Agriculture

Senior 2

Student's Book

Contents

UNIT 1

SOIL

Introduction

Soil is an important natural resource used in agricultural production. It should, therefore, have the necessary nutrients to support and sustain crop production.

A fertile soil can be determined by observing its physical characteristics and carrying out soil tests. It can also be deduced by observing its plant's indicatory signs. The plant's signs that indicate the lack of certain nutrients in the soil are known as nutrient deficiency symptoms.

Soil fertility can be improved by adding organic manures and inorganic fertilisers into the soil.

This unit explores the various characteristics of a fertile soil and their plant's indicatory signs, factors affecting soil fertility, availability of nutrients in the soil and improvement of soil fertility through the application of organic and inorganic fertilisers. The photographs below gives an over view of the unit.

Deep and well formed soil

Shallow soil showing stunted crops growing on it

Healthy bean plant on fertile soil

Withered crops due to lack of water

1.1 Definition of soil fertility

Activity 1.1: Using search engine or library textbook, define the soil fertility.

Soil fertility is defined as the ability of the soil to provide crops with the required nutrients in their proper proportions for sustained high production.

The supply of these nutrients must be adequate for crops to grow well and produce high yields indefinitely.

1.2 Characteristics of fertile soil and its plant indicators

Activity 1.2: Visit the school farm or a neighbouring farm and carry out the following activities:

(a) Observe the colour of the soil in the farm.
(b) Determine the type of soil by feeling the soil between your fingers when dry and when wet, then carry out the ribbon test.
(c) Estimate the soil pH by use of a pH meter or colour indicator paper method.
(d) Observe the leaves of the crops in the farm and identify symptoms of nutrient deficiencies if any.

Fertile soils have the following characteristics:

Good depth: Deep soils give plant roots a greater volume to obtain plant nutrients and provide strong anchorage. Crops growing in shallow soils get less nutrients and are liable to lodging.

Fig. 1.1: Weak crops growing on a rocky ground

Well drained: Well drained soils are properly aerated. This promotes healthy root development and prevent the build up of carbon (IV) oxide to toxic levels in the soil. Most plants die in waterlogged soils due to lack of air.

Fig. 1.2: Yellowing plants in a waterlogged or flooded area

Good water-holding capacity: This ensures that enough water is retained for plant use. Soils that lose water easily are not able to sustain crop growth in case of a dry spell.

Adequate nutrients supply: The soils should supply the nutrients required by plants in their correct amounts and in forms that are available to the crops. Crop nutrients deficiency symptoms are seen in soils with less nutrients.

Correct soil pH: Different crops require different soil pH. Soil pH affects nutrients available since certain plant nutrients are only available at specific soil pH. Extremes of soil pH lead to crop failure.

Adequate lime to keep the pH around neutral: Most crops do well at pH around neutrality (pH of 6.5 – 7.5).

Free from excessive infestation of soil borne pests and diseases: Crops growing in healthy soil produces high yields of high quality and low yields are experienced in soils infested by pests and diseases.

Dark colours: The dark colour absorbs the heat of the sun, thus improving soil temperature. Soil temperature affects the rate of reactions taking place in the soil. It also affects the activities of soil micro-organisms. Light coloured soils have poor heat absorption and retention capacity.

Fig. 1.3: (a) Black cotton soil

Fig. 1.3: (b) Light coloured soil

Not saline: Fertile soils are free from excessive accumulation of salts which lead to water stress in plants.

Fig. 1.4:(a) Vigorously growing plant indicate fertile soils

Fig. 1.4: (b) A plant showing leaf chlorosis indicate soil deficient in essential mineral elements

1.3 Factors affecting soil fertility

Activity 1.3: Using adequate material carry out the following activities:

a) Grow 2 sets of crops (tomato or kale) in portable containers labeled A and B.

b) Provide water to the crop in container labeled B for a period of 2-3 weeks to act as a control experiment and make observations to present in the class.

Soil fertility is affected by the following factors:

(a) Availability of water in the soil

Soil water come from rainfall or irrigation in arid and semi-arid areas. Soil water is useful in plants in many ways. It acts as a transport agent, a cooling agent and as a raw material in the process of photosynthesis. As a transport agent, water transports nutrient elements absorbed from the soil to the various points of utilisation in the plant. Lack of enough water means these nutrients are not transported to where they are needed in the plant and this may lead to impairment in the process of photosynthesis. The result of water shortage (stress) in plants is retarded growth, reduced crop yields or total crop failure in extreme water shortage. Therefore, availability of water in the soil affects soil fertility. There must be adequate water in the soil for it to produce to its maximum potential. Study the illustration (a) and (b) in Fig 1.5 below and identify the one showing plants growing under water stress.

Fig. 1.5: (a) Plant given enough water

Fig. 1.5: (b) Water stress

(b) Water drainage

Excessive water in the soil is equally not good. The soils become waterlogged. Such soils lack enough air and respiration in roots and other living organisms is impaired. The results is poor nutrients uptake especially where active transport is involved. Therefore, too much water in the soil affects soil fertility. Excess water in the soil should be removed through the provision of proper drainage to ensure adequate supply of air in the soil.

(c) Activity of soil micro - organisms

Soil micro-organisms play an important role in soil fertility;

- Decomposers; Termites and earth worms break down organic matter in the soil into humus. This process releases plant nutrients into the soil.

Fig. 1.6:(a) Termites

Fig. 1.6: (b) Earthworms

- Nitrogen fixing bacteria in the soil such as *Rhizobium* that lives in the root nodules of leguminous crop convert free nitrogen in soil air into nutrients which are absorbed by plants. Other free living bacteria that fix nitrogen into nitrates in the soil include; Azotobacter and clostridium. These bacteria improve the fertility of the soil.
- Denitrifying bacteria that live in waterlogged and compacted soils convert nitrates into nitrogen gas and Ammonium ions into Ammonia gas. These gases escape into the atmosphere thus lowering the fertility of the soil. Proper drainage of the soil improves the activity of nitrogen fixing bacteria which are aerobic and impairs the activity of denitrifying bacteria which are anaerobic.
- Some soil living organisms are pathogenic and cause diseases to crops. For example, most fungal and bacterial diseases are soil borne. Other soil living organisms attack, for example, nematodes attack crop roots resulting in wilting.

Fig. 1.7: Tomato plant roots attacked by nematodes

1.4 Factors affecting the availability of plant nutrients

Activity 1.4: Watch a video that shows the following topics and discuss factors affecting the availability of plant nutrient.

(a) Effects of water stress on crop production.

(b) Mineral deficiency symptoms in crops.

(c) Effects of saline soils on crop production.

The following are factors that affect the availability of plant nutrients:

(a) Soil pH: Soil pH affects the availability of various nutrients, for example, low pH makes phosphorus and molybdenum less available while high pH makes manganese, potassium, iron, boron and zinc less available.

(b) Organic matter content: Soil organic matter is broken down by micro-organisms to release nutrients. The residue known as humus increases the cation exchange capacity (CEC) of the soil thus making more nutrients available to the plants.

(c) Soil texture: It influences the drainage and aeration of the soil. Coarse textured soils tend to be free draining and lose a lot of nutrients through leaching and, therefore, are less fertile. Fine textured soils, for example, clay tend to be waterlogged during the rainy season and, therefore, are poorly aerated as a result of which respiration in plant roots is impaired and therefore are not able to absorb plant nutrients. The activity of decomposers and Nitrogen fixing bacteria are reduced while the activity of the denitrifying bacteria is increased. Moderately textured soils are well aerated and, therefore, plant roots are able to

absorb nutrients. The activities of decomposers and Nitrogen fixing bacteria are also at their optimum, thus making nutrients available to the plants.

Fig. 1.8: (a) Moderate texture

Fig. 1.8: (b) Desert texture

Fig. 1.8: (c) Fine texture

Fig. 1.8: (a), (b) and (c) shows different textured soils. Identify the one best suited for growing crops.

(d) Climate: Climatic factors such as rainfall and temperature affect the availability of plant nutrients. Rainfall of high intensity results in soil erosion and washing down of soluble nutrients thus making them unavailable to the plants. High temperatures result in volatilisation of soil nutrients such as nitrates and Ammonium ions. This makes nitrogen unavailable to the plants.

(e) Leaching of soil nutrients: Leaching is the washing down of soluble nutrients from the soil especially after a heavy downpour of rain. The nutrients move to lower horizons of the soil, where they are out of reach by plant roots. This makes the nutrients unavailable to the plants. Leaching is more common in sandy soils which are free draining.

(f) Soil compaction: When the soil is compacted, air content is reduced. This leads to poor respiration of plant roots and other living organisms in the soil. The plant roots are unable to absorb nutrients while micro-organisms are unable to act on organic matter to release nutrients. The activities of denitrifying bacteria are also increased resulting in unavailability of nitrogen to plants.

(g) Crop removal: Continuous cropping results in a lot of nutrients being removed from the soil through harvesting. This eventually makes the soil infertile. The soils should be replenished by addition of organic fertilisers or inorganic fertilisers. Crop rotation also helps the soil to regain its fertility and especially where the land is left uncultivated for sometime.

(h) Use of sensitive crops: Different crops have different nutrient requirement, for example, maize requires a high amount of nitrogen, phosphorus and potassium while beans require less nitrogen and more phosphorus. Too much nitrogen in maize causes succulency and lodging while in beans it leads to vegetative growth instead of production of pods.

(i) Nutrient interactions in the soil: The presence of some nutrients in the soil may hinder the availability of others. For example, excess phosphorus in the soil leads to unavailability of iron as it is converted into insoluble compounds which cannot be absorbed by plants. In this form, iron is said to be fixed or unavailable.

1.5 Symptoms of mineral nutrient deficiencies

Activity 1.5: Draw a table of deficiency symptoms in plants according to observation of the photgraph or live plants displayed with nutrient deficiency symptoms

Table 1.1: Comparison between healthy and deficient plants

Healthy plant	Deficient plant	Symptoms identified	Deduction
(a) Strawberry plant 	Stunted plant 		
(b) Raspberry plant/ leaves 	Chlorotic leaves 		
(c) Healthy green leaves (citrus) 	Yellow patches between the veins in leaves 		

(d) Healthy citrus branch 	Shoot-tips drying backward in citrus 		
(e) Healthy tomato plant 	Purple colour in fruits 		
(f) Healthy citrus leaves 	Leaves curled along the margin 		
(g) Healthy maize plants 	Lodging in maize plants 		
(h) Developed root nodules 	Lack of root nodules 		

Activity 1.6: Observe and identify deficiency symptoms in crops after a periode of 3 up 4 weeks

Deficiency symptoms are physical signs showing that a crop is lacking some mineral elements. Some of the mineral nutrient deficiency symptoms include:

(a) *Yellowing of the leaves*: In this case, plant leaves lose chlorophyll and become yellow, which is also referred to as chlorosis. Chlorosis is a common occurrence in the deficiencies of nitrogen, potassium and sulphur. The deficiency of magnesium results in a special type of chlorosis where only the parts between the veins become yellow. This type of chlorosis is referred to as inter-veinal chlorosis.

(b) *Stunted growth*: This is slowed growth also known as dwarfing in extreme conditions. It results in a situation where the deficiency leads to the impairement of the process of photosynthesis. It may occur in the deficiencies of nitrogen, phosphorus, potassium, sulphur and calcium.

(c) *Die back*: This is the drying of the plant from the shoot tips downwards. It may occur as a result of calcium deficiency.

(d) *Premature fall of leaves and flowers*: This is common in the deficiency of nitrogen and potassium.

(e) *Production of a purple pigment*: Known as anthocyanin instead of chlorophyll. It can also appear after chlorosis. Anthocyanin is common in the case of nitrogen, phosphorus and magnesium deficiencies.

(f) *Leaf curling*: It is also known as leaf roll where plants have folded leaves. It is due to lack of magnesium.

(g) *Lodging*: This is falling off of crops due to weak stems and poor root development. This is due to lack of phosphorus and potassium.

(h) *Poor nodulation in leguminous plants:* This is mainly due to lack of phosphorus and sulphur.

(i) *Leaf scorch*: Edges of leaves appear scorched due to lack of potassium.

1.6 Definition of organic manures

Activity 1.7: Use search engine or library textbook to define the organic manures.

Organic manures are materials that are derived from decomposed plants and animal remains, which are to be applied to the soil to release plant nutrients. The end-product of this decomposition process is known as humus. Humus greatly influence soil chemical properties such as soil pH and Cation Exchange Capacity (CEC). They supply a wide range of essential plant nutrients. The nutrient content in organic manures cannot be

quantified. Organic manure are important for the following reasons:

- They supply a wide range of essential plant nutrients.
- They influence the soil pH and cation exchange capacity.
- They have a long residue effect in the soil.
- They improve soil physical properties such as water-holding capacity, capillarity, drainage and aeration.
- They reduce toxicity in the soil by absorbing harmful chemicals.

1.7 Types of organic manures

Activity 1.8: Identify the types of organic manure provided by comparing their preparation technic, then after discuss the characteristics of plants used as green manure

Organic manures are classified as follows:

Manures are classified on the basis of the method of preparation and the materials from which they were made. There are four types of organic manures based on this classification. They include:

(a) Compost manure: This is manure prepared from composting or heaping organic materials and allowing them to decompose under controlled conditions, either in a pit or a heap. The compost materials include crop residues and animal waste or plant material only. The following factors should be taken into consideration in selecting a site for preparing compost manure:

- Drainage – The place should be well drained to avoid waterlogging which may lead to leaching of nutrients from the manure.
- Direction of prevailing winds – The site should be away from the dwelling place to prevent bad odour being blown from the compost manure to the homestead.
- Size of the farm – The site should be centrally placed within the area of the farm where manure is to be used as manures are bulky to transport.
- Accessibility – This makes it easy to transport the materials used to make the manure when ready.

(b) Farmyard manure: This manure is prepared from a mixture of animal waste and litter used as beddings in animal houses. The mixture is then allowed enough time to decompose before it is used as manure. The quality of farmyard manure is determined by the following factors:

- The type of animal used – Dung from fattening animals has a high level of nutrients than that from dairy animals. Dung from non-ruminants such as pigs

and poultry, which absorb less nutrients from their feed has a higher level of nutrients than that from ruminant animals.

- Types of food eaten – Feedstuffs that are highly nutritious result in manure which has a high level of nutrients.
- Type of litter used – The best litter is that which has a high urine absorption capacity, decomposes fast and has a high nutrient content.
- Method of storage – Farmyard manure should be stored in a well sheltered place with a leak-proof roof and a concrete floor to prevent loss of nutrients through leaching and vapourisation.
- Level of decomposition – Well rotten manure is rich in nutrients and is easy to handle and mix with the soil.

(c) Night soil: This is manure prepared from human waste (urine and faeces). Defaecation is done in a container or bucket at night. The faeces which may or may not include urine are then covered with soil. The material is now called night soil. The night soil is collected by a night soil collector and then deposited somewhere to undergo decomposition. The night soil is then treated to make it safe for handling. This is usually done to get rid of worms which may be in the human waste and to remove other heavy metals. This practice is common in areas with a high population density especially in urban areas where there are no sewage systems. This type of manure may be used in flower farms but may not be suitable for vegetable crop gardens.

(d) Green manure: This is manure prepared from green plants. The plants are grown and then incorporated into the soil to improve soil fertility. Leguminous plants such as ground nuts, cowpeas, sun hemp cloves, lucerne and beans are preferred as they also fix nitrogen, otherwise maize, sorghum and sunflower may also be used.

Characteristics of plants used as green manure include the following:

- Highly vegetative or leaf for faster decomposition.
- Fast growth rate so that they may take a shorter time in the field.
- Have a high nitrogen content.
- Able to rot or decompose quickly.
- Hardy and, therefore, able to grow in poor conditions.

1.8 Types of composts

Activity 1.9: Using search engine or library text books describe the types of composts

There are two types of composts. These are:

(a) Heap compost – This type of compost is prepared by heaping the material to be composed in a heap or stack on the ground. The materials are held together by posts which are fixed at a distance of 1.2 m apart to form the four corners of the heap. Timber boards are fixed on the sides to hold the heaped materials.

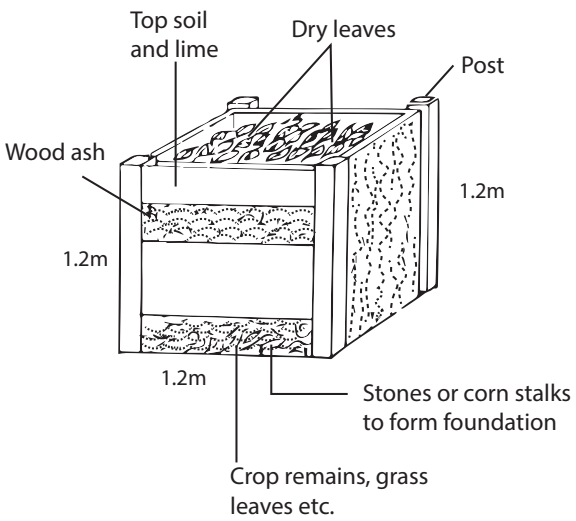


Fig. 1.9: Compost heap showing posts at the corners

(b) Pit compost – This type of composed is prepared by placing the materials in a pit. This method of preparation is also known as the indore method after a place called Indore in India where it was derived. In this method, the materials to be composted are packed into a pit measuring 1.2 m long, 1.2 m wide and 1.2 m deep. The materials are placed in layers starting with fibrous materials such as maize stalks which form the foundation of the compost layers.

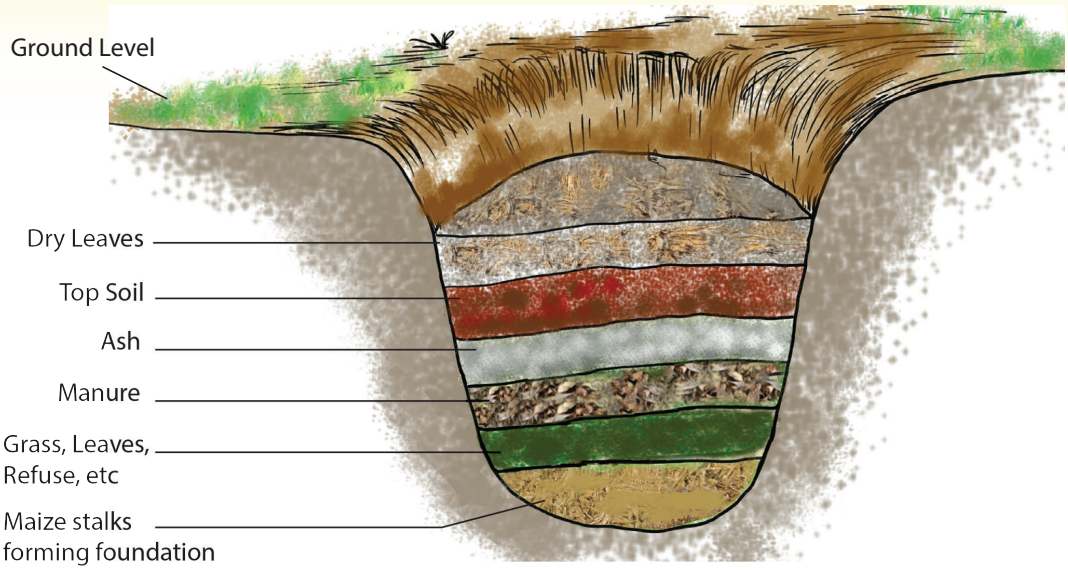


Fig. 1.10: Layers of materials in a compost pit

1.9 Steps in making compost manure using the pit method

Activity 1.10: Visit a farm where compost manure is being prepared. Then carry out, discuss and record your observation on the following activities:

1. Observe the method of composting being used in the farm.
2. Take note of the sitting of the compost pit or heaps in reference to the homestead and the area where the manure is to be used.
3. Take the measurements of the compost pits or heaps.
4. List the materials being used in composting and note their use.
5. Note the order in which the material are being packed in the compost pit.

The following are the steps in making compost manure using the pit method:

(i) Select a suitable site for digging the compost pit.

(ii) Clear the vegetation on the site.

(iii) Mark the size of the pit using pegs.

(iv) Dig out a pit measuring 1.2 m long, 1.2 m wide and 1.2 m deep.

(v) Collect materials for preparing compost manure which should include the following:

- Maize stalks, wheat straws or rice straws (whichever is available)
- Fresh grass, hedge trimmings, prunings, fresh young weeds and kitchen waste
- Wood ash

- Well rotten manure
- Garden soil
- Dry leaves
- Phosphatic or potassic fertilisers

(vi) Arrange the materials in the pit in layers as follows:

- Pack 10 cm fibrous materials of maize stalks, wheat or rice straws at the bottom of the pit to form the foundation of the compost materials.
- Add a 15 – 10 cm layer of fresh materials such as fresh grass, trimmings, prunings, weeds and kitchen waste.
- Add a 2.5 cm layer of well rotten manure to provide nutrients for the micro-organisms.
- Add a 2.5 cm thin layer of wood ash phosphatic or potassic fertilisers to improve the level of phosphorus and potassium in the resulting manure.
- Add a 2.5 cm layer of top soil to introduce micro-organisms into the compost pit.
- Repeat the above sequence of layers until the pit is full.
- Add a layer of soil to cover the pit and then cover it with any leaves.
- Push a long stick through the middle of the pile bottom of the pit to monitor the temperature in the middle of the pile. The temperatures should be controlled accordingly. If too hot, sprinkle some water and if too cold, turn the materials. Normal composting temperatures should be between 60°C and 65°C. The materials produce no heat when fully decomposed.
- Regularly turn the materials for even decomposing.

Activity 1.11: By pit method, prepare compost manure and then present the precautions during compost manure preparation

When preparing compost manure, the following precautions should be taken:

(a) Keep the materials moist during the dry season. This is to facilitate decomposition.

(b) Avoid compacting the materials in the pit. This allows air supply for microbial activities.

(c) Ensure that running water does not get into the pit during the rainy seasons. This is to prevent waterlogging which prevents leaching of nutrients from the compost materials.

(iv) Check the temperature stick every week to ensure normal composting temperatures and help test when the materials are fully decomposed.

1.10 Steps in making farmyard manure

Activity 1.12: Visit a zero grazing unit, observe the various steps used in making farmyard manure, take note of the material used as beddings in the animal sleeping cubicles. Observe the storage of the farmyard manure and then present the findings in the class.

The following are steps in the preparation of farmyard manure:

(a) Provide beddings in the houses of farm animals. The beddings may be either grass, wood shavings or sawdust, maize stalks, maize cobs or coffee husks.

(b) Allow time for the animals to deposit their droppings and urine on the beddings and to mix them through trampling.

(c) Remove the mixture of the droppings and beddings using a shovel or manure fork from the animal houses and replace it with new beddings. This is shown in fig. 1.11.

(d) Place the materials removed from the animal houses in a specially prepared shed and add new layers of the used beddings until a heap is formed.

(e) Give the materials in the heap time to decompose. It may take 4 – 6 months for the materials to be completely decomposed. The manure is now ready for use in the farm.

Fig. 1.11: A shed for storage of farmyard manure

1.11 Main inorganic fertilisers

Activity 1.13: By visiting a shop where inorganic fertilizers are sold, name the fertilizers supplied/sold, observe the color of various fertilisers, manipulate them by touching and calculate the fertilisers ratio of the compound fertilisers in the shop from the fertiliser's grade indicated on the bags and then present your findings in the class.

Inorganic fertilisers are chemically prepared compounds that are added to the soil to improve its fertility. They contain one or more of the three primary macro-nutrients, namely Nitrogen, phosphorus and potassium (NPK).

A fertiliser that contains only one of the primary macro-nutrients is known as a **straight fertiliser**, for example, urea. A fertiliser that contains two or more (three) of the primary macro-nutrients is known as a **compound fertiliser**, for example, Diammonium phosphate (DAP) and various NPK fertilisers such as 20–20–0, 10–10–10, 20–10–10 and 17–17–17.

The main inorganic fertilisers include:

(a) **Urea:** This is a nitrogenous fertiliser which contains 45–46% nitrogen and has the following properties:

- It induces negligible acidity.
- It has a white granular appearance.
- It is highly susceptible to volatisation and prone to leaching as it is highly soluble in water.
- It has a high scorching effect due to the ammonium content.

Urea is rarely used, except in crops such as sugar cane, which has a high absorption capacity.

(b) **Diammonium phosphate (DAP):** This is a compound fertiliser with a grade 18-46-0.

(i) It contains 18% nitrogen and 46% phosphate.
(ii) It is moderately acidic.
(iii) It has a grey granular appearance.

(c) **NPK fertilisers:** These fertilisers contain nitrogen, phosphates and potassium oxide in varying proportions. NPK fertilisers include 23-23-0, 17-17-17, 20-10-0 and 15-15-15. They are used when planting cereals and grass crops used for forage.

Unit Summary

Soil fertility is the ability of the soil to provide crops with the required nutrients in their proper proportions. For sustained high production, fertile soils are characterised by the following:

- Good depth
- Proper drainage
- Good water-holding capacity
- Adequate nutrients supply
- Correct soil pH
- Free from excessive infestation of soil borne pests and diseases
- High organic matter content
- Not saline

Soil fertility is affected by availability of water. Water drainage and the activity of soil micro-organisms. The availability of soil nutrients is affected by the following factors:

- Soil pH also known as soil reaction
- Organic matter content of the soil
- Soil texture
- Climate
- Leaching of soil nutrients
- Soil compaction
- Crop removal
- Use of sensitive crops
- Nutrients interactions in the soil

Lack of essential nutrients in the soil is indicated by certain signs on the crops. These signs are known as deficiency symptoms.

