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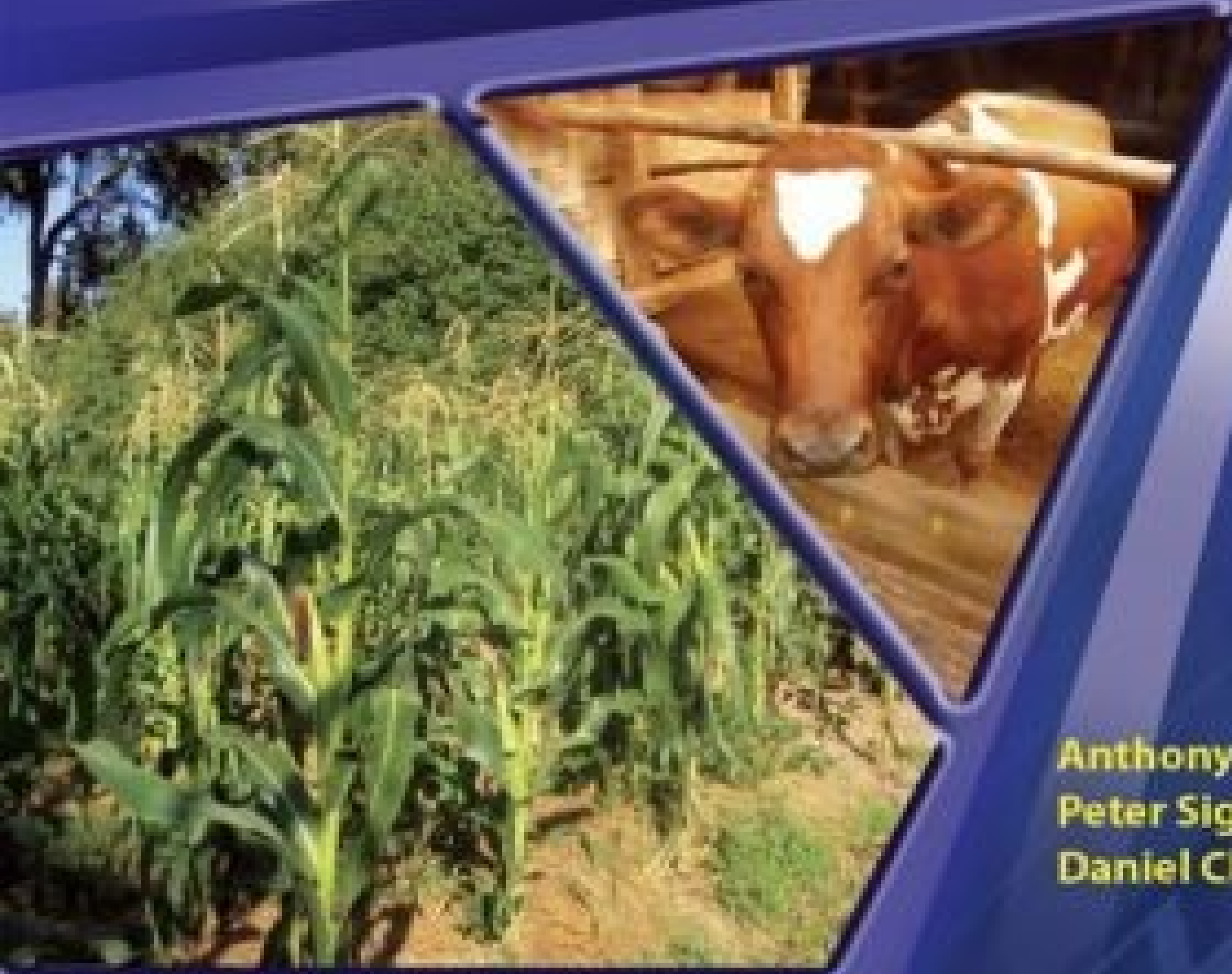
Malawi

Senior Secondary Agriculture Form 3



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Agriculture

Form 3

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Distributed throughout Malawi by:

Grey Matter Ltd.
P.O. Box 2608
Lilongwe, Malawi
Tel: 01755411/01920788
Fax: 01755430
Email: distribution@greymattermw.com

Under agreement with the publishers

Longhorn Publishers
Funzi Road, Industrial Area,
P.O. Box 18033, Nairobi, Kenya

First published 2012

Design and layout by Steve Nganyi.

ISBN 9996 014 207

Printed by English Press Ltd
Off Enterprise Road, Industrial Area,
P.O. Box 30127 - 00100, Nairobi, Kenya

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Unit 1 Physical Properties of soil

Objectives

By the end of this unit, you should be able to:

(a) List the physical properties of soil .

(b) Describe soil texture .

(c) Determine soil texture .

(d) Identify textual classes of soil .

(e) Explain the effects of soil texture on crop production .

(f) Describe soil structure .

(g) Identify types of soil structure .

(h) Explain the effects of soil structure on crop production .

(i) List the methods of maintaining and improving soil structure .

(j) Explain how each of the methods listed in (i) above maintain the structure .

Soils

Soil is the uppermost layer of the solid crust of the earth consisting of rocks that have been reduced to small fragments and have been more or less changed chemically, together with the remains of plants and animals that live on it and use it. This loose material is where plants, by means of their roots find footholds (anchorage) and nourishment thus are able to grow.

The physical properties of soil

Soils are characterised by their physical or chemical properties. These include certain specific characteristics in the construction and constitution of the horizons. The physical properties of soil are:

• Texture.

• Structure.

• Colour.

• Temperature.

• Consistency.
• Porosity.
• Depth.

(a) Texture	-	This refers to the relative proportion of various sizes of mineral particles in the soil that is, sand, silt and clay. This is the fabric of the mineral component of the soil mass resulting from the relative proportion of the three particle sizes.
(b) Structure	-	This refers to the overall arrangement, grouping or aggregation of the soil particles that is, grouping of sand, silt and clay to form different shapes and sizes of soil units.
(c) Colour	-	A soil type has a specific colour due to the mineral composition from the parent material. For instance, a rock containing a lot of iron is brownish, reddish or orange in colour, soils with a lot of silica are white, and soils with a lot of humus are dark - coloured. Soil colour can be altered by soil erosion when the mineral content in soil particles are washed away or leached.
(d) Temperature	-	Soil temperature indicates the heat transfer in the soil. Soils with a lot of organic matter have high heat capacity.
(e) Consistency	-	This refers to the degree of cohesion of the soil particles and the resistance offered in the force tending to rupture or break up the soil aggregates. It is closely related to the property of compactness. It is determined by the structure, texture of the soil, the cementing materials and by the pore space.
(f) Porosity	-	This refers to the air spaces between soil particles. For example, finely porous soil is characteristic of fine soil particles. It depends on the texture of soil.
(g) Depth	-	This is the profile of the soil. A vertical cut through the soil horizons (layers) gives the depth. Thin or young soil has a shallow depth. Relief greatly influences the depth of the profile. On hilly areas, the soil as it is

formed is subject to erosion and thus shallow profile; whereas at the foot of the hills, the profile is deep.
In desert and semi-desert regions the profile is shallow, in regions of higher rainfall the depth of the profile increases.

Soil texture

Soil texture refers to the relative proportion of various sizes of mineral particles in a soil. The components of soil mineral matter are sand, silt and clay.

These particles vary in sizes.
Sand: 0.02 − 2.0 mm diameter.
Silt: 0.002 − 0.02 mm diameter.
Clay: less than 0.002 mm diameter.

Depending on the proportions of mineral matter particles present in the soil, soil will be fine or coarse-textured. A *fine texture* is brought about by clay, while a *coarse texture* is a characteristic of sand. Therefore, soil texture sometimes refers to the feel of the soil. It is the percentage composition of sand, silt and clay particles in a soil sample.

The following experiments are used to determine soil texture:

Experiment 1.1: To determine the textual type of soil

Apparatus

- Samples of soil.
- Water in a beaker.

Procedure

1. Pick a small amount of the soil between your forefinger and thumb then wet it.
2. Press it between the fingers. How do you feel?
3. Take another sample and similarly wet it.
4. Try to roll it into a ball. Does it keep its shape?

Observations

Soil	Properties
Sandy	• It feels gritty. • It does not keep shape when rolled.
Sandy loam	• It keeps its shape when rolled. • It feels gritty.
Clayey	• It feels sticky, the stickier it is the more clay it contains.
Silty	• It is soapy or has silky feel. It cannot be rolled.
Loam	• It is slightly sticky and flexible; it can be rolled.
Sandy clay	• Sticky and slightly gritty. It can be rolled.
Silty clay	• Is it silky as well as sticky. It can be rolled.

Practical Activity 1.1

Visit the area around your school and observe the soil texture in your environment.

Sifting (Sieving) soil samples

Experiment 1.2: To separate different particles sizes in the soil

Apparatus

• Different sized sieves.

• Soil samples.

Procedure

• Pass the soil sample through a series of sieves.

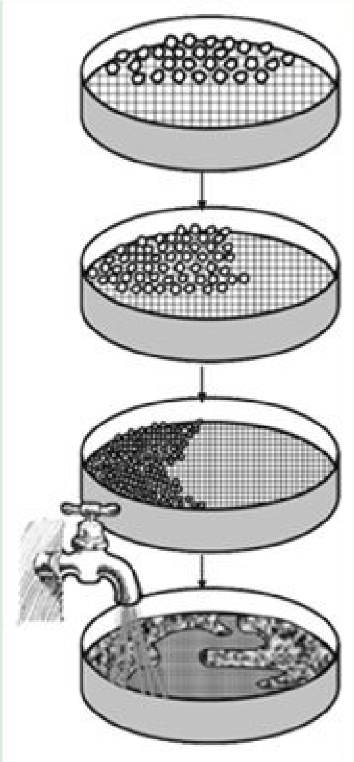


Fig. 1.1: Separating particles of soils in different sized sieves .

Observations

- The coarsest mesh of 2 mm allows all particles to pass through but retains gravel particles.
- When that sieved soil is passed through the sieve mesh of 0.2 mm, it sieves all other particles but retains sand particles.
- When the remaining soil is again sieved by 0.02 mm mesh, it retains fine sand particles.
- The remaining materials are placed in a sieve with fine meshes which cannot pass through the fine mesh easily thus water is used to suspend the clay particles and carry it leaving the fine silt.

Conclusion

Soil can be separated to different particle sizes namely; sand, clay and silt.

Experiment 1.3: To show that soil is made up of different sized particles

Apparatus

- Garden soil.
- Water.
- Sodium carbonate.
- 250 cm^3 measuring cylinder.

Procedure

1. Put about 50 gm of garden soil in a 250 cm^3 measuring cylinder.
2. Add about 5 - 10 gm of sodium carbonate powder.
3. Add about 150 cm^3 of water.
4. Cover the mouth of the cylinder with your palm, hold the bottom with the other hand and shake thoroughly.
5. Leave the contents to settle for about 30 minutes.

Observation

The soil particles settled in different layers depending on particle sizes. Gravel settles at the bottom, followed by coarse sand, silt and clay. Humus is suspended at the surface of the water.

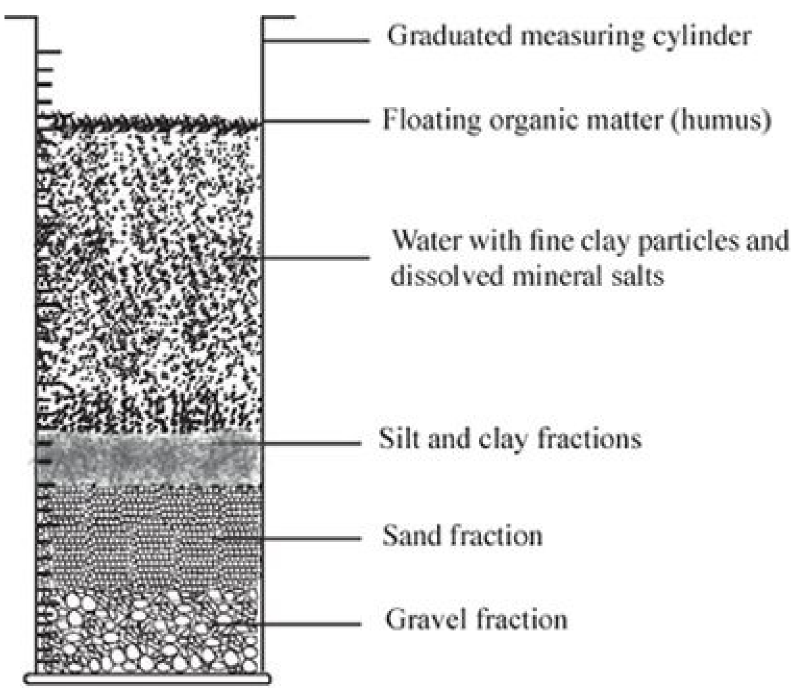


Fig. 1.2: Sedimenting soil particles .

Conclusion

Soil is a mixture of different sized soil particles (mineral particles).

Textural classes of soil

The combination of the three particles in a soil can be presented in a triangular manner resulting in various textural classes.

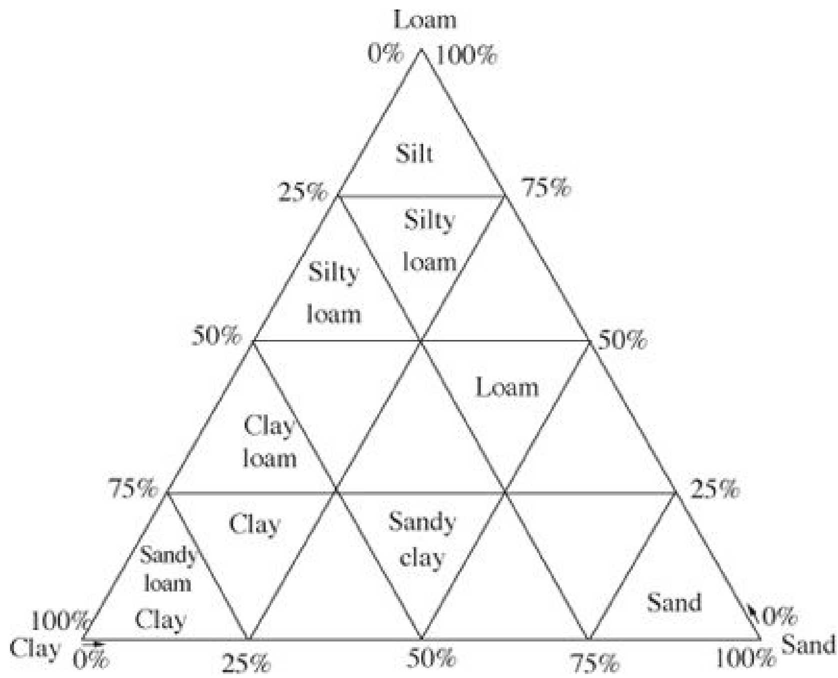


Fig. 1.3: Soil textural classes .

Sandy soils

Composition	*Characteristics*
50 – 80% sand. 20 – 50% clay + silt. 0.1 – 3% organic matter.	• Very well drained. • Coarse textured (gritty). • Moderately fertile. • Low water holding capacity. • Slightly acidic. • Less stable structure, hence prone to soil erosion. • Highly aerated. • Low density and light soils. • Low capillarity.

Silty loams

Composition	*Characteristics*
20 – 30% sand. 70 – 80% clay + silt. 0.1 – 4% organic matter.	• Well drained. • Good water holding capacity. • Fine textured. • Moderately fertile and aerated. • Cast formed does not break easily.

Clayey loams

Composition	*Characteristics*
20 – 50% sand. 20 – 60% silt + clay. 0.1– 6% organic matter.	• Fine textured. • Poorly aerated. • Poorly drained. • High nutrient content. • Easily waterlogged. • Only suitable for flood irrigated crops for example rice.

Clayey soils

Composition	*Characteristics*
Clayey soils contain more than 40% clay.	• Sticky when wet. • Hard when dry. • Very poorly aerated. • Very poorly drained. • High fertility. • High capillarity. • Can be improved by drainage. • Smooth plastice. • Swells when dry. • Cracks when dry. • High water retention. • Has fine soil particles.

Loamy soils

Composition	*Characteristics*

30 – 50% sand. 50 – 70% silt and clay. 0.1– 4% organic matter.	• Well drained. • Moderately textured. • Fertile. • Good water holding capacity. • Slightly acidic. • Easy to dig. • These are the best soils for crop production.

Experiment 1.4: To find out the water holding capacity and porosity of the soil

Apparatus

- Measuring jars.
- Funnels.
- Cotton wool.
- Water.
- Sandy soil.
- Clay soil.
- Loam soil.
- Stop clock.

Procedure

1. Dry the soil samples in the sun.
2. Crush all the soil samples except sandy soils.
3. Plug large filter funnels with cotton wool.
4. Place the three different types of soil of equal masses in the funnels.
5. Place each funnel in separate measuring cylinders, then quickly pour 20 ml of water into the funnels.
6. Determine the time taken for any known volume of water to drain through each of the soil types in each measuring cylinder. Find the volume of water collected and determine the amount of water retained in all the set-ups.

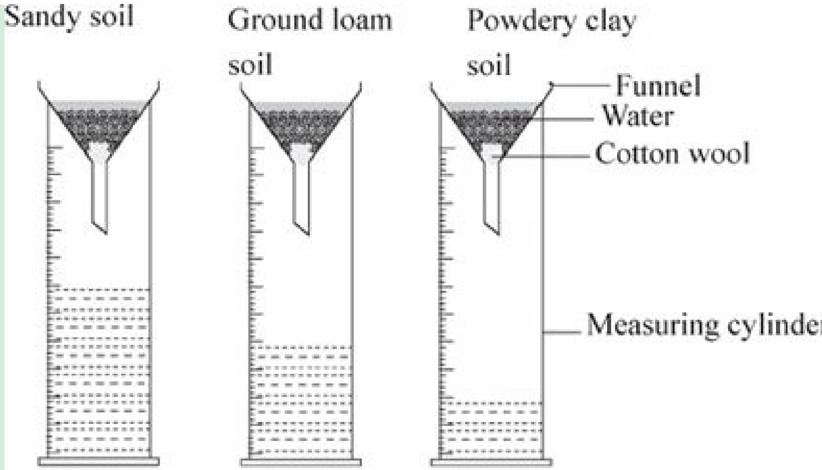


Fig. 1.4: To compare porosity and water holding capacity of different soils .

Observation

After 5 minutes, water levels in different measuring cylinders vary.
Water level is highest in measuring cylinder with sandy soil, followed by loamy soil while measuring cylinder with clay soil contains the least amount of water.

Conclusion

- The most porous soil is sandy soil, followed by loam soil and then clayey soil.
- Clay has the highest water holding capacity.

Experiment 1.5: To determine the capillarity of soil

Apparatus

- Three long capillary tubes.
- Cotton wool.
- Dry sand.
- Clay and loam soils with high percentage of organic matter content.
- Water trough, clock and a ruler.

Procedure

1. Close one end of each tube with a plug of cotton wool.
2. Crush all soil except sandy soils.
3. Fill each capillary tube with a different soil type.
4. Support each tube with a clampstand in an empty water trough.

5. Pour water into the water trough to a depth of 10 cm.
6. Remove the tubes from the trough after 5 minutes and measure the height of water in every tube. Then leave the apparatus overnight and measure again. Plot the results on a graph paper against time (in minutes) on the x-axis and water height (in cm) on y-axis.

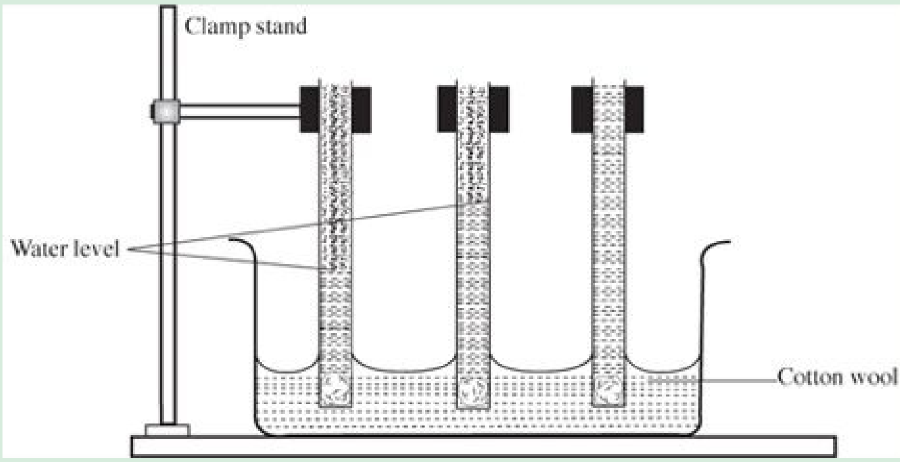


Fig. 1.5: Capillarity rates of different soils .

Observation

Water rises fastest in sandy and loamy soils but very slowly in clay soil in the first 5 minutes. However, after an overnight stay, the water level in clay soil is highest, followed by loamy soil and finally by sandy soil.

Conclusion

Clayey soil has the highest capillarity because of the fine pore spaces. Loamy soil has organic matter which absorbs water relatively fast. Sandy soil has the poorest capillarity because of large pore spaces.

Experiment 1.6: To examine the building materials of soil

Apparatus

- Hand lens.
- Light microscope.
- Petri dishes.
- Soil samples or particles.

Procedure

1. With the aid of a hand lens, examine a pinch of sand and a pinch of loam soil.
2. Set up a light microscope and use low, medium and high power objectives to view silt and clay particles.

   What are sand particles?
   What are silt particles?
   What are clay particles?

Effects of soil texture on crop production

Soil texture brings about different textual classes which affect crop growth because they differ in the following properties:

- Fertility.
- Organic matter content.
- Drainage.
- Aeration.
- Water - holding capacity.
- Capillarity.

These properties have direct influence on the performance of crops. For example, most crops grow well and produce high yields in fertile soils with good aeration and drainage. Such crops include; maize, tobacco and horticultural crops.

Light textural soils, that is, soils with coarse texture like sand, have large and numerous air spaces (well aerated). They are also well drained. However they are poor in soil fertility because they allow much leaching as water passes through them easily. If such soils are irrigated and fertilizers added, they become suitable for agriculture especially growing horticultural crops. For example, sandy loam support vegetables and cereals; sandy soils are suitable for crops like Irish potatoes and groundnuts.

Soil texture influences the ease of working or cultivating a soil, for example, clay soils are hard to work on unlike sandy soils. Clay soils, if limed, can be good agriculturally than sandy soils since they are less leached.

Practical Activity 1.2

Divide yourselves in groups and discuss the effects of soil texture on crop production.

Soil structure

Soil structure is the physical appearance of the soil in relation to the way the soil particles are grouped or arranged. Soil particles are joined together by colloids and humus which have cementing action. The sizes and shapes of the aggregated particles vary giving rise to various types of soil structure.

Practical Activity 1.3

In groups of three, research and discuss types of soil structure.

Types of soil structure

Soil structures include:

- Single-grained.
- Crumby.
- Granular.
- Prismatic.
- Columnar.
- Platy.
- Blocky structures.

Single grained structure

In this type of structure, the soil particles are not cemented together. Particles are tiny and spherical. This structure is normally found in loose topsoils in arid areas. This type of soil structure is characteristic of sandy soils.

It is prone to wind erosion and not very suitable for crop production.

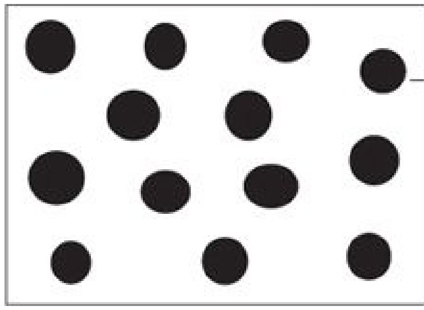


Fig. 1.6: Single grained structure .

Crumby structure

A crumby structure consists of tiny, porous aggregates of irregular shape. It gives the first stage of aggregation, from single-grained structure, where a few particles are joined together. This is one of the best structures for crop production as particles allow enough air space. The soil particles are loosely fitted together.

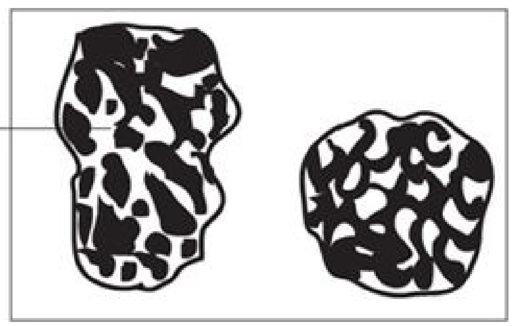


Fig. 1.7: Crumby structure .

Granular structure

These are granules made of friable, rounded aggregates of irregular shape not exceeding 1.2 cm in diameter. It is normally found in the topsoil of cultivated soils. These aggregates are loosely packed, explaining why this soil structure is easily affected by cultivation and trampling. The soil particles lie loosely and are readily shaken apart. This structure is found in the topsoil of cultivated soil and in the subsoil of land under grass or bush.

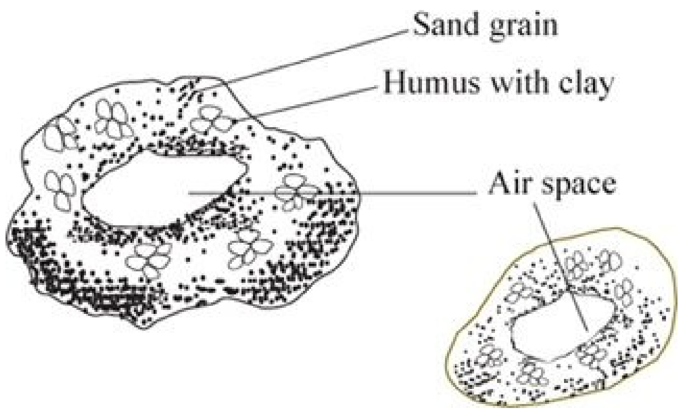


Fig. 1.8: Granular structure .

Prismatic structure

In this structure, soil aggregates are cemented in the form of vertically oriented pillars. Their tops could be shaped in such a way that they are level, plane and clean cut, thus named prismatic. Aggregates form distinct columns of various lengths, with shiny surfaces and sharp edges.

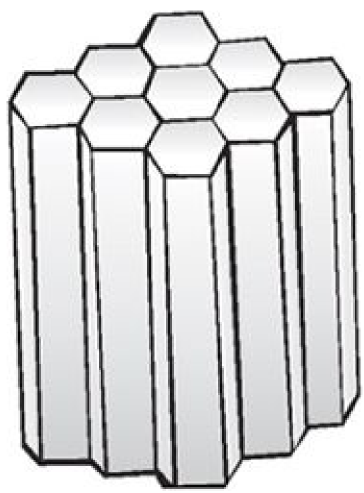


Fig. 1.9: Prismatic structure .

These are normally located in the subsoil horizons of arid and semi- arid soils. They are common in fine-textural soils.

Columnar structure

When soil aggregates (particles) are arranged vertically 15cm or more in diameter but their tops are rounded, they are referred to as columnar structures. These columns are very similar to prismatic, only that their tops are rounded and they are cylindrical. They are found in subsoils of arid and semi-arid areas.

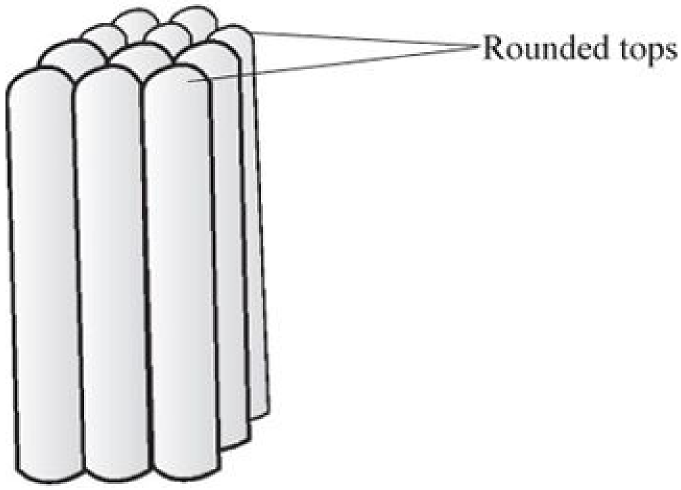


Fig. 1.10: Columnar structure .

Platy structure (Pyramidal)

These are soil aggregates that are arranged in thin horizontal layers known as plates. The plates overlap each other and thus make such soils poor for crop production as there is poor root penetration. Plates are commonly found in forests and in cattle sheds where there is a lot of organic matter. This structure provides poor aeration of soil which hinders water percolation. Platy structure is also found in the top of clayey soils, but is mostly noticeable on the surface layers of virgin soils and those soils from parent material.

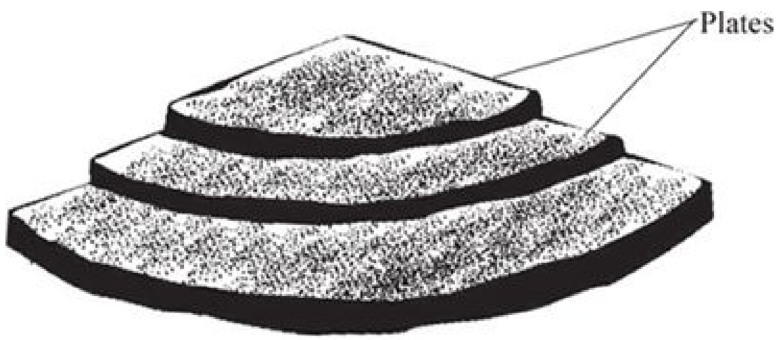


Fig. 1.11: Platy structure .

Blocky structure

In this structure, the soil aggregates are arranged in rectangular blocks because they easily fit together. The blocks have six irregular faces. They are normally found in fine textured subsoils. It is referred to as **blocky** because the edges of the cubes are sharp and have distinct rectangular faces. The blocks range from 1-10 cm in thickness. Also termed as cuboidal. They are confined to subsoils.

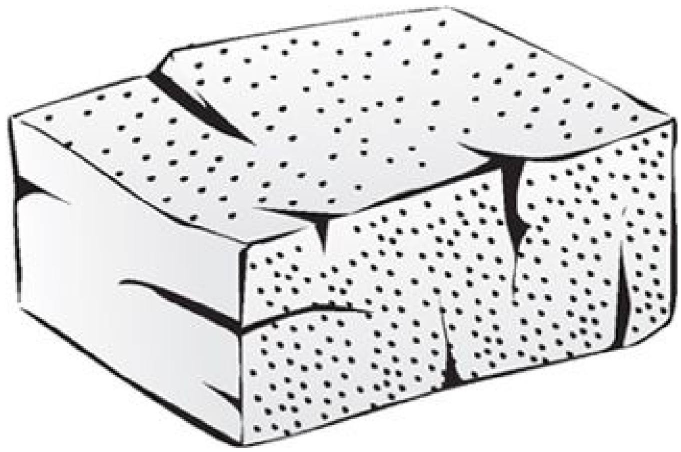


Fig. 1.12: Blocky structure .

Effect of soil structure on crop production

- The water holding capacity of the soil is influenced by the soil structure. Water is very essential for the proper growth of crops.
- Soil structure influences the air spaces available in the soil, and therefore, its aeration. Structures that do not allow enough air space, for example, platy and blocky, are not suitable for proper crop growth since plant roots require air for respiration.
- It influences the drainage of the soil. Structures such as granular and crumby are well drained as they have enough air spaces for water. Most crops with the exception of rice, require well drained soils for optimum growth and production.
- Root penetration will highly depend on the soil structure. Structures, such as, platy will hinder root penetration.
- Soil structures influence microbial activities in the soil due to increased air availability. Poor structures impede decomposition of organic matter.
- It influences circulation of gases in the soil, for example, carbon dioxide released by soil micro-organism must be expelled from the soil so that it does not build up to toxic levels. This is facilitated by free air circulation which is influenced by the soil structure. Platy structures are poorly aerated, while crumby structures are well aerated.
- Well developed soil structure ensures a high percentage of germination and root branching due to good water retention and aeration plus soil heat transfer.

Practical Activity 1.4

Form various groups and discuss the effects of soil structure.

Methods of maintaining and improving soil structure

There are some farming practices which improve the structure of soil thereby maintaining soils that are suitable for crop production. These farming practices are:

- Application of organic manures.
- Tilling of the soil at the right moisture content.
- Crop rotation.
- Minimum tillage.
- Cover cropping.
- Fallowing.
- Liming.
- Cropping systems.

1. Application of organic manures : They bind loose soil particles together thus improving water holding capacity and will increase the microbial activities.
2. Tilling of the soil at the right moisture content : This will enable the breakdown of large soil clods without clodding or puddling
3. Crop rotation : Sound crop rotation should include cover crops and crops which help bind soil particles together.
4. Minimum tillage : This helps to prevent over pulverization of soil which makes it liable to erosion. It also prevents exposure of soil moisture to loss.
5. Cover cropping : This prevents splash erosion and increases water infiltration into the soil. It also reduces loss of soil moisture.
6. Mulching : Use of organic mulch helps in improving nutrients status of the soil after decomposition, and it helps reduce soil erosion.
7. Fallowing : This helps the destroyed soil structure to reform because it is given time to recover.
8. Liming : Application of agricultural lime helps in improving the drainage an aeration of heavy soils through flocculation.
9. Cropping systems : This include intercropping and mixed cropping that help in covering soil thus improving water infiltration and moisture retention. Inclusions of legumes help in addition of nutrients.

Experiment 1.7: To research on types of soil structures

Apparatus

- Hand lens.
- Soil particles.

Procedure

With the aid of a hand lens examine the structure of loamy, clay and sandy soil.

Practical Activity 1.5

1. Visit various farms near the school and access the soil types. Relate to the crops grown.
2. Carry out a project in the school garden on practices used for maintaining soil structure.

Revision Exercise 1

1. List down the various physical properties of soil.
2. Differentiate between soil texture and soil structure.
3. Differentiate between organic matter and humus.
4. State four characteristics of loamy soils.
5. Discuss the effects of soil structure on crop production.

Unit 2 Chemical Properties of soil

Objectives

By the end of this unit, you should be able to:

(a) List chemical properties of soil .

(b) Define the term pH .

(c) Explain the factors affecting soil pH .

(d) Set up an experiment to test soil pH .

(e) Relate soil pH to plant growth .

(f) Modify soil pH .

(g) Outline the factors affecting nutrient status of the soil .

(h) Explain how much each factor affects nutrient status of the soil .

(i) Define the term 'Cation Exchange' (CEC) .

(j) Appreciate the importance of CEC on plant growth .

Chemical properties of soil

The building materials of soil are mineral particles and organic matter . These substances are composed of chemical elements and they include:

- pH.
- Salinity.
- Nutrient status.
- Cation Exchange Capacity (CEC).

pH

Soil pH or soil reaction refers to the *acidity or alkalinity of the soil solution* or *potential hydrogen ion concentration in the soil* .

Soil pH is determined by the concentration of the hydrogen ions (H^+) or the hydroxyl ions (OH^-) in the soil solution. If the pH is less than 7, then the soil is acidic; if it is 7, then the soil is neutral; and if it is above 7, the soil is alkaline.

As the hydrogen ions (H^+) in the soil solution increase, the pH decreases making the soil solution to become more acidic (less alkaline). As the hydroxyl ions (OH^-) in the solution increase, the solution becomes more alkaline (less acidic).

For the estimation of pH, the pH scale (ranging 1-14) is used.

The pH in the soil can be lowered by the use of acidic fertilizers and increased by liming or by use of basic fertilizers.

The pH scale

The term pH stands for the “potential hydrogen” ion concentration. Soil pH can be defined as *the negative logarithm (to base 10) of the hydrogen ion concentration* , or, simply as *the level of acidity of the soil:*

$$pH = -\log (H^+)$$

The pH scale covers a range of values from 1 to 14 with value 7 being neutral. The hydrogen ion concentration in a litre of pure water is 0.0000001 or 10^{-7} . Since pH is equal to the negative logarithm of the hydrogen ion concentration, then the pH of water is:

$$pH = -\log 10^{-7}$$

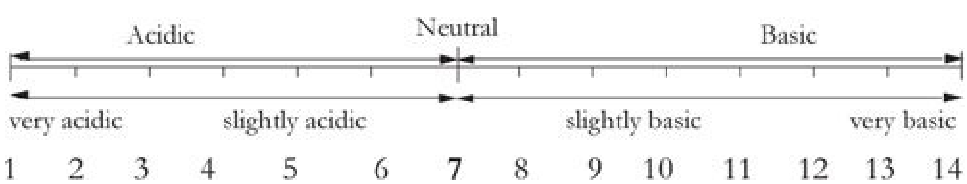


Fig. 2.1: pH ranges .

$$\begin{aligned} pH &= \log_{10}^{-7} \\ &= -(-7)_1 \end{aligned}$$

$$pH = 7$$

Pure water thus has a pH of 7 and is considered *neutral* . The acidity or alkalinity of a solution is determined by its hydrogen ion concentration. pH values below 7 indicate acid solutions, whereas pH values above 7 indicate basic (alkaline) solutions. Solutions with low pH values are strongly acidic while solutions with high pH values are strongly basic.

Soil pH

Soils become acidic when they lose bases. This is mainly brought about by leaching and cropping. Leaching is a major concern in areas with high rainfall. In poorly drained, waterlogged soils, acidity is due to the presence of insoluble acids.

Factors affecting soil pH

- The parent material from which the soil was formed : Soils developed from basic rocks like limestone, generally have higher pH values than those formed from acid rocks.
- Rainfall : Water passing through the soil leaches basic nutrients such as calcium and magnesium from the soil. They are replaced by acidic elements such as aluminium and iron. For this reason, soils formed under high rainfall conditions are more acidic than those formed under arid conditions.
- Pollution of the soil through human activities : Exhaust fumes from automobiles pollute soils thus interfering with their pH.
- Type of fertilizer applied : Acidic fertilizers like urea decreases soil pH.
- Living organisms : The decomposition of organic matter in the soil due to presence of soil micro-organisms adds soil acidity, humus or dead organic matter adds to soil acidity.
- Farming practices : Farming practices such as monocropping affect the soil pH depending on the type of crop grown for a certain period of time. Leaching reduces the mineral content in the soil hence affecting soil pH.

Test for soil pH

There are various methods of testing soil pH. The most common methods are:

(a) *Universal indicator solution:* This solution results from mixing several acid-base indicators together. When this is added to a soil solution, the colour change is matched with the colours on the pH charts.

(b) *Use of pH meter:* This is a device used to determine the pH of a soil solution. The equipment is expensive and may only be found in agricultural laboratories.

Experiment 2.1: To determine the pH of soil samples using universal indicator solution .

Apparatus

- Test tubes.
- Universal indicator solution.
- Indicator colour charts.
- Barium sulphate powder.
- Soil samples.
- Distilled water.

Procedure

1. Place a soil sample in a test tube to a depth of about 1 cm.
2. Add an equivalent amount of barium sulphate to the test tube containing the soil sample, to ensure flocculation and precipitation of colloidal clay.
3. Fill the test tube with distilled water to within 4 cm from the top.
4. Shake the test tube thoroughly.
5. Allow the contents to settle, then add 8–10 drops of the universal indicator solution.
6. Shake the test tube well and allow the contents to settle.
7. Hold the test tube against the printed colour chart.
8. Compare each colour on the chart with the colour of the suspension and note the pH of the colour which matches it most closely.

Practical Activity 2.1

In groups of five, discuss the significance of soil pH to plant growth.

Significance of soil pH to plant growth

- The pH of the soil determines the chemical properties of the soil. This in turn dictates the type of crops to be grown in a given area such as tea which does well in acidic soils.
- Soil pH affects the availability of different nutrients to the plants such as phosphorus is not available at low pH, whereas potassium and iron are not available at high pH. A majority of the important plant nutrients become readily available to crops when the pH of the soil is around 5 - 6.5.
- If the pH is very low, the concentration of certain nutrients for example, iron, manganese and aluminium in the soil increases to toxic levels.

• A majority of the useful soil organisms are most active when the soil pH is approximately 5.5 - 8. Very low pH levels inhibit the activity of nitrogen-fixing bacteria.

• Low soil pH encourages the multiplication of fungi, thus soil-borne fungal plant diseases are common in acidic soils. Diseases caused by soil-borne bacteria are common in alkaline soils. Plant damage by nematodes is more common in acid soils.

• Different crop species react differently to pH. Some crops are adversely affected by low or high pH. For each crop species, there is an optimum pH range for proper growth.

The table below shows the recommended pH values for certain crops.

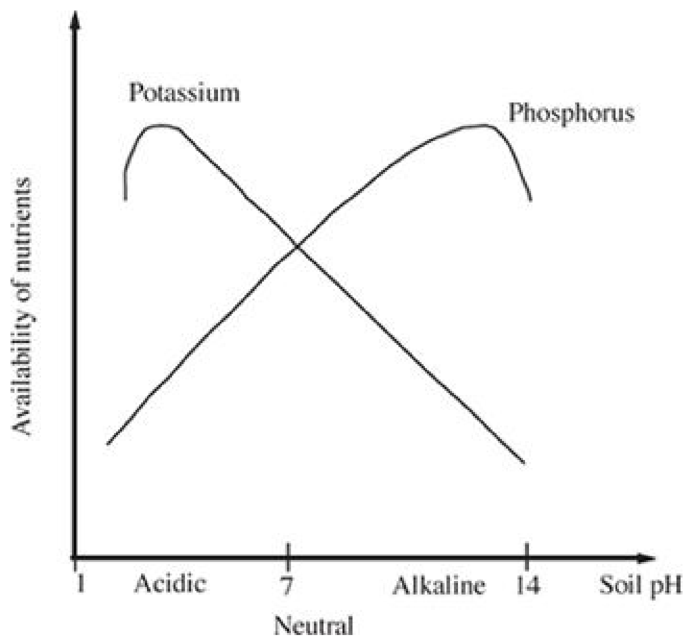


Fig. 2.2: Nutrient availability .

Recommended pH values of some crops

Crop	pH range	Crop	pH range
Banana	5.0 – 8.0	Mango	5.5 – 7.5
Cabbage	6.5	Tea	4.0 – 6.0
Coffee	5.3 – 6.0	Sugarcane	4.2 – 8.5
Cotton	5.0 – 6.0	Orange	5.0 – 7.0
Rice	5.5 – 6.5	Pyrethrum	5.6
Barley	7.0 – 8.0	Tobacco	5.5 – 6.5
Sorghum	5.0 – 8.5	Bean	6.0 – 7.0
Maize	6.0 – 7.0	Cocoyam	5.5 – 6.5
Pawpaw	6.0 – 6.5	Sweet potato	5.6 – 6.6
Pineapple	.5 – 6.5	Irish potato	5.0 – 6.0
Groundnut	6.0 – 6.5		

Table 2.1: Recommended pH values of some crops .

Modification of soil pH

Many soils in areas of humid conditions become acidic. They are said to be acidic because they manifest certain chemical properties similar to those of acids. For example, an acidic soil when sufficiently moistened with pure distilled water turns blue litmus paper red. Acidic soil is harmful to crops in several ways:

- It causes lack of certain nutrients and makes them less available.
- It favours development of physiological or nutritional diseases.
- It makes the soil less responsive to fertilizer and manure treatments.
- It favours growth of certain weeds.

Soils in dry areas tend to accumulate certain salts, thus become salty.

Such soils are not good also to crops since they similarly make certain nutrients unavailable/less available. Such soils with extreme acidity and alkalinity need to be modified. Soil pH modification is carried out through the following ways:

1. Lime application

Lime application is termed as liming of the soil. This is the only economic way of correcting soil acidity. This is the application of neutralizing substances containing lime (calcium oxide) known as agricultural lime . Whenever any such material is mixed in an acidic soil, a chemical reaction starts between the lime and the soil, resulting in a disappearance of the acidic conditions of soil if sufficient amount is applied. Lime improves the soil in several ways:

- Available calcium is added.
- Acidity and certain poisonous substances are neutralised, thus creating a more favourable environment in the growth and activity of the helpful soil bacteria. It also helps the growth of tender roots and makes nitrogen fixing bacteria available.
- Some plant-food elements in soils are available, like phosphorus.
- Greater returns are secured from fertilizer or manure application since it removes the temporary increase of acidity from these materials.
- The continued use of lime in acid clays and clay loams tends to improve their structure and hence favours the development of good tilth and help flocculates the soils.
- Weeds can be controlled easily.

Any acids formed in the soil through natural processes are neutralized by lime when present.

In soils, certain substances other than acids may be formed which prove injurious if allowed to accumulate. For example, aluminium compounds in very acidic soils. Lime destroys the poisonous effect of many of these substances.

Weeds grow better in acidic soils since most crops cannot thrive in acidic soils. In slightly acidic soils, crops do well while weeds are smothered. For example, sheep sorrel thrives well in acidic soils.

2. Application of organic manure (organic matter)

Manure are animal wastes or plant remains which are fully decomposed. Such materials when applied to the soil have nourishing elements beneficial to the plants. It is applied by ploughing into the soil or discing it in.

When organic manure is applied to heavy soils like clay, it helps to improve on drainage and aeration of soils by creating more pores in such soils, that is, making hard and compact soil loose and porous. It also reduces acidity in such soils and makes elements like phosphorus more available.

3. Application of fertilizers

Inorganic fertilizers when applied to the soil result in soil reaction. Some inorganic fertilizers have acid-inducing effects in the soil thus reducing the soil pH, for example, ammonium sulphate should be applied to alkaline soils to reduce alkalinity. On the other hand, some inorganic fertilizers are neutral or basic in reaction, for example, calcium ammonium nitrate. Such fertilizers can be applied to acidic soils to neutralise acidity and thus modify its pH.

Salinity

Soil salinity refers to the presence of too much salts in the soil. This is most pronounced in the top soil surface. Salt can be transported to the soil surface by capillarity from the salt laden water table and then accumulate due to evaporation of water. They can also accumulate due to human activities, for example, use of potassium fertilizer which accumulates phosphate salts. As soil salinity increases, it results in soil degradation.

The ions responsible for salinisation are Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- . Sodium salt accumulation makes soil have poor structure which prevents water infiltration. Sodium chloride is the predominant salt. In dry regions salts may accumulate leading to naturally saline soils.

Salinity in dry lands occurs due to high water table. Salts are brought up by capillarity. Also saline soil occurs due to lack of precipitation. Salinity from irrigation can occur over time whenever irrigation occurs, since almost all water (even natural rainfall) contains some dissolved salts. When the plants use the water, the salts are left behind the soil and eventually accumulate. Soil salinity makes it difficult for plants to absorb soil moisture. Salinisation from irrigation water increases due to poor drainage.

Salinity results in detrimental effects of plant growth and yield. Plants will not be able to get available nutrients in the soil. It also results in reduction of water quality for use by plants. Soil erosion is the eventual result from constant drainage of saline water.

Salinity can be reduced by leaching soluble salts out of the soil with excess irrigation water.

Also reduction of water table by use of drainage method like *tile method* and *sub-surface method* to flush excess water. In addition, salt-tolerant plants can be grown. However most crops are negatively affected by salinity.

Nutrient status

Nutrients are substances needed by plants and animals to grow. Nutrients in the soil determine soil fertility.

Factors affecting the nutrient status of the soil

Nutrient status of the soil depends on several factors:

- Soil depth and good tilth.
- Availability of plant nutrients in correct amounts and right proportions.
- Suitable moisture supply.
- Plenty of air in the soil.
- Presence of helpful soil organisms.
- Good soil pH.
- Absence of harmful agents in the soil such as too much salts or alkali.
- Absence of weeds.

These factors should be maintained in order to make soil fertile. However, there are intervening factors which make the soil lose its fertility status. These are:

- Nature of the parent material.
- Leaching.
- Soil erosion.
- Nutrient uptake by plants.
- Methods of cultivation.

(a) Parent material

The main types of rocks that constitute the parent material of most soils are:

- Igneous rocks.
- Sedimentary rocks.
- Metamorphic rocks.

This diversity in the type of parent material has given rise to many different soils. Parent material influences the physical and chemical properties of the soil. For example, *granite* and *sandstone* which are rich in the mineral quartz gives rise to sandy soils while *volcanic lava* which is low in quartz produces clayey soils. The two types of soil have very different chemical and physical properties. By influencing the chemical and physical properties of the soil on the other hand, the parent material will in a way control the type of crop to be grown. This is because of the mineral content in it. The soil can also retain fertility or easily loosen the fertility depending on its nature.

Parent material also determines the soil colour which in a way has influence on nutrient maintenance. For example:

- Sand grains tend to give whitish or grayish-white colour.
- Mica gives glittering appearance which may be whitish or blackish.

Soil colour is a physical characteristic of the soil hence determines the mineral composition of the parent material.

- Lateritic soils containing a lot of iron is brownish in colour.
- Darkish soils absorb a lot of heat and thus have relatively high temperatures which contribute to the fertility of the soil and influence the activities of soil micro-organisms making them more active, thus accelerating the rate of decomposition of organic matter.

(b) Leaching of basic nutrients

When rain falls, water percolates into the deeper layers of the soil. As water passes through the soil, some elements or nutrients are washed off the soil particles and down deep into the soil layers where they may not be available to plants. This process of loss of soil nutrients from the top soil layers to the deeper soil layers is called leaching . The rate at which leaching occurs depends on:

- Age of the soil.
- Situation of the soil on the land, that is, topography.
- Amount and distribution of rainfall.

Young soils formed from deposited volcanic materials are subjected to less leaching than older soils in the highland areas. They are also less fertile than those found in the valleys and river plains.

(c) Soil erosion

Soil erosion is the removal of top soil which is rich in plant nutrients. This is caused by agents of erosion like running water, wind and human activities. The nutrients or organic matter present in the top soil is carried away eventually leading to loss of nutrients.

Soil erosion due to running water develops in stages as:

- Splash erosion removing few particles of soil.
- Rill erosion developing small rills or channels which may be insignificant on bare soil surfaces.
- Sheet erosion where water flows over a whole flat field removing soil *en masse* .
- Gully erosion where water cuts deeply into the soil profile forming gapping valleys.

All these result in loss of soil nutrients and thus fertility loss.

Similarly wind erosion removes small, light, soil particles especially on well prepared seedbeds with pulverized soil. Areas of violent winds, especially arid and semi-arid regions experience wind erosion. This type of erosion also leads to loss of soil nutrients.

(d) Nutrient uptake by plants

The common elements required by plants are:

- *Nitrogen* .
- *Phosphorus* .
- *Potassium* .
- *Calcium* .
- *Sulphur* .
- *Oxygen* .
- *Hydrogen* .
- *Magnesium* .
- *Carbon* .

Traces of *iron, iodine, manganese, molybdenum* and *boron* are also required. Most of these elements are found in the soil forming soil solutions which are absorbed by plant roots. Soil water furnishes oxygen and hydrogen while air provides carbon and oxygen.

Plant nutrients are absorbed from the soil. If these nutrients are not replenished through application of fertilizers and manures then the soil loses fertility. Remains of crops should usually be ploughed into the soil to return some of the nutrients into it.

(e) Method of cultivation

Some methods of cultivation accelerate loss of soil nutrients. Such methods include:

- Ploughing across the contours.
- Ploughing along river banks.
- Over-cultivation.
- Ploughing when the soil is wet or having high moisture content.
- Bush clearing or deforestation and burning of the land.

