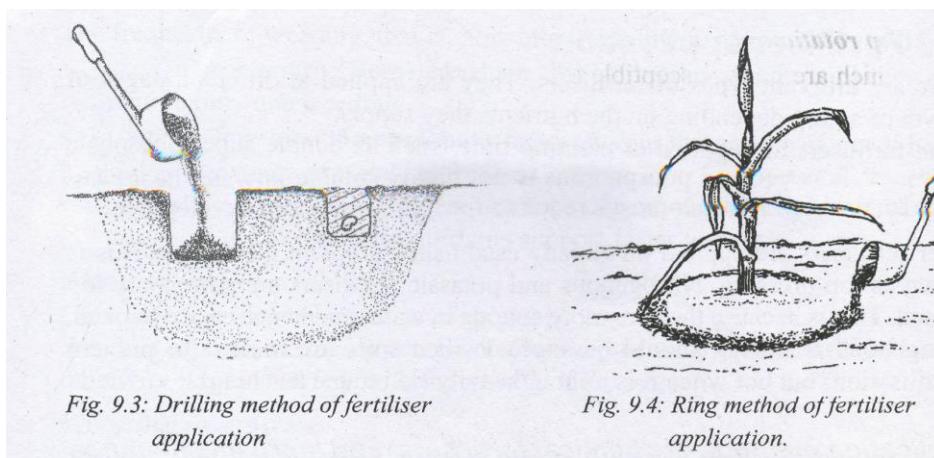


Fig. 9.3: Drilling method of fertiliser application

Fig. 9.4: Ring method of fertiliser application.

Factors to consider before applying fertiliser

- Soil analysis should be done to establish the level of nutrients in the soil.
- The soil pH should be determined to ensure it is appropriate for the type of fertiliser.
- The availability and amount of soil moisture.
- The method of application.
- The quantity and cost of fertiliser required.
- The time of application.

Table 9.3: Types and properties of fertilisers

Summary of various types of fertilisers					
Fertiliser Colour	Formula Appearance	Forms available for plant use	Soil reacti on	Nutrient Composition	Acidi c

<i>Ammonium (NH⁺SO₄²⁻; NH₄⁺ and White Crystalline sulphate SO₄²⁻)</i>		21% N 26% S
<i>Ammonium NH₄NO₃ NO; and White Crystalline nitrate NH₄⁺</i>	Acidic	34-35% N
<i>Ammonium / (NH₂SO₄! NO₃, 1 sulphate Nitrate + NH₄NO₃)</i>	Neutral	26% N 13.5% S 1 21% N 10-20% CaO
<i>Cakium \ NH₄NO₃ + j NH₄⁺, 1 Ammonium ' CaCO₃ Nitrate</i>	Acidic	
<i>Urea CQQSIH_a)₂'; NH₄⁺</i>	White Granular !	Neutral 45-48% N
<i>Single super j Ca⁺P O²⁻TPO/-, J phosphate + CaSO₄ Ca²⁺</i>	5O ₄ ²⁻ Creamy Granular White	Neutral 18-21% P ₂ O ₅
<i>Double or j PO₄²⁻, i Triple super i phosphate</i>	>O ₄ ²⁻ - jGrey Granular	Neutral 40-49%P ₂ O ₅
<i>Soda rPO/-phosphate</i>	Grey Powdery	Neutral 20% P ₂ O ₅ 30% FeO 30% CaO and trace elements
<i>Basic slag P₂O₅[^]</i>	LaO Grey Powdery	Basic 15-16% P ₂ O ₅ 40-50% CaO and trace elements

<i>! Potassium Chloride (muriate of potash)</i>	<i>White Crystalline j to Red</i>	<i>Neutral 48-62% K₂O impurities of Ca, Mg, S and some trace elements</i>
<i>Potassium Sulphate K₂SO₄ 1 K⁺, SC sulphate</i>	<i>Yellow Crystalline</i>	<i>Neutral 42-52% K₂O</i>

Fertiliser grade or analysis

It is important to know the amount of each specific nutrient contained in a fertiliser. This is made possible by calculating its fertiliser grade (fertiliser analysis). The analysis or grade is found by determining the chemical percentage of specific nutrients present in a fertiliser.

$$\text{Percentage of nutrient} = \frac{\text{Nutrient content}}{\text{Total weight of fertiliser}} \times 100.$$

$$\frac{\text{Nutrient content}}{\text{Total weight of fertiliser}} \times 100$$

The fertiliser grade or analysis must be known in order to determine the correct amount of nutrient or fertiliser to apply per unit hectare.

Calculating rates of fertiliser application

Farmers use fertiliser analysis to calculate the amount of nutrient(s) or fertiliser to apply on their farms. Once the recommended fertiliser application rate is known, then the amount of nutrient required per hectare can be easily established.

Example 2

How much of P₂O₅ is there in 850 kg of single superphosphate (18% P₂O₅)?

The single superphosphate is 850 kg.

The percentage of P₂O₅ in it is 18%.

$$\text{Weight of P}_2\text{O}_5 \text{ in this is: } \frac{18}{100} \times 850 = 153 \text{ kg}$$

Example 3

A farmer wants to apply 60 kg of N per hectare on her Irish potato farm. How much Sulphate of Ammonia (20% N) does she require?

For every 100% sulphate of ammonia fertiliser, there is 20% N in it.

Thus in a 100 kg SA there is 20 kg N in it.

What amount of SA does 60 kg N contain?

$$\underline{60} \times 100 = 300\text{kg}$$

20

The fertiliser ratio

Fertiliser ratio is the relative percentage, expressed as a ratio, of the NPK present in a fertiliser.

For example, 17-17-17 can be expressed as a fertiliser ratio of 1:1:1. To calculate the fertiliser ratio, use the smallest figure to divide through the rest. The fertiliser ratio is only expressed in compound fertilisers.

Liming of soil

Liming is the application of agricultural lime to an acidic soil in order to amend it. Lime contains calcium in form of limestone ($CaCO_3$) and hydrated lime ($Ca(OH)_2$).

Importance of liming

- *It removes toxic elements such as aluminium from acidic soils.*
- *It improves soil structure through flocculation of soil particles.*
- *It reduces the acidity of soil.*
- *It hastens the decomposition of organic matter by improving microbial activity.*
- *It avails nutrients like nitrogen and phosphorous in absorbable forms.*
- *It improves nodulation in legumes.*

9.6: Major diseases of maize and groundnuts

Crop disease may be defined as an alteration in the state (physiological order) of a plant or its parts which interrupts normal functioning.

The diseased plant deviates from normal growth and development. The study of the cause, origin and nature of plant diseases is known as plant pathology. A pathogen is a disease-causing micro-organism, such as protozoa, bacteria, virus, fungus and nematode.

Classification of crop diseases

Plant diseases can be classified into three major groups according to their cause. They are:

- *Fungal diseases*
- *Viral diseases*
- *Bacterial diseases*

(i) Fungal diseases

A majority of plant diseases are caused by fungi. The fungi which cause diseases in plants live on the plants as parasites and attack plant parts such as roots, leaves, stems or fruits. Parasitic fungi are made of masses of thread-like structures called mycelia which produce seed-like structures known as spores. The spores may be carried to other plants by water, wind or other pests.

Examples of fungal diseases are smuts, blights, rusts and damping off.

(ii) Viral diseases

These are caused by microscopic organisms called viruses. The general symptoms of viral diseases are:

- (a) Chlorosis - This is yellowing of the leaves.
- (b) StuntMgrowth'- The plant exhibits dwarfness.
- (c) Mosaic mottling - These are light and dark patches found on the plant leaves.
- (d) Necrosis-This refers to the death of plant tissues such as leaves, stems or fruits.
- (e) Leaf curls -These are curved or spiral shaped leaves.

Examples of plant viral diseases are tristeza, maize streak, greening disease of citrus, tobacco mosaic, rosette and ratoon stunting disease of sugarcane.

(iii) Bacterial diseases

Bacteria are microscopic pathogens that are larger than viruses and cause severe damage to plant cells.

Examples of bacterial diseases includes black arm of cotton, bacterial wilt in potatoes and tomato canker in tomatoes.