These symptoms include the following:

- Chlorosis/yellowing
- Stunted growth/retarded growth /dwarfing
- Dieback
- Premature fall of leaves and flowers
- Production of anthocyanin pigment
- Leaf curling
- Lodging
- Poor nodulation in legumes
- Leaf scorch

Soil fertility is improved by addition of organic manures and inorganic fertilisers.

Manures are organic substances added to the soil to improve its fertility. There are four types of organic manures. These include:

- Compost manure
- Farmyard manure
- Green manure
- Night soil

Inorganic fertilisers are chemically prepared compounds which are added to the soil to improve its fertility.

The main inorganic fertilisers include urea, DAP and NPK.

Key Terms

1. **Soil fertility** – This is the ability of the soil to provide crops with the required nutrients in their proper proportions for sustained high production.
2. **Soil pH** – This is the degree of acidity or alkalinity of a soil solution.
3. **Saline soils** – Soils with excessive amounts of salts.
4. **Irrigation** – Artificial application of water to the crops.
5. **Water stress** – Shortage of water in crops.
6. **Stunted growth** – This is slowed growth in crops.
7. **Waterlogged soils** – Soils with excessive amount of water.
8. **Pathogenic** – Disease causing.
9. **Chlorosis** – Yellowing of leaves.
10. **Leaf curling** – Folding of leaves.
11. **Nodulation** – Production of swellings called nodules in the roots which habour nitrogen fixing bacteria in leguminous crops.
12. **Macro-nutrients** – These are mineral elements needed by plants in large amounts.
13. **Micro-nutrients/trace elements** – These are mineral elements that are needed by plants in small amounts.
14. **Anaerobic respiration** – Respiration that takes place only in the absence of oxygen.
15. **Aerobic respiration** – Respiration that takes place only in the presence of oxygen.
16. **Fungal disease** – Diseases caused by fungi.
17. **Bacterial diseases** – Diseases caused by bacteria.
18. **Microbial activity** – The activity of micro-organisms.

19. **Agrochemicals** – Agricultural chemicals.
20. **Compost manure** – Manure prepared by composting (heaping) vegetative materials.
21. **Farmyard manure** – Manure prepared from animal wastes mixed with litter.
22. **Green manure** – Manure prepared by incorporating green plants into the soil.
23. **Night soil** – Manure prepared from human waste.
24. **Inorganic fertilisers** – These are chemically produced compound components added to the soil to improve its fertility.
25. **Fertiliser grade/Analysis** – The amount of each nutrient contained in a fertiliser expressed as a percentage.
26. **Fertiliser ratio** – Amount of each nutrient contained in a fertiliser expressed as a ratio of N: P_2O_5: K_2O.
27. **Hygroscopic** – Ability to absorb atmospheric water moisture.
28. **Volatilisation** – Ability to escape into the atmosphere in form of a gas.
29. **Zero grazing unit** – Structures used for holding animals in a livestock rearing system that does not allow animal to graze on pastures.
30. **Straight fertiliser** – A fertiliser that contains only one of the primary macro-nutrients (NPK).
31. **Compound fertiliser** – A fertiliser that contains two or more of the primary macro-nutrients (NPK).
32. **Complete fertiliser** – A fertiliser that contains all the three primary macro-nutrients (NPK).
33. **Organic manures** – These are fertilisers that are made from animal matter, human excreta or vegetable matter.
34. **Nitrogenous fertiliser** – A fertiliser that contains nitrogen as the only primary macro-nutrient.
35. **Potassic fertiliser** – A fertiliser that contains potassium as the only primary macro-nutrient.
36. **Phosphatic fertiliser** – A fertiliser that contains phosphorus as the only macro-nutrient.
37. **Ribbon test** – A test used to determine the amount of clay in a soil by rolling wet soil between the palms.
38. **Active transport** – Process through which ionic substance are absorbed by plants against a concentration gradient using energy.

Revision Questions

1. Define soil fertility.
2. Explore five characteristics of fertile soils.
3. State three factors that affect soil fertility.
4. (a) Define soil pH.
   (b) Describe how to estimate soil pH using a pH meter.
5. Name two free living bacteria that fix nitrogen in the soil.
6. The diagrams below show plants with mineral deficiency symptoms. Study them carefully and then name the mineral elements lacking in the soil in each case.

(a)

(b)

(c)

7. Explain five factors that influence the availability of nutrients in the soil.
8. Give two ways of expressing the nutrient content of a fertiliser.
9. (a) What is night soil?
   (b) Draw a well labelled structure of a compost heap showing how the layers follow each other.
10. State the factors that determine the quality of farmyard manure.
11. Analyse the plants listed below for their suitability in the production of green manure:
    (i) Beans
    (ii) Napier grass
    (iii) Desmodium
12. What is the meaning of the following terms:
    (i) Leaching?
    (ii) Volatilisation?

13. What is the importance of the following materials used in the preparation of compost manure:
    (i) Well-rotten manure?
    (ii) Garden soil?
    (iii) Wood ash?
14. What is the meaning of the following terms as used in describing inorganic fertilisers:
    (i) Straight fertiliser?
    (ii) Compound fertiliser?
    (iii) Complete fertiliser?
15. Describe the characteristics of the following inorganic fertilisers:
    (a) UREA
    (b) DAP

UNIT 2

MUSHROOMS

Introduction

Though mushrooms are classified as vegetables, they are not plants as such, but belong to the fungi kingdom. However, they provide several important nutrients to human beings and this makes their cultivation beneficial. Mushrooms are divided into two categories, the poisonous and the edible mushrooms.

This unit gives an insight on the identification of the edible mushrooms from the non-edible ones. It also gives practical experiences on how to grow the edible mushrooms. The process of growing mushrooms starts with the gathering and preparation of substrate materials where the mushrooms are grown, mushroom tube making and arranging the tubes in prepared nursery beds. Also addressed in this unit are the conditions suitable for mushrooms establishment and growth, up to the time they are ready for harvesting. The pictures below gives an over view of the unit.

Edible mushroom

Edible mushroom

Non-edible mushroom

Gathering and preparation of the substrate

Mushroom tubes ready for arranging in the nursery

Mushrooms growing on hanging tubes

Harvesting of mushrooms

2.1 Definition of mushroom

Activity 2.1: Using search engine or library, find out the meaning of mushroom.

Mushroom is the fruiting body of a macro-fungus.

A fungus is a non-photosynthetic organism that feeds on dead plant materials and organic matter.

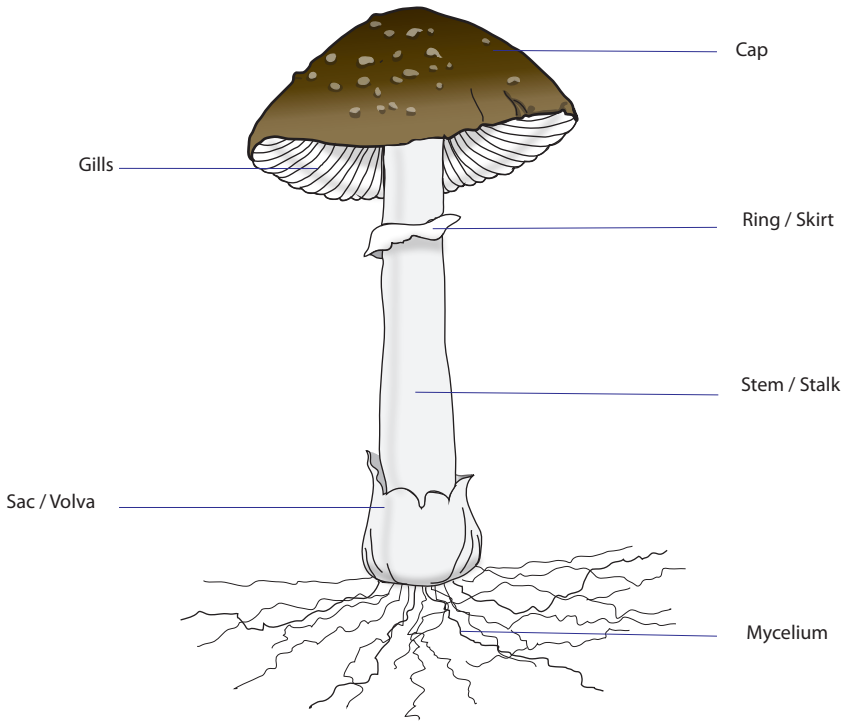


Fig. 2.1: Parts of a mushroom

2.2 Types of mushrooms

Activity 2.2: Using the reference provided, differentiate the types of mushrooms and identify which ones are for commercial production.

There are two types of mushrooms:

- Edible types.
- Non-edible types or poisonous mushrooms

(a) **Edible types of mushrooms:** These are mushrooms that are eaten by human beings without causing any harm.

There are five common types of edible mushrooms grown in East Africa.

(i) Button mushrooms (*Agaricus spp*) – Has very short stalks almost non-visible when growing. It is white in colour and the cap looks like a button.

(ii) Oyster mushroom (*Plerotus spp*) – Completely white with oyster shell shape.

(iii) Shiitake mushroom (*Lentinula edodes*) – Has a large brown cap which cracks when overgrown.

(iv) Chinese mushroom (*Ganoderma*) – They are pink in colour with brown stalks.

(v) Lions mane mushroom (*Hericium erinaceus*) – It is white in colour and the caps have cotton like appearance.

Fig. 2.2: (a) Button mushroom (Agaricus spp)

Fig. 2.2: (b) Oyster mushroom (Plerotus spp)

Fig. 2.3: (a) Shiitake mushroom (Lentinula edodes)

Fig. 2.3: (b) Chinese mushroom (Ganoderma)

Fig. 2.3: (c) Lions mane mushroom(Hericium erinaceus)

(b) **Non-edible types of mushrooms**

These are poisonous though they resemble and taste like the edible mushrooms. They include:

(i) *Amanita phalloides* – Golden brown in colour with staut stalk.

(ii) *Gyromitra infula* – Brown in colour but appear red when cooked. They have a white stock.

(iii) *Amanita muscaria* – This is red in colour with white cotton-like spots on the cap. It has a white staut stalk and is the most poisonous of all mushrooms in this category.

(iv) *Chlorophylum molybdites* – It is white in colour with a white ring on the stalk.

Fig. 2.4: (a) Amanita phalloides

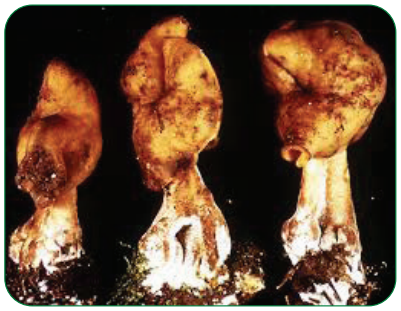


Fig. 2.4: (b) Gyromitra infula

Fig. 2.4: (c) Amanita muscaria

Fig. 2.4: (d) Chlorophylum molybdites

2.3 Propagation of mushrooms

Activity 2.3: By search engine or library textbook, describe the stages involved in mushroom propagation.

Mushroom propagation is the practice of growing mushrooms. It involves mushroom compost making, spawning or seeding the compost, casing and pinning.

Compost making: Involves gathering of materials such as bargasse, coffee husks, sawdust, rice husks and sterilising them by heating in steam. Other materials such as lime and molasses are added.

Spawning: Involves sprinkling of mushroom spores on the sterilising culture which is then left to establish under controlled conditions of temperature and humidity.

Casing and pinning mushrooms: Involves transferring the established mycelium into mushroom tubes, logs or a mushroom house containing substrate.

Fig. 2.5: (a) Mushroom tubes

Fig. 2.5: (b) Spawning substrate

Fig. 2.5: (c) Arranging in a room

2.4 Production of mushroom tubes

Activity 2.4: Prepare mushroom tubes by filling polythene bags with muxed substrates and supplements (lime, animal concetrate, soya meal and molasse).

A mushroom tube is a sack, polythene bag or crate containing growing materials which have been sterilised and used to grow mushrooms.

The materials needed in the mushroom tube making include:

(a) Substrate or compost – This constitutes of grass chaff, saw dust, straw, sugarcane bargasse, dry groundnut waste, banana fibres, dry banana leaves, straws, maize cobs and stalks.

These materials mainly provide carbohydrates.

(b) Containers such as empty gunny bags, sisal sacks, crates, wooden racks and polythene bags.

(c) Equipments – The following equipment are required:

- Drum which is clean
- A big cooking pan or *sufuria* with lid
- Plastic rings
- Cotton wool
- Preparation table or large leakproof paper.
- Weighing scale
- Water
- Fuel for heating, for example, firewood or charcoal
- Methylated spirit
- Mushroom spawn or seeds

(d) Supplements – These are added to provide different types of nutrients needed for mushroom growth. They include; lime, molasses, animal concentrates and soya bean meal.

The steps followed in making mushroom tube include:

- **Gathering of compost making materials.**
- **Mixing substrate with supplements:** These materials are gathered, chopped into small pieces and washed clean using water to remove soil particles. They are then mixed with supplements.
- **Drying:** The compost material should not be very wet because it encourages growth of unwanted fungi and bacteria. Excess water is, therefore, removed by squeezing.

- **Packing up or bagging:** The semi-dried compost material is crushed and packed in polythene bags or gunny bags known as tubes.
- **Composite sterilisation:** The competitive micro-organisms such as bacteria and unwanted spores of other fungi are killed through steaming for 3 hours or using chemicals such as isopropyl alcohol and hydrogen peroxide. After sterilisation the compost is left to cool overnight.
- **Mycelium sowing:** The preparation table is sterilised and the mushroom substrate spread on it. The mushroom spawn is spread evenly on the substrate and covered. The temperature and humidity is controlled at 20°C and 90 – 95% humidity. The substrate with white mycelium is transferred to mushroom tubes or the field.

Fig. 2.6: Mushroom tubes

2.4.1 Factors affecting mushroom tube making

Activity 2.5: Make visit to a cooperative or a household producing mushroom and identify the factors affecting mushroom tube making. After discussion of field visit findings, present them in the class.

Mushroom tube making is affected by the following factors:

1. Availability of mushroom substrate material: such as sawdust, straw, sugarcane bargasse.
2. Availability of transport: The materials for making compost are bulky, therefore, they should not be acquired from a distant source. They should be easily transported using wheelbarrow, lorries and tractor trailers.
3. Cleanliness of the substrate material: Dirty substrate introduces unwanted bacteria and fungi, which interfere with growth process.
4. Method of sterilisation: Once the mixed substrate materials have been packed, there are several methods of sterilisation. The cost of the equipment or chemical determines the method used which include use of pressure cookers, use of a drum or large cooking pot with water. Chemicals on the other hand are expensive and require a trained person to use.
   It is cheaper to heat in steam at 70°C , 80°C for 3 – 4 hours in a drum.

5. Type of packing materials: The recommended packing material is use of clear polythene bags measuring 25–30 cm wide against 45 cm length although this is subject to the availability and laws of the country.

2.5 Mushroom cultivation techniques

Activity 2.6: Cultivating mushrooms in the nursery

Carry out the following activities:

(i) Prepare a mushroom house by cleaning and watering the walls.
(ii) Transfer the mushroom tubes in the house and hang them by the rods from the roof.
(iii) Make small holes on the side of the mushroom tubes.
(iv) Provide shade to prevent direct light.
(v) Water the mushroom tube once a day by sprinkling or spray misting.
(vi) Weed by removing unwanted or old mushrooms.
(vii) Crop the mushrooms between 7 and 14 days or four days after the fruiting caps begin to appear.

Mushroom cultivation involves the transfer of spawned mushroom to growth material or the substrate into a specially prepared room where light, temperature and humidity are controlled. In this room, the young mushrooms are cared for until they are ready to be harvested, where they can be sold fresh or they can be dried, packed and sold. It involves the following:

1. Inoculation process

This process involves introducing mushroom spawn into the sterilised substrate. The spawn is evenly spread over the substrate at the rate of 7 kg per one tonne wet substrate. Different mushroom types have different spawning rate. The lighter the spore ratio to the substrate, the faster the colonisation of the sterile substrate.

Study the photographs provided in the Table 2.1 and then identify the activities being carried out, materials required for each stage and the procedure.

Table 2.1: Stages of inoculation process

	Stage	Materials required	Procedure
(a)			
(b)			
(c)			
(d)			

(e)			

2. Arranging mushroom tubes in the nursery bed

After the process of inoculation, the polythene bags with sterile substrate are arranged in a nursery bed.

NB: Good mashroom reduction depends on the amount of carbohydrates, proteins and calcium. The recommended amount are 5-10% of substrate weight carbohydrates, 2-4% of proteins and 2% calcium uniforme of line water.

This is a room specially prepared with benches where humidity, temperature and light are controlled. The bags are either packed on a bench or hang from the roof or an elevated point after the mycelium spread and seen as a white mass. The bags are opened or holes made on the plastic bags. The recommended size of bags should be 30 cm wide and 45-90 cm long for areas transformation and management.

Fig. 2.7: (a) Hanging method

Fig. 2.7: (b) Use of bench method

3. Shading

Mushrooms which are grown in green houses or fields should be provided with a shade to prevent strong light.

4. Watering and weeding

Watering is important to maintain the humidity of the substrate. The air humidity should be maintained at between 90% and 95%. This prevents production of mushrooms with a scaly skin. Watering is done by sprinkling or spray misting water once a day. It is also necessary to make holes measuring 1cm diameter on the polythene bag. This allows the small mushroom heads to force themselves out of the bag. Weeding is done by removing unwanted or old mushrooms.

Fig. 2.8: Watering the seedbed

5. Harvesting

Mushroom will start to appear in 7–14 days. They should be picked when fully grown or when they stop growing. This happens 4 days after the fruiting caps begin to appear. Picking is done by twisting the mushroom stalk once to free them from the substrate medium. All old or aborted mushrooms should be removed from the substrate surface and discarded. After harvesting, the substrate should be kept moist to allow growth of another crop of mushrooms.

Harvesting can be done 4–5 times depending on the species but the greatest harvest takes place between the first and second harvest.

Fig. 2.9: Harvesting of mushrooms

2.6 Factors affecting mushroom cultivation

Activity 2.7: Using search engine or library texbook find out the factors affecting mushroom cultivation.

The following factors are required to ensure a good crop of mushrooms:

- **Light:** Mushrooms require light to grow but not direct sunlight. Regular strong reading light is sufficient. The mushroom cultivation house can also be left dark overnight. Shading can be provided to minimise light.
- **Temperature:** Mushrooms grow well in a temperature range of about 20°C – 25°C. It is recommended to put a thermometer to monitor the temperature of the mushroom cultivation house.
- **Water and humidity:** It is important to water the mushrooms to maintain the humidity at between 90 and 95% every once a day. Too little water makes the growth of mushrooms slower and leads to cracking of the fruiting caps. Too much water results in rotting of the substrate which encourages growth of unwanted bacteria and fungi.
- **Amount of oxygen:** Oxygen is required to stimulate growth. It is necessary to open the windows or liners to encourage free circulation of air. Lack of fresh air will prevent mushrooms from growing and produce long stringy mushrooms.

2.7 Mushroom diseases: Mushroom cultivation is subject to attack by both bacteria and fungal diseases.

(a) Fungal diseases

- **Dry bubble:** Caused by a fungus *Verticillum fungicola*. The symptoms include brown spots on the mushroom caps and is controlled by reducing the relative humidity and temperature to 14°C, disinfection of the substrate by steaming and disinfecting harvesting tools.
- **Wet bubble:** Caused by a fungus *Mycogone pemicosa*. The symptoms include malformed cap and stalk. The disease mushrooms are covered with white mycelium on the cap. A foul smell is also produced. The control involves steaming of the substrate at 70–80°C for at least three hours.
- Other fungal diseases include Mildew and Aphanocladium disease.

(b) Bacteria diseases which affect mushrooms include brown blotch, mummy disease and drippy gill.

Unit Summary

A mushroom is a fruiting body of macro-fungus whose parts or whole body are utilised.

There are two types of mushrooms.

- Edible mushroom
- Non-edible mushroom. These are mostly poisonous.

Mushroom propagation is the agricultural practice of growing mushrooms using special facilities and mushrooms growing rooms. It involves mushroom tube making, inoculation, incubation, watering and weeding mushrooms and finally harvesting mushrooms. Mushroom propagation begins with substrate/compost making which is washed, sterilised and packed in bags either plastic bags or gunny bags in a process known as mushroom tube making.

A mushroom tube is a sack or bag made of polythene containing mushroom growing materials that have been sterilised.

Mushroom growing materials include sawdust, grass chaff, dry groundnut waste, straw, maize cobs and chopped maize stalks.

Mushroom growing containers include sisal sacks, polythene bags, empty gunny bags, crates and wooden racks.

Mushroom growing equipment includes a large metal drum or large cooking pot with a lid, plastic rings, weighing scale, water, fuel such as firewood and charcoal, methylated spirit and mushroom spawn seeds or mushroom spores.

Mushroom supplements include animal concentrate, soya meal, rice bran or wheat bran, molasses and lime. The process of mushroom tube making involves:

- Gathering of substrates or compost manure.
- Washing of substrate.
- Mixing substrate with ingredients and supplements.
- Drying.
- Packing the substrate in tubes.
- Compost or substrate sterilisation.
- Mycelium sowing.
- Observation of growing mycelium.

Substrate sterilisation involves boiling of the substrate in steam at 70 – 80°C for 3–4 hours or using a pressure cooker heating the substrate at 120°C for 15 minutes.

Mycelium spores or spawn should be obtained from reputable mushroom growing. Apply 0.3–0.5 kg of spawn per 6–8ft^3 of sterilised substrate or 0.3–0.5 kg of spawn

per 12–15ft^3 or 7 kg of spawn per tonne of wet substrate.

The factors affecting mushroom tube making include:

(i) Availability of mushroom substrate materials.

(ii) Availability of transport.

(iii) Cleanliness of substrate.

(iv) Method of sterilisation.

(v) Type of packing material.

(vi) Type and amount of mycelium spores and spawn used during inoculation.

(vii) Temperature and humidity of the substrate.

Mushroom cultivation involves the transfer of spawn mushroom to growing material then transferring the same to a specially prepared nursery bed with controlled light, temperature and humidity.

Key Terms

1. **Mycelium** – These are fungal threads that spread over and in the substrate which later sprout to mushroom.
2. **Spores** – These are minute mushroom seeds that appear like powder. They are spread over a sterile culture substrate during inoculation.
3. **Compost or substrate** – This is a mixture of straw, sawdust, lime water, wheat bran and soya meal where the spores are inoculated after sterilisation.
4. **Nursery bed** – This is the space used to grow mushrooms where the temperature, humidity, light and oxygen concentration are controlled. They can also be referred to as shelves.
5. **Mushroom** – This is a fruity body of macro-fungus.
6. **Mushroom tube: is a sack** – Bag or crate containing mushroom growing materials.
7. **Bagging** – This is the process of putting mushroom growing substrate in a bag or tray.
8. **Compost sterilisation** – This is the process of killing germs and other unwanted micro-organisms in a substrate using heat, steam or chemicals.
9 **Spawning** – This is the introduction of a pre-sown substrate mycelium known as a spawn into a substrate by sprinkling.
10. **Inoculation** – Used similarly as spawning.
11. **Bargasse** – The fiber remnants of sugar cane after it has been crushed to extract the juice.

12. **Gunny bags** – Bags made of sisal fibers.

Revision Questions

1. What is a mushroom?
2. Name two types of mushrooms.
3. (a) Name four edible mushroom types.
   (b) Name four non-edible mushroom types.
4. Identify the mushroom type shown in the figure below:

5. Which of the following statements best describes mushroom propagation?
   A. Transfer of mushroom tubes into specifically prepared rooms where environmental conditions are controlled.
   B. An organic substance originating from plants and used to grow mushroom.
   C. Allowing a mushroom spawn to colonise a substrate by providing the optimum condition for mushroom growth.
   D. Introduction of a spawn into a subtrate by sprinkling.
6. Give examples of mushroom growing substrate or materials.
7. Describe the processes involved in making mushroom tubes.
8. Outline the importance of compost/substrate sterilisation.
9. List factors affecting mushroom tube making.
10. Carry out the activities involved in mushroom cultivation.
11. Why is it important to spread the spawn or spores over the surface of the substrate while planting or inoculating the substrate?
12. State the importance of watering the substrate during mushroom cultivation.
13. Carry out the harvesting of mushrooms.
14. Explain how the following factors affect mushroom cultivation:
    (a) Water and humidity.

(b) Mushroom diseases.

15. The following activities are carried out during mushroom production process:

(i) Gathering and chopping substrate.

(ii) Watering of the mushroom tubes.

(iii) Packing the bags containing substrate in the nursery bed.

(iv) Sterilising substrate to kill harmful organisms.

Which set of activities is correct for mushroom inoculation process?