Also some methods of farming like shifting cultivation (slash and burn type), and mono-cropping lead to loss of soil nutrients. In mono-cropping, when the same crop is grown on the same piece of land every year the soil becomes exhausted of plant nutrients since the plant roots absorb them continuously without replenishing. One crop grown continuously will absorb the same amount of nutrients and from same soil level thus depleting them.

Continuous cultivation of land has a tendency of the soil losing fertility and finally becoming unproductive. The soil becomes dusty and liable to erosion. In addition, there is loss of soil cover.

Cation Exchange capacity (CEC)

Cation Exchange Capacity (CEC) is the degree to which soil can absorb and exchange cations, that is, measure of its ability to hold and release various nutrients. Exchangeable cations may become available to plants. Plant roots also possess cation exchange capacity. Hydrogen ions (H^+) from the root hairs and micro-organisms may replace nutrient cations from the exchange complex on soil colloids. The nutrient cations are then released into the soil solution where they can be taken up by the adsorptive surfaces of roots and soil organisms.

They may however, be lost from the system by drainage water. High levels of one nutrient may influence the uptake of another, that is, antagonistic relationship. For example, potassium ion (K^+) uptake by plants is limited by high levels of calcium ion (Ca^{2+}) in some soils; high levels of potassium can in turn, limit magnesium ion (Mg^{2+}) uptake even if magnesium levels in soils are high.

Cation exchange capacity (CEC) also refers to maximum quantity of total cations of any class that a soil is capable of holding at a given pH value, for exchange with the soil solution. A cation is a positively charged ion for example, NH_4^+, K^+ and Ca^{2+}. CEC is used as a measure of fertility in nutrient retention capacity and the capacity to protect ground water from cation contamination.

Soil particles and organic matter have negative charges on their surfaces. Mineral cations can adsorb to the negative surface charges or the inorganic and organic soil particles. Once adsorbed, these minerals are not easily lost when the soil is leached by water and they also provide a nutrient reserve available to plant roots. These minerals can then be replaced or exchanged by other cations that is, cation exchange. CEC is highly dependent upon soil texture and organic matter content.

In general, the more clay and organic matter in the soil, the higher the CEC. Clay content is important because these small particles have a high ratio of surface area to volume.

Different types of clays also vary in CEC.

Factors that affect cation exchange capacity

- Type of clay colloids.
- The pH, that is, CEC increases with an increase in soil pH.
- Relative concentrations of the cations in the soil.

Importance of cation exchange capacity on plant growth and absorption of plant nutrients

Cation exchange capacity (CEC) is important because it shows the soils ability to supply the important nutrients, notably calcium, magnesium and potassium. The stronger the soil colloid's negative charge, the greater is its capacity to hold and exchange the cations. A high CEC enables plants get nutrients for growth and production.

As plants roots take up cations, other cations in the soil water replace them on the colloid. High concentration of one cation forces other cations off the colloid and takes their place. This competitive rate avails cations to plant roots for uptake. CEC varies according to the type of soil.

Humus has the highest CEC value because organic matter colloids have large quantities of negative charges. Clay has a greater capacity to attract and hold cations. Sands have no capacity to exchange cations because it has no electric charge. This can be improved by adding organic matter. Clay soils are thus richer in nutrients than sandy soils.

Practical Activity 2.2

Visit the school farm and carry out the following activities:

(a) Prepare two plots of 4m × 3m until they are ready for planting.

(b) In one plot apply too much calcium Ammonium nitrate and little amount of muriate of potash.

(c) In plot two apply alot of muriate of potash and less amount of calcium Ammonium nitrate.

(d) Put down the observations until the crop matures.

(e) Write down a conclusion of the experiment.

Revision Exercise 2

1. Define the term soil pH.
2. State the effects of soil pH on crop production.
3. (a) What is liming?

   (b) State the importance of liming the soil.
4. State the factors that influence pH.
5. (a) What is soil salinity?

   (b) What are the causes of soil salinity?
6. What is Cation Exchange Capacity (CEC)?
7. What does the term fixation of phosphorus mean?
8. State the factors which determine Cation Exchange Capacity (CEC) of the soil.
9. Discuss factors that affect soil fertility.

Topic 2: Crop Production

Unit 3 : The Plant Parts and Functions
(Seed and Planting Materials)

Unit 4 : Essential Plant Nutrients

Unit 5 : Weeds, Weeding and Crop Protection

Unit 6 : Cropping Systems

Unit 7 : Fruit Production

Unit 3 The Plant Parts and Materials (Seed and Planting Materials)

Objectives

By the end of this unit, you should be able to:

(a) Label parts of a plant .

(b) State functions of parts of the plant .

(c) Identify and label parts of a legume and cereal seed .

(d) Describe the functions of different parts of the seeds .

(e) List examples of vegetative planting materials .

(f) Label parts of vegetative planting materials .

(g) Distinguish the terms 'sexual and asexual' propagation .

(h) Enumerate the advantages and disadvantages of sexual and asexual propagation in crop production .

Introduction

Plants require the following conditions for their growth:

- Oxygen and carbon dioxide from the air.
- Water and dissolved mineral nutrients from the soil.
- The energy from the sun which comes as heat and light energy.

Parts of a plant

Each part of a plant has a particular function for the plant to grow well. The following are the parts of a plant.

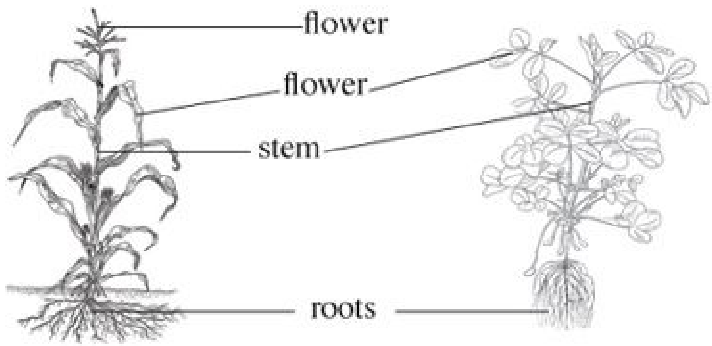


Fig. 3.1: Cereal plant .
Fig. 3.2: Legume plant .

Functions of parts of the plant

(a) The roots

Grow below the ground surface.

Functions of the roots

- Hold the plant firmly in the soil.
- Absorb water and dissolve nutrients from the soil.
- Some roots act as food storage organs.
- Help to retain moisture in the soil.

Types of roots include:

(a) *Tap root;* made up of one main root with several side roots attached to it.

(b) *Fibrous roots;* several roots grow downwards and each of them develop side roots or lateral roots.

(b) The stem

It is the green part growing above the ground from which leaves and flowers develop.

Functions of the stem

- Supports the leaves and the flowers.
- Space out the leaves for them to receive sufficient sunlight.
- Carry water and nutrients from the roots to the rest of the plant.
- Carry food materials from leaves to the rest of the plant.
- Carry out photosynthesis in green plants.

> ***Note :*** If a section is cut across the stem and examined under a microscope, the cells and tissues are seen as follows:

- *Epidermis:* It is the outer layer of cells which surrounds the stems and encloses the rest of the stem tissues.
- *Cortex and pith cells:* Form the body of the stem and allow circulation of air.
- *Xylem:* They are long and narrow and their role is to carry water and mineral salts up the stem from the roots.
- *Cambium:* They are actively growing cells and are living. They lie between the xylem and phloem.

(c) The leaves

They are flat green structures which are grown from the stem.

Functions of leaves

- Manufucture plant food during the process of photosynthesis.
- Cooling the plant by the evaporation of water during transpiration.

> ***Note:*** If a thin section is taken through a leaf from top to bottom, the following parts can be seen:

(i) Epidermis

It is one cell thick. It protects the leaf from damage and infection. The cells are transparent hence sunlight can pass through them for photosynthesis to take place.

(ii) Palisade

It is a layer of cylindrical cells beneath the epidermis that have chloroplast containing chlorophyll. This is where photosynthesis takes place. Cells have air spaces for carbon dioxide and oxygen to enter and leave the cells.

(iii) Spongy layer

It has large vacuoles and air spaces between them. It allows air to circulate freely through the leaf and reduce weight.

(iv) Vascular bundles

Xylem vessels and sieve tubes are contained inside.

(v) Stomates

They are small openings on the surface of the leaf through which water can pass out. Each stomate is enclosed by two guard cells which swell to allow more water vapour to pass out and shrink to close the pores and reduce water loss.

Seeds of legumes and cereals are made up of several parts such as:

Parts of a seed

A seed develops from an ovule after fertilization. Seeds of legumes and cereals have different parts as shown below.

Differences between the parts of a legume and a cereal seed

Legume seed	**Cereal seed**
• Has two cotyledons.	• Has one cotyledon.
• Cotyledons is the major food storage part.	• Endosperm is the major food storage part.
• Testa is the seed cover.	• Pericarp is is the seed cover.
• Shows epigeal germination.	• Shows hypogeal germination.

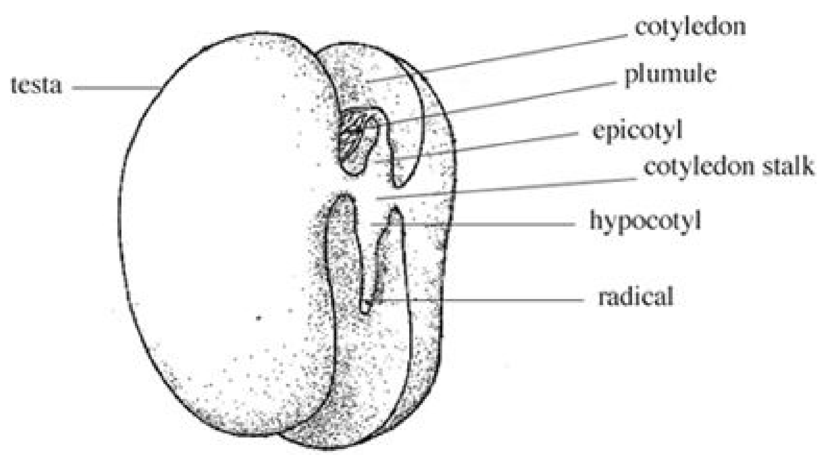


Fig. 3.3: Longitudinal section of a legume .

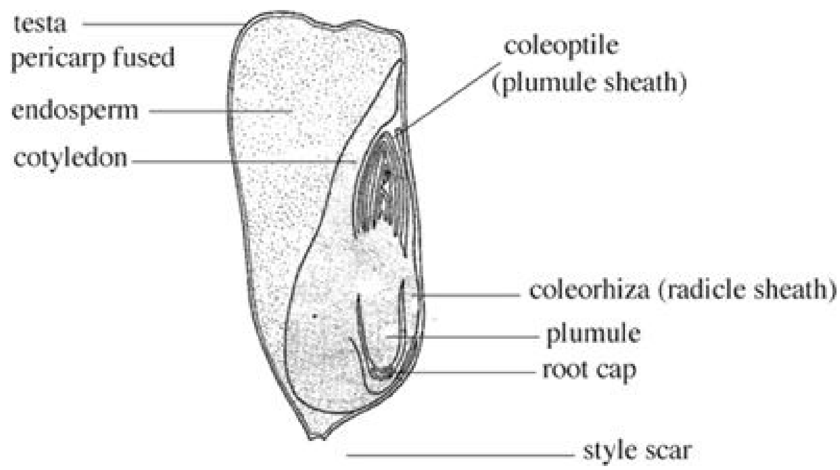


Fig. 3.4: External section of a cereal .

Functions of different parts of the seed

(a) Testa : It is the tough hard outer coat. It protects the seed from fungi, bacteria and insects infections.

(b) Hilum : Is a scar which attach ovule to the ovary wall.

(c) The micropyle : Is a tiny pore in the testa opposite the tip of the radical. Allows water and air to enter the embryo before germination.

(d) The radical : It is the part which grows and develops into the root system of the plant.

(e) The plumule : It is the leafy part of the embryonic shoot.

> ***Note:*** The growing point which arise from the tip of the embryo stem above the attachment of the cotyledons is called epicotyl and the part below is the hypocotyl.

(f) The cotyledons : Cereals have seeds with only one cotyledon while legume seeds have two cotyledons. They contain food reserves used by the plant during the early stages of germination.

(g) Endosperm : It forms the food reserves of a seed before germination.

(e) Coleoptile : This is the outermost covering that protects the shoot tip.

Propagation by seed *(Sexual propagation)*

The use of seeds to produce new plant individuals is called sexual propagation .

It involves the union of a female gamete (ovule) with a male gamete (pollen grain) during fertilization.

This occurs during the process of pollination, that is, the transfer of pollen grains from the male flower part to the female flower part, for fertilization to take place. Pollination can be either self or cross.

In self pollination the pollen grains transfer is within the same plant and this produces new plants which are in every way the same as the parent plant. Cross-pollination however, occur when pollen grains transfer is between different plants and this may result in the loss of some of the good characteristics due to the “crossing.” The selection of cross-pollinated crops, for example, use of seed maize must therefore be carried out regularly each season owing to the changes brought about by cross pollination.

Vegetative planting material

Vegetative planting materials are parts of plants other than seeds which can be used to produce new individual plants. The vegetative parts have the ability to grow into a whole new individual plant. The use of vegetative materials for plant propagation is called *asexual reproduction* .

Examples of vegetative plant parts are:

- Stems.
- Leaves.
- Suckers.
- Tubers.
- Bulbs.
- Splits.
- Crowns and slips.
- Food storage organs.
- Vines.

Vegetative propagation is used in the growing of many crop plants. Some of these plant parts are storage organs such as:

- Bulbs.
- Rhizomes.
- Corms.
- Tubers.
- Suckers.

(a) **Stem:** Cuttings can be developed from stems or roots. Stem cuttings can be either raised in a nursery such as in tea or planted directly in the field such as in sugarcane. Most cuttings for perennial crops are obtained from the hard section of the plant part that is, tea cuttings. For sugarcane, setts cuttings are usually taken from the soft upper parts of the shoot.

(i) Single-leaf stem cuttings for tea propagation: These are obtained from the middle part of stems of selected mature trees, and then planted in polythene sleeves filled with rooting medium. They are then placed in a nursery. High relative humidity must be maintained for their rapid growth and development.

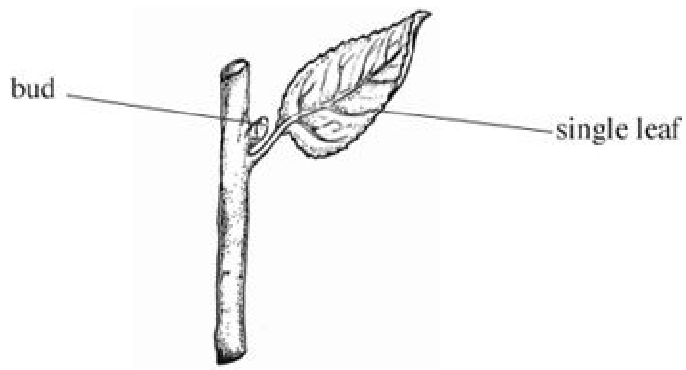


Fig. 3.5: Single leaf stem cutting of tea .

(ii) Setts for sugarcane propagation: Sizeable cuttings are planted directly in the seedbed. Setts with three nodes are prepared and subjected to heat treatment or treated with an organo-mercurial fungicide against ratoon stunting disease. Each sett usually measures 30 - 45 cm long.

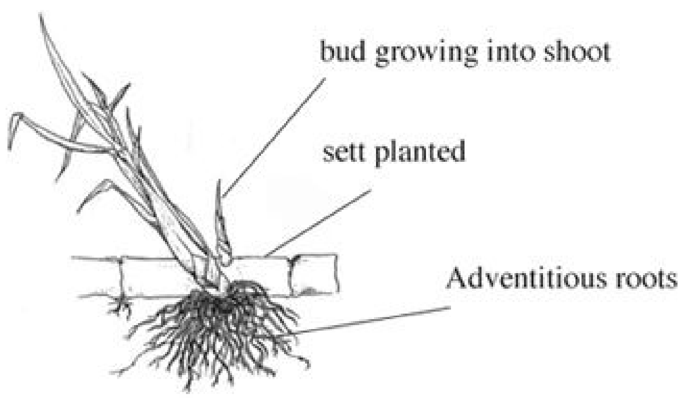


Fig. 3.6: Sugarcane setts .

(b) Suckers: These are lateral branches of a stem with terminal buds at the tips. They grow from the base of the underground stem just beneath the soil surface. New shoots grow along the sucker with adventitious roots developing below the stem. Examples of plants produced by suckers are banana, sisal and pineapple.

Fig. 3.7: Banana sucker .

(c) Stem tuber: This is a swollen tip of underground stem bearing a number of reduced scale leaves. Each scale leaf surrounds the 'eye' of the tuber. The eye is actually the bud. The buds produce aerial shoots and adventitious roots grow at the base. Examples include the Irish potato and Jerusalem artichokes.

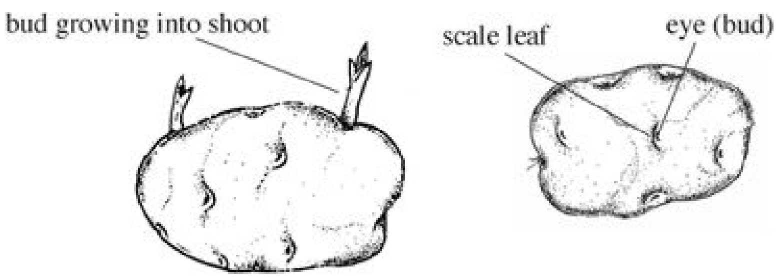


Fig. 3.8 (i) and 3.8 (ii): Irish potato tubers .

(d) Bulb: This is a flattened stem with nodes bearing fleshy scale leaves surrounded by some dry scale leaves. Buds arise in the axils of the fleshy scale leaves. The food is stored in the fleshy scale leaves and not in the stem. Adventitious roots are found at the base of the stem. Examples of bulb crops are onion and garlic.

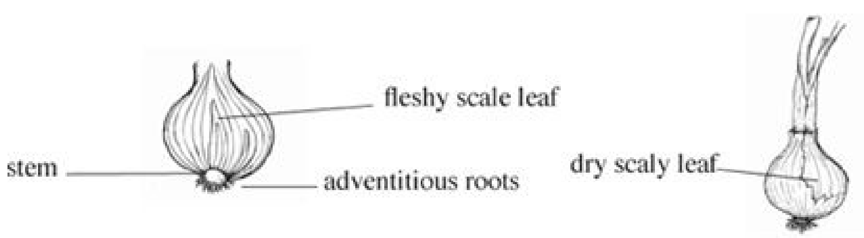


Fig. 3.9: Onion bulb .

(e) Crown and slip: These are used for pineapple propagation. Crown is borne at the fruit top. Crown, when used, produces a more even growth of plants in the field. Slip develop on the sides of stems above the suckers. Slips do not provide uniform growth in the field but grow very fast. These two vegetative materials carry the same parental characteristics.

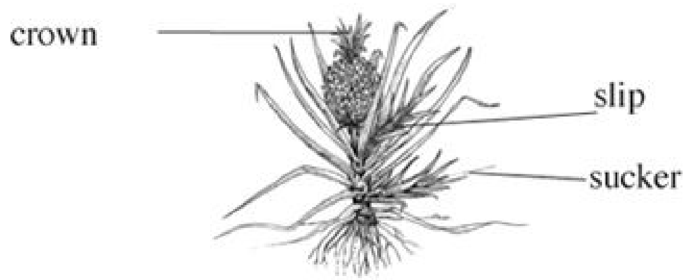


Fig. 3.10: Pineapple plant .

(f) Bulbils: These are obtained from a sisal plant at the end of its life.

These are several small vegetative materials at the top of the sisal pole. These materials fall on the ground and are collected as planting materials. When used, there is uniformity in crop growth in the field.

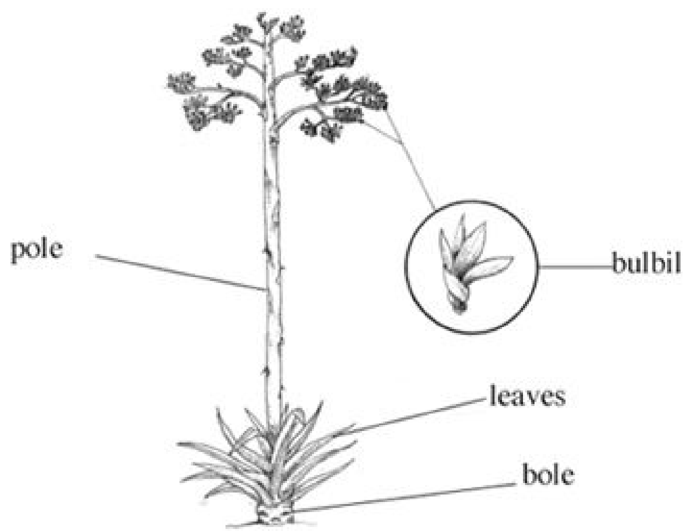


Fig. 3.11: Sisal pole and bulbils .

(g) Splits: These are vegetative materials used in the propagation of pyrethrum. They are obtained from pyrethrum clones that have desirable characteristics such as high yields and a high pyrethrin quality.

The selected clones are first multiplied in nurseries to generate a lot of vegetative growth. They are then divided into several vegetative planting materials complete with leaves and root systems called ***splits*** **.** A split should have a good root system. A split can be small with only one or two leaves. The splits should be planted as soon as possible, preferably on the same day of uprooting and splitting.

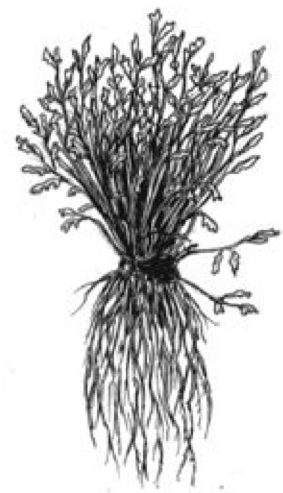


Fig. 3.12 (a): Pyrethrum bunch .

Fig. 3.12 (b): Pyrethrum splits .

(h) Vines: These are stem cuttings with or without leaves used to propagate crops such as sweet potatoes. Each vine should have at least two nodes. The buds located at the nodes grow into shoots. Adventitious roots develop at the base of the node.

Fig. 3.13: Sweet potato vine .

Other storage organs used as vegetative planting materials are:

(i) Rhizomes: These are horizontal underground stems which possess scale leaves and buds. The leaves are reduced to thin scales. In some plants, adventitious roots are present. Examples of plants with rhizomes are *edible cana* and *lily* .

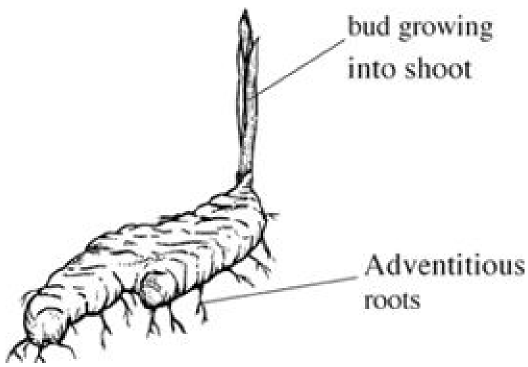


Fig. 3.14: Rhizome .

(ii) Corms: These are short, thick, underground stems protected by dry scale leaves. A corm has one or more buds located on the underside of the leaf with adventitious roots at the base. The corm shrivels when the food reserves are used up as the buds grow into aerial shoots. Examples of crops with corms are cocoyam (arrowroots), and crocus.

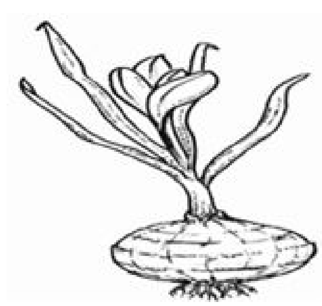


Fig. 3.15: Corms .

Differences between sexual and asexual propagation

Sexual propagation	Asexual propagation
1. The resulting plant vary from the parents.	1. The resulting plant is true to type (similar to the parent).
2. Materials are smaller hence easy to handle.	2. Materials are bulky hence not easy to handle.

3. Seed formation may fail if pollination and fertilisation does not occur.	3. Seed formation does not depend on pollination and fertilisation.
4. Tiny seeds may fail to germinate if they exhaust food reserves before emerging.	4. Planting material cannot fail to germinate because of large food reserves.
5. Seeds can be stored for long.	5. The planting materials cannot be stored for long.

Advantages of sexual propagation

- It is the cheapest method of crop propagation because seeds are easily available.
- The seed is the most convenient method of storing planting material since they can be easily dried and preserved over a long period of time.
- It results in new plant varieties through cross pollination.
- It saves on planting time as seeds can be easily handled.
- It is handy and less bulky, thus easy to store.

Disadvantages of sexual propagation

- Some plants have tiny seeds which may fail to germinate. This is because the seeds exhaust the food reserves before emerging above the soil surface.
- Seed formation may fail if the factors influencing pollination and fertilization are absent.
- Cross-pollination may result in new plant acquiring undesirable characteristics which are different from those of the parent plant.
- Soil borne pest may destroy the seeds before rain falls.
- Off-types may develop due to mutation.

Practical Activity 3.1

Collect propagation materials in your area, identify and draw well-labelled diagrams of the materials.

Practical Activity 3.2

1. Obtain two plants, a legume and a cereal. Compare their leaves, looking carefully at the arrangement of the veins.

   (a) What are the differences between the legume and the cereal leaves?

(b) State two other ways in which the two plants differ.
2. Draw a diagram of a legume and a cereal plant. Label the various parts.

Practical Activity 3.3

1. Collect seeds of legumes and a cereal. Split open the legume seeds and observe the inside part, do the same for the seed of cereal.

   Explain the differences and similarities of the two seeds.
2. Make a careful drawing of the cereal seed and label the following parts:
   - Style scar.
   - Testa.
   - Radical.
   - Plumule.
   - Endosperm.

Revision Exercise 3

1. Outline the differences between a tap root and adventitious roots.
2. Name the main parts in the external structure of a plant.
3. State the functions of the following parts in a plant:
   (a) Micropyle.
   (b) Roots.
   (c) Leaves.
   (d) Testa.
4. What is the function of a cotyledon in a leguminous plant?

Unit 4 Essential Plant Nutrients

Objectives

By the end of this unit, you should be able to:

(a) List the essential plant nutrients .

(b) Classify the essential plant nutrients into macro-nutrients and micro-nutrients .

(c) Explain the role of the essential plant nutrients in plant growth and crop production .

(d) Explain how the essential plant nutrients are developed from soil .

(e) Describe the deficiency signs of essential plant nutrients .

(f) List sources of essential plant nutrients .

(g) Apply appropriate chemical fertilizer and organic manures .

Introduction

To gain a clear understanding of some of the fundamental principles of crop production, it is necessary to know the extent to which soils may affect plant growth. Soils supply plants with water and nutrients such as minerals which they require for proper growth and development. These nutrients are referred to as *essential elements* . The essential elements are either found naturally occuring in the soil, or can be supplied through application of organic manures and artificial fertilizers. Artificial Fertilizers are also known as *inorganic fertilizers* .

The essential elements

There are sixteen essential elements necessary for good plant growth. These are:

- Carbon.
- Hydrogen.
- Oxygen.
- Nitrogen.

- Phosphorus.
- Potassium.
- Sulphur.
- Magnesium.
- Calcium.
- Manganese.
- Iron.
- Boron.
- Zinc.
- Copper.
- Molybdenum
- Chlorine.

Some of these elements are obtained from the air and water while others are supplied by the soil.

Essential elements from the air and water: Plants get most of their carbon and oxygen from the air through stomatal gaseous exchange. Hydrogen cannot be directly derived from the air, but absorbed from soil water by plant roots.

Essential elements from the soil: These are the macro-nutrients and micro-nutrients supplied to the plant from the soil in solution form. They must be present in their right proportions, suitable amounts and absorbable forms. The presence of certain elements in excess may hinder the availability of the other nutrients.

Classes of essential elements

The essential elements are classified according to the quantities required by the plants, thus:

(a) *Macro-nutrients:* These are elements required by plants in large quantities. Macro-nutrients can be grouped either as primary or secondary elements.

(i) *Primary elements:* These are elements which must be present for proper plant establishment. They are nitrogen, phosphorus and potassium (N P K). They are also referred to as *fertilizer elements* .

(ii) *Secondary elements:* These are required in large amounts but in lesser quantities than primary macro-nutrients. They include:

- Carbon.

- Hydrogen.
- Oxygen.
- Calcium.
- Magnesium.
- Sulphur.

(b) Micro-nutrients: These elements are needed in relatively small quantities. They are also referred to as *trace elements* . They include:

- Iron.
- Manganese.
- Copper.
- Zinc.
- Boron.
- Molybdenum.
- Chlorine.

Essential elements required in small amounts from the soil	***Essential elements required in large amounts***	
	From the air and water	***From the soil***
Copper	Carbon	Nitrogen
Iron	Hydrogen	Calcium
Manganese	Oxygen	Phosphorus
Boron		Potassium
Zinc		Sulphur
Molybdenum		Magnesium
Chlorine		

Table 4.1: Source of essential elements .

The macro-nutrients

(a) Nitrogen

The Role of nitrogen

- It promotes vegetative growth (foliage growth that is, leaves).
- It improves the quality of leafy crops such as cabbages and kales.

- It is a constituent of chlorophyll and, as such, it encourages healthy green leaves, that is, leaves become luxuriantly green.
- It is important in the formation of proteins in plants, that is, tends to increase the protein content in all crops.
- In cereal crops, it increases the size of grains and their protein content, for example, finger millet.
- It regulates the availability and utilisation of phosphorus and potassium.

Effects and symptoms of nitrogen deficiency

- Leaves suffer from chlorosis, that is, they lose chlorophyll and become yellowish green or pale green. This is associated with the formation of anthocyanin (purplish-green in colour) in crops like tomatoes and maize.
- Decrease in plant growth leading to short, stunted crops.
- It may induce early leaf fall.
- It can cause premature ripening of the fruit crops.
- 'Firing' (change of colour to dry appearance) of the tips and margins of mature leaves may occur in cereals.

Effects and symptoms of excess nitrogen

- Leaf scorching on contact with nitrogenous fertilizers.
- Lodging (due to excessive succulency and weakening the stems) may occur.
- Excess vegetative (foliage) growth may curtail the development of desired products such as grains, seeds, fruits and tubers. This can have the effect of delayed plant maturity and lowering the quality of fruits or seeds.
- Excess nitrogen can cause poor formation of pods in legumes.

Sources of nitrogen

- Artificial fertilizers for example, sulphate of ammonia and calcium ammonium nitrate.
- Organic manures such as farmyard, compost manure and green manure.
- Nitrogen due to lightning effect.
- Fixation by the nitrogen-fixing bacteria for example, *Rhizobium spp* . found in root nodules of some legumes.

Forms in which nitrogen is made available

Nitrogen is commonly absorbed as nitrate ions (NO_3^-) and ammonium ions

(NH_4^+).

Ways in which nitrogen is lost from the soil

Loss of nitrogen nutrient in the soil occurs through the following processes:

- Soil erosion.
- Leaching especially in lateritic (soft porous) soils.
- Volatilization, that is, loss of nitrogen in gaseous form from hot and dry soil.
- Utilisation by plants.
- Use by micro-organisms found in the soil, that is, immobilisation of nitrogen.

(b) Phosphorus

The role of phosphorus

- It promotes root establishment and development especially secondary roots.
- It hastens leaf development and encourages greater growth of shoots.
- It improves crop quality, that is, palatability particularly in horticultural, forage and cereal crops.
- It hastens maturity of crops.
- It is necessary for flowering, seeding and fruiting of crops, that is, stimulates blooming (flowering) and seed formation.
- It strengthens stems in cereal crops thus preventing lodging.
- It is an important constituent in the formation of proteins.
- It influences cell division and is essential in various metabolic processes.
- It stimulates nodule formation in the legumes.
- It is necessary for the metabolism of carbohydrates for example, during respiration.
- It increases plant resistance to disease attack and contributes to the general hardness of crops.

Effects and symptoms of phosphorus deficiency

- Growth of the plant is stunted and maturity delayed.
- There is poor grain, fruit and seed formation. Dead spots may be observed on the fruits and seeds.
- Stalk is unusually thin. The stems are weak in cereals.
- There is poor root development.

- Lateral buds remain dormant.
- Leaves change colour from green to blue or purplish-green as a result of increased anthocyanin.
- There is premature leaf-fall.
- Tubers of crops like Irish potatoes become small and few.
- Appearance of rusty-brown spots in potato tubers.

Sources of phosphorus

- Soil organic matter, for example, crop residues.
- Artificial fertilizers, for example, phosphatic fertilizers.
- Organic manures, for example, guano, farmyard manure.
- Weathering of phosphate-containing rocks.

Form in which phosphorus is absorbed

Phosphorus is absorbed from the soil solution in form of phosphate ions ($H_2PO_4^-$).

Ways in which phosphorus is lost from the soil

Phosphorus is lost from the soil through:

- Soil erosion.
- Leaching.
- Utilization by crops.
- Fixation by iron and aluminium.

(c) Potassium

The role of potassium

- It is essential for nitrogen metabolism and protein synthesis.
- It increases plant vigour and disease resistance. The plant stalks are strengthened making them less prone to lodging and to bacterial or fungal infections.
- It promotes root development.
- It helps in synthesis of sugars and starch and their translocation.
- It helps in plant metabolism.
- It is essential for chlorophyll formation.

- It regulates the availability and use of nitrogen and phosphorus. It assists in the uptake of nitrates.
- It increases the size of grains and seeds.
- It is necessary for the neutralisation of organic acids in plants.
- It acts as an activator for different enzymes.
- It enhances plant tolerance to cold and other adverse weather conditions.
- It increases crop quality for example, in cut flowers.

Effects and symptoms of potassium deficiency

- Plants lodge before maturing.
- Leaves of crops develop a burnt appearance on the tips and margins, that is, they are scorched. Scorching starts with older leaves.
- Leaves curl.
- Upper leaf surface lose chlorophyll and become yellow or chlorotic, premature leaf fall.
- Stunted plant growth with stems having shorter internodes.
- Fruit or seed is somewhat shrivelled.
- Plants like beans, potatoes and sugar beet are prone to rust attack.

Sources of potassium

- Crop residues.
- Organic manures.
- Commercial fertilizers, for example, Muriate of potash.
- Potassium bearing mineral rocks, for example, potash feldspars and micas such as biotite.

Form in which potassium is absorbed

It is absorbed as potassium ions (K^+) in soil solution.

Ways in which potassium is lost from the soil

Potassium in the soil is lost through:

- Crop utilisation.
- Leaching.
- Soil erosion.
- Fixation in the soil.

(d) Magnesium

The role of magnesium

- It is important in chlorophyll formation, that is, it is responsible for maintaining the green colour in plants.
- It promotes the formation of fats and oils in oil crops like groundnuts, soya beans and sunflower.
- It enhances the nitrogen fixing power of the legumes.
- It activates the synthesis and translocation of carbohydrates and proteins in plants.
- It aids in the absorption and translocation of phosphorus.

Effects and symptoms of magnesium deficiency

- There is loss of green colour in plants between the leaf veins which starts from the bottom leaves and gradually moves upward. This is called *interveinal chlorosis* .
- Leaves curve upwards along the margins and become brittle.
- Leaves are abnormally thin.
- Stalks become weak.
- Plants develop long unbranched roots.

Sources of magnesium

- Organic manures.
- Commercial fertilizers, for example, soda phosphate, basic slag and muriate of potash.
- Agricultural lime.
- Weathering of mineral rocks containing magnesium.

Form in which magnesium is absorbed

Magnesium is absorbed from soil solution in form of magnesium ions (Mg^{2+}).

Ways in which magnesium is lost from the soil

- Crop removal.
- Soil erosion.
- Leaching.

(e) Sulphur

The Role of sulphur

- It is essential for protein synthesis.
- It increases the oil content in oil crops such as groundnuts and soya beans.
- It is essential in the formation of some vitamins, for example, Vitamin B_1 .
- It is essential for the activation and activities of certain enzymes, for example, co-enzyme A.
- It influences nitrogen fixation by legumes.
- It aids in the formation of cells.
- It is essential in chlorophyll formation.
- It is essential for carbohydrate metabolism.

Effects and symptoms of sulphur deficiency

- Leaves become completely chlorotic, especially the lower (older) leaves.
- Stems become very thin and woody.
- Growth of plant in stunted.
- Nodule formation in legumes is reduced.

Sources of sulphur

- Commercial fertilizers, for example, ammonium sulphate nitrate.
- Atmospheric sulphur dioxide later forming acid rain (sulphurous acid).
- Soil minerals containing sulphur.

Form in which sulphur is absorbed

Sulphur is absorbed as sulphate ions (SO_4^{2-}). Some plants take it in through leaves as sulphur dioxide (SO_2).

Ways in which sulphur is lost from the soil

- Soil erosion.
- Leaching.
- Volatilization in the form of hydrogen sulphide gas (H_2S).

(f) Calcium

The role of calcium

- It is essential for protein synthesis.

- It forms calcium acetate which helps to strengthen plant cell walls.
- It is used in the elongation of plant apical tips and roots.
- It helps in root development.
- It is essential in the formation of the middle lamellae in plant cells.
- It increases the protein content of mitochondria.
- It raises the soil pH thus increasing the availability of phosphorus and potassium to plants. A higher soil pH is ideal for the action of nitrifying bacteria (nitrification).
- When added to clay soils, it flocculates the soil particles thus facilitating good aeration, water infiltration and retention.
- It helps in the translocation of carbohydrates in plants.

Effects and symptoms of calcium deficiency

- Poor growth of terminal buds and root-tips. Terminal buds die under severe deficiency. Plant exhibits stuntedness.
- Leaves become chlorotic, particularly along margins of younger leaves.
- Leaves roll up.
- The plant has a tendency to shed flowers and buds prematurely.

Sources of calcium

- Organic manures.
- Commercial fertilizers, for example, Calcium Ammonium Nitrate (CAN).
- Agricultural lime.
- Weathering of limestone rock.

Form in which calcium is absorbed

Calcium is absorbed from the soil in form of Calcium ions (Ca^{2+}).

Ways in which calcium is lost from the soil

- Soil erosion.
- Leaching.
- Utilization by crops.

(g) Carbon, Hydrogen and Oxygen

These essential elements are found in abundance in plants. They are constituents of organic compounds making up the bodies of living organisms.

Plants manufacture carbohydrates using simple substances like carbon dioxide from the air and hydrogen from water.

Plants also synthesise proteins in their bodies by use of carbohydrates combined with other essential elements such as nitrogen, phosphorus and sulphur.

Oils in plants are also made of elements carbon, hydrogen and oxygen.

These three essential elements, carbon, hydrogen and oxygen have no deficiencies, that is, cannot be lacked by plants. Carbon and oxygen are present in large quantities in the air and are constantly taken in by plants during photosynthesis. Hydrogen is derived from water.

The micro-nutrients

(a) Boron

Boron is associated with calcium utilisation within the plant. Boron is absorbed as borate ion (BO_3^{3-}). Whenever the proportion of calcium to boron is unbalanced due to boron deficiency, the terminal bud of the plant fails to develop properly.

Boron requirement in a plant is extremely small. However, a slight increase over the required amount will result in severe toxicity.

Boron deficiency is indicated by a change in colour at the tips of growing shoots. The terminal bud becomes light green with traces of reddish-brown. It may cause the shoot tip to die and flowering may fail to occur.

(b) Copper

It is an activator or catalyst for various chemical reactions within the plant. It is absorbed as copper ions (Cu^{2+}). It promotes formation of Vitamin A. It also regulates the functions of nitrogen. Its deficiency results in foliage with a chlorotic condition showing bleached appearance.

Citrus fruits show die back of new shoots and the stem is marked with a reddish brown secretion (gummy exudates). Cereals show chlorotic leaf tips and failure to set seeds.

(c) Iron

Iron is essential for the formation of chlorophyll. It is absorbed as Ferrous ions (Fe^{2+}). It is also necessary in the plant respiration and metabolism processes. Its deficiency causes leaf chlorosis that is, paleness at the leaf tips and margins while the veins remain green. The young leaves become affected first and may curve in an upward direction for example, in cabbage.

(d) Manganese

It is associated with copper and zinc metabolism. It is absorbed as manganese ions (Mn^{2+}). It acts as a catalyst in plant growth processes. Its deficiency results in chlorosis in young leaves. The loss of colour is often followed by the development of dead tissue spots (necrosis) and dead spots may drop off giving the leaf a perforated appearance.

(e) Molybdenum

It is associated with nitrogen utilisation. It is absorbed as molybdenum ions (MoO_4^-) It is required in minute amounts. Plants with excess molybdenum can be toxic to livestock. Its deficiency results in retarded plant growth and yellowing of leaves.

(f) Zinc

It is associated with availability of iron and manganese which are essential in chlorophyll formation. It is absorbed as zinc ions (Zn^{2+}). Its deficiency results in reduced fruiting. The plants terminal leaves may become abnormally small.

(g) Chlorine

It stimulates the activity of some enzymes and influences carbohydrate metabolism. It is absorbed as chloride ions (Cl^-). There is normally no established deficiency in most soils. Rainfall water supplies sufficient amounts of chlorine to the soil.

Depletion of essential plant nutrients from the soil

The essential plant nutrients get depleted from the soil through several processes.

(i) Crop removal

When crops grown in the field reach maturity, they are harvested. The crop product harvested and other plant body parts which were build using nutrients absorbed from the soil, go away with the nutrients from that soil. It is advisable to replace nutrients absorbed by the plant from that soil through fertilizer or manure application and burying of crop remains.

(ii) Soil erosion

This is the removal of the top soil rich in plant nutrients by agents of erosion like running of water (water run-off) wind and human activities. This leads to loss of soil fertility.

(iii) Drainage (leaching)

This is letting away excess water from the land through percolation. Such water flow has dissolved soil nutrients. Surface irrigation also leads to loss of soil nutrients. Alternatively, when water infiltration occurs it results in loss of plant nutrients by leaching process.

(iv) Volatisation

This is the loss of soil nutrients in gaseous form, for example, nitrogen element. This process occurs mostly in dry soils.

(v) Fixation

This is the changing of the nutrient from available form into unavailable form through soil reaction.

Summary of macro-nutrients and micro-nutrients			
Elements	**Chemical symbol**	**Absorbable forms**	**Deficiency symptoms**
Macro-nutrients			
Nitrogen	N	NO_3^-, NH_4^+	Chlorosis, stunted plant growth, early leaf fall, premature ripening of crops and firing of tips and margins of mature leaves.
Phosphorus	P	$H_2PO_4^-$, HPO_4^{2-}	Stunted plant growth, poor formation of grain, fruit and seeds, leaves turn purple due to anthocyanin and premature leaf fall.
Potassium	K	K^+	Leaf curling, chlorosis followed by premature leaf fall, lodging of plants before maturity, stem with shorter internodes, shrivelled seeds and fruits.
Magnesium	Mg	Mg^{2+}	Interveinal chlorosis, leaf curling, abnormally thin leaves and long and unbranched roots.
Sulphur	S	SO_4^{2-}, SO_2	Leaf chlorosis, thin, hard and woody stems and reduced nodulation in legumes.
Calcium	Ca	Ca^{2+}	Premature shedding of flowers and buds, leaf roll, chlorosis and poor growth of terminal buds and root tips.
Micro-nutrients			
Boron	B	BO_3^{3-}	Failure of terminal bud development. Flowering may also fail to occur.
Copper	Cu	Cu^{2+}	Chlorosis with a bleached appearance, die back in citrus fruits.
Iron	Fe	Fe^{2+}	Chlorosis of leaves starting with the youngest. Affected leaves curve in an upward direction.

Elements	Chemical symbol	Absorbable forms	Deficiency symptoms
Macro-nutrients			
Manganese	Mn	Mn^{2+}	Chlorosis between veins of young leaves, tissue necrosis which may drop to give a plant perforated appearance.
Molybdenum	Mo	MoO_4^-	Yellowing of leaves, stunted plant growth.
Zinc	Zn	Zn^{2+}	Reduced fruiting and abnormally small terminal buds.

Table 4.2: Macro-nutrients and micro-nutrients .

Practical Activity 4.1

Visit the school farm to observe deficiency symptoms in crop plants and prescribe a solution to the problem.

Inorganic fertilizers

They are a source of concentrated form of the macro-nutrients. Some inorganic fertilizers also contain traces of micro-nutrients.

Application methods of chemical fertilizers and organic manures

1. Broadcasting: This is the random spreading of the inorganic fertilizer 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 fertilizer spreaders in large scale farming.
2. Drilling: This is the direct placement of fertilizer in the planting hole or furrows. The fertilizer 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* .
3. Side dressing/Banding : This is the placement of fertilizer in continuous or discontinuous patterns beside the crop. It is commonly done in perennial crops since they have extensive root systems. The method is also called *side-*

dressing when the fertilizer is placed one or two spots beside the crop and *ring application* when the fertilizer is placed in a circle around the plant near the edge of the shadow of the canopy at noon. Banding is used when top-dressing crops with nitrogenous or potassic fertilizers. Row planted crops can also be side-dressed.

4. Foliar application: This is the spraying of fertilizer 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 fertilizer is absorbed through the leaf surface.
5. Injection into the soil: This is used in specialised cases, for example, in green houses. In this method, fertilizers in liquid form are injected into the soil under pressure.
6. Irrigation method: In this method, the fertilizer is mixed and applied with the irrigation water. It is also called *fertigation* .

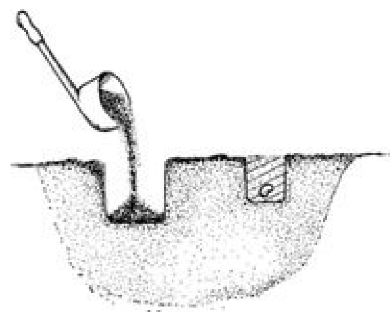


Fig. 4.3: Drilling method of fertilizer application .

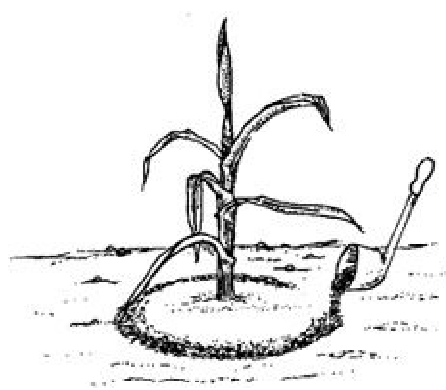


Fig. 4.4: Ring method of fertilizer application in maize .

Factors to consider before applying fertilizers

(i) Soil analysis should be done to establish the level of nutrients in the soil.

(ii) The soil pH should be determined to ensure it is appropriate for the type of fertilizer.

(iii) The availability and amount of soil moisture.

(iv) The method of application.

(v) The quantity and cost of fertilizer required.

(vi) The time of application.

Practical activity 4.2

Visit the school farm, working in groups of five, prepare three plots and plant maize in all the three plots. In plot one apply green manure, in plot two apply composit manure and in plot three apply farmyard manure. Make observations as the crop grows. Write a report of the observations.

Revision Exercise 4

1. List three types of organic manures.
2. Describe the characteristics of a good green manure crop.
3. Name the livestock which has the highest manure value.
4. What are the factors to consider when selecting a site for compost manure?
5. Name two methods of preparing compost manure.
6. Name the macro-nutrients.
7. State any four deficiency symptoms of phosphorus in crops.
8. State the sources of nitrogen in the soil for crops.

Unit 5 Weeds, Weeding and Crop Protection

Objectives

By the end of this unit, you should be able to:

(a) Define the term 'weed' .

(b) Identify common weeds in Malawi .

(c) Explain the importance of weeds in crop production .

(d) List the methods of weed control and explain the advantages and disadvantages of each .

(e) Control weeds in a field of a selected crop .

(f) Explain the meaning of the term crop protection .

(g) Identify common pests and diseases of a crop field and differentiate between a pest and a disease .

(h) Explain the economic importance of pest and diseases to field crops .

(i) Describe the methods of pests and disease control .

(j) Control pest and diseases of field crops .

Introduction

Weeds are of great significance to man's farming activities since they have extensive influence on land productivity. Weed problems, their importance, and how to control them must therefore be studied for successful agricultural production. Effects of weeds can be felt extensively if their invasion is not curbed. Weeds can cause considerable loss in crop yields thus, there is need to take necessary weed control measures.

In this unit, we shall discuss weeds, their identification and importance as well as their control measures.

Definition of a weed

A weed is a plant growing where it is not wanted. It is a plant whose de-merits far outweigh its merits. For example, a volunteer crop such as a maize plant can be taken as a weed in a bean field.

Practical Activity 5.1

Visit a nearby crop field and identify the weeds on the farm. Record your observations.

Weed identification

For proper weed control measures to be employed, farmers need to be able to correctly identify the weeds. They also must appreciate their economic importance in agricultural production. Identification of weeds can be achieved through the following ways:

(a) Personal experience with the weeds.

(b) Use of aids such as textbook illustrations or specialist publications dealing with weeds.

(c) Assistance from resource persons for example, field extension officers and the research stations.

Weeds are identified by use of names that are acceptable by the International Committee on Botanical Nomenclature (ICBN). According to this system of naming organisms, no two plants share a name.

Weeds are identified using common English names and their botanical names. Botanical names are written in a conventional way. Each plant is given two names. The first name refers to the genus and the second name is for the species to which the plant belongs.

The first letter of the first name begins with a capital letter, while the first letter of the second name starts with a small letter. The names are underlined separately or typed in italics, for example, *Bidens pilosa*, *Tagetes minuta* .

Common weeds of Malawi

1. Black Jack *(Bidens pilosa) (Chisoso)*

It belongs to the family *compositae* and has erect stems growing up to 100 cm high. Its stem is smooth and bears compound leaves. The leaves have serrated margins.

It has white ray florets and yellow disc florets. It produces black seeds with hooks. It is commonly found on exhausted soils (poor soils).

The weed can be controlled by cultivation or using herbicides such as MCPA, paraquat and 2,4-D.

Fig. 5.1: Black Jack .

2. Mexican marigold *(Tagetes minuta)*

It belongs to the family *compositae* . It is also known as tall khaki weed. It is an annual herb with creamy yellow flowers and long serrated and scented leaves. It has black fruits with a large number of seeds. This weed can be controlled by cultivation or using herbicides such as 2, 4 -DB, 2,4-D, MCPA & MCPB.

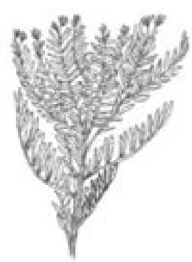


Fig. 5.2: Mexican marigold .

3. Oxalis

There are many species of this weed but the most common is *Oxalis latifolia* . It is a perennial weed and is very common in the highlands. It is shade tolerant but also grows in open sunny areas. It has broad, triangular leaflets and purple coloured flowers. It has an erect aerial stem. It has bulbils which it propagates with. The bulbs are very resistant to drought and enable the weed to survive long periods of drought.

Oxalis affects crops in nurseries and in the field. It has serious effects on maize crop yields.

It can be controlled using contact herbicides for example, *Paraquat*, *Amino triazole* and *Glyphosate* . Crop rotation is also an effective control measure.

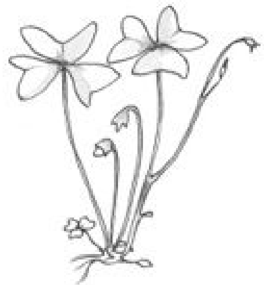


Fig. 5.3: Oxalis spp .