Disease	Casual agent	Symptoms	Control measures
Maize smut	<i>Fungus ustilago maydis</i>	<ul style="list-style-type: none"> Plants severely dwarfed. Abnormal development of tassels. Black masses of spores on the cob and tassel. 	<ul style="list-style-type: none"> Plant resistant maize varieties. Use certified seeds. Crop rotation. Rogueing.
Maize rust	<i>Fung Virus us Puccina spp</i>	Red brown powdery pustules on leaves.	<ul style="list-style-type: none"> Practise crop rotation. Plant resistant varieties. Plant early.
Maize streak	Virus	<ul style="list-style-type: none"> Yellow parallel lines on the leaves which eventually turn yellow with long strips of green patches. Stunted growth in plants during early periods of growth. Cobs produced are often half-filled or contain 	<ul style="list-style-type: none"> Early planting. Use resistant varieties. Rogueing. Field hygiene. Crop rotation. Use certified seeds.

		<i>few or no seeds.</i>	
<i>Grey leaf spot disease</i>	<i>Fungus Cercospora zae maydis</i>	<i>Leaf lesions. Chlorosis. Leaf blight.</i>	<ul style="list-style-type: none"> • Plant resistant varieties. Practise crop rotation ¹ • Destruction of crop residues. ¹ Use of appropriate fungicides. ¹ weed control.
<i>Rust</i>	<i>Fungus Puccina arachidis</i>	<ul style="list-style-type: none"> • Orange coloured pustules appear on the lower leaf surface and rupture exposing brown spores. • Leaves become necrotic. 	<i>Observe quarantine Spray appropriate fungicides</i>
<i>Early and late leaf spots</i>	<i>Fungus Cercospora spp.</i>	<ul style="list-style-type: none"> • Lesions which are dark brown with a yellow halo. • Leaves become chlorotic, then necrotic and later fall off. 	<ul style="list-style-type: none"> • Practise crop rotation • Removal of volunteer groundnut plants • Spray with appropriate fungicides.

<i>Fusarium</i> wilt	<i>Fungus</i> <i>Fusarium</i> <i>oxysporum</i>	<ul style="list-style-type: none"> Young seedling become yellow and wilt. Plants dry up and die 	<i>Seed treatment with appropriate fungicides.</i>
Anthracnose	<i>Fungus</i> <i>Colletrichum</i> <i>arachnidis</i>	<ul style="list-style-type: none"> Small water soaked yellowish spots appear on the lower leaves. The lesions enlarge and cover entire leaflet. 	<i>Spray mancozeb</i>
Dry root rot/ dry wilt	<i>Fungus</i> <i>Macrophomina</i> <i>phaseolina</i>	<ul style="list-style-type: none"> Water soaked yellowish spots appear on the lower leaves. The spots spread upwards to the aerial parts and down into the roots. Death of plants. 	<i>Irrigation Seed treatment.</i>
Bud necrosis/ Bud rot/ Bud light	Virus: Tomato spotted wilt	<ul style="list-style-type: none"> Death of terminal buds. Chlorotic rings on leaves. Stunted growth. Small distorted mottled leaves. Small and 	<ul style="list-style-type: none"> Early planting. Control vectors. Plant resistant varieties. Intercropping. Seed treatment. Field hygiene.

		<i>reduced pods in late infections.</i>	
<i>Groundnut rosette virus</i>	<i>Virus</i>	<ul style="list-style-type: none"> • <i>Chlorosis in the whole plant.</i> • <i>Stunted growth. Small curled leaflets.</i> • <i>Dark green mosaic.</i> 	<i>Early planting.</i> ¹ <i>Control vectors.</i>
<i>Groundnut blight</i>	<i>Fungus:</i> <i>Sclerotium rolfsii</i>	<ul style="list-style-type: none"> • <i>Wilt occurs in patches and a white mycelium is found on the roots.</i> • <i>Sunken brown lesions on the stems</i> 	<i>spray appropriate fungicides.</i>

Harmful effects of plant diseases

- They decrease crop yields by altering the normal plant physiological processes interfering with the plant's growth or killing it.
- Lower crop quality. This affects grading for marketing.
- Some diseases may lead to contamination of crops. For instance, aflatoxins produced by fungi in poorly stored cereals can poison and kill consumers of the produce.
- Disease control increases the cost of production.

Disease control measures

Plant disease control measures are broadly classified into:

- Cultural control measures.
- Chemical control measures.
- Biological control.
- Legislative control.

(a) Cultural control measures

These are agronomic practices used to reduce the infestation or spread of plant diseases without the use of chemicals. They include:

- Use of disease-free planting materials - Use of certified seeds or healthy planting materials minimises occurrence of plant diseases in crop fields.
- Use of disease resistant varieties prevents crop infection by the particular disease.
- Quarantine regulations to help prevent introduction and spread of diseases in new field areas or into the country.
- Practising of field hygiene that is rogueing and destruction of infested crop residues.
- Crop rotation - It leads to the interference of life cycles of most pests which act as disease vectors such as aphids which transmit the virus causing tobacco mosaic or rosette in groundnuts.
- Proper seedbed preparation - This exposes soil-borne pathogens to the sun thus killing them. This is a very effective control measure for most fungal diseases that are soil-borne, such as damping off and fusarium wilt.
- Proper pruning - Tree diseases can be effectively controlled by proper pruning. Pruning eliminates the humid micro-climate within the tree bush making it unsuitable for multiplication of disease-causing organisms. For example, Coffee Berry Disease can be controlled by this method.
- Hot water treatment of setts helps to control ratoon stunting disease in sugar cane.

- Proper drying of cereals and pulses helps to prevent occurrence of aflatoxins.
- Proper spacing of crops - In some crops such as groundnuts, wider spacing results in serious infections of groundnut rosette disease, while closer spacing minimises the disease.

(b) Chemical control measures

These control measures involve use of chemicals to eradicate the disease or kill the disease vectors. They include:

- Seed dressing of planting materials with the appropriate chemicals – for example Lindcme and cerasan to control seed-borne fungal diseases.
- Soil fumigation or sterilisation by use of appropriate chemicals - for example Lindane to control soil-borne diseases.

- Spraying crops with appropriate chemicals as a preventive or curative measure. For example spraying coffee with Delan or Daconil for the control of Coffee Berry Disease.

(c) Biological disease control measures

This is a method which involves use of living organisms in a bid to control crop diseases. The living organisms are aimed at reducing the population of pests that are vectors to crop diseases. For example, the lady bird beetle is a predator of aphids thereby reducing their population.

Reduced population of aphids consequently lowers the incidence of viral diseases transmitted by aphids, such as groundnut rosette disease, maize streak, citrus tristeza and citrus greening.

(d) Legislative

This involves use of laws passed by parliament that prohibit introduction of crop diseases into the country. Methods of legislative control:

- Quarantine administration
- Seed certification
- Notification order

It requires inspection and certification of imported plant materials to ascertain they are disease free. It involves sampling of imported materials and hence it is not very effective.

The law also prohibits introduction of plant materials from regions of known disease outbreaks (areas under quarantine).

9.7: Crop pests

Crop pests are categorised into: Field pests Storage pests

Field pests

These are pests that attack either maize or groundnuts while growing in the fields and they include:

- *Insect pests such as aphids (*Eriosomatinae spp.*) and maize stalk borer (*Busseola fusca*).*
- *Rodents such as rats and moles.*
- *Birds such as weaver bird (*Quelea aethiopica*) and mouse bird.*
- *Some mammals such as apes, monkeys, antelopes and buffaloes.*

Storage pests

The pests attack grains in their places of storage. The common storage pests in elude weevils and rats.

Major pests of groundnuts

*(a) Red hairy caterpillars (*Amsacta albistriga*, *A. Moorei*)*

The larvae are hairy reddish brown with black bands on either heads or top abdomen. They have long reddish brown hair all over the body.

Symptoms

Caterpillars cause loss of leaves of the crop. All the leaves are eaten away leaving the main stem only.

Control measures

- *Deep ploughing during the dry season*
- *Early sowing*
- *Intercrop with castor for every 5 rows of groundnut*
- *Use of crop rotation*
- *Use of trap crops*
- *Irrigation*
- *Field hygiene*

*(b) Groundnut leaf miner (*Aproaerema modicella*)*

Shiny white eggs are laid singly on the underside of the leaflets. The larva is green with a dark head and prothorax.