A. (i) and (iii)

B. (i) and (iv)

C. (ii) and (iii)

D. (ii) and (iv)

UNIT 3

FRUITS

Introduction

Fruit growing is a type of horticultural production that contributes a lot to the economy of Rwanda. The growing of fruits is known as pomoculture. Fruits are very good source of food nutrients and especially vitamin C (ascorbic acid). They may be eaten raw in salads or processed to produce various fruit products.

This unit explores the importance of fruits, the fruits cultivated in Rwanda, propagation methods of fruits, orchard management practices, processing and preservation of fruits. The unit also explores some of the products processed from fruits such as jams, mamalade, jelly and juices.

The following pictures give an overview of the unit:

Assorted fruits grown in Rwanda

Training fruits

Pruning of passion fruits

Harvesting oranges

Passion fruits ready for processing

Fruit juice

Preserved fruits

3.1 Fruit tree definition

Activity 3.1: Using internet or library textbook find out the meaning of fruits

A fruit tree is a plant which bears fruits that are consumed or used by humans and some animals. All trees that are flowering plants produce fruits. Fruits are the ripened ovaries of flowers which may contain one or more seeds.

The cultivation of fruits is known as pomoculture while the scientific study of fruits is referred to as pomology.

3.2 Importance of fruits

Activity 3.2: By a fiel trip to a farm with an orchard to identify types of fruits grown, discuss the importance of each fruits and fruits tree identified and then discover other fruits grown in Rwanda which are not in visited orchard.

Fruits have the following importance:

(i) *Nutritional importance*: Fruits provide foods rich in minerals, vitamins, proteins carbohydrates, fibre and water. They also help to diversify human diet through providing a variety of colours and flavours.

(ii) *Provide income*: Fruit farmers earn income by selling the fruits.

(iii) *Provide employment*: Fruits growing is a direct employment to fruit growers and fruit vendors.

(iv) *Industrial development*: Secondary industries develop as a result of raw materials from the fruit farming. Examples of fruit processing industries include, fruit canning and manufacture of fruit juices and jam.

(v) *Ecological functions*: Fruit growing is a way of protecting the environment since most fruit crops are trees and vines which creep on the surface thus protecting the soil.

(vi) *Aesthetic value*: Fruit crops beautify the environment as most of the landscaping and garden design plants are fruit crops.

(vii) *Medicinal value*: Some fruits are used to produce herbal medicine, for example, seeds from papaya fruits are used as dewormers; while others contain anti-cancer compounds and healing properties.

(viii) *Traditional functioning*: Some fruits are used to make brew which is used in social functions.

(ix) *Diversification functions*: Fruit growing provide a good balance between food crops and cash crop growing. Those fruits which are all season provide food and money to the farmers as they wait for the cropping seasons.

3.3 Fruits cultivated in Rwanda

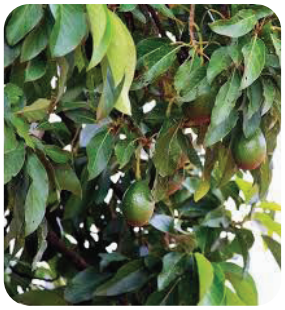
Activity 3.3: By search engine or library textbook, list the fruits cultivated in Rwanda

The following is a list of some of the fruits grown in Rwanda:

- Avocados
- Papaya
- Mangoes
- Tamarillo
- Citrus
- Pineapples
- Passion fruits
- Strawberries
- Guavas

Table 3.1 below shows photographs of various fruit trees and fruits cultivated in Rwanda. Study the photographs, identify the fruit trees and name their respective fruits.

Table 3.1: Cultivated fruit trees in Rwanda and their fruits

Name of the fruit tree	Name of fruit
 (a) _____	 _____
 (b) _____	 _____

 (c) _____	 _____
 (d) _____	 _____
 (e) _____	 _____
 (f) _____	 _____

 (g) _____	 _____
 (h) _____	 _____
 (i) _____	 _____

3.4 Propagation methods of fruits

Activity 3.4: Use internet or library book to carry out the following activities:

Search on how the following methods of fruit propagation are carried out.

(a) Seed propagation

(b) Vegetative propagation.

Fruit crops are propagated **using seeds** or **vegetative materials.**

3.4.1 Seed propagation

Some fruit types produce seeds which are viable and are planted either directly in the field or raised in nurseries before transplanting. Some fruit seeds such as citrus, passion fruits, papaya, avocado, mangoes, tamarillo and strawberries need the following preparation before planting:

(i) *Extraction of the seeds from the fruits*: Fruit seeds are normally found inside a hard protective endocarp which may take long to rot to allow the seed to germinate. Examples of such fruits include citrus, passion fruits, papaya, tamarillo.

(ii) *Washing and cleaning*: This is done to remove the mucilage which may prevent the seeds from absorbing water when planted.

(iii) *Drying*: This is to reduce the moisture content of the seeds preventing rotting.

(iv) *Breaking dormancy*: This is carried out to make sure that seeds germinate immediately when the conditions are suitable.

(v) *Seed dressing*: Seeds are mixed with fungicides and insecticides to make sure that they are not affected by soil borne pests and diseases in the field before germination.

3.4.2 Vegetative propagation

This is the establishment of fruit trees using plant parts other than seeds.

Some fruit trees are propagated vegetatively using the following methods:

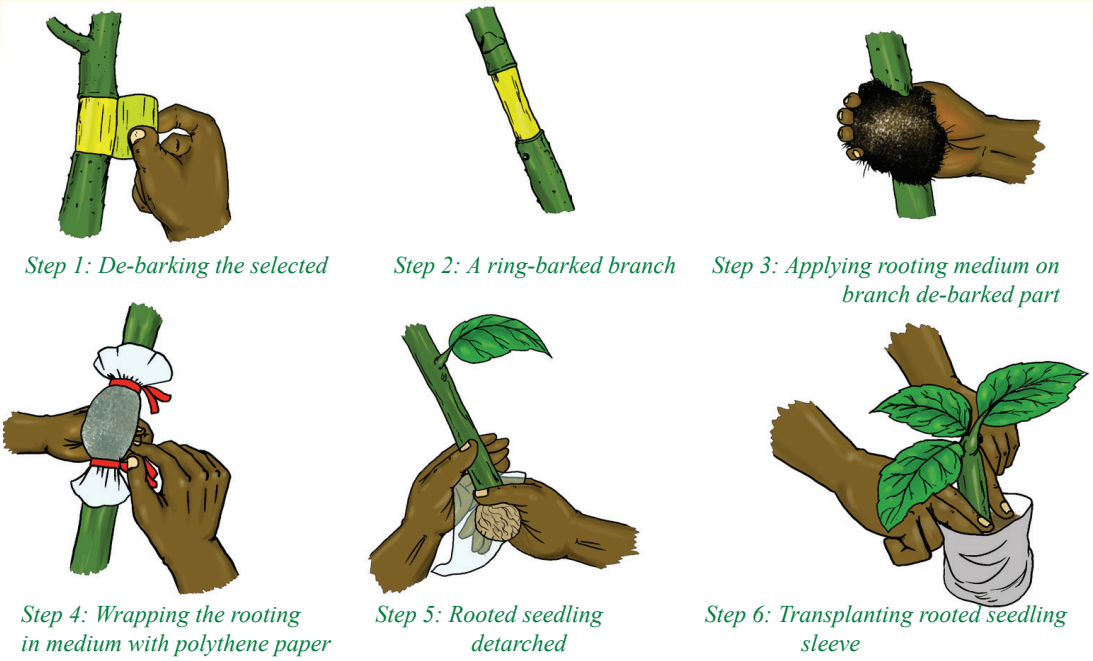
(a) **Layering**: This is the process by which a part of the plant is induced to produce roots while still attached to the mother plant, then removed and planted so that it can grow as an individual plant. This method of propagation is carried out in order to induce rooting on cuttings which cannot produce roots when detached from the mother plant. The following fruits are propagated by layering; Avocado, citrus, strawberriesm passion fruits, Apples, Plums.

N.B: In some cases rooting medium is required to induce rooting.

Methods of layering

(i) Aerial layering (marcotting)

This method of layering is commonly used in hardwood plants and branches which are high up above the ground. The following illustrations show the steps followed in aerial layering.



Step 1: De-barking the selected

Step 2: A ring-barked branch

Step 3: Applying rooting medium on branch de-barked part

Step 4: Wrapping the rooting in medium with polythene paper

Step 5: Rooted seedling detarched

Step 6: Transplanting rooted seedling sleeve

Fig. 3.1: Steps in aerial layering (marcotting)

(ii) Tip layering

A branch bearing a terminal bud is bent to the ground and held with a peg 20 cm behind. The tip is then covered with a moist layer of soil. The tip is left exposed. Roots will develop from the nodes at the pegged area of the branch. It is then cut off from the mother plant and transplanted in the field.

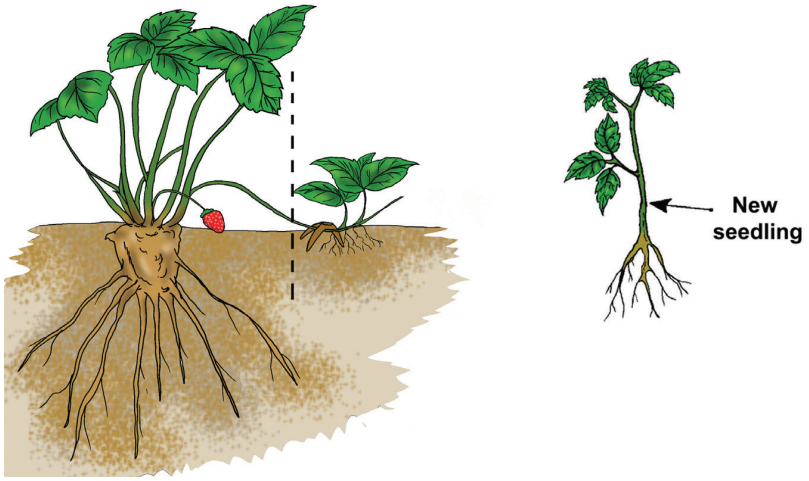


Fig. 3.2: Tip layering in strawberries

(iii) Trench layering

A shallow trench is made near the base of plant to be layered. A low growing branch of the plant is bent and laid into the trench. The branch is then held at different positions with pegs. The branch is covered with a layer of moist soil and left in position for a few weeks. The branch will produce roots at every pegged point. This will grow into individual plants which are then detached from the mother plant and planted in the field.

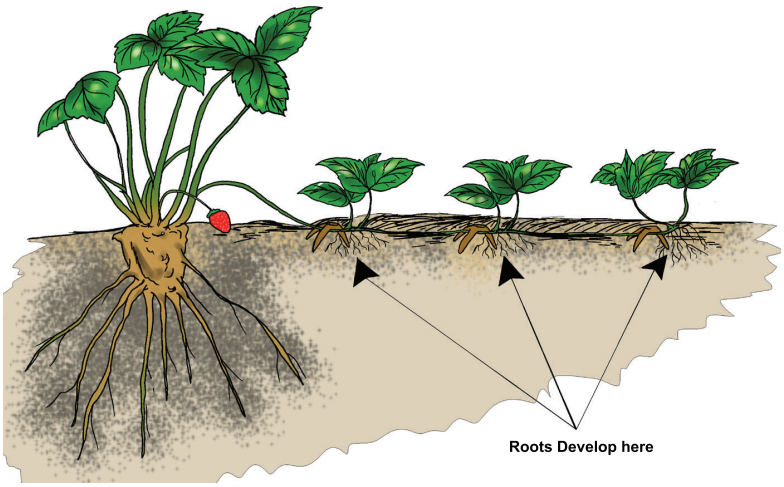


Fig. 3.3: Trench layering in strawberries

(iv) Compound layering (serpentine)

In this method the branch is bent several times to the ground and the bent parts are held with pegs. The pegged areas are covered with moist soil and left to produce roots. After rooting the branch, it is cut into several parts each bearing roots and planted in the field as individual plants.

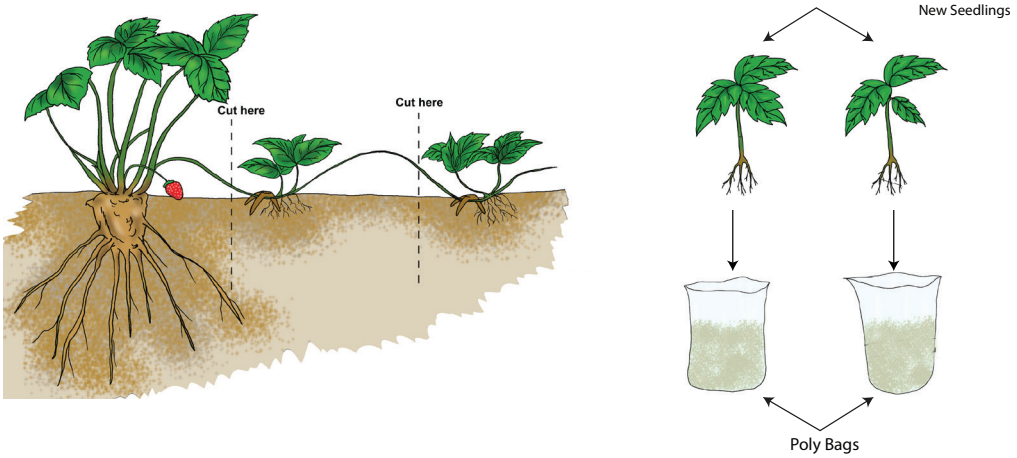


Fig. 3.4: Compound/serpentine layering in strawberries

(b) **Grafting**:

This is the practice of uniting two separate woody stems together to grow into a new plant. In this case two plant species types or varieties are used. The plant which provides the rooting system is known as the scion. The scion develops into the shoot. In order for the process of grafting to succeed, the rootstock plant should have the following characteristics:

- Be compatible with the scion. That is the rooted should form a successful union with the scion.
- Be tolerant to soil-borne diseases and pests.
- Be adaptable to soil conditions such as salinity and waterlogging.
- Have an extensive rooting system to absorb nutrients from a large area.
- Be efficient in transporting water and mineral salts to the scion.
- Be able to transmit desirable characteristics to the scion, such as dwarfing, vigour and fruit size.
- Be locally available.
- Have the same economic life as scion.

The scion should be obtained from a high yielding disease free and mature mother plants with good nutritional value.

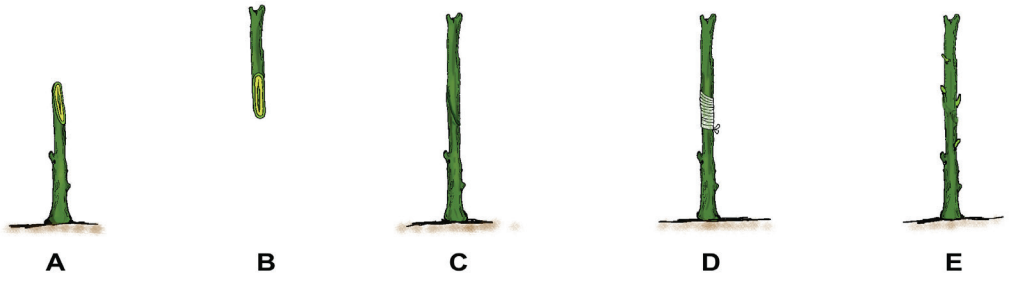
The methods of grafting are identified by the shape of the cuts made and the part of the plant where the union takes place.

The rootstock plant is established in the nursery and left to grow until their stems acquire the desired thickness.

Methods of grafting

(i) Whip or tongue grafting

This is the uniting of two separate woody stems of the same diameter usually of pencil thickness.

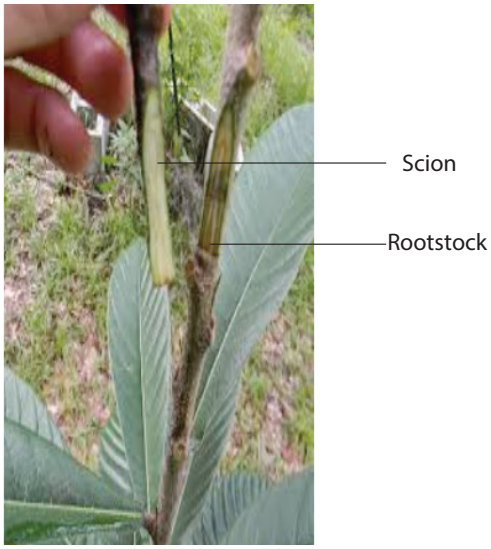


A and B – Matching 'tongue' cut on both scion and rootstock
C – Scion wood cut placed on the rootstock cut
D – Grafting union in place
E – Healed whip graft

Fig. 3.5: Whip/tongue grafting procedure

(ii) Side grafting

This method of grafting is carried out when the rootstock plant has a larger diameter than the scion stick. It is commonly done in avocado fruit trees.



Step I: Scion to be joined to the rootstock

Step II: The scion producing leave buds

Step III: Scion actively growing

Fig. 3.6: Side grafting in avocado

Other methods of grafting include approach grafting, bark grafting, notch grafting, cleft grafting and bud-grafting.

(c) Stem cuttings

These are portions of the stems which are cut into different sizes to be used for propagation of fruit trees. A stem cutting should have leaf buds which develop into shoots. They should produce leaves or sprout as soon as they are planted into the rooting medium. Once the cuttings develop roots and shoots, they give rise to new plants. Stem cuttings are used in propagating strawberries.

3.5 Grafting of avocado and citrus fruit trees

Activity 3.5: Visit a farm with avocado and citrus tree nursery and carry out the following activities:

(i) Observe the grafting of an avocado and citrus fruit trees.
(ii) Discuss and record your observation.

Avocado and citrus fruit trees grown from seeds do not produce quality fruits, so, grafting is done to improve the quality of the fruits.

Varieties of avocado that can be used for grafting include: Fuerte, Bacon, Gwen Hass, LambHass, Pinkerton, Reed and Zutano while those of citrus include: Oranges, grapefruits, lemons, mandarins and limes.

Avocado and citrus fruit tree seedlings are grown in the nursery using seeds. After germination, the seedlings are pricked out and transplanted into suitable containers such as polythene bags. Once the seedlings grow to the required diameter that is pencil thickness, grafting can be done. The planted seedlings provide the rootstocks.

3.5.1 Grafting of avocado fruit trees

Activity 3.6: Describe the methods used in grafting of the avocado seedlings using search engine or library textbook

The following are methods used in grafting avocado trees:

1. Whip grafting – This is the best technique of grafting on seedlings with a small diameter such as the ones established in the nursery. The following procedure is used when making a whip graft:
   (i) A mature green wood with buds, is selected from desirable varieties.
   (ii) The green wood is cut to about 2.5–60 cm long and leaves removed to leave buds. This becomes the scion.
   (iii) To make a whip graft a matching "tongue" cut is made on both the scion and the rootstock seedlings which is growing in the nursery. This is done by slicing downwards into the wood as shown in figure 3.7.
   (iv) The tongues should be the same length to allow the scion and rootstock to lock together.
   (v) The union is then wrapped together with a polythene strip or cellotape and grafting wax applied.

Fig. 3.7: Matching 'tongue' cut on both scion and rootstock

(vi) The plants are placed under a shed to protect the new whip graft from the sun until the scion begin to grow.

(vii) Any growth from the lower part of the rootstock is removed.

(viii) New shoot from the graft is supported by staking and then the tape removed.

The diagrams below show steps followed when carrying out whip grafting in avocado. The steps have been disarranged. Study the diagrams and arrange the steps in the order in which the practice is carried out.

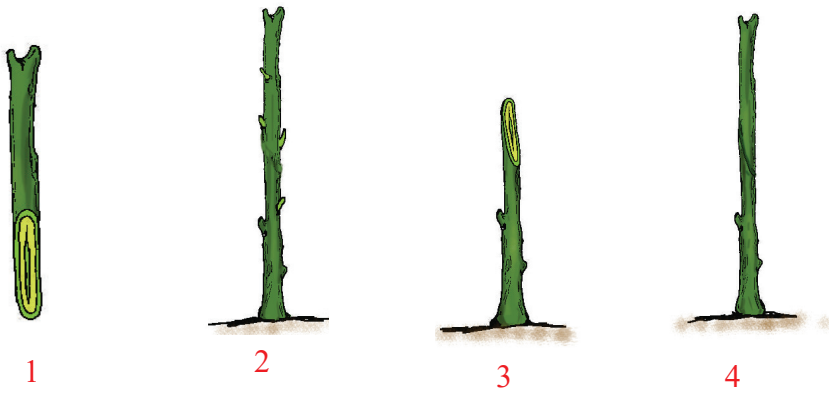


Fig. 3.8: Whip grafting procedure disarranged

2. Bark grafting – This type of grafting is best suited for avocado trees with large diameter.

3. Top working – This is the process of changing fruit varieties on a mature tree. Most citrus and avocado are top worked by bark grafting. Top working should be done during the rainy season for the graft to succeed.

3.5.2 Grafting citrus fruit trees

Activity 3.7: Describe how budding on citrus seedlings is done using search engine or library textbook.

The most common method of grafting in citrus is budding. Budding refers to a method of grafting where a single bud is used as a scion. It is the standard method used to propagate citrus, though used widely in avocados. It is the easiest method when propagating a large number of plants in case the scion stems are few. Budding is also suitable for tree rootstocks or branches from 0.6–2.5 cm in diameter.

Budwood should be taken only from high producing disease free, tree mother plants and from below the most recent flush of new growth for citrus. However, for avocado the best budwood should be located near the terminal end of the shoots that have matured leathery leaves. T-budding is the most common method of budding in citrus and avocado fruit trees.

T-budding procedure

1. A scion shoot is selected and cut from the mother plant as shown in fig 3.9 (a).
2. The leaves on the shoot are pruned off to leave the leaf petioles and buds. The upper weak and the lower hard parts are removed. This leaves a scion stick with well developed leaf buds as shown in figure 3.9(b).

Fig. 3.9: (a) Shoot from the mother

Fig. 3.9: (b) Ready scion sticks with several leaf buds and leaf petioles

Fig. 3.9: (a) and (b) Preparation of scion sticks

3. A T-cut is made on the stem of the rootstock seedlings at about 25–30 cm above the ground as shown in Fig. 3.10 (a). The bark around the T-cut is gently loosened from wood, using the tip of the budding knife as shown in Fig. 3.10 (b). All the side shoots, leaves and thorns from the lower part of the stem are removed.

Fig. 3.10: (a) T-cut on the rootstock

Fig. 3.10: (b) T-cut opened

4. A bud is cut from the scion stick with a sharp budding knife as shown in figure 3.10(a). The scion stick is held with its upper end towards the body and the knife drawn towards the body to remove the bud with the bark of the shoot as shown in Fig. 3.11(b).
5. The bud is pushed down into the T-cut of the rootstock and held with the bark as shown in figure 3.11 (c). The upper part of the bud is removed as shown in figure 3.11 (d).
6. The bud is firmly bound with the budding tape or polythene strip to prevent entry of water. Budding wax is applied around the tape as shown in figure 3.11 (e).
7. The upper shoot of the rootstock seedling is left to grow as a nurse branch. It is then cut off completely when the bud grows and develops about six leaves as shown in figure 3.11 (f).

Fig. 3.11: (a) Cutting the scion bud

Fig. 3.11: (b) Cut scion (bud)

Fig. 3.11: (c) Open T-cut of the root stock

Fig. 3.11: (d) Scion (bud) inserted into the T-cut

Fig. 3.11: (e) Wrapping the union with a tape

Fig. 3.11: (f) A successful budded seedling

Fig. 3.11: (a), (b), (c), (d), (e) and (f) Budding procedure

3.6 Orchard management practices

Activity 3.8: By field trip to an orchard to identify how to select a site for establishment of an orchard, describe the factors to be considered, discuss them and present the findings in the class.

When the tree seedlings are ready for planting, they should be transplanted from the nursery to a properly selected site in order to establish an orchard.

3.6.1 Site selection for an orchard

The first requirement when establishing an orchard is to choose a suitable site. When selecting the site, bear in mind that the orchard will have a productive life of more than 15 years, and if the wrong site is selected, the productive life will be shortened and may be uneconomical.

The following factors should be considered when selecting an orchard site:

(a) Slope of the land: A gentle to moderate slope facing the northernly direction will ensure that the trees will receive sun rays for a maximum number of hours per day. Sunlight is necessary for the ripening of the fruits to give them the required colour. Low lying areas should be avoided to avoid cold, mist and frost during the wet seasons.

(b) Drainage: The soil profile of the area will dictate the water movement in the soil. Soil profile in an orchard should be deep to allow good drainage of water. A well drained soil allow roots to grow well with a good supply of air.

(c) Top and subsoil: Most fruit trees prefer a light deep soil, which hold a lot of plant nutrients water and air. The subsoil should be well weathered without layers of stores which restrict root growth.

(d) Windbreaks: A suitable orchard site should be well sheltered from strong wind to avoid breaking the trees distorting their growth and to reduce the rate of evapotranspiration. Windbreak trees should be planted one or two years before the orchard is established. Strips of dense growing trees such as Pines and Hekea saligna can be planted on the wind-ward side of the site. Mountain ranges or natural forests can also act as windbreaks.

(e) Nearness to the homestead: Orchards should be located near or around the owners homestead for ease of management and to provide security. Fruits planted far away from the homestead fall prey to thieves and heavy losses are incurred.