4. Double thorn *(Oxygonum sinuatum)*

It is a sprawling annual herb with angular spiny fruits which are sharp pointed at each end. It causes injury to feet if stepped on. It is a common weed in cultivated areas especially in murram soils. The weed is controlled by cultivation or application of herbicides such as, 2,4-D, 2,4-DB, MCPA.

Fig. 5.4: Double thorn .

5. Thorn apple *(Datura stramonium) (Dosa)*

It is an annual herb which belongs to the family *solanaceae* . It is common in arable land and waste lands. Thorn apple has large alternate ovate leaves with toothed margins and white flowers which are funnel shaped. The stems are erect and can grow as high as 150 cm. It has thorny fruits which contain several dark brown seeds. The weed is effectively controlled by cultivation, slashing or application of herbicides such as 2,4-D, *Paraquat* , MCPA and *Simazine* .

Fig. 5.5: Thorn apple .

6. Couch grass *(Digitaria scalarum)*

This is a perennial grass with well developed rhizomes. It has an inflorescence which has slender spikes arising from the upper part of the stem. It is common in the wetter regions of the country.

Control measures include deep cultivation or use of herbicides such as *Dalapon* and *Glyphosate* .

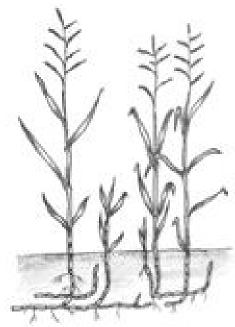


Fig. 5.6: Couch grass .

7. Nut grass *(Cyperus rotundus)*

It is a perennial sedge and has over 50 related different species. Nut grass is considered to be the most serious weed in the world. It is common in arable land all over the country. It consists of an inflorescence with many small spikelets borne at the end of the stem. It has underground bulbs or tubers which makes it difficult to control.

Use cultivation and herbicides such as MCPA and 2,4-D for effective control. Nut grass affects yields of crops such as coffee, wheat and beans.

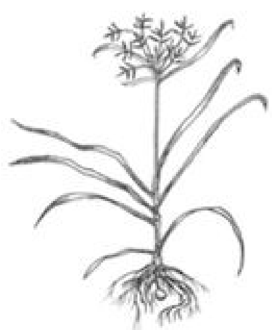


Fig. 5.7: Nut grass .

8. Wandering Jew *(Commelina benghalensis)*

It is common in arable lands and waste lands. It has spreading or climbing stems up to 60 cm long. The leaves and stems are fleshy. It has blue flowers and propagates by seed or vegetatively. Control using herbicides at early stages of weed growth for example, MCPA or by cultivating during dry seasons.

Fig. 5.8: Wandering Jew .

9. Sow thistle *(Sonchus oleraceus)*

It is an annual herb which exhibits vertical growth. It is common in arable lands in wetter highland areas. It exudes a milky latex when cut and has blue-green leaves with seratted margins. The flowers are yellow and produce hairy white pappus seeds that are dispersed by wind. Mostly used to feed rabbits.

Sow thistle is controlled by chemicals such as *Duron* and *Simazine* 2,4-D.

Fig. 5.9: Sow thistle .

10. Devil's horse whip *(Achranthes aspera)*

It is an annual herb, which belongs to the family *Amaranthaceae* . It has tough stems, pink flowers and protruding terminal spikes. Its fruits stick easily to the animal's hair or human clothes, and are thus dispersed. It can be controlled by herbicides 2,4-D and MCPA or through cultivation.

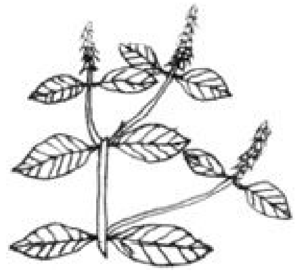


Fig. 5.10: Devil's horse whip .

11. Macdonald's eye/Gallant soldier *(Galinsoga parviflora)*

This is an annual herb found widespread in the arable and waste lands of the country. It bears yellow flowers and has erect stems (up to 60 cm high) which branch a lot. The leaves are hairy and ovate. The weed is controlled by cultivation or by use of herbicides *Paraquat* and *Simazine* .

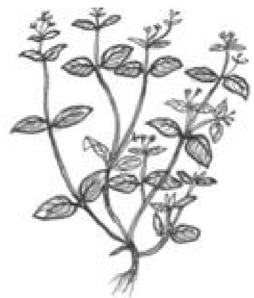


Fig. 5.11: Macdonald's eye (Gallant soldier) .

12. Sodom apple *(Solanum incanum) (Nthula)*

It belongs to the family *Solanaceae* . It is a perennial shrub found in pasture lands, marginal areas and at road sides. It has pricky, erect, branched stems that grow as high as 1.8 m. Sodom apple has alternate ovate leaves with a wavy margin. It bears purple blue to white flowers with almost spherical berries which are yellow when ripe. It has well developed underground rhizomes, making it difficult to control. It can be controlled by cultivation and by use of herbicides for example, 2,4-D & MCPA.

Fig. 5.12: Sodom apple .

13. Black night shade *(Solanum nigrum)*

It belongs to the family *Solanaceae* . It is an annual herb found in the arable and waste lands of the country. It has clusters of white flowers and produces green berries which turn red-pink on ripening. It has been used as a vegetable. This weed is controlled by cultivation, slashing or use of the herbicides *Paraquat* and *Simazine* .

Fig. 5.13: Black night shade .

14. Chinese lantern *(Nicandra physalodes)*

It belongs to the family *Solanaceae* . It is an annual herb. It has erect stems. The leaves are alternate with deeply toothed margins. It bears pale blue flowers with white centres. It produces berries which are almost spherical and are yellow in colour containing numerous seeds. Cultivation and use of the herbicides *Paraquat* and *Simazine* are effective control measures.

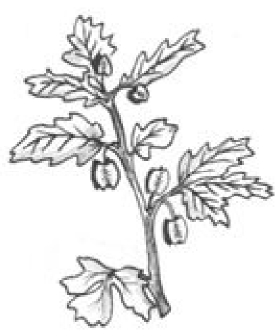


Fig. 5.14: Chinese lantern .

15. Bracken fern *(Pteridium aquillinum)*

It belongs to the family *Polypodiaceae* . It is found in areas with high rainfall or near forest lands. It has underground rhizomes from which the solitary erect fronds grow. It is poisonous to cattle. Effective control measures are cultivation and use of herbicides.

Fig. 5.15: Bracken fern .

16. Bristly fox tail *(Seteria verticillata)*

It is also known as love grass and belongs to the family *Gramineae* . It is an annual grass, tufted and is found widespread in coffee, wheat and barley growing areas. It has spike-like cylindrical inflorescence and readily attaches to animal skin by means of its barbed bristles. Control measures include use of herbicides for example, 2,4-D *Atrazine* and through cultivation.

Fig. 5.16: Bristly fox tail .

17. Cleavers *(Gallium spurium)*

It is also known as goose grass. It belongs to the family *Rubiaceae* . It is an annual weed, commonly found in arable highlands. It bears greenish-white flowers that form two dark seeded fruits. This weed smothers cereal crops and makes harvesting difficult. It can be controlled by cultivation and use of herbicides such as 2, 4-D and MCPA.

Fig. 5.17: Cleavers .

18. Stinging nettle *(Urtica massaica)*

It belongs to the family *Urticaceae* . It is common in highland grasslands, forest plantations and arable fields. It is a perennial herb with stinging hairs on the leaves and stems. The leaves are hairy with serrated margins. It has an irritating effect on human skin. The weed is controlled by cultivation or by use of the herbicide MCPA.

Fig. 5.18: Stinging nettle .

19. Fat hen/Goosefoot *(Chenopodium murale)*

It belongs to the family *Chenopodiaceae* . It is an annual weed common in pasture and arable fields in the highlands. It has either erect or spreading branches. The leaves are wedge shaped at the base and have pointed teeth on each margin. It bears green flowers in clusters and forms fruits with a single black shiny seed. Control measures are cultivation, slashing or use of the herbicide MCPA.

Fig. 5.19: Fat hen .

20. Wild oats *(Avena fatua)*

It belongs to the family *Gramineae* . It is an annual grass with long stems (culms) as high as 30-150 cm. It produces tillers at the base. It is common in areas where cereals are grown. It bears branched, spreading inflorescence and produces long hairy grains. It can be easily controlled through mechanical means for example, pulling by hand, cultivation, or by use of the herbicide *Tri-allate* and *Prophan* .

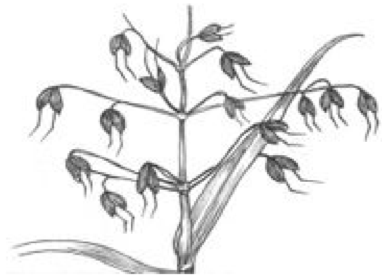


Fig. 5.20: Wild oats .

21. Lantana/Tick berry *(Lantana camara)*

It is a perennial shrub that belongs to the family *Verbenaceae* . It forms impermeable thickets in wastelands and grasslands receiving adequate annual rainfall. The stems are erect and can grow up to 3.6 m high. The leaves have toothed margins and rough upper surfaces. The most troublesome varieties have flower heads with pink-purple flowers. Some have yellow, pink, red or white flowers. It produces green fruits which ripen into shiny black clusters. Its leaves are poisonous to livestock. Control measures are cultivation and by use of herbicides, such as, 2,4-D and through slashing.

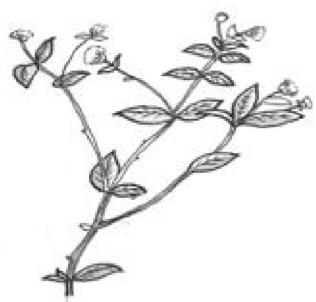


Fig.5.21: Tick berry .

22. Witch weed *(Striga hermontheca)*

It is an annual herb which is parasitic on maize, millet, sorghum. It belongs to the family *Scrophulariceae* . It has erect branched stems, and roots that are much reduced and attach to the roots of host plants. It bears brightly coloured pink flowers which later develop numerous, tiny dark seeds. The seeds are stimulated to germinate by exudates from roots of host plants.

It can be controlled by crop rotation, trap crops, uprooting and use of herbicides such as 2,4-D and MCPA.

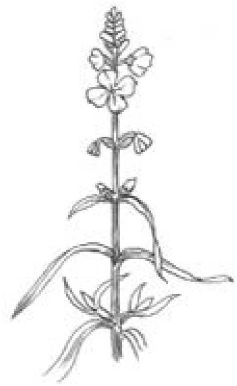


Fig. 5.22: Witch weed .

23. Water hyacinth *(Eichhornia crassipes)*

This is an aquatic weed that is known to be very destructive. It is a floating plant that has a thick fleshy rhizome, purple flowers and long roots which hang down in a mass of water such as in a lake. Water hyacinth can also anchor in mud. It can be washed from one section of the lake to another by being drifted by wind.

Fig. 5.23: Water hyacinth .

Effects of water hyacinth include:

- Clogging of water masses which impedes navigation.
- Hinders the movement of fishing boats.
- It contributes to reduction of some aquatic animals and increases others. This brings about an imbalance in the system.
- Reduces the recreational value of water masses for example, swimming,

yachting, sailing.

- It is very expensive to control.

Despite the harmful effects of water hyacinth, it has some beneficial uses:

- Used for making furniture, hats and baskets which are of economic value.
- Used in the preparation of manure.

Control

- The weed is susceptible to 2,4-D and other herbicides but because of its harmful effects on aquatic life, their use is strongly discouraged.
- *Biological control using Neochetina beetle to eat up the weed* . This beetle is known to completely destroy the water hyacinth. However, this method of control is slow since a very large number of beetles is needed to totally wipe out the weed.
- *Mechanical control* . This involves use of a machine called *Aquarius weeder* to uproot the weed. The uprooted weed is then carried to a given site where it is destroyed.

24. Creeping Indigo *(Indigofera spicata)*

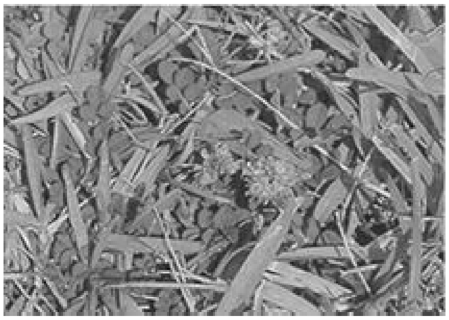


Fig. 5.24: Creeping indigo .

This is a woody perennial weed that has a tendency to creep. It produces red flowers and has grey leaves. It has a tough stem and a deep tap root system. The creeping indigo is a common weed in pasture grasses as well as in crop fields.

Control: Effective control involves repeated application of 2,4-D and MCPA.

25. Rape weed *(Brassica napus)*

This is an annual weed that grows up to about 90 cm high. It has large blue green leaves arranged alternately and pale yellow flowers borne on thin flower stalks. Lower leaves have hairy growths and the stems lack flower stalks.

Fig. 5.25: Rape weed .

Methods of weed control

It is of great importance to control weeds on time to minimise their effects on crops. Timely weed control gives the crops a head start in growth before serious weed competition sets in. First weeding for most of the crops should be done 1–2 weeks after germination. It is desirable to make the crop fields weed-free throughout the growing periods.

The following are the main weed control methods:

(i) Cultural weed control

These are agronomic practices which minimize introduction of weeds in the farm or reduce their effects. Cultural methods of weed control include:

(a) Use of clean planting materials which prevents introduction of weeds into the field.

(b) Thorough (clean) seedbed preparation for example, deep ploughing to expose perennial weeds such as couch grass and nut grass to harsh conditions thus killing them.

(c) Proper spacing of crops; this provides adequate crop cover that shades out the weeds.

(d) Early planting to give the crops a head start so that they grow and establish faster before weeds emerge.

(e) Mulching to cut out sunlight from reaching the weeds causing them to suffocate and die off. Weeds such as oxalis and double thorn can be effectively controlled by mulching.

(f) Use of cover crops to smother weeds for widely spaced crops.

(g) Parasitic weeds are effectively controlled by crop rotation. *Striga spp* (witch weed) thrives in a field continuously planted with maize. Rotating maize with a different crop helps to control the weed.

(h) Flooding is an effective way of controlling terrestrial weeds such as Black jack and Wandering Jew since they cannot withstand waterlogged conditions. This method has been used successfully in rice growing fields. However it encourages aquatic weeds.

(ii) Mechanical weed control

This involves the suppression or eradication of weeds by manual means. Here, farm implements such as hoes, harrows, slashers and pangas are used to eliminate weeds or suppress their growth. Mechanical weed control methods expose weeds and exhaust food stores in the plants' storage thereby killing the weed.

In this method, weeds are controlled through:

- Cultivation or tillage.
- Slashing or mowing.
- Uprooting.

For effective control, cultivation should be carried out during the dry season to ensure the weeds die.

Slashing involves removing the weeds top growths. It is effective in the control of annual weeds.

Uprooting is done where weeds are scattered especially in pasture and closely spaced crops like in a nursery.

Advantages

- It is cheap hence suitable in small scale farming.
- Tillage opens up the soil facilitating water infiltration. This minimises soil erosion.
- Tillage helps to incorporate organic matter into the soil when the weeds decompose, improving the soil structure and fertility in the process.
- Mowing is quick and convenient especially in wet soil.

Disadvantages

- Excessive tillage destroys soil structure and makes the soil vulnerable to soil erosion.
- It is labour consuming that is, requires a lot of manpower.
- Tillage may not be very effective especially on wet soils as weeds are quickly re-established.

- It may disturb crop roots retarding normal growth of crops.
- Exposes soil to evaporation.
- Mowing is effective in plants with underground reproductive structures.

Fig. 5.26: Mechanical method of weed control (by use of hoes) .

(iii) Biological weed control

This involves the use of living organisms such as insects or larger animals to suppress weed growth. Examples of biological control methods are:

- Grazing livestock in a farm to control weeds. This is possible where the crops cannot be eaten by the livestock for example, fruit tree plantations. Most grass weeds can be effectively controlled using this method.
- Use of geese to control weeds in cotton fields.
- Using larvae of cacti moth to control pricky pear *(Opuntia species.)*
- Using cover crops to smother weeds for example, growing sweet potatoes in a maize plantation.

Advantages

- Once established it is self-perpetuating.
- There is little or no environmental degradation.
- Saves on labour.

Disadvantages

- It does not eliminate weeds completely.
- Effective biological weed control requires expensive research to identify and develop the appropriate biological agents and to reproduce them.

(iv) Chemical weed control

This involves use of chemicals to control weeds. The chemicals are called herbicides. Herbicides are usually available in concentrated form and must be diluted with water before application.

Advantages

- Less labour requirements. It is cheaper than mechanical weed control especially in large-scale farming.
- It is effective for controlling weeds which cannot be easily eradicated by mechanical methods, for example, in closely spaced crops.
- It helps maintain soil structure since soil is not tampered with.
- It is an effective means of controlling noxious (harmful) weeds for example, couch grass.
- Efficient in both dry and wet soils.

Disadvantages

- It requires skills in mixing and application of the herbicides. If not skillfully done, it can have adverse effects on crop production.
- It can result in environmental degradation as some herbicides have long residual effects.
- The sprayers and herbicides are expensive.

(v) Legislative weed control

These are laws or regulations which are enacted by the government to prevent introduction of harmful weeds into the country. It requires certification of imported plant material to ensure they are weed free.

The limitation of this method is that in most cases only sample specimens are checked while the bulk of the materials that could contain weeds may escape official censorship.

Should there be laxity in enforcement of weed control legislation, some of the prohibited plant materials may gain access into the country.

Classification of herbicides

Herbicides are chemicals used to control weeds. They are usually available in concentrated form and must be diluted with water before application.
Herbicides are classified on the following basis:

(a) Type of weeds controlled

Certain herbicides are more effective on broad leaved weeds for example, *2, 4-5T* , others on narrow leaved weeds for example, *glyphosate* , while others act on both such as *paraquat* .

(b) Time of application

Different herbicides are most effective when applied at certain stages of weed growth. This can either be done after emergence or before emergence of the crop, hence there are:

- Pre-emergence herbicides:
  These are applied after the crop has been sown but before germination such as *Duron* and *MCPA* .
- Post-emergence herbicides:
  These are applied after the crop has emerged. Application of the herbicide is done either before the weeds emerge or after their emergence, for example, *Atrazine* and *Simazine* are applied in a maize field before emergence of weeds.
- Pre-planting herbicides: These are applied before the crop has been sown.

(c) Formulation

This refers to the physical form in which the herbicide is available. Herbicides are available in different forms:

(i) Liquids

These are soluble in water or organic solvents. They are diluted to a suitable concentration.

(ii) Wettable powders

They are available in a finely ground particle form. They are mixed with water to form a suspension for example, *Atrazine* and *Simazine* . A spreader is applied in the suspension to prevent flocculation. A spreader is a substance which causes dispersion of particles in a suspension such that they do not stick together.

(iii) Granules

These are applied directly onto the soil. They are preferably used where spraying is difficult to carry out.

(d) Mode of action

There are three modes of action of herbicides:

(i) Contact herbicides

These kill only that part of the weed with which they come into direct contact for example, *Paraquat* . Thorough wetting of the weeds is therefore necessary in using these herbicides.

(ii) Systemic herbicides/Translocated herbicides

These are absorbed into the plant's transport tissue and translocated from one part of a plant to another thereby killing the whole plant, for example, *2,4-D*, *Dalapon* .

They are most effective when applied to actively growing weeds.

(iii) Soil sterilants/Soil acting herbicides

These are applied in the soil and act as sterilants. When applied at very high concentration they totally inhibit plant growth. Examples are *Duron*, *Methyl bromide* and *Metham sodium* .

(e) Selectivity of herbicides

Selectivity is the ability of herbicides to kill certain weeds while having very little effect on others. On this basis, there are two categories: **selective herbicides** and **non-selective** herbicides. **Selective herbicides** kill some plants and not others while **non-selective herbicides** kill all the plants in the field of application.

Non-selective herbicides include *Paraquat* and *Diquat* while selective herbicides include: *Round up* (used on grass weeds), 2,4-D, *Hussar* and *Atrazines* (for broad leaved weeds).

Methods of application

(a) Spraying

Most of the herbicides are sprayed on to the weeds or on the soil surface. This is done by use of simple hand sprayers or mechanically by use of tractor mounted sprayers. Spraying is done after dilution of the herbicide with water or organic solvents.

(b) Mixing soil sterilants. These herbicides are in granular form.

Weed control in selected crop

The selected crop is maize. Maize weeds start growing after the maize has germinated. When the crop has developed enough leaves to carry out photosynthesis, the following methods of weed control can be applied:

(i) Mechanical weed control: This involves cultivation between the spaces by use of a hand hoe and preferably when the amount of rainfall is low.

(ii) Chemical weed control: This involves the use of herbicides like *Round up* , the spraying is done with a lot of care to prevent the herbicides from coming into contact with the leaves. This method is applied when there are a lot of grass weeds. The herbicide kill the weeds in question effectively.

Safety measures in use of agricultural chemicals

1. Carefully read and follow manufacturer's instructions.
2. Wear protective clothings for example, overalls, breathing masks, gloves, boots and goggles during spraying.
3. Never smoke or eat anything while spraying.
4. Never blow or suck blocked nozzle.
5. Spray along the wind to avoid drift of the chemical to non-target species and also to avoid inhaling the chemical.
6. Wash your body thoroughly and change clothes after spraying.
7. Dispose properly any left-overs and empty containers that is, bury them deeply. Do not throw them in gardens, bushes or pasture land.
8. Wash the spraying equipment away from water sources.
9. Store away chemicals in a safe place, out of reach of children and away from food stores.
10. Clean the spraying equipment thoroughly since the equipment may be used for different applications of herbicides or acaricides.
11. Allow the correct time to elapse before harvesting any sprayed crop so that the chemical applied breaks down to safe levels.
12. Keep proper records of all chemical applications. This avoids repeat application of chemicals to a crop that had already been treated.

Classification of weeds

Weeds are classified based on various characteristics, for example, their growth cycle or morphology.

1. Classification on the basis of growth cycle

This classification is based on the reproductive cycle, that is, how long the plant takes to complete its life cycle. In this classification, weeds are annual, biennial or perennial.

(a) Annual weeds

These are weed plants which complete their life cycle within one year. They exhibit the following characteristics:

- They have a rapid growth rate. Most weed plants grow fast and are capable of completing two or three life cycles within a year.
- They produce a lot of seeds which can be easily dispersed.
- They are only propagated by seed.
- They spread and colonize a large area very quickly.

Examples: Black jack *(Bidens pilosa)* and thorn apple *(Datura stramonium)* .

(b) Biennial weeds

These are weeds which complete their life cycle within a period of two years. Their common characteristics include:

- They are herbaceous in their first year of growth and produce a lot of seeds in the second year, after which they die.
- They are mainly propagated by seed.
- Have serious effects on crops if not properly controlled that is, they cause a drastic reduction in crop yields.

Examples: Rape weed *(Brassica napus)* .

(c) Perennial weeds

These weeds are capable of surviving for more than two years irrespective of prevailing climatic conditions. They exhibit the following characteristics:

- Take a long time to mature and produce seeds.
- Propagation is possible by both seed and vegetative plant parts.
- Their life cycles do not stop with production of seeds.
- They are more difficult to control than annual and biennial weeds.
- They have underground stems or storage organs which enable them to survive harsh climatic conditions.

Examples of perennial weeds include: couch grass *(Digitaria scalarum)* , sodom apple *(Solanum incanum)* and tick berry *(Lantana camara)* .

2. Classification based on plant morphology

Weeds are classified according to the size or shape of the plant leaves. In this case, they can be either broad leaved or narrow leaved weeds.

(a) Broad leaved weeds

These are annual or perennial weeds commonly found on arable land or new pasture leys. Examples of annual broad leaved weeds are thorn apple and black jack. Perennial broad leaved weeds include *wandering jew* and *oxalis* .

(b) Narrow-leaved weeds

These are mainly perennial or annual grass weeds. Both types are difficult to control. Examples include couch grass and nut grass.

Importance of weeds in crop production

Weeds cause a great decline in agricultural production in the following ways:

- *Competition for water, nutrients, space and light* .

  Weeds compete with crops for nutrients, space, light and water. Most weeds are heavy feeders. This leads to a drastic reduction in crop yields if the weeds are not controlled in the field. Yield losses of up to 90% due to weeds have been recorded in a tomato crop.

- *Harbour pests and diseases* .

  Some weeds are alternate hosts of crop pests and diseases, for example, the mallow weed harbours cotton stainers.

- *Poisonous to man and livestock* .

  Some weeds are poisonous for example, *Datura stramonium* (thorn apple) and *Solanum incanum* (sodom apple).

- *Reduction of quality of farm produce* .

  Some weeds can contaminate and lower the quality of farm produce, for example, if mexican marigold *(Tagetes minuta)* is consumed by dairy cows prior to milking, it taints the milk. Black jack *(Bidens pilosa)* spoils the wool of sheep, where as seeds of wild oats lower the quality of wheat.

- *Blockage of water channels* .

  Some aquatic weeds, for example, Salvinia *(Salvinia molesta)* and the water hyacinth *(Eichornia crassipes)* can block irrigation channels or increase the rate of evaporation of water. Aquatic weeds may also deprive fish and other aquatic animals of oxygen causing them to die.

- *Irritation* .

  Some weeds, such as the stinging nettle *(Urtica massaica)* irritate workers when the plant leaves get in contact with any part of their bare skin. The itching effect reduces the efficiency of farm labour.

- Some weeds are *parasitic* on crops depressing their growth and lowering their yields, for example, *Striga spp* . on cereals, *Phorandedron spp* . (mistle toe) on avocado and pear trees.

- Some weeds are *allelopathic* that is, they produce chemical compounds which suppress or inhibit germination of seed crops. A common example is the tick berry (*Lantana camara*).
- *Weed control increases the cost of production* .

  Weeds increase the cost of production through increased labour costs, purchase of herbicides, cleaning of adulterated produce, impediment of harvesting of the crop.

Benefits of weeds

- *Vegetables* .

  Some weeds are used as vegetables for example, pigweed *(Amaranthus spp)* , and black night shade *(Solanum nigrum)* .
- *Medicinal value* .

  Some weeds have traditionally been used as herbal medicine to cure diseases in humans and farm animals for example, the roots of sodom apple *(Solanum incanum)* have been used to treat constipation.
- *Soil vegetation cover* .

  Weeds act as a soil vegetation cover minimising loss of soil moisture through reduction of the evaporation rate. They also prevent the removal of topsoil by erosion agents. Examples are grass type weeds, such as, couch grass *(Digitaria scalarum)* and nut grass *(Cyperus rotundus)* .
- *Source of soil nutrients* .

  When weeds decompose, they release nutrients into the soil which are made available for use by crops. Leguminous weeds for example, *desmodium fix* nitrogen in the soil.
- *Mulching material* .

  Dead dry weeds may be used as organic mulch for crops, for example, dry couch grass is good for use as a mulching material in banana or coffee plantation.
- *Livestock feed* .

  Some weeds serve as feed for livestock and wild game for example, wandering jew, black jack.

Factors contributing to the competitive ability of weeds

- Weeds produce a very large number of viable seeds, for example, fleabane, black jack, sow thistle.
- Ability to withstand unfavourable conditions. Seeds of a number of weeds can remain viable in the soil for a long time until suitable germination conditions set in. Examples are double thorn and witch weed.
- Some weeds have good dispersal mechanisms that make them spread fast for example, black jack, devil's horse whip, gallant soldier.
- Some weeds propagate by use of vegetative parts for example, wandering jew, nut grass, oxalis, couch grass.
- Some weeds have short life cycles. Most weeds are capable of growing very fast and reaching maturity early and produce seeds within a period of 1-3 months. Examples are double thorn, gallant soldier, mexican marigold.
- Weeds have the ability to survive even in soils with low nutrient level, for example, *Lantana camara* (tick berry), couch grass, double thorn.

Practical Activity 5.2

1. Prepare weed albums using the common weeds around your school. Mount weeds discussed and give the common name and botanical name and the problems they cause to farmers.
2. Visit a nearby farm and identify weeds present and observe their adaptive features.
3. Control weeds in the school using any of the methods discussed.

Revision Exercise 5 A

1. Define the term weed.
2. List ten weeds found within your school neighbourhood.
3. Give two weeds that are poisonous to man and livestock.
4. State the economic importance of weeds.
5. Why is couch grass difficult to control?
6. State five cultural ways of controlling weeds.
7. State the advantages of biological weed control.
8. State six precautions one should take while using herbicides.

9. What are the limitations of chemical weed control?
10. Briefly explain the legislative weed control measures.
11. Name three biological agents used in weed control, specifying the weeds controlled by each agent.
12. Differentiate between pre-emergence and post-emergence herbicides.
13. State the various ways of classifying weeds.
14. Discuss any five importances of weeds in:
    (a) Crop plant production.
    (b) Animal production.

Crop protection

These are the measures taken to ensure optimum crop performance with little interference by external factors. It is achieved through weed control and pest and disease control.

A pest is an organism that destroys crop produced in the field or store while a disease is any alteration in crop physiological functions due to living organisms and non-living factors. All these affect crop production leading to drastic losses in both crop quantity and quality. Thus it is necessary to protect crops against weeds, pests and diseases.

Pests may also introduce disease causing organisms which interfere with normal performance of crops. For example, groundnut aphid introduces groundnut rosette virus to groundnut crop leading to stuntedness and lowered yields. Disease are due to pathogens.

Differences between a pest and a disease

Pests	Diseases
• Are larger organisms	• Are pathogenic organisms.
• Consume crop produce wholly or partly.	• Kill plant tissues and organs.
• Most of them are controlled by spraying insecticides.	• Most of them are controlled by spraying fungicides.
• They are normally within the environment and they cause	• They are usually not within the environment but when they strike

economic losses when they are many.	they cause high economic losses.

Plant pests and diseases

A pest can also be defined as any living organism that destroys crops either directly or indirectly by introducing pathogenic effects. The word pest is derived from a latin word *pestis* which means plague or a contagious infection. The word pest may also be defined as a destructive organism affecting crops. Pests include organisms such as insects, mites, nematodes, birds, large animals and rodents.

Practical Activity 5.3

1. Visit nearby crop fields and observe pests and diseases.
2. Collect specimen or samples of pests and diseased plants.

A plant disease may also 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 for example, protozoa, bacteria, virus, fungus and nematode.

Classification of pests

Crop pests can be classified on the basis of:

(a) Mode of feeding of the pest

This is determined by the nature of the mouth parts of the pest. On this basis we have the following categories:

(i) With biting and chewing mouth parts

These are the most destructive of all crop pests. They include large animals, such as, elephants, apes and wild pigs; insects, such as, locusts, armyworms and termites; rodents and birds.

They cause physical damage to plant leaves, stems, roots, flowers, fruits and seeds. Damage to leaves reduces the photosynthetic area of the plant reducing the efficiency of photosynthesis. Destruction to the stems interferes with efficiency in the transport system of plants, affecting the general growth and may even result in plants dying.

(ii) With piercing and sucking mouth parts

These are mainly insects. They pierce plant tissues and suck the cell sap from phloem and may introduce disease-causing organisms for example, aphids transmit viral diseases in groundnuts and tobacco, cotton stainers transmit fungal diseases in cotton. Some sucking insects secrete toxic substances into the plant that can damage the shoots or cause distorted growth for example, antestia bug in coffee.

Other examples of pests with piercing and sucking mouth parts are thrips, fruit flies, cotton leaf hoppers, scales and mites.

(b) Crop parts attacked

There are five categories of pests on the basis of the crop parts attacked:

(i) Root feeders

These either feed on the plant roots or attack the plant root system causing the death of the whole plant. Examples: sugarcane termites *(Pseudocanthotermes militaris)* and nematodes which attack roots of Irish potato plants.

(ii) Stem borers

Adult moths lay their eggs between leaf sheaths and plant stems. The eggs hatch into larvae which bore into the plant stems eating the stem tissues and thus interfering with the plant transport system. Example is maize stalk borer *(Busseola fusca)* .

(iii) Leaf feeders

These are either large animals such as elephants, buffaloes and cattle or insects which damage the leaves. Examples of insect leaf feeders are coffee leaf minor *(Leucoptera spp)* and coffee thrips *(Heliothrips coffea)* .

(iv) Fruit feeders

These mainly feed on fruits and seeds. Examples are: American bollworm *(Heliothis armigera)* and antestia bugs *(Antestiopsis spp)* which attack cotton and young coffee berries, respectively. Others are large animals such as monkeys, apes and wild pigs.

(v) Grain-eaters

These are mainly insect pests which attack crops in the store for example, maize weevils *(Sitophilus zeamais)* , bean bruchid *(Acanthoscelides obtectus)* , rats

(Rattus rattus) , birds such as sudan dioch *(Quelea quelea aethiopica)* and guinea fowl.

(c) Field pests

Field pests attack crops in the field. Examples are:

• Insect pests for example, maize stalk borer.

• Mites.

• Nematodes.

• Rodents, such as, squirrels and moles.

• Birds for example, *Quelea quelea aethiopica* , weaver birds and mouse birds.

• Molluscs for example, snails.

• Other large animals.

(d) Stage of growth of crop attacked

Some field pests attack crops before their physiological maturity causing considerable damage to the crops. Examples: Armyworms, aphids, bollworms, cutworms. Other pests attack crops after maturity, for example, weevils.

Identification of common pests and diseases of field crops

The following are some of the pests that attack crops in a field.

1. Army worms

These are larval stages of the moth *Spodoptera exempta* . They feed on crop leaves.

Fig. 5.27: Army worm .

2. Cutworms

These are larvae of moths that lie hidden in the soil or at the base of seedlings. Presence of cutworms is indicated by fallen seedlings.

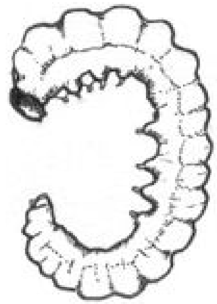


Fig. 5.28: Cutworm .

3. Locusts

Both the nymph and adult stages cause considerable damage to growing crops. They eat exclusively all vegetation that is, plant leaves, shoots, barks of trees.

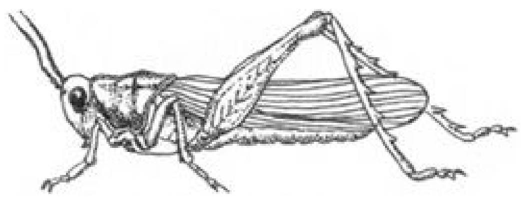


Fig. 5.29: Locust .

4. Moths

The larval stage of the moth causes serious damage to plants. For example, the potato tuber moth has its caterpillars burrowing in the tubers making black tunnels filled with excreta.

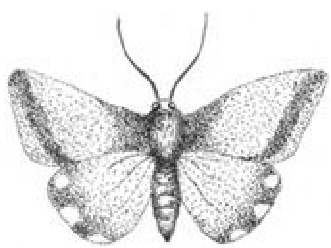


Fig. 5.30: Moth .

5. Fruit fly

The larval stage is the most destructive. They attack mainly citrus fruits making tunnels in them and cause rotting of the fruits.

Fig. 5.31: Fruit fly .

6. Mealy bugs

There are many types of mealy bugs for example, pineapple mealy bug and the coffee mealy bug. Mealy bugs have sucking mouth parts and suck sap from the plant leaves transmitting viruses in the process.

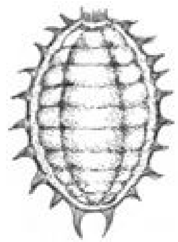


Fig. 5.32: Mealy bug .

7. Nematodes

Nematodes are also called eelworms. They are microscopic legless worms found in the soil. They attack different plant parts such as roots, stems, leaves and bulbs.

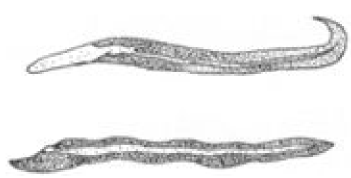


Fig. 5.33: Nematodes .

8. Thrips

These are small, slender and yellow-black insects. They have piercing and sucking mouth parts, hence suck sap from plant leaves, flowers and fruits.

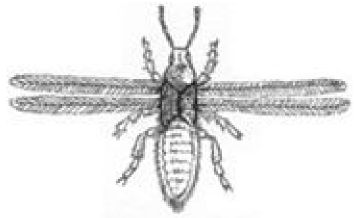


Fig. 5.34: Thrip .

9. Beetles

The common beetle which destroys crops is the rhinocerous beetle *(Oryctes monocerous)* . It is large, black and shiny with a horn on its head. It damages unopened leaves at the growing point.

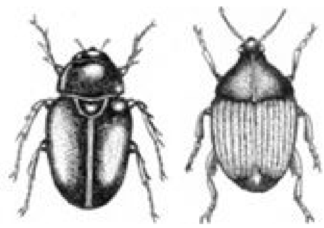


Fig. 5.35: Beetles .

10. Weevils

The common weevils are the bean bruchid *(Acanthoscelides obtectus)* and the maize weevil *(Sitophilus zeamais)* . They have long curved snouts which they use to bore into the seed or grain.

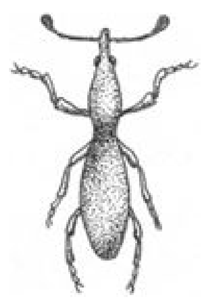


Fig. 5.36: Weevils .

11. Birds

Birds eat certain insect pests thus maintaining a balance in the ecosystem. Birds damage fruits such as tomatoes and pawpaws.

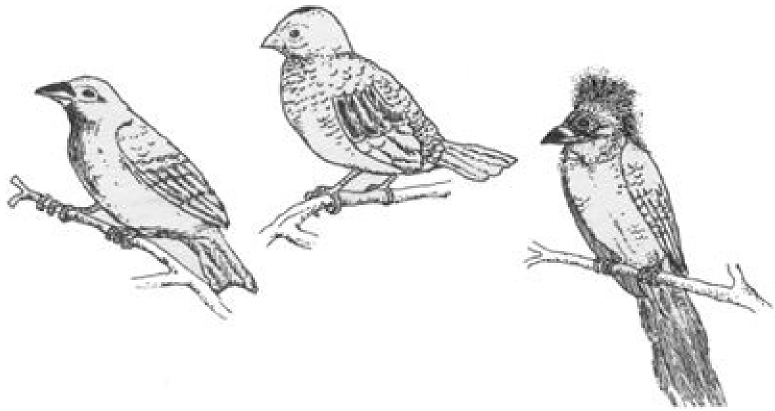


Fig. 5.37: Weaver bird, sudan dioch and mouse bird respectively .

12. Rodents

These include squirrels which uproot young germinating cereals, seedlings and also eat fruits. Other rodents are moles and rats.

Fig. 5.38: Squirrel, rat and mole .

13. Bollworms

These are larval stages of certain moths. The larval stage is known as a caterpillar and is quite destructive as it feeds on leaf tissue. This reduces the photosynthetic surface area. Bollworms bore holes in bean pods.

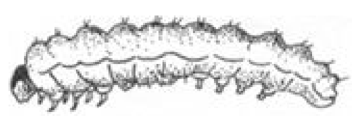


Fig. 5.39: Bollworm .

14. Stainers

Both the adult and nymph stages cause destruction to crops. They are sucking insects. The adults are brightly coloured with red brown, black and white stripes on their abdomen.

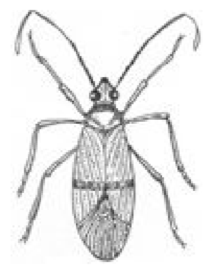


Fig. 5.40: Stainer .

15. Leaf miners

These are larvae of tiny white moths. They make holes in the pallisade tissue of leaves forming mines which appear as irregular brown blotches on the leaves' upper surface.

Fig. 5.41: Leaf miner .

16. Aphids

These are small insects found in clusters around stems and young shoots on the leaf's underside. There are many different species of aphids such as the green aphid, brown aphid and black aphid.

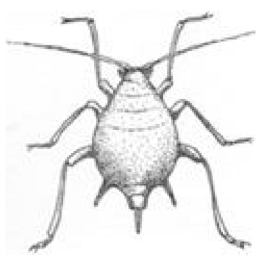


Fig. 5.42: Aphid .

17. Stalk borers

These are larval stages of many species of moths. The larvae bore into the stems of maize, sorghum e.t.c and feed on the stem tissue.

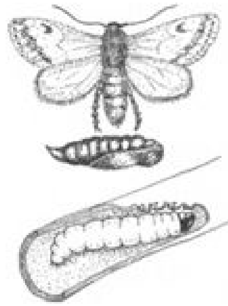


Fig. 5.43: Stalk borer .

18. Loopers

These are larval stages of certain flies. They are green in colour and feed on the leaves of plants.

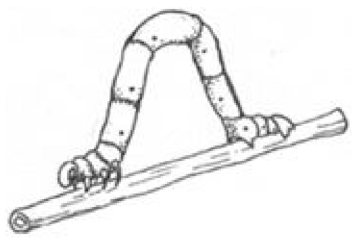


Fig. 5.44: Looper .

19. Scales

There are different types of scales such as the red scales, soft green scales, soft brown scales and mussels. These organisms are circular in shape, others have elongated bodies while others have oval shapes.

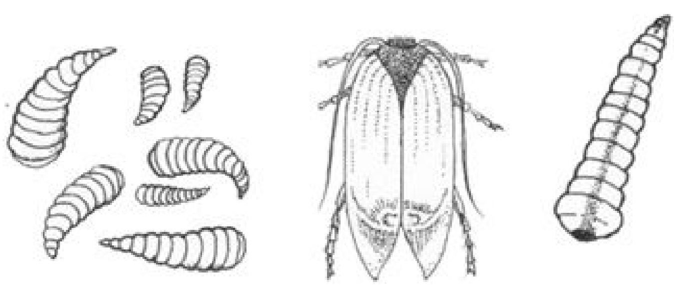


Fig. 5.45: Scales .

Classification of diseases

1. Fungal diseases

(a) Smuts

These are caused by fungi. The major smut diseases are the common maize smut *(Ustilago maydis)* , head smut *(Sphacelotheca reiliana)* of sorghum and loose smut of wheat *(Ustilago tritici)* .

Fig. 5.46: Head smut (in maize) .

(i) Head smut

It is more prevalent than common maize smut and appears when cobs silk and tassels are fully open. The spores are formed in the tassel and silk.

Symptoms

• Plants are severely dwarfed.

• Abnormal development of tassels.

• Black masses of spores on the cob and tassels.

• Increased tillering.

(ii) Common maize smut

Symptoms

• Presence of white galls on the stalk and leaves.

• In young growing plants, infection may kill or retard plant growth.

Control

The smuts disease can be controlled through the following:

• Planting resistant maize varieties.

• Use of certified seeds.

• Crop rotation.

• Rogueing.

(iii) Loose smut of wheat

The infected wheat head forms no grains. The axis of the ear becomes black in colour. It can be controlled by planting resistant wheat varieties and by the use of certified seeds.

(b) Blasts

This is a disease caused by fungi. Its effect is extensive where there is heavy application of nitrogenous fertilizer and in hot and humid conditions. It mainly affects rice crop.

Symptoms

- Brown spots with grey centres on the leaves.
- Stems become infected just below the inflorescence.

Control

- Plant resistant varieties for example, Basmati 217, 1R8, IR22, IR257.
- Use appropriate fungicides.

(c) Maize leaf blight

This is a fungal disease of maize which is characterized by oval, grey and thin lesions on the leaves. It is controlled by planting resistant varieties.

(d) Blights

These are fungal diseases of Irish potatoes and tomatoes. There are three types of blights which attack crops of the family solanaceae.

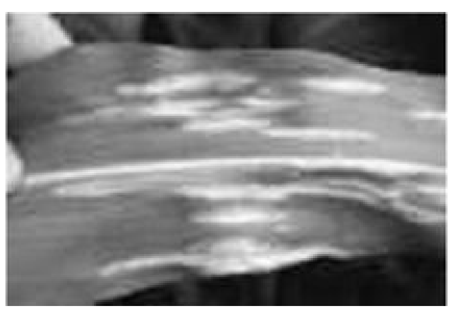


Fig. 5.47: Leaf blight in maize .

(i) Early blight

This is caused by fungus *Altenaria solani* . It is characterised by stem cankers on seedlings and premature leaf fall and sometimes, falling of tomato fruits.

(ii) Late blight

This is caused by fungus *Phytophthora infestans* . It causes dark brown lesions on leaves and stems, rapid withering and drying out of plant leaves. Blights are controlled by spraying of appropriate fungicides such as copper fungicides, dithane M45, Ridomil MZ.

(iii) Bean halo blight

This is caused by bacterium *Pseudomonas syringae* . It occurs in beans. Small water soaked spots with a yellow green halo appear on the leaf and pods. The spots on pods may start producing a creamy white mass of bacteria. The disease is controlled by planting certified seeds, destroying crop residues and planting resistant varieties of the crop.

(e) Rusts

These are fungal diseases which affect cereals, beans and coffee.

(i) Rusts in cereals

They are caused by *Puccinia spp* . Symptoms include red or brown pustules formed on the leaves. The disease attacks wheat, barley, maize and oats. It is controlled by using resistant crop varieties, practising field hygiene and close season.

Fig. 5.48: Rust in maize .

(ii) Coffee leaf rust

The disease is characterised by:

- Premature leaf fall or defoliation.
- Yellow spots on the leaves.

Control

- Plant resistant varieties.
- Spray coffee with copper fungicides.
- Practise open pruning.

Fig. 5.49: Coffee leaf rust .

(f) Leaf spot

This is a fungal disease common in oranges. It is caused by *Alternaria citrii* . It is characterised by large blotches with yellow spots on the leaves. It is controlled by use of appropriate fungicides such as *Ridomil* MZ.

Fig. 5.50: Panama disease .

(g) Panama disease

It is a fungal disease caused by *Fusarium oxysporum* . It affects banana.

Symptoms

Yellowing of lower leaves which later hang downwards.

Purple discolouration of vascular tissue of the stems and rhizomes. It can be controlled by planting resistant varieties, planting healthy suckers and destroying infected plants.

(h) Cigar end rot

This is a fungal disease caused by *Verticillium theobromae* . It affects bananas. The tips of banana fruits look like ash on the end of the cigars. It can be controlled by removing dead floral remains from the young banana tips.

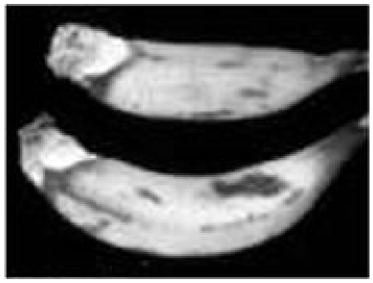


Fig. 5.51: Cigar end rot .

(i) Die back

This is a fungal disease of coffee. It is characterised by death of young shoot of the infected plant. The dying starts from the shoot tips and moves downwards hence the name die back. It is controlled by using appropriate fungicides and providing windbreaks in the crop field.

(j) Wilts

Fig. 5.52: Bacterial wilt in tomatoes .

These are caused by fungi and bacteria and are characterised by wilting of the plant even under wet conditions. It may lead to eventual death of the plant. The disease attacks crops such as bananas, cotton, groundnuts, pigeon peas, okra and cabbages. The wilting caused by fungus, *Fusarium spp* is called fusarium wilt whereas bacterial wilt is caused by *Pseudomonas spp* . The disease attacks tomatoes and Irish potatoes.

Control

Rogueing, use of certified seeds, crop rotation, planting resistant varieties, soil sterilisation and quarantine regulations.

(k) Damping off

This is also called seedling disease. It mainly attacks plants during the early stages of growth that is, in the nursery bed. It is caused by fungi or bacteria which are soil-borne or seed-borne. It is characterised by:

• Failure of seed germination.

• Collapse of seedlings after germination.

• White growth at the base of seedlings.

It is controlled by regulating watering of seedlings in a nursery. Over watering and overcrowding of seedlings should be avoided to allow enough light to reach the seedlings.

(l) Coffee Berry Disease (CBD)

The disease is caused by fungus *Colletotrichum kahawae* (formerly called *Colletotrichum coffeanum)* .

Symptoms

• Falling off of flowers and berries at pin head stage.

• Black and brown patches form on nearly ripe berries.

• There is twig die back.

Control

Proper pruning, planting resistant varieties and using sprays of copper fungicides.

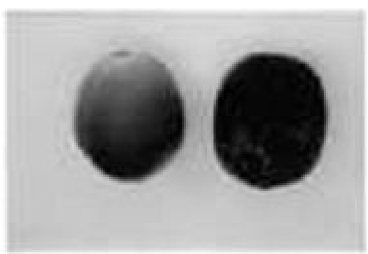


Fig. 5.53: Coffee berry disease .

(m) Armillaria root-rot

This is a fungal disease that attacks tea. It is caused by *Armillaria melea* fungus.

Symptoms

• Slow die back of the tea plant.

• White mass of fungus under the bark.

Control

Removal of infected bushes plus all its roots or by ring barking of tea bushes six months before land preparation.

(n) Mildew

This is a fungal disease which attacks crops like maize, onions and cabbages. In maize.

Symptoms

- Chlorotic streaking
- Mottling
- Stunting
- Malformation of silk and tassels
- Excessive tillering.

Control

Rogueing that is, uprooting and burning infected plants. In vegetables, use appropriate fungal sprays.

2. Viral diseases

(a) Maize streak

This is an important plant viral disease in Malawi transmitted by leaf hoppers.

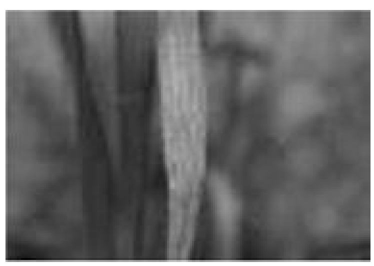


Fig. 5.54: Maize streak .

Symptoms

- Yellow longitudinal stripes which run parallel to the midrib and start as small scattered spots in young leaves.
- Stunted growth in plants during the early period of growth.
- Cobs produced are often half filled or contain few or no seeds.

Control

- Timely planting.
- Rogueing.
- Field hygiene that is, destruction of crop residues.

• Crop rotation.
• Having a closed season.
• Certified seeds.

(b) Mosaic

This is a viral disease characterised by presence of yellow and dark green patches on leaves. It attacks crops like cassava and groundnuts. It is controlled by planting of resistant varieties and rogueing.

(c) Greening disease

Fig. 5.55: Greening .

This is a viral disease of citrus, characterised by formation of small yellow or mottled green leaves. It is also characterised by presence of moulds on stored citrus fruits. This disease can be controlled by spraying the crop with appropriate insecticides to kill the disease vectors, that is, aphids.

(d) Tristeza

This is a viral disease which affects citrus. It is also known as stem pitting or quick decline. The attacked citrus tree plant exhibits stunted growth and death of rootstock. The disease is controlled by planting resistant varieties and using healthy budding materials. It is also controlled by eradication of aphids and scales which act as vectors.

(e) Rosette

This is a viral disease that attacks tobacco and groundnuts. It is characterised by stunted growth and production of many small leaves with many auxiliary shoots. The disease is controlled by using appropriate insecticide sprays and destruction of crop residues.

(f) Ratoon stunting disease

This is a viral disease affecting sugarcane. It is characterised by decline in crop growth vigour and excessive tillering leading to a dense stool. The disease control measures include: planting of disease-free setts and treating setts with hot water before planting.