Symptoms

- *Brown blotches on the leaf*
- *Leaflets stuck or webbed together*

- Severely attacked fields looked burnt from a distance

Control measures

- Use cowpeas or soyabeans as trap crops
- Use of crop rotation
- Field hygiene
- Mulching with rice straws causes reduction in leaf miner attacks
- Intercropping
- Chemical control with appropriate insecticides

(c) Gram pod borer (*Helicoverpa armigera*)

Eggs are spherical in shape and creamy white in colour. The colour of the larva could be between green and brown. It has dark brown grey lines on the body with lateral white lines.

Symptoms

- Larva feeds on flowers and buds.
- Symmetrical holes or cutting scion on leaflets.

Control measures

- Deep ploughing during the dry season.
- Intercropping
- Use of chemical insecticides.

(d) Groundnut aphids (*Aphis craccivora*)

Symptoms

- Wilting of tender shoots during hot weather.
- Stunting and distortion of the foliage and stems.
- They excrete honey dew on which sooty mould form a black coating.
- Act as vectors for the groundnut rosette virus.

Control measures

- Timely sowing
- Handpicking and destruction
- Use of chemical insecticides

(e) Jassids (*Empoasca kerri*)

Adults have elongated wedge-shaped bodies, active and green in colour.

Symptoms

- Whiteness of veins and chlorotic patches.

- Heavily attacked crops appear yellow and scorched.

Control measures

- Timely sowing
- Use of crop rotation
- Intercropping with millets.
- Use of irrigation
- Chemical control with insecticides.

(f) Thrips (*Scirotothrips dorsalis*)

These are small slender and yellow-black coloured insects. They have piercing and sucking mouth parts.

Symptoms

- Tender leaves show yellowish green patches on the upper surface and brown necrotic areas and silvery sheen on the lower surface
- Stunted plants.

Control measures Spray insecticides.

(g) Termites (*Odontotermes*)

Symptoms

- Wilting of plants in patches.
- Termites penetrate and hollow pit the tap root and stem thus killing the plant.
- Termites bore holes into pods and damage the seeds this weakens the shells making them liable to entry and growth of fungus that produce aflatoxins.

Control measures

- Destroy termite colonies.
- Use well decomposed manure.
- Timely harvesting.
- Chemical control with insecticides.
- Irrigate frequently.
- Seed treatment.

(h) White grubs (*Holotrichia serrata*)

Symptoms

- Feed on roots and damage pods.

- Grabs feed on root hairs, resulting in pale wilted plants drying in patches.

Control measures

- Deep ploughing in dry season.
- Use well decomposed organic fertiliser.
- Early planting.
- Chemical control with insecticides.
- Seed treatments.

(i) Pod borer (*Anosolabis stalli*)

Symptoms

- Young pods showing holes with excreta inside.
- Pods without seeds.

Control measures

- Chemical control with insecticides.
- Soil sterilisation.

Major pests of maize

(a) Maize stalk borer (*Busseola fusca*)

These are larvae of moths which are dark green in colour. They feed on aerial parts of maize. Their attacks result into death of the central growing points of the crop. Affected leaves and stems have characteristic windows or holes.

They move through stems tunnelling them resulting in weakened stems which later fall off.

Control measures

- Remove and destroy all crop residues.
- Apply Endosulfan or Diazinon granules down the funnel of each plan when the maize is about 30 cm high.
- Practise early planting.
- Practise close season of at least two seasons.
- Practise crop rotation.

(b) Pink Stalk borer (*Sesamia calamistis*)

The larvae bore into the stem of maize plants weakening the plants.

Early attack results in destruction of the plant's central shoot.

Control measures

(i) Field hygiene.

(ii) Use of recommended chemicals insecticides.

(iii) Destruction of planted alternate host crops.

(c) Maize aphid or plant lice (*Phopalosiphum maydis*)

These are soft, dark green insects which feed in clusters and are found in the inflorescence especially when there is water shortage in the soil. They suck sap from the green husks of cobs and leaves. The attacked leaves and husks appear black in colour.

Control measures

- Early planting.
- Spray with recommended chemical insecticides.

(d) Maize webworm (*Cryptoblabes gnidiella*)

The larvae are long and dark brown in colour. They form silken webs on cobs.

The larva first feed on the leaves preceding flowers removing the chlorophyll and later on the milky grains.

They form webs around maize cobs and flowers.

Control

Spray recommended chemical insecticides.

(e) Army worm (*Spodoptera exempta*)

Army worms feed on crop leaves. They move in large swarms and eat up all the vegetation during their invasion.

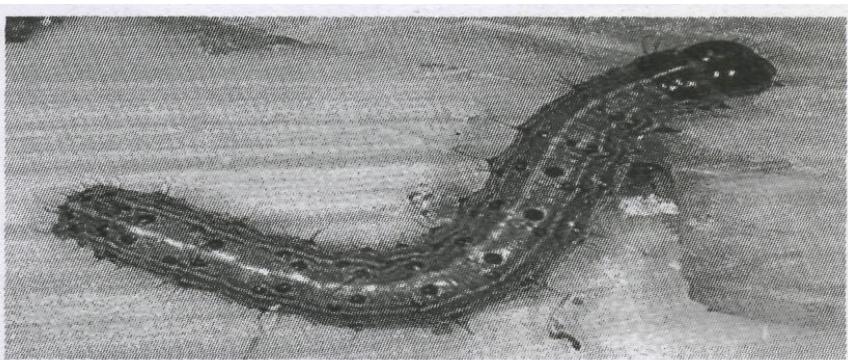


Fig. 9.5: Army worm

Control measures

- Use of recommended chemical insecticides.

(f) Weevils (*Sitophilus zeamis*)

The adult have long curved snouts which they use to bore into grains.

Damage is caused by their larvae as well as their adults.

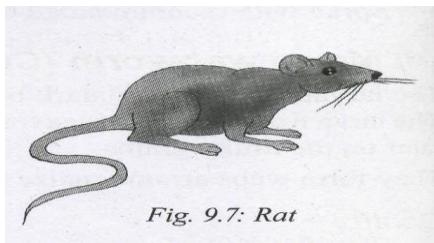
Control measures

- *Timely harvesting*
- *Use of recommended chemical insecticides.*



(g) Rats

These are rodents and have sharp strong teeth capable of gnawing, breaking and chewing grains. They are very destructive in stored grain.



Control measures

- *Use of recommended chemicals*
- *Biological control through use of cats.*
- *Use of rat traps.*

Harmful effects of pests

- *Pests may cause physical destruction to crops by eating leaves, stems, roots or flower tissues.*
- *If not controlled, pests can cause considerable reduction to crop yields.*
- *Some pests lower crop quality. For example, cotton stainers stain cotton lint lowering the crop's quality.*
- *Some pests are disease vectors sucking pests such as aphids, mealy bugs and cotton stainers transmit viruses and fungi causing disease infections in the crops.*
- *Some pests suck sap, depriving the plant of its food leading to low yields.*

Pest control practises

Most pests will often be present in the farm. In pest control considerations, minor pest attacks may be tolerated incase the damage is not very serious. When the pest population causes damage beyond what can be contained the infestation is said to have reached economic injury level.

Therefore necessary control measures and assessment of the nature of damage must be undertaken. There are various control measures that can be adopted to minimise pest population. The measures are categorised into:

- Cultural control measures.
- Physical (mechanical) control measures.
- Biological control measures.
- Chemical control measures.
- Integrated pest management (IPM).
- Legislative pest control measures.

(a) Cultural control practices

This is the manipulation of the environment, making it unfavourable for survival of pests. The basic principle of cultural control is the disruption of the development cycle of the pests by exposing them to adverse conditions which may kill them, or deny them food.

Cultural control practices include:

- Use of clean planting materials
- Timely planting
- Proper seedbed preparation ,
- Resistant crop varieties
- Weed control
- Observing field hygiene
- Mulching
- Close season
- Trap crops
- Proper spacing
- Timely harvesting
- Crop rotation
- Proper plant nutrition

(i) Use of clean planting materials

Planting of seeds or vegetative materials free from pests helps in establishing pest free crops. This is very effective in controlling banana weevils.