(f) Nearness to a source of water: Watering fruit trees during drought and low rainfall seasons will ensure regular fruit production. The possibility of installation of water system should be planned and included when laying out an orchard before establishment. A permanent water supply source should be nearby to make irrigation easy.

(g) Previous crops: An orchard should be sited in a place where no other fruit trees had been grown to avoid pest and disease transmission and carry over.

(h) Accessibility: Orchards should be in a place which is easy to reach and well supplied with roads for easy collection and transportation of fruits.

3.6.2 Planting fruit trees in an orchard

- **Land preparation to establish an orchard**

Activity 3.9: Carry out land preparation for establishing orchard, discuss the practices to be done and present them in the class.

The following practices are carried out during the establishment of an orchard:

Land preparation: When the orchard site is selected, land preparation should be done early. If an orchard is to be established, a virgin land should be prepared at least one year before planting the fruit trees.

The following operations should be carried out during land preparation:

(a) Clearing: Trees and bushes should be removed and de-stamping carried out. Some trees should be left on the windward side to act as windbreaks. Manual clearing is carried out using hand tools while mechanical clearing is done using mowers, bulldozers and power saws depending on vegetation type.

(b) Primary cultivation: This is carried out by opening up and inverting the soil properly. Perennial weeds should be removed and allowed to dry up.

(c) Secondary cultivation: One harrowing is necessary to reduce the size of soil clouds. Otherwise the seedbed for fruit tree growing should be left rough since planting holes are used.

- **The layout of the fruit trees in an orchard**

Activity 3.10: By using adequate provided materials explain the triangle or square laying out systems in an orchard.using either tringular or square systems.

An orchard should look neat with fruit trees planted at right angles to each other and in straight lines. This is because an orchard has a long productive life and, therefore, should add the aesthetic value or beauty to the farm. It should enhance the panoramic view of the farm far as long as it exists.

There are two methods used in laying out fruit trees in an orchard. These include:

(a) The triangular system

(b) The square system

a. The triangular system

This method is also referred to as hexagonal system. In this system, 3 trees planted next to each other form the shape of an equilateral triangle, while 6 trees form a regular hexagon with the seventh tree at the centre of the hexagon as shown in figure 3.12. The advantage of using this pattern is that more plants can be grown in a given area.

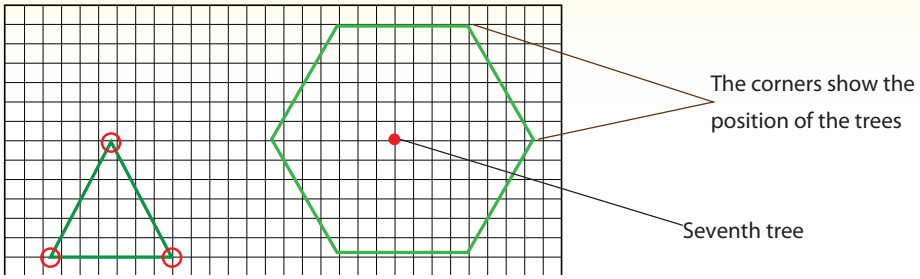


Fig. 3.12: The triangular hexagonal system

The procedure of establishing the triangular system is as follows:

(i) Determine the position where the first row will be using a chain or a garden line of a length twice spacing between two fruit trees. For example, if the spacing is to be 7 metres between the trees, then the garden line or the chain to be used should be 14 metres long.

(ii) Prepare 3 rings out of plain wires with a diameter of 80 mm and attach the rings to the planting line, one at each end and the third one at the middle as shown in figure 3.13.

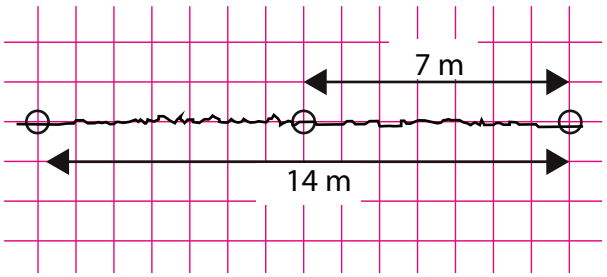


Fig. 3.13: Planting line or chain

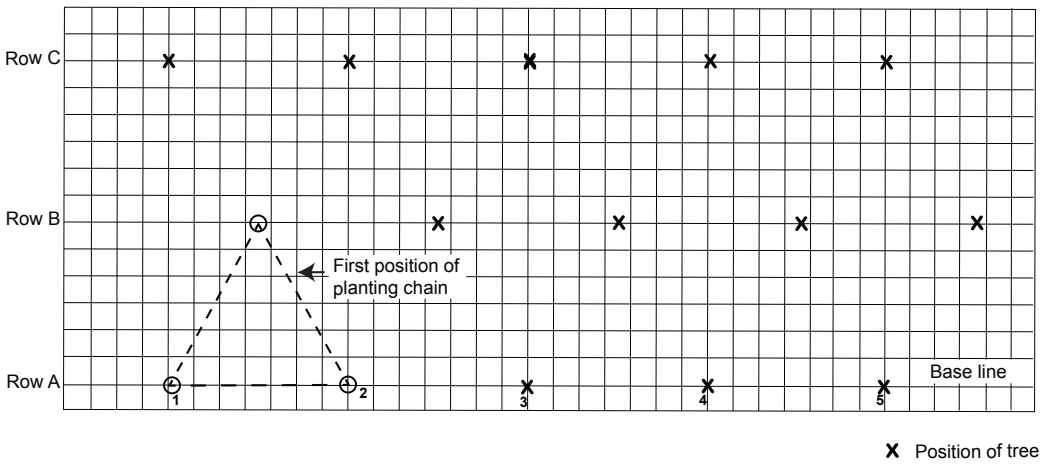


Fig. 3.14: Tree positions in the hexagonal system

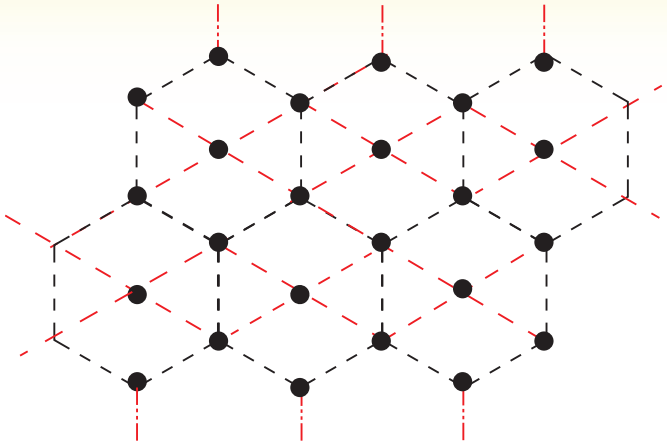


Fig 3.15: Hexagonal pattern of the orchard after establishment

(iii) Place the planting line with the rings along the base line of the orchard and drive a peg at the centre of each ring to mark the planting holes.

(iv) Pick the planting line and place the first ring over the third peg, then pull the line straight over the base line and mark the next two planting holes on the point where rings 2 and 3 are.

(v) Repeat this until all the planting holes on the base line have been marked with pegs.

(vi) Return to the first peg and put the first ring over this peg and the third ring over the second peg. Pull the planting line from the centre ring until the two halves of the planting line are tightly stretched.

(vii) Drive a peg in the centre ring of the planting line to mark the positioning of the first planting hole in the second row of trees.

(viii) Unhook the first ring, leaving the third ring over the third peg of the base line. Pull the centre ring so that the two halves of the planting line are tight. This marks the position for the second planting hole in the second row.

(ix) Place all the pegs marking the planting holes position in this way, row after row until the end.

(x) When finished the planting hole position will have been marked with pegs in the orchard to form the pattern shown in figure 3.15.

b. The square system

In this pattern, all the fruit trees are planted at a right angle to each other, as a result of which every four trees form a perfect square. The advantages of this pattern include:

(i) It is easy to understand and lay out.

(ii) The overhead can be cultivated in all the four directions that is between the rows, within the rows and across the diagonals.

The right angle pattern is established using the 3:4:5 method of constructing a right angle. The procedure is as follows:

(i) Establish a baseline, which is the first row planting positions.

(ii) Measure a distance of 3 metres from one of the baseline hole positions.

(iii) Measure 4 metres on the perpendicular from the end of the baseline. This is done by drawing a hypotenuse in such a way that it measures exactly 5 metres long as shown in figure 3.16(a).

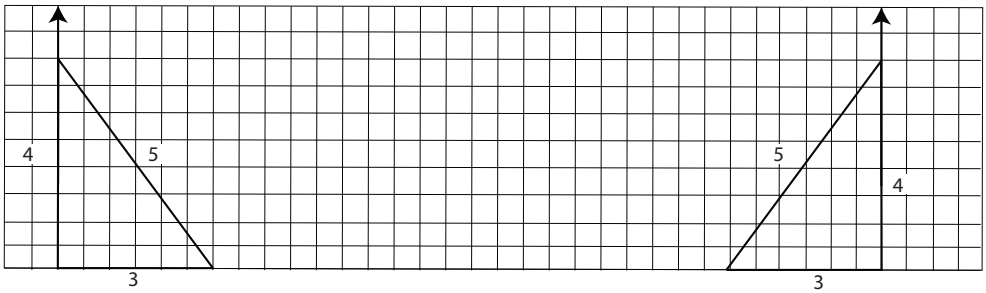


Fig. 3.16: (a) Constructing a right angle by the 3:4:5 method

(iv) Follow the same procedure at the other end of the baseline.

(v) Lengthen the perpendicular lines to the required distance, for example, if the trees are to be planted at a spacing of 7 metres apart, then mark the baseline and the perpendicular sides at 7 metres.

(vi) Use two planting lines to determine the position of each tree as shown in figure 3.16(b).

After planting and establishing the orchard, the fruit trees will form a square pattern as shown in figure 3.16 (b).

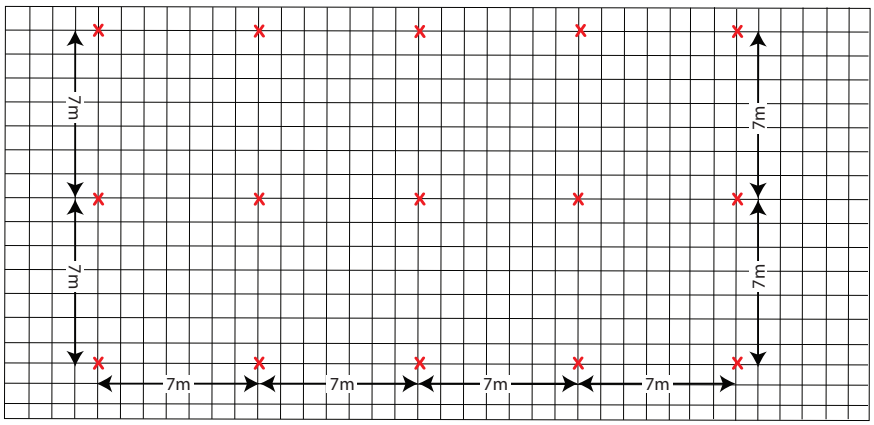


Fig. 3.16: (b) Planting layout in the square system

Other patterns include:

(a) Quincox patterns – This method is almost the same as square method except that the trees are planted in the centre of the square.

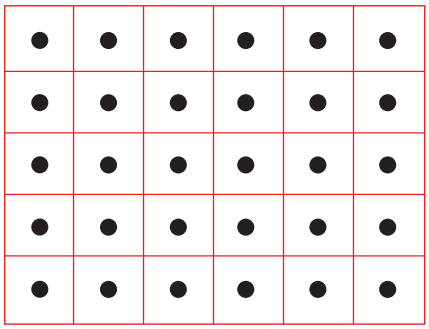


Fig. 3.17: Quincox pattern

- **Preparation of planting holes**

Activity 3.11: Using the materials provided prepare the planting holes according to the layout already made, discuss the procedures to be adopted and present the findings in the class.

The size of the planting holes vary with the type of fruit trees planted though an average sized hole of 60 cm × 60 cm × 60 cm is normally used for most tree crops. The spacing depends on the type of fruit trees. The top soil is separated from the subsoil when digging the holes.

The following procedure is adopted for making the holes:

(i) Establish the centre of the hole already marked by the peg.

(ii) Remove the peg and dig out the top soil up to 30 cm deep and place it on one side of the hole.

(iii) Dig out another depth of about 30 cm of the sub-soil and place it on the opposite side of the hole.

(iv) Refill about 30 cm of the hole by putting back some of the subsoil.

(v) Prepare a soil mixture of:

- Top soil
- Organic manure
- 300 g of phosphatic fertiliser such as double superphosphate (DSP)
- 1 table spoonful of insecticide powder such as furadan or Aldrin wetable powder (40%)

(vi) Re-fill the hole with the soil mixture prepared.

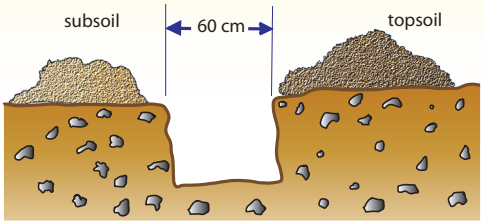


Fig. 3.18: (a)

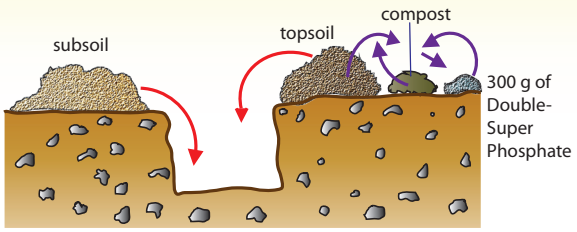


Fig. 3.18: (b)

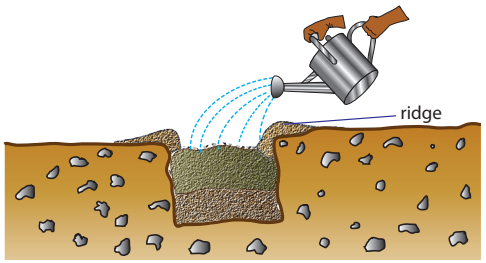


Fig. 3.18: (c)

Fig. 3.18: (a), (b) and (c) Preparing the planting holes

- **Transplanting fruit trees**

Activity 3.12: Transplant fruit trees seedlings by respecting the procedures to be followed and present the process in class.

The best time to plant fruit trees is at the beginning of the long rains so that the trees can get enough water to grow vigorously. It also allows for a higher percentage take and prevents more gapping.

If the seedlings are transported from far, the roots should be covered with a damp sack or in case of sleeved seedlings, they should be watered and kept under a shade awaiting transporting.

After the orchard tree patterns are established, the next activity is to plant the seedlings. The seedlings are planted in holes which are established on the positions marked by the pegs. These pegs should mark the spacing between the trees within the rows interplant spacing and the spacing between the rows. The spacing used dictates the plant density per area which is known as plant population.

When transplanting the fruit seedlings, the following procedure should be followed:

(i) Scoop a small hole in the centre the size of the seedling to be planted.

(ii) Water the seedlings thoroughly in the nursery and in the polythene sleeves. This prevents root damage when uprooting in case of bare roots seedlings, it helps the bag to slide out of the roots with ease.

(iii) Select the healthy and vigorous seedlings.

(iv) Remove the seedlings from the polythene sleeves carefully by inverting the container as shown in figure 3.19.

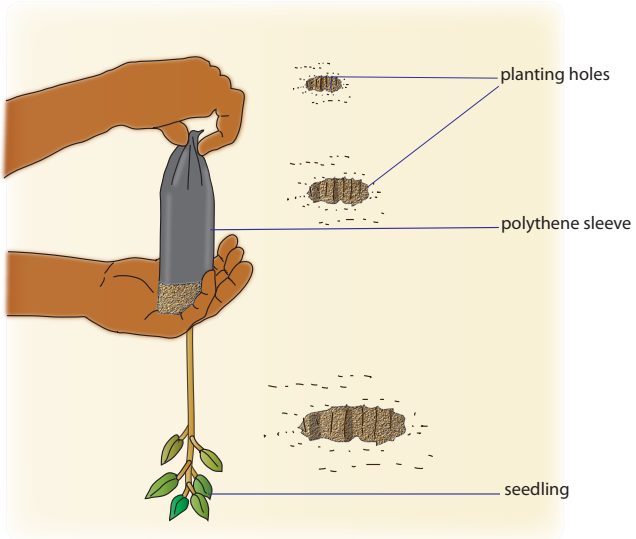


Fig. 3.19: Remove container carefully by inverting

(v) Place the seedlings in the hole and cover well with top soil up to the level it was in the sleeve.

(vi) Firm the soil around the base of the seedling and apply water.

(vii) Apply a layer of mulch around the seedlings to prevent drying.

The illustrations below show the procedure used when preparing holes and transplanting fruit tree seedlings.

Study the illustrations below and then arrange them in the order in which the practice is carried out. Then identify each stage.

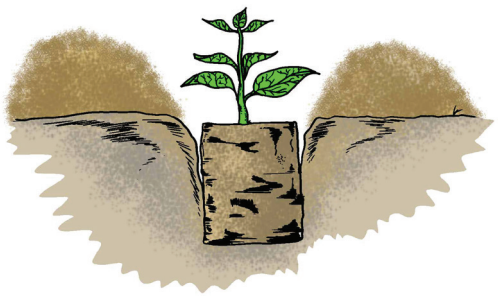


Fig. 3.20: (a)

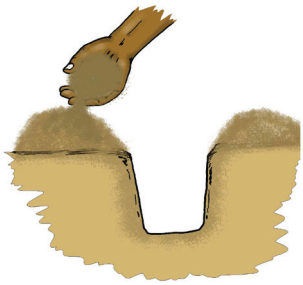


Fig. 3.20: (b)

Fig. 3.20: (c)

Fig. 3.20: (d)

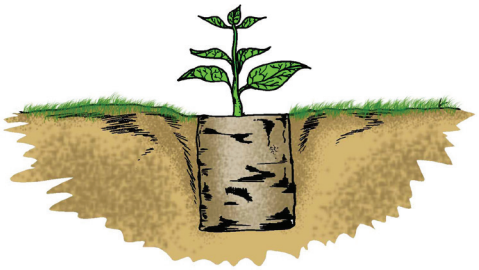


Fig. 3.20: (e)

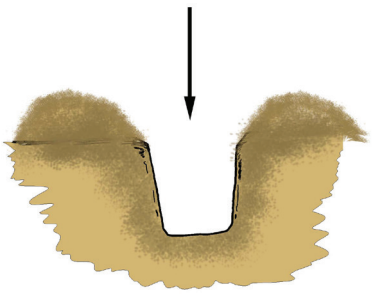


Fig. 3.20: (f)

Fig. 3.20: (a), (b), (c), (d), (e) and (f)Transplanting tree seedlings

3.6.3 Watering

Activity 3.13: Using the material provided, water the fruit trees every morning and evening for 2-3 weeks during the dry season, describe different watering methods to be adopted and present them in the class.

Methods of irrigating fruit trees

Most fruit trees require moist soil all the year round, particularly during the time of blossoming and fruit set. Lack of water when the trees are blossoming causes poor fruits set and poor growth of new wood. This may lead to shedding of most flowers prematurely. Though most fruit trees have long taproots that penetrate up to 1–2 metres deep to absorb underground water, watering during the dry period helps to bring the top 1 metre of the soil up to its field capacity. This is where 85% of the feeder roots are found. A permanent source of water supply is required. The following methods are used to irrigate fruit trees:

1. Sprinkler irrigation

There are two types of sprinkler irrigation.

(a) Overhead irrigation: This is where water is sprinkled above the canopy of the fruit trees.

Fig. 3.21:Overhead irrigation

It helps to clean dust from the leaves making photosynthesis efficient. However, clean water should be available to pass through the pipes and nozzles without blocking. The water requires high pressure to flow through the pipes. This method encourages fungal diseases.

(b) Underhead irrigation: The sprinklers are placed under the crop. The water does not touch the tree canopy which remains dry. It is suitable for healing the ground, that is, sealing the cracks on the ground which prevents tearing the tree roots.

Fig. 3.22: Underhead irrigation

2. Drip or trickle irrigation

Water application is controlled and emitted only around the roots of each tree. The pipes used can be underground or above the ground. Weed growth is controlled since not the whole land gets water. It is suitable in dry areas.

(a) Using pipes

(b) Using bottle

Fig. 3.23: Drip irrigation

3. Furrow irrigation

Water is delivered to the plant through furrows which are dug in the ground to carry water from the main water source which could be a river or a dam. The water applied to the root should be controlled to prevent damaging the roots.

Fig. 3.24: Furrow irrigation in plants

3.6.4 Pruning Fruit trees

Activity 3.14: Watching a video on pruning of fruit trees to identify the reasons and methods to carry out pruning and specify the interval of time of this process.

Pruning refers to the removal of unwanted parts of a plant. It is the reduction of plant parts to achieve specific objectives. The parts removed may be leaves, shoots, flowers, fruits, roots and branches.

3.6.5 Pests and disease control in fruit trees

Activity 3.15: By search engine/photographs of pests and diseases of fruits/magazines cuttings showing pictures of fruits pests and diseases/library books, identify different fruit bert and deseases, discuss and present in the class how they damage fruit tree.

(a) Pests

A fruit pest is a living organism that causes damage to fruits and fruit trees. It is estimated that 35% of the total losses of fruits in the orchard is done by pests infestation.

The main categories of pests which attack orchard trees include:

(i) Leaf defoliator: These are insect pests which remove leaves or eat part of the leaf materials, reducing the surface area for photosynthesis. They include army worms, birds, leaf hoppers, loppers and leaf skeletonisers. Some of these pests are shown in the pictures below. Identify each one of them.

(i)

(ii)

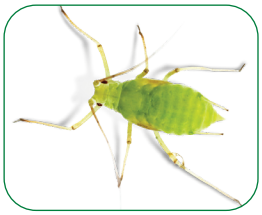
(iii)

(iv)

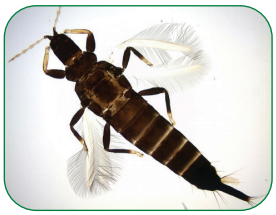
(v)

(ii) Sap suckers: These pierce and suck out the nutritious sap from the different parts of the fruit trees. They include mites, thrips, scales, bugs and aphids. They are mostly serious during the dry season. They transmit diseases to the fruit trees.

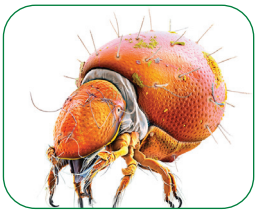
Some of the sap sucking pests are shown in the pictures below. Study them and identify them.



(i)



(ii)



(iii)

(iv)

(iii) Stem and fruit borers: These include, fruit flies, banana weevils and false candling moths of citrus and others. They also burrow through the stems and fruits, laying their eggs and causing fruit fall and fruit rot.

Below are pictures of some stem and fruit boring pests. Study and identify them.

(i)

(ii)

(iii)

(iv) Nematodes: These are soil-borne pests which attack the roots of young and old fruit trees. They attack the vascular bundles and cause them to swell forming galls. These swellings prevent water and mineral transportation in the trees, thus causing water stress.

Fig. 3.25: Nematodes

(b) Diseases

A fruit disease is any alteration in the normal functioning of a fruit or fruit trees and other parts.

Diseases of fruit trees are identified by the organisms which cause them. These organisms include fungi, bacteria and viruses.

(i) Fungal diseases: Include, fruit rot, blights and damping off.

(ii) Bacterial diseases: Include leaf spots, wilts and soft rot.

Fig. 3.26: Soft rot in citrus

(iii) Viral diseases: Include leaf curls, yellow motting, mosaics, rossetting and greening disease of citrus. They interfere with the physiological functioning of the plant and so affect fruit formation.

Fig. 3.27: Leaf curl

Methods of controlling pests and diseases in fruit trees

Activity 3.16: After identifying different fruit pests and diseases, explain their control methods from search engine / library textbook and present the findings in the class.

The following methods are used to control pests and diseases in a fruit orchard:

(a) Chemical control

Use of the recommended chemicals to kill the organisms or the vectors. The chemicals are applied to the targeted parts of the plant through dusting, spraying or smearing to kill the organisms. The safety period after application of chemicals should be observed before the produce is used to prevent poisoning.

Fig. 3.28: Spraying fruit trees using knapsack sprayer

(b) Cultural methods

These include uses of practices which interfere with the life cycle of the organism preventing its development, practices such as pruning, mulching and weed control are used.

(c) Physical methods

These include, trapping, killing and removal of the affected material to prevent spreading of diseases and pests.

(d) Biological methods

This is the use of living organisms to control pests. Natural enemies known as predators consume large numbers of destructive organisms. Other enemies known as parasitoides also destroy fruit pests. These organisms are susceptible to chemicals. They multiply when cultural methods are used.

(e) Integrated management

This approach uses a combination of all the pest and disease control methods to compliment each other. Where chemicals control methods are used, efforts should be made to prevent killing the biological agent and avoid environmental pollution.

Reasons for pruning fruit trees

(i) To restrict the growth of the tree which controls the size. This will help make some operations such as spraying and harvesting easy.