3. Bacterial diseases

(a) Black arm

This is a bacterial disease which affects cotton. It is also called bacterial blight.

Symptoms

- Leaves turn brown and dry up.
- Black lesions on the main stems which eventually break off.

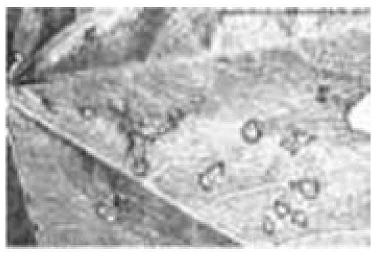


Fig. 5.56: Black arm .

Control

- Planting resistant varieties.
- Field hygiene by burning crop residues.
- A closed season of one year.

Harmful effects of plant diseases

- They decrease crop yields by altering the normal plant physiological processes interferring 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.

Economic importance of pests and diseases of field crops

- Pests may cause physical destruction to crops by eating leaf, stem, root or flower tissues.

- If not controlled, pests can cause considerable reduction in crop yields.
- Some pests lower crop quality for example, maize stalk borers bore maize stalks leading to poor performance thus low crop quality. Cotton stainers stain cotton lint lowering the crop's quality.
- Some may cause irritation to workers reducing their efficiency for example, some caterpillars in crop.
- Pest control measures increase production costs since huge sums of money are spent on chemicals and the necessary spraying equipment.
- Some pests are disease vectors for example, sucking pests such as, aphids and mealybugs transmit viruses causing disease infections in the crops.
- Excessive use of pesticides can cause environmental degradation. Some of the pesticides are non-biodegradeable. This leads to soil and water contamination that will eventually affect man.
- Suck sap, depriving the plant of its food.

Plant disease control measures are broadly classified into:

- Cultural control measures.
- Chemical control measures.

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 occurence of plant diseases in crop fields.
- *Use of disease resistant varieties* . This prevents crop infection by particular disease (coffee variety) is resistant to Coffee Berry Disease.
- *Quarantine regulations:* This help prevent introduction and spread of diseases in new field areas or into the country.
- *Practising of field hygiene:* For example, rogueing and destruction of infested crop residues.
- *Crop rotation:* For example, alternate plants of solanaceae family with other types of crops to control blights. Crop rotation leads to interference with life cycles of most pests which act as disease vectors for example, aphids which transmit the virus causing tobacco mosaic or rosette in groundnuts.
- *Proper seedbed preparation:* This exposes soil-borne pathogens to the sun and

predators thus killing them. This is a very effective control measure for most fungal diseases that are soil-borne, for example, 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:* This help to control ratoon stunting disease in sugar cane.
- *Proper drying:* Drying of cereals and pulses helps to prevent occurrence of aflatoxins.
- *Proper spacing of crops:* In some crops for example, groundnuts, wider spacing results in serious infections of groundnut rosette disease, while closer spacing minimises the disease.

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, *Lindane* and *Cerasan* to control seed-borne fungal diseases.
- Soil fumigation or sterilization 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.

Control of pests and diseases in a selected crop

The selected crop is citrus fruits.

Control of pests

The common pests which attack citrus crop in the field are citrus psyllids.

Control

- Spray regularly by use of insecticides to prevent the vectors which are transmitters of diseases for example, greening disease which is transmitted by the vectors.

- The disease is controlled by use of healthy planting materials like the bud wood and bud stick should come from a healthy plant to prevent the spread of the disease.
- It can also be controlled by planting disease resistant materials.

Methods of pest and disease control

Most pests will always be present in the farm. In pest control considerations, minor pests may be tolerated by the plant and so it may not be economical to control them. When the pest population causes damage beyond what can be tolerated by the plant, 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 or eradicate pests. 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 pest control

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:

(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 crop is unlikely to be attacked by the stalk borer.

(iii) Proper seedbed preparation

Seedbed preparation should be thorough and preferably cultivated in the dry season to expose 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 crubs and nematodes which affect young seedlings.

(iv) Resistant crop varieties

Cultivation of crop varieties which have mechanisms of resisting pest attack like 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 ensures little or no plant materials that harbour pests in the field. Examples of field hygiene practices are burning of crop residues of previous seasons, which helps control the cotton bollworm and rogueing which controls scales.

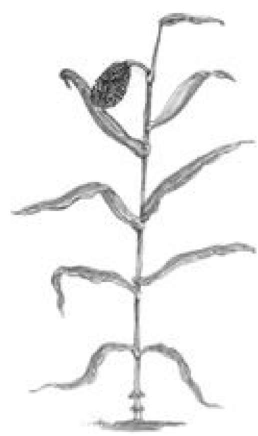


Fig. 5.57: Gooseneck sorghum .

(vii) Mulching

This is an effective way of controlling certain pests. For example, coffee thrips and antestia bugs are predated on more once the crop is mulched. The pests attach 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 disease and pest build up. Most maize pests and the *Striga spp* 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 stalk borer 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, weevils and brown scales.

(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 should not be grown in succession in the same piece of land as they are susceptible to similar pests for example, nematodes attack cabbage crop and tomato crop.

(xiii) Establishing healthy crops

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 use of certified seeds and application of manures or fertilizers.

(b) Mechanical pest control

This is also referred to as physical 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:

(i) Irrigation or flooding

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

(ii) Use of lethal temperatures

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

(iii) Suffocation

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

(iv) Hand picking, 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 the 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.

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

These are methods which employ the use of living organisms which are natural predators of the pest. Examples are:

Predator	**Target pest**
Parasitic wasp	Whitefly in citrus, coffee mealy bug.
Lady bird beetle	Aphids, cottony cushion scale.
Praying mantis	Giant looper.
Cats	Moles, rats, mice and other rodents.
Chicken	Cotton stainers, 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

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.
- Sterilization of implements.

Classification of pesticides

There are different types of pesticides. They can be classified in various ways:

(i) Mode of entry

The following classes can be identified on this basis:

- *Stomach poisons:* These enter the pest through the mouth during feeding and poison the pest.

- *Contact poisons:* These kill the pest when it comes into contact with the chemicals as they get absorbed through the skin cuticle.
- *Fumigants:* These enter the pest respiratory system in form of fumes suffocating the pest to death.
- *Systemics:* These chemicals may be applied into the soil or directly on to 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.

(ii) Type of pest controlled

On this basis we have the following classes of pesticides:

- *Insecticides;* which kill insect pests. For example, diazinon, dimethoate, fenthion and fenitrothion.
- *Rodenticides;* which kill rodents such as rats, mice and squirrels. For example, nomui and red cat.
- *Nematicides;* which kill nematodes. For example, nemacur, nemagon and temic.

Factors that affect the efficiency of pesticides

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

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

- *Concentration of the pesticide:* A pesticide has a higher efficiency when applied in its correct concentration.
- *Weather conditions at the time of application:* Rain water washes away the pesticide therefore avoid applying chemicals on rainy days.
- *Timing of application:* The efficiency of the chemical is high when applied at a time when the pest is most susceptible for example, at the larva or nymphal stage rather than at the adult stage when some pests may become resistant to the pesticides.
- *Persistence of the pesticide:* Those pesticides which have long residual effect are more effective in killing the pests. This is because such pesticides retain their strength for long before breaking down into constituent compounds which are harmless.
- *Pest resistance* . Some pests have developed resistance to certain pesticides and

this reduces their efficiency.

Advantages of chemical pest control

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

Disadvantages of chemical pest control

- Chemicals are expensive to purchase.
- Chemicals that have long residual effects may cause environment pollution for example, 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 for example, ladybird, beetles, butterflies, bees, birds.
- Some target pests may build up resistance, hence rendering the chemical ineffective.

(e) Integrated pest management (IPM)

This is a strategy which involves use of a combination of the various pest control methods in a well organised and harmonious way. Biological pest control agents are used and supplemented with cultural and physical methods as well as the use of pesticides. This approach has been adopted in the production of horticultural crops exported to the European Union. These markets are very strict on the presence of chemical residue in the produce.

(f) Legislative pest control measures

This involves imposition of rules and regulations that aim at preventing introduction and spread of diseased or pest infested materials across borders.

Classification of plant diseases

Plant diseases can be classified into three major groups according to the cause:

(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 and rusts.

(ii) Viral diseases

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

- *Chlorosis:* Yellowing of the leaves.
- *Stunted growth:* The plant exhibits dwarfness.
- *Mosaic mottling:* These are light and dark patches found on the plant leaves.
- *Necrosis:* This refers to the death of plant tissues for example, on leaves, stems or fruits.
- *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 include: Black arm of cotton and bacterial wilt in potatoes and tomatoes.

Note: Other causes of plant diseases are:

- Nutritional imbalances where plants experience deficiency of certain mineral salts in the soil affecting their normal growth.
- Physiological disorders for example, Blossom end rot disease in tomatoes caused by water stress or infrequent watering of seedlings in the nursery.

Practical Activity 5.4

1. Visit a crop farm and identify the common pests and diseases and investigate the control measures employed by the farmer.
2. Collect common pests, identify them and preserve them in the school laboratory.
3. Collect specimens of crops attacked by different diseases, mount them on a wall-chart and identify them.

Revision Exercise 5B

1. Differentiate between plant pest and disease.
2. Give two examples of pests in each of the following categories:
   (a) Biting and chewing pests.
   (b) Piercing and sucking pests.
3. State and briefly explain the main causes of crop diseases.
4. Define the following terms:
   (a) Economic injury level.
   (b) Integrated pest management.
5. State the main ways of classifying pests.
6. Outline the main symptoms of nematode attack in a banana plant.
7. A farmer noticed her citrus plants having sooty leaves. On closer scrutiny, she found some green circular organisms which appeared immobile in clusters on the leaves and twigs.
   (a) Which pest had attacked her crop?
   (b) How can she control the pest?
8. What is biological pest control and what are its advantages?
9. Explain the harmful effects of pests to a farmer.
10. Giving examples in each case, state the various classes of crop diseases.
11. Name the causes of each of the following plant diseases:
    (a) Coffee berry disease.
    (b) Cigar end rot.
    (c) Maize streak.
12. Give the control measures of common maize smut.
13. Explain how crop rotation helps in disease control.
14. Banda wanted to establish a tree nursery. He was advised to sterilise the nursery soil before sowing the seeds. Explain how he can carry out the sterilization.

Cropping Systems

Unit 6

Objectives

By the end of this unit, you should be able to:

(a) Explain the meaning of the term 'cropping systems' .

(b) List types of cropping systems .

(c) Analyse the activities in each cropping system .

(d) Select cropping systems which can promote higher crop yields .

Cropping systems

Cropping system refers to an arrangement in which various crops are grown together in the same field. The cropping systems practised in drylands differ from those followed in high rainfall areas or moderate rainfall areas. For example, cropping system in dry lands involves only those crops which can be grown under dry land conditions and requires less water to complete their lifecycle. These can include both drought resistant and drought tolerant plants.

Types of cropping systems

- Crop rotation.
- Monocropping.
- Intercropping.
- Mixed cropping.
- Continous cropping.
- Bush fallowing.
- Shifting cultivation.

1. Crop rotation

Crop rotation is a system of growing different crops on the same piece of land in an orderly sequence or definite order. This helps to preserve and maintain soil fertility and productivity. Crops which have different growth habits and nutrient requirements are grown on the same piece of land in an orderly sequence. It can be done seasonally, for example, half-yearly, annually or after two years. Crop rotation ensures soil fertility and productivity only if it is supported by good crop husbandry and agronomic practices which include early planting, establishment of correct plant population and timely weeding.

Different crops have different nutrient requirements. If one particular type of crop is grown every year on the same piece of land, the soil gets exhausted of these nutrients and the crop yield is lowered. However, if a different crop with different nutrient requirement is grown, the soil gets ample time to get back the nutrients lost through the crop grown in the previous season.

This is the formulated sequence established to practise principled crop rotation. The programme can be designed for a two-year, three-year, or four-year period, depending on the amount of hectarage available at the farmer's disposal.

The farmer can have several fields or sub-divide his or her field into several plots corresponding to the rotation programme a farmer settles on.

(a) Two-year rotation programme

First year	-	Maize
Second year	-	Peas or Beans

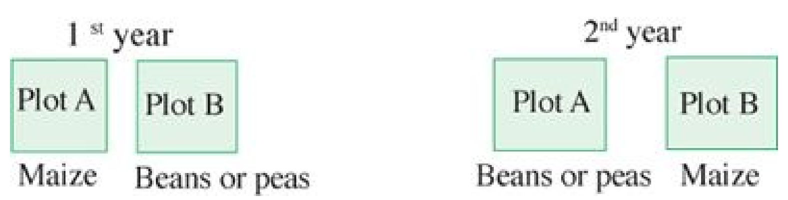


Fig. 6.1: Two-year rotation progtamme .

(b) Three-year Rotation programme

First-year	-	Tomato
Second year	-	Sorghum
Third year	-	Beans or peas

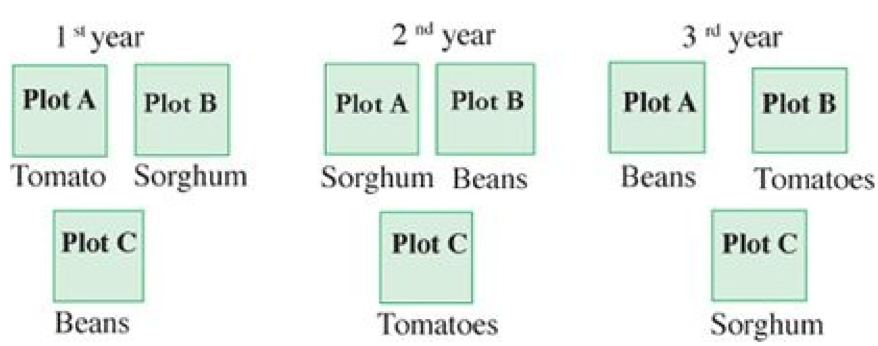


Fig. 6.2: Three-year rotation programme .

> ***Note:*** It is recommended that at the end of rotational programme, the land should be under fallow period.

(c) Four-year Rotation programme

First year	-	Cotton
Second year	-	Maize
Third year	-	Beans
Fourth year	-	Cabbage

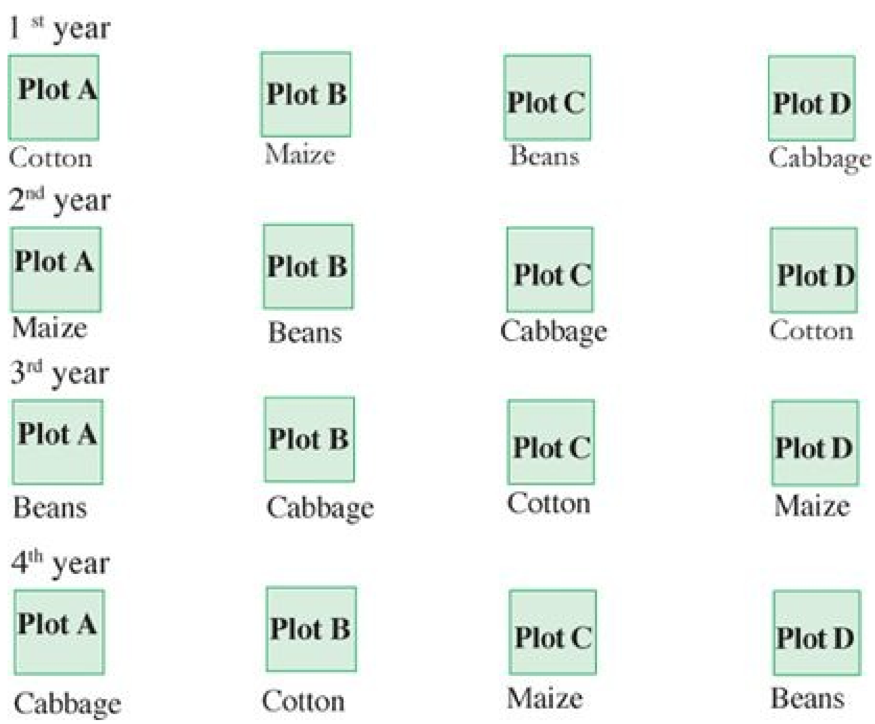


Fig. 6.3: Four year rotation programme .

Principles of crop rotation

The following factors must be considered for any crop rotation programme:

- Gross feeders should be planted early in the rotation programme. Gross feeders are plants which require a lot of nutrients from the soil. Crops with a smaller nutrient demand should then follow.
- Cover crops, for example, sweet potatoes, should be alternated with crops with unitary stem that is, vertical crops like the cereals. Cover crops help to

minimise surface run-off.

- Deep-rooted crops should be alternated with shallow-rooted crops to encourage uniform utilization of nutrients at different soil depths.
- Crops with similar;
  - nutrient demands,
  - growth characteristics,
  - disease, pest and weed attacks, should not follow each other in the rotation.
- Pasture leys (established grass fields) or bush fallows should be encouraged in the rotation. Fallow land rebuilds the soil structure and reduces soil erosion.
- Alternate legumes such as beans, peas, groundnuts with other crops so as to enrich the soil with nitrates.
- Crops which are easy to weed should alternate with crops which are difficult to weed. Under this arrangement, grass weeds which tend to build up under the later type of crops will be removed. Alternate crops associated with different weed types.
- Select the crop sequences which produce the highest yields first and allow for easy control of weeds, pests and diseases.
- Select crops that will provide for good labour utilisation throughout the farming period.

Importance of crop rotation

Crop rotation has the following advantages:

- *Helps control build up of soil-borne pests and diseases:* Crops of the same family are usually prone to similar disease infection and pest attack. So when such crops are grown in succession in the same field, they tend to encourage build up of pests and diseases. Good crop rotation practice helps break up the life cycle of such crop pests and diseases. For example, nematodes which attack crops of solanaceae family can be controlled by crop rotation.
- *Maintenance of soil fertility:* Leguminous crops such as beans have the ability to fix free nitrogen into nitrates which is made available for use by other crops. Therefore, inclusion of legumes in rotational programme improves and sustains soil fertility.
- *Soil conservation:* Alternation of vertical growing crops such as maize and coffee, with cover crops such as beans and groundnuts ensures that the empty spaces previously left bare are covered. This minimizes soil run-off. Also, during the fallow period (ley phase), the soil is protected from agents of

erosion.

- *Effective maximum utilisation of nutrients:* Crops vary in their nutrient requirements and feeding levels. Certain nutrients are absorbed in relatively large quantities by particular crops. For example, cereal crops absorb large amounts of nitrogen from the soil but less amounts of phosphorus and potassium. On the other hand, tubers heavily use phosphorus and potassium. Alternating such crops ensures that there is equitable utilization of the nutrients or minerals available in the soil. Rotating deep-rooted crops with shallow-rooted crops, facilitates use of soil nutrients at all levels of soil layers accessible to plants.
- *Evens out labour requirements:* Good crop rotation evens out labour requirements over the year.
- *Rotations spread financial risks over several crops:* It is an insurance against failure of one crop especially if it is practised under mixed cropping.
- *It aids in weed control:* There are certain weeds which are associated with particular crops. For example, parasitic weeds like *Striga spp* (witch weed) which are specific to cereal crops, for example, maize, can be easily controlled by rotating cereals with non-cereal crops.
- *Improvement of soil structure:* During fallow period (ley phase) the soil particles coalesce as there is no soil disturbance. Also, growing of grasses and certain trees with extensive root system binds the soil particles together, hence improving the soil structure.

2. Monocropping

This is the establishment of a pure stand of one crop in a field, for example, maize, beans, tea, coffee and wheat. The farmer grows only one type of crop on the same piece of land throughout the farming seasons.

Fig. 6.4: Pure stand of bean crop plantation .

Advantages

- Operations like weeding, disease and pest control and harvesting are easily done.
- It is easy to mechanise field operations.
- There is optimum utilisation of applied fertilizer and manure as a result of correct plant population establishment.

Disadvantages

- Continuous growing of one crop may lead to depletion of a particular nutrient resulting in low crop yields.
- It encourages build up of pests and diseases.
- It is difficult to control parasitic weeds on the crop for example, *Striga spp* in maize crop.
- There is total loss in case of crop failure.
- There may be little profit realization in case of the crop price reduction in the market.
- Lack of soil cover encourages erosion particularly when crops that grow upwards are planted continuously.

3. Intercropping

This is the growing of two or three crops in association, for example, maize, beans, fingermillet. All the crops are grown on the same piece of land. Intercropping also means interplanting.

Examples of intercropping.

- Finger millet and maize.
- Finger millet and sorghum.
- Simsim and fingermillet.
- Maize and groundnuts or sorghum.
- Banana with coffee.
- Maize with bean.
- Sorghum with cowpeas.

Fig. 6.5: Intercropping of cassava with kales .

Advantages

- High crop yields per unit area.
- It provides ample soil cover especially when cereals are interplanted with legumes. This minimises soil erosion.
- There is no total loss in case of outbreak of pests and diseases. It is an insurance against total loss.
- There is supplementation of nutrients in the soil when legumes are included. For example, legumes supply nitrates which cereal crops require.
- Some act as nurse crops, for example, maize nurses the beans.
- There is maximum utilisation of the soil nutrients when deep-rooted and shallow-rooted crops are interplanted.

Disadvantages

- Field practices such as weeding and pest and disease control become difficult.

- It is not possible to mechanise the field operations like spraying against pests and diseases.
- There is wastage of fertilizer applied due to less plant population since crops planted do not respond to some applications and require different fertilizer treatment.
- It is not possible to use herbicides in weeding since they can kill some of the desired crops.

4. Mixed cropping

This is the growing of different crops in different plots on the same farm at the same time for example, mixing annual crops with perennial crops on the same farm. The crops may be grown in successive strips. For example, on a slopy land, plant sweet potatoes uphill, followed by a strip of bananas, and then maize.

Fig.6.6: Spinach, onion, maize and kales grown in separate sections of same farm .

Advantages

- There is diversification of crop production.
- It helps in control of pests and diseases since some crops will act as barriers, or ‘trap crops’, against the pests and diseases. For example, sorghum can be used as a ‘trap crop’ in maize fields to keep birds off.
- Some crops act as cover crops and are effective in reducing soil erosion. This enhances soil and water conservation.
- Inclusion of legumes adds nitrogen into the soil.
- It acts as insurance against total failure. It spreads the risks of total loss due to specificity of certain diseases and pests.

- It spreads the harvesting. This is important where certain crops do not have good storage and where late and early maturing crop varieties are used.
- Planting crops of different rooting systems leads to maximum soil utilisation.

Disadvantages

- Land could be a limiting factor, that is, large scale production may not be possible for the various enterprises/crops.
- Lack of specialisation.
- High labour requirements.

5. Continous cropping

It is the system of planning crops on a piece of land continuously without allowing the land to rest (fallowing). It can be one crop grown on more than one crop grown on the same piece of land without alternating.

Advantages

- Farmers specializes on arable farming only.
- Reduces cost in land preparation.

Disadvantages

- High build up of pests and diseases.
- Loss of soil fertility, hence low crop yields.
- Destruction of soil structure which may encourage soil erosion.

6. Bush fallowing

This is a system of farming whereby farmers clear land to cultivate and grow crops continuously until the fertility goes down. Then the piece of land is left to regenerate bush and regain the lost fertility. The farmer can again return to bush clearing and cultivating the land again.

Advantages

- Land is left to regain fertility hence increased crop yields.
- Soil erosion is minimized since the land is left under fallow for sometimes.

Disadvantages

- Low crop yields.
- Encourages buildup of pests and diseases.
- Impracticable where land is limited.

7. Shifting cultivation

This is a system of farming which involves clearing of forested area, cultivating it continuously until the soil fertility goes down then abandoning it. The farmer then shifts to another area with no intention of coming back to that piece of land.

Advantages

- Reduced soil erosion.
- No build up of pest and diseases.
- Low capital investment.

Disadvantages

- Low yields.
- Not possible in high population areas.

Agroforestry

Agroforestry is a land use appproach that takes the agronomic component, trees, shrubs and livestock into consideration.

Agroforestry refers to land use systems and practices in which woody perennial trees are deliberately grown on the same piece of land as crops and/or animals.

Forms of agroforestry

a) Agrosilviculture

The word *'agro'* refers to crops while *silviculture* is the science of growing trees and shrubs. Hence, agrosilviculture is the growing of a combination of trees, shrubs and crops in agricultural production. It may be practised by planting rows of crops such as legumes intercropped with maize and rows of shrubs like *Calliandra, Leucaena or Sesbania sesban* which run in an east to west direction to facilitate sunning.

For instance, the shrubs should be spaced 270 cm × 60 cm to allow three rows of maize crops in between its rows. The trees and shrubs grown must bear some of the following desirable qualities:

- They should be able to enrich the soil with nutrients.
- Have the ability to create suitable micro-climates for crop production.
- Be deep rooted.
- Exhibit fast growth.

b) Silvopastoral

This is a form of agroforestry which incorporates trees or shrubs in animal pasture. The name silvopastoral is derived from *"silviculture"* which refers to the science of growing trees and shrubs, and *"pastoral"* meaning animal rearing. It involves establishing the trees and shrubs at a wide spacing of about 8-20 metres between the rows. The spacing facilitates maximum availability of light to the pasture for proper growth.

The trees grow unchecked. Examples of trees grown under silvopastoral include:

- Fruit trees such as pears which grow in high altitudes; mangoes and avocados which grow in medium altitudes and cashew nuts and coconuts in low altitudes.
- Trees for wood and timber production, for example, *Acacia spp, Markhamia spp* and whistling pine *(Casuarina equisetifolia)* .

Fig. 6.7: Silvopastoral .

c) Agrosilvopastoral

This refers to incorporating trees or shrubs with animal pasture and crops. The trees or shrubs are established at a wide spacing and pruning is carried out on the trees regularly. Crops or pasture crops are grown in between the tree rows. Suitable tree species for this form of agro-forestry are *Calliandra* , acacia and whistling pine.

Importance of agroforestry

i) Source of income

Products of trees and shrubs such as fruits, poles, timber and fodder can be sold to earn money. Fodder crops such as *Calliandra* are suitable substitutes for dairy meal thus saving money.

ii) Source of wood fuel

Wood fuel is becoming very scarce in most parts of the country and fast growing shrubs and trees are a good source of wood fuel. This will minimise cutting down of natural trees thus conserving the environment.

iii) Environmental benefit

Trees help protect the soil against erosion by wind. They also minimise the effects of surface run off and splash erosion and improve percolation and infiltration of water into soil. This increases water reservoirs in water catchment areas. Trees also have an aesthetic value on the landscape, especially in the homestead.

iv) Labour saving

Growing of wood fuel trees on the farm especially in rural areas where people depend on wood fuel as their main source of energy will save people a lot of time spent walking long distances collecting firewood. The available saved time can be used on other productive activities.

Practical Activity 6.1

1. Visit the school farm and identify the cropping systems used in the farm.
2. Carry out a two-year rotation programme using maize and beans in the school farm and make observations.
3. Visit neighbouring farms to the school and identify the various cropping systems which can promote higher crop yields in Malawi.

Revision Exercise 6

1. What is crop rotation?
2. Outline the principles of crop rotation.
3. State the importance of crop rotation.
4. Define the following terms:
   (a) Monocropping.
   (b) Continuous cropping.
   (c) Mixed cropping.
5. What is the difference between bush fallowing and shifting cultivation?

6. (a) What is intercropping?

   (b) State advantages of intercropping.

7. Explain the various field management practices that may assist a farmer to control pests and diseases.

Unit 7 Fruit Production

Objectives

By the end of this unit, you should be able to:

(a) Discuss the importance of fruits .

(b) Select suitable site for mango production .

(c) Identify a suitable mango variety .

(d) Prepare the site and plant mango trees .

(e) Mulch around the planting station .

(f) Weed the mango field .

Importance of fruits

'Pomology' is the art and science of growing fruits. A fruit is a developed ovary of a flower which may be seedless or with seeds. Fruit growing is the cultivation of edible fruits either raw or processed. Fruits are important since they can be grown for a variety of reasons.

(a) Economic importance

Fruits are exported to other countries to earn foreign exchange. The foreign exchange can then be used by the country to buy other products for example, petroleum products and machinery.

(b) Socio-economic importance

Fruits provide raw materials for the production of juices. After extraction of juice, the by-product can be utilised as a source of manure and livestock feeds.

The fruit trees can also be used as a source of fuel, fencing, construction of houses, to provide shade and for aesthetic value.

(c) Nutritional importance

Fruits are important sources of nutrients such as vitamins, proteins and minerals. For example, citrus and oranges are important sources of vitamins A and C.

Site selection for mango production

The area or site chosen for mango production is very important since the site determines the quality and quantity of the crop.

Select a good site for mango production. The good site should be:

- Well drained area – The field to be used for mango production should be free of waterlogging. It should be of low water table.
- Fertile soils – The land selected for mango production should be fertile.
- Soil depth – For better yields, the soil should be deep to allow extensive roots development.
- Salinity – The crop has low tolerance to salts.
- Slopes facing sunshine – Grown on east-west slopes. The crop does well in open sunshine. It is sensitive to cold.

Mangoes

Mango varieties

Kent

It is a vigorous grower, has compact growth habit and an upright canopy (over 30ft). Its fruit weighs 20 – 26 ounces and they are oval shaped with a rich sweet flavour. They usually turn greenish-yellow colour with red bluish colour as they mature.

Erwin

Its fruit has a fragrance and no fibres. The tree grows to a height of 15 – 20 feet, with long dark green leaves.
Flowers are one foot long and have purple panicles. Its fruits are oval shaped, orange to pink in colour with a dark red blush.
They are susceptible to anthracnose, bacterial black spot and stem end rot.

Tommy Atkins

Has a long shelf life. It is tolerant to handling and transportation with little or no bruising or degradation. The colour of the fruit is purplish and they are good for processing.

Zill

Has poor storage characteristics. Its fruits are oval in shape, has rounded base and rounded apex. Have thin skin which is yellow with dark red bush. The fruits flesh is yellow, fibreless, have a sweet smell and strong aroma.

The trees grow vigorously nd develop large spreading canopy.

Keitt

They lack fibre and are poor producers. They are also larger than other varieties. Trees grow vigorously but do not reach heights over 20 feet. The fruits are oval in shape and have rounded apex, the skin colour is green with light red blush. The flesh is sweet with no fibre. This variety is disease resistant.

Anderson

It is large in size. It is also long and slender containing a small lateral beak. Its skin is thick and has a green to yellow colour with some crimson bluish.

Self Assessment

1. Discuss the advantages and disadvantages of indigeneous mangoes of Malawi such as *Boloma dodo* .
2. Explain why indigeneous mangoes are disliked at international fresh fruit markets.

Site preparation to plant mango trees

(i) Clearing the land

Seedling of the mango are raised in the nursery. Land is cleared of big trees by use of axes and machete.

Nurseries are sited on light warm soils. Seedbed is ploughed early to allow enough time for the soil to weather and the organic matter to die.

Second ploughing is done to kill perennial weeds.

(ii) Digging of holes

Large holes are prepared of 60 cm – 90 cm in square since mangoes have a large taproot.

The spacing is 10 m × 12 m or 12 m × 12 m.

(iii) Applying manures

Top soil is mixed with 20 kg of farmyard manure 60 g of double superphosphate or 120 g.

(iv) Applying nitrogen fertilisers

It is applied when the roots are established, done 3 – 6 months after transplanting.

In the 1st year, apply 100 g of calcium ammonium nitrate in two split applications.

In the 2nd year, apply 200 g of calcium ammonium nitrate

In the 3rd year, apply 300 g of calcium ammonium nitrate.

Thereafter, apply double nitrogen that is 400 g of calcium ammonium nitrate per tree per annum in two split application.
Excess fertilisers are not recommended because they injure the plants, that is there will be too much roots at the expense of fruits.

Planting mangoes

Seedlings are raised in the nursery. Seeds are obtained from healthy and mature trees. Seeds are planted immediately due to low viability.
The husk is removed for the seed to germinate easily.

It is planted with the plumule facing upwards. They germinate in 2 – 4 weeks. When they are 10 cm in height then they are transplanted to the polythene sleeves or baskets, if left for too long, they will develop a tap root hence a polythene sheet or sheet of iron is placed underground.
They are ready for transplanting to the main field between 6 – 12 months. Those meant for budding are ready when pencil thick. They are planted at the same depth as they were in the nursery and the roots are not disturbed. Holes are filled, firmed and a basin is made around the seedling.

Mangoes are planted at the start of the rains or if the rains are absent, irrigation is done.

Mulching of mango seedlings

Mulching is the application of dead organic material on the soil like dry grass, polythene material to provide a soil cover around the plants and between the rows. The mulching material should not come in contact with the fruit tree. A perenial groundnut is best when used.

Purpose of mulching

- It prevents soil erosion by erosive agents like water or wind.
- Reduces the soil temperature, hence the rate of water evaporation will be minimised.
- Mulching smoothers out the weeds.

- If the mulch is of plant origin, they decompose to add plant nutrients thus improving soil fertility.
- They also improve the soil structure by acting as cementing agent of the soil particles.
- It conserves the soil moisture hence the available moisture in the soil will be utilised by the crop plants.
- Mulch material improves the water infiltration by reducing the speed of runoff.

How to mulch

When the desired crop will have been planted following the recommended spacing, mulch material is spread between the spaces of the crop. The material to use vary from dry grass to inorganic materials like black polythene papers. These materials should never come in contact with the crop.

Practical Activity 7.1

1. Visit a plantation of mangoes and
   (a) make observation on how mangoes have been mulched.
   (b) write down the observations made.
2. Working in groups of five members practice the mulching practices, by mulching the crops in the farm.

Weeding mango fields

Weeding is essential when mango trees are young. The tree should be kept clean within 3 m radius spacing. The other space can be used for planting other crops like beans, maize and cassava.

In mature plantations, the weeds are slashed or grazed by livestock.

During weed control, care should be taken to avoid damaging the tree roots. Do not heap dried weeds around the fruit tree stems.

Methods used to control weeds

- Intercropping.
- Slashing.
- Mulching.
- Cover cropping.

- Cultivation.
- Use of herbicides.

Weeds can cause considerable loss to crop yields therefore there is need to take necessary weed control measures. Weeding is one method of controlling weeds in a mango field.
Weeding is essential when a mango tree is young. The tree should be kept clean within a 3 m radius.
In old plantations, the weeds are either slashed or grazed by livestock.
Weeding can be done using any or a combination of the following methods.

  - Slashing or mowing.
  - Cultivation or tillage.
  - Uprooting.

Farm implements that can be used include hoes and machetes.
Care should be taken not to damage tree roots.

Pests and disease of mangoes

Crop pests and diseases are of great concern to the farmers because of the damage they cause to crops. A plant pest can be defined as any living organism that destroys crops either directly or indirectly by producing pathogenic effects. The pests that attack mangoes include:

- Mango weevil.
- Thrips.
- Mango scales.
- Mango fruit fly.

Disease of mangoes refer to any harmful physiological disorder in a mango plant caused by pathogenic effects.
Diseases of mangoes include:

- Anthracnose *(Collectortridium gloesporioides)* .
- Powdery mildew *(Oidium mangiferae)* .

Pests and disease control

Control of pests and diseases in mangoes is important. This ensures a higher quality and quantity of the fruit yields.

Pests of mangoes include:

(i) Mango weevil *(Sternochetus mangiferae)*

Nature of damage

The larva stage of mango weevil enters the fruit and attack the seed and eat up the seed. Point of entry is not visible, the path of the larvae entry is hardened. They cause premature fall of the fruits or rotting in store.

Control

Proper disposal of the fallen fruits like picking them and burying or burning them hence the larva will not mature.

(ii) Thrips

Nature of damage

Suck the sap from all tender parts making them to go rusty and they leave black shiny excreta on the leaf. They reduce the photosynthetic area leading to wilting.

Control

Spray with appropriate chemicals.

(iii) Mango scales

They are small, white, flat and elongated insects.

Nature of damage

They attack all tender parts, scales excrete sugary substances which is a host for sooty moulds. Due to sucking of the sap, the leaf wilts thus reducing the photosynthetic area.

Control

Frequent spraying by use of malathion or any other appropriate insecticides.

(iv) Mango fruit fly *(Ceratitis cosyra)*

They are white maggots which grow up to 1 cm long.

Nature of damage

Eat the flesh of the fruit causing premature colouring of the fruit.

Control

Pick fallen fruit and bury or burn them.

Spray appropriate insecticides.
Diseases of mangoes include:

(i) Anthracnose *(Collectotridum gloeosporioides)*

Symptoms

Black round spots on the leaves, fruits petioles and twigs.

Nature of damage

Fruits are bitter and sugarless.
Reduction in photosynthetic area.

Control

Spray copper fungicides every fortnight.

(ii) Powdery mildew *(Oidium mangiferae)*

Symptoms

Whitish powder on the tender or actively growing parts, which eventually reduce the final yields because of the reduction of the photosynthetic area.

Control

Spray fungicides like kerathane every fortnight.

Practical Activity 7.2

1. Visit the school garden, observe and identify mango pests and diseases.
2. Working in groups identify the mango varieties at the school farm.

Revision Exercise 7

1. List three varieties of mango trees.
2. State the importance of fruit production.
3. Explain factors to consider when selecting the site for mango production.
4. State the purposes of mulching mango seedlings.
5. Give three importance of weeding a mango field.
6. (a) List the pests of mangoes.
   (b) List the common diseases of mangoes.

Topic 3: Animal Production

Unit 8 : Livestock Feeds and Feeding

Unit 9 : Livestock Management and Production Systems

Unit 8

Objectives

By the end of this unit, you should be able to:

(a) Distinguish classes of livestock feeds .

(b) List feed nutrients and explain the functions of feed nutrients .

(c) Identify sources of feed nutrients .

(d) Explain the importance of feeding animals .

(e) Outline factors to consider when feeding animals .

(f) List breeds of sheep and goats .

Introduction

Two main factors tend to influence animal productivity:

• The genetic potential of the animal.

• The animal environment for example, climate, feeding and management.

The genetic potential of animals is influenced by the type of breed. However, the environment modifies these genetic factors.

Feeding plays an important role in the productivity of an animal as it involves the provision of nutrition to livestock.

Nutrition refers to the provision of food nutrients required by animals for proper body functioning.

Livestock feeds

Animal foods are termed as **feeds** **.** A feed is a mixture of several feedstuffs that will supply the required nutrients to animals. Feedstuff is food material containing one or more nutrients.

Classification of feedstuffs

The feedstuffs are classified on the basis of their nutritional status or on their bulkiness.

Feedstuffs are classified as:

- Roughages.
- Succulents.
- Concentrates.

Practical Activity 8.1

1. Observe the samples of livestock feed provided by your teacher.
2. Classify the feed.

1. Roughages

These are feedstuffs which have a high crude fibre content. They contain over 20% crude fibre in their dry matter. They are low in digestibility and therefore form the bulk of the ruminant diet. Ruminants are able to digest roughages by use of micro-organisms present in their rumen.

There are two types of roughages:

- Green or succulent roughages.
- Dry roughages.

(a) Succulent roughages

General characteristics of succulent roughages

- They are bulky, with a high mass matter per unit.
- They have a high moisture content (20% - 50%) with low dry matter content.
- They have a reasonably high crude fibre content.
- They are rich in carbohydrates and low in proteins.
- They contain carotene, which is rich in vitamin A.
- Their nutritional value is determined by the forage type and stage of maturity at the time of feeding.

Types of succulent roughage

(i) *Young pasture grass:* These form the main diet for livestock for example, kikuyu grass, star grass.

(ii) *Fodder crops:* These are forages that are harvested and fed to livestock or are preserved as silage or hay. They include napier grass, maize stalk, guatemala grass, sorghum and sudan grass.

(iii) *Pasture legumes:* These are rich in proteins and minerals. Examples are lucerne, *Desmodium spp, Glycine spp* .

(iv) *Browsing trees and shrubs:* They are mainly found in semi-arid areas and are good feeds for sheep and goats for example, Acacia.

(v) *Brassica vegetables (cabbages, kale):* Kale is widely used as livestock feed and is rich in vitamins and minerals.

Other succulent roughages are sweet potatoes vines, turnips, and russian comfrey.

(b) Dry or coarse roughages

These are plant feeds which contain very little moisture (less than 20%) and are low in feed value. They are, however, good for bulkiness. They include hay, straws and stovers, chaff, oats. They are prepared from grasses, legumes and other crop residues as hay.

Hay is a good source of vitamin A and D. The greener the hay the more the vitamin A it contains. Stover refers to the after–harvest of maize while, straws refers to after–harvest of crops like oats, wheat, barley.

Dry roughages are very fibrous, have low energy value and are used to provide bulk feeding in animals.

2. Succulents

These include roots and tuber crops, banana trunks and leaves.

General characteristics of succulents:

- They have a high moisture content of 75–90%.
- They are low in crude fibre that is, 5–10%.
- They are low in proteins.
- They are low in minerals except potassium.
- They stimulate the appetite and hence increase dry matter intake.
- They act as mild laxatives during the dry seasons when the coarse roughages cause digestive problems.

3. Concentrates

These are feeds whose dry matter is high in carbohydrates and proteins and are low in crude fibre. They supplement grazing in ruminants.

There are two types of concentrates:

- Carbohydrate (energy) concentrates.
- Protein concentrates.

(a) Carbohydrate concentrates

They are also referred to as energy concentrates since they are rich in energy. Sources of carbohydrate concentrates include:

- *Cereal grains;* for example, maize, wheat, oats, barley and sorghum.
- *Processed cereals;* such as wheat bran, maize bran and barley bran which are rich in phosphorus but low in calcium.
- *Molasses;* these are rich in energy and are good supplements for other feeds.
- *Brewer's by-products* .

(b) Protein concentrates

These have a high protein content in their dry matter.

Sources of protein concentrates include:

Legumes and oil seeds; these are rich in protein content. Examples are sunflower, beans, peas or cowpeas.

Legumes and oil seed cakes (meals); these are from plants such as palm oil, sunflower, coconut, groundnut and cotton. They are by-products following the extraction of oil from legumes and seed, and are used to make meals.

Non-protein nitrogen source; an example is urea which is produced synthetically as an animal feed. It is an important protein feed for ruminants.

Animal by-products; these are highly digestible, rich in proteins and highly palatable. These include by-products of milk and meat. Examples are, bone meal, meat meal, blood meal, fish meal and liver meal.

Whole milk and milk products; whole milk is balanced feed for the young. Whey and skim milk are also used.

Other animal feeds include:

Mineral and vitamin supplements; these are minerals or vitamins added to livestock feeds for example, mineral licks such as Macklic salt.

Feed additives; these consist of hormones and antibiotics incorporated in commercial feed but it is not feed. They are used to promote growth and disease resistance as well as to improve feeding efficiency in animals. Examples are coccidiostats used against coccidiosis and stilboestrol used in beef animals to increase meat and muscle.

Feed nutrients

The main functions of food is to provide energy to maintain and keep the animals warm, promote body building and for repair of worn-out tissues so as to keep animals healthy for production.

The feed given to livestock should provide the following nutrients:

- Water.
- Carbohydrates.
- Fats and oils (lipids).
- Proteins.
- Vitamins.
- Minerals.

Functions of feed nutrients

1. Water

Water is the most abundant constituent of an animal's body tissues. About 50–80% of animal body is composed of water depending on the age of the animal. The newly born animals have about 75–80% water in their body. A mature animal has 55–65% water.

Food taken in by animals contains a considerable percentage of water, for example, succulent feed has 90% water.

Water performs various functions, namely:

- It helps in transportation of food nutrients within the body.
- It acts as a medium for many body functions for example, digestion.
- It acts as a solvent for various substances.
- It helps in the regulation of body temperature.
- It is an essential component in most body fluids, for example, blood and digestive juices.
- It makes cells turgid thus maintaining the shape of the body.
- It lubricates the body joints.

Sources of water for animals

(a) Free water; water taken in directly that is, through drinking.

(b) Bound water; water contained in feeds.

(c) Metabolic water; water produced through metabolic activity.

Factors influencing water requirements of an animal

(a) *Biological factors:* These are factors within the body of the animal. They include:

- *Animal species* for example, cattle, sheep and goats. Goats take less quantity of water than cattle.
- *The animal breed:* exotic animals consume larger quantities of water than indigenous cattle.
- *Age of an animal* that is, mature animals take more water than younger ones.
- *Physiological status of the animal* for example, pregnancy, sickness and lactating animals. Animals require relatively small quantities of water when sick but take in large amounts during gestation period.

(b) Environmental factors

- *Temperature;* animals consume more water when environmental temperatures are high.
- *Humidity;* animals take in less water when humidity is high.

(c) Type of diet

Dry or succulent types of feed influence the amount of water animals consume. Animals need more water when they are fed on dry feed than on succulent feed.

Water requirement for various livestock

Type of livestock	**Daily amount of water required**
1. Working ox	32 litres
2. Lactating cow	32 +14 litres per every litre of milk produced.
3. Goats and sheep	5–10 litres
4. Lactating sow	23 litres

Table 8.1: Water requirement for various livestock .

Effects of inadequate water to animals

- Low metabolic rate.

• Low productivity.

• Loss in body weight.

Under normal conditions, an animal takes an average amount of water. Too much water tends to reduce the amount of dry matter consumed.

2. Carbohydrates

Carbohydrates contain carbon, hydrogen and oxygen. Carbohydrates are high in energy reserves. Carbohydrates can be divided into two groups namely:

• Sugars: Sweet tasting carbohydrates, for example, glucose, fructose and sucrose.

• Non-sugars: These are tasteless compounds of carbohydrates for example, cellulose.

Classification	Name	Source
Monosaccharides or simple sugars Formula: ($C_6 H_{12} O_6$)	Glucose	Sweet maize, ripe fruits.
	Fructose	Mainly found in fruits.
	Galactose	Found with glucose upon breakdown of milk sugar.
Disaccharides (double sugars), Formula: ($C_{12} H_{22} O_{11}$)	Lactose	Milk.
	Sucrose	Sugarcane and beet roots.
	Maltose	Found in the germinating seeds.
Polysaccharides (complex sugars). Formula: [$(C_6 H_{10} O_5)_n$]	Starch	Grains, tubers, roots.
	Glycogen (animal starch)	Found in liver and small quantities in muscles
	Cellulose	Found in cell walls of fibrous feeds

Table 8.2: Sources of carbohydrates .

Carbohydrates form the largest quantity of food that animals consume. They contain 50–75% dry matter. Animal carbohydrates have less quantity of dry matter than plant carbohydrates. Carbohydrates in animals may be stored in the liver in form of glycogen. These carbohydrates are oxidised to release energy.

Sources of carbohydrates

- Cereals, for example, wheat bran and maize bran.
- Root crops such as sweet potatoes and cassava.
- Tuber crops for example, Irish potatoes, edible cana.
- Molasses.
- Normal grass.

Functions

- Provide animals with energy for their daily requirements.
- Excess carbohydrates are converted to fats and stored as energy reserves within the body.

3. Fats and oils (lipids)

They are related to carbohydrates because they contain carbon, hydrogen and oxygen. However, the carbon to hydrogen to oxygen ratio is higher than in carbohydrates.

Functions

1. They are essential constituents of body cells.
2. They serve as condensed energy reserves. Fats provide two times more energy than carbohydrates.
3. Excess fat stored in the body acts as insulating layer in animal's body and prevents loss of heat.
4. They are carriers of fat soluble vitamins A, D, E and K.
5. Fats are oxidised to release metabolic water for example, in camels.

Sources of fats and oils (lipids)

They are mainly derived from the animal products such as:

- Milk.
- Meat meals.
- Liver meals.
- Fish meals.

Fats are found in plant food such as:

- Groundnuts.
- Cotton seed.
- Sunflower seed.

Excess carbohydrates are converted and stored as fats.

4. Proteins

Proteins are complex substances made up of chemical units called *amino acids* . They differ from carbohydrates because of the addition of the element nitrogen, sulphur, and sometimes, phosphorus. There are two types of amino acids: *Essential amino acids and Non-essential amino acids* . There are about 20 amino acids found in proteins.

Animal proteins are of the highest quality because they contain most of these amino acids. Essential amino acids are those required by the animals but cannot be synthesised by their bodies, while non-essential amino acids are those that can be synthesized in the body and therefore need not be supplied in the diet.

Protein requirements by ruminants and non-ruminants

Mature ruminants are able to synthesise most of the essential amino acids in their rumen with the help of micro-organisms. The micro-organisms use simple nitrate compounds obtained from the forage and convert them to amino acids. Young ruminants require high quality proteins because their rumens are still not well developed.

Non-ruminants should be supplied with high quality protein feed because they are unable to synthesize amino acids. Deficiencies of protein can occur when the animals are not fed with enough protein feed.

Functions

- Building of animal body tissues.
- Repair and replacement of worn out body tissues.
- Provide body resistance to diseases through synthesis of antibodies.
- For synthesis of hormones and certain enzymes.
- Can be metabolised to give out energy.

Sources

- Forage such as young growing grass, pasture legumes, silage, and leguminous hay, for example, desmodium and lucerne.
- Concentrates of:
  (a) *Plant origin* - For example, cotton seed cake, soya bean cake.
  (b) *Animal origin* - For example, milk, meat meal, fish meal, liver meal, blood meal.

Effects of protein deficiency

- Retarded growth.
- Lowered productivity.
- Lowered reproductivity due to reduced animal vigour.
- Lowered resistance to diseases and infections.

5. Vitamins

These are organic compounds which regulate various body processes for healthy growth and reproduction.

There are 15 vitamins considered essential in animal nutrition. These are classified according to their solubility as:

(a) *Fat soluble vitamins* - For example, Vitamins A, D, E, and K. These vitamins can easily be stored in the body.

(b) *Water soluble vitamins* - For example, Vitamin B complex and Vitamin C.

Most livestock feeds contain the vitamins required by animals. Some vitamins are synthesised in the animal's body for example, vitamin K and vitamin B complex are synthesized by ruminant animals in their rumen. Vitamin C is synthesized in the body tissues of most animals under normal conditions, while vitamin D is synthesized in the animal skin when exposed to the sun.

Functions of vitamins

- They act as co-enzymes (organic catalysts) in body reactions.
- They promote healthy growth.
- They prevent diseases in animals.
- They help in bone formation for example, vitamin D.
- Vitamin K helps in clotting of blood.
- They help in muscular activity.
- Vitamin A helps improve eye vision.

(a) Fat soluble vitamins

Vitamin A *(Retinol)*

This can be synthesised from carotene in the intestines or liver of livestock. Vitamin A or carotene can also be obtained from:

- Green forages.

- Carrots.
- Tomatoes and some fruits.
- Yellow maize.
- Good hay and silage.
- Milk (colostrum).
- Liver oils.

Functions of Vitamin A

- It is essential for the maintenance of healthy epithelial cells which are involved in general growth and disease resistance.
- It is important for clear vision.
- It protects mucous membranes and the structure of developing bones.

Deficiency symptoms

- Night blindness; there is poor vision especially under dim light.
- Keratitis (inflammation of cornea); this is characterised by excessive watering, softening and clouding of cornea, drying of conjuctiva and ultimately the opacity of the cornea. Total blindness occurs in severe cases.
- Retarded growth in animals.
- Rough coats and dry scaly skins.
- Low disease resistance.
- Deformity of the bones and general lack of co-ordination in animals.
- In breeding animals, infertility, abortion, calving of dead, weak or blind calves may occur.

Control of deficiencies

Provide adequate green feeds or supplementary vitamin A.

Vitamin D

Vitamin D can be synthesised in the presence of sunlight.

Sources of vitamin D

- Egg-yolk.
- Milk (colostrum).
- Cod liver oil.
- Green grass.