(ii) Timely planting

This involves growing of crops early before pests build up. This enables the crop to grow healthy and escape pest attack. For example, early planted maize crops are unlikely to be attacked by the stalkborer.

(Hi) Proper seedbed preparation

Seedbed preparation should be thorough and preferably cultivated in the dry season. This helps in exposing soil-borne pests to the adverse conditions or to predatory birds which eat them up. This ensures a clean seedbed free of soil-borne pests, such as chafer grubs and nematodes, which affect young seedlings.

(iv) Resistant crop varieties

Cultivation of crop varieties which have mechanisms of resisting pest attack. For example, highly tillering sorghum compensates for shoot fly attack, whereas goose necked sorghum discourages birds.

(v) Weed control

Certain weeds act as alternate hosts for crop pests. For example, mallow weed harbours cotton stainers. Therefore, controlling weeds in a field of crops helps avoid pest attack in the crops.

(vi) Observing field hygiene

Field hygiene involves farming practices that ensure little or no plant materials that may harbour pests in the field. Examples of sorghum. Field hygiene practises are burning of crop residues of previous seasons, which helps control the cotton bollworm and rogueing which controls scales.

(vii) Mulching

This is an effective way of controlling certain pests. For example, coffee thrips and antestia bugs are predated the more once the crop is mulched. The pests attach themselves on the mulch exposing themselves to predatory agents.

(viii) Close season

This is a period during which a particular crop is deliberately not grown in a given area in order to control pest build up. Most cotton pests can be effectively controlled by this method. The principle of this method is that the pests will starve to death during the absence of that particular crop.

(ix) Trap crops

These are crops which attract pests diverting them from the main crop. The trap crop is grown together with the main crop. The pests can be killed by use of other means while on the trap crop. For instance, rows of sorghum in a

maize field reduce incidences of stalkborer attack on maize as the adult fly prefers the sorghum plants.

(x) Proper spacing

When crops are properly spaced it becomes difficult for pests to move from one plant to the other. However, closer spacing in groundnuts reduces aphid attack.

(xi) Timely harvesting

Harvesting crops in good time prevents serious attacks by pests. For example, a delay in harvesting maize exposes the crop to extensive damage by rats and weevils.

(xii) Crop rotation

Crops which are more susceptible to a particular pest are alternated with others which are not susceptible to it. For example, crops in Solanaceae family such as tomatoes and Irish potatoes should not be grown in succession as they are susceptible to similar pests.

(xiii) Proper plant nutrition

Healthy plants are known to be more resistant to pest attack, for example, aphids cause minimal damage to healthy bean crops. This is achieved by application of right amounts of manures and fertilisers.

(b) Mechanical pest control practices

These are also referred to as physical means of pest control. It involves using mechanical means to kill the pests and creating physical barriers to prevent pests from getting into contact with their target crops. Mechanical control measures include:

- *Irrigation or flooding*
- *Use of lethal temperatures*
- *Suffocation*
- *Handpicking, trapping and killing*
- *Creation of physical barriers*
- *Proper drying*
- *Use of scare crows*
- *Use of explosives*
- *Distress calls*

(i) Irrigation or flooding

Irrigation drowns pests such as leaf miners and aphids while flooding suffocates moles in the soil. Overhead irrigation washes away aphids from cabbages.

(ii) Use of lethal temperatures

This involves application of extreme temperatures to control pest development especially in post-harvest management practices. For instance, hot water is used to control the pink bollworm in cotton seeds.

(iii) Suffocation

Some storage bins are filled with carbon dioxide to inhibit pest multiplication or survival.

(iv) Handpicking, trapping and killing

This involves catching the pest and killing it. It is effective in controlling pests such as rats, moles, birds and giant loopers using special traps.

(v) Creation of physical barriers

Metal plates fixed on posts for raised granaries prevents vermins like rats from gaining entry into the stores. Use of sticky materials on tree trunks helps to control pests like scales in citrus trees. Fences physically keep off the large animals.

(vi) Proper drying

Crops to be stored for long periods must be properly dried to very low moisture levels. This ensures the produce is hard enough to limit pest damage on the grains. Cereal crops are best stored after proper drying (to a moisture content of 11 -13%).

(vii) Scare crows

Scare crows are human figure-like objects used to scare away birds and other large animals from a field of crops. Animals such as monkeys and squirrels have been successfully controlled by this method.

(viii) Use of explosives

These are thrown at breeding places of birds at night to kill or scare them off.

(ix) Distress calls

Sound of a captured pest or that of its predator is replayed from a loud speaker scaring away pests.

Note: Mechanical pest control measures have the merit of not causing environmental pollution and the demerit of being costly. Some require a high level of skills to be effective.

(c) Biological pest control practices

These are methods which employ the use of living organisms which are natural predators of the pests.

Table 9.5: Predators and their target pest

Predator	Target pest
Parasitic wasp	White fly in citrus, coffee mealy bug
Lady bird beetle	Aphids, cotton cushion scale
Praying mantis	Giant looper
Cats	Moles, rats and mice
Chicken	Cotton stainers and termites

Biological methods have the advantage of being self-perpetuating, cause no environmental pollution and save on labour. However, it takes too long to research for the correct biological agent.

(d) Chemical pest control practices

This is the use of chemicals to control pests. The chemicals are known as pesticides. Application of pesticides is done in a number of ways:

- Dusting
- Spraying
- Fumigation of the soil and the produce
- Sterilisation of implements

Classification of pesticides

There are different types of pesticides. They can be classified according to the following aspects.

- Mode of entry
- Types of target pests

(a) Mode of entry

The following classes can be identified on this basis :

(i) Stomach poisons: These enter the pest through the mouth during feeding and poison the pest.

(ii) Contact poisons: These kill the pest when it comes into contact with the chemicals as they get absorbed through the skin cuticle.

(in) Fumigants: These enter the pest respiratory system in form of fumes suffocating the pest to death.

(iv) Systemics: These chemicals may be applied into the soil or directly onto the plant. They get absorbed into the plant tissues where the chemical is translocated to other plant parts such as stems, leaves and flowers. When pests feed on such plants, they get killed.

(b) Types of target pests

On this basis, we have the following classes of pesticides.

(i) Insecticides: They include diazinon, dimethoate, fenthion and fenitrothion. These kill insects.

(ii) Rodenticides: These kill rodents such as rats, mice and squirrels. Examples include nomui and red cat.

(iii) Nematicides: These kill nematodes. Examples are nemacur, nemagon and temic.

Factors that affect the efficiency of applying pesticides

Note: Efficiency of a pesticide refers to its ability to kill the intended pest upon application.

Effectiveness of pesticides in controlling pests is influenced by the following factors.

(i) Concentration of the pesticide: A pesticide has a higher efficacy when applied in its correct concentration.

(ii) Weather conditions at the time of application: Rain water washes away the pesticide. Therefore, avoid applying chemicals on rainy days.

(iii) Timing of application: The efficiency of the chemical is high when applied at a time when the pest is most susceptible; such as at the larva or nymphal stage rather than at the adult stage when some pests may become resistant to the pesticides.

(iv) Persistence of the pesticide: Those pesticides which have long residual effect are more effective in killing pests. This is because such pesticides retain their strength for long before breaking down into constituent compounds which are harmless.

(v) Pest resistance: Some pests have developed resistance to certain pesticides and this reduces their efficiency.

Advantages of chemical pest control

- It is a relatively fast method of pest control.
- It has low labour requirements.

Disadvantages

- Chemicals are expensive to purchase.
- Chemicals that have long residual effects may cause environmental pollution such as DDT.
- Use of chemicals requires skills especially in mixing and application.
- Due to the broad spectrum effects, some pesticides can destroy beneficial soil organisms and predator insects such as ladybirds, beetles, butterflies, bees and birds.
- Some target pests may build up resistance, hence rendering the chemical ineffective.

(e) Legislative pest control measures

This involves enactment of laws by the parliament that prohibit entry of crop pests from other countries. All crop produce imported to Malawi must be inspected and certified as free from pests before it can be released for use.

(f) Integrated pest management (IPM)

This is a new strategy of pest control which combines various pest control methods. Cultural, biological, physical and use of pesticides are all practised in a bid to reduce pest population.