(ii) To train the plant: This helps achieve a certain direction of growth. The morphology and shape of the trees can be controlled.

(iii) To maintain the health of the trees: This is achieved by removing the diseased parts, to prevent disease spread. Reducing the plant parts opens the plant, thus reducing the micro-climate conducive for disease multiplication.

(iv) To change plant cycles: This helps improve the performance of the crop by rejuvenating the old to new growth.

(v) Improve yields and control quality: When the number of flowers and fruits are reduced, quality produce is achieved. This gives a balance between the amount of leaves and the fruits. It makes sure that the fruits get enough nourishment to enlarge and become good quality.

(vi) Removal of old and unproductive parts: All those branches in a tree which have given maximum cropping should be removed. This ensures that there will be production of fruits every year.

When is pruning carried out?

Pruning is carried out:

(a) After the rainy seasons: Pruning is carried out to remove the water shoots, that is, the succulent flesh growth that appears out after rainy season. Those shoots are poorly lignified and break easily.

(b) After harvesting: This is to remove all the old branches and those that were broken in the process of harvesting.

Methods of pruning fruit trees

There are three basic techniques of pruning fruit trees. These are:

(i) Pinching out – This method is mainly to reduce the height of the tree while increasing the spreading of the tree to achieve a wider canopy. It is commonly done in avocado, citrus and tamarillo.

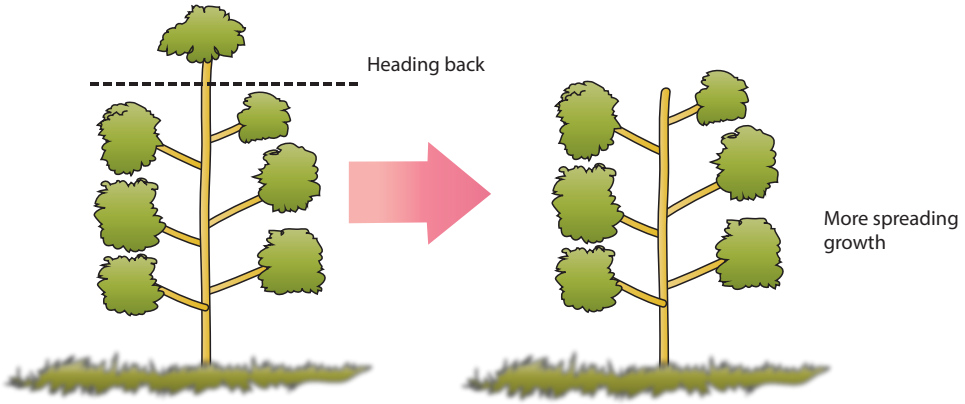


Fig. 3.29:Pinching out a fruit seedling

(ii) Coppicing – This is the cutting of the whole tree stem 30 cm above the ground to leave a stump. New shoots grow out of the stump to provide several bearing points.

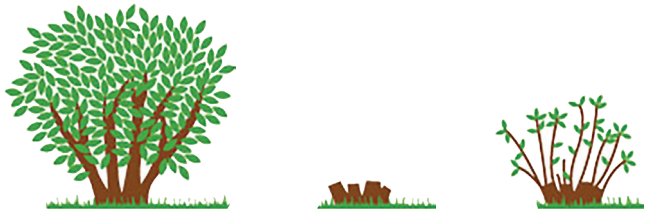


Fig. 3.30: Coppiced fruit tree

(iii) Thinning out – This is the removal of some of the branches within the stem to reduce the number of branches and thus opening up the canopy. The tree gives a better yield.

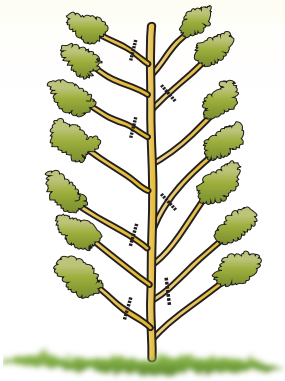


Fig. 3.31: (a) Before thinning

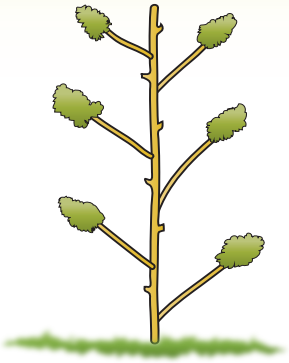


Fig. 3.31: (b) After thinning

(iv) De-shooting: This is the removal of the water shoots. Water shoots are the vigorous, weak and succulent shoots with fleshy growth. They usually shoot out quickly after the rains. They slow the growth rate of the trees.

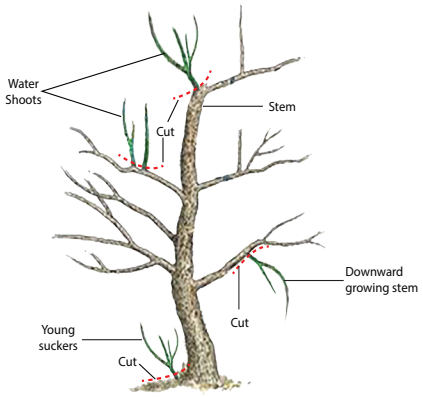


Fig. 3.32: (a) Fruit tree with water sprouts

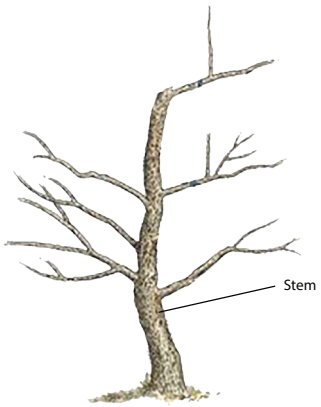


Fig. 3.32: (b) Fruit tree with water sprouts removed

(v) Training – This is the practice of encouraging the tree to grow in the desired manner in terms of shape and direction. In some cases, training of fruit trees can be done without necessarily cutting the tree while in other cases the tree parts are cut off.

Fig. 3.33:Training fruit trees

Training is carried out in fruit trees established in an orchard for the following reasons:

(a) *To increase productivity*: This is more so in vine growing fruits such as passion fruits and grapes. The vines are exposed widely to the sunlight for more photosynthesis and greater yield.

(b) *To improve quality of fruits when the trees are trained*: It is possible to produce clean fruits with improved colour, juice content and dry matter content due to exposure to light.

(c) *Ease of carrying out cultural practices*: Such as weed control, pest and disease control and harvesting.

(d) *Aesthetic value*: Training makes the trees in an orchard look beautiful and admirable.

Activity 3.17: By adequate tools, prun citrus trees, discuss the process and present the findings in the class.

Fig. 3.34: Pruning of passion fruits

3.7 Definition of processing and preservation of fruits

Activity 3.18: Make a field trip to a fruit processing and preservation plant or factory and carry out the following activities:

(1) Observe all the types of fruits which are processed and preserved in the plant or factory.

(2) Taste the type of fruits and fruit products which are processed there in the plant or factory.

(3) Discuss the definition of processing and preservation of fruits as observed in the plant.

Fruits require processing and preservation after harvesting. The processing of fruits can be done in the farm immediately after harvesting, at home and in fruit processing plants or factories.

Fruit processing

Fruit processing is any deliberate change or transformation of a raw fruit by physical or chemical means before it is available for use or consumption. It ranges from minimally processed items to more complex preparation that combine ingredients such as sweeteners, spices, oils, flavours, colours and preservatives with many variations. Processing of fruits is used to add value as well as increase the shelf-life of the products so as to offer a variety of flavour, aroma, colour and texture to the diet.

Fruit preservation

This involves preventing the growth of organisms which bring about spoilage of fruits and fruit products. It includes processes that inhibit visual deterioration such as enzymatic browning reactions in certain fruits after they are cut. When preserving fruits, maintaining their nutritional value, texture and flavour is important.

3.8 Importance of processing and preservation of fruits

Activity 3.19: Using search engine or library textbook, discuss the importance of processing and preservation of fruits

When fruits are harvested they undergo physical and physiological changes which make them become inedible, lose taste and nutritional value. As long as the fruits are not harvested, their quality can remain relatively stable, though exposed to damages by pests and disease-causing organisms. However, harvesting cannot be postponed for a long time and when time comes fruits have to be harvested.

Fruits have high moisture content and are generally acidic foods which are relatively easy to process to offer a variety of products. They are, therefore, processed for the following reasons:

(i) Make them convenient to handle.
(ii) To avail them throughout the year and when off season.
(iii) To give them a longer shelf-life.
(iv) To produce a variety of products giving consumers a wide choice.
(v) To reduce the poisoning effects which may be as a result of spoilage caused by microbial infection.

3.9 Objectives of applying post-harvest technologies

Activity 3.20: By search engines find out the importance of applying post-harvest technologies in fruits.

It is estimated that about 50% of the total quantities of fruits harvested in any farm is lost in the period between production and consumption. These losses can be minimised through application of different post-harvest technologies.

The objectives of post-harvest technologies include:

(a) To maintain quality

The quality of fruits is measured by its flavour, appearance, texture and nutritive value. Processing of fruits helps to preserve these qualities. The quality of the fruits may be reduced after harvesting, through:

(i) Physical spoilage
(ii) Physiological aging
(iii) Insect damage
(iv) Mechanical damage
(v) Chemical and enzyme spoilage
(vi) Microbial spoilage

Physical spoilage is caused by dehydration. Physiological aging occur as soon as the biological cycle is broken through harvesting. These processes cannot be prevented but they can be delayed allowing the fruits a longer shelf-life.

(b) To protect food safety

When fruits undergo microbial spoilage caused by yeast, moulds and bacteria, they may become contaminated with poisonous waste from these organisms. These wastes cause food poisoning which is dangerous and can cause death. Post-harvest preservation of fruits keeps them away from contaminants. Fruits should be preserved within 4 – 48 hours after harvesting.

(c) Reduce physical losses

Physical spoilage is brought about by dehydration, poor handling and damage by insects or rodents leads to high losses of fruits. Post-harvesting handling and processing help reduce such losses.

(d) Reduce loss in market value

Traders lose a lot of fruits due to physical deterioration brought about by poor storage. Cold storage facilities help to reduce such losses by keeping the fruits succulent and fresh. Storage disorders in fruits include getting shrivelled, tainting, softening of the outer peel and physiological injuries such as blemishes and internal browning. These reduce the market value of fruits.

After the fruits are harvested, growers should follow proper management technologies so as to offer a fresh and good looking product to the consumers in order to get maximum returns for their investment. The recommended post-harvest technologies are applied to preserve the produce.

3.10 Preservation techniques of fruits

Activity 3.21: By internet search/library book, find out the preservation techniques in different fruits. Watch a video showing fruit processing and preservation techniques, discuss the observation and present the comment in the class.

There are several techniques used to preserve fruits. These techniques depend on availability of resources, equipment, a scale of production, skill available and the level of technology.

(a) Freezing techniques

Freezing of fruits and fruit products is a common practice used by many consumers to preserve fruits. Cold temperatures act in retarding the spoilage of fruits. This inhibits microbial action and slows metabolic processes which leads to breakdown of fruit sugars to alcohol. To achieve extended period of storage, fruits and fruit products are stored below the freezing point of water that is at about -23°C. Rapid freezing generally increases improved texture of fruits upon thawing. The fruits undergo blanching to inactivate fruit enzymes responsible for off-flavours, browning and softening. Blanching is a process which consists of heating the fruit in steam and then cooling it quickly before freezing.

Fig. 3.35: Freezing techniques

(b) Curing techniques

This is also known as dehydration. It is among the oldest and most common method of fruit preservation. The moisture in the fruit is driven off, to leave a stable product that has a moisture content below the level preferred by micro-organisms to grow. Fruit curing can be done through sun drying, hot-air dehydration and freeze drying. It has the following advantages:

(i) It gives the fruits and fruit products a long shelf-life if stored under proper conditions.

(ii) It does not reduce the calories, minerals and vitamins in the fruits.

(iii) Reduces costs which may be incurred in handling and transporting heavy fruits. Dried or cured fruits are reduced in weight by 75–90 per cent.

A chemical such as sulphur (IV) oxide is used to inactivate the fruit enzymes before dehydration while sodium sulphate is used to treat the fruits to control browning.

Fig. 3.36: Drying fruits

(c) Canning techniques

This technique is used in high acid fruit products. The fruits or fruit products are hot-filled or heated in hermetically sealed containers at a temperature range of 88°C. The heat is used to destroy organisms that decompose fruits and to inactivate some enzymes.

Fig. 3.37: Canning fruits

(d) Refrigeration techniques

This is the process of keeping fruits in cold temperatures usually provided by a refrigerator. Cold temperatures prevent the growth of micro-organisms that are harmful to the fruits, for example, bacteria, yeasts and moulds. The moisture control in the refrigerators help to slow the deterioration of the fruits by reducing the favourable conditions for micro-organisms.

Refrigeration also slows down the fruits natural processes that lead to ripening and eventual decay. In this case, the chemical processes that cause plants to grow and ripen also cause them to decay, thus, refrigeration helps to slow the process.

(e) Sugaring technique

Sugar has been used as a food preservative for many years. Storing fruits in honey is an old technique. Fruit preserves are made by heating fruits with sugar. It tends to draw water from micro-organisms a process known as plasmolysis. This kills them, therefore, the fruits remain safe from microbial spoilage.

Sugar preserves fruits either in an anti-microbial syrup or in crystalline form where the preserved fruits are cooled in sugar to the point of crystallisation and the resulting product is stored dry. This method is commonly used in the preservation of the skins or peels of citrus fruits and in the making of jams and jellies.

(f) Fermentation technique

In this process, the carbohydrates in the fruits are converted to organic acids and alcohol. Yeast is used to break down the fruit sugars. The fruits are placed in a container where water, sugar and starter culture are added. The starter culture can be yeast or whey. They are left closed for 2–10 days. The fermented fruits can be canned and kept refrigerated.

3.11 Some fruits to be processed

Activity 3.22: Visit an orchard to observe the various fruits grown and identify which require processing.

Fruits with high moisture content and highly acidity require processing to preserve their flavour, aroma, colour and texture. Such fruits include strawberries, passion fruits, papaya, pineapples, citrus and tamarillo.

1. Strawberries – Strawberries should be harvested when completely ripe, after which stemming, washing and sorting is done. The sorted fruits are stored in coolers or cold rooms. They are further sorted into grades according to sizes. They can be freeze-dried. Dried strawberries are mixed in snack packages and cereals. Strawberries are also used to make fruit leather. Fruit leathers are home-made dried fruit rolls. Jams and jellies can also be made from strawberries as a way of preservation.
2. Passion fruits – These are the easiest fruits to process. They are used to make juices and juice concentrates of which a certain proportion of water is removed to make it concentrated.
3. Papaya – These fruits are used to make juices. Fresh fruits are chilled at room temperature. They can only last for 2–3 days and a week when refrigerated.
4. Pineapples – Fresh pineapple fruits are cut into various shapes and then canned in sugar syrup heated in a water bath. Juice, jam and jellies are also made from pineapples.
5. Citrus – Citrus are valuable source of vitamin C. They produce fresh juice which is canned or frozen. Their skins is dried or sugared and used for production of oils. The white membrane is used for pectin production. Citrus juice is used to produce wine after fermentation.
6. Tamarillo – Fresh tamarillo are blended together with water and sugar to make juice. Tamarillo jam and jellies are other preserves from the fruits.

3.12 Products processed from fruits

Activity 3.23: By search engine/library textbook, identify the products processed from different fruits grown in Rwanda.

Fruits are processed to produce the following products:

Fruit jam

The term "jam" refers to a product made of whole fruit cut pieces or crushed and then heated with water and sugar to activate pectin before placing in containers. Jams are made from small fruits with distinct colours and soft texture when ripe.

The proportion of sugar and fruit varies according to the type of fruit and its ripeness though equal measures are used. When the mixture is heated to a temperature of 104°C, the acid and pectin present in the fruit reacts with the sugar and the jam will set on cooling. There are two main methods of jam production.

(i) Open pan method – This method is used to produce large quantities of home-made jam with traditional flavours.

(ii) Use of a vacuum vessel – The jam is placed under a vacuum container which reduces the boiling temperature to between 65°C and 80°C depending on the desired results. This method helps retain the volatile flavour compounds from the fruits as opposed to the open method thus making the jam better than where the sugars are burned on an open pan. Further heating 95°C – 100°C temperature is needed to kill off micro-organisms present. It is then cooled and packed in glass or plastic jars which are sterilised.

Steps in making fruit jam

Ingredients

(i) Sweet tasting ripe fruits

(ii) Pectin powder (this is optional)

(iii) Sugar

(iv) Fruit juice (of your choice)

(v) Butter or margarine

Procedure

1. Collect all the ingredients needed.
2. Sterilise the containers needed for jam storage.
3. Wash and cut the fruits into small cubes (1.25 cm).
4. Crush the fruits with a wooden spoon or a potato masher.
5. Place the mashed fruits into a large saucepan and add lemon juice ($\frac{1}{4}$ cup).
6. Add $\frac{1}{4}$ cup lemon juice and $\frac{1}{2}$ teaspoon of butter or margarine and stir. Butter can be warmed first.
7. Boil the fruit mixture when stirring and let it continue bubbling.
8. Pour in the sugar and continue boiling and stirring. Use enough amount of sugar to fruit ratio.
9. Allow the fruit mixture to simmer for 5–20 minutes to make a thick syrup consistency.
10. Remove the mixture from the heat.
11. Skim out any foam or bubbles off the top surface.

12. Place the jam into sterilised containers or jars and seal.
13. Boil the jars with the jam in them for 10 minutes in a water bath.
14. Remove the jars from the water bath and cool by washing them in cold water and store.

Marmalade

This is a fruit preserve made from the juice and the peels of citrus fruits boiled with sugar and water. It is produced from sweet orange, mandarins, limes, grape fruits, lemons and other citrus fruits or their combination. The citrus peel has a distinctive bitter taste which gives the product its flavour. The difference between jam and marmalade is that marmalade contains fruit peels.

Steps in making marmalade from orange

1. Peel the oranges and cut them into small pieces.
2. Remove the white skin of the pulp from each piece.
3. Separate the peels and boil them in water until tender.
4. Cut the tender peels into small pieces.
5. Grate the skin of lemons.
6. Mix the finely chopped pieces of oranges, grated skin of lemons and the boiled peels of orange in a pan.
7. Add white sugar and boil for 20 minutes.
8. Leave to cool and store in sterilised jars.

Jelly

This is a clear or transluscent fruit juice and is set by using its natural pectin. It is a gelatin-based dessert. It is made through the process similar to that of jam making with additional step of filtering out the fruit pulp after the initial heating. The filtering process is done using a muslin cloth called the jelly bag. This makes the jelly clear and sparkling.

Steps in making jelly

Ingredients

(i) Fruits
(ii) Sugar
(iii) Water

Procedure

1. Cut peeled fruits into small cubes.
2. Cook the crushed fruit with water until soft and starts to lose its colour.
3. Strain out the solids and simmer the juice.
4. Add sugar and then boil until the liquid reaches 104° C to 106° C to thicken. It should be able to fall in a sheet off the side of a spoon.
5. Pour into sterilised jars.
6. Store in a refrigerator.

Juice

Fruit juices are delicious and full of nutrients. They come from the liquid part of succulent fruits. The process of extracting juice from fruits requires a blender or a juicer, though some fruits can be squeezed by hand pressing to produce juice.

To extract juice the fruits are washed, peeled and chopped into small slices. Seeds are removed if any and the fruits slices are put in a juicer or blender for extraction. The juice extracted is kept fresh in the refrigerator for several hours.

Steps in making fruit juice

Ingredients

(i) Orange fruits

(ii) Juicer or lime squeezer

(iii) Large juice containers or jars

Procedure

1. Clean the fruits and remove the peels.
2. Remove the white peel.
3. Chop the fruits into pieces or cubes.
4. Place the fruit cubes into a hand juicer. Alternatively, squeeze using up and down movement in a container that can hold all the juice.
6. Let it cool at room temperature then place in a refrigerator.

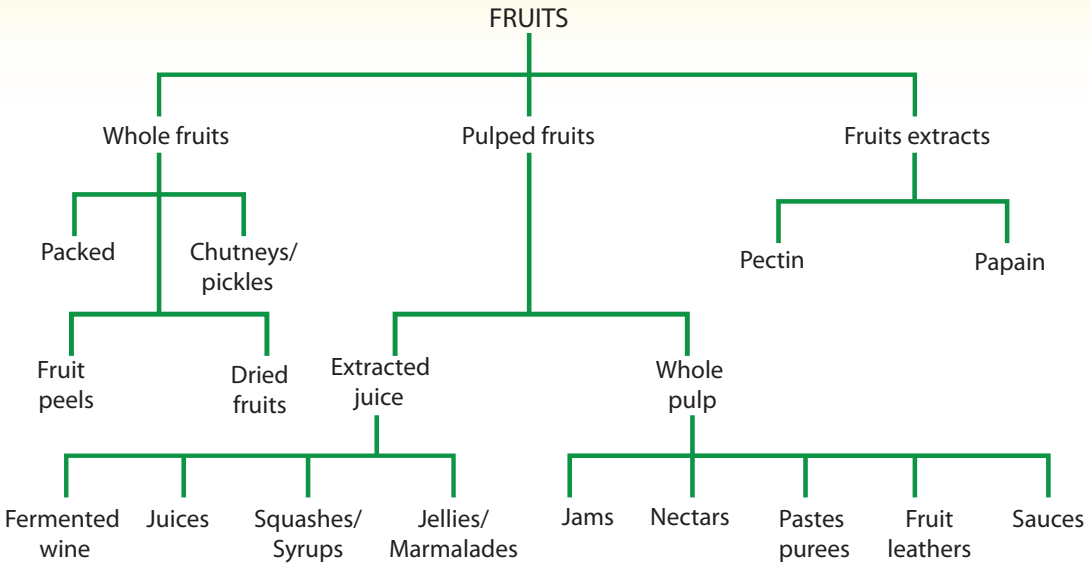


Fig. 3.38: Flow chart of fruit processing

Unit Summary

- A fruit is an enlarged ovary of a flower which may contain or may not contain seeds. Fruits have nutritional and economic values in human. Fruit trees protect the environment as well as provide a balance between food crop and the growing of cash crop to farmers.
- Fruits cultivated in Rwanda include avocados, papaya, tamarillo, citrus, passion fruits, strawberries and pineapples. Fruit trees are propagated by use of seeds as well as vegetatively. Vegetative propagation involves use of methods such as layering, grafting and use of stem cuttings.
- Avocado and citrus fruit trees are grafted to improve their quality and growth characteristics, increase yields and reduce their maturity period. Methods of grafting carried out in avocado and citrus include whip grafting, bark grafting and bud grafting. T-budding is the most commonly used method of grafting citrus and avocado.
- Fruit trees are grown in an orchard which is sited in a properly selected place in order to have a long productive life. Fruit trees in an orchard should be planted in an orderly manner to provide the beauty and enhance the panoramic view of the farm. The triangular and the square systems are used to lay out fruit trees in an orchard.

- Fruit tree seedlings are raised in the nursery before they are transplanted. They require management such as watering, pruning, pest and disease control while growing in the field. Fruits are perishable farm produce and so require different types of processing and preservation in order to add their value, improve flavour, appearance and increase their keeping quality. The techniques of preservation in fruits include refrigeration, freezing, sugaring, canning, curing and fermentation.
- Fruits are also processed to produce such products as jam, juice, marmalade and jellies. This increases their shelf-life, reduce bulkiness and offer consumers a wider choice of products.

Key Terms

1. **Ovaries** – Parts of a flower which develops into a fruit and a seed or seeds.
2. **Diversification** – Growing several types of crops on a piece of land to safeguard against total failure.
3. **Flavour** – A characteristic taste.
4. **Secondary industries** – Manufacturing or processing industries developed as a result of fruit production so as to process fruit products.
5. **Ecology** – The study of living things in relationship to their surroundings.
6. **Plant propagation** – Multiplication of plants and planting materials.
7. **Vegetative propagation** – Multiplication of plants using plant parts other than seeds.
8. **Dormancy** – A condition where seed or bud in which germination cannot take place even after provision of necessary conditions for germination.
9. **Fungicides** – Chemicals used to control fungal diseases.
10. **Insecticides** – Chemicals used to control insect pests.
11. **Pesticides** – Any agro-chemicals used to control destructive organisms referred to as pests.
12. **Nitro-culture** – A growth medium mixed with nitrogen fixing bacteria.
13. **Mucilage** – A viscous substance found on the fruit or seed coat which prevents water absorption.
14. **Endocarp** – The inner part of a fleshy fruit which covers the seed.
15. **Mother plant** – Mature plants from which vegetative planting materials are acquired.
16. **Rooting medium** – A mixture of hormones nutrients, and substrate on which plants can grow and attach roots.