Functions

- It promotes the absorption of calcium in the alimentary canal.
- It is involved in calcium - phosphorus metabolism and depositio in bones and teeth.

Vitamin E *(Tocopherol)*

Sources of vitamin E

- Green leafy forages.
- Good green hay.
- Cereal grains.
- Oil seed.

Function
It is an anti-sterility vitamin that is, it enhances reproduction in animals.

Vitamin K

Sources of vitamin K

- Green forages, particularly lucerne, kale, cabbages.
- Good hay.
- Cereal grains.
- Fish meal.
- Egg-yolk.

Vitamin K can be synthesised in the rumen of animals.

Functions
It helps in clotting of blood.

Deficiency
Its deficiency results in excessive bleeding, even in light cuts. Vitamin K deficiency is common in chicken.

(b) Water soluble vitamins

Vitamin C *(Ascorbic acid)*

It can be synthesised in certain tissues of some farm animals hence it is not critical in animal nutrition.

Sources of vitamin C
It is found in fresh fruits for example, citrus and in green leafy vegetables.

Functions

• It is important for connective tissues (collagen) in the bone.

• It increases resistance to disease in animals.

Vitamin B complex

It is composed of various groups. Most of them play the role of co-enzymes in various body processes. It can be synthesised in the rumen of ruminants. However, it should be supplied to non-ruminants and to young ruminants which still have undeveloped rumens.

(a) Vitamin B_1 (Thiamine)

It is a co-enzyme involved in carbohydrate metabolism.

Sources of vitamin B_1

• Brewer's yeast (a rich source).

• Cereal grains.

• Legumes.

• Green forages.

• Hay.

• Milk.

• Egg-yolk.

Deficiency symptoms

It results in muscular weakness, nervous disorders and paralysis, especially in pigs and chicken.

(b) Vitamin B_2 (Riboflavin)

It acts as a co-enzyme in protein and carbohydrate metabolism.

Sources of vitamin

• Green forages.

• Hay.

• Yeast.

• Skimmed.

• Milk.

• Liver.

Deficiency symptoms

Deficiency is characterised by poor growth and nervous disorders. In chicken, there is 'curled toe paralysis' whereby the toes tend to curl inward and the chicks walk on hocks.

(c) Vitamin B $_{12}$ (Cyanocobalamin)

It is a co-enzyme in the synthesis of nucleic acids, carbohydrates and lipids. Animal protein foods are good sources of Vitamin B_{12} .

Deficiency symptoms

It is unlikely to occur in adults. It is characterised by poor growth and poor limb co-ordination in young animals.

6. Minerals

Minerals are required in relatively small amounts. They are essential for a number of bodily activities. There are about 15 essential minerals categorized into:

(a) **Macro-nutrients:** These are required in large quantities. They include calcium, phosphorus, chlorine, sulphur and magnesium.

(b) **Micro-nutrients:** These are required in relatively small amounts. They are referred to as trace elements. They include:

- Iron.
- Zinc.
- Copper.
- Manganese.
- Iodine.
- Cobalt.
- Molybdenum.
- Selenium.

Livestock need mineral supplements in their feed to meet their bodily mineral requirement. The mineral requirements for livestock vary with age and level of production. For example, young animals require more calcium and phosphorus for bone-formation. Milking cows require calcium and phosphorus for milk formation. Layers, need more calcium for egg shell formation.

Excess or deficiency of minerals can be detrimental. They therefore need to be supplied in correct amounts.

Functions

- They are useful constituents in bone and teeth formation, for example, Calcium (Ca), Phosphorus (P) and Magnesium.
- They are constituents of organic compounds for example, blood contains minerals like iron, calcium and cobalt.
- They are essential in formation of animal products for example, milk and eggs.
- Cobalt is a component of vitamin B_{12} and iodine is a component of thyroxine hormone.
- Helps in maintenance of correct acid-base balance in body fluids. Such minerals include sodium, chlorine, phosphorus and magnesium.
- They are constituents of enzymes which act as catalysts.
- They are constituents of hormones and nucleic acids.

(a) Macro-nutrients

Calcium and Phosphorus

They are essential for bone and teeth formation. Calcium is also necessary in egg shell formation. Phosphorus is an important constituent of the cell nucleus and protoplasm where it is found in form of phospholipids.

Sources of calcium and phosphorus

- Milk.
- Meat.
- Bone meal.
- Ground limestone.
- Oyster shells.

Deficiency symptoms

- *Rickets:* It occurs in young animals whereby bones become soft or weak and brittle (can easily fracture). This weakening of bones results in bending of limb bones, ribs and swelling of joints. In mature animals, there is soft bones (that is, pelvic bones) which can easily break especially during parturition. In poultry, it results in soft beaks and soft shelled eggs.
- *Milk fever:* Occurs in dairy cows shortly after calving down due to a decline in calcium. It is common in cows that produce a lot of milk.
- *Pica:* This is a condition where the animal craves for salt due to phosphorus

deficiency.

- *Infertility:* Which results in poor breeding. This is evident in animals with irregular heat or absence of heat.
- *Reduction in yields :* For example, reduced egg or milk production.

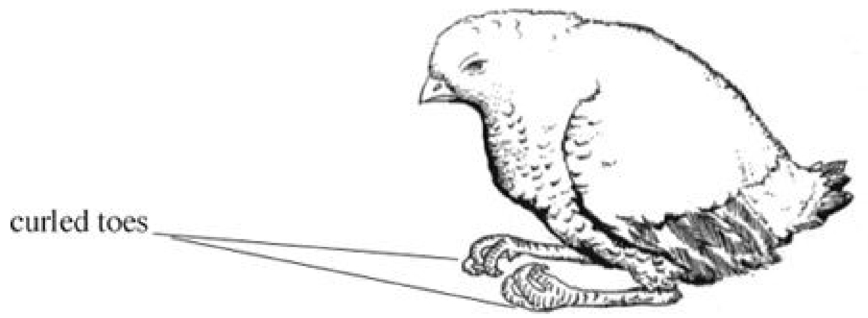


Fig. 8.3: Chicken with curled toe paralysis due to Vitamin B_2 deficiency .

Potassium, sodium and chlorine

They are found in body fluids and soft tissues. They perform the following functions:

- They maintain the acid-base balance and osmotic pressure in the body cells.
- They regulate water metabolism.
- Potassium plays an important role in the transmission of nerve impulses. It is also involved in carbohydrate metabolism.
- Sodium is the chief base (cation) in blood plasma contributing up to 93% of the bases. It is a constituent of cellular fluids. It is important in muscular contraction.
- Chlorine is associated with sodium functions. It is a constituent of the gastric juice.

Potassium deficiencies

Forage supply enough potassium and so its deficiency doesn't usually arise.

Sodium deficiency symptoms

- Loss of appetite.
- Loss in weight.
- Reduction in growth and fall in lactation.
- In poultry, there is a decrease in egg production and incidence of cannibalism is increased.

Sulphur

Most of the sulphur in the body is supplied through amino acids for example, methionine. It is also found in hormone insulin. Lack of sulphur leads to low production of wool in sheep and feathers in birds.

Magnesium

Role of Magnesium:

- It is important in the formation of body skeleton. 70% of Magnesium is found in the body skeleton and 30% in the tissue fluid.
- It is necessary for the activation of enzymes particularly those concerned with carbohydrate metabolism and translocation of phosphates.
- It is necessary for the excitation of nerves and muscles.

Sources of magnesium

- Leafy vegetables.
- Cereal grains.
- Milk.

Most of the feed given to animals contain sufficient amounts of magnesium.

(b) Micro-nutrients

Iron

It is useful in haemoglobin formation. It is also a constituent of:

- Blood serum.
- Spleen.
- Liver.
- Bone marrow.
- Kidney, where it is stored.

Deficiency symptoms

Outdoor animals which have access to leafy green forages or to soil, do not usually suffer from iron deficiency. Confined animals, especially piglets, may suffer from iron deficiency leading to anaemia.

Sources of iron

- Green vegetables.
- Liver.

• Fish meal.

• Cereals and grains.

Zinc

It is found in many body tissues. It helps in enzyme action as well as in many physiological functions. It is found in high concentrations in skin, hair and bones. It is associated with normal hair or wool growth. It also promotes general growth.

Deficiency symptoms

Zinc deficiency results in *paraketosis* which occurs in pigs, calves and lambs. Paraketosis is a skin disease resulting in the swelling of joints, reddening and cracking of the skin, scaly skin on the ears, and a rough hair coat. It also causes poor feathering in poultry, slows/reduces growth in chicks, and reduces hatchibility in hens.

Sources of zinc: Meat, liver meals, salt minerals licks, cereals and grains.

Copper

It is necessary for:

• Haemoglobin formation.

• Pigmentation of fibres, hair and wool.

• For production of crimp in wool.

Deficiency symptoms

Abnormal growth of wool lacking in crimp.

Black wool in sheep tends to appear white. It can also cause bleached hair in cattle, and feather de-pigmentation in poultry.

Sources: Legumes and cereal crops.

Molybdenum

It is used in enzyme activation. In ruminants, it stimulates the action of rumen micro-organisms.

Iodine

It is a constituent of thyroxine hormone which is produced by the thyroid gland. Thyroxine controls body metabolism and growth rate.

Deficiency symptoms

Iodine deficiency results to:

• Goitre which is characterised by a swollen neck.
• Young animals show retarded growth.
• In mature animals, the males may become infertile or lack libido
• Poor foetal development.

Manganese

It is an important constituent of enzymes that influence reproduction.

Deficiency symptoms

• Delayed sexual maturity in females and irregular ovulation.
• Head retraction in chicken is a sign of manganese deficiency.

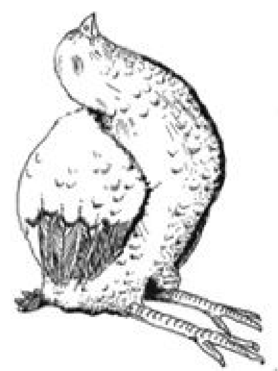


Fig. 8.3: Head retraction in a chick due to deficiency of manganese .

Cobalt

It is a constituent of Vitamin B_{12} . It stimulates appetite in ruminants.

Practical Activity 8.2

1. Visit a commercial agricultural shop dealing in agricultural products and observe samples of livestock feed. Classify the feed you observed.
2. Working in groups of five, tabulate feed nutrients and mention their functions.

Importance of feeding animals

For an animal to produce or grow well, it must be fed on a balanced diet or on the correct amount of ration. A **balanced ration** is the daily feed allowance per animal in the correct amount and having all the nutrients in the right proportions. Such rations contain carbohydrates, proteins, minerals, vitamins, fats and water

in their right proportions.
For an animal to grow and reproduce well, it should be given both maintenance and production ration (complete feed).

Examples:

- Dairy meal is a complete feed for dairy cattle.
- Layers mash for laying birds, sow and weaner for pigs.

Goats and sheep breeds

Sheep Breeds	**Goats**
• Romney marsh	• Boer
• Corriedale	• Anglo-nubian
• Hampshire down	• Jamnapari
• Black head persian sheep	• Saanen
• Merino	• Toggenburg
• Karakul	• Angora
• Dorper	• Galla

Sheep breeds

There are exotic and indigenous breeds of sheep.
Sheep can be kept for:

- Mutton and fat.
- Wool production.
- Dual purpose (both meat and wool).

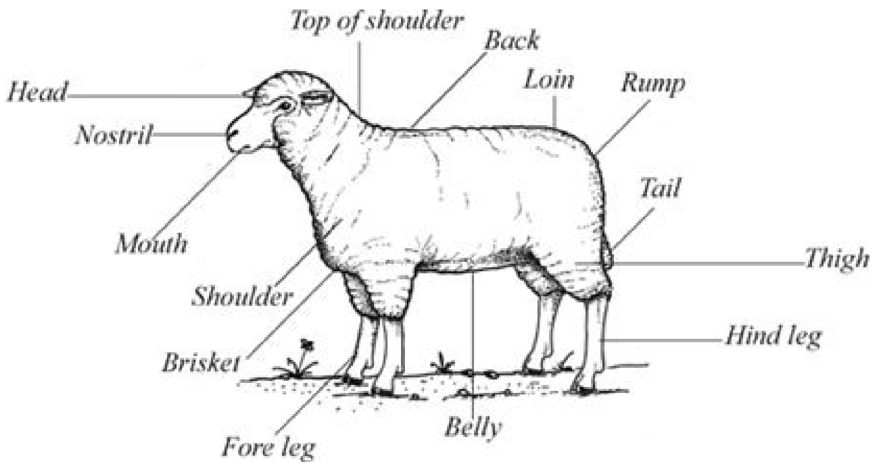


Fig. 8.4: Parts of a Sheep .

Characteristics of mutton sheep

- They are blocky.
- Have a level top line.
- Have a wide rump and loin.
- Have short legs.

Characteristics of wool sheep breeds

They provide wool used for textile industries. They can be further classified according to the quality of wool produced that is, fine wool breeds, for example, **Merino;** medium wool breeds for example, **Corriedale;** and long wool breeds for example, **Romney marsh.**

Merino

Origin: Along the North Coast of Africa, then spread to Spain where it was improved.
Size: Rams, 63 – 80 kg liveweight.
Ewes, 49 – 57 kg liveweight.

Appearance

- Wool, hooves and horns are white in colour.
- A lot of wool which comes down to the legs and the face.
- White face.
- Mouth and nostril are pink in colour.
- Rams have horns which grow in a spiral shape.

Characteristics

- Give long wool which is slow in shrinkage.
- The wool has fine crimp, that is, series of waves in fibre, the closer the crimps, the higher the quality.
- Wool staple length is 8 cm – 10 cm.
- It is kept in medium and moderate rainfall areas.
- Slow in maturity and has a lambing percentage of 100.
- Have a well developed flocking instinct, hence easy to manage.
- Susceptible to foot rot, worms and respiratory diseases, such as, pneumonia.
- Have drooping rump.
- Small and angular in shape.
- They are hardy, that is, can survive on poor pasture fields.

Fig. 8.5: Merino .

Dual purpose sheep breeds

Corriedale

Origin:	New Zealand.
Size:	Ram weighs 84 kg – 114 kg liveweight.
	Ewe weighs 57 kg – 84 kg liveweight.

It is a cross breed of Lincoln Wool Sheep and the Merino.

Characteristics

- Fleece wholly cover the body of the sheep.
- Open white face, therefore it cannot suffer from wool blindness. (Wool blindness is a condition where the eyes are covered by the wool).

- It is white with blackish spots.
- Hornless, docile and hardy.
- Fleece is heavy and of good length and weighs 5 – 5.5 kg per shearing.
- Lambing percentage of 100 – 125 as a result of twinning.
- It is a dual purpose breed kept in high rainfall areas.

Romney Marsh

Origin:	Romney in England.
Size:	Ram weighs 100 – 114 kg liveweight.
	Ewe weighs 84 – 100 kg liveweight.

Characteristics

- Wide poll and covered with wool.
- Face and legs are white.
- Nostrils, lips and hooves are black.
- Fleece is long and weighs 3.6 kg to 4.1 kg per shearing.
- Average in prolificacy.
- Can suffer from wool blindness.
- It is kept in high rainfall areas and is a dual purpose breed.

Fig. 8.6: Romney marsh .

Hampshire Down

Origin:	England.
Size:	Ram weighs 100 – 136 kg liveweight.

Ewe weighs 81 – 102 kg liveweight.

Characteristics

- Face and ears are dark brown and are covered with wool.
- Fleece is of poor quality because of black fibres.
- Lambing percentage is 125 – 140 due to high twinning rate.
- Important producer of fine quality mutton.
- Used for crossing with the local breed to improve the mutton quality.
- It is hardy and can do well on poor pasture.
- Prolific and matures early.

Karakul

Origin: Former USSR, Iran, Iraq, India and South Africa. It is kept for fur production which is used to manufacture carpets.

Characteristics

- The fleece is brown or black.
- It has drooping ears.
- Rams have spiral horns while the ewes are hornless.

Mutton sheep breeds

Dorper

- It has a good growth rate and is highly prolific.
- It was developed by cross breeding dorset horn and black head persian.
- It is white in colour with a black head and neck.
- It is suitable for hot and dry conditions.
- Dorset Horn is a dual purpose breed.

Fig. 8.7: Black head persian sheep .

Black head persian sheep

Kept for mutton production.
Origin: Persia.
Colour: White except for the black head and neck.

Characteristics

- Polled.
- Well developed dewlap.
- Have fat rump.
- Tail curves at the end giving rise to another small tail.

Goat breeds

Goats can live on very scanty vegetation where it is otherwise difficult for other livestock to survive. They are good foragers. They browse on tree leaves, shrubs and coarse grass. Goats are kept for meat, milk and hair.

Meat goats

East African Goats

They are small and hardy. They are the most successful indigenous breeds in the semi-arid lands. Their colour ranges from pure white to pure black with various intermixes of roan and spickle brown. Horns vary in length from 2.5 cm to 20 cm. Tassels are found in the breed up to 30%. Adult males weigh upto 35 kg, while adult females weigh 25 kg to 30 kg. They take 5 - 6 months to mature, and have the ability to survive in harsh conditions.

Galla goat

Galla is also known as the Boran or Somali Goat.

Colour:	White. They have white hairs with black skin, nose, feet and under the tail.
Size:	Billy, 30 – 40 kg liveweight.
	Nanny, 25 – 30 kg liveweight.

They are mainly reared for meat but recent research indicates they have good milk production potential.

Galla females breed well and live long (upto the age of 10 years). Galla goats have a very strong dental system. They are docile, easy to handle, and do better in the low altitude areas. Ears are upright and point forward.

Fig. 8.8: Galla goat .

Somali goat

Is a member of the Galla goats. It is white in colour and weighs between 40 kg and 50 kg liveweight.

Samburu goat

This is still a member of the Galla goat.
It weighs 40 – 44 kg in liveweight.

Boer

This was developed in South Africa. It is an exotic breed used for cross-breeding with local breeds for meat production. The breed is reared for meat production.

Characteristics

- Fast maturing.
- Has long ears and hair.
- Produces twins or triplets.
- Has a rapid growth rate and weight gain.

Anglo-Nubian goat

Origin : North East Africa.
Colour : Mixed roan though white-coloured goats are more common.

Characteristics

- Has long legs.

- Ears droop.
- Polled.
- Adult female weighs 60 – 75 kg.
- Can produce 1 – 2 litres of milk per day.
- Good for meat production.
- Males are sold to the local farmers for cross breeding to improve the local animals.

Fig. 8.9: Anglo-Nubian Goat .

Jamnapari goat

This is a cross breed between the Indian Jamnapari and the Egyptian Nubian.
Origin: India.
Colour: Ranges from white, roan to black.

Characteristics

- Ears are large and flopped.
- Females weigh 45 – 60 kg liveweight.
- Horned.
- Can produce 1 – 1.5 litres of milk per day.
- Kept for meat production.

Dairy goat breeds

These have a high milk production capacity.

Toggenburg

Origin: Switzerland.

Colour: The body is brown with white patches. It has white ears and a white stripe on the face and neck.

Characteristics

- Has erect ears pointing backwards.
- They are polled or horned. Horns in males are long and curve back.
- Female weighs 40–50 kg.
- Nanny produces 2–3 litres of milk per day with a butterfat content of 3.5 %.
- Has long hair.
- Face slightly dished.
- Has tassels on either side of the neck.
- Suffer from heat stress resulting in lack of appetite.

Fig. 8.10: Toggenburg .

Saanen goat

Origin: Switzerland.
Colour: White or creamy white.

Characteristics

- Ears are erect and point forward.
- Usually polled.
- Weighs 50 – 80 kg liveweight.
- Can produce 2 – 3 litres of milk per day for 3 months with a butter fat content of 3.5%.

Fig. 8.11: Saanen goat .

Mohair goat breeds

Angora goat

Origin: Angora in Asia.

Characteristics

- It is kept for production of mohair.
- Average mohair production is 3.64 kg per goat.
- Commonly reared in USA and South Africa.
- It is white in colour.

Fig. 8.12: Angora goat .

Other breeds of goats are the **French Alps** and **British Alpine.** The British Alpine has been used to upgrade the local breeds of goats.

Practical Activity 8.3

1. Visit a nearby farm or village and carry out research on appropriate breeds of sheep and goats for the area.

2. Fill the table below.

The table below shows some breeds of sheep and goats appropriate for certain areas in Malawi.

Sheep		Goats	
Breed	**Area**	**Breed**	**Area**
Romney Marsh			

Housing for sheep and goats

Housing is an important consideration where goats and sheep are to be enclosed. The simplest structural accommodation suffices for range goats and sheep. In the daytime, shade should be provided when the sun is intense. At night dry quarters are essential with or without overhead covering (roof). Shelter from rain is one of the most important factors in goat husbandry. Protection from cold may also be needed but usually a windbreak is all that is required. The house will have to be designed for:

- A specific location.
- Climate.
- Herd size.
- According to local material available. The house must fulfil some requirements if the goats are to stay healthy and productive.

Requirements

(a) It must be warm and well ventilated but not draughty. Goats are particularly susceptible to the effects of bad or poor ventilation associated with crowding in unsanitary buildings. When they are so herded, high mortality from pneumonia often follows.

(b) It must be dry and easy to clean. The floor should be made of concrete or rammed earth and sloped for drainage.

(c) It must have enough light especially if the goats are being kept indoors for long periods. In that case an outside exercise yard has to be provided too, since goats are active animals and cannot stay healthy if cooped up.

(d) It must have facilities to feed indoors. There should be feed racks for hay, feed troughs, mineral licks and water troughs.

(e) There should be subdivisions in the house to separate different types of animals like:

- Milking does.
- Does about to kid.
- Kids.
- Weaner doelings.
- Weaner buckling.
- Bucks.

(f) There should be a large communal pen and several individual pens.

Construction of sheep and goat house

Space requirements

Enough space per animal has to be available. If kept in individual pens, 2.25 m^2 should be calculated. If kept in groups, the area per animal can be reduced depending also on whether the goats go out for grazing or not. For kids or goats up to 30 kg; 1m^2 for 2 kids ought to be calculated.

If enough straw is available throughout the year a deep litter makes a good floor cover.

Very wet patches are removed every day and fresh straw added to make the surface clean and dry. Wood shavings or sawdust can also be used as beddings. If no straw or wood shavings are available, shelves or benches made of boards raised 50 cm off the ground and attached to the wall can be used. The fodder racks should be made high enough to allow the goats to pull the feed down as they would do if they were browsing. A platform 70 cm high can be made for the goat to stand on when being milked so that she is at a good milking or working level for the milker.

Materials used to construct a sheep and goat house

In Malawi, materials which can be used to construct a sheep and goat house include the following:

- Poles.
- Bamboos.
- Thatch grass.
- Brick and stones.

• Sisal string.

Procedure for constructing a goat and sheep house

1. Assemble the materials required.
2. Lay out the site using tape measure, mallet, pegs and strings.
3. Clear the area of any bush or plants and dig the foundation.
4. Use poles to stake out the corners of the house.
5. Lay stones in foundation until ground level.
6. Build up the wall upto about 60 cm then use bamboo to raise the rest of the wall upto the rafters.
7. Use poles and bamboo to construct the rafters on the roof.
8. Cover the roof with grass thatch and use sisal strings to tie the grass to the roof poles.

Practical Activity 8.3

1. Under the supervision of your teacher, construct a sheep and goat house using:
    - Poles.
    - Bamboo.
    - Thatch grass.
    - Brick.
    - Stones.
2. While constructing the house:
    (a) Outline the requirements of a goat's house to enable the animal to be healthy and productive.
    (b) Outline the procedures for constructing a sheep or goat's house.

Grazing and browsing by sheep and goats

Browsers feed on leaves, bark and green stems from plants while grazers feed on vegetation at or near ground level.

Browsers – goats

Grazers – sheep and goats

Sheep are excellent converters of forage into meat and fiber. Sheep consume a variety of forages and selectively graze on numerous weeds and other pasture menaces such as roses and blackberry.

Sheep prefer to graze on hillsides and steep slopes.

Companion grazing of sheep with other species of livestock like cattle or goats results in greater pasture utilization and high quality pasture than when a single species is grazing alone.

Class and stage of production of the animals dictate the type and quality of forage to be grazed. Lactating ewes with lambs are placed on the highest quality pasture to increase milk production hence improve lamb growth.

Dry, non-pregnant ewes are placed on lower quality forage. Strategic allocation of pasture forage through use of controlled grazing provides longer grazing season and improve overall forage utilization per unit area of land.

Controlled grazing is achieved by use of high tensile electric wire and electrified temporary fence.

Sheep are excellent grazers. On the other hand goats are both grazers and browsers.

Goats are difficult to hand-feed. Although they can be fed on standard agricultural produce, they do best when their fodder is composed of a variety of vegetation which is often difficult to collect and troublesome to stall-feed. In the tropics, it is unusual to confine the goats except at night or when it is necessary for their safety.

Nutrition in goats and sheep can be achieved in the following ways:

1. Free range

The rangeland or ranch should be divided up into paddocks or areas which are grazed for 2-3 months each. Ideally one area should be left ungrazzed for the whole year so that it can rest and reseed itself. Goats like eating acacia pods but will also eat bark and roots hence they are very useful on a ranch in keeping down regrowth. Normally goats browse rather than graze and any range which does not provide browsing cannot be considered adequate.

However, good roughage such as sweet potato vines and groundnut tops should be provided for the growing and fattening of goats.

2. Herding

In the drier areas sheep and goats are herd over extensive grazing land. Where pasture is extensive and dispersed, they are more often herd with sheep or cattle or with both, than as self-contained flock. Goats are extremely hardy and require little attention unlike sheep. They find many bushes or browse palatable and derive considerable nourishment and minerals from them.

The lactating mothers should not be allowed to wonder far away from their young kids and lambs.

3. Tethering

Sheep and goats can be tethered with a chain and a pin. However, if space allows, the chain can be threaded on a strong wire stretched tightly along the ground. The chain is free to slide along the wire, thus giving the goat a greater range. A goat must not be tethered out in the morning and left to take its chance until brought in at night. The pin must be moved several times a day and if there is no natural shelter, a small shed which can provide shade must be provided to keep the goat away from wind, rain or strong sunlight. If this is not provided the goat must be kept indoors when conditions are bad. However in tethering, goats must be provided with good quality hay.

4. Stall feeding or Zero grazing

Sheep and goats can be kept intensively indoors. This is possible in the high potential areas where there is land shortage. This system is advantageous because:

- There is no fencing costs.
- There is less problems with parasites and worms build up on infection.
- Elimination of possible destruction of young trees and crops.

A daily ration for each goat can consist of 4 kg of green vegetable such as sweet potato vines and grasses such napier grass; 1 kg of good hay; and 0.5 kg of concentrates. The concentrates should consist of 70% grain, 15% cotton-seed cake and 15% meat and bone meal.

Milking goats particularly need calcium, so feeds rich in calcium such as lucerne and clovers should be fed. Mineral licks should be also given to high yielding goats to supply the necessary minerals.

The effects of some mineral deficiencies are:

- Cobalt - wasting of animal.
- Copper - poor reproduction, anaemia.
- Calcium - breakdown in high milkers.

• Iodine - still births, thyroids, low yields.

Suitable feeds for sheep and goats

Sheep and goat feeds can be classified as:

• Forage plants.

• Roots.

• Roughages.

• Concentrates.

It is important to select appropriate feed for sheep and goat in order to realise maximum production. Let us now study the feed in detail.

(a) Forage plants

The vast variety of different forage plants include

- Grasses.
- Legumes (for example, lucerne).
- Shrubs, (for example, salt bush).
- Bushes and trees whose leaves are browsed.

Grasses form the largest part of the group. Legumes have higher crude protein and mineral contents for equivalent stages of growth. The leaves of bushes and trees are rich sources of nutrients.

Examples of forage plants that are suitable for grazing sheep are:

• *Panicum maximum* (guinea).

• *Cynodon plectostachyus* (Giant star), *Chloris gayana* (rhodes) *Pennisetum clandestinum* (kikuyu grass).

• *Vigna sinensis* (cow pea).

• *Medicago sativa* (lucerne or alfalfa).

• *Leucaena leucocephala* .

• *Atriplex rummularia* (salt bush).

• *Cajanus cajan* (pigeon pea).

• *Acacia nilotica* .

• *Acacia tortilis* (acacia).

(b) Roots

Roots are composed entirely of nutrients, water and energy. Common examples are:

- Cassava *(Manihot esculenta)* .
- Sweet potatoes *(Ipomoea batatas)* .
- Arrow roots *(Canna edulis)* .
- Yams *(Dioscorea spp.)* .

With most of these, the leafy part is also good quality forage. Sweet potato vines are a particularly good example. Succulents conserved by ensiling (silage) generally have feeding volumes similar to the parent crop.

(c) Roughages

The main characteristic of these is their high crude fibre content which limits the digestibility. Their sources are almost entirely from mature plants, which means that the proportion of crude protein is low and they are also a poor source of energy. There are two main sources: *mature pasture* and the *residues from crops* from which grain has been harvested.

Dry forages (from mature pasture) vary considerably in quality. In the arid zones with a very short growing season and a rapid cessation of growth, the mature dry forage frequently has levels of crude protein above the critical threshold. In addition, it has lower levels of crude fibre, than equivalent stages of growth in wetter areas, resulting in a much higher digestibility than would be expected. This makes "standing hay" of considerable feeding value. Conserved hay also falls into this group, and its nutrient content is dependent on the composition of the plant at the time of conservation and the efficiency of conservation.

Straws and helms (the residues from crops) after harvesting for example, cereal or legume grains. Being derived from fully matured plants, their nutrients value is often low particularly if the parent crop was a cereal. Sheep can also graze on small weeds in the field which are of high nutritional value.

(d) Concentrates

They have a high proportion of energy or protein. They are derived from plants. In addition, a number of animal by-products are protein concentrates.

Energy concentrates are almost all from cereal grain crops for example, rice, maize, sorghum, millet and wheat. The by-products from the processing of these cereals are often a good source of energy and should be utilized for stock feed. The protein content varies from medium levels in wheat and sorghum to low levels in rice. In these foods the phosphorus content is high and the calcium content is low. Also, cereals and their by-products are poor sources of vitamins A and D, except for yellow maize which has a high carotene content (vitamin A). Concentrates can be classified into

- Protein concentrates of plant origin.
- Protein concentrates of animal origin.

(i) Protein concentrates of plant origin that are used for stock feed most commonly are the by-products from the manufacture of vegetable oils. The oil seeds whose by-products are most frequently available are:

- Groundnuts.
- Cotton seed.
- Sesame.
- Soya bean.
- Sunflower.
- Coconut.

The crude fibre content varies considerably depending on the amount of husk that was present with the seed. When the crude fibre content is high the product is best utilised by ruminants. Legume grains are also hardly available for stock feed, except as shed grain in the harvest field. All these plant proteins are usually rich in phosphorus, and have negligible amounts of vitamins.

(ii) Protein concentrates of animal origin are the by-products from the processing of carcasses, fish or milk. They are a rich source of high quality protein, and minerals and may contain important amounts of vitamins. If available for stock feeding they are usually fed to poultry and pigs rather than sheep.

Principles of rationing

A **ration** is the amount of feed given to an animal within 24 hours to meet its maintenance and production requirements. The amount of feed given to an animal depends on the following factors:

(i) *Body size, live weight or breed of the animal:* Large sized animals and exotic ones consume more feed than indigenous or small sized animals.

(ii) *Physiological condition of the animal* , (that is, pregnancy, health status of the animal, or level of hunger): Pregnant and healthy animals eat large amounts of feed, as well as, hungry animals. Sick animals consume less feed.

(iii) *Age of the animal:* Young animals require more energy for maintenance than old animals thus consume more food per unit weight.

(iv) *Level of production or the purpose for which the animal is kept:* Highly productive animals consume correspondigly high amounts of feed.

(v) *Previous feeds already eaten by the animal* , that is, what is already in the alimentary canal of the animal.

Note: Other than the above factors, the amount of feed consumed by an animal will also be determined by the form in which it is fed, the palatability of the feed, and the weather conditions at the feeding time, that is, ambient temperature.

The choice of the feedstuff to use depends on:

• The cost of the feedstuff.

• Its nutritional composition (found in feeds table).

• Its availability.

• The physical or processing nature of the feedstuff such as, particle size of feedstuff, colour, smell, presence of foreign bodies in the feedstuff.

Ration computation

Livestock feed is either commercial or home-made. Commercial feed is manufactured by commercial firms. They usually contain additives and are well balanced, that is, the amount of nutrients are very close to the theoretical amounts necessary for maintenance and production. Commercial feed is expensive.

Home-made feed is prepared by the farmer and is cheaper than commercial feed. However, it has the following disadvantages:

(i) Mixing of the various feedstuffs may not be thorough.

(ii) Grains are seasonal and may not be available at the time they are required.

(iii) Farmers may lack technical know-how on feed value formulation.

In balancing rations the following factors should be taken into consideration:

• Feeding standards.

• Nutrient composition.

• Economic factors.

Methods of Ration computation

(a) Trial and error method

This method is used where a farmer has animal feed grown in the farm, such as, beans, soya beans, peas, maize, sorghum, sunflower. The farmer mixes various feed in correct proportions and gives them to the animals. Through experience gained by watching the animal responses to the feed, the farmer will know the right proportion of the feed to use when computing the ration.

	Nature of feedstuff	Dry matter (DM)%	Digestible crude (DCP) protein %	Total digestible nutrientsTDN %	Starch equivalent %
1.	Maize grain	86	6.8	81	80
2.	Wheat	86	9.8	80	73
3.	Maize bran	80	23	76	82
4.	Wheat bran	86	11	66	42
5.	Rice husk	88	6	70	65
6.	Sunflower seed cake	90	34	70	54
7.	Cotton seed cake	90	35	75	65
8.	Meat meal	90	67	66	91
9.	Fish meal	92	62	72	58
10.	Blood meal	91	74	60	68
11.	Napier grass	24	0.6	-	8.5
12.	Rhodes grass	28	1.5	-	5.5
13.	Guinea grass	26	0.5		10.5

Table 8.3: Feed values for various livestock feeds .

(b) Pearson's Square method

Sometimes, a farmer may want to blend (mix) two or more feeds together into a mixture containing a certain definitive percentage of some major nutrient required in the prepared ration. The percentage of the nutrient to be obtained from the feed must be specified. Also the values of the nutrient contained in the two feedstuffs must be known. Those values are obtained from feed tables. (Refer to Table 8.3 for feed values). When using this method, one of the feedstuffs to be used must have a lower nutrient value than the required feed.

Example: A ration containing 20% DCP is to be made from ground maize and fish meal. Given that ground maize contains 7% digestible crude protein and fish meal contains 62% digestible crude protein, calculate the amount, in kilograms, of each feedstuff required to prepare 100 kg of the feed.

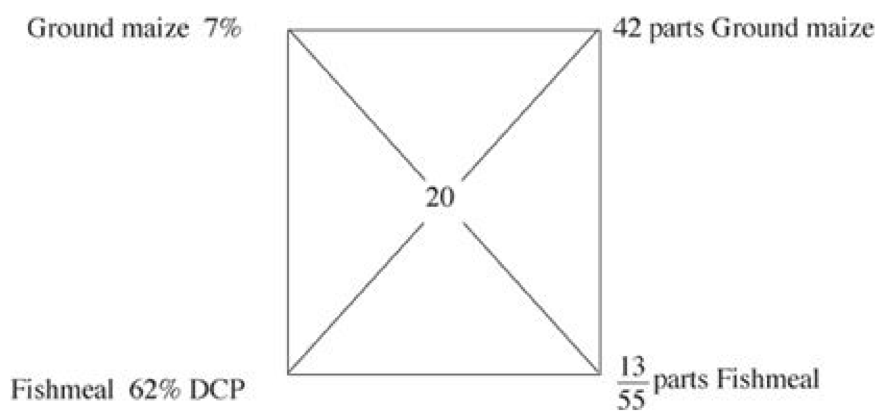
Procedure

(a) Draw a square.

(b) Place the DCP% desired in the ration mixture in the middle of the square.

(c) Draw diagonals of the square.

(d) Place the values of the DCP% of the feeds to be used on the left corners of the square.



(e) Subtract diagonally across the square the small number from the large one regardless of the sign and write the resultant values on the right side corners.

(f) The resultant values obtained represent the proportions of the amount of feeds to be used in the mixture. Add up the parts to obtain at the base what will be used to calculate amount of each feedstuff to be used in feed preparation.

Thus, to obtain 100 kg of a feed ration with 20% DCP, then:

ground maize part: $\frac{42}{55} \times 100 = 76.4$ kgs

Fish meal part: $\frac{13}{55} \times 100 = 23.6$ kgs.

Feeding

For an animal to produce or grow well, it must be fed on a balanced diet or on the correct amount of ration. **A balanced ration** is the daily feed allowance per animal in the correct amount and having all the nutrients in the right proportions.

Such rations contain carbohydrates, proteins, minerals, vitamins, fats and water in their right proportions.

For an animal to grow and reproduce well, it should be given both maintenance and production ration (complete feed).

Examples: Dairy meal is a complete feed for dairy cattle, layers mash for laying birds, sow and weaner for pigs.

Reasons for selecting sheep and goat feed

- They provide a balanced diet.
- They are locally available since they are made from local crop residues.
- Some can be bought cheaply.
- Some can be grown in the farm.
- They are free from toxic substances.
- They can be dried and stored for use during the dry season.
- They contain lots of nutrients.

Practical Activity 8.4

Visit the local community and choose the farmers who rear sheep/goats. Observe the feeds used for feeding these animals.

Revision Exercise 8

1. State the factors which influence livestock productivity.
2. State two way of classifying animal feedstuffs.
3. Name different nutrients provided to the bodies of animals by feeds.
4. State four factors within the animal's body that influence water requirements.
5. State the functions of fats and oils in the animal's body.
6. Differentiate between a roughage and a succulent feed.
7. State three ways in which a production ration may be utilized by cattle.
8. State two desirable qualities of a livestock ration.
9. What is the difference between browsers and grazers in livestock management.
10. Outline the reasons for selecting sheep and goat feeds.

11. Using a Pearson's square, formulate a 90 kg feed ration for a dairy goat with a 15% protein content using maize meal flour (21% protein) and bean meal 45% protein.

Unit 9

Livestock Management and Production Systems

Objectives

By the end of this unit, you should be able to:

(a) Select an appropriate breed of sheep/goat for the area .

(b) Identify a suitable sheep/goat house .

(c) Construct appropriate house for sheep/goat .

(d) Explain the feeding behaviour of sheep/goat .

(e) Identify suitable sheep/goat's feed .

(f) Identify the diseases and parasites of sheep and goat .

(g) Explain how to control diseases and parasites of sheep and goats .

Diseases of sheep and goats

Introduction

A disease can be defined as any alteration in the state of the body of an animal, or of its organs, which interferes with its proper functioning. Disease infection in an animal's body is detected by the outward visible signs of the disease referred to as *symptoms* . Most diseases have specific symptoms, though certain diseases have common symptoms.

The period of time between infection and appearance of disease symptoms is called the incubation period.

Livestock diseases are categorised into:

- Protozoan diseases.
- Bacterial diseases.
- Viral diseases.
- Nutritional diseases.

1. Protozoan diseases

Protozoa are microscopic, unicellullar organisms transmitted by vectors for example, ticks and tsetse flies.

The common protozoan diseases include:

• Anaplasmosis.

• Coccidiosis.

• Trypanosomiasis or Nagana.

(a) Anaplasmosis or Gall sickness

This disease mainly attacks cattle and sometimes sheep and goats.

Cause

The disease is caused by the protozoa *Anaplasma marginale, Anaplasma ovis* and *Anaplasma centrale* which are transmitted by the blue tick *(Boophilus decoloratus)* . It can also be transmitted from mother to young one or by biting insects such as mosquitoes, flies and mechanically through contaminated surgical instruments.

Incubation period is between 10 – 100 days.

Symptoms

• Animal develops fever that is, a rise in body temperature.

• An animal develops constipation or releases hard dung.

• Mucous membranes become pale and in some cases jaundiced due to anaemia.

• Fast breathing and fast heart beat.

• No rumen movement that is, no chewing of cud.

• Yellowish urine.

Control measures

• Tick control measures. For instance, dipping or spraying of the animal.

• Control biting insects.

• Use clean surgical instruments when carrying out operations such as castration.

Treatment

Intramascular injection of antibiotics and iron injections, like *iron dextran* .

(b) Coccidiosis

The disease is known to attack kids and lambs.

Cause

Coccidiosis is caused by a protozoan known as *Coccidia* of the *Eimeria species. Coccidia* attacks the alimentary canal of animals especially the small and large intestines and the liver.

The main predisposing factor is overcrowding in livestock housing.

Symptoms

• Copious bloody diarrhoea.

• Sudden death in kids may occur.

Control measures

• Maintain hygiene in animal and poultry houses.

• Use prophylactic drugs for example, coccidiostats in food or drinking water.

• Isolate infected animals.

• Maintain appropriate numbers in animal houses.

Treatment

The disease has both preventive and curative treatment. In preventive treatment provide coccidiostats in foods or drinking water. Use appropriate drugs for example, furazolidone, amprollium, coccidiostats for curative treatment.

(c) Trypanosomiasis/Nagana

This disease affects sheep and goats.

Cause

Nagana is caused by a protozoan of *Trypanosoma* species transmitted by tse-tse flies. It can also be transmitted by other biting insects and contaminated syringes. The common *Trypanosomes* which cause trypanosomiasis are *Trypanosoma vivax*, *T. congolense* and *T. brucei* . This disease is common in the tropical climates which provide warm humid conditions favourable for the breeding of tsetse flies.

Incubation period is 1 - 3 weeks.

Symptoms

• Staring coat.

• Enlargement of superficial lymph nodes.

• Chronic loss of condition that is, the animal loses appetite.

- Animal is exhausted and very weak.
- Anaemic conditions occur with a tendency of the animal to lick and eat soil.
- Lachrimation and inflammation of cornea which may lead to blindness.
- Loss of hair at the tail switch.
- Belly region becomes swollen.
- Fast breathing.
- Intermittent fever.

Control measures

- Effective control of tsetse fly which act as a disease-transmitting vector.
- Confinement of game animals in game parks as these act as alternate hosts for the disease vectors.
- Breeding trypano-resistant animals.

Treatment

Use appropriate drugs for example, novidium, berenil, evidium or any other trypanocidals.

2. Bacterial diseases

Bacterial diseases include the following:

- Foot rot.
- Contagious abortion *(Brucellosis)* .
- Scours.
- Black quarter.
- Mastitis.
- Anthrax.
- Pneumonia.

(a) Foot rot

This disease is also referred to as pododermatitis. The disease affects sheep and goats. However, sheep are the most vulnerable. It is an infectious and contagious disease.

Cause

It is caused by the bacteria *Fusiformis necrophorus, Fusiformis nodosus* or *Spirochaeta penortha* .

Predisposing factors

- Filthy, wet and muddy conditions: Wetness causes the skin between the hooves to soften and thus become vulnerable to cutting by sharp objects. This exposes the animal to the bacterium.
- Presence of stones and other sharp objects in grazing fields: These may injure the animals causing wounds through which the bacterium can gain entry into the animal's body.
- Long untrimmed hooves: May lead to the hooves cracking. The cracks provide a way through which the bacterium can gain entry into the animal's body.

Symptoms

- Animal feet get swollen particularly below the hock.
- Lameness in the severe stages of the disease.
- Foul smell and pus oozes from the hoof.
- Sheep often kneel while grazing if the front legs are infected.
- Animals lie down most of the time. This can be observed when the hind feet are infected.
- Animal becomes emaciated due to poor feeding most of the time.

Control measures

- Provide a clean environment for the animals. Avoid grazing animals in damp, muddy or marshy land.
- Carry out regular foot examination and hoof trimming.
- Provide animals with footbath of 3% formalin or 5% copper sulphate solution at the entrance to animal sheds.
- Isolate sick animals.

Treatment

Administer antibiotics for example, sulphur drugs or tetracycline. Clean animal foot using antiseptic and apply protective dressing.

(b) Contagious abortion

This is a zoonotic disease which affects cattle, goats and sheep. The disease is also known as brucellosis, bang's disease or malta disease.

Cause

It is caused by the bacteria *Brucella melitensis* in sheep and goats. Transmission may be through ingesting contaminated pastures or water or by mating with an infected partner.

The disease also affects man and care should be taken in handling a foetus born of an infected animal. Milk from an infected cow should not be consumed.

Incubation period 3 weeks to 6 months.

Symptoms

- Abortion in late gestation (3rd trimester).
- Retention of the afterbirth after the abortion.
- A yellow, brown, slimy discharge from the vulva may occur.

Control measures

- Cull and slaughter infected animals then dispose of them properly.
- Disinfect areas contaminated with uterine discharges.
- Vaccinate all young animals against the disease.
- Proper disposal of aborted foetus.
- Use of artificial insemination.
- A blood test should be carried out for all breeding herds in order to detect the infected ones.

Treatment

There is no effective treatment for the contagious abortion disease though use of antibiotics may help relieve discomforts caused by the disease.

(c) Scours

The disease is also referred to as colibacillosis or white scours. It affects: lambs and kids.

Cause

It is caused by a bacterium known as *Escherichia coli* which usually attacks young animals during the first week of birth. *E. Coli* inhabits the animal's intestines.

Predisposing factors

- Unhygienic conditions in the house of young animals. Dampness and chilly conditions in the animals house contribute to the development of scours.
- Poor feeding practices for example, over feeding the calf with milk, kids/ lambs replacers.
- Abrupt temperature changes which causes stress.
- Lack of sufficient colostrum.
- Deficiency of Vitamin A.

Symptoms

- In kids, there is white or yellowish diarrhoea with a pungent smell.
- Rapid dehydration.
- Initial rise in body temperature but which later drops below normal.
- Extremeties feel cold to the touch.
- Undigested milk curd. Blood and mucus stains occur in the animal faeces.
- Dullness.
- Loss of appetite.

Control measures

- Ensure cleanliness in the animal housing. Avoid dampness on the floor of the animal houses.
- Proper feeding for example, milk at the right temperature, correct amount and at regular intervals.
- Observe hygiene during parturition.
- Avoid overcrowding in the animal house.
- While training calves to drink from the bucket, maintain high hygiene standards.

Treatment

- Provide antibiotics to the sick animals.
- As soon as symptoms appear, give the following treatment:
  - Replace milk with warm water mixed with glucose on the first day of sickness.
  - On the second and third day, give half the normal ration of milk and an equal proportion of the glucose solution.
  - On the fourth day, resume the normal milk ration.

(d) Black quarter

It is also referred to as black leg. The disease affects sheep and goats.

Incubation period is 1 to 5 days.

Cause

It is caused by a bacterium called *Clostridium chauvei* . In sheep, infection may occur after shearing, docking, castration and crutching if wounds are inflicted on the animal.

Symptoms of black quarter

- Rise in body temperature.
- Gas filled swellings of heavy muscles of neck and legs.
- Grunting and grinding of teeth by the animal.
- Acute lameness of hind legs.
- Loss of appetite.
- Death within 12 – 48 hours.
- Black meat which has a sweet smell in the hind legs if examined after death.
- Animal stops chewing cud.
- There is blood stained exudate from the anus and nose with characteristic smell of rancid butter.

Control measures

- Regular vaccination of young stock preferrably at six months interval until they are 2 – 2½ years and thereafter once annually. Use Blanthrax vaccine.
- Restrict livestock movement that is, quarantine.
- Do not open the carcass of animals that have died of this disease. Instead, properly dispose of the carcass that is, completely burn or deeply bury the carcass at more than 2 metres deep and sprinkle with quick lime.

Treatment

Treat with antibiotics such as penicillin, tetracycline, chlorotetracycline, oxytetracycline.

(e) Mastitis

It is an infectious disease of mammary glands which affects cattle, sheep, goats, pigs and camels.

Cause

It is caused by different species of bacteria such as *Streptococcus spp, Staphylococcus spp, Pasteurella spp* .

Predisposing factors

- Injury to the udder or teats: These allow micro-organisms entry into the udder.
- Poor milking hygiene in dairy goats.
- Teat sores.
- Incomplete milking: When milk is left in the teat canal, it acts as a culture media for bacterial growth in dairy goats.
- Level of milk production: High milk producers are much more prone to mastitis than low milk producers.
- Genetic factors: Some breeds are more susceptible to mastitis than others.
- Pendulous udders: These are liable to mechanical injuries which facilitate mastitis infection.

Symptoms

- Blood clots or pus in milk.
- Pain in the udder or teats as milking is done.
- Swollen or inflammed udder.
- Rise in body temperature.
- Clots in milk or milk appearing as a clear liquid.
- Drop in milk yield in dairy goats.
- Blocked teat canal.
- Rapid and weak pulse.

Control measures

- Practice farm hygiene.
- Immediate treatment of infected animals to avoid the spread of the disease.
- Test for mastitis before milking to avoid spread to healthy dairy goats.
- Applying milking jelly or milking salve after milking to prevent drying and cracking of teats. Use teat dip on each teat, after milking in dairy goats.
- Use good milking techniques that is, squeeze method, complete milking in dairy goats.

- Infuse long acting antibiotics into the teat canals during drying off period.
- Cull those animals which do not respond to treatment.
- Vaccinate with mastivac. This is administered once in a year.

Treatment

Administer anti-mastitis drugs or antibiotics such as tetracycline, streptomycin or penicillin. If udder is inflammed give corticosteroids.

(f) Anthrax

Anthrax affects sheep and goats. It is zoonotic, infectious and a notifiable disease.

Cause

It is caused by a bacterium known as *Bacillus anthracis* . The bacterium is transmitted by grazing on contaminated pastures or feeding on contaminated concentrates. *Bacillus anthracis* is capable of forming spores outside the animal body and can live in the soil for over 50 years. The bacterium may access the body through wounds or insect bites.

The disease occurs in three forms:

- The very acute form, in which the animal dies very fast after showing a few symptoms.
- The acute form, in which the animal dies in about 2 days after showing some symptoms.
- Chronic anthrax where the animal takes time before dying.

The incubation period is 1 - 4 hours.

Symptoms

- High fever.
- Shivering.
- Difficulty in breathing.
- Presence of blood stains in the faeces and in milk.
- Diarrhoea which is blood stained.
- Watery blood which is tar-like oozes through all natural openings (orifices). The blood does not clot easily.
- Absence of rigor mortis. Rigor mortis is the stiffness of the carcass.

- Sudden death followed by fast decomposition.
- There is extensive bloat in the rumen after death and other parts of the belly also get swollen.

Control measures

- Proper disposal of the carcass that is, burning or burying 2 m deep into the soil. Quick lime is sprinkled on the carcass to kill any bacteria present. The site must be fenced off to prevent other animals from grazing on it.
- Imposition of quarantine whenever there is an outbreak.
- Annual vaccinations using Blanthrax vaccines.
- Proper inspection of meat.
- Do not open the carcass of an animal suspected to have died from anthrax.
- Disinfect the animal house with formalin.

Treatment

Treat all sick animals with antibiotics for example, Penicillin. Animals can also be given large doses of anti-anthrax serum.

(g) Pneumonia

This is a notifiable disease that infects the lung tissue. It affects kids and lambs.

Cause

It is caused by a bacterium *Mycoplasma mycoides* , viruses, dust particles or presence of worms in the lungs.

Predisposing factors

- Poor ventilation.
- Overcrowding.
- Age of animal: Young animals are more prone to the disease than adult animals.
- Dampness and chilliness in the animal houses.