9.8: Crop harvesting procedures

Crops should be harvested on time. This helps reduce crop losses through drying before harvesting is essential so as to avoid later spoilage of the produce due to rotting or mould attack. Immature harvesting leads to cracked grains.

Harvesting at the wrong stage may also lower the quality of produce or even render the product unusable.

Stage and timing of harvesting

There are a number of factors which determine the stage of harvesting a given crop. These are:

- Intended use of the crop
- Prevailing weather conditions
- Market demand
- Pest and disease outbreaks

1. Intended use of the crop

The stage of harvesting is determined in most cases by the use to which the crop is put or in what form it is needed. For example maize for silage is

harvested wholly when it is at the silking stage; green maize is harvested when the cobs are not yet dry (that is husks are still green); maize for shelling is harvested when it has dried properly (that is maize grains have very low moisture content).

2. Prevailing weather conditions

Loss of produce can occur when the crop is harvested late such as in pulses which shatter and throw their seeds when completely dry. These seeds start sprouting when rains set in. Crops such as cotton must be harvested during dry periods before onset of rains.

3. Market demand

A crop can be harvested earlier when the market demand is high. This allows the farmer to benefit from the high market prices.

4. Pest and disease outbreaks

Pest and disease attacks can influence the stage of harvesting crops, such as weevil or rodent attacks on maize can be prevented by early harvesting.

Harvesting of groundnuts

There are various stages of harvesting groundnuts. They include:

- *Lifting*
- *Drying Shelling*

(a) Lifting

Groundnuts should be lifted when most of them are mature. Maturity is indicated by darkening of the veins on the inner surface of the shells and yellowing of most of the leaves.

Delay in harvesting may lead to crop losses through germination of some nuts. Harvesting is done by hand pulling in sandy soils or use of hand hoes in heavy soils. Mechanical harvesters may also be used to lift the seeds.

(b) Drying

After lifting the plants, turn them upside down and leave them to dry in the field for a few days. The nuts are then removed by hands.

(c) Shelling

Hand shelling or hand operated machines can be used in shelling nuts.

Harvesting maize

Maize is ready for harvest in 3 to 5 months depending on cultivar and altitude. Maize is harvested when the leaves and husks are dry. The maize

crop may be cut and stooked in the field to allow cobs to dry. The cobs are then removed by hand and stored.

Maize can also be harvested by use of combined harvesters in large scale. The maize cobs are later shelled.

Unit 10

Pig Production

Introduction

Pig farming is a more profitable enterprise compared to keeping other livestock

such as cattle, sheep and goat management, due to the following:

- (i) They have a high prolificacy: A sow is able to give birth to several piglets at one farrowing. Some give birth to up to 16 piglets per litter,
- (ii) The gestation period in pigs is shorter than it is in cattle, sheep and goats; averaging 115 days. It is possible to get two litters per year from one sow.

The common sowing is 3 months 3 weeks and 3 days.

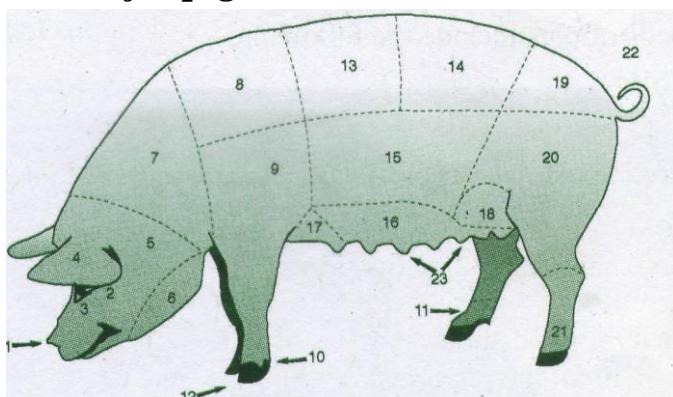
However, pig farming in Malawi has not been exploited to the maximum. Some of the factors that hamper pig production are:

- (i) Religion: Islamic communities neither rear pigs nor eat their products,
- (ii) Culture: Some communities do not accept pig rearing and their products.

Pigs are reared for either pork or bacon production.

- *Pork is meat from a young pig weighing 45 - 50 kg at 4 months old. The meat is not salted. Bacon is meat from an old pig weighing 110 kg live weight slaughtered at 7-9 months. Bacon meat is salted. It is normally obtained from the back and sides of the pig.*
- *Pigs also provide bristles used for making synthetic leather fabrics.*

Parts of a pig



1. Snout 5. Cheek 9. Foreleg
2. Face 6. Jowl 10. Dewclaw
3. Eye 7. Neck 11. Pastern
4. Ear 8. Shoulder 12. Hoof (toes)

13. Back 16. Belly 21. hind leg
14. Loin 17. Fore flank 22. Tail
15. Side 18. Hind flank 23. Teats
19. Rump 20. Ham

10.1: Breeds of pigs

(a) Local breeds

Local breeds in Malawi are not commonly reared for commercial purposes. Most of them are kept by households in the small holder communities. Majority of them are actually owned by women. All this is despite the fact that:

- they have the ability to utilise fibrous feeds and red sorghum better,
- Higher parasite and disease tolerance.
- Superior organoleptic properties,
- Suitability to organic production.

Local pig breeds are predominantly black, but some are black and white, black and brown and white and brown.

There are several reasons that have led to sidelining of the local pigs,

- (i) Negative perception against the local breeds,
- (ii) Negative perception against the free range production system,
- (iii) Lack of access to markets and viable marketing strategies,
- (iv) General lack of information with regard to carcass and processing quality of local pigs.

(b) Exotic breeds

The exotic breeds of pigs include the following.

(i) Large White

Origin: Yorkshire in Britain.

It is widely reared in many parts of Malawi. It is mainly kept for pork production.

Characteristics

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- Is long, large and white in colour.
- Has erect ears.
- Has a dished face and snout.
- Most prolific of all the pig breeds.
- Has good mothering ability.
- Can be affected by sunburn.
- Matures late.
- Good converter of feeds into meat.
- Fairly hardy.
- Has strong hind legs.
- Has a sagging back and a level underneath.

(ii) Danish Landrace

Origin: Denmark Colour: White

Characteristics

- Longer than the Large White.
- Ears are long and droop over the face.
- Good for bacon production.
- As prolific as the Large White.
- Has good mothering ability.
- Requires high level of management skills.
- The back is sagging and hind legs are weak. Has a straight snout.

(iii) Essex Saddle Back and Wessex Saddle Back

Origin: South of England in Britain.

Colour: Black with a white band that runs down the shoulders in most breeds.

Shape: Body is long and curved.

Characteristics

- Have a straight snout.
- Good for pork and bacon production.
- Excellent for extensive rearing system.
- Good foragers.
- Excellent mothering ability.
- Has drooping ears.

Essex saddle back is similar to Wessex saddle back only that all legs of the Wessex Saddle Back are white.

(iv) Berkshire

Origin: England

Colour: Black with white feet, face and tail end.

Characteristics

- Face is dished.
- Ears are erect.
- Produce good meat especially bacon.

(v) Tarn worth

Origin: England

Colour. Red, varying from light to dark. It is often referred to as 'Sandy pig'.

Characteristics

- Breed is good for bacon production.
- Has long legs.
- Slow growth rate.
- Hardy hence can do well in extensive systems rearing.
- Sows are not prolific and they have poor mothering ability.

(vi) Duroc Jersey pig

Origin: Britain

Colour: Pure black

Characteristics

- Good for meat but the carcass is of poor quality.
- Fast growth rate and early maturity.
- Sows produce large litters.
- Sows have good mothering ability.
- Due to black colour they do not suffer from sunburn.
- They are nervous and not as prolific as the other breeds.

10.2: Management systems for pig production

There are different systems of pig rearing which are categorised according to the resources allocated, such as labour, skills and capital. From this, there are three systems of pig rearing namely:

(a) Extensive system

- (b) *Semi-intensive system*
- (c) *Intensive system*
- (a) ***Extensive system***

This is a system of pig rearing where they are allowed to move and forage freely in an enclosed piece of land.

A simple structure is constructed to provide shelter at night and against bad weather.

Foraging can be supplemented with kitchen waste and crop remains.