17. **Ring-barking** – Removal of the bark from a stem to leave an exposed ring.
18. **Polythene sleeves** – These are polythene bags made to specific dimensions for raising seedlings singly.
19. **Wooden pegs** – Strong pieces of sticks with sharp ends used for marking hole positions.
20. **Terminal bud** – The topmost part of a stem or shoot where elongation takes place.
21. **Transplanting** – The practice of removing seedlings from the nursery or polythene sleeves to the holes in the seedbed.
22. **Detach** – Disconnect by cutting.
23. **Economic life** – The productive period of plant growth which is profitable to the farmer.
24. **Dwarfing** – Reduced in size or becoming smaller than normal.
25. **Compatible** – Can exist, breed together or able to form a successful union.
26. **Scion stick** – The part that contains buds which grow to become a new shoot after grafting.
27. **Leaf bud** – A vegetative part of the leaf which grows into a shoot or a branch.
28. **Staking** – The practice of supporting a creeping plant with a stick in order to grow upright.
29. **Water shoot** – A vigorous sprout arising from the trunk or the main branch of the tree.
30. **Nurse plant** – A branch left on a rootstock to provide food to the young growing bud. The nurse plant is pruned off when the bud grows into a shoot.
31. **Containerised seedlings** – Seedlings planted singly in a container such as a sleeve.
32. **Windbreaks** – Trees or other barriers used to prevent and reduce the speed of wind over planted crops.
33. **Evapotranspiration** – Loss of water vapour from the leaf surface through evaporation.
34. **All weather roads** – Roads that allow vehicles to move through without getting stuck regardless of the season.
35. **Baseline** – The position of the first row of the fruit trees in an orchard. It is used as a guide when marking the position of the planting holes.
36. **Hypotenuse** – This is the longest side of a right angled triangle. It forms the

diagonals of two right angled triangles joined together.

37. **Wettable powder** – Agro-chemicals in powder form that cannot dissolve but mix well with water.
38. **Soil field capacity** – A state where soil holds enough water for the plants.
39. **Blossoming** – Starting to produce flowers.
40. **Fruit set** – After pollination when the flower wither and fruit forms.
41. **Canopy** – The top foliage of a growing plant.
42. **Vascular bundles** – Vessels that transport water and nutrients in a plant.
43. **Flush growth** – New plant parts that sprout suddenly and at once.
44. **Lignification** – The process of thickening due to deposition of complex carbohydrate materials known as lignin.
45. **Apical dominance** – Prevention of sprouting of lateral buds due to the presence of a terminal bud.
46. **Cultural practices** – Routine crop production practices carried out to control weed pests and diseases.
47. **Capping** – Cutting off the terminal bud of a plant to allow spreading.
48. **Determination** – Change in quality of a product from good to bad.
49. **Enzymes** – Chemicals produced in plants that are used to regulate metabolic rate.
50. **Physiological changes** – Changes that occur in the functioning of an organism.
51. **Tainting** – Having traces of an unwanted substance such as colour, flavour or smell.
52. **Lethal** – Sufficient to cause death.
53. **Pectin** – A complex polysaccharide extracted from fruits mainly citrus and used as a jelly agent to make jellies and jams.
54. **Parasitoides** – A living organism used as a biological control agent to parasitise crop pests.
55. **Predator** – A living organism that eats other organisms that destroy crops.
56. **Blemish** – A mark or stain that spoils the natural beauty.
57. **PVC pipes** – Plastic pipes made of rigid polyvinyl chloride.

Revision Questions

1. What is a fruit?
2. State the importance of fruits.
3. List four types of fruits grown in Rwanda.

4. State two methods of propagating fruit trees.
5. State three methods of vegetative propagation used in fruits.
6. Name one type of fruit propagated through stem cutting.
7. The following are illustrations showing the steps followed while carrying out T-budding in avocado fruit trees. Identify the various steps indicated by each illustration.

(i)

(ii)

(iii)

(iv)

(v)

(vi)

8. List four factors to consider when selecting a site for an orchard.
9. Describe the operations carried out when preparing land for an orchard.
10. Name two methods of laying out fruit trees in an orchard.
11. List three methods of pruning fruit trees.
12. Match the photographs of the pests below with the type of damage they cause to fruit crops.

(a)		(a)	Burrow through fruits, laying eggs and causing fruit fall and fruit rot.
(b)		(b)	Cause swellings in roots preventing transporting of water and mineral salts.
(c)		(c) (d)	Pierce and suck sap from different parts of the fruit trees. Eat parts of the leaf reducing surface area for photosynthesis.

13. Differentiate between processing and preservation as applied in fruits.
14. State four objectives of applying post-harvest technologies in fruits.
15. List the preservation techniques used in fruits.
16. Differentiate between jam and marmalade.
17. Carry out the preparation of fruit jam from strawberries.

UNIT 4

LEGUMES

Introduction

A legume is any dicotyledonous plant that belong to the family *leguminosae* also known as *fabaceae*. They are mainly grown for their grain seed known as pulse or as food for livestock known as fodder. Legumes may also be grown for preparation of green manure. Common pulses grown in Rwanda for human consumptions include beans, peas, groundnuts and lentils while legume fodder include lupins, white clover/ lucern and desmodium.

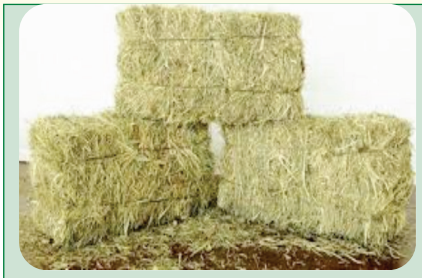
This unit will help explore the legumes grown in Rwanda, importance of legumes, propagation methods, cultural practices in legumes, post-harvest techniques for soya beans, groundnuts and conservation of fodder legumes for feeding animals. The following pictures give an insight to the unit:

Mixed grain pulses

Soya bean plant

A crop of groundnuts

Lucern plant



Hay bales

Feeding cattle with cured lugume fodder

4.1: Definition of legumes

Activity 4.1: By search engine or library textbooks, find out the meaning of legumes.

A legume is a plant which bears a fruit known as a pod. Such pod seeds or vegetative parts are used as food for human and livestock. Legumes grown for seeds are referred to as pulses while those for livestock feed are referred to as fodder legumes.

4.2 Legume names and types

Activity 4.2: By field trip to an agricultural farm dealing with legumes, identify cultivated legumes and classify them (folder and pulses).

Table 4.1: Cultivated legumes for humans and fodder

#	*Legume*	*Identity*	*Consumed by*
1			
2	 		

3			
4	 		
5			
6	 		
7			

8	 		
9			

(iii) Classify the legumes into:
  (a) Pulses – edible by human.
  (b) Forage legumes

(iv) Discuss and record your findings.

(v) Present your findings to your class.

(vi) Take the teacher's summary notes.

Legumes are divided into:

1. Fodder legumes
2. Legumes edible by humans

Legumes edible by humans include:

(a) Beans
(b) Soya
(c) Peas
(d) Groundnuts
(e) Lentils

Fodder legumes include:

(a) Lupins
(b) White clover
(c) Lucern
(d) Desmodium

4.3 Importance of legumes

Activity 4.3: A field visit to find out the importance of legumes

Visit an agricultural farm dealing with legume production and then carry out the following activities:

(i) Identify the legumes cultivated in the farm.

(ii) Classify the legumes into fodder and pulses.

(iii) Find out the importance of each legume to:

  (a) Human being

  (b) Livestock

  (c) The environment

Legumes are important source of proteins and roughages for both humans and livestock.

The following are the importance of legumes:

(a) Feed for human beings and livestock

Legumes used as livestock feed are referred to as pasture or fodder. The flowers of legumes provide nectar and pollen for honey bees. Other legumes such as beans, peas, ground nuts and soya beans are used as food for human beings. These legumes provide proteins, minerals and vitamins to both livestock and human beings.

(b) Provide stakes for climbing crops

Legumes such as pigeon pea, calliandra, leuceana and sesbania have woody stems. They provide support to climbing crops such as tomatoes and climbing beans.

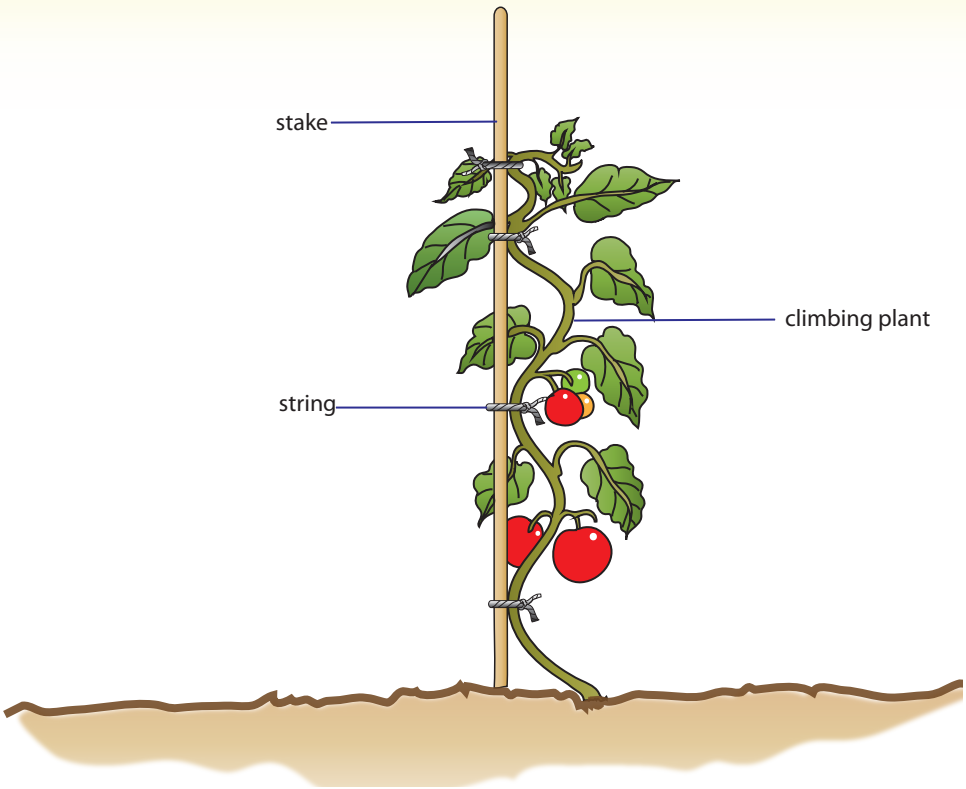


Fig. 4.1: Staked plant

(c) Improve soil fertility

Legumes, in association with nitrogen fixing bacteria in their root nodules, fix nitrogen to the soil improving fertility. Leaves drop to the ground and decompose to form humus. Humus releases nutrients to the soil. Some legumes have a long tap root system which enables them to utilise nutrients from the lower soil horizons. These also bring up leached nutrients to the surface.

(d) Soil conservation

Legumes conserve soil in the following ways:

- They are used as cover crops preventing soil erosion.
- Their roots are deep and extensive thus binding soil particles together. This improves soil structure.
- Legumes conserve soil moisture by preventing excessive evaporation through the provision of surface cover.
- Leaves that drop from the legume plants decompose to form humus that binds soil particles together.

(e) Raw materials for food processing industries

Legumes such as soya beans and ground nuts are used as a source of vegetable oils, margarine and peanut butter. Soya bean is ground and used to make protein based supplements used as human food and concentrates for livestock.

(f) Source of income

Legumes are sold to provide income for the farmer such as bean seeds, French beans and fodder for livestock.

(g) Medicinal value

Some legumes provide chemical compounds which protect the body against various diseases and disorders such as cancer, depression, indigestion and metabolic imbalances.

(h) Source of fuel

Woody legumes are harvested through lopping and coppicing and used as a source of fuel. Such legumes include calliandra, leuceana and sesbania.

4.4 Propagation methods of legumes

Activity 4.4: Visit a farm producing legumes, discuss the methods of propagating legumes practiced in a farm.

Propagation is the practice of generating new plant to multiple crops. In legumes, it can be done using materials such as cuttings, layers and seeds.

Cuttings

A cutting is a part of a plant which can develop into a new plant when removed from the mother plant. Legumes are propagated from stem and root cuttings.

These plant parts are given the necessary conditions to produce new plants. The new plants are similar in characteristics to the mother plant.

Conditions necessary for rooting of cuttings:

(a) *Temperature*: Warm temperatures are required at the root zone for proper rooting of cuttings. The optimum temperature required by most plant species is 22° C – 27°C during the day and 15°C–21°C during the night.

(b) *Relative humidity*: Proper rooting of cuttings require high humidity which helps to reduce the rate of transpiration. To regulate the humidity, special structures such as greenhouses can be used.

(c) *Light intensity*: Soft wood cuttings need high light intensity to produce roots and shoots. Hardwood cuttings will produce roots well in dark conditions. These conditions are easy to provide when cuttings are used in green houses or other special structures.

(d) *Oxygen supply*: Proper ventilation is required in the structures where the rooting of cuttings is carried out. This is to supply plenty of oxygen required for root formation. The rooting medium used should be well aerated.

(e) *Chemical treatment*: Cuttings can be treated with medium containing rooting hormone to induce faster root formation. These hormones include: Indoleascetic acid (IAA), Indolebutyric acid (IBA) and Naphthaleneacetic acid (NAA).

(f) *Leaf area:* Soft root cuttings should be planted with the leaves due to the fact that they require a lot of carbohydrates to develop roots. These leaves carry out photosynthesis. The hardwood cuttings leaves are pruned off before planting since the cuttings have a lot of stored carbohydrates which is used for rooting.

Layering

Layering is inducing of part of a plant to produce roots while still attached to the mother plant. The rooted plant is then cut and planted. Layering promotes a high success rate in legume propagation since it prevents water stress and carbohydrates shortage that affects cuttings. Layering may be enhanced by wounding part of the plant to be layered or bending it sharply and covering it with a rooting medium.

Methods of layering legumes include:

(i) Mound or stool layering
(ii) Tip layering
(iii) Simple layering
(iv) Trench layering
(v) Compound or serpentine layering
(vi) Aerial or marcotting layering

The different methods of layering in legumes are carried out as follows:

(i) Mound (stool) layering

- Cut the plant back to about 2.5 cm above the ground.
- Mound moist soil over the emerging shoots.
- Keep the soil moist.
- Detach the new seedling from the mother stump and plant separately.

Examples of legumes layered through this method include green leaf desmodium, silver leaf desmodium, perennial soya bean.

Fig. 4.2: Mound/stool layering

(ii) Tip layering

- Dig a hole about 7.5 cm deep.
- Force the branch with the shoot into the hole leaving about 15 cm of shoot above the ground.
- Hold this branch with a peg.
- Support the shoot with a stick as shown.
- Cut off the new rooted shoot and plant as a new plant.

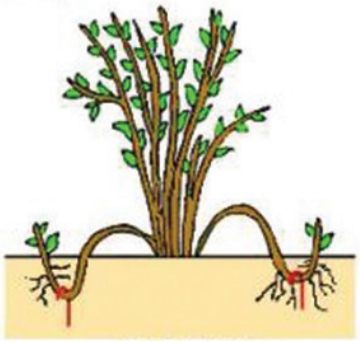


Fig. 4.3: Tip layering

(iii) Simple layering

- Bend the stem to the ground.
- Hold it in place using a peg leaving about 15 cm of the shoot above the ground.
- Cover the part of the ground with moist soil.
- Keep the soil moist.
- Detach the seedling from the mother plant once the roots are formed and plant it separately.

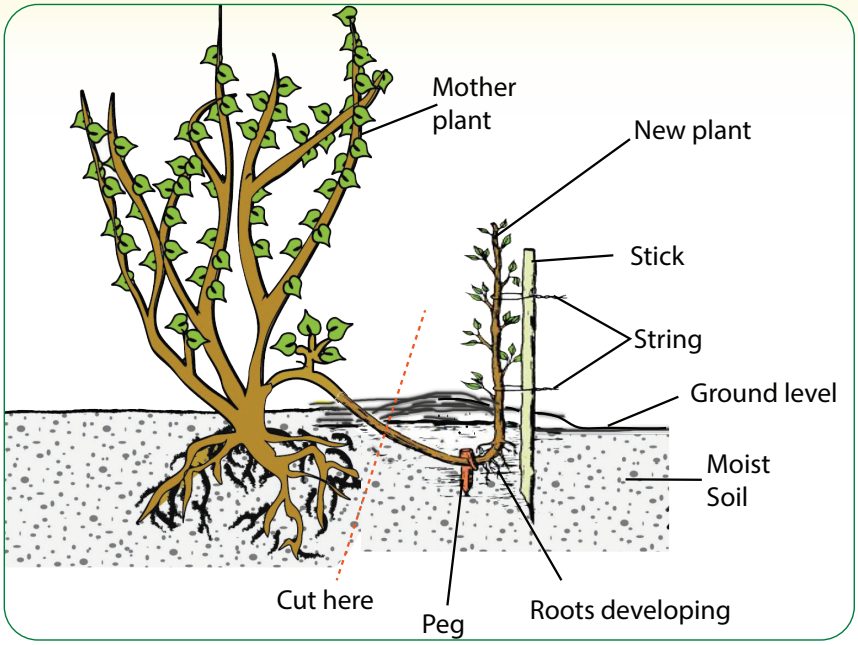


Fig. 4.4: Simple layering

(iv) Trench layering

- Dig a trench about 7.5 cm deep next to the mother plant, and about 90 cm long.
- Force the branch into the trench and hold it in place with pegs about 30 cm apart from each other.
- Cover with moist soil.
- Keep the soil moist.
- Detach and uproot each separate part and plant in different holes.

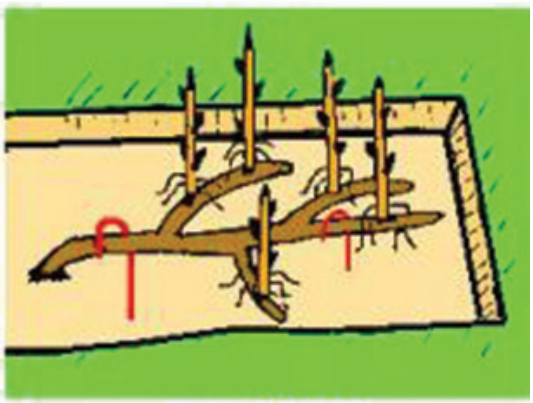


Fig. 4.5: (a) Trench layering

Fig. 4.5: (b) Trench layering showing the wires holding the branch

(v) Compound or serpentine layering

- Force a branch from the mother plant onto the ground.
- Hold it in place at intervals of above 30 cm apart using pegs.
- Cover the pegged portions with moist soil.
- Keep the soil moist.
- Cut the shoots off their mother branch and plant.

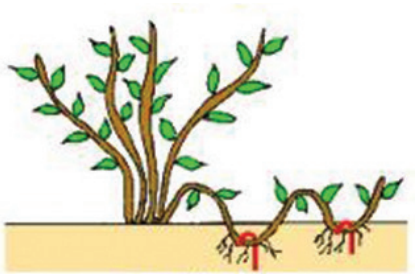


Fig. 4.6: Compound/serpentine layering

Seed Propagation in Legumes

Legumes are also propagated using seeds. Some legume seeds require special treatment before planting. The treatment methods include:

(a) Breaking seed dormancy.
(b) Seed inoculation.
(c) Seed dressing.

(a) Breaking seed dormancy

It is carried out to increase the germination percentage. This is done using the following methods: Soaking in water, mechanical scarification, light burning, use of growth regulators such as gibberellins and stratification.

(b) Seed inoculation

In areas deficient with Rhizobium bacteria, legume seeds should be coated with an inoculant or nitroculture. These are preparations which contain the right strain of Rhizobium bacteria depending on the legume. This encourages nodulation and nitrogen fixation.

(c) Seed dressing

This is coating the seeds with a fungicide or insecticide or both of them. These chemicals protect the seed from damage by pests and diseases. Certified seeds are obtained when they have been inoculated and dressed with chemicals. Inoculated seeds should not be dressed with chemicals.

4.5 Cultural practices in legumes

Activity 4.5: Visit a school farm where legumes are grown and carry out the following activities:

1. Observe the cultural practices carried out when growing legumes.
2. Prepare the land for planting soya beans or groundnuts.

These are routine practices carried out in the farm during the production of a legume crop from planting to harvesting. They include, land preparation, sowing, gapping, thinning, weeding, fertiliser application, pest and disease control and harvesting.

(a) Land preparation

All the vegetation should be cleared before primary cultivation. This should be done during the dry season to allow the weed to dry. Tree stumps should be removed. Land should be dug or ploughed and then harrowed to the required tilth. A fine tilth is required for small seeds, while large seeds require medium tilth. Where the land is sloppy, soil conservation measures should be carried out.

(b) Sowing

Sowing should be done early at the onset of the rains so that the plants can make maximum use of available rains or moisture. Holes are made at the recommended spacing for each crop. The seeds are then placed in the holes at the recommended rate. Small seeded legumes may be drilled or broadcasted. The seeds are then covered with soil. During planting, phosphatic fertilisers are then covered with soil. The rates used depend on the type of fertiliser. Hand planting can be done on small farms while tractor planters are used on large farms.

(c) Field management practices

After crop emergence, the following field management practices are carried out:

(i) *Gapping* – Seeds that did not germinate should be replaced so as to maintain the correct plant population.

(ii) *Thinning* – Excess seedling that germinate in one hole or in clusters should be removed to prevent competition for moisture, light, nutrients and space.

(iii) *Weed control* – Field should be kept weed free especially during the early stages of growth. Shallow weeding is done to prevent root damage. Weeding should be carried out when soil is moist. Mechanical weeding should not be carried out during flowering to prevent knocking of flowers. Weeding should not be carried out on a wet day to prevent spread of fungal infection. It is recommended

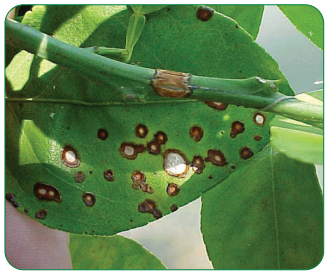
to uproot weeds during flowering. Chemical weed control is discouraged in growing of pulses. This is because they are sensitive to chemicals. Herbicides may be used in forage legumes.

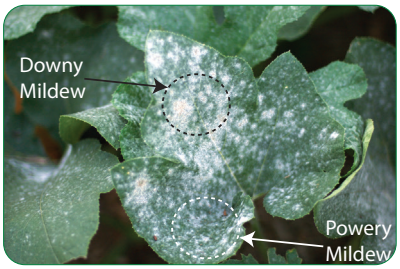
(iv) *Fertiliser application* – Phosphatic fertiliser are used during planting.

(d) Disease control – Legumes are affected by fungal, bacterial and viral diseases.

Fungal diseases include angular leaf spot, blights, anthracnoses, rusts, mildews and vascular wilts. Table 4.2 (a) shows legume crops attacked by fungal diseases. Study the symptoms and then name the crops attacked and the control measures for each disease.

Table 4.2:(a) Fungal diseases of legumes

	Disease Illustration	Crops attacked	Control measures
(a)			
(b)			
(c)			

(d)			
(e)			
(f)			
(g)			

They are controlled using the following methods:

(i) Regular spraying using fungicides before the crop is attacked.

(ii) Planting certified seeds to prevent disease transmission from the seed to the growing crop.

(iii) Use of resistant varieties.

Bacterial diseases include: Bacterial blight and halo blight. Table 4.2 (b) shows symptoms of legumes suffering from bacteria diseases. Study these symptoms and then name the crops attacked and control measures for each disease.

Table 4.2: (b) Bacterial diseases of legumes

	Disease Illustration	Crops attacked	Control measures
(a)			
(b)			

Bacteria diseases are controlled through the following methods:

(i) Rogueing to ensure infected plants do not transmit diseases to healthy plants.

(ii) Use of clean and certified seeds to prevent infection.

(iii) Crop rotation breaks the life cycle of the disease.

(iv) Close season to starve the disease organisms already in the soil to death.

(v) Control of vectors to prevent spread of diseases.

Viral diseases include rosettes, mosaics and leaf curls. These diseases are controlled through the following methods:

(i) Rogueing.

(ii) Use of certified seeds or planting material.

(iii) Crop rotation.

(iv) Control of vectors.

(e) Pest control

There are few pests of economic importance to legumes. These include the pea blue butterfly and aphids.

These pests are controlled through:

(i) Rogueing

(ii) Crop rotation

(iii) Use of recommended insecticides

(iv) Proper spacing

Fig. 4.7: Pea blue butterfly larvae (Lampides boeticus)

(f) Harvesting of Legumes

The stage of harvesting legumes is determined by use of the specific crop products. Pulses are harvested when the grains are mature and dry. They are uprooted and placed on a tarpaulin for threshing. Fodder legumes are harvested when they are highly nutritive and have adequate foliage yield. This is when about 50% of the crop has flowered. They are harvested, chopped into smaller pieces and taken to the zero-grazed animals or dairy animals when they are being milked.

4.6 Growing of soya beans and groundnuts

Land preparation

It is done during the dry season by slashing previous crop residue, weeds and destumping. Digging or ploughing deeply the soil, harrowing to medium tilth and making of planting holes is done before the rainy season.

Holes dug for soya bean are spaced at 45 cm × 30 cm while for groundnuts are spaced at 60 cm × 15–30 cm and a depth of at least 5 cm depending on soil moisture conditions.

Planting

Done at the onset of rainfall. A teaspoon of phosphate fertiliser such as double super phosphate is applied per hole. Plant one to two seeds per hole and cover lightly with soil.