Symptoms

- Severe respiratory problems.
- Abundant mucoid nasal discharge.
- Fever.
- Animal appears dull and loses appetite.

- Abnormal lung sounds such as bubbling, hissing and gurgling.
- After slight exercise, the animal coughs due to congestion of bronchioles.

Control measures

- Keep young animals in warm houses.
- Treat early cases of the disease with antibiotics.
- Avoid overcrowding in animal houses.
- Isolate sick animals.
- Ensure proper ventilation in the animal houses.

Treatment

- Give antibiotics such as tylosin, tetracycline to affected animal.
- Keep the affected animals in warm pens.

3. Viral diseases

These diseases are highly infectious and there is no effective curative treatment so far. The success of their control highly depends on prevention.

Diseases under this category include:

- Rinderpest.
- Foot and mouth disease.

(a) Rinderpest

The disease affects sheep and goats. It is a highly infectious and contagious disease. It is classified as a notifiable disease.

Cause

It is caused by a virus known as *Paramyxovirus* . The virus can be transmitted by direct contact, discharges on beddings or containers, ingestion or inhalation. The virus is present in urine, faeces and body fluids of affected animal. Animals that are less than one year are immune to the disease.

The incubation period is 3-9 days.

Symptoms

- Rapid rise in body temperature.
- Mucous membranes of the mouth and nose become red hot and painful.
- Dry and cracked muzzle.

- Smelly ulcers develop in the mouth and nose.
- Laboured breathing and persistent cough.
- Profuse diarrhoea.
- Eye and nasal discharge.
- Animals grinding their teeth.
- Staring coat.
- Death in 2-10 days.

Control measures

- Imposition of quarantine in cases of outbreak.
- Vaccination of all animals more than one year old. This should be done annually. The immunity may last 3 – 7 years and in some cases for a lifetime.
- Kill all the affected animals and dispose of properly.
- Disinfect animal houses.
- Isolate sick animals.

Treatment

Nurse the animal by giving antibiotics, fluids and electrolytes.

(b) Foot and mouth disease

This disease affects sheep and goats. It is highly contagious and infectious. It is categorised as a notifiable disease. The disease mainly affects exotic breeds of animals as indigenous cattle have some tolerance to it.

Cause

It is caused by *Enterovirus* . There are several strains of the virus for example, "A", "O" and "C". The virus can be found in milk, semen, blood, saliva, nasal and oral discharges of the affected animal. The virus can be transmitted through contaminated litter, machinery, garbage, feet and syringes. It can also be transmitted via aerosols where it may be blown by wind up to 50 km away.

Incubation period is 2 – 7 days.

Symptoms

- High fever which lasts for only a few hours.
- Profuse and continuous salivation.
- Vesicles (blisters) form in the mouth, muzzle, teats, udder, coronet and between

the hooves which later open leaving wounds.

- Kicking of feet.
- Lameness due to vesicle formation in the interdigital space and coronet.
- Inflammation of tongue, lips and gums making it difficult for the animals to eat.
- Great reduction in milk production.

Control measures

- Imposition of quarantine in case of outbreak.
- Vaccination every six months.
- Disinfect the animals' hooves.
- Slaughter, burn and bury affected animals.

Treatment

Nurse the animal by giving it antibiotics, multivitamins, fluids and electrolytes

4. Nutritional diseases

These are diseases that occur in animals due to either nutritional deficiencies or metabolic disorders.

(a) Milk fever

The disease is also known as *parturient paresis* . It affects dairy goats and ewes.

Cause

Low calcium level in the blood, a condition referred to as hypocalcaemia.

Susceptibility

This disease is more common in heavy milking dairy goats. It commonly occurs in goats that are extensively fed on feeds rich in proteins but low in calcium. Hence there is no adequate calcium replacement in the body compared to its removal through milk secretion. The condition is also likely to occur between the 3rd and 4th lactation when milk production is at its highest either a few days to parturition or a few days after.

Symptoms

These are observable within 12 – 72 hours before or after calving.

- Muscular twitching causing the animal to tremble.

- Staggering as the animal moves.
- Inability to stand. The animal lies down on its side most of the time.
- Dull and staring eyes with dilated pupils.
- Extremely feel cold to touch.
- Animal lies on the sternum with neck twisted on one side. This is called sternal recumbency.
- Breathing becomes slow and weak.
- Body temperature falls.
- General paralysis. The animal's body functions such as urination, defaecation and milk secretion stop. This is followed by death.

Control measures

- Feed animals on a diet rich in calcium especially during pregnancy and early lactating periods.
- Give intramuscular injection of calcium 2-3 days before calving.
- Dairy goats with past cases of milk fever should be partially milked for the first ten days that is, partial milking every two hours for the first few days. Then increase the milking level gradually until after 10 days. Thereafter carry out normal milking.
- Cull susceptible animals.

Treatment

- Injection of calcium borogluconate solution intravenously, calfojet or calcijet intramuscularly.
- Pump air into the udder to limit milk synthesis.

(b) Bloat

This disease is also called tympanites. The disease affects sheep and goats.
It is a condition in which gases accumulate in the rumen due to rapid fermentation of the feed eaten by the animal. The rumen becomes so distended that it compresses the lungs and other internal organs. It may result in death.

Cause

Bloat is caused by:

- Feeding animals with large amounts of legume and lush forage for example, cabbage leaves and lush grass. This causes rapid fermentation producing a lot of gas in the stomach faster than the gas can escape through the aesophagus.

- Abrupt change in feeds given to animals for example, from very dry feeds to very succulent feeds. Since the rumen is not used to the new feed, indigestion occurs.
- Blockage of oesophagus by large food particles such as potatoes, manigolds and carrots.
- Injury to the nerve supply of the rumen causes paralysis of the rumen.

Symptoms

- Distension of the left side of the abdomen due to gas or froth accumulation which can be felt by pressing with hand.
- Difficulty in breathing.
- Profuse salivation.
- Animal lies down and is unable to rise up.
- Grunting and kicking at the belly.
- Death within hours due to pressure on blood vessels, heart and lungs.

Control measures

- Provide dry roughages just before feeding the animal on green and succulent or wet pastures.
- Feed livestock on wilted grasses and pasture legumes.

Treatment

- Exercise the sick animal by walking it around. This will mix up the rumen contents and help in the escape of gases.
- Use medicinal oils as defrothing agents such as liquid paraffin or turpentine mixed with vegetable oil.
- Epsom salt can be used to empty the stomach since it acts as a laxative.
- A stomach pump can be used to remove the gas. The pump is inserted into the rumen through the oesophagus.
- In extreme cases, trocar and canula or sharp sterilised knife is used to pierce through the skin of the rumen. After piercing, the gases escape and the animal is relieved.
- Methyl silicone injected directly into the rumen to prevent frothing.

Practical Activity 9.1

1. Make a visit to a ranch or nearby livestock farm and learn more about livestock diseases and their management. Learn about the vaccination schedules for different animals.
2. Accompany the area livestock officer as he or she attends to a sick animal in the school neighbourhood.
3. Carry out vaccination of birds in the school poultry farm.

Revision Exercise 9 A

1. What is a disease?
2. State three disease-causing organisms in livestock.
3. Identify the major symptomatic difference between East Coast Fever disease and Nagana in cattle.
4. List animals which are attacked by the following diseases:
   (a) Foot rot.
   (b) Black quarter.
   (c) Anaplasmosis.
5. State any four predisposing factors for each of the following diseases:
   (a) Mastitis.
   (b) Scours.
   (c) Pneumonia.
6. What do you understand by proper carcass disposal?
7. Name any two farm animals that may suffer from milk fever.
8. (a) State the cause of milk fever in dairy goats.
   (b) State four symptoms of milk fever in a dairy goat.
9. How would you control anthrax?
10. Briefly outline the causes and control of bloat in sheep.
11. State three common protozoan diseases in livestock.
12. What is meant by the incubation period of a disease?
13. State the diseases caused by the following micro-organisms.
    (a) *Theileria parva* .
    (b) *Bacillus anthracis* .
    (c) *Iridovirus* .
    (d) *Paramyxovirus* .

Parasites of sheep and goats

Introduction

Parasites are organisms which derive part or all their nourishment from other organisms, referred to as, *hosts* . The host-parasite relationship is greatly beneficial to the parasite but harmful to the host. Sheep and goats suffer adversely as hosts to a variety of parasites. Discussed below are some of the effects of parasites on sheep and goats.

Effects of parasites on sheep and goats

- Some parasites compete with their host for food nutrients, for example, tapeworms and roundworms which affect sheep and goats.
- Some parasites pierce through and lay eggs in the skin of the host causing damages to the skin and predisposing the host to other infections for example, sheep mites.
- Some parasites feed on the body tissue of the host, for example, blood-sucking worms and protozoa, such as, *Trypanosomes* .
- Some parasites, such as the tapeworm, cause mechanical obstruction of internal digestive passages.
- Some parasites act as vectors of some diseases for example, ticks feed on the blood of animals and in the process, transmit various diseases, such as *Anaplasmosis* .
- Some parasites cause inflammatory reactions in their host causing irritation, and in extreme cases, death for example, lungworms, liverflukes and mites.

General symptoms of parasitic attack on livestock

- General emaciation (thinness).
- Slow live weight gain, even under proper feeding, resulting in retarded growth.
- Rough hair coat.
- Tendency to be pot-bellied.
- Swellings in the jaw region.
- In the case of blood-sucking worms such as tapeworms, animals suffer from anaemia, diarrhoea, loss of appetite and in severe cases, the host may die.
- Presence of the parasites on the body of the host.

Classification of parasites

Parasites are grouped into two classes depending on whether they live in or on the host:

1. **External parasites (Ectoparasites) :** Feed on the host externally that is, outside the body. In this category are mites and insects such as tsetse flies, lice and ticks.
2. **Internal parasites (Endoparasites) :** Live inside the body of the host. Included in this group are worms such as tapeworms and liverflukes.

External parasites

External parasites or ectoparasites are usually found on or under the skin of the hosts body. Examples are

- Lice.
- Ticks.
- Mites
- Tsetse flies.

Signs of infestation by external parasites

- Presence of parasite or eggs on or under the skin of the animal's body.
- Irritation of the skin.
- Loss of hair, fur, feathers and wool.
- Sores or wounds on the skin.
- Emaciation.
- Symptoms of some vector transmitted diseases for example, Anaplasmosis, Nagana.

Effects caused by external parasites

- Anaemia due to sucking of blood by the parasites for example, ticks.
- Protozoan diseases for example, East Coast Fever, Trypanosomiasis.
- Damage to skin for example, scabies in sheep.
- Death of host under heavy infestation.

1. Ticks

Ticks are common external livestock parasites responsible for the transmission of a number of serious livestock diseases. They also cause anaemia and damage the skin as a result of their bites.

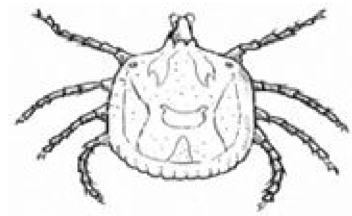


Fig. 9.1: A tick .

Types of ticks

There are two types of ticks:

(a) Soft ticks (*Argasidae*): have a tough leathery outer coating.

(b) Hard ticks (*Ixodidae*): have a hard, shield-like, covering at the upper surface in males. The females have a small area behind the head.
Hard ticks are more harmful to their hosts than soft ticks. Soft ticks undergo several nymphal stages in their life cycle, whereas hard ticks go through only one nymphal stage.

Tick control

There are several measures used to control ticks:

(a) Chemical dipping and spraying:

The chemicals used to kill ticks are known as **acaricides** **.** Tick control can be achieved by the application of acaricides once or twice a week depending on the seriousness of tick infestation. In order for the acaricide to give effective results, the dilution must be done according to the manufacturer's instructions. Do not over-dilute dipwash or spraywash. At the same time, the concentration should not be too high as it risks poisoning the animals.
Methods of acaricide application include:

- Dipping.
- Spraying.
- Hand-dressing.

The acaricide used must be of the correct strength and be applied to all body parts.

> ***Note:*** Hand-dressing involves application of acaricide by hand where spraywash may not reach for example, in the inner grooves of ears by use of pyegrease.

(b) Fencing

Tick control can be effectively practised where a farm is enclosed by a fence.

Fences restrict movement of animals, thus minimising the spread of ticks. Double fencing and use of zero grazing units ensure effective tick control.

(c) Rotational grazing

Where practised, rotational grazing reduces the build-up of ticks in pasture.

(d) Burning of infested pasture

Adult ticks, their eggs and moulting larvae and the nymphs, can be destroyed by burning infested pasture. These method is mostly used in range lands.

(e) Ploughing the land

This buries ticks deeply in the ground thus killing them.

2. Tsetse flies

Tsetse flies are blood-sucking insects which attack sheep and goats. They mainly inhabit humid, bushy areas and can be found under certain shade trees. Tsetse flies become active during the day (especially in the morning and evening), and attack by inflicting painful bites causing the animal to jump or run around in pain. Tsetse flies (*Glossina spp*) transmit trypanosomiasis (nagana) in livestock. Areas heavily infected with tsetse flies are unsuitable for human settlement and livestock keeping.

Control

The following measures are used to control tsetse flies:

- Clearing bushes in areas infested by tsetse flies.
- Spraying the infested vegetation with appropriate insecticides.
- Sterilization of the male tsetse flies by use of chemicals.
- Trapping of the flies using special nets treated with appropriate chemicals. The chemicals are usually laced with insect-attracting pheromones.
- Creating buffer zones near game reserves thereby preventing the transmission of infection from wild animals to livestock.

Fig. 9.2: Tsetse fly (Glossina spp.)

3. Mites

Mites are eight-legged, round-bodied and crawling arachnids. They are white in colour, and have dark legs. They burrow into the skin of the animal causing great irritation. Mites affect sheep and goats.

Control

Dipping or spraying animals.

Sheep scab

Sheep scab is caused by the mite *Psoroptes ovis* which lives on the skin of sheep.

Effects of attack

Mites pierce the skin and feed on the fluid which oozes from the wound.

Control

Successful eradication of the mite is through dipping of the flock in acaricide solutions. However, before dipping the animal should be cleaned with soap and water to remove dirt, skin debris and grease.

Fig. 9.3: Sheep affected by sheep scab .

4. Lice

These are wingless insects with a diamond shaped body which attack sheep. Lice are usually host- specific therefore, the ones that infest sheep are called **sheep lice.**

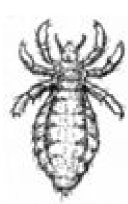


Fig. 9.4: Louse .

Sheep lice

Sheep lice feed on the head and hairy part of the lower body. The foot louse attaches itself on the foot and lower leg of sheep. The brown body louse sticks on the upper sides of the body.

Effects of infestation

Lice are a source of irritation to the livestock causing restlessness, constant scratching and rubbing of the animal against surfaces. This has the effect of interrupting feeding.

Sheep infected with lice:

- Lose vitality.
- Lose weight.
- May have retarded growth.

Control measures

A single dipping ensures effective control of lice. All sheep must be treated in the same dipping operation as one untreated animal can re-infect the entire flock.

5. Keds

Keds are tiny, hairy, wingless, blood-sucking flies. They mainly attack sheep.

Effects of infestation

They cause irritation and the sheep responds by scratching and kicking continuously at the infestation site. Eventually, the sheep and suffer from loss of appetite and weight. The keds excreta discolours the wool, lowering its quality.

Control measures

Keds can be controlled by dipping or hand spraying using the appropriate acaricides. It is advisable to first shear the sheep before dipping.

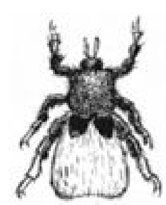


Fig. 9.5: Ked .

Internal parasites

The internal parasites are also referred to as endoparasites.
Endoparasite worms *(helminths)* can be divided into:

- Flatworms *(platyhelminthes)* for example, flukes.
- Roundworms *(nemathelminthes)* .

1. Flatworms

The flatworms can be grouped into:

- **Trematodes:** These are flatworms with flattened dorso-ventral bodies that is, the back and belly are close together. Trematodes are mostly hermaphrodite, that is, they possess both male and female reproductive organs.
- **Cestodes:** This group of flatworms have body sections with complete reproductive organs, with one nervous and excretory system continuous running through the body. The head part attaches the worm to the host of the body by hooks or suckers. The separate sections bud off one - by - one, making a long chain. Those sections farthest from the head are the oldest buds for example, tapeworms.

(a) The liver fluke *(Fasciola spp.)*

Liver flukes attack sheep and goats causing a disease called *fasciolasis* or *distomatosis* which results in weight loss in the affected animals. Flukes inhabit bile duct of the animal host and cause damage to the liver. Liverflukes are prevalent in low-lying, wet marshy lands or areas prone to flooding. The most important species of the liverfluke are *Fasciola hepatica* and *Fasciola gigantica* .

Fasciola hepatica is grey or grey-pink in colour, with a conical projection at the anterior end and a tapering body to the posterior. It has two suckers, one in the centre of the conical projection, and the other on the ventral surface close to the conical projection.

Effects of attack

- Digestive upsets due to blocking of bile duct.
- Swollen abdomen.
- Emaciation and, in extreme cases, recumbency leading to death.
- Anaemia occurs as a result of the destruction of liver tissues.
- Oedema in the jaws (swollen lower jaw).

Control measures

- Routine drenching with use of appropriate drugs. Use anthelminthic drugs for example, Nilverm.
- Destroy water snails by treating swampy water with copper sulphate.
- Fence off heavily infested swampy areas to prevent farm animals from grazing in such infested areas.
- Drain swampy areas within the farm.

Life cycle of liver flukes

The eggs enter the bile duct, are carried into the intestines and passed out in the faeces. In moderately warm temperature, the eggs hatch in water to produce the first larval stage called the **miracidium** (in about 9 days).

The miracidium swim in the water by means of cilia which cover the body. On coming in contact with the water snail, the intermediate host, they penetrate into the body. In the water snail, they develop into **sporocysts** **.** These reproduce asexually and multiply into **radiae** **.** They later develop into a larval stage called **cercarium** and further develop into metacercarium, which is the encysted infective stage.

Mature metacercariae, leave the snail and attach themselves onto grazing grass. They enter the definite (primary) host by ingestion when animals graze on infested pasture or drink contaminated water. Inside the body of the primary host, the metacercariae hatch into adult form, penetrate the intestinal wall and inhabit the liver where they develop for a period of 5 - 6 weeks. They then enter the bile duct and become sexually mature. The cycle takes about 6 - 7 weeks.

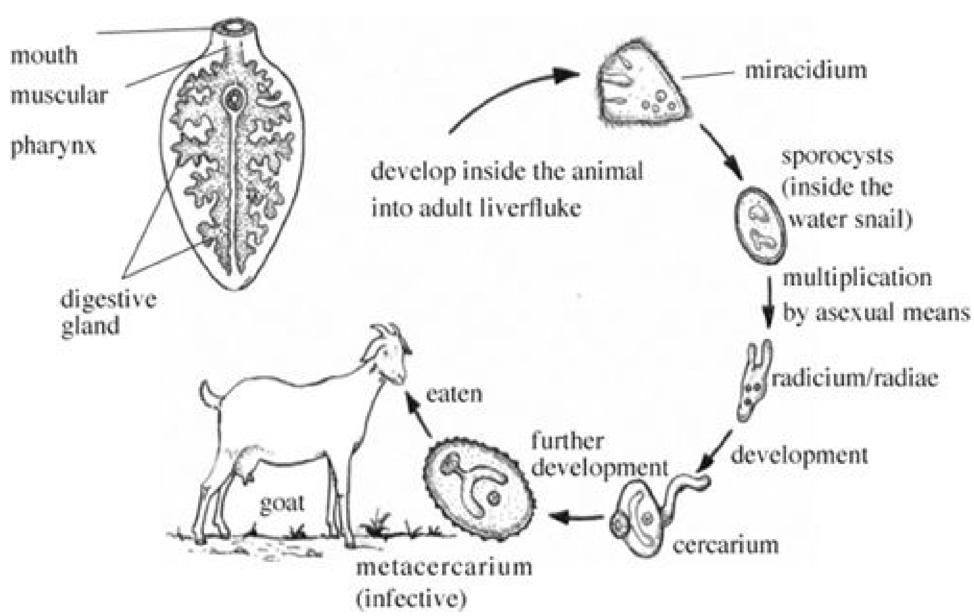


Fig. 9.6: The life cycle of liver fluke, Fasciola hepatica .

(b) Tapeworms *(Taenia spp.)*

A tapeworm consists of a head (**scolex**) and a chain of body segments referred to as **strobila .** Each segment is called a proglottid. The scolex possesses suckers and hooks for attachment onto the host. The proglottids have a common nervous system and a rudimentary excretory system. Each proglottid has its own male and female sex organs. Tapeworms affect humans, as well as, livestock such as cattle, sheep, goats, and pigs. The two most common tapeworm species that affect livestock are: *Taenia saginata* and *Taenia solium* . Tapeworms *(Taenia spp)* are host-specific, such that, *Taenia saginata* (the beef tapeworm) affects cattle only, where as, *Taenia solium* (the pork tapeworm) only affects pigs.

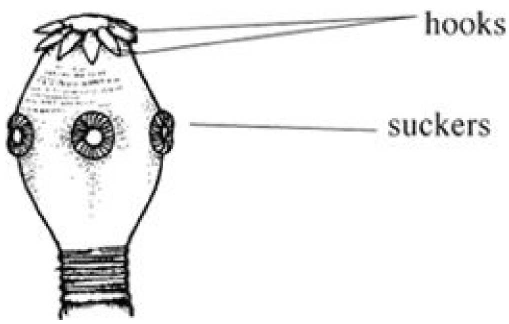


Fig. 9.7 (a): Tapeworm head (scolex) .

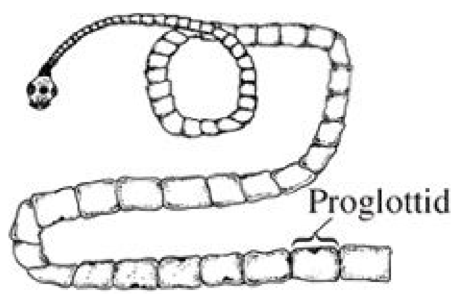


Fig. 9.8 (b): Strabila .

Life cycle of tapeworms

The life cycle of tapeworms starts with the passing out of eggs in the faeces. The eggs are usually passed out while still intact in the proglottids which break off from the rest of the strobila. The proglottids degenerate on the grass, leaving the uterus to remain as a sac containing the embryonated eggs. The sac bursts open releasing the eggs which are eaten by the intermediate host (cow or pig).

Within every egg, an embryo, known as the **oncosphere** develops, transforming into a bladderworm. The bladderworm hides within the muscle tissue of the animal. Sometimes, the bladderworm buds off giving rise to many bladderworms. The hidden bladderworms remain within the muscles of the intermediate host. When the intermediate host is slaughtered and its meat consumed raw by man (the primary host), the bladderworms become active. They attach themselves to the intestine walls feed and develop into adult tapeworms.

Effects of tapeworm attack

(i) Rough hair coat.

(ii) Digestive disturbances, for example, diarrhoea and occasional constipation.

(iii) Pot belly.

(iv) Anaemia (lack of blood).

(v) Oedema.

(vi) Egg segments or proglottides in the faeces.

Control measures

- Routinely deworm animals using appropriate drugs, such as *Nilzan* .
- Plough the pasture land to kill the cysts.
- Proper disposal of human waste for example, use of latrines.
- Proper cooking of meat.
- Rotational grazing.
- Proper meat inspection.

2. Roundworms *(Ascaris spp.)*

These are usually cylindrical in shape and pink-white in colour. They exist separately as male and female sexes. Roundworms inhabit the alimentary canal of livestock. Livestock affected are cattle, sheep, goats and pigs.

The common species of roundworm are *Ascaris lumbricoides* (affect cattle and sheep), *Ascaris suum* (attack pigs) and *Ascaris galli* (affect poultry).

The life cycle of roundworms

The roundworm may exhibit two different life cycles that is, **direct** or **indirect.**

- In the **direct** life cycle, eggs hatch into larvae which are free-living, enter the host through food, or penetrate through the skin.
- In the **indirect** life cycle of *Ascaris spp* , the infection may occur through any of the following ways:

- Eggs hatch into larvae in the open ground which are then picked by an intermediate host. When the primary host feeds on this intermediate host, they get infected.
- Larvae from hatched eggs penetrate through the skin of an animal and develop within the intermediate host. Blood-sucking animals then ingest them (they act as carriers or vectors) during the feeding and the larvae continue to develop inside the carrier. These vectors will transmit the larvae to the primary hosts when they bite them. The larvae then develop inside the primary host to maturity.

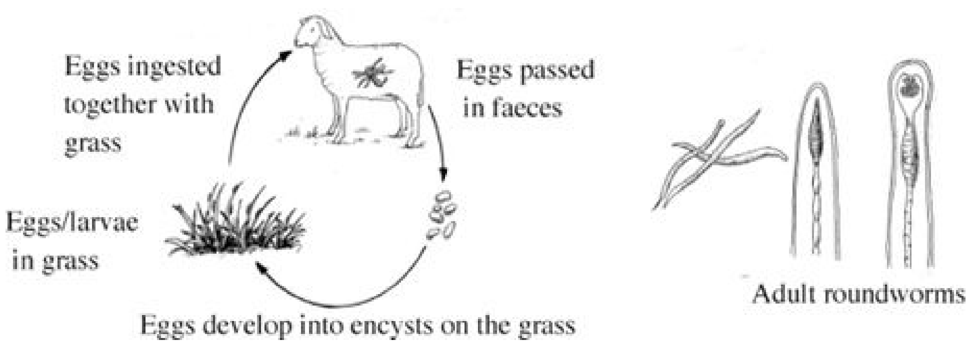


Fig. 9.9: Life cycle of roundworms (Ascaris lumbricoides) .

The life cycle of roundworms (Ascaris lumbricoides)

Eggs laid in the intestines of primary host are passed out in the faeces. On the ground, they hatch into infective larvae. This infective stage is called **encyst** and is resistant to adverse environmental conditions. The **encysts** are found on grass whereby they are picked (ingested) by a grazing animal. They then bore through the intestinal walls into the blood stream and are carried by the circulating blood into the heart or lungs where they penetrate into the trachea. They are then coughed out into the mouth or re-swallowed.

In the intestines, they develop into adult worms and start another cycle. Male and female worms mate and upon fertilization, the females lay eggs.

Signs and symptoms of roundworm attack

- Retarded growth.
- Scours.
- Anaemia.
- Pot belly appearance.
- Stiff dry coat.
- Diarrhoea.

- Constipation.

Control measures

- Avoid grazing animals on muddy grounds.
- Avoid grazing animals on wet grass early in the morning when the larvae are active.
- De-worm animals using appropriate drugs for example, *Nilverm* .

Control of diseases and parasites in sheep and goats

(i) Vaccination

Vaccinate the goats as per recommendations of the veterinary officer against anthrax, foot and mouth disease and tetanus.

(ii) Control of mastitis

Goats with mastitis should be milked last to prevent the spread of infection to other goats as mastitis can cause a reduction in yields of at least 10%. After milking, use a teat dip containing a suitable antiseptic.

(iii) Foot trimming

Overgrown hooves predispose foot rot infection. They also cause lameness in goats and make them unable to walk properly. Routine hoof trimming should be done.

(iv) Dosing and drenching

Goats should be drenched on a routine basis once or twice a year, normally at the onset of rains. Internal parasites can be controlled through giving drugs especially just before and after kidding. Kids should be dosed 2-3 weeks after birth and then once a month thereafter. However, parasite infestation can be reduced through the following management practices:

- Clean housing where no dung or dirt, wet bedding is allowed to accumulate.
- Clean water supply which has not been fouled by goats.
- The grazing area should be changed every 4-5 days and not be grazed again for about six weeks.
- The danger of taking up parasites while grazing is bigger early in the morning while the grass is still wet.
- Infestation is higher in wet weather (or on wet ground) than in dry weather (or on dry ground).

(v) Dipping or spraying

Dip or spray the goats against ticks regularly. Use a sheep and goats plunge dip. Ticks can also be controlled through rotational grazing in case of intensive system.

The external parasites of sheep

Sheep ticks

Ticks are grouped as *Ixodidae* (hard ticks) and *Argasidae* (soft ticks). The hard ticks found in sheep are *Ixodes spp. Rhipicephalus spp. Ambylomma spp. Hyalomma spp. Haemophysalis spp. Boophilus spp* . and *Dermacentor spp* . The soft ticks are *Ornithodorus spp* . and *Otobius spp* .

The hard ticks feed as larvae, nymphae and adults, there being a moult after the larval and nymphal stage. These ticks may conveniently be placed in three classes:

1. One-host ticks ; the entire parasitic life-cycle is spent on one host for example, *Boophilus spp* .
2. Two-host ticks ; the larvae and nymphae infest one host and the nymphal moult occurs on the ground. The adults seek a second host on which to feed for example, *Rhipicephalus evertsi* and *Hyalomma spp* .
3. Three-host ticks ; all three stages parasites separate hosts and each moult takes place on the ground for example, *Rhipicephalus appendiculatus, Ixodes ricinus* and *Amblyomma spp* .

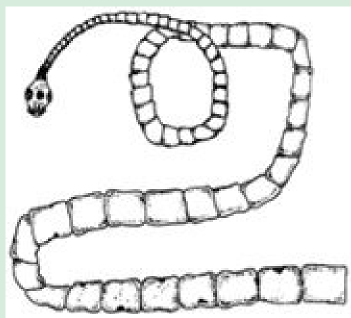
Ticks adversely affect sheep production through direct injury and blood loss, by the introduction of toxins and by the transmission of disease organisms. Toxins introduced by the female tick as she feeds may cause paralysis and death. A wide variety of bacterial, protozoal, viral and rickettsial diseases are transmitted by ticks to sheep.

Practical Activity 9.2

1. Study and identify the various ticks found on the livestock in the school's neighbourhood.
2. Visit a slaughter house near the school and observe any internal parasites, especially liverfluke, in the carcasses.
3. Practice control of parasites using the animals reared on the school farm.

Revision Exercise 9 B

1. State four non-chemical methods of controlling ticks in sheep and goats.
2. State three symptoms that may be observed in an animal attacked by liverfluke.
3. Name the causal agent for each of the following diseases.
   (a) Anaplasmosis.
   (b) Trypanosomiasis.
4. Study the diagram below and answer the questions that follow:



   (a) Identify the parasite.
   (b) How is the parasite passed from livestock to human beings?
   (c) State two methods by which this parasite can be controlled.
5. State four signs of infestation by external parasites in livestock.
6. Name an intermediate host for each of the following internal parasites:
   (i) Tapeworm (*Taenia saginata*).
   (ii) Liverfluke (*Fasciola hepatica*).

Topic 4: Agricultural Marketing

Unit 10 : Marketing Forces

Unit 11 : Marketing Channels and Agencies

Unit 12 : Effects of Population Distribution on Marketing

Unit 10 Marketing Forces

Objectives

By the end of this unit, you should be able to:

(a) Define and differentiate the terms price elasticity of demand and supply .

(b) Choose an appropriate entreprise combination .

(c) Calculate the price elasticity of demand and supply for tomatoes .

(d) Explain the degrees of price elasticity of demand and supply .

(e) Describe the significance of different degrees of price elasticity of supply and demand .

Introduction

For most farmers, it is normally assumed that agricultural production is complete upon harvesting the produce. However, the goods and services produced must reach the consumers for successful agricultural production. The various processes involved in ensuring that the produce reaches the consumers constitute agricultural marketing. Agricultural marketing is carried out by various agents and organisations.

Elasticity of demand (Ed)

When there is a change in the price of a commodity, the demand is expected to change. The extent to which the demand changes in response to change in price varies. The measure used to determine this response is known as **elasticity of demand** . Therefore, elasticity of demand can be defined as *the sensitivity of demand to change in price or degree of responsiveness of demand to change in price* .

Elasticity of demand (E_d) can be calculated using the following formula:

$$E_d = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

where Δ Q is change in quantity demanded.

Δ P is change in price.

P is the original price before the change.

Q is the original quantity demanded before the change.

Example: Below is a demand schedule for tomatoes in a market.

Price (MK) kg	Quantity demanded (kg)
20	200
16	300
12	400
8	500
4	600

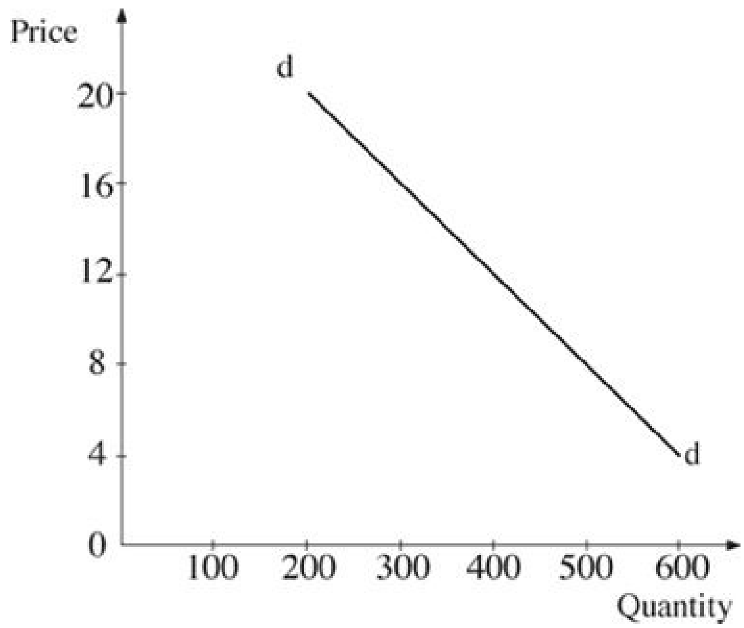


Fig. 10.1: Graph showing demand schedule for tomatoes .

Elasticity of supply (Es)

Elasticity of supply (E_s), is the measure of the level of response of supply to change in price, that is, it is the sensitivity of supply to changes in price.

Elasticity of supply is calculated using the following formula:

$$E_s = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

where ΔQ = change in quantity supplied.
ΔP = change in price.

P = the initial price.
Q = the initial quantity supplied.

Differences between elasticity of demand and elasticity of supply

Elasticity of demand	**Elasticity of supply**
• When the price rises the demand decreases that is the consumers decline to buy more when the price rises.	• When the price rises the supply increases that is the suppliers will be willing to supply more when the prices are favourable.
• The response of demand to an increase in price is higher than the response due to a decrease in price.	• The response of supply to an increase in price is higher than the response due to a decrease in price.
• The response to change in price is immediate because the market forces and commodities are readily available.	• The response to changes in price takes long because of the long duration of production.

Elasticity of demand for tomatoes

i) Increases from MK. 16 to MK. 20.

$$E_d = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

$$= \frac{(300 - 200)}{(20 - 16)} \times \frac{16}{300}$$

$$= \frac{100}{4} \times \frac{16}{300} = 1.33$$

ii) Decreases from MK. 8 to MK. 4.

$$E_d = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

$$= \frac{(600 - 500)}{(8 - 4)} \times \frac{8}{500}$$

$$= \frac{100}{4} \times \frac{8}{500} = 0.4$$

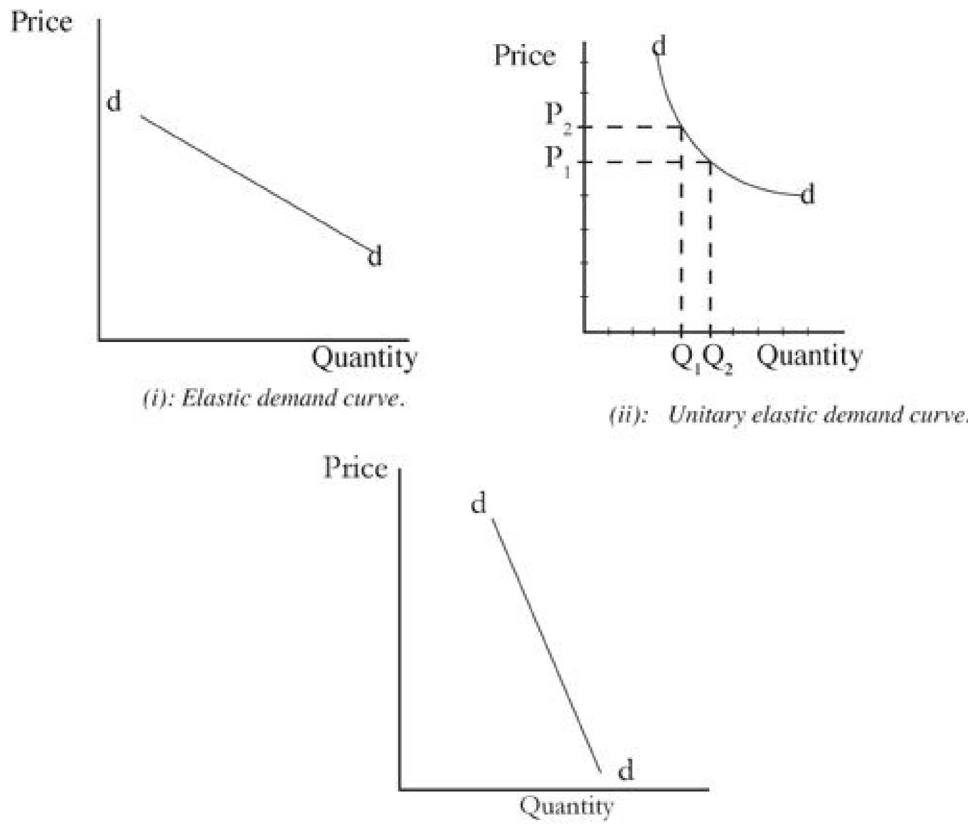
Note: The positive or negative sign in the calculation of elasticity demand should be ignored.

From the above calculation, the response of demand to an increase in price is higher than the response that is as a result of a decrease in price. If elasticity of demand (E_d) is more than one (1), it shows that a slight change in price brings a relatively bigger change in the quantity demanded. Such a demand is said to be **elastic.**

If elasticity of demand (E_d) is less than one, it shows that a change in price does not bring about a noticeable change in quantity demanded. Such a demand is said to be **inelastic.**

When E_d is one (1), it indicates that a change in price of a commodity results in an equivalent change in the quantity demanded. Such demand is said to be **unitary.**

Most agricultural commodities have an inelastic demand. This is because they are basic commodities and an increase in price may not greatly affect their demand. If the price of the commodities fall, their consumption may rise only very slightly. Commodities such as beer and cigarettes exhibit inelastic demand while luxury goods such as cars, television and radios depict elastic demand.



(i): Elastic demand curve.

(ii): Unitary elastic demand curve.

(iii) Inelastic demand curve.

Fig. 10.2: Graphs showing the different types of demand .

The price elasticity for demand and supply of tomatoes

Price (MK/kg)	20	24	28	32	36	40
Quantity supplied (kg)	200	250	290	320	350	375

Table. 10.1: Supply schedule for tomatoes .

Elasticity of supply E_S when the price:

i) Increases from MK. 20 to MK. 24.

$$E_S = \frac{\triangle Q}{\triangle P} \times \frac{P}{Q}$$

$$= \frac{(200 - 250)}{(24 - 20)} \times \frac{20}{100}$$

$$= \frac{50}{4} \times \frac{20}{100} = 1.25$$

ii) Decreases from MK. 36 to MK. 32.

$$E_S = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

$$= \frac{(350 - 320)}{(36 - 32)} \times \frac{36}{350}$$

$$= \frac{30}{4} \times \frac{36}{350} = 0.77$$

The response of supply to an increase in price is higher than the response due to a decrease in price.

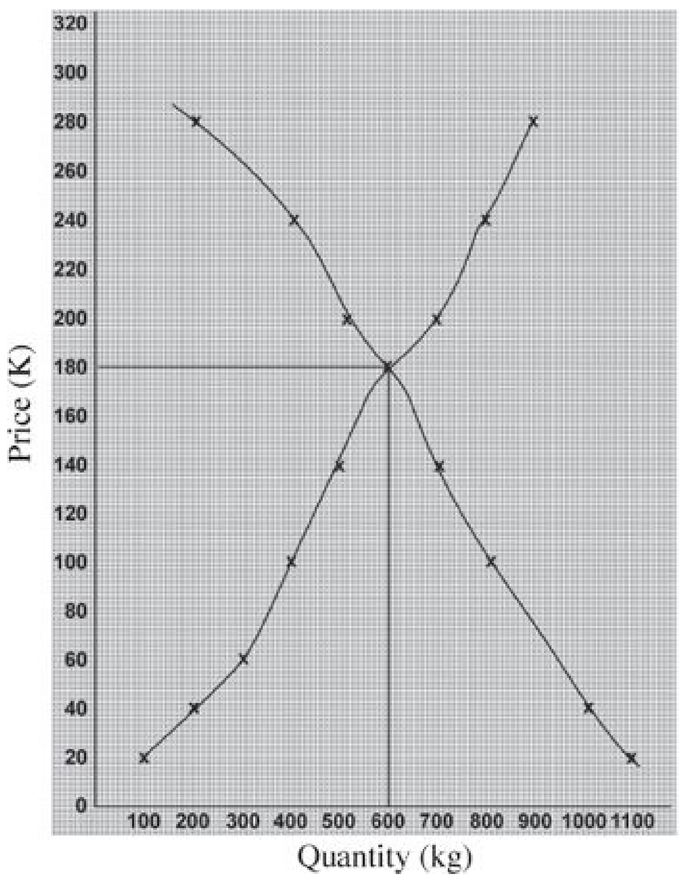


Fig. 10.3: Graph showing supply curve .

Degrees and significance of price elasticity of demand and supply

Elasticity of supply can be classified into three types:

i) Inelastic supply

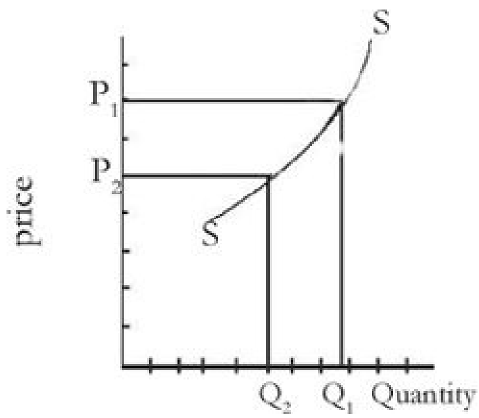


Fig. 10.4: Graph showing inelastic supply curve .

This is when the elasticity of supply (E_S) is less than one. When changes in price bring about very slight changes in supply, the supply is said to be **price inelastic.** The supply curve is very steep. This is the type of supply exhibited by agricultural goods.

When the price increases, the quantity supplied cannot increase indefinitely. This is because most of the products have a long duration of production. On the other hand, when price decreases, the quantity supplied cannot be reduced indefinitely as the commodities are highly perishable.

ii) Unitary elastic supply

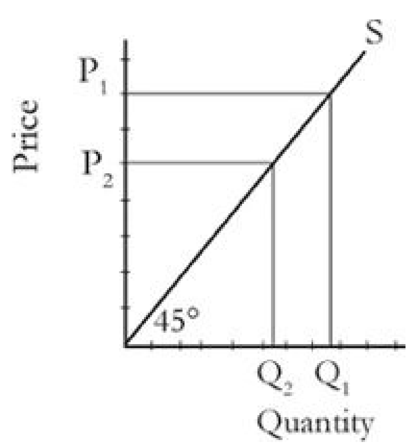


Fig. 10.5: Graph showing unitary elastic supply curve .

This occurs when a change in price brings a change in supply in equal proportions, that is, the value of the elasticity of supply E_S is equal to 1. The supply curve is a straight line and cuts both axes at an angle of 45°. Unitary elastic supply is common with goods which can easily be stored as buffer stock for example, cereals.

iii) Elastic supply

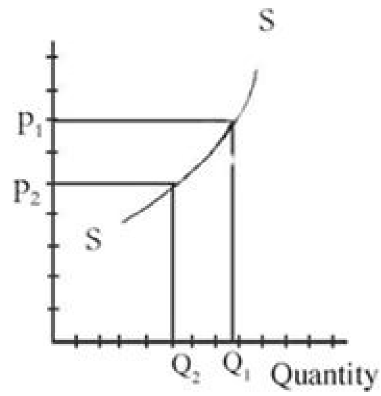


Fig. 10.6: Graph showing elastic supply .

The elasticity of supply (E_S) is said to be elastic when the change in supply is more than one (1). When price increases, the quantity supplied increases at a higher proportion. If price falls, the quantity supplied falls at a greater proportion such that the supply curve is less steep. Elastic supply is common with products which can be produced fairly fast when there is price increase or those which can be withdrawn from the market and stocked when the price falls, for example, manufactured goods such as umbrellas.

Revision Exercise 10

1. Define the term ‘market’.
2. Define the following types of market structures:
   (a) Perfect market.
   (b) Monopoly.
   (c) Oligopoly.
   (d) Monopsony.
3. Define the term ‘demand’.
4. State the law of demand.
5. Distinguish between the demand schedule and demand curve.
6. Describe the factors that influence demand of agricultural goods and services.
7. Define elasticity of demand.
   (a) If the elasticity of demand is greater than one, what does this show?
   (b) Describe the type of demand with an elasticity of demand greater than

one.

(c) If the elasticity of demand is one, what does this show?

(d) Describe the type of demand with an elasticity of demand of one.

(e) If the elasticity of demand is less than one, what does this show?

(f) Describe the type of demand with an elasticity of demand of less than one.

(g) Complete the table below showing demand schedule of tomatoes. Show your working.

Price (MK/kg)	**Quantity demanded (kg)**	**Elasticity of demand**
10	200	
8	300	
6	400	
4	500	
2	600	

8. Define the term 'supply.'
9. State the law of supply.
10. Distinguish between the supply schedule and supply curve.
11. Define 'elasticity of supply.'

(a) If the elasticity of supply is greater than one, what does this show?

(b) Describe the type of supply with an elasticity of supply of greater than one.

(c) If the elasticity of supply is one, what does this show?

(d) Describe the type of supply with an elasticity of supply of one.

(e) If the elasticity of supply is less than one, what does this show?

(f) Describe the type of supply with an elasticity of supply of less than one.

Unit 11 Marketing Channels and Agencies

Objectives

By the end of this unit, you should be able to:

(a) Explain the meaning of the terms 'marketing channels' and marketing agencies .

(b) List marketing channels and marketing agencies .

(c) Explain the roles of channels and agencies in marketing of agricultural commodities .

(d) Explain the meaning of marketing costs and marketing margin .

(e) Relate marketing costs and marketing margins .

Marketing channels

Marketing refers to all the processes involved in the transformation and flow of goods and services from the farm to the consumer. The processes involved in marketing are known as **marketing channels** **.**

The marketing channels include:

i) Buying and assembling

Most traders buy agricultural produce either in small quantities or in large quantities from farmers and store in warehouses for sale later on. The buying is usually carried out by individual traders or marketing boards. These produce is usually assembled in the stores.

ii) Selling

This refers to the activities that assist in presentation of the product to the consumer for eventual buying. Selling involves bargaining for better prices and displaying the produce in the market. Selling is only complete when the consumer accepts the product and pays for its value.

iii) Transportation and distribution

This is the physical movement of the products from one point to another.

The produce may be transported from:

a) Buying centres to the factory for processing.

b) Buying centres to the consumers either within or outside the country.

c) Processing factories to the wholesalers or retailers.

Distribution ensures consumers get the produce at the right time and within easy reach.

iv) Packing

Packing refers to putting produce in containers such as sacks, crates, boxes or baskets. Packing aims at facilitating transportation of the produce, protects the produce against damage and bad weather conditions, prevents theft and adulteration. Packing also assists in quantification of produce into appropriate weights or amounts which can be easily handled.

v) Storage

Agricultural produce is seasonal. It is characterised by excess supply during harvesting and scarcity during inter-harvest periods. To ensure availability of the produce between harvest seasons, storage is necessary. Storage protects the produce against damage by pest and from deterioration due to bad weather. It also allows agro-based industries to get raw materials throughout the year or throughout the manufacturing period.

vi) Processing

This refers to changing the state of a product into a more acceptable or usable form. For example, wheat is ground into flour where raw milk changed into powder milk, yoghurt or cheese, hides and skin into leather. Processing also increases the shelf life of most produce and allows consumers to choose a wide variety of forms for certain produce, for example, fresh meat or canned meat.

vii) Grading and standardisation

Grading refers to sorting the produce in terms of quality. It makes it easy to assign a price tag to the produce depending on its quality. Grading enables consumers to buy the quality they prefer. Grading is usually done according to various market standards.

viii) Advertisement

This is the art of informing, stimulating and educating the consumer on the particular product. The consumers are made aware of the presence and advantages of a particular commodity in the market. Advertisement aims at persuading the consumer to buy the product at the expense of competing products.

ix) Packaging

This is carried out after processing of the produce. Packaging is the wrapping of the produce with the materials in which it is finally presented to the consumers to buy. Packaging eases transportation of a product and makes the product presentable to consumers. Packaging also helps to keep the product safe from any contamination.

x) Collection and analysis of market information

This involves gathering information on the market situation for particular products. The information aids in price determination, where and when to sell or buy. This helps to sell the produce at the best price in the markets.

xi) Financing

Capital is needed to finance all the market functions right from purchase of the raw materials to the final sale of the finished goods. After procuring goods, marketing agencies need time to prepare them for the consumer before they can earn any returns. Sometimes, farmers expect to be paid before the produce is sold. Marketing agencies therefore require money to carry out various activities.

xii) Risk bearing

The time period between buying of the produce, that is, raw materials from the farmer to the time when it is sold may sometimes be very long. During this period, other unforeseen happenings can occur, for example, price fluctuations, change in government policy, theft of the produce or change in consumers preferences. Therefore, it is prudent for the marketing agency to be ready for such risks. Some of these risks can be insured against by purchase of insurance premiums.

Types of marketing channels

In Malawi marketing channels are involved in the transformation and flow of goods and services from the farmer to the consumer. This include:

(i) One tier.

(ii) Two tier.

(iii) Three tier.

(iv) Four tier.

One tier

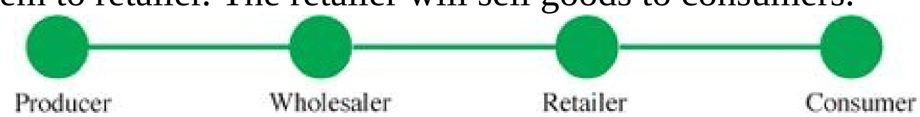
This is the process where the consumers buy goods directly from the producers.

Two tier

This is marketing channel that involves middlemen who buy goods from the producer and sell them to consumers.

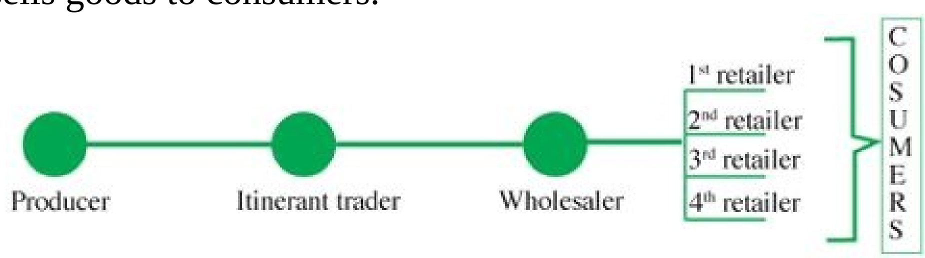
Three tier

This is a marketing channel where the wholesaler buys goods from the producer and sell them to retailer. The retailer will sell goods to consumers.