The system is cheap and less laborious however the pigs do not gain weight fast hence not appropriate for commercial pig rearing.

Advantages of extensive system

- *Low capital investment.*
- *Does not require a lot of skills.*
- *Droppings are evenly spread in the field.*
- *Less laborious.*

Disadvantages of extensive system

- *Increases piglet mortality due to chilling.*
- *High likelihood of predation or theft.*
- *Pigs take long to reach market weight.*
- *Cannot be practised where the size of land is small.*
- *Has low profit per unit area,*

(b) Semi-intensive system

This is a system that combines extensive and intensive systems of rearing pigs. The pigs are raised in pens and outside at different stages of growth. When outside, they look for feed by foraging but those indoors are provided with sufficient feed, water and other requirements. The piglets and fattening stock are always kept indoors.

(c) Intensive system

In this system, the pigs are permanently kept indoors in a structure known as piggery. They are provided with adequate feeds and water at all times. This system is most appropriate for commercial pig rearing.

The pigs put on weight faster than in other systems, it is easier to control parasites and diseases. The pigs can also be easily managed.

Advantages of intensive system

- Can be practised even on a small piece of land.
- Allows a higher stocking rate.
- Pigs reach market weight early.
- Pigs are secure against predation or theft.
- Piglets are protected from adverse weather conditions.
- Has high profit per unit area.
- Manure accumulates faster.

Disadvantages of intensive system

- Parasites and diseases may spread fast.
- Requires high capital investment.
- Requires a lot of skills.
- Requires a lot of labour.

10.3: Breeding in pigs

- The selected male and female pigs should be mated at the right age and weight. The gilts, despite becoming sexually mature early, should not be mated until 12 months old, weighing about 100 kg.
- A sow should be served 4 days after weaning her piglets.

The sow or gilt should be mated when it shows signs of heat. The sow on heat is taken to the boar to ensure successful mating after which it is returned to her pen. The farmer should observe return of heat on the mated sow or gilt after 21 days and repeat mating. Natural mating is the most common method in serving pigs.

Note: The sow or gilt should be put on high level of quality feeds 2-3 weeks before and after mating. This is called flushing.

Signs of heat

The sow on heat shows the following signs.

- Restlessness.
- There is clear slimy mucous discharge from the vulva.
- Swelling and reddening of the vulva.
- Frequent urination.
- Occasional grunting. Trross rvfarroetite.
- It mounts other pigs in the pen.
- It stands motionless when others mount it.

Gestation

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This is the period of time from conception to farrowing. It lasts 112-115 days (3 months, 3 weeks and 3 days).

During the gestation period the (in-pig) sow or gilt should be fed on adequate feeds and clean drinking water and concentrates.

During the last 3 weeks of farrowing the in pig sow or gilt is fed on extra high quality feeds. This is known as steaming up.

Importance of steaming up

- Ensures strong and healthy piglets.
- Stimulates growth of alveolar tissue of the udder hence more milk production upon farrowing.
- Ensures a strong and healthy sow hence less likelihood of complications during farrowing.

Management of pigs during parturition

Preparation for farrowing should be started at least one week before the expected date.

Signs of parturition in pigs

The sow which is about to furrow shows the following signs.

- It becomes restless and begins to collect bedding materials at one corner to make a neat nest.
- Loss of appetite.
- The udder and teats become enlarged and filled with milk. The vulva becomes enlarged and red.
- The muscles on either side of the tail slacken.

Preparation for farrowing

The following is done when preparing sows for farrowing.

- Deworm the sow.
- Wash and spray the sow against ectoparasites using appropriate chemicals.
- Clean and disinfect the farrowing pen.
- Take the sow to the farrowing pen at least 5-7 days before the expected date of farrowing to familiarise it with the environment.

- Provide a farrowing crate so that the piglets are born in a perfect and well protected environment. This ensures that the piglets are not cannibalised by the sow.
- Create a creep area with infra-red light. This keeps the young piglets warm and protects them from pneumonia and being crushed by the sow.
- Two days to farrowing, feed the sow entirely on bran which acts as a laxative. Mix sow and weaner meal with wetted bran and feed the animal up to 2-3 days after farrowing.
- Provide clean water Adlibitum.

The sow normally farrows with no difficulty. Do not interfere but watch closely. Normal parturition takes between 2-4 hours although many sows take a lesser duration. In case of difficulty during farrowing, such as prolonged labour period with no piglets coming out, contact a veterinary officer for assistance.

If the piglets get stuck close to the vulva, the attendant should shift the piglets into proper position and pull them out as the sow labours. Ensure the sow is pressed

down by use of a farrowing crate. The attendant must thoroughly wash the hands and wear gloves before providing any assistance.

Care after farrowing

After farrowing carry out the following practices.

- (i) Ensure the piglets are breathing properly. Remove mucus from the mouth and nostrils using a clean cloth.
- (ii) Ensure the piglets are safe by moving them away from the sow as each is born.
- (iii) Tie, cut and disinfect the navel cords of each piglet. Disinfect by applying iodine solution.
- (iv) Weigh each piglet and record the birth weight.
- (v) Remove and discard the after-births and any still borns.
- (vi) Count and record the number of piglets born.
- (vii) Place the piglets under infra-red light. In the absence of infra-red light, chilled piglets can be immersed in lukewarm water up to the head, then dried. Keep them in a warm place until they gain enough strength, then take the piglets to the sow for suckling.

10.4: Rearing piglets

Piglets are very delicate and high mortality rates can be experienced within the first 3 days due to:

- Being crushed by the mother. Crushing of the piglets is prevented by providing a farrowing crate and guard rails in the farrowing pen.
- Chilling: Chilling is prevented by providing an infra-red bulb or any other source of heat in the creep area.
- Piglet anaemia: Piglet anaemia is controlled by providing iron supplements to the piglets either in form of iron paste, smeared on the teats of the sow or in form of a solution injected intravenously into the piglets.

Ensure the piglets get colostrum and later enough milk up to the 10th day. A day after farrowing carry out teeth clipping. This is the cutting of the sharp canines at gum level using a teeth cutter.

Importance of teeth clipping

- Avoid injury of the sow's teats or udder hence reduce incidences of mastitis.
- Reduce the likelihood of piglets injuring one another when playing or fighting.
- Reduce incidence of piglets injuring the farmer during handling of piglets.
- Makes the piglets docile, hence easy to handle.

Castration

This is a practice carried out on male piglets not selected for breeding. The most common method of castration is the open method. Here, a scalpel blade is used for removal of the testes surgically.

Castration is done at the age of 3 weeks.

Procedure for castrating piglets

1. Gather the tools and materials, that is scalpel, disinfectant and cotton wool.
2. Restrain the piglet appropriately.
3. Using one hand, squeeze the testes and hold.
4. Disinfect the scrotal surface.
5. Using a scalpel make an incision on the scrotum.
6. Squeeze out the testis through the incision until the spermatic cord is extended.
7. Cut the spermatic cord using a scalpel.
8. Repeat the above for the other testis.

9. Disinfect the wound. 10. Release the piglet.

Advantages of castration

- It controls breeding.
- It controls breeding diseases.
- It prevents inbreeding.
- It enhances growth rate of piglets.
- It makes the piglets docile hence easy to handle.

10.5: Piggery

Pigs are housed in a structure known as piggery or pig sty. Pigs are very sensitive to extreme weather conditions. Therefore, a piggery should provide warmth and be well-ventilated. Pig housing is more emphasised in intensive system.

Essential features of a piggery

- (a) Farrowing pen - It is used for farrowing and ensuring the safety of the piglets. The pen is provided with a farrowing crate to prevent the sow from lying on the piglets and a heat source to protect the piglets against chilliness. It contains a creep area where only the piglets can access creep feed.
- (b) Weaners pen - It is where weaned pigs are kept. It should have a feeding, watering and resting section.
- (c) Boar pen - This is where breeding boars are kept. It gives room for sows to be served during the breeding season.
- (d) Gilts pen - It is used for keeping young female pigs up to the age of service (usually 12 months).

Other parts of a piggery unit include:

- (i) Feed store - This is used for storing feed.
- (ii) Records room - This is used for keeping feed and weight records.
- (iii) Running yard - This is an extension of the pens. The yards are used for dunging and for sunbathing.
- (iv) Water troughs or drinking nipples - These are used as watering points for the pigs.