Field practices

These are carried out after germination which take place between 5 and 9 days. These practices include:

- Gapping to replace seeds where germination failed to take place or damaged by pests.
- Thinning is done by uprooting overcrowded seedlings leaving only vigorously growing seedlings to maintain correct plant population.
- Control weeds through tillage, uprooting and use of selective herbicides against grasses. Avoid weeding during flowering as this knocks off flowers reducing pod formation.
- Apply farmyard manure at a rate of 10 tonnes per hectare.
- Control diseases and pests through rogueing, regular spraying with fungicides, planting certified seeds, use of resistant varieties, close reason and using recommended insecticides against insect pests.

Harvesting

Soya beans are harvested when mature and dry by uprooting. Groundnuts pods are also uprooted by using a forked hoe. The plants are further dried on a tarpaulin. Threshing is done by hitting with a light stick or using machines known as threshers. The seeds obtained are winnowed and further dried. The seeds are then dusted to control pests, and packed in bags and taken for storage or the market.

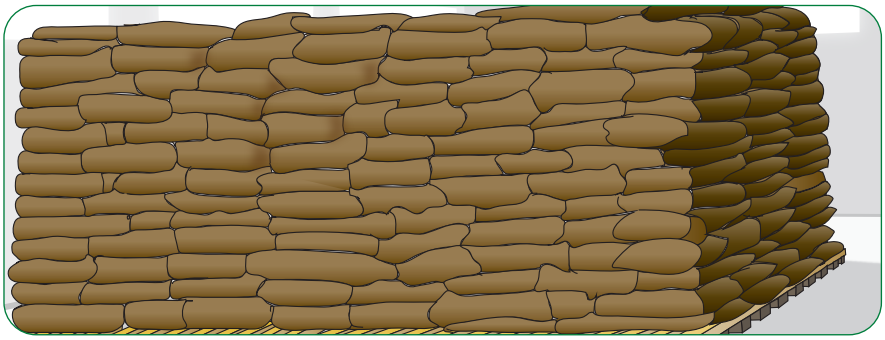


Fig. 4.8: Soya bean bags on a rack.

4.7 Post-harvest techniques for soya beans and groundnuts

Activity 4.6 Make a visit to the farm where legumes such as groundnuts and soya beans are grown and then:

(1) Observe the following post-harvest techniques of legumes drying, cleaning, handling, packaging and conditioning.
(2) Discuss in groups the ways the post-harvest techniques are done.

Post-harvest techniques are practices carried out to prepare produce for use or for marketing. Post-harvest practices carried out for legumes used by human beings for food are different from those carried out for fodder legumes grown for livestock.

Post-harvest activities carried out for legumes edible by humans (soya bean and groundnuts) include:

- *Soya beans*

(a) *Threshing* – This can be done manually or mechanically when soya beans are dried. Manual threshing is common in Rwanda while mechanical threshing may be cost effective for large-scale production.
(b) *Winnowing* – Should be done if threshing is done manually. Wind energy is used to separate the chaff from the grains.
(c) *Drying* – The grains are spread on a clean surface under the sun to reduce the moisture content to 1– 12.
(d) *Handling* – Soya bean grains should be handled with a lot of care to prevent contamination and post-harvest losses. The grains may be affected by aflatoxin which causes food poisoning to human beings.
(e) *Conditioning, packaging and storage* – Soya beans should be stored at a moisture content of 11 – 12. The dryness can be ascertained by cracking with teeth or dropping on a bottle. Dry soya beans will produce a characteristic rattling sound when properly dry. The dried grains should be packed in 50 – 100 kg bags. The bags are placed on a rack to prevent chilling from the floor. Good storage influences the quality and this reduces the chances of germination while in the store. High temperature should be avoided as this increases deterioration and reduces seed viability.

- *Groundnuts*

(a) *Shelling*: This is the removal of the nuts from the shells. It can be done manually or by a hand operated machine which separates the shells from the nuts.

(b) *Drying*: The shelled grains are sun-dried to a moisture content of 6.6 – 7%. Driers can be used in case of a cloudy day.

(c) *Cleaning and grading*: Cleaning is done to ensure that all foreign materials such as weed seeds, split seeds, stones and leaves are removed. The nuts are then sorted according to colour and size.

(d) *Handling*: The nuts should be handled carefully to prevent contact with water. Water increases the chances of growing moulds, some of which produces aflatoxin. Aflatoxin causes food poisoning to human beings and livestock.

(e) *Conditioning, packaging and storage*: Dry nuts should be packed in dry containers such as gunny bags, pots and gourds. The bags are stacked up to 10 bags high on separate stacks to allow free circulation of air. The bags are piled on wooden racks to avoid damage from dampness. The bags should be dusted with insecticides to protect the pods from storage pests.

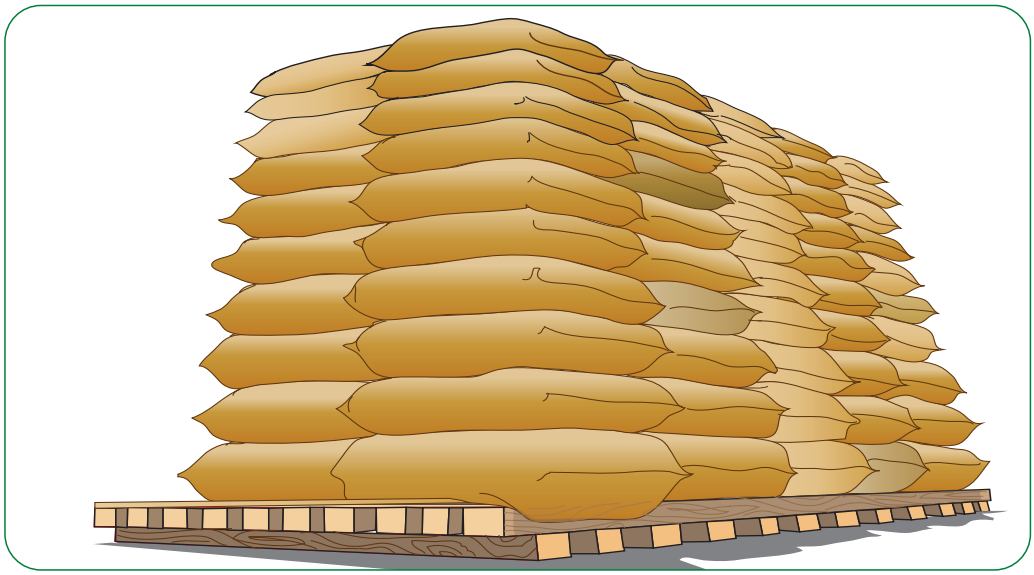


Fig. 4.9: Groundnut bags on a rack

Fodder legumes

Activity 4.7: Carry out hay making using a baling box by respecting steps provided by different references (Search engine or library textbooks).

Fodder legumes can be stored as hay or silage. Hay is fodder that is preserved dry while silage is fodder preserved in succulent or wet form.

Steps in hay making

(i) The crop for hay making is cut at the right stage when 50% of the crop is flowering. The cut fodder is spread on the ground under a shade to dry.

(ii) It is then turned regularly as it dries to ensure uniform drying.

(iii) The crop should be dried for 2 – 3 days.

(iv) The fodder should retain its original colour and rattle with a little noise.

(v) When the stems are twisted, they should not break and sap should not ooze out.

(vi) The fodder crop should be chopped using a machete to make it easy to compact during baling.

(vii) A baling box with the dimensions of the hay bales measuring (75 cm × 30 cm × 30 cm) should be used in making the hay.

(viii) Two strings are placed at each end of the baling box.

(ix) The box is filled with dry fodder. It is now called hay.

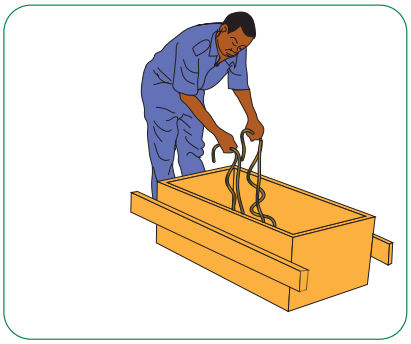
(x) The hay is compressed to form a compact cube in the box.

(xi) The bale is tied tightly with a string and the box turned upside down to remove the bale of hay.

(xii) The hay bales are then stored in a shed.

The illustrations below show the process of making hay. The steps followed are not placed in the order in which they take place. Study the illustrations and then arrange them in their correct order.

(i)



(ii)

(iii)

(iv)

(v)

b. Silage Making

Activity 4.8: Carry out silage making using a trench silo by respecting steps provided by different references (Library textbooks/search engine)

Using the materials provided, carry out the following activities:

(i) Harvest the fodder crop and chop the crop into small pieces.
(ii) Allow the materials to wilt.
(iii) Use the materials provided to prepare silage.
(iv) Discuss and record your findings.
(v) Present your findings to the class.
(vi) Take teacher's summary notes.

Silage is livestock feed made from fodder which is partially fermented, stored and fed to animals. Silage is prepared and stored in structures known as silos. Succulent legumes such as lucerne are used.

Ensiling procedure

1. The crop is ready for harvesting when about 20 –50% of the plants have flowered.
2. A trench measuring 5 m long × 3 m wide and 1.25 m deep is prepared.
3. The site should be on a gently sloppy ground to encourage drainage.
4. Cut the crop and chop into small pieces using a machete or a chaff cutter.
5. The chopped plant material is wilted.
6. A polythene sheet is laid in the trench. It should be large enough to overlap on the surface.
7. The chopped materials are filled into the silo and compacted at every stage.
8. Heavy rollers can be used to compact the material or a drum full of water is used to compact the materials.
9. The temperature of the material should be taken using a silage thermometer. The optimum temperature is maintained at 32°C.
10. The material is then covered with the plastic sheet to keep out oxygen and maintain anaerobic conditions.
11. A layer of soil is put over the polythene sheet to form a dome shape.
12. A trench is dug around the silo to prevent water runoff from entering the silo.
13. The temperatures should constantly be checked during the first three weeks until the temperature becomes stable. The silage is then ready for use by livestock.

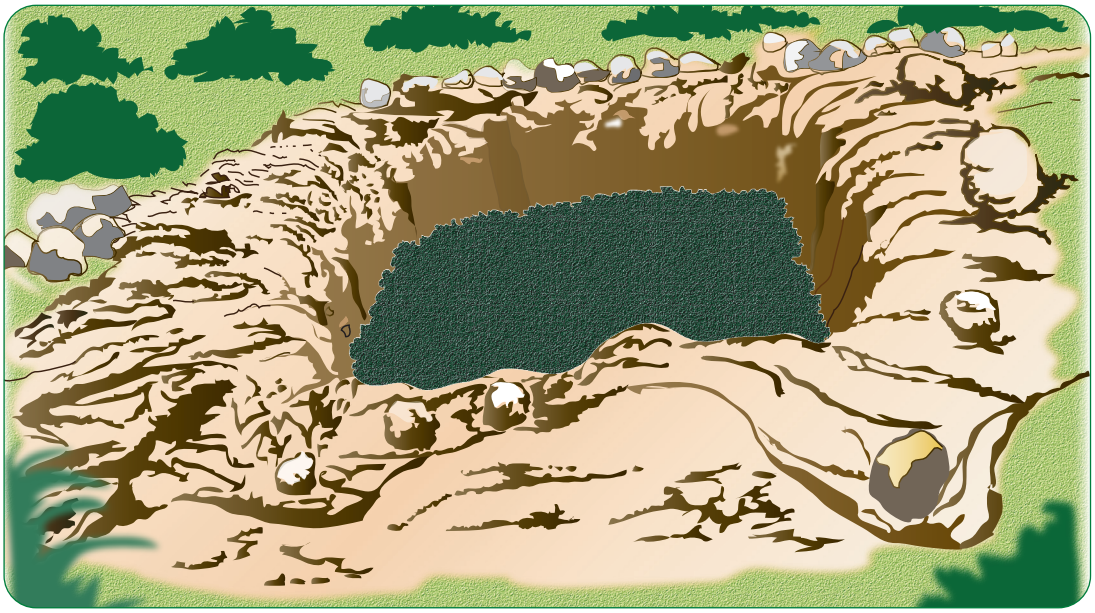


Fig. 4.10: Silage making(trench silo)

Unit Summary

- A legume is a plant which bears a fruit known as a pod.
- Legumes are classified into:
  (i) Pulses – eaten by human beings.
  (ii) Fodder – eaten by livestock.

Legumes are very important to human beings as they provide essential proteins to human beings and livestock. They provide vegetables for human diet and are useful as a supplementary feed for livestock. Many legumes have medicinal properties. Fodder trees and shrubs are also useful in agroforestry and help in reducing soil erosion by acting as wind breakers. They also bind soil particles thus improving soil structure and soil properties. Fodder trees and shrubs also provide flowers improving bee keeping. Some legumes such as desmodium are important in controlling stalk borers and the witch weed. Other legumes such as the pigeon peas are a source of stakes for climbing plants. Legumes are propagated by seeds and vegetatively by cuttings. Their post-harvest techniques include threshing, shelling, drying, conditioning, cleaning, handling, packaging and storage.

Key Terms

1. **Pulses** – Grain legumes used as human food.
2. **Fodder** – Pasture cut before feeding to livestock.
3. **Agroforestry** – Growing of trees or shrubs, pastures (keeping livestock) and growing crops on the same piece of land.
4. **Stakes** – Supports for growing plants.
5. **Plant propagation** – Multiplication of plants.
6. **Dormancy** – A period when planting material cannot sprout or germinate even though they are provided with necessary condition for germination.
7. **Scarification** – Mechanical breakage of a seed coat to break dormancy.
8. **Growth regulators** – Hormones that control growth.
9. **Certified seeds** – Seeds that are of high quality and resistant to disease attack.
10. **Threshing** – Separation of the seed from the pod. It also refers to shelling.
11. **Conditioning** – Preparing produce to escape rotting and attack pests, for example, by drying to the correct moisture content.
12. **Viability** – Ability to germinate or sprout.

13. **Crop rotation** – Growing of different crops on the same piece of land in particular order or sequence.
14. **Inoculation** – Coating legume seeds with the right type of artificial nitrogen fixing bacteria to stimulate production of root nodule.
15. **Herbicides** – Chemicals that kill weeds.
16. **Sorting** – Selecting to separate into grades.
17. **Grading** – Grouping according to size, colour, texture and quality.
18. **Forage** – Plant material either growing naturally or planted for the purpose of feeding to livestock.
19. **Hay** – Fodder preserved in dry form.
20. **Silage** – Fodder preserved in wet form.
21. **Silo** – Structure for preserving silage.
22. **Ensiling** – Preparation of silage.

Revision Questions

1. What is a legume?
2. Select common legumes grown in Rwanda.
3. Describe the importance of legumes in soil conservation.
4. Give two classes of legumes depending on the use.
5. Predict the characteristics of soil where legumes are grown.
6. Below are post-harvest practices carried out in groundnut production. Study them carefully and answer the question that follows:
   (i) Conditioning
   (ii) Shelling
   (iii) Cleaning and grading
   (iv) Packing and storage
   Which of the following arrangement represents the correct order?
   A. (ii), (iii), (i), (iv)
   B. (i), (ii), (iii), (iv)
   C. (ii), (i), (iv), (iii)
   D. (iii), (iv), (ii), (i)
7. Carry out three post-harvest techniques in groundnuts.
8. Give characteristics of legumes used for:
   (a) Hay making
   (b) Silage making

9. Carry out the preparation of hay.
10. What is seed inoculation?
11. Give five methods of breaking dormancy in legume seeds.
12. The following operations are carried out during the growing of legumes in the field:
    (i) Inoculation
    (ii) Harrowing
    (iii) Thinning
    (iv) Pest and disease control
    (v) Drying in the sun

    Which of these operations are carried out during the growing of soya beans?
    A. (i) , (ii)
    B. (iii), (iv)
    C. (iii), (v)
    D. (ii), (iv)

UNIT 5

RUMINANTS

Introduction

Ruminants are mammals that are able to acquire nutrients from plant-based food by use of microbes in a specialised stomach compartment known as rumen. They include domestic and wild animals as well. Domestic ruminants include animals such as cattle, sheep and goats. Each has different 'types' of animals based on the product it is kept for and 'breeds', based on the place of origin and characteristics.

This unit deals with cattle, sheep and goats, describing their characteristics, management in terms of feeding, housing, diseases that attack them and their symptoms and control. The pictures below give an overview of the whole unit.

The Ankole cattle

Friesian breed

A goat limping

Goats in a goat house

Local sheep

5.1: Definition of ruminant

Activity 5.1: By search engine or library textbook find the meaning of the term ruminant

A ruminant is a herbivorous mammal that chews cud and has a specialised stomach which ferments plant based food material known as rumen.

Ruminants have four stomach chambers namely rumen, reticulum, omasum and abomasum.

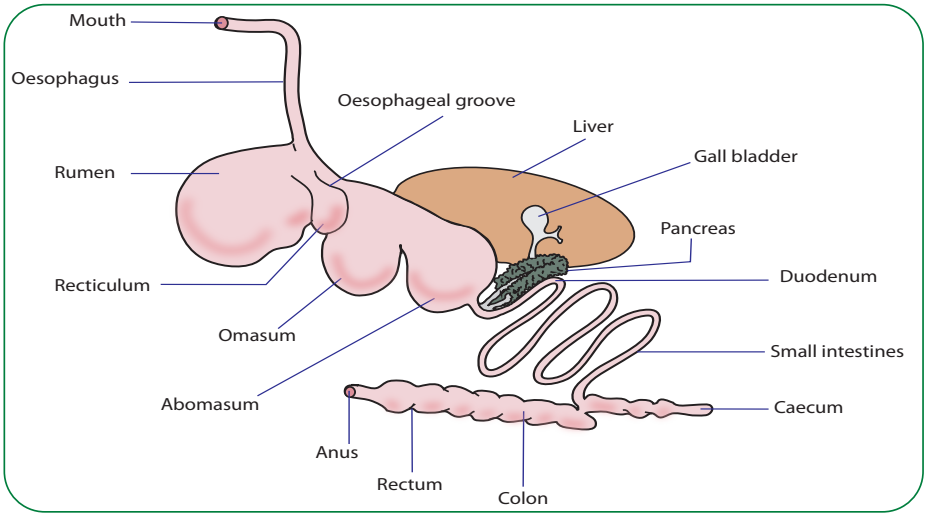


Fig. 5.1: Digestive system of a ruminant

5.2 Ruminant species reared in Rwanda

Activity 5.2: By visiting on agricultural and veterinary school or ruminant farm to observe ruminant reared in Rwanda describe the ruminant species observed and find out other ruminant which are not reared in visited farm.

The ruminant species of animals kept in Rwanda include cattle, sheep and goats.

Study the photographs below which show livestock species kept in Rwanda. Identify the animals which are ruminants and name each one of them.

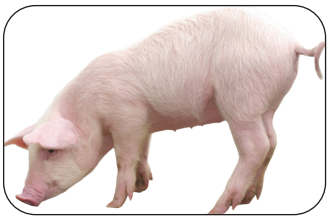
(i)

(ii)

(iii)

(iv)

(v)



(vi)

5.3 Ruminant breeds and their characteristics

Activity 5.3: Watch a video show on different ruminant breeds as well as use the colour photographs and magazine provided to identify the different ruminant breeds and find out the characteristics of each breed.

Ruminant breeds are identified using external features such as colour, size, body conformity and the origin.

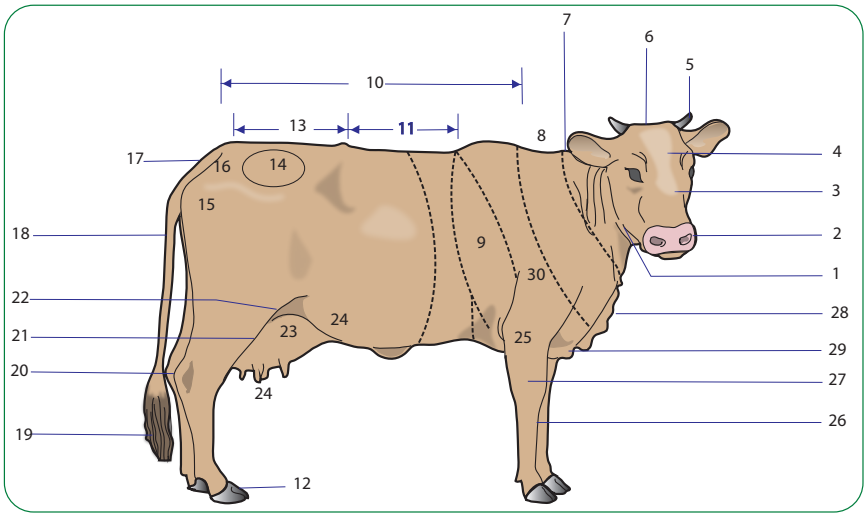
(a) **Cattle breeds** – they include the Ankole, Friesian and Jersey.
They are divided into dairy, beef and dual-purpose breeds.

(b) **Goat breeds** – are divided into dairy goats and meat goats. Dairy goats include Saanen, Togenburg and Alpine. Meat goats include local goats, Boer and Ethiopian galla.

(c) **Sheep breeds** – are divided into mutton sheep and wool sheep. Wool sheep include Merino, Corriedale, Mountain white and Romney Mursh. Mutton sheep breeds include local sheep and Dorper.

5.3.1 Characteristics of Cattle Breeds

To understand the characteristics of cattle breeds, it is important to learn the parts of the body of cattle.



Key

1.	Jaw	8.	Withers	15.	Hip joint	22.	Flank	29.	Brisket
2.	Muzzle	9.	Heart girth	16.	Pin bone	23.	Udder	30.	Shoulder joint
3.	Nose-bridge	10.	Back	17.	Tail head	24.	Milk wells		
4.	Fore-head	11.	Loin	18.	Tail	25.	Elbow		
5.	Horn	12.	Hoof	19.	Switch	26.	Knee		
6.	Poll	13.	Rump	20.	Hock	27.	Fore-leg		
7.	Neck	14.	Plate	21.	Stifle joint	28.	Dewlap		

(a) *Ankole Cattle*

This is an indigenous cattle originally from the Sanga cattle which is native to Africa. It has the following characteristics:

(i) Long distinctive horns that can reach a length of up to 1.2 metres each.

(ii) Brown in colour or deep red though there are some shades of black and white.

(iii) Medium in size with bulls weighing 450 – 730 kg, cows weigh 430 – 540 kg, calves are born with a live weight of 14 – 23 kg.

(iv) Have a pendulous dew lap and umbilical fold.

(v) Have humps of varying sizes.

(vi) They are more tolerant to tropical diseases and well adapted to local climate.

(vii) They are mainly kept for meat and milk. They produce about 1 – 2 kg of milk per day.

Fig. 5.3: Ankole cattle

(b) Friesian

It is also known as Holstein and is an exotic dairy breed from Holland. It has the following characteristics:

(i) Black colour with white patches or white colour with black patches.

(ii) It is large in size with bulls weighing 900 – 1000 kg and cows 550 – 680 kg. Calves are born with a weight of 35 – 40 kg.

(iii) It produces the highest amount of milk per lactation period which is 9,150 kg per lactation of 305 days with good management.

(iv) The heifers mature at 21 months and calves down the age of 30 months.

(v) It is well adapted to the highlands of Rwanda.

Fig. 5.4:Friesian breed

(c) Jersey

This is the smallest of the exotic dairy breeds. It originated from the English Channel Island breeds. Jersey breed has the following characteristics:

(i) The colour varies from light yellow brown or fawn to a shade of black.

(ii) It has protruding black eyes and the tail switch and muzzle are black in colour. It has a slightly dished face and a wedge shape.

(iii) This is the smallest of all dairy breeds. The bulls weigh 540 – 820 kg and cows weigh 350 – 450 kg. The calves are born with a live weight of 20 – 25 kg.

(iv) The cows produce 4, 270 kg of milk per lactation period of 305 days with good management. Its milk has a butterfat content of 5 – 5.3%.

(v) The heifers mature early at between 15 and 18 months and have their first calving at between 24 and 27 months of age.

(vi) It is adapted to the medium altitude to high altitude regions of Rwanda.

Fig. 5.5:Jersey

5.3.2 Characteristics of Goat Breeds

Goats are small hardy ruminants mainly kept by small-scale farmers.

The following diagram shows the general parts of a goat.

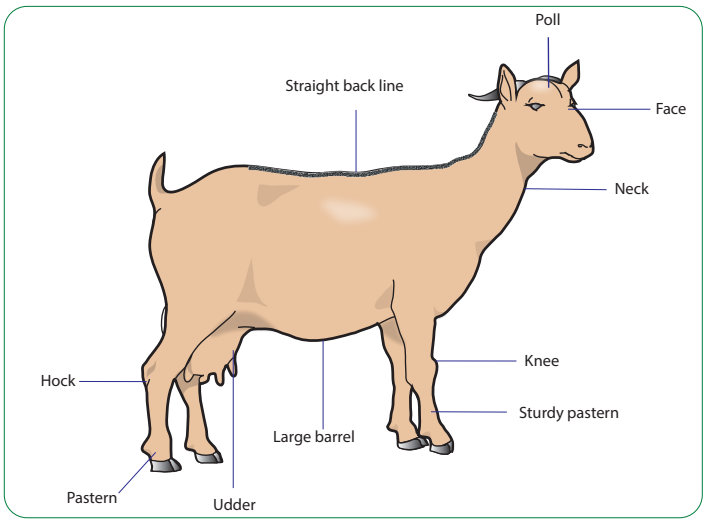


Fig. 5.6: Parts of a goat

Goat breeds include:

(a) *Saanen*:

This breed originated from Switzerland and is mainly kept for milk production. It has the following characteristics:

(i) Large in size.
(ii) White in colour.
(iii) Has upright ears pointing forward.
(iv) Have an average milk production of 3 – 3.5 litres per day with a butterfat content of 4%.