Four tier

This is a marketing channel where itinerant traders buy produce from the farmer and sell them to the wholesalers. The wholesalers then sell to the retailers and the latter sells goods to consumers.



Marketing agencies

These are organizations which carry out one or more of the marketing functions.

(i) Marketing boards for example, ADMARC.

(ii) Co-operatives.

(iii) Processors.

(iv) Itinerant traders.

(v) Wholesalers.

(vi) Retailers.

(vii) Commission agents and brokers.

Roles of ADMARC

- They plan, monitor and regulate crop production.
- They license crop production for example, tobacco.
- They regulate and control the quality and supply of planting seeds.

Co-operatives

These are societies and unions which help farmers to market their produce for example, Tobacco Association of Malawi.

Roles of co-operatives

- Carry out all marketing functions on behalf of the farmers.
- Provide short-term credit facilities to their members. This may be in terms of inputs or cash loans payable by the end of the production period.
- Negotiate for fair prices for both input purchase and sale of farmers produce.
- Distribution of farm inputs to their members.
- Provide extension services and machinery hire services to their members.
- Advise their members on new and better methods of production.
- Keep records on all activities of the co-operative and inform the members accordingly during annual general meetings.
- Pay dividends to their members.
- Some provide banking services to their members.
- Some invest money on behalf of the farmers.

Roles of processors

These are public or private manufacturing companies. They process agricultural produce and sell them on behalf of the farmers.

Roles of itinerant traders

They are referred to as middlemen. They buy produce from farmers and sell them either to the ultimate user or processors.

Role of wholesalers

These are individuals or organization who buy goods in large quantities from the producers or processors and sell them to retailers.

Role of retailers

These are traders who buy goods from wholesalers and resell to consumers. For example, butcheries, supermarkets and green grocers.

Role of commission agents and brokers

These are traders who assist in buying or selling of produce at a fee on behalf of producers and buyers; they have specialized knowledge of the market.

Brokers do not handle the goods but negotiate for sales and bring the buyers and sellers together.

Marketing costs and margins

These are expenses incurred by marketing agencies.
Costs are all of the expenses incurred in organizing and carrying out marketing process. It is the charge which should be made for many marketing activities for example, assembling, transport, storage, grading, processing, wholesaling and retailing which are the stages in marketing channel and involve expenses.

The actual costs for any commodity will depend on circumstances for example, distance in between production and consumption and the state of the roads, the bulkiness or value-to-weight ratio of the crop, perishability, the length of storage period and the amount of processing and packaging that is required.

There are several types of costs.

Concept of cost

Cost is the price paid for goods and services used in a production process. It is arrived at by multiplying the quantity of input factor used by the unit price of the input factor.

(a) Types of cost:

(i) Fixed Costs (FC)

These are costs of inputs which do not vary with the level of production, for example, rent of land, depreciation of machinery and salaries of permanent labourers.

(ii) Variable Costs (VC)

These are costs of inputs which vary with the level of production, for example, cost of feeds, cost of fuel, cost of fertilizers and wages of casual labour.

(iii) Total Costs (TC)

This is the sum total of all fixed costs (FC) and all variable costs (VC).
TC = FC + VC.

(iv) Average Cost (AC)

This is the total cost (TC) divided by the number of units of output (Y).

$$AC = \frac{TC}{Y} = \frac{FC + VC}{Y}$$

(v) Average Variable Cost (AVC)

This is the total variable cost divided by the units of output realised.

$$AVC = \frac{VC}{Y}$$

(vi) Average Fixed Cost (AFC)

This is the total fixed cost divided by the number of units of output realised.

$$AFC = \frac{FC}{Y}$$

(vii) Average Total Cost (ATC)

This is the sum of average variable cost and average fixed costs.

ATC = AVC + AFC.

(viii) Marginal Cost (MC)

This is the extra cost incurred in the production of an additional unit of output. It is indicated by the change in variable cost divided by the change in output (Y).

$$MC = \frac{\text{Change in VC}}{\text{Change in Y}} = \frac{\Delta VC}{\Delta Y}$$ where Δ (delta) means change

Marketing margin

In marketing of the produce, once the structure of a marketing channel has been established, then it is easy to collect information on the price at which the product is bought and sold at each stage in the marketing process. With a product that remains essentially unchanged during the marketing process, the difference between the price per unit of that product at the farm gate and the price per unit when sold to the final consumer (the retail price) is termed as the total gross margin or the total price spread. The farm gate price can be shown as the percentage of the retail value, that is,.

$$\frac{\text{Farm gate price} \times 100}{\text{Retail price}} = \text{farmer's share (in percentage)}$$

Margins can be calculated for each stage in the marketing channel. For instance, a farmer-wholesaler or wholesaler-retailer gross margin can be calculated. A marketing margin represent the charge which organizations make for providing marketing services.

Relationship between marketing costs and marketing margins

The aim of every farmer is to get high profits. In any production process, profit is maximum when marginal cost is equal or almost equal to the marginal revenue. Profit relates directly to cost of production and the revenue realised (income realized).

Total revenue in production is calculated by multiplying the total product by the unit price of the product. From the total revenue one can calculate the net revenue by subtracting total cost from total revenue. This is the profit of the production, that is, marketing margin. See the example below.

Example

Total Yield of crop in (kg)	Price per kg	Total income Revenue (MK)	Total Cost of Production (MK)	Marketing Margin (MK)
Maize 1000(kg)	MK. 200	MK. 200,000	MK. 100,000	MK. 100,000
Tobacco 500(kg)	MK. 300	MK. 150,000	MK. 80,000	MK. 70,000
Beans 100(kg)	MK. 400	MK. 40,000	MK. 30,000	MK. 10,000

Revision Exercise 11

1. Define the term marketing.
2. Describe the factors that influence supply of agricultural goods and services.
3. Suggest solutions to marketing problems faced by the agricultural industry.
4. What are marketing functions?
5. Explain the marketing problems a dairy farmer faces in Malawi.
6. Define the terms:
   (a) Marketing channels.
   (b) Itinerant traders.
7. Discuss the processes that are involved in the transformation and flow of goods and services from the farm to the consumer.
8. Describe the four marketing channels in Malawi.

Unit 12 Effects of Population Distribution on Marketing

Objectives

By the end of this unit, you should be able to:

(a) Describe the population distribution in Malawi .

(b) Describe the effects of population distribution on marketing .

Population distribution in Malawi

Population distribution refers to the arrangement or spread of people in a given area or how the population of an area is arranged according to variables such as age, race or sex.

Malawi's population was estimated at 12,105,000 by the United Nations in 2003. The annual population growth rate from 2000 – 2005 was 2.01% with the projected population for the year 2015 at 15,65,000. The population density in 2002 was 92 per sq. km, one of the highest in Africa. It was estimated by the Population Bureau that 25% of the population lived in urban areas in 2001. The capital city, **Lilongwe,** had a population of 765,000 in that year. Other cities include **Blantyre** (331,588), **Mzuzu** (44,238) and **Zomba** (42,878). According to the United Nations, the urban population growth rate for 2000 – 2005 was 7.3%.

The population growth is 1.61% per annum.
Other factors which affect population growth are:

- Diseases.
- Chronic malnutrition.

Population distribution by gender of age 18 years and over by region and districts

Below is a table depicting population distribution in Malawi as per the census in 2008.

	Age		
District & Region	**Total 18+**	**Male 18+**	**Female 18+**
Malawi	**9,096,617**	**4,396,788**	**4,699,829**
Northern Region	**798,221**	**378,905**	**419,316**
Chitipa	80,166	37,579	42,587
Karonga	126,494	59,481	67,013
Nkhatabay	101,179	47,755	53,424
Rumphi	79,947	38,552	41,395
Mzimba	338,817	158,782	180,035
Mzuzu City	66,665	34,502	32,163
Likoma	4,953	2,254	2,699
Southern Region	**2,807,362**	**1,321,933**	**1,485,429**
Mangochi	370,500	170,248	200,252
Machinga	224,339	103,487	120,852
Zomba Rural	276,396	127,749	148,647
Zomba City	46,240	24,657	21,583
Chiradzulu	141,584	63,104	78,480
Blantyre Rural	163,952	77,806	86,146
Blantyre City	344,513	181,715	162,798

Mwanza	44,184	20,746	23,438
Thyolo	280,441	128,095	152,346
Mulanje	253,003	112,911	140,092
Phalombe	145,851	66,617	79,234
Chikwawa	208,078	102,155	105,923
Nsanje	111,209	51,718	59,491
Balaka	147,195	67,283	79,912
Neno	49,877	23,642	26,235
Central Region	**5,491,034**	**2,695,950**	**2,795,084**
Kasungu	616,085	306,768	309,317
Nkhota Kota	301,868	149,721	152,147
Ntchisi	224,098	109,349	114,749
Dowa	556,678	272,732	283,946
Salima	340,327	166,779	173,548
Lilongwe Rural	1,228,146	599,955	628,191
Lilongwe City	669,021	339,030	329,991
Mchinji	456,558	227,373	229,185
Dedza	623,789	297,676	326,113
Ntcheu	474,464	226,567	247,897

Source: Preliminary report of population and house and census 2008 by National Statistical Office P.O. Box 333, Zomba Malawi .

Note: The results also show that a district level, the highest percentage of the population live in Lilongwe followed by Mangochi. The district with the least populations is Likoma.

Effects of population distribution on marketing

- *Direction of flow of commodities;* products will be moved to areas with large populations because of the ready market.
- *Mode of transport, in areas where the population is low;* transport could be carried out in small carts while in populated areas use better mode of transport due to the bulky nature of the products.

- *Length of marketing channels;* areas with large population, the marketing channels involves many agents making the marketing process lengthy.
- *Quantity of the products;* more products will be taken to areas with high population and vice versa.
- *The range and form of the product needed;* large population have various need hence great variety of products is marketed.

Practical Activity 12.1

Visit the local market and make observation of the effect of price on certain commodities for example, bread. Write a report of the observation.

Revision Exercise 12

1. Define the following terms:
   (a) Elasticity of demand.
   (b) Elasticity of supply.
2. Explain the relationship between marketing costs and marketing margins.
3. Explain what happens to the demand when the price of a commodity changes.
4. Use the supply schedule for tomatoes below to calculate the elasticity of supply when the price changed from MK20 to MK24.

Price MK/kg	20	24	28	32	36	40
Quantity supplied kg	200	250	290	320	350	375

5. List four marketing channels in Malawi.
6. Explain the term enterprise combination.
7. List the marketing agencies in Malawi.

Topic 5: Farm Business Management

Unit 13: Farm Records

Unit 13 Farm Records

Objectives

By the end of this unit, you should be able to:

(a) State the reasons for keeping records .

(b) Describe the types of farm records .

(c) Keep records .

(d) Identify factors considered when selecting enterprise contribution .

Farm records

A **farm record** is a set of information stored or retained by the farmer about farm events as they occur in the farm business.

It is permanent information about the farm kept for future reference. This information must be collected, stored and analysed properly. It may then be used in the decision making process for example, in farm planning.

Just like any other business, farming aims at maximising profit. This is only possible through keeping of accurate records of all farm transactions and the analysis of these records.

Record keeping will prevent guessing or estimating in the farming business. This is because the records kept are precise, concise, complete, and show actual amounts, weights and measurements.

Reasons for keeping farm records

Farm records are kept for the following reasons:

- Provide a history of what has been happening on the farm. This can be used for comparison purposes.
- Help in planning and budgeting. This will enable the farmer to make appropriate choices and decisions in the farm.
- It is a requirement by financial institutions before any loan can be approved to determine the need and capability of the farmer to service or repay the loan, as well as, to determine whether the farmer can benefit from the credit if advanced.

- Determine the financial status of the farm. This will help in detecting theft/fraud or losses very early and in resolving the situation.
- Help in settling disputes under joint ownership if one of the partners dies, that is, not having a will.
- Help in proper management of various routine livestock or crop production practices. For example, farm records assist the farmers to know the dates of calving, vaccinations, harvesting.
- Provide actual trading information for income tax accessors to avoid overtaxation.
- For comparison purposes between farmers dealing with the same enterprise. This helps to discover the causes for the differences.
- For determining profits or losses in order to know whether business should be expanded or discontinued.
- Helps in settling insurance claims for example, in case of fire or any other accident in the farm.
- Provide labour information for example, terminal benefits.

Types of farm records

There are many different types of records kept in a farm. They vary in the information or details they contain depending on the particular use. However, a farmer should maintain a simple system of record keeping. The various types of records kept in the farm include:

(i) Inventory records.

(ii) Production records.

(iii) Financial records.

(iv) Breeding records.

(v) Feeding records.

(vi) Health records.

(vii) Field operation records.

(vii) Labour records.

(ix) Marketing records.

Breeding records

These records contain details about the breeding programmes of the livestock.

They contain mating and parturition dates, animals used for breeding, age of the animal.

The information contained in the breeding record varies with each livestock species.

Examples of breeding records

Cattle breeding records

Information on these records includes:

(i) Name, number of the cow and dam (animal identification mark).

(ii) Date when the cow was served.

(iii) Date of pregnancy diagnosis.

(iv) Calving date (expected and the actual).

(v) Sex and weight of the calf.

(vi) Sire used for serving.

(vii) Remarks for example, difficult calving.

The format of the breeding records vary.
Example of a breeding record.

CATTLE BREEDING RECORD

Dam .... Sire ....
Weight at 1st service .... Age at calving ....
Age at 1st service .... Date of conception ....

Heat dates	Service A.I/natural mating	Pregnancy diagnosis date	Date of drying off	Actual date of calving	Calf sex	Calf no. and weight at birth	Remarks

Fig. 13.1: Cattle breeding records .

Sheep breeding records

Information includes:

• Ewe number.

• Service period (date).

- Lambing date.
- Number of lambs born.
- Number of lambs weaned.
- Remarks.

Number of ewes	Service period (month)	Lambing date	Number of lambs born	Lambing percentage	Number of lambs weaned	Remarks

Fig. 13.2: Sheep breeding records .

Pig breeding records

Information includes:

- Sow number.
- Sire number and breed.
- Date of service.
- Average weight of piglets at birth.
- Actual date of farrowing.
- Expected date of farrowing.
- Number of piglets.
- Remarks.

Feeding records

Proper feeding is an important prerequisite for any successful livestock production. A farmer needs to provide livestock with adequate feeds. It is also important to monitor the stock level in the feed store so that the animals have enough feeds at all times.

Information in a feeding record

- Enterprise name.
- Type of feed.
- Amount of feeds received.

• Remarks, for example, feed palatable.
• Amount of feeds used.
• Balance of feed.
• Number of animals.

NAME OF ENTERPRISE:...........................TYPE OF FEED:.............					
Date	Number of animals	Amount of feed received	Amount of feed used	Balance of feed	Remarks

Fig. 13.3: Feeding records .

Production records

Production records show the amount of produce (yield) by various animals. These include milk, eggs, crops and honey. The information contained in the records therefore varies.

Milk production record

This indicates the amount of milk produced by each lactating cow in the morning and evening. The records are used to calculate the totals for every month and subsequently for the whole lactating period. These records are very useful when one is carrying out culling in livestock.

Month..										
	Dates									
Cow's name/No.	1st		2nd		3rd.				31st	Total
	a.m	*p.m*	*a.m*	*p.m*	*a.m*	*p.m*	*a.m*	*p.m*	*Total*	
Milk to customers										
Milk to calves										
Total										

Fig. 13.4: Milk production records .

Egg production record

This shows the eggs laid every day, the number of broken eggs and the laying percentage. It acts as a parameter for good management and assists in establishing the vices in birds, for example, egg eating.

Date	Number of layers	Number of eggs collected	Number of eggs broken	Number of eggs not broken	Laying %	Remarks

Fig. 13.5: Egg production records .

$$\text{Laying \%} = \frac{\text{Number of eggs collected}}{\text{Number of layers}} \times 100$$

Health records

Health is an important factor that influences the productivity of livestock. Therefore, a farmer should closely monitor livestock at all times. These records show disease control measures taken for example, vaccination dates, treatment dates, drugs used and disease symptoms. When culling animals, these records are consulted.

Example of a Health Record

Name of animal/ Number of animal						
Date	Symptom	Diagnosis	Veterinarian	Treatment	Cost	Remarks

Fig. 13.6: An example of a health record .

Vaccination records

Vaccines are given to animals to produce immunity against specific highly infectious diseases for example, anthrax, foot and mouth disease, rinderpest and newcastle in poultry.

Disease	Date 1	Date 2	Date 3	Date 4

Fig. 13.7: An example of vaccination record .

De-worming records

Internal parasites such as worms are a major cause of low yields in livestock. Therefore there is need to control worms. Deworming must be done at regular intervals for effective control. Deworming records will remind a farmer of the last date of deworming, date of next deworming and the drug used for example, *Nilverm* .

Name/ No. of animal ....

Dewomer	Date 1	Date 2	Date 3	Remarks

Fig. 13.8: An example of deworming record .

Field operation records

These are records that show various field operations in crop production. The field operations include: Planting, weeding, harvesting, land preparation and fertilizer application. The expected and actual dates for these operation must be recorded.

Information contained in the field operation records are:

- Plot or field number.
- Area of the field (that is, in terms of hectarage).
- Crops planted.
- Date of ploughing.
- Date of planting.
- Fertilizers used, amount applied and date of application.
- Type of seed used, the amount and cost.
- Diseases and pests identified and cost of control.
- Weeding dates, methods, and cost.
- Harvesting date, quantities of produce.
- Labour. How many workers are hired and their wages.

Inventory records

An inventory is a document that shows the assets in a farm. There are two types of inventories. Consumable goods inventory, which is used to record the materials used in the production process, for example, agro-chemicals, drugs and animal feeds. Permanent goods inventory, which takes stock of the farm machinery, tools, and equipment available in the farm. It should indicate the number and condition of the tools and remarks stating whether the tools are adequate, need repair, or replacement.

Consumable goods inventory

This shows receipts and issues of consumable items.

Folio No.					Item					
Date	Receipt				Issues					
	Qty	Sign	Qty	Sign	Qty	Sign	Qty	Sign	Qty	Sign

Fig. 13.9: An example of receipts and issues record .

Permanent goods inventory

Date	Item	Quantity	Written off	Balance instock/ depreciation value	Remarks

Fig. 13.10: An example of inventory of goods .

Labour records

There are two types of labour used in the farm that is, *hired labour* and *family labour* . Hired labour can either be casual or permanent.

A farmer needs to keep records on labour use. This helps in the payment of wages and calculation of operation costs. The record which shows daily duties attendance is called a **master roll.** A farmer might also keep a labour allocation record to show how many people were allocated a specific enterprise. This would help calculate profit for each enterprise.

Date	Item	Quantity	Written off	Balance instock/ depreciation value	Remarks

Fig. 13.11: An example of labour records .

Marketing records

Marketing records are very important in intensive or large scale farming. Although other records like cash analysis, journals and ledgers assist a farmer in easily calculating the income from sales, marketing records help in establishing harvesting trends (that is, periods) and markets where the produce or commodity was sold. This helps the farmer to compare prices for various markets and to determine where to sell in order to achieve maximum profits.

Commodity ……………………… Field No. ………………………………					
Date	Amount sold	Price/unit	Total revenue	Where sold	Remarks

Fig. 13.12: An example of marketing records .

Financial records

Farming is a business where several transactions are carried out. Farm managers, therefore, keep systematic entries of various activities and transactions carried out within the farm.

There are several financial books kept in the farms.

Cash book

This is a book where all financial transactions are recorded. It records money received and paid out. A cash book thus keeps records of transactions that involve receipts and payments of cash or by cheques. The simplest form of cash book is the single column cash book. For example:

CASH BOOK

DR. **CR.**

SALES & RECEIPTS — PURCHASES AND EXPENSES

Date 2003	Particulars	Amount	Date 2003	Details	Amount
		MK.			MK.
1st Jan	Balance brought forward	4000.00	Jan 3	Bought 3 bags layers mash	3600.00
Jan 10	Sold 2 bags of irish potatoes	6000.00	Jan 14	Bought 2 bags of fertiliser	4800.00
Jan 15	Sold 20 trays of eggs	4800.00	Jan 20	Bought pangas and slashers	2400.00
Jan 22	Sold carrots	1200.00	Jan 21	Bought broiler finisher mash	6000.00
Jan 25	Sold broilers	10000.00	Jan 22	Bought acaricide	4000.00
Jan 28	Sold green maize	8000.00	Jan 29	Bought poultry vaccine	2000.00
Jan 31	Sold dairy culls	12000.00	Jan 30	Bought dewormer	3000.00
			Jan 31	Balance carried down	10100.00
		46000.00			**46000.00**
Jan 31	Balance brought down	10100.00			

Fig. 13.13: Sample of a single-column cash book .

(ii) Ledger

This is the principal book of accounts. Entries contained in all other books are entered here. It shows all financial transactions of the farm in a summarized form.

(iii) Balance Sheet

This is a financial statement that indicates the value of assets and liabilities of the farm business at the end of an accounting period (financial year). It is usually drawn on the last day of a financial period. It should show the farm business in a state of balance.

ZOMBA FARM Balance sheet as at 31st December, 2004					
LIABILITIES	MK.	Cts.	ASSETS	MK.	Cts.
Current liabilities			Current assets		
....	....	.....	....	....	.....
....	....	.....	....	....	.....
....	....	.....	....	....	.....
Long-term liabilities			....	....	.....
....	....	.....	Fixed assets		
....	....	....	....	....	.....
Total liabilities	....	.....	....	....	.....
Net worth	....	....	....	....	.....
Total	....	.....	Total assets	....	.....

Fig. 13.14:Balance sheet format .

Keeping records of selected animal and crop

Below is the record of a milk producing animal (dairy cow). It indicates the amount of milk produced by each lactating cow in the morning and evening.

Milk production record.

Month-September 2011

	Dates						
	1		2		3		
Cow's name	A.M	P.M	A.M	P.M	P.M	A.M	TOTAL
Lusinga	10	8	12	10	12	9	49
Holland	6	4	8	5	8	4	35
London	18	10	17	9	15	10	79
Milk to customers	24	24	20	20	18	18	
Milk to calves	10	10	8	8	6	6	
TOTAL	34	22	37	24	35	23	163

Fig. 13.15:Amount of milk produced by lactating cows .

Crop production records can also be represented as shown below.

Type of crop: Maize

Field No./Plot 3 Area of land 1 HA

Crop planted	Date of ploughing	Date of planting	Fertilizer used	Amount in bags	Harvesting Date	Remarks
Maize	20/1/2011	8/2/2011	S.S.P	3	8/8/2011	
Beans	7/1/2011	7/2/2011	D.A.P	1	2/9/2011	Good harvest

Note:

D.A.P: Diammonium phosphate

S.S.P: Single Superphosphate.

Revision Exercise 13 A

1. List any six types of farm records kept by a farmer.
2. Why should a farmer keep records?
3. What is the importance of keeping health records by a farmer who owns dairy cattle?
4. Differentiate between a permanent goods inventory and a consumable goods inventory.
5. (a) Differentiate between assets and liabilities in farm accounts.

   (b) The transactions below show Gondwe's farm financial position as at the end of the year 2010. Use the information to answer the questions that follow.

   Cotton valued at 5,000/=
   Coffee and tea bushes valued at 120,000/=
   Bank Loan 150,000/=
   Livestock feed bought on credit from Farm Supplies 20,000/=
   Livestock (poultry, dairy cattle and rabbits) 80,000/=
   Debtors 25,000/=
   Cash box has 15,000/=
   Livestock feed in store 5,000/=
   Bank account reads 22,300/=

   (i) List all the farm assets and their total monetary value.

   (ii) List all the farm liabilities and their total monetary value.

   (iii) Draw a balance sheet for Gondwe's farm.

   (iv) Show whether the business is solvent or insolvent.

6. Use the following information extracted from Mawindo farm accounts to answer the question that follows.

Bought fertilizer (D.A.P.) 20,000/=, maize seeds at 10,000/=, sold two bulls at 10,000/=, Broilers at 50,000/=, sold beans to Mariya school at 26,000/=, and maize to a grain store at 10,000/=, sold milk at 25,000/=, the farm paid 1,500/= on casual labour for slaughtering broilers. Towards the end of the year, the farm bought 5 bags of dairy meal at 2,400/= each, and 10 bags broiler finisher at 15,000/=. The opening valuation was recorded as four hundred thousand and five hundred Kwachas. At the end of the year, the farm recorded the following:

Animal feed in store 10,000/=

Fertilizer in store 5,000/=

Dairy cattle worth 60,000/=

Tools and Equipment 120,000/=

Land valuation at 260,000/=

Farm buildings at 60,000/=

Prepare a profit and loss account for Mawindo's farm as at the end of the year 2008.

Enterprise combination

This is a relationship which shows how different enterprises relate to one another. A combination of input factors can be used to produce several products. The relationship helps to determine what to produce, that is, the combination of enterprises which will give maximum revenue.

The relationships include:

1. Supplementary relationship

Where an increase in one product may not lead to decrease in output of another, the relationship is said to be supplementary, for example, growing beans in a coffee plantation, beans will not affect the output of coffee.

2. Complementary relationship

Here, an increase in production of one product results in an increased production of the other, for example, intercropping legumes and cereals, forage and dairy production.

3. Competitive relationship

This is where an increase in the production of one product leads to a decrease in the production of the other product. For example, a farmer may have 20 hectares of land which is appropriate for maize, sorghum or a combination of both. If more of either maize or sorghum is planted, the output of the other declines. This is because the two enterprises are competing for the same resources (land).

Farm enterprises

Information can be accumulated by types of receipts and expenses for the farm as a whole or by type of receipts and expenses for each enterprise within the farm. An enterprise is defined as *any segment of the farm business that can be readily isolated by accounting procedures or separated from others according to its receipts and expenses* . Enterprises can be classified as:

1. *Production enterprises* such as maize, beef and poultry that produce a marketable product.
2. *Service enterprises* such as tractors, combine harvesters and agro-vet outlets that produce services to each other and to the production enterprises but do not normally produce a marketable product.
3. *Holding enterprises* such as storage, capital, warehouse and feed mill that holds input and products until they are used on a service enterprise or production enterprise or until they are marketed. The capital enterprise is a running inventory of the capital invested in and used to operate the farm.

Factors to consider when selecting enterprise

A farmer has several enterprises to carry out financial records on or several production enterprises to choose from. The choice of an enterprise is determined by:

(a) *The type of enterprise itself;* that is, production or service enterprise.

(b) *Environmental factors;* a production enterprise chosen will depend on the conditions suiting it in an area.

(c) *Farmer's knowledge and skills concerning the enterprise* .

(d) *Available resources such as capital to establish it* .

(e) *Government policy;* the government may want a certain production enterprise, for example, maize production to be located in a certain region.

The above factors listed above affect or influence selection of enterprise combination as follows:

1. Government policy: Certain crops could be of high value like cocaine but the government cannot allow its growth despite its high value.

2. Availability of capital: Some enterprises before choosing consider their financial status when starting. Some crops require high initial capital therefore, the farmer must take that into consideration.
3. Tastes and preferences of the consumers: Before embarking on any enterprise the farmer must consider the market for example, rearing of pigs in a Muslim area, Muslims are against pigs therefore there will be no market.
4. Environmental factors: These are mainly climatic factors like rainfall, one has to know the distribution per annum and the total amounts per annum.
5. Technical skills: The farmer has to choose enterprise combination where he/she has the knowledge on the management through the performance period.
6. Type of enterprise: The farmer must know whether it is for production or providing services as processing.

Determination of enterprise combination

A procedure is followed for determination of enterprise combinations. The procedure is designed to aid in determining what should be budgeted or programmed.

1. List all the enterprises to be considered in the farm plan and tentatively determine their relationships. An enterprise may be supplementary or complimentary to each other.
2. Select one enterprise that is found to be the most profitable. Select by use of budgets or from analyzing farm accounts.
3. Select the next most profitable enterprise and determine if its selection will increase income.

Practical Activity 13.1

Visit a school farm manager's office or a nearby farm and identify the various records kept.

Revision Exercise 13 B

1. What is an enterprise?
2. List the factors considered in selecting an enterprise.
3. Explain the term enterprise combination.

Topic 6: Agricultural Technology

Unit 14: Farm Energy

Unit 15: Irrigation Systems

Unit 16: Land Drainage

Unit 14 Farm Power (Energy)

Objectives

By the end of this unit, you should be able to:

(a) Give the meaning of the term 'Farm energy' .

(b) Explain the forms of farm energy .

(c) Outline sources of farm energy .

(d) Observe safety measures when using farm energy .

Introduction

Modern farming involves the use of many different farm machinery and equipment in the production process. Farm machinery helps to accomplish most of the farm operations more efficiently and effectively. This has led to farm mechanization in most commercial farming activities. Farm mechanization refers to the use of energy-driven machinery and implements to carry out certain farming activities. **Farm energy** is the capacity of a physical system to do work in the farm. **Energy** is defined as the capacity of work that can be done per unit time. Power is necessary in the farm to enable different operations to be performed. In this unit, we shall discuss various forms of farm energy in the farm and their sources.

Forms of farm energy

The following are the common forms of energy in the farm:

- Diesel fuel.
- Wood fuel.
- Matches.
- Sunlight.
- Paraffin.
- Bio-gas.
- Wind energy.
- Hydro-electric power.

Wind energy

Air has weight and when it moves, it does so with a velocity. The product of its weight and velocity gives us wind energy. Moving air is what is referred to as wind. Wind power is a cheap source of energy and is suitable for use in areas with a wind velocity of about 32 km per hour.

Wind energy can be harnessed by use of wind mills. A windmill of about 3.6 m in diameter on a tower of 12 metres height and receiving wind at a velocity ranging between 6 – 37 km per hour can generate 0.1 – 0.9 HP (horse power) of electricity.

Wind energy may be used for the following farm operations:

- Pumping water from boreholes.
- Generating electricity.
- Winnowing crops such as beans, millet and rice soon after threshing.

Fig.14.1: Elecricity-generating windmill .

Advantages

- It is inexhaustible.
- Equipment used in harnessing wind energy have low maintenance costs.
- Non-pollutant.

Disadvantages

- Wind energy is unreliable.

• Its direction cannot be controlled.

• High initial costs in setting up a windmill.

• It is limited to areas where wind is prevalent.

Biogas

Biogas is a flammable gas produced when organic matter is decomposed by micro-organisms within a certain range of temperature, moisture content and acid conditions. The main raw material used in the production of biogas is animal waste. However, gabbage, plant leaves, grasses, crop straws and industrial wastes may be used.

The main components of biogas are methane (60–70%) which burns with a blue flame. Other constituents are carbon dioxide (29%), nitrogen 1%, carbon monoxide (0.1%), oxygen (0.1%) and minute amounts of hydrogen sulphide. The structure used to generate this gas is known as a **digester.** The structure can be constructed on the ground surface or below the surface.

The organic materials are first mixed and diluted with water, then pushed down the inlet pipe into the digester. After sometime, fermentation takes place and gas bubbles come out into the gas holder which is fitted with a pipe to convey the gas to the kitchen. The residue is termed as **slurry material** and is pushed over the partition in the digester by incoming raw materials, then out through the outlet pipe into slurry drying pans where it is collected and used for making manures.

Fig.14.2: Biogas digester .

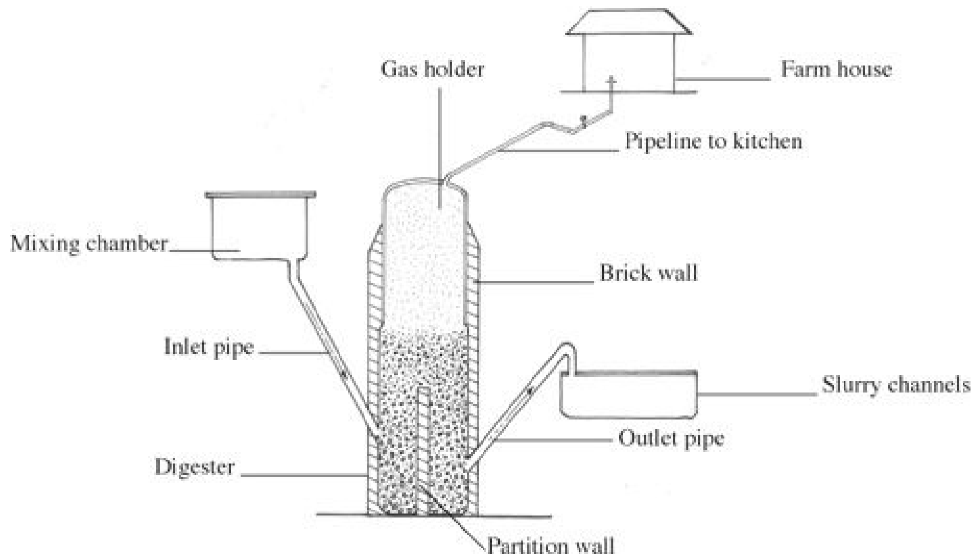


Fig.14.3: A Biogas plant structure .

Biogas has various uses such as:

- For heating and cooking.
- For lighting.

Advantages

- It is environment friendly, that is, uses waste products.
- It is cheap to generate once the digester is installed.
- It is an excellent source of manure.
- It has low maintenance costs.

Disadvantages

- High level skills are required for its installation.
- It is most appropriate where animals are reared under zero grazing.
- It is labour intensive.
- Requires large quantities of raw materials.
- Relatively high installation costs.
- Limited to a few farm operations.

Wood energy

This is the cheapest and most common source of energy. Wood fuel is widely available in Malawi. The demand for wood fuel continues to increase as its availability steadily declines. This has led to clearance of forest lands, which has contributed to environmental degradation.

To conserve this energy, improved cooking stoves have been developed to help reduce use of wood fuel. Wood fuel is used for:

- Cooking, heating and lighting.
- Blacksmithing.
- Processing farm produce, for example, curing of tobacco leaves and smoking fish.

Advantages

- It is a cheap source of energy to those in the rural areas.
- Less skills are required in preparation of charcoal.
- It is easily available in many parts of the country.

Disadvantages

- Leads to environmental degradation that is, deforestation, soil erosion and air pollution.
- Limited to very few operations in the farm, that is, heating and cooking only.
- Its smoke contributes to air pollution.

Fossil fuels

These are hydrocarbon compounds that are used to provide power through their combustion, for instance, petroleum.

(a) Petroleum

Petroleum products such as kerosene, petrol and diesel are used to provide energy. Kerosene is the main source of energy used for lighting and cooking in most Malawian households. Petrol and diesel fuels are used for driving motor engines, for example, vehicles, tractors and generators.

Petroleum is generated from crude oil through a process called **fractional distillation.** The energy generated by these engines may be used to carry out the following operations:

- Ploughing and harrowing.
- Transporting farm produce.
- Spraying of herbicides or pesticides.
- Mowing grass.

- Lighting of homes.
- Pumping water for irrigation.

Advantages

- It has a high energy output.
- Engine energy increases efficiency and precision in carrying out farm operations.
- It is labour saving.

Disadvantages

- It is very expensive to produce.
- Some machines operated by this type of energy may not be used in certain landscapes, for example, steep slopes.
- A major pollutant.
- Not renewable.

Hydro electric power

This is electric energy generated from flowing water. The falling water rotates turbines which are connected to a generator to produce electricity.

Advantages

- It is environment friendly, for example, it does not cause pollution.
- It can be used in a variety of farm operations.
- It is inexhaustible.
- It is cheap to maintain once established.

Disadvantages

- It is very costly to generate hydro-electric energy.
- The machines used for energy generation have high maintenance costs.
- Energy generation is affected by fluctuation of water levels in the rivers.

Fig.14.4: A hydro power dam .

Sunlight energy

Solar energy is obtained from the sun. It is the most abundant source of energy used by plants and animals. Research has established that radiant energy received from the sun in only 30 minutes is equivalent to the energy consumption level of the whole earth within one year.

Solar energy can be utilised in two forms:

- Heat energy : This may be used to dry crops, such as, cereal grains and pyrethrum, and for cooking or heating.
- Light energy : Solar panels are used to trap solar rays and convert them to electrical energy. The stored electricity may be used for pumping water, heating water for domestic use, cooking and lighting. Light energy is used by plants in photosynthesis.

Advantages

- It is inexhaustible.
- It is readily available, especially in the tropics.
- Non-pollutant.

Disadvantages

- It is unreliable. During cloudy days or days of low sunlight intensity, it is not possible to harness adequate solar power.
- It is relatively expensive to install.
- It requires skills to install and maintain.
- It cannot be used directly in most farm operations, for example, light energy

has to be converted into electrical energy before use.

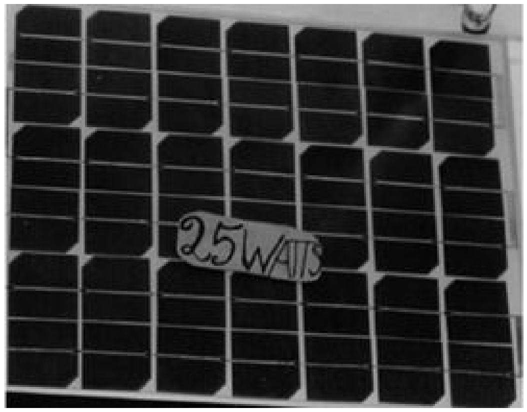


Fig.14.5: Solar panel for generating electrical power .

Sources of farm energy

Farm energy sources are used to generate different forms of farm energy. The following are the sources of farm energy:

- Paraffin.
- Wood fuel
- Sun.
- Animal wastes.
- Diesel.

Safety measures when using farm energy

There has been an increase in the number of hazards facing the farmer and his farm workers in handling and use of farm energy many of these accidents are caused by carelessness and ignorance and many are caused by neglect.

In an attempt to reduce the number of accidents on farms many regulations have been introduced governing the safety requirements to farm energy.

- Power cables should not run overhead buildings. No buildings should not be constructed under the power cables, for example, electricity cables. This is to prevent accidental fires. Also the extension of electric wires within farm buildings should be done by an expert electrician. Disconnect electric current before any work is done on an electrical conductor. Circuits should not be overloaded.
- In the use of portable motors and batteries use heavy rubber cords which are moisture proof.

- Fumes from farm machinery are dangerous. When using inside buildings, proper ventilation should be ensured. Exhaust fans are used to remove fumes. Carbon monoxide is dangerous and is produced by gasoline engines, stoves and furnaces. Never stay in a room with burning charcoal in a furnace without proper ventilation.

Practical Activity 14.1

1. Visit a local village and make observation of how animals have been harnessed to provide energy in the farm.
2. Visit a workshop tools' store and make observation of the arrangement of the tools and equipment. Make notes on the safety measures given to the users.

Revision Exercise 14

1. What is farm energy?
2. Explain how diesel energy can be used in the farm.
3. State the advantages of wood energy in the farm.
4. Give the limitation of wind energy in the farm.
5. State three safety measures when using farm energy.

Irrigation Systems

Unit 15

Objectives

By the end of this unit, you should be able to:

(a) Select an irrigation system .

(b) Establish an irrigation unit .

(c) Manage an irrigation unit .

Introduction

Irrigation is the artificial application of water in a seedbed for the purpose of growing crops. Irrigation is used under the following circumstances:

- *Dry areas :* Where rainfall is inadequate and hence insufficient for crop production.
- *During long dry periods:* Crops such as coffee, citrus fruits, pineapples and other horticultural crops, require irrigation during the dry season to sustain high production. Vegetables and other crops can fetch high market prices if grown under irrigation during the rain-off season.
- *When growing paddy rice* . This requires flooded seedbeds.

Factors to consider when selecting an irrigation system

There are various methods of irrigation systems in use. Each method depends on one or all of the following factors during selection.

- *Availability of water* . If water is limited, drip irrigation will be preferred over sprinkler irrigation.
- *Land topography* for example, for flood irrigation, the land ought to be level enough that is, furrow irrigation is only possible on gentle, sloping land.
- *Type of crop to be grown;* for example, for rice growing, basin irrigation is preferred over sprinkler irrigation. For perennial crops such as coffee and pineapples, overhead sprinkler irrigation is most suitable.
- *Soil type* ; heavy soil such as clayey is suitable for furrow irrigation.
- *Availability of capital;* expensive irrigation require more capital.

Problems associated with irrigation and their solution

- *Shortage of water;* this is solved by construction of dams which collects water during the heavy rainy seasons.
- *Lack of technical skills* ; this can be rectified by training farmers and more agricultural officers staff.
- *Pollution of the water* ; this can be solved by avoiding use of agricultural chemicals in the farm.
- *Wastage of water;* this is solved by following the recommendations given by the agricultural officers.
- *Uneven distribution of water;* this can lead to waterlogging in some areas while other areas do not get enough. This problem can be solved by proper laying out of the water channels.
- *Siltation of canals;* this is solved by efficient control of soil erosion on the upper side of the source of water and avoid digging close to the river banks.
- *Saline water;* it may affect plant roots. This is solved by carrying out soil tests before establishing the system or application of appropriate chemicals.
- *Some type of irrigation may be too expensive* . Solution is to use locally available materials and borrowing of agricultural credits.
- *Irrigation may encourage fungal diseases;* in some crops therefore choose the type of irrigation where water will not touch the leaves.

It is important to determine frequency and time of watering in an irrigation unit.

Factors to consider when determining frequency and time of watering

- *Topography* : The land must be fairly level (gentle sloping) for the water to flow by gravity.
- *Amount of water supply:* Plenty of water is required due to high wastage through seepage and evaporation.
- *Soil type:* The soil must be able to hold water for a long period of time and should preferably be clay soil.
- *Evaporation rate* : Where the evaporation rate is high, there is a lot of wastage of water and the crops get little or no water. The rate of evaporation should be minimised.
- *Type of crop grown* .

Every irrigation unit has its own method of establishment.

Establishment of an irrigation unit

There are four methods of irrigation namely:

- Surface irrigation.
- Overhead or sprinkler irrigation.
- Drip or trickle irrigation.
- Sub-surface irrigation.

(a) How to establish 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.

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.

Surface irrigation can be practised in three ways namely: **flood irrigation** , **furrow irrigation** , and **basin irrigation** .

(i) How to establish 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 the opening of sluice gates in the field. Flood irrigation requires that land be as near flat as possible.

Fig. 15.1: Flood irrigation, furrow supply water into a field .

Advantages

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

Crops, such as, cotton and fruits are irrigated through flooding.

Disadvantages

- Wastage of water that is, a lot of water is required.
- Water is unevenly distributed causing water logging in some areas while other parts do not get enough.
- Siltation of the canals is common.

(ii) How to establish 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 through the furrows, it wets the soil. 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. Furrow irrigation is commonly practised where horticultural crops are grown.

Advantages

- Reduces fungal diseases, for example, leaf blight since there is no contact with leaf of the crop.
- Relatively cheap to establish and maintain.
- Requires less skill.

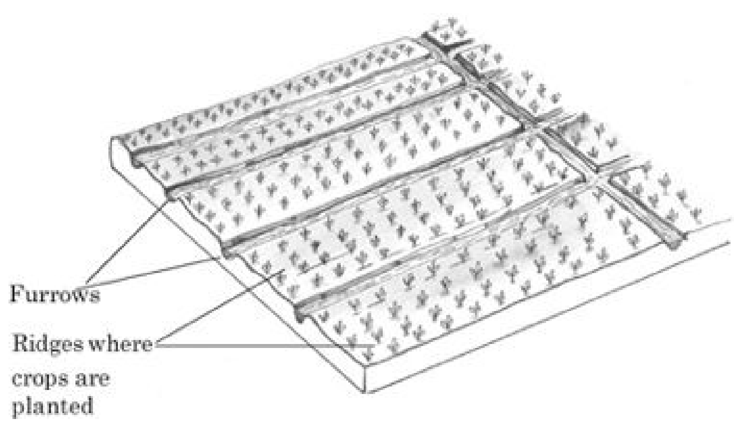


Fig. 15.2: Furrow irrigation .

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.

(iii) How to establish basin irrigation

It is the flooding of an entire area enclosed by earth embankments known as *dykes/levees* . The depth of the water is controlled by the dykes/levees. The ground should be levelled and the 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 there is a basin created for each tree crop.

Disadvantages

- It is expensive to establish.
- It results in accumulation of a lot of salts in the soil.
- It cannot be used in slopy areas.
- Floods may destroy the basins during heavy rains.
- A lot of water is wasted.
- There is a high incidence of water-borne diseases for example, bilharzia and malaria.

Fig. 15.3: Basin irrigation .

(b) How to establish overhead or sprinkler irrigation

Overhead irrigation is the application of water to crops in form of small droplets like rain. This can be done by means of sprinklers, watering cans, or hose pipes.

Sprinklers are mounted on vertical pipes which allow water to pass through at high pressure.

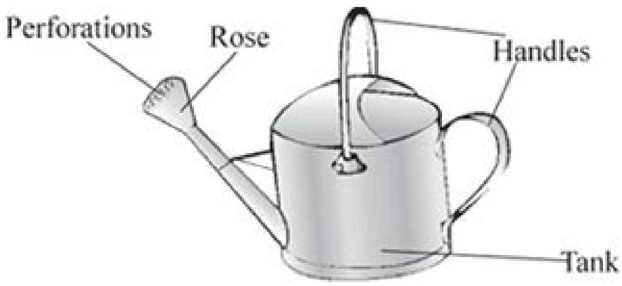


Fig. 15.4: Watering can .

Types of sprinklers

There are two main types of sprinklers namely:

(i) The **continuous rotating sprinklers** suitable for small scale irrigation.

(ii) The **spring loaded sprinklers** suitable for large scale irrigation.

Advantages

- Water is evenly distributed in the farm.
- It minimises wastage of water.
- It can be used on slopy grounds or flat areas.
- One can irrigate a large area by changing the location of sprinklers in turns.
- Soluble fertilizers can be applied together with irrigation water, for example, nitrogenous fertilizers (fertigation). This saves on time and labour.

Disadvantages

- The initial cost of installing the pumps, pipes and sprinklers is high.
- It encourages fungal disease outbreaks for example, blight in tomato and Coffee Berry Disease in coffee due to water accumulating on the leaves. This water creates a micro-climate necessary for fungal growth.
- It can cause erosion if not properly controlled, especially, in slopy areas.
- It requires establishment of a windbreak to prevent water drift, which may make the method in-efficient.
- Maintenance of the system requires specialised skills.
- It results in uneven distribution of water to crops depending on their distance from the sprinkler.

Fig. 15.5: Overhead irrigation using hose pipe .

Fig. 15.6: Overhead irrigation using sprinklers (continuous rotating type) .

Maintenance

- Repair any broken parts.
- Check the sprinkler nozzles regularly for any blockage.

(c) How to establish drip or trickle irrigation

Drip irrigation involves application of water in small droplets within the plant root system. It is carried out by use of polyvinyl pipes with perforations. As water passes through the pipe, it comes out in small quantities through small perforations and drips to the ground wetting the soil. The pipes are laid along the crop rows. The pipe's perforations are put according to the spacing of the crops. Bottles can also be used mainly for small scale growing of horticultural crops and trees. Crops irrigated using this method are fruit trees, coffee and paw paw trees. Most horticultural farms use this irrigation method within the green houses.

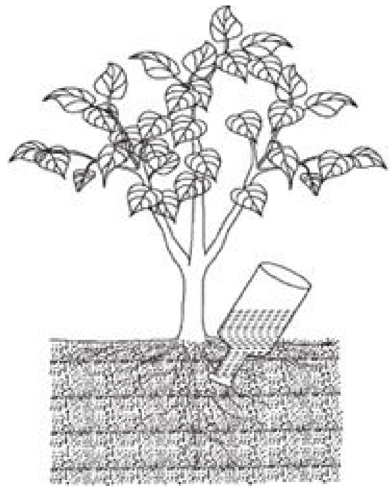


Fig. 15.7: Drip/trickle irrigation using a bottle .

Advantages

- Economical use of water as it is only supplied at the root of the crop.
- Water under low pressure can be used as long as it is flowing along the pipe.
- It minimizes outbreak of diseases such as blight and Coffee Berry Disease as water is applied directly at the root zone and does not come in contact with plant leaves.
- It reduces competition with weeds as little water gets in between the rows.

Disadvantages

- The pipes used are expensive to buy and instal. This makes the method suitable only for intensive farming.
- When using perforated pipes, only clean water must be used to avoid blockage of the perforations.
- Requires high technological skills to instal and maintain.

Maintenance

- Repair broken pipes.
- Unblock the perforations.
- Flush the pipes or blocked bottle mouth piece with phosphoric acid in case the soil is slightly saline.

(d) How to establish sub-surface irrigation

In this system, perforated pipes are laid underground. Water passes through the pipes and then seeps into the surrounding soil. The method is not very common but is suitable for tree crops such as citrus and coffee.

Advantages

- Once the pipes are laid, it is labour-saving.
- It can be practised on slopy or flat land.
- Water does not cause soil erosion as it is only administered in small amounts.
- Fungal diseases such as blight in tomatoes are reduced because water does not come in contact with plant leaves.

Disadvantages

- The pipes are very expensive.
- The pipes are easily destroyed during land preparation.
- The efficiency of the method relies on high soil capillarity.
- Sediments may block the nozzles thus hindering effective irrigation.

Maintenance

- Unblock any blocked nozzles.
- Repair or replace blocked pipes.
- Regularly flush the pipes with phosphoric acid to remove any salts present in pipes, especially when soils are saline.

Management of an irrigation unit

When managing an irrigation unit, care is taken to ensure the functionality of the unit. To achieve this, some factors must be considered.

Factors to consider when managing an irrigation unit

- The value of the crop under irrigation; if the price of the produce is high then the management will also be of high quality.
- Level of education of the farmers; where farmers are enlightened then there will be a lot of efficiency and vice versa.
- Discipline of the farmers; where farmers are disciplined then losses due to carelessness are minimal.
- Capital investment high investment requires high standard of management.
- Type of irrigation; technical knowhow for every type of irrigation differ.

Practical Activity 15.1

Carry out a project on crop production using any of the irrigation methods suitable for the school farm. You can use the drip, basin or overhead irrigation method.

Revision Exercise 15

1. State the factors to be considered when choosing the method of irrigation in a given area.
2. What is the difference between a weir and a dam?
3. What determines the type of irrigation equipment to be used on a given farm?
4. Mention the soil type which best suits surface irrigation.
5. Under what conditions would irrigation be recommended?
6. Name three types of surface irrigation.

Unit 16 Land Drainage

Objectives

By the end of this unit, you should be able to:

(a) Explain the meaning of the term 'land drainage'

(b) Explain the importance of 'land drainage' .

(c) Describe methods of land drainage .

Introduction

Land drainage is the practice of removing excess water from the land to make it suitable for agricultural production. It also refers to the rehabilitation of swampy (marshy) lands. This is a method of land reclamation.

Importance of land drainage

- Once drained, a wide range of crops can be grown.
- The soil becomes well aerated because the water which occupied air spaces is removed.
- It results in high activity of soil micro-organisms thus improving the rate of decomposition of organic materials to release minerals and other nutrients. This is due to good aeration and optimum soil temperatures.
- It reduces incidence of soil and water-borne pests and diseases for example, malaria and bilharzia.
- There is an increased amount of land available for crop production, hence it is used as a land reclamation method.
- Increases soil volume.

Methods of land drainage

(a) Surface drainage

Methods of surface drainage include:

- Open ditches.
- Cambered beds.