Qualities of a good piggery

- Easy to clean.
- Draught free especially the farrowing pen.
- Well lit.

- Well ventilated.
- Floor should drain away urine and water. Leak-proof roof.
- Farrowing pens should have guard rails.

Remember: A piggery unit must be strong, otherwise the pigs can destroy the structure. The floor should be made of concrete for easy cleaning.

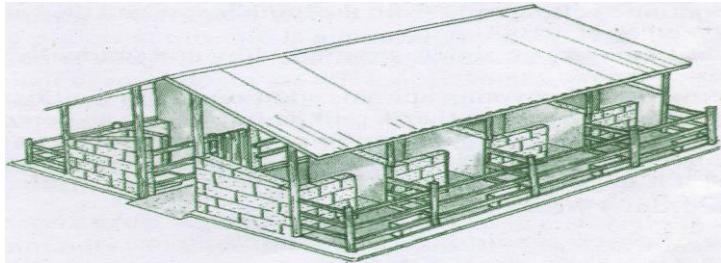


Fig. 10.7: Piggery units

Note: The floor of the piggery should be free draining to avoid accumulation of water which can result in disease infections.

Maintenance of a piggery unit

- (i) Clean the unit regularly.
- (ii) Change the bedding regularly.
- (iii) Repair any broken parts.
- (iv) Avoid dampness by repairing leaking roofs.

10.6: Feeding pigs, major parasites and diseases of pigs and their control and prevention

Pigs should be fed on the right type of feed as per their age.

(a) Piglet stage (10 days- 8 weeks)

- Piglets continue getting milk from the mother sow and they are introduced to creep feed on the 10th day.
- The quantity given per piglet is initially low and gradually increased as the piglets increase in size.
- The practise of giving young animals additional high quality feeds in form of pellet to supplement mother's milk is referred to as creep feeding.
- Each class of animals has a specific requirement for their young ones. For example, in piglets, it is carried out from 10 days of age to 4 weeks; in lambs, it is done from 2 weeks to 14 weeks of age; while in kindlings, it is done from 4 weeks after birth.

The importance of creep feeding

- It leads to higher weaning weight.

- It promotes fast growth because the young do not rely on the mother's milk only.
- It helps in the full development of the digestive system as the young get accustomed to digesting solid feed in addition to the milk.
- It prevents over-suckling of the mother thus promoting good body condition at weaning.

Qualities of a good creep feed

- Highly digestible.
- High in energy content.
- Highly palatable.
- Rich in digestible crude protein (between 20- 24% DCP).
- Rich in minerals such as iron and calcium among others.
- Rich in vitamins A, B complex and D.

(b) Weaner's stage (8 weeks -50 kg)

- The weaners are fed on sow and weaner meal.

(c) Fattener's stage (50 kg-market)

- The pigs are fed on pig finisher or fattener meal.
- They should be given adequate feed in respect to their body weight.
- Pig finisher meal has the lowest digestible crude protein (DCP) level, which is 12%.

Weaning

This is the gradual introduction of solid feeds and gradual reduction of milk consumption in piglets.

The piglets are separated from the mother sow at 8 weeks of age.

Weaning process

Piglets can be weaned through the following systems.

(a) Old weaning system at 8 weeks.

Weaning piglets at this age is a natural process. By this time the sow's milk production is declining substantially and solid feed consumption by piglets is sufficient to meet about 70-80% nutritional requirements.

(b) Recent system at 4-6 weeks.

This involves separating the mother sow and piglets at 4-6 weeks of age. The piglets' solid feed consumption accounts for 50-60% of the nutrients

requirements and therefore no serious problems should be encountered with weaning at this age.

Factors considered when weaning

1. *Piglet immunity - Passive immunity from colostrum is transient and declining to very low concentrations by 14 days of age.*
 - *Piglets do not start building its own active immunity until about 21 days of age.*
 - *Acquiring active immunity is a slow process even if they are exposed to antigens as part of the disease control program. So piglets have little protection for another 2-3 weeks.*
2. *Post weaning fertility - Early weaning does not necessarily lead to fast return of the sow into oestrus.*
3. *Availability of skilled attendants to take care of the piglets.*
4. *Availability of proper facilities.*
5. *Feed costs.*

Advantages of very early weaning

- *Better disease control. Piglets are separated from mother sow when their passive immunity is still high, hence cannot get infected by pathogens in the mother's body.*
- *Uniform piglet growth is achieved.*
- *There is better sow productivity.*

Disadvantage of very early weaning

- *There is potential delayed fertility in sows especially gilts.*
- *Very early weaning requires very special facilities such as isolated, precisely controlled environments adjusted as piglets grow.*
- *Very early weaning relies on competent and dedicated attendants.*

Basic essentials for satisfactory weaning

(i) Minimise distress

Piglets should be properly pre-conditioned and kept with some members of the same litter. (ii) Physical environment

- *Maintain piglets within the pen.*
- *Have adequate group sizes such as 10-20 per pen, so that they can huddle together to effectively conserve heat when it's cold.*

(iii) Feeding

- Provide palatable rations that meet all nutritional requirements of the piglets.

Wallowing in pigs

This is a unique behaviour of pigs whereby they roll on and spread their bodies with mud.

Importance of wallowing

It has cooling effects; wallowing is more frequent in hot weather. It helps to control sun burns especially those with low pigmentation. It helps to control external parasites.

Common parasites in pigs

The following are the common parasites that infest pigs.

1. Roundworms (*Ascaris suum*)

This is the most common internal parasite in pigs. They are usually cylindrical in shape and pink or white in colour. The adult measures more than 8 inches long. The adult lives in the small intestine.

Life cycle of roundworms

- Eggs laid in the primary host are passed out in the faeces.
- On the ground they hatch into infective larvae 10 days after being laid. This infective stage is called encyst and is resistant to adverse environmental conditions, it can remain viable up to 30 years.
- The encysts are found on grass where they are picked (ingested) by grazing pigs.
- They then bore through the intestinal walls into the bloodstream and are carried into the liver and then into the lungs where they penetrate into the trachea. They are coughed out into the mouth ad are re-swallowed.
- In the intestines, they develop into adult worms and start another cycle. Male and female worms mate and upon fertilisation, the females lay eggs.

Signs and symptoms of roundworm attack

- (a) Retarded growth
- (b) Scours
- (c) Anaemia
- (d) Pot belly appearance
- (e) Diarrhoea
- (f) Constipation

Control measures against roundworms

- (a) Avoid rearing pigs in muddy grounds.
- (b) Avoid grazing pigs in wet grass in the morning when the larvae are active.
- (c) De-worm pigs using appropriate dewormers regularly.

2. Whipworm (*Trichuris suis*)

This is another common endoparasite in pig production. It inhabits the alimentary canal of pigs.

Signs and symptoms

- (a) Loss of appetite
- (b) Diarrhoea with mucus and blood stains
- (c) Dehydration
- (d) Death

Control measures

- (a) Raising pigs in confinement.
- (b) Deworming with appropriate dewormers.

3. Mange (*Sarcopres scaibei*)

This is the major external parasite of pigs. They live on the skin of pigs. They burrow through skin layers digesting the tissues.

Signs and symptoms of mange

- (a) Thickened and reddened skin around the ears, shoulders, stomach and between the legs.
- (b) Animals will scratch themselves until they damage their skins.

Control measures

- (a) By washing the animals clean.
- (b) Spray with appropriate acaricides.

4. Mites

These are eight-legged round-bodied crawling arachnids. They are white in colour and have dark legs.

They also burrow into the skin of pigs causing great irritation.

5. Lice

They are wingless insects with a diamond-shaped body. They are blood sucking insects.

Common diseases of pigs

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The following are the common diseases of pigs.

1. African swine fever

It is caused by iridovirus which is transmitted by contact with wild pigs or through contact with infected garbage. Transmission is also possible by ticks of Ornithodoros spp.