(i) Open ditches

This is the most widely used method of removing excess water from a field. U or V- shaped open ditches are constructed. They must be deep and wide enough in order to be effective.

Advantages

- Large quantities of water can be easily drained.
- It is cheaper to use.

Disadvantages

- It has high maintenance costs, that is, it requires constant removing of silt after a period of use.
- It interferes with the agricultural mechanisation of certain operations.
- It takes off valuable land space which could have been used for planting of crops.
- Soil erosion may arise if the ditches are not well designed.

(ii) Cambered bed

Another method of surface drainage is by making large heaps of soil in form of big and broad ridges or mounds on which crops are grown. The water collects and drains into the spaces between the mounds (ridges) allowing the crops on the mounds to grow well on the aerated soils. Crops are planted on the raised beds. Water flows away through the spaces between the ridges by gravity.

Advantages

- It intercepts water that flows laterally down the slopes.
- Excess water is discharged from the land making it suitable (arable) for crop growing.
- It is the easiest and cheapest method of reclaiming a swampy area.

Disadvantages

- High maintenance cost due to constant repairs.
- It can form a breeding place of mosquitoes.
- Perennial weeds establish themselves in the drains.
- It causes some difficulties in using farm machinery.
- Farm animals can injure themselves in the open ditches.

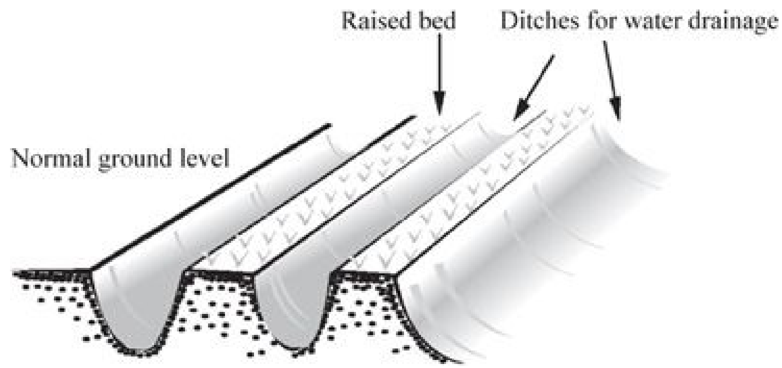


Fig. 16.1: U-shaped open ditches .

b) Sub-surface drainage

This is a drainage system in which the pipes or tunnels conducting away excess water are laid below the soil surface. The pipes have openings at the joints which allow free water to enter through. Water collected in the pipes is led away to the desired locations for example, rivers or dams. This kind of drainage system does not interfere with field operations.

Sub-surface drainage methods include mole drains, use of porous or perforated pipes, and French drains.

(i) Mole drains

Mole drains are small tunnels constructed below the soil surface. They resemble the mole tunnels. They are usually made by a tractor pulling a cylindrical plug under the ground in a process known as *moling* .

In steep areas, erosion can occur blocking the mole drains. Moling is done on crop land as the soil dries out.

(ii) French drains

They are also called rubble or stone drains. French drains are ditches dug to a depth of 60 cm, and filled with small and medium-sized stones. The stones are then covered with trash and light soil. Water slowly drains from the surrounding area into the drain. French drains are constructed along the contours.

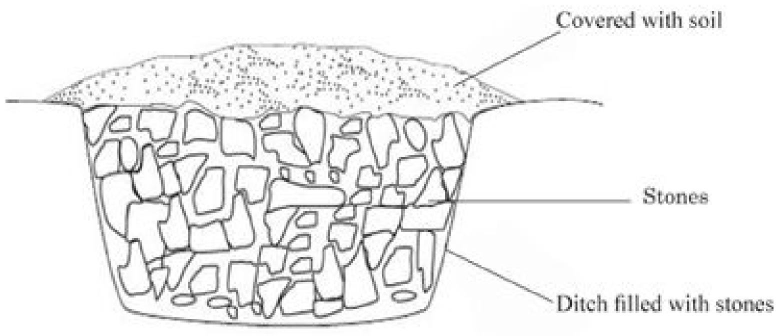


Fig. 16.2: French drains .

(iii) Porous pipe drains

Short pieces of pipes about 30 – 40 m long, are placed under the ground and run from end to end. There are gaps between the pipes to allow water to drain into them and be conducted away. The pipes are either made of clay, concrete, plastic or steel. Perforated pipes can also be laid underground such that water sips through the perforations and is conducted away. Plastic pipe drains are preferred to the clay ones because they are cheaper and require a narrow trench, hence less disturbance of the soil.

Advantages

- Does not reduce agricultural land.
- Does not interfere with movements of machines.
- Does not intercept water that flows laterally down the slopes.
- Does not interfere with field operations.

Disadvantages

- High maintanance costs due to constant repairs.
- Blockage of tunnels at steep areas can occur due to soil erosion.

(c) Pumping

This is a very costly method of drainage. It is done as a last resort when all the other methods have failed. It involves the use of pumps to conduct away water to areas where it may be needed.

(d) Planting deep rooting crops

Deep rooted plants, such as eucalyptus, should be planted in marshy areas. Their roots penetrate deep in the soil creating waterways for water to seep through. The trees also take up a lot of water which is then lost through transpiration.

Causes of poor drainage

Poor drainage can be due to:

- Too much rainfall in flat or low lying areas.
- High amounts of clay particles in the soil. These have high water holding capacity.
- Presence of impermeable rock near the soil surface.
- Formation of hard pans in the soil. This prevents water percolation into lower soil depths.
- High water table.

Self Assessment

1. Plan a visit outside the school to identify the following sources of water:
   (a) Surface water.
   (b) Underground water.
2. How is water obtained in your school?
   Mention the source, means of conveyance, and treatment before use.
3. Visit a water treatment plant. Note the various stages and chemicals used in water treatment.
4. Identify the rain water harvesting structures within the school compound.

Practical Activity 16

1. Working in groups of five, carry out any type of irrigation appropriate at the school farm using the available materials.
2. Write the report of the observation of the crop grown until maturity.
3. Working in groups, apply any of the learned methods of drainage to drain a swampy area within the school.

Revision Exercise 16

1. Describe how French drains are constructed.
2. Outline the construction of cambered beds.
3. Give the advantages of open ditches,
4. Explain the causes of poor drainage.

Topic 7: Agricultural Experimentation

Unit 17: Basic Principles

Basic Principles

Unit 17

Objectives

By the end of this unit, you should be able to:

(a) Use scientific approach to experimentation .

(b) Identify problem for conducting an experiment or investigation .

(c) Design an agricultural experiment .

(d) Conduct an agricultural experiment .

Scientific approach to experimentation

Scientific experimentation in agriculture is actually research. Research is an investigation into something. It is a careful investigation or inquiry through research, that is, a systematic inquiry that is designed to collect, analyse, interpret and use data collected,

Experimental research

Experimental research is a type of research in which the approach is through control of the objects of the study. The researcher tries to describe causal relationships between the independent and dependent variables . Variable is a concept that can take on different quantitative values for example, income. If one variable depends upon or is a consequence of the other variable, it is termed as dependent variable , and the variable that affects the dependent variable is termed as an independent variable. The researcher can manipulate the independent variable at will because he or she has control over it.

Agricultural problems requiring experimentation

Malawi needs to be self-sufficient in food supplies so as to be able to feed her population.

Since agriculture is the main pillar of the economy of the county, a lot of research is going on in order to increase agricultural production. Some of the main objectives of agricultural research are:

- Improve crop and livestock production techniques.
- Develop improved varieties, types of crops and livestock breeds.

- Improve pasture and fodder quality.
- Develop techniques for controlling diseases and pests of various crops and diseases and parasites of livestock.
- Determine suitable ecological zones for various crops and livestock.

Research problems

- Efficient crop production techniques.
- Efficient livestock production techniques.
- Improved breeds of livestock.
- Improved pasture or fodder for livestock.
- Crop diseases and control.
- Livestock diseases and control.
- Crop pests and control.
- Livestock parasites and control.
- Ecological zones suitable for crops.
- Ecological zones suitable for livestock.
- Aspects of crop processing.
- Utilization of crop by-products.
- Irrigation potential.

Experimental design

Decisions regarding what, where, when, how much, by what means concerning an inquiry or a research study constitutes a research design.

What is research design?

A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. In fact the research design constitutes the blueprint for the collection, measurement and analysis of data.

The research design decisions are based on the following questions:

- *What is the study about?*
- *Why is the study being made?*
- *Where will the study be carried out?*

- *What type of data is required?*
- *Where can the required data be formed?*
- *What period will the research cover?*
- *What will be the sample design?*
- *What techniques of data collection will be used?*
- *How will the data be analyzed?*
- *In what style will the report be prepared?*

The research design is needed because it facilitates the smooth sailing of the various research operations, thereby making research as efficient as possible. This yields maximum information with minimum cost.

A good design should be flexible and efficient.

It should minimise bias and maximise reliability of data collected and analysed.

It should give the smallest experimental error.

Layout of an experimental design

An experimental design layout may be given by the following simple formula:

$$\begin{array}{lcl} \text{Group 1} & : & R\,0_1 \quad \times \quad 0_3 \\ \text{Group 2} & : & R\,0_2 \qquad\quad 0_4 \\ \hline\hline & & \Longrightarrow \end{array}$$

Where, R — refers to random sample selection process to form two groups on the horizontal row.

O — refers to observations or measurements on the groups (that is, either treatment on some or no treatment.

1 – 4 — represent the number of groups sampled for example, 0_1 and 0_2 are pre-tests and 0_3 and 0_4 are post-tests.

X — refers to the experimental treatment effect applied to experimental group only (that is, $0_1 \times 0_3$ are experimental groups, and 0_2 ,0_4 are control groups).

$\Longrightarrow$ — Time period moving from left to right (that is, from pre-test to post-test);

$=$ — The two horizontal lines represent two groups.

Agricultural experimentation

Problem statement

What is the effect of fertilizer application on maize production in the southern region of Malawi?

Hypothesis

To find out the effects of using different types of fertilizer on maize yield per hectare in southern region of Malawi.

Observing the differences

The researcher in the field will select randomly a group of maize farmers (random size is very important). The groups may be divided into two: One to be given the types of fertilizers and the other to grow the crop without fertilizer application (control group). After the production period is over the yields from each of the two groups are recorded (data). The data collected is then used to give the findings of the agricultural experiment.

Research experiment

An experiment involves manipulation of independent variables to determine their effect on a dependent variable. In a true experiment, the independent variables are the treatments.

For example, a researcher may be interested in finding out the effect of using different types of fertilizer on maize yield per hectare.

The independent variable in this example is the type of fertilizer and the dependent variable is the maize yield in bags or tonnes.

Experimental methods are used to establish causal relationships between variables. To minimize errors in experimental research, strict sampling procedures should be followed. Use of control groups also enhances the validity of results. The experimental group which has been subjected to the treatment is compared to a similar group but which has not received the treatment.

A sample is a group in a research study from which information is obtained. It is a randomly selected group that is observed in a study. Selecting a sample ensures representativeness in a mathematical study.

Types of experimental designs

Experimental designs are divided into **single-group designs** and **control group**

designs. Research design is chosen based on a range of factors: Feasibility, time, cost, ethics, measurement problems and what you would like to test. The design of the experiment is critical for the validity of the results. The typical designs are:

1. One-short case study: In this, a single group is subjected to treatment and the dependent variable is observed or measured.
2. Pretest – post-test design: This type checks whether the groups are different before the manipulation starts and the effect of the manipulation. Pretests sometimes influence the effect.
3. Solomon four- group design: In this type, there are two control groups and four experimental groups. Half of the groups have pretest and the other half do not have a pretest.
4. Randomised post-test only control group: In this, the control group is only used in post-test. A control group is one that is not receiving the same manipulation as the experimental group.

Stages in conducting experimental research

1. Selecting a problem ; researchers ask a question that deals with the issues of sufficient consequences to warrant an investigation. The question must be meaningful so as to be answered through scientific investigation.
2. Analytical stage ; carry out an exhaustive study on the area of research, that is, literature review. It gives the background of formulating a hypothesis for the research.
3. Selecting and developing a research study ; this is done by use of questionnaires, checklist etc. some problems require experimentation. Developing a research study helps to arrive at the appropriate methodology.
4. Collecting and interpreting data ; this involves collecting data through questionnaires and interviews. The data should be analyzed scientifically and appropriate interpretation made.
5. Presenting the research results ; provide a clear, concise presentation of the the research findings by proper records.

Practical Activity 17

1. Visit the local area and choose any area of study and carry out experimental research.
2. Write down the observations and the findings

Revision Exercise 17

1. What is an experimental research?
2. Outline the main objectives of agricultural research.
3. What is a research design?
4. Give two methods of experiment designs.
5. Outline the stages in conducting experimental research.

Topic 8: Challenges in Agricultural Development

Unit 18: Population Growth and the Environment

Unit 19: Population Growth and Food Security

Unit 18 Population Growth and the Environment

Objectives

By the end of this unit, you should be able to:

(a) Explain the meaning of the term 'soil erosion' .

(b) Explain how rapid population growth accelerates soil erosion .

(c) Describe how soil erosion may cause silting and flooding .

(d) Recognise the effects of soil erosion on the physical environment .

(e) Explain how rapid population growth may contribute to the occurrence of droughts .

(f) Explain how rapid population growth contributes to depletion of water resources .

(g) Describe ways of conserving water and develop an appreciation to the need to conserve water .

(h) Explain how fish farming may be used to meet the demand for fish by the growing population .

Introduction

The human population of Malawi is growing fast and with this growth, various challenges have arisen. The shared resources such as land, water and food are being strained as never before.

In this unit, we shall discuss some of these challenges and the possible solutions.

Most of these challenges involve the degradation of the environment as people seek to exploit the limited resources. Soil erosion is one of the effects of increased human population.

Practical activity 18.1

Visit an eroded area and make observations at the site. Draw the features observed.

Soil erosion

This refers to the process of removal and carrying away of topsoil. It can also be defined as the detachment and transportation of soil minerals from one place to another.

Soil erosion affects the topsoil and this destruction ultimately affect crop yield. The following are some of the characteristics of eroded areas:

Characteristics of eroded areas

- They have thin top soil in gentle slopes while the top soil in steep areas is completely stripped away.
- Formation of gullies.
- No vegetation in some areas.
- Exposed rocks and stones.
- Not fit for agricultural purposes.

Relationship between population growth and soil erosion

As the population grow, the human activities increases leading to exposure of the soil to erosive agents.

How rapid population growth accelerates soil erosion

The following are some of the ways in which population growth accelerates soil erosion.

- Clearing of forests hence exposing the soil to splash erosion, surface run-off and wind erosion.
- Human activities like road construction, buildings leading to development of deep gullies.
- Overcultivation of the land leading to destruction of soil structure.
- Mechanical changes of soils through continous tillage and compaction by heavy machinery leading to formation of hardpans, thus higher run-off of water instead of infiltration into the soil.
- Overgrazing leading to exposure of the soil to erosive agents.

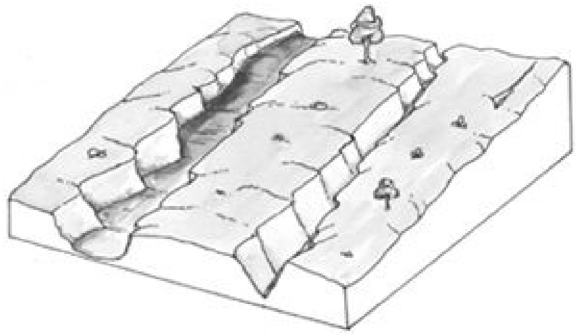


Fig. 18.1: U-shaped and V-shaped gulleys .

Fig. 18.2: Rill erosion .

Cause-effect problem tree for soil erosion

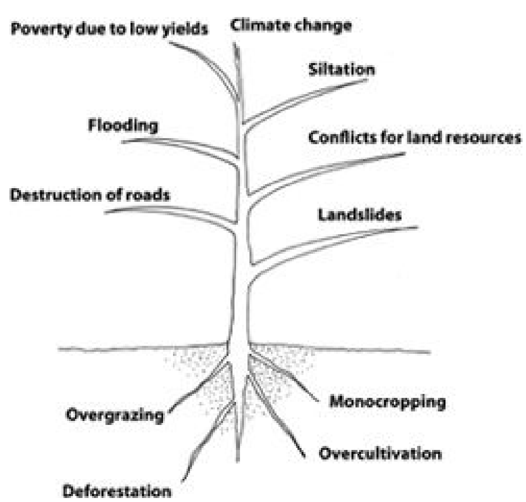


Fig. 18.3: Cause effect probem tree for soil erosion .

Influence of soil erosion on silting and flooding

Soil erosion will carry a lot of soil and deposit it in the dams, making the water to overflow thus causing flooding downslope.

Practical activity 18.2

Visit an area where silting and flooding has occurred and record your observation.

The effects of silting and flooding

- Pollution of water sources, especially from the use of agro-chemicals which will be washed to the water sources.
- Reduction in the amount of water in the dams because of deposition of the washed soil particles.
- May cause death to human beings or livestocks if excess water flows to residential areas.
- Lodging of the trees due to excess water.
- Destruction of farm crops as a result of flooded water.
- Destruction of aquatic organisms like fish as a result of siltation.

Cause-effect problem tree on silting and flooding

Below is a cause-effect problem tree on siltation and flooding.

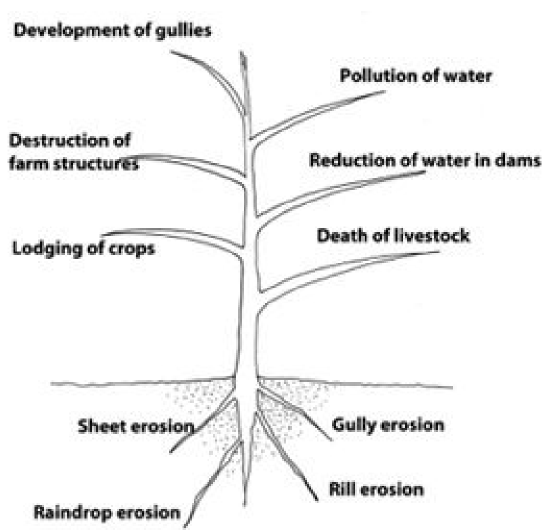
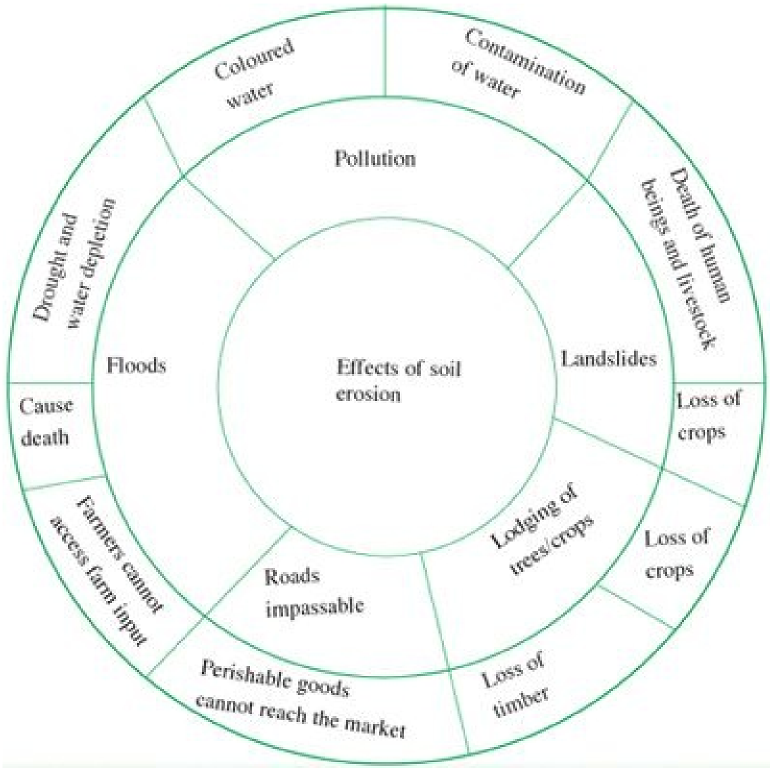


Fig. 18.4: Cause effect probem tree on silting and flooding .

Futures wheel on the effects of soil erosion

Future wheel is an instrument for graphical visualisation of direct and indirect future consequences of a particular change or development.

It is a way of organising thinking and questioning about the future.



Effects of soil erosion

Soil erosion has many effects on the physical environment. Some of them are:

- Siltation due to deposition of excess washed soil particles on dams.
- Pollution of surface and groundwater, that is, the rainwater will carry fertilizers, herbicides etc to the sources of water.
- Landslides especially on hilly areas, part of the land may slide downwards thus destroying farm structures like roads and fences.
- Lodging of trees and crops, when the roots are exposed as a result of soil carried away trees or crops will fall over due to lack of support.
- Make the roads impassable by vehicles due to deposition of fine particles of soil on the road, thus making the vehicles to skid.
- Loss of soil nutrients as a result of carrying away top soil leading to soil infertility.

Relationship between rapid population growth and frequency of drought

The human population growth is rising at an alarming rate. This means that there is competition for the natural resources leading to overexploitation of these resources. Forests have been cleared to make way for human habitation and farming activities. This has in turn led to climate change and drought. Population growth determines drought frequency in the following ways:

- Population growth leads to clearing of forests leading to loss of plant and wildlife species, hence an increase in green house emissions.
- Development or commercialisation of the land surface leading to water stress or drought which will intensify difficulties in meeting consumption level thus causing a lot of negative effects on the delicately balanced ecosystems.
- Lack of clean water due to high rate of population as a result of lack of access to birth control.
- High consumption lifestyles of food particularly in developed countries leading to huge drain on the local resources.

Depletion of water resources

Below is a cause-effect problem tree on drought.

A cause-effect problem tree on drought

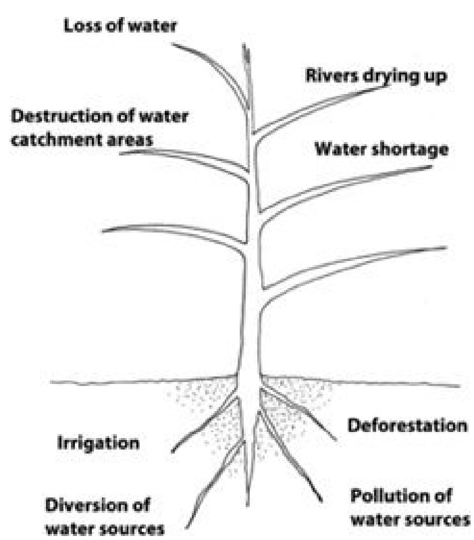


Fig. 18.5: Cause-effect probem tree on drought .

How rapid population growth contributes to the depletion of water resources

Rapid population has caused a lot of challenges to water resources like:

- Deforestation of forests to create room for agricultural production, this leads to destruction of catchment areas.

- Loss of catchment sites leading to drying up of rivers.
- Pollution of water sources from the toxic substances from agro-chemicals and sewage systems.
- Destruction of fish breeding grounds leading to serious shortage of protein sources and other aquatic resources.
- Conflict between wildlife and man for the scarce water resources leading to poaching.
- Migration of the population near the water sources and settlements are established.

Practical Activity 18.3

1. Working in groups of five play a game depicting the relationship between rapid population growth and depletion of water resources.
2. Make notes on the relationship of rapid population growth and depletion of water resources.

Conservation of water

Water conservation is usually carried out in areas that experience periods of water scarcity. There are a number of water conservation methods that include: dams, contour controlled bunds, box ridges and grass cover.

Practical Activity 18.4

Visit your neightbourhood and observe how water conservation is carried out.

(a) Dams

A dam is a barrier constructed across a river or a dry valley to hold water and raise its level to form a reservoir or a lake. The dam impedes water flow. In most cases, the dam’s embankments are earthen. The embankments, however, should be free of trees and bush to prevent damage and discourage water seepage.

This is a very suitable way of harvesting water in the dry areas or areas experiencing seasonal flooding.

Practical Activity 18.5

1. Draw a dam and describe it to your study group.
2. What features surround a dam?
3. A dam is usually shaped like a triangle.

Fig. 18.6: A dam .

(b) Contour control bunds

These are banks of earth built along the contours. The interval between one bund and the next depends on the slope of the land. They are closer on steep slopes and wider on less slopy land that is, they may be built 25 m apart. The banks may be reinforced by planting grass on the soil heaps. Bunds have a base of 1–2 m wide and 0.6 m high.

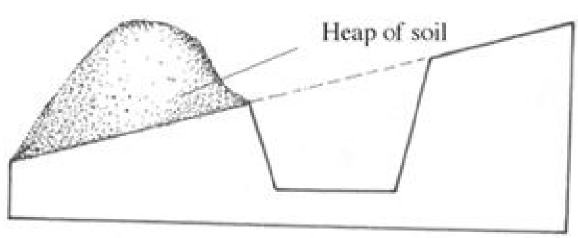


Fig. 18.7.: Bunds .

(c) Box ridges

These are boxes of galvanised wire mesh filled with stones. They are built across slopes and gullies. The gabions are very heavy and thus able to resist the strong force of fast running waters in gullies or streams. Gabions vary in size, from small to very large. They can be made on site or brought when already made.

They slow down the speed of flowing water. As water passes through it, it reduces its erosive ability. They also trap the soil being washed down the stream. These structures are placed either at the gulley bottoms or arranged in rows along the contour on slopy land.

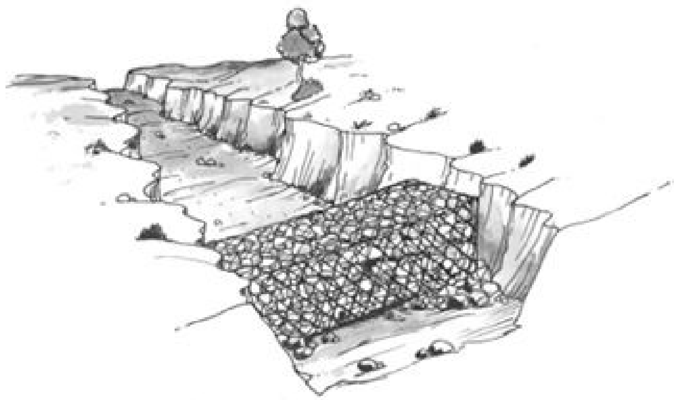


Fig. 18..8: Gabions/porous dam .

(d) Grass cover

This is planted to reduce the impact of rain drops, encourage higher water infiltration and minimise the volume of surface run-off.

Grass cover can be planted across a slope alternating with other crops as alongside.

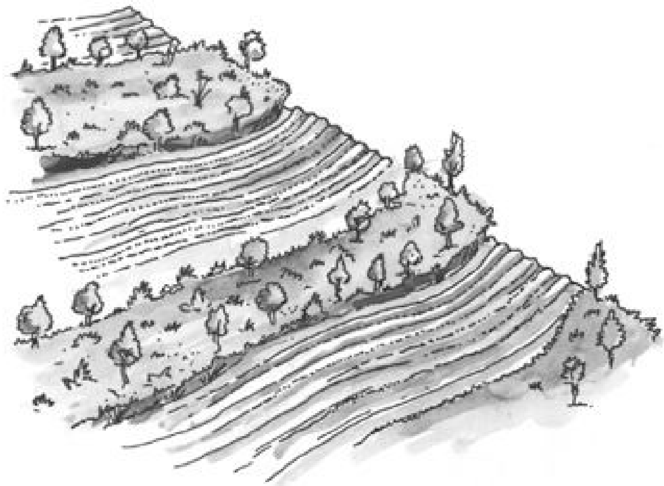
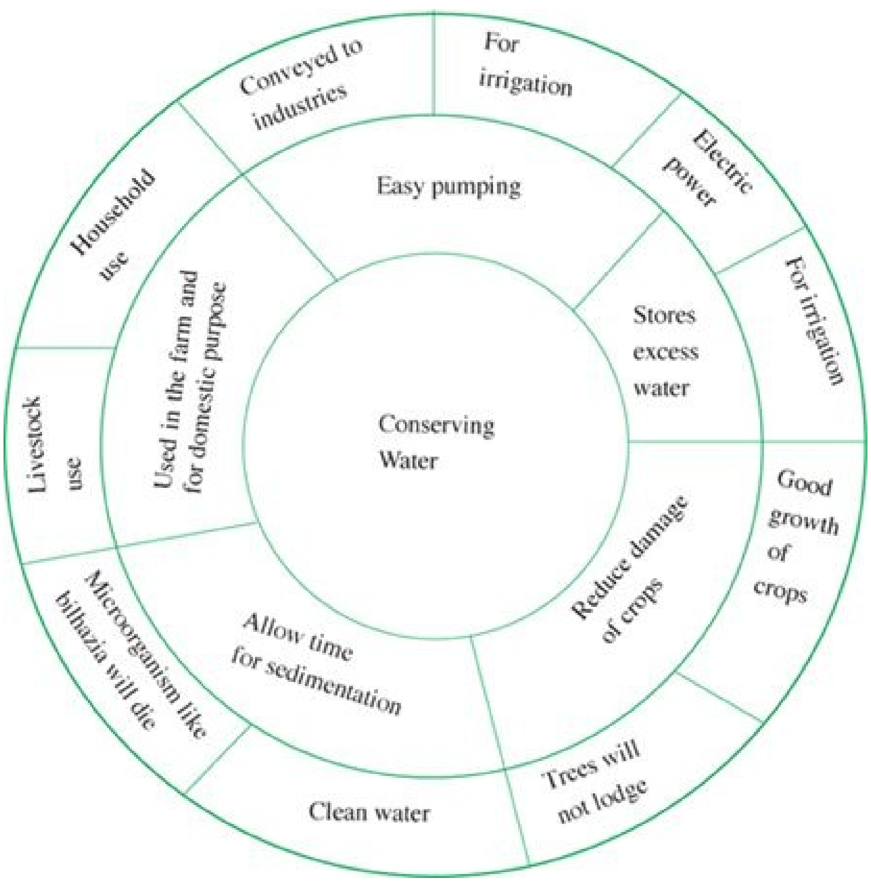


Fig. 18.9: Contour farming with grass cover .

Practical Activity 18.6

- Use the methods discussed above to conserve water in your school.

Futures wheel on importance of conservation



Importance of conserving water

The reason why water is conserved is because it is getting scarce yet it is an essential commodity, these are reasons for conserving water.

- For use during the dry season, therefore, excess water during the rainy season is conserved for future use, for example, in irrigation.
- For easy pumping to industries and factories, that is, the higher the volume the easier it is to pump water.
- To reduce damage to crops and trees, when flowing water is directed to a storage facility, it is less likely to flood and cause damage.
- When water is conserved the soil particles will settle down at the bottom, thus resulting in clean water for drinking.
- Conserved water is easy to be used by livestock and domestic purposes.

Fish farming for the growing population

Fish farming involves raising fish commercially in tanks or ponds, usually for food.

Fish farming to meet the demand for fish by the growing population

There is an increasing demand for fish hence widespread overfishing in lakes such as L. Malawi, L. Chirwa, L. Chinta and L. Malombe, seas and rivers such as Shire River. This has reduced the fish supply. Fish farming offers another source of food for the growing population. This type of farming can be carried out both at subsistence and commercial level. This is due to the fact that land requirement is low since a small area of land can accommodate a **pond** as long as water supply is reliable. Fish is also a cheap source of protein for the growing population.

In addition, fish farming ensures constant supply of fish all year round, as opposed to relying on the natural seasons in lakes and rives when fish is abundant.

Practical Activity 18.7

1. Visit the local area and survey consumption of fish by families by the local community.
2. Make reports of the findings of the survey.

Revision Exercise 18

1. Give two importance of conserving of water.
2. List three ways of conserving water in the farm.
3. Explain how fish farming will meet the demand for fish by the growing population.
4. Outline the benefits of fish farming to a community.

Unit 19 Population Growth and Food Security III

Objectives

By the end of this unit, you should be able to:

(a) Explain the meaning of the term ‘food security’ and ‘food for self sufficiency’ .

(b) Explain how the growing can achieve self sufficiency in food .

(c) Determine the role of estates in food production for the growing population .

(d) Develop an appreciation of the importance of estates in food production .

(e) Explain how proper food storage ensures food security for the growing population .

(f) Identify ways of ensuring food security through proper storage .

Population growth and food security

Food security

Food security is the availability of food and one’s access to it.

African countries population is growing much faster, therefore in order to meet the challenges of increasing population, it is necessary for the African countries to use crop protection measures that enable them to produce more food on less land to satisfy their needs.

Food for self sufficiency

This involves producing food to satisfy hunger throughout the year.

A household is considered food secured when its occupants do not live in fear of hunger or starvation.

Ways of achieving self-sufficiency in food

The following are the ways of achieving self-sufficiency in food.

• Change of diet to avoid exploitation of one source of commodity, that is, feeding should be diversified.

- Improved varieties of crops and animals adopting genetically modified organisms (GMOs) like fast maturing crops and animals.
- Use of fertilizers to accelerate the growth of crops and improvement of yields and quality.
- Provision of credit facilities to farmers to enable them to purchase farm inputs and prepare the land.
- Provision of marketing facilities for proper storage of excess food.
- Alien species of animals and plants are introduced to the local environment to increase genetic potential.
- Training of farmers through various methods to acquire the latest information from research stations and other scientists.
- Use of appropriate methods like when harvesting fish, use a method which will spare the young ones to continue multiplying.
- Changing personal attitudes and practices, to avoid destruction of natural resources.

Role of estates in food production

Estates are large scale farmers who produces a lot of food to feed the people, some of their roles are:

(a) Increasing food production

- Large scale production of food for commercial purposes and to meet the subsistence needs of the people.
- Provides casual employment to many workers (Ganyu) which will enable the workers to purchase food hence raise the standard of living.
- Have proper storage facilities for the produce, this will drastically minimise storage losses.
- Provide training to the farmers through demonstrations and by working in their farms. They acquire skills.
- They employ economies of scale hence are able to produce food at a cheaper cost.
- Have better facilities like their own research station therefore they are able to produce crops which are fast maturing, disease resistant and drought tolerant.

(b) Training farmers

Provide training and education for farmers through demonstrations, seminars and hands-on training on the farms.

Practical activity 19.1

- Divide yourselves into two groups and debate on the importance of estates in food production.

Importance of proper storage for food security

It is estimated that 30 – 40% of the crops produced are lost to pests in Africa hence proper storage has to be imposed. The following are the importance proper storage.

- Reduce spoilage like if cereals are stored in leaking roofs they get spoilt and become poisonous to man.
- Ensure availability. Food has to be stored to serve the people throughout the year.
- To prevent pests from attacking them hence reducing their shelf life and quality.
- To safe-guard the produce against theft and pilferage.
- For speculative prices. At harvest time, the prices are very low but later the prices shoots up.
- To feed the people throughout the year without any shortage at certain times.
- To safeguard against bad times such as serious drought.

Food storage facilities

The term food storage means keeping harvested crops in good condition so that they remain fit for future use. Most crops need to be stored after harvesting. However, there are a few that are sold to consumers immediately since their storage can be quite expensive. Certain crops, such as, cereals and sunflower seeds require proper drying before storage. It is estimated that poor storage accounts for up to 10% of the global crop losses annually.

The main storage problems are:

- High crop moisture contents.
- Infestation by moulds.
- High storage temperatures and high incidences of pest attacks, especially in

tropical countries.

Importance of crop storage

- To save seeds required for planting.
- To provide food between harvesting seasons.
- To provide farm animals with food even during periods of pasture scarcity.
- To provide safekeeping of harvested produce for consumption all the year round that is, avoid adulteration of the produce.
- To reduce and avoid heavy losses which may otherwise occur in the field.

Ways of storing food to ensure food security

(a) *Traditional granaries* : These vary with communities, types of produce to be stored and the construction materials used. Some communities put crop produce in simple containers or pots; others used to leave the produce hanging on poles outside in the homesteads. Nowadays, granaries are used in most farming areas though their structural design exposes the produce to rain and to attacks by insects and rodents. However, modifications have been made to traditional store structures by constructing the floors and walls using timber and the roofs with corrugated iron sheets.

(b) *Modern granaries* : Modern storage structures are used for bulk storage of grains. They handle large quantities of grains either in bags or bare. Examples are silos and bins like Hermetic Cyprus bins. They conform to storage requirements.

Good storage structures should have the following requirements:

(i) Vermin-proof.

(ii) Well ventilated.

(iii) Rain-proof.

(iv) Easy to load and off-load.

(v) Easy to clean.

(vi) Damp-proof.

Fig. 19.1: Traditional grannary .

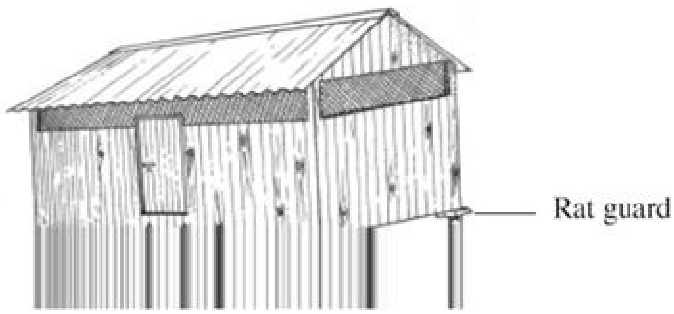


Fig. 19.2: Modern grannary .

(c) Sacks

These are stored in a structure that is free from damp, insect attack and rodent.

Advantages of sacks

- Gunny bags can be easily isolated and labelled to contain different grain products without the risk of mixing grains.
- Gunny bags can be easily moved, especially when transfering the stored products.

(d) Silos

A silo is an air-tight storage facility that is specially constructed to allow easy loading and off-loading grain. Most modern silos are fitted with conveyor belts to transport the grains up or down the silo.

Practical Activity 19.2

1. Visit a nearby farm. Study the storage hygiene practices carried out in a modern store. Notice how storage bags are stacked.
2. Carry out harvesting and preparation for storage of either maize or beans in the school farm.

Farm produce store

These are structures used for storing cereal produce such as maize, millet, sorghum, wheat, finger millet. They can also be used to store pulse crops for example, peas and beans.

Requirements of a good farm produce store

(i) *Damp proof:* Ensure the roof is not leaking and that there are no cracks on solid walls. Dampness encourages fungal or weevil attack on the grains. Preferably construct a store raised off the ground, that is, about 60 cm above the ground.

(ii) *Easy to clean:* Good hygiene is very important for successful storage of farm produce. Therefore, it is necessary that the store be easy to clean.

(iii) *Vermin-proof:* Rodents such as rats, mice can cause great damage to the stored produce. Prevent entry of such rodents by fitting rat guards or deflectors on the posts.

(iv) Should have *proper ventilation* to allow free circulation of air.

Cold rooms

It is a facility used in food storage. The materials stored must be of high value to justify the cost of electricity. The following are examples of foods stored in cold rooms; fish, broiler meat, horticultural crops which must reach the market when they are fresh.

Practical activity 19.3

Visit local area near the school. Make observation of how the local farmers store harvested crops.

Revision Exercise 19 A

1. What is the importance of crop storage?
2. What are the constructional requirements of a good grain store?
3. List the food which require cold room storage.
4. Explain why cereal crops are best stored in silos.

Population growth and agricultural development

Importance of mixed cropping and mixed farming

Farmers may choose to grow crops and / or keep livestock depending on the land available, capital, labour availability and socio-cultural values of the farmers. The following are some of the farming systems usually adopted by farmers.

Mixed cropping

This refers to growing two or more crops in the same field but in specific sections of the farm at the same time.

Mixed farming

This is the practice of growing crops and keeping livestock on the same piece of land at the same time.

Effectiveness of mixed cropping and mixed farming in supporting growing population

Mixed farming and mixed cropping have effectively supported growing population in the following ways.

- Providing a well balanced diet to the population because of a variety of farm produce hence reduction of malnutrition.
- Through sale of the products the standard of living has been improved.
- High income from the products thus reducing poverty throughout the year.
- It is an insurance against total loss in case of rain failure.
- The mixture improves the soil fertility hence high crop yields to meet the demand of the growing population.
- Soil degradation is minimised due to complete soil cover and because of high soil fertility a lot of vegetation will grow rapidly.
- Helps in controlling pests and disease spread hence the cost of production is low, therefore the population will get high profits.
- Maximum utilisation of soil nutrients hence no wastage of the nutrients in both layers.

Importance of mixed farming in supporting growing population

Mixed farming is very important in supporting growing population in the following ways:

- The population will obtain both crops and animal products at the same time.
- The growing population will obtain both animal products and crop products

thus, avoid suffering from malnutrition.

- The growing population will get an income throughout the year.
- Growing crops will benefit from the animals manure therefore, the growing population will incur less cost in the purchase of fertilizer.

The extent to which mixed cropping and mixed farming are used in the community

Most of the local community members have adopted mixed cropping and mixed farming due to the small pieces of land size as a result of the increase in population growth.

This practice is carried out where farmers have not specialised in farming.

Where the two practices have been carried out, the standard of living of the community members generally improve as compared to single enterprises. However, the major limiting factor of this system is divided attention and lack of enough resources.

Revision *Exercise 19 B*

1. Define the following terms:
   (i) Mixed cropping.
   (ii) Mixed farming.
2. State the importance of mixed cropping and mixed farming in growing population.
3. Analyse the effectiveness of farming systems in supporting growing population.

Agricultural development agencies and services in Malawi

The following are some of the agencies.

- **Cold Storage** which handles perishable products of high value.
- **ADMARC** – Agricultural Development and Marketing Corporation which process and export some farm produce.
- **Research stations** carry out research in various crops for example, tobacco, tea, coffee, sugar, tree and nuts.
- **Agricultural corporation** deals with the licensing of certain crops.

• **Dairy board** is concerned with the breeding of dairy cattle.

• **Processors** – process raw agricultural products into utilisable form.

Services offered by the agricultural development agencies

• Research stations engage in various research activities including food security, nutrition, water supply and economic empowerment of farmers, sustainable development and conservation of natural resources. They also carry out research on livestock diseases and their control.

• Marketing for example, ADMARC promote small holder production of the following crops: Beans, peas, groundnuts, rice, sorghum and sunflower seeds.

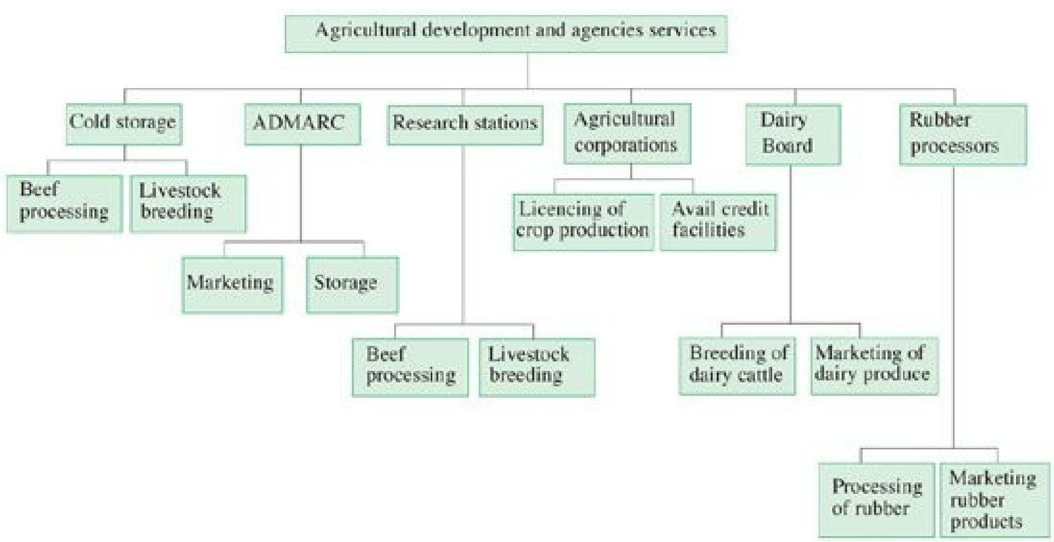
• ADMARC market agricultural produce and inputs. It also plays a food security role in the country's maize market.

• Infrastructure is concerned with the development of agricultural transport systems such as roads and storage facilities.

• Extension: They disseminate the new farming skills from the research stations to the farmers in the rural areas. This will eventually result in high production to meet the needs.

• Processing: They process raw agricultural products into utilisable form and reduce the bulkiness and increase the value.

• Production credit: This is the advancement of money in kind or cash to enable the farmers to prepare their land in good time or purchase livestock requirements.



Importance of agricultural development services to the growing

population

Due to growing population, there is a need to increase the output per unit area of land to meet the demand of the growing population. Some of the importance of these services are:

- The production of food crops and livestock products will rise leading to surplus products being exported to earn foreign exchange.
- Because of the regulation of production of certain crops, this will maintain the prices at high levels.
- Promotion of horticultural production for commercial and self sufficiency, this will reduce the occurrence of food deficiency diseases such as malnutrition.
- Good roads to enable the farm produce reach the market quickly particularly perishable crops, thereby earning high income for the farmers and the government.
- When farmers are given production credits, the volume of production will rise hence more food to the population.
- Small scale farmers will be able to get market for their produce due to bulk selling, thus earning more to meet the domestic demand.

Gender bias in agricultural technology

Gender bias – This refers to a favouritism of a person due to sex, which results in discrimination against males or females.

Gender bias reduces agricultural productivity and slows down agricultural development as follows:

- Women cultivate more than half of all the produce that is grown, women produce upto 80% of the basic food yet they get little recognition and they are not paid.
- Women spent a lot of their time in unpaid work in the household as opposed to renumerative employment of men.
- When they are engaged in any employment like agricultural industries, they are paid less than the males and have less job security.
- Women do not own tractors but instead the men are the owners and drivers.
- Women do 90% of the work and receive 10% of the income and own 1% of the wealth. Title deeds are in the name of the man.
- When using ox-cultivation the women drive the animals while the man holds

the equipment.

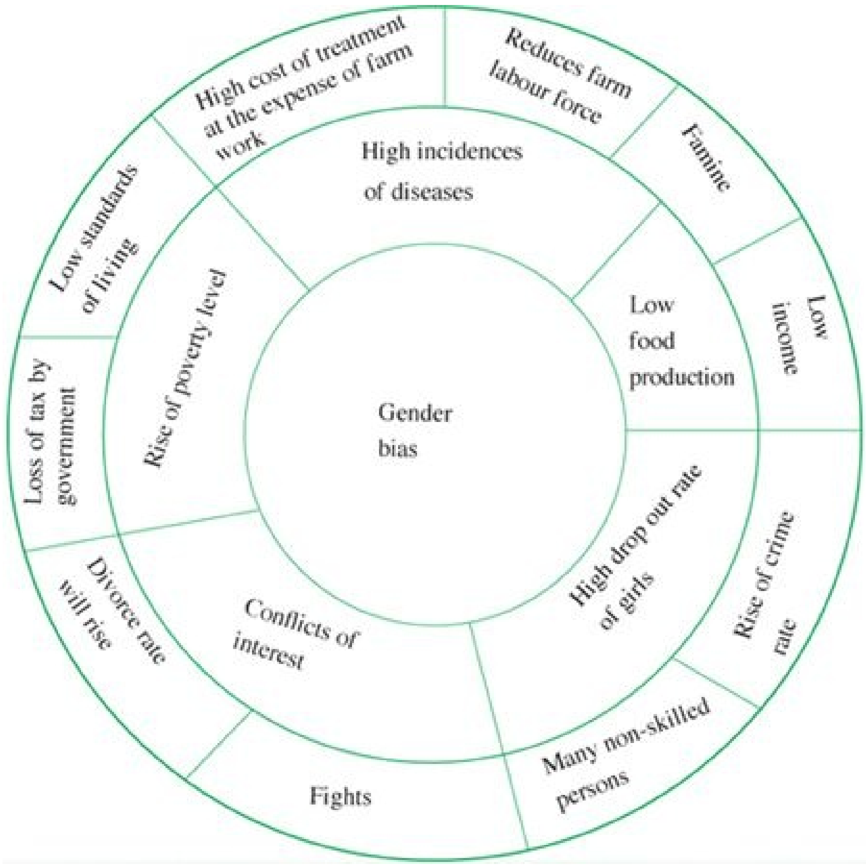
- Women are the ones who generally process farm produce but the men pocket the proceeding from the sale of the produce.

Implications of some gender biased agricultural technology on agricultural production

This leads to the following issues:

- Low food production as the energies are divided not concentrate on one enterprise.
- High incidences of diseases due to inadequacies of food quantity and quality.
- High rate of poverty as a result of inadequate sources of income.
- Conflicts of interest leading to quarrels and eventually high rate of divorce.
- Women are not motivated to put all their effort in the production process hence less production.

Futures wheel on effects of gender biased application of agriculture technology



Practical Activity 19.4

Visit the local area and make observation of the following:

- The driver of the tractor if applicable.
- Roles or duties of each member of the family.
- Cash crop grown.
- Sketch futures wheel on the effects of gender biased application of agricultural technology of the local area.

Revision Exercise 19 C

1. What is gender bias?
2. Explain the effects of gender bias in agricultural technology.
3. Give examples of agricultural activities where gender bias is common.

Sample Examination Paper

PAPER I
Subject Number: M012/I
This paper has two sections, A and B. Section A has ten questions and Section B, four questions. Answer all the ten questions in this section.

Section A (60 marks)

1. (a) What is an experimental design? *(1 mark)*
   (b) Name any three experimental designs. *(3 marks)*
2. (a) What is soil structure? *(1 mark)*
   (b) Explain any four soil structures. *(4 marks)*
3. Give four reasons for raising mango seedlings in a nursery. *(4 marks)*
4. (a) State three reasons for feeding livestock. *(3marks)*
   (b) Name the three classes of feeds. *(3 marks)*
   (c) Differentiate between production ration and maintenance ration. *(2 marks)*
5. Study the design given below of a cropping system and use it to answer the questions that follows.

1ST YEAR

Plot A	Plot B	Plot C	Plot D
Cotton	Maize	Beans	Cabbage

2ND YEAR

Plot A	Plot B	Plot C	Plot D
Maize	Beans	Cabbage	Cotton

   (a) Identify the type of cropping system. *(1mark)*
   (b) State any four principles which must be followed to make the system work. *(4 marks)*
   (c) State any three advantages of this type of cropping system. *(3 marks)*
6. (a) Explain five symptoms of trypanosomiasis disease in goats. *(5 marks)*

(b) Explain any five effects of parasites in sheep and goats. *(5 marks)*

7. Explain any two uses of solar energy in the farms. *(5 marks)*
8. Differentiate between elastic and inelastic demand. *(2 marks)*
9. (a) What is soil erosion? *(1 mark)*

   (b) Explain how rapid population growth accelerates soil erosion. *(5 marks)*

   (c) State any five effects of flooding. *(5 marks)*
10. Explain the functions of water in the body of an animal. *(3 marks)*

Section B (40 marks)

Answer all the four questions in this section. Your answers should be in an essay form .

11. (a) Explain the harmful effects of plant diseases. *(4 marks)*

    (b) Explain the cultural measures of plant disease control. *(6 marks)*
12. Discuss how rapid population growth contributes to depletion of water resources. *(10 marks)*
13. Explain how the various vegetative materials are used for propagation. *(10 marks)*
14. Explain how soil pH influence crop growth and production. *(10 marks)*

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The authors have served in the education sector in various capacities where they have contributed immensely in the field of Agriculture. They also have a wide experience in teaching and curriculum development.

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ISBN 999601420-7
9789996014208