Signs and symptoms

- (a) Fever of about 40°C - 41°C .
- (b) Characteristic paralysis of hindquarters. The pig moves about on its forelegs only.
- (c) Difficulty in breathing.
- (d) Constipation followed by blood stained diarrhoea.
- (e) Lack of coordination of the nervous system.
- (f) Pig's skin, snout, abdomen and ears appear blue (cyanosis).
- (g) Lacrimation. This is watery discharge from the eyes. (h) Coughing and vomiting.

Control measures

- (a) Keep off wild pigs.
- (b) Do not feed pigs on garbage.
- (c) Slaughter and properly dispose of the affected pigs.
- (d) Carry out quarantine.

2. Pneumonia

This disease infects the lung tissue. It is a common disease of piglets.

Cause

It is caused by the bacterium Mycoplasma mycoides, viruses, dust particles or presence of worms in the lungs.

Predisposing factors

- (a) Poor ventilation.
- (b) Overcrowding.
- (c) Age: Young animals are more prone to the disease than adults.
- (d) Dampness and chilliness in the pig houses.

Signs and symptoms

- (a) Severe respiratory problems.
- (b) Abundant mucoid nasal discharge.

- (c) Fever.
- (d) Piglet appears dull.
- (e) Loss of appetite.
- (f) Abnormal lung sounds such as bubbling, hissing and gurgling
- (g) After slight exercise, the piglet coughs due to congestion of bronchioles.

Control measures

- (i) Keep piglets in warm pens.
- (ii) Treat early cases of the disease with antibiotics.
- (iii) Avoid overcrowding in animal pens.
- (iv) Ensure proper ventilation in the piggery.

3. Piglet scours

This disease is also referred to as colibacillosis or white scours.

Cause

It is caused by a bacterium known as *Escherichia coli* which usually attacks young piglets during the first week of birth. *Escherichia coli* inhabits the animals intestines.

Predisposing factors

- (a) Unhygienic conditions in the house of piglets. Dampness and chilly conditions in the piggery contribute to the development of scours.
- (b) Poor feeding practises such as overfeeding of the piglets, lack of colostrum or irregular feeding programme.
- (c) Abrupt temperature changes.
- (d) Deficiency of vitamin A.

Signs and symptoms

- (a) White or yellowish diarrhoea with a pungent smell.
- (b) Rapid dehydration.
- (c) Initial rise in body temperature but which later drops below normal.
- (d) Extremely cold to touch.
- (e) Dullness
- (f) Undigested milk curd.
- (g) Blood and mucus stains occur in the faeces, (h) Soiled tail and back of the thighs.
- (i) Loss of appetite.

Control measures

- (a) Ensure cleanliness in the animal housing. Avoid dampness on the floor of the animal houses.
- (b) Proper feeding
- (c) Observe hygiene during parturition.

4. Piglet anaemia

This is a disease of piglets because they are born with limited supply of iron. If the piglet does not have access to iron in the first 2-3 weeks, its red blood cell capacity to absorb oxygen is impaired (anaemic).

Cause

Insufficient or low levels of red blood cells.

Signs and symptoms

- Pale skin.
- Rapid breathing.
- Jaundiced sometimes slight yellow appearance.
- Mucous membranes of the eyes are pale.
- Scours, sloppy diarrhoea.
- Signs of haemorrhage.
- General weakness.

Control measures

- Administer iron injection within the first week after birth.
- Give iron paste to piglets.

Control and prevention of diseases and parasites in pigs

Pigs are susceptible to attack by a number of parasites and diseases, which may compromise their health and consequently their performance.

The farmer should strive to keep his pigs healthy through the following practices.

- Cleaning and disinfecting the pig house regularly.
- Cleaning the feed and water troughs and disinfecting them.
- Practise routine deworming of the pigs to control endoparasites.
- Wash and spray the pigs using appropriate chemicals to control external parasites.
- Isolate sick pigs to prevent spread of diseases.
- Administer iron injection or paste to piglets to control piglet anaemia.

- Treat sick pigs using appropriate drugs to prevent spread of diseases.
- Practise proper disposal of carcass to prevent spread of disease.
- Keep away wild pigs from the farm to control African swine fever disease.
- Maintain a footbath at the entry of pig house to prevent introduction of disease.
- In case of outbreak of African swine fever, all animals should be slaughtered and carcass disposed of properly.
- Vaccinate regularly against common diseases.

GLOSSARY

Azotobacter spp.: A free-living nitrogen-fixing bacterium. Adlibitum: Provide water in plenty for the animals to drink at will.

Bacon: Treated or cured Pig meat from the back and the sides.

Base interest rate: The minimum interest rate that investors will accept for investing in a non treasury security.

Battery cage system: A method of rearing birds where they are confined in a wire cage.

Blocking: The practice of placing similar test-objects together.

Bush fallowing: A method of farming where small plots of land are cleared and cultivated for 2 to 5 years and then left under natural vegetation for a much longer, period usually more than five years.

Capillary water: A form of soil water that occurs in form of a thin film around soil particles.

Compound fertiliser: This is an inorganic fertiliser that supplies more than one of the primary macronutrients.

Credit service: These are loan services.

Deep litter system: A method of rearing poultry where birds are confined within a house whose floor is covered with absorbent litter.

Dibbling: Opening of the soil with a stick or machete to place seeds or fertiliser.

Dykes/ levees: These are embankments made of soil used to hold water within a level basin.

Ears: Seed bearing head or spike of a cereal plant

Effective interest rate: The Interest rate in a loan restated from the nominal interest rates as an interest rate with annual/compound interest payable.

Erect bunch variety: Vertically growing variety.

Evapotranspiration: The process by which water is lost from the soil, water bodies and growing plants.

Farming system: The way a farmer organises and carries out farming activities in his/her farm

Fertigation: Application of fertiliser together with irrigation water.

Gender roles: These are culturally accepted duties of either the male or female members of a given community.

Hardpan: A hard impermeable layer of compacted clay particles that may occur in the subsoil of some soil profiles.

Homogenous block: A group of similar test-objects placed together.

Humus: An end product of the decomposition of organic matter that cannot be broken down further.

Hygroscopic water: A form of soil water that occupies the micro-pores of the soil.

Hygrosopy: The tendency of a substance to absorb moisture from the atmosphere.

Inorganic matter: A component of soil that is derived from the breakdown of the parent rock.

Intensive farming: A farming system that is characterised by high capital investment and maximum utilisation of land.

Land reclamation: A practice that is done to convert a land that was once unsuitable for agriculture to being suitable for it.

Leaf chlorosis: A phenomenon whereby leaves of growing plants turn yellow in colour.

Level basin: This is a levelled ground surrounded by dykes. Litter: A group of young ones born by a sow at the same time.

Meloidogyne: A species of nematodes that attacks Irish potatoes in the field.

Mixed farming: A method of farming that involves growing of crops in the same field but in different sections of the farm at the same time and rearing of livestock.

No-till cropping: A method of farming system that is characterised by low capital investment and usually carried out on large pieces of land.

Organic matter: A component of the soil that is derived from plant and animal remains.

Pigsty: A structure used in rearing pigs.

Plant pathology: Study of the cause, origin and nature of plant diseases.

Pork: Untreated meat from pigs or fresh pig's meat.

Prolific: The ability of a mother animal to protect and feed its young ones.

Ranching: A method of rearing livestock in vast land.

Randomisation: The practice of assigning objects of study to an experimental unit purely by chance.

Replication: The repetition of a basic experiment.

Rhizobium spp.: A symbiotic nitrogen-fixing bacterium found in association with leguminous plants.

Saline water: Water that has a lot of mineral salts dissolved in it. Seedbed: Is a piece of land prepared ready to receive planting materials.

Sluice gate: An opening in a water canal that regulates the flow of water into the crop field.

Soil profile: This is the vertical arrangement of soil layers from the topsoil to the parent rock.

Straight fertiliser: This is an inorganic fertiliser that supplies only one of the primary macronutrients.

Strigga spp.: A parasitic weed that attacks crops of the grass family, such as maize. It is also known as the witch weed.

Superfluous water: A form of soil water that occupies the micro-pores of the soil.

Tiers: Rows of battery cages placed on top of one another.

Treatment: This is what a researcher deliberately imposes on experimental units.

Variable: A measurable aspect of an experiment.

Volatilisation: This is the process by which a solid compound changes into gaseous form.

Zero grazing: Rearing of cattle in a confined area in a shed or yard.