Fig. 5.7: Saanen goat

(b) *Alpin*

This is an exotic dairy breed that originated from Britain. Its characteristics include:

(i) The colour varies from brown chamois colour to white or grey stripes on its back. It may also have facial stripes.
(ii) Medium sized with males weighing 77 kg and females weigh 61 kg.
(iii) Has backward pointing horns and has a beard.
(iv) Kept mainly for milk production 2,134 litres of milk per lactation period.

Fig. 5.8: Alpine goat

(c) *Local goats (small East African goats)*

The local goats are indigenous to Rwanda and other East African countries. They are mainly kept for meat and are small in size. They have the following characteristics:

(i) The colour ranges from pure white to pure black with mixes of roan and speckled brown.
(ii) Males weigh up to 30 – 40 kg and females weigh 25 – 30 kg.
(iii) Have backward pointing horns, males have mane and beards.
(iv) They are kept for milk and meat.

Fig. 5.9: Small East African goat

(d) *Ethopian Galla*

This is an indigenous meat goat, mainly found in the horn of Africa. It has the following characteristics:

(i) It is white in colour but with a black skin. The muzzle underneath the tail and feet are black in colour.

(ii) The males weigh up to 70 kg while the females weigh 45 – 66 kg.

(iii) Mainly kept for meat and milk production.

(iv) It is a hardy breed and is kept mainly in the marginalised areas.

Fig. 5.10: Ethiopian Galla goat

(e) *Boer*

This goat was developed through crossing indigenous goats from South Africa. It has excellent meat quality. It has the following characteristics:

(i) It has white bodies with a distinctive brown head.

(ii) It has long pendulous ears.

(iii) It is fast growing reaching a slaughter weight of 22 – 36 kg in about 90 days.

(iv) Males weigh about 76 – 89 kg when mature and females weigh 70 kg.

Fig.5.11: Boer goat

5.3.3 Characteristics of Sheep Breeds

Sheep are small ruminants covered with wool or hair.

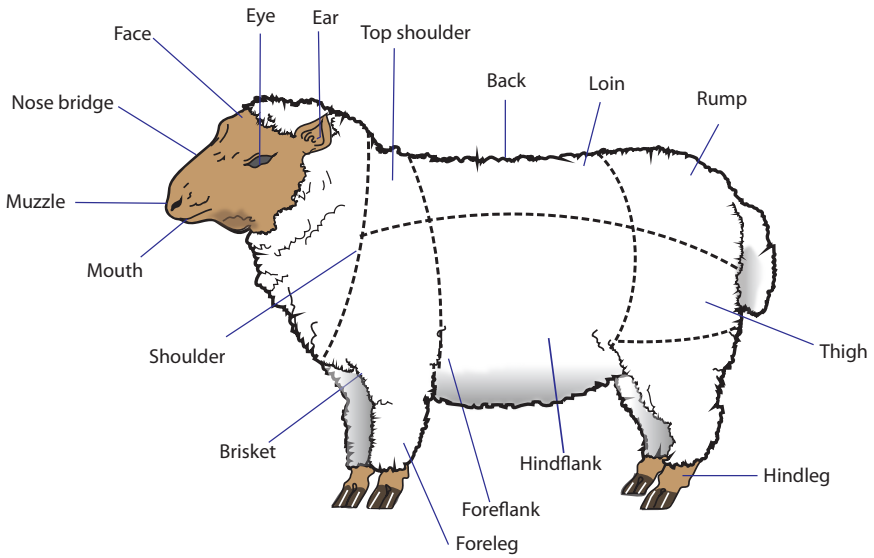


Fig. 5.12: Parts of a sheep

(a) Local Sheep

Local sheep are native to Rwanda and other East African countries. They have the following characteristics:

(i) Have small bodies weighing an average of 40 – 60 kg when mature.

(ii) They have different colour shades ranging from dark brown to white or a mixture of the colours.

(iii) They are hardy and are kept in the marginalised areas with little rainfall. They are kept for mutton production.

Fig. 5.13: Local sheep

(b) Mountain white sheep

These sheep originate from Wales and are mainly kept for wool production. Their characteristics include:

(i) They are a small hardy breed.

(ii) Males have horns while females are polled.

(iii) They produce wool of a staple length above 5 cm – 7.5 cm.

(iv) They survive well in cool mountainous regions of Rwanda.

Fig. 5.14: Mountain white sheep

(c) Merino Sheep

This is an exotic breed that originate from Spain. It is kept for wool production. It produces the finest type of wool. It has the following characteristics:

(i) Small bodied with a dropping rump and narrow chest.

(ii) Muzzle is flesh coloured.

(iii) Hooves, wool and horns are white in colour.

(iv) Hardy breed that is kept under extensive conditions.

(v) Can tolerate cool highland places.

(vi) Mainly kept for wool, whose staple length is 8 – 10 cm.

Fig. 5.15: Merino breed

(d) Corriedale Sheep

It is a dual purpose breed which originated from Australia and has the following characteristics:

(i) It is polled with the head covered with wool that covers the eyes. It hence suffers from wool blindness.

(ii) Produces good quality wool of medium staple length of 8.9 cm – 15.2 cm.

(iii) Rams weigh 84 – 90 kg.

(iv) Used to crossbreed with other breeds to improve wool and mutton quality.

(v) Has a broad body.

Fig. 5.16: Corriedale sheep

(e) Dorper

It is fast growing mutton sheep developed in South Africa. It has the following characteristics:

(i) It is white in colour with a black head.

(ii) Has a short fleece and, therefore, suitable for rearing in hot and dry areas.

(iii) Fast growing with male weighing 82 kg – 91 kg.

(iv) Has a high lambing percentage producing twins.

Fig. 5.17: Dorper

5.4: Ruminant shelter standards

Activity 5.4: By field trip to a farm where ruminant are reared observe the ruminant shelter and explain the factors to consider when constructing the ruminant shelter.

Ruminant shelters are farm structures which are built to house ruminants. They vary in size, design and shape depending on the type of animals housed.

Ruminant shelters should have the following features:

(i) Be spacious to accommodate a number of animals without causing congestion.

(ii) Secure to protect the animals from dangerous wild animals and thieves. Strong materials made from timber, wood, steel or concrete are used. Other deterent features such as electricity, thorns, broken glass can be included.

(iii) Proper drainage which allows urine, water and other waste products to flow off preventing accumulation. It also facilitates easy cleaning.

(iv) Be free from draught winds, these are cold winds which can predispose the animals to respiratory diseases such as pneumonia.

The following are factors to consider when constructing ruminants shelter:

(a) Siting ruminant shelters

When siting livestock shelters, the following factors should be considered:

(i) *Location of the homestead*: Should be located at a place where there is a good view so that the farmer can quickly assess the condition of the ruminants even from the farm house.

(ii) *Accessibility*: The farmer should be able to get to the shelter from any part of the farm with ease.

(iii) *Security*: The livestock shelter should be safe from wild animals, thieves and other stray livestock.

(iv) *Direction of prevailing wind*: The shelter should be on the leeward side of the homestead so that bad smells cannot drift to the homestead.

(v) *Well-drained place preferably gently sloping*: This encourages free movement of running water that prevents damp conditions.

(vi) *Relationship with other structures*: Livestock structures should be close to one another so as to save time and have efficient labour management when carrying out routine farm activities.

(vii) *Farmer's tastes and preferences*: The shelters should satisfy farmer's liking.

(viii) *Nearness to water and electricity*: Water should be easily available in these

shelters for cleaning and for animals to drink. Electricity is required for performing some operations such as operating milking machines.

(b) Materials for construction

The materials selected for construction of shelters should be:

(i) Durable so that they would not be replaced or repaired frequently.
(ii) Available to allow a farmer have ease of choice and construction.
(iii) Cheap or affordable.
(iv) Suitable for the enterprise.
(v) Suitable to the prevailing environmental conditions.
(vi) Strong for the intended use of the structure.
(vii) Easy to work with.

Activity 5.5: While a visit to a multipurpose farm where different ruminant are reared, observe the material used for construction of shelter, how those materials have been arranged and explain different operations carried out when constructing shelters.

5.4.1 Cattle shelters

Cattle that are properly housed perfom better than those kept outside without shelters. These shelters help to protect cattle from adverse weather conditions as well as keep off diseases.The commonest cattle shelters include sheds, zero grazing unit, milk sheds and calf pens.

a) Cattle shed

This is a simple, roofed structure, usually made of wood or metal used as a shelter for animals. Most cattle sheds have open walls.

Fig.5.18: A simple cow shed

b) Zero grazing

This is a structure for housing dairy animals where feed and water are provided within the unit. It is an intensive system of dairy production that allows for easy monitoring of animals.The animals are not exposed to the environmental hazards compared to open grazing.The floor of zero grazing unit should be concrete from the milking stalls to the walking and dunging area.The sleeping cubicles should have an earthen floor which is soft to give comfort to the sleeping cow.

Construction material for zero grazing unit include:

- Corrugated iron sheets for roofing
- Wooden posts
- Rails which are of timber
- Concrete (cement, sand and ballast)
- Nails, bolts and nuts

Fig. 5.19: Zero-grazing unit

Zero grazing unit should also have a feeding and watering area, calf pen and an area for chopping or preparing the feeds. The concrete floor should have side drainage to lead water, urine and dung to disposal area.

c) Calf pens

This is an enclosure for confining calves. It can be constructed as part of the zero-grazing unit or as separate unit. Calf pens are constructed near the milk sheds to make it easy to feed the calves with milk at body temperatures. They can be movable or permanent depending on the dairy management in the farm.

Requirement of the calf pens

A good calf pen should have the following:

Well ventilated – This to provide fresh air to prevent air borne organisms, minimise dust, eliminate noxious odours, remove excess moisture and heat without causing a lot of draught on the calf.

Free from draught – Calves need a dry, draught-free environment to maintain their body temperature and give calves the comfort they require.

Well drained – The floor should be of materials that can drain urine and allow droppings to fall off. Blatted floors which warm bedding materials are recommended.

The walls should not be painted to prevent lead poisoning since calves have a habit of licking the walls. Young calves should be single housed to prevent licking each other which creates digestion problems from hair swallowed, as it forms indigestible balls. Calves can be put into group pens at the age of 4 months after weaning. Groups of 6 –12 calves are allowed in one pen which is spacious enough to prevent overcrowding.

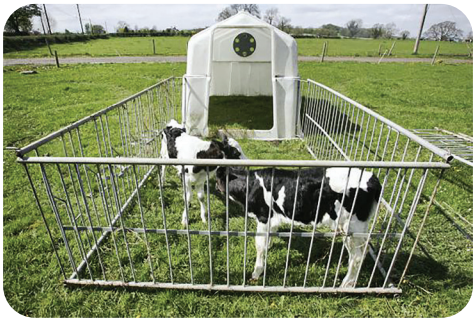


Fig. 5.20: (a) Movable calf pen

Fig.5.20: (b) Permanent calf pen

5.4.2 Sheep shelters

The type of shelters used for sheep depends on the weather conditions of an area. Traditional barns, pole buildings or metal buildings can be used. A low cost shelter to protect the animals from cold and hot sun is preferred.The shelters should be built on an elevated well drained area, well protected from the wind.

The house can be divided into pens for lambing, the ewe with lambs, the ram and for the rest of the sheep. This is in case the animals are confined.The floor should be slatted and with bedding to keep the hair sheep warm and wool sheep clean.
Sheep shelter resemble the same one used for the goats as shown in Fig. 5.21.

5.4.3 Construction of a Goat shelter

Activity 5.6 By use of adequate material, construct a goat shelter by respecting requirements and procedures provided by different references.

A goat shelter is a place where goats are kept.

Goat shelters are made based on the following:

(i) Age groups of animals to be housed.
(ii) Sex of animal to be housed.
(iii) Type of enterprise either dairy production or meat production.
(iv) Environmental conditions such as prevailing wind.
(v) Topography and drainage.
(vi) Skills of the farmer.

Requirements of a goat shelter

(i) Spacious enough to allow freedom of movement.
(ii) Free from draught winds.
(iii) Well ventilated and dry to avoid humid conditions.
(iv) Easy to construct and undertake repairs whenever necessary.
(v) Strong to support the intended weight of goats and farmer while working inside.

Procedure of constructing a goat shelter:

(i) Select a suitable site.
(ii) Clear vegetation around the site at least 3.3 m × 3.3 m for three goats.
(iii) Measure the dimension of the structure you intend to keep the goats.
(iv) Mark the four corners of the site using wooden pegs.
(v) Dig holes at least 60 – 90 cm deep at the corners.
(vi) Place poles in the holes and reinforce with concrete.
(vii) Allow the concrete to firm and dry.
(viii) Pack soil into the hole and ram it firm.
(ix) Fix wooden boards on the sides exposed to the windward side.
(x) Make a wall plate by fixing wooden frames 2 – 4 inches wide against the wall.

(xi) Fix rafters over the sloping length of the goat house.

(xii) Fix the purlins at considerable length from each other and then fix the iron sheets.

(xiii) Construct a raised slated floor at least 0.6 m – 0.9 m above the ground by fixing a firm wooden floor frame using wooden beams measuring 3 inches by 4 inches.

(xiv) Fix wooden planks over the frames to leave spaces of about 1.4 cm – 1.6 cm apart to allow droppings to fall.

(xv) Construct an inclined passage to the door with an elevation of less than 45°.

(xvi) Place feeder waterers and raised bed where the goat can rest. Place straw on the bed.

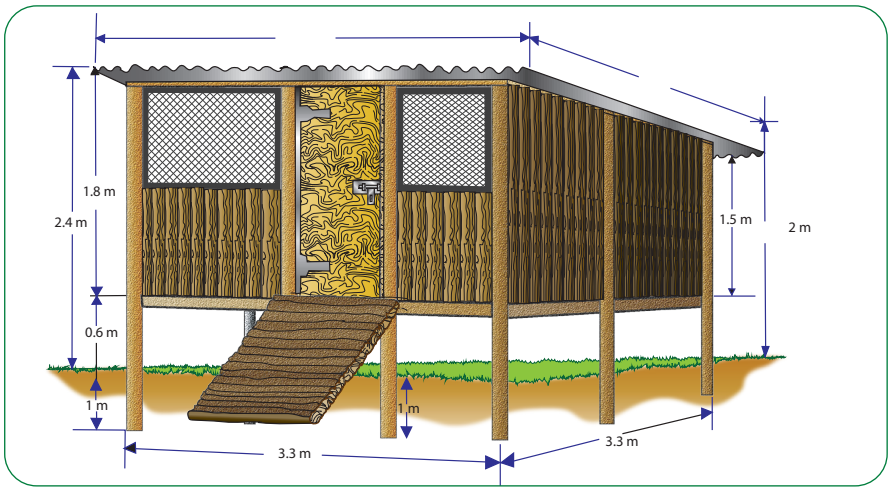


Fig. 5.21: Goat shelter

5.5 Selection criteria for goats, sheep and cattle

Activity 5.7: A field trip to ruminant farm to identify the characteristics of different ruminant breeds based on products given and explain the criteria to consider when selecting each ruminant breed.

Selection is a process of choosing livestock with unique characteristics for a production enterprise. Livestock are mainly kept for products such as milk, meat, skin and hide and wool or hair.

(a) Selection of goats

- **Dairy goats**: When selecting a dairy goat, the following should be considered:

(i) Udder structure and teat placement should be large and well rounded and not hanging below the hocks. The teats should be two in number and not fish teats, teats with spots or bottle-shaped teats.

(ii) Grow fast and mature early.

(iii) Should be alert and active.

(iv) Should have normal but good appetite.

(v) The mucous membranes or membranes within the eyes, nose, ears, anus and tongue should be bright pink.

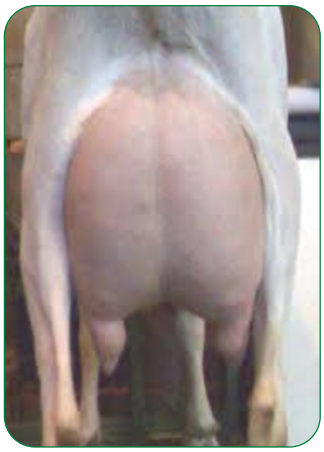


Fig. 5.22: Udder structure of a dairy goat

- **Meat goats**: The following criteria should be considered:

(i) Should have well proportioned natural base.

(ii) Should have a well muscled body which is deep and balanced.

(iii) Should have a high growth rate potential and be good converters of forage to meat.

(iv) Should have fast growth to get to market weight early.

Fig. 5.23: Meat goat (Boar buck)

(b) Selection of sheep

- **Mutton Sheep**

When selecting sheep for mutton production, the following characteristics should be considered:

(i) A wide straight back.
(ii) Smooth shoulders.
(iii) Fullness through the heart or girth area.
(iv) A good spring of ribs.
(v) Long well balanced body with adequate skeletal size.
(vi) The feet and forelegs should be straight and not bowed or wide apart with strong feet and pasterns. The hind legs should be normal spaced and the rump in line with the hocks.
(vii) The mouth should be normal without the upper or lower jaw longer than the other.

Fig. 5.24: Mutton sheep (Dorper ram)

- **Wool sheep**

When selecting wool sheep consider:

(i) Wool with long staple length with low shrinkage and crinkle.
(ii) Fleece should be white colour for easy dyeing.

Fig. 5.25: Wool sheep

(c) Selection of cattle

- **Dairy Cattle**

Dairy cattle breeds should have the following characteristics:

(i) Wedge shaped body to triangular in shape with wide hind quarters and a tapering shape towards the head.
(ii) Well developed hind quarters with big room for larger udder.
(iii) Large and well developed udder and teats with prominent milk veins.
(iv) Lean body with little flesh.
(v) Large stomach capacity.
(vi) Mild temperament and docile.
(vii) Fertile with short calving period.
(viii) Reduced navel.

Fig. 5.26: Jersey cow

- **Beef cattle**

When selecting beef cattle breeds, the following criterias are considered:

(i) Head should be large, with thick neck.
(ii) Should have a straight topline for exotic.
(iii) The legs should be short to support a heavy body.
(iv) The main body and ribs are cylindrical, well fleshed and muscled.
(v) The hump should be large and erect for local breeds.
(vi) The hoofs and pastern should be wide and strong to support a heavy body.
(vii) The animal should have a normal walking gait and limping.
(viii) The body should be fat with deep muscles.

In beef breed cows, the teats are small and udder is reduced in size.

5.6 Feeding ruminants

Activity 5.8: Using search engine or library textbook, explain the types of feeds given to ruminant.

The various feeds and folders used in livestock feeding are broadly classified as:

- Folder
- Concetrates
- Feed supplements and feed additives

Ruminants are fed with the fodder and concentrates. Fodder crops are grown and then harvested before feeding livestock.

(a) Fodder species for ruminants

The types of fodder grown include:

(i) Grass

(ii) Legumes

Grass fodder

These supply energy in form of cellulose to livestock. They are succulent leafy grasses and include:

(i) Napier grass

(ii) Guatemala grass

(iii) Sudan grass

(iv) Maize

Legume fodder

These mainly supply proteins to livestock. They are leafy legumes. The leaves, flowers and pods are consumed. These include:

(i) Lucerne

(ii) Desmodium

(iii) Vetch

(iv) Leuceana

(v) Sesbania

The following photographs show different types of legume and grass fodder used to feed ruminants.

Study them then identify and classify the fodder into either legume or grass.

(i)

(ii)

(iii)

(iv)

(v)

(vi)

(b) Concentrates

Concentrates are livestock feeds which have a high nutritional value and little fibre.

There are two types of concentrates. These include:

Energy concentrates

They provide energy to the ruminants. Energy concentrates have a high content of carbohydrates. They include molasses, ground flour of various grains.

Protein concentrates

These are livestock feeds with high protein content. They are mainly obtained from animal sources such as milk, blood, bones, plants, mainly legumes or oil crops such as beans, soya, ground nuts, simsim and sunflower. Seeds are ground to produce a meal or a cake.

(c) Food supplements

Vitamins

These are supplements given in form of premixes where various concentrated vitamins in powder, dissolved liquid form or injectables are given to livestock. Vitamins provide essential growth requirement and include vitamins A, B, C, D, E and K.

Minerals

These are given as food supplements. They are required in small amounts to support various metabolic processes in the livestock bodies. The minerals include phosphorus, calcium, iron, iodine, zinc, copper, cobalt, chlorine and sodium. Mineral salts are given in form of powders or mineral blocks.

Fig. 5.27: Vitamins premix

Fig. 5.28: Mineral blocks

5.6.1 Feeding goats

Activity 5.9:Visit a farm around your school or within school farm where the ruminants are kept and carry out the following activities:

(1) Find out the types of feeds given to goats, sheep and cattle and record your findings.

(2) Ask the frequency of feeding the goats, sheep and cattle with the different nutrients or food substances.

(3) Discuss and extrapolate the different ingredients of a goat, sheep and cattle diets.

(4) Make a feeding plan for different ruminants according to age groups.

Feeding goats mainly involves giving plant materials. Goats should also be fed according to their age and type of enterprise, either milk goats or meat goats. The following are some of the feeding practices for goats:

(a) Creep feeding or feeding of kids.

(b) Feeding when weaning goats.

(c) Feeding of adult goats which involve:
  (i) Flushing
  (ii) Steaming up
  (iii) Fattening

There are two main reasons for feeding goats:

(i) Maintenance

(ii) Production

When carrying out maintenance, all food nutrient requirements are provided in their correct proportions but only to sustain the animal life. While feeding for production, an extra amount above the maintenance is given to support production such as milk production and meat production.

Factors affecting nutrient requirement of goats

These factors include:

(i) Activity level in terms of production and maintenance.

(ii) Stage of pregnancy of kidding rate.

(iii) Stage of lactation or amount of milk produced.

(iv) Rate of growth.

(v) Type of production enterprise.

(vi) Body condition such as weight and health status.

(vii) Market requirements.
(viii) The age and weight of the goat.

(a) Feeding young goats

After birth the young goats can either be fed naturally and be allowed to run with their mothers and to suck naturally. This practice is common with meat goats such as Ethiopian Galla and Boer.

Artificial feeding or hand feeding

Artificial feeding

Young goats are separated from their mothers after 7 days. Milk is then given to the young goats using baby bottles and teats or using clean buckets.

Artificial feeding is done to dairy goats or goats which have been orphaned early. Each kid is given about 0.5 litres of milk per day at the beginning and is increased to 1.25 litres of milk per day by the third week. Bottle feeding is done twice a day in the morning and evening. Dairy concentrates such as dairy meal and good quality hay or wilted Lucerne is introduced at 3 – 4 months of age.

Fig. 5.29: (a) Bottle feeding

Fig. 5.29: (b) Natural suckling

Importance of feeding young goats with colostrums

Colostrum is the first milk that a doe produces after giving birth.

Colostrum has the following properties:

(i) Highly digestible.
(ii) Contains antibodies to protect the young goats from diseases.
(iii) Highly nutritious and contains minerals, vitamins, proteins and important sugars.
(iv) Acts as a laxative to clean the stomach contents.

(b) Feeding weaning goats

Weaning is the introduction of solid feeds to kids of young goats. They introduce micro-organisms in the rumen and make rumen strong to adapt and accept solid feeds.

Early weaning is done at 35 days of age and when there is a limited supply of milk. The following feeds can be given:

(i) Hay
(ii) Wilted lucerne
(iii) Dairy concentrates
(iv) Milk in limited amounts

Late weaning is mainly done to meat goats. Weaning is mainly done when the young goats are two and a half times their birth weight, for example, if they were born at 5 kg weight they should be weaned at about 5 kg of weight.

Young goats suffer from weaning shock where they suffer from diarrhoea and weight loss.

(c) Feeding adult goats

Goats are browsers and prefer feeding on leaves from twigs and short trees. Goats would browse on moist indigenous shrubs such as acacia, lantana and grass.

This can be supplemented using:

(i) Pasture hay
(ii) Lucerne
(iii) Grain rations
(iv) Concentrates in form of dairy meal
(v) Salt licks or mineral licks
(vi) Vitamin premixes
(vii) Enough clean water

Feeding plan for goats

The following is a summary of the feeding plan for different age groups:

Kids

- Suckle colostrum during the first 3 – 4 hours and continue for three days. Meat goats are left with mothers to continue sucking until weaning.
- Dairy goats are separated after 7 days and hand feeding is done or bottle feeding is done. Giving 0.5 litres of milk per day for first week and increased to 1.25 litres of milk per day by 12th week or weaning time twice daily.

- Introduce soft herbage in form of wilted lucerne and hay at 8 weeks or two and a half times the birth weight.
- Daily meal can be given at a rate of 250 grams per day, also an artificial grain mix can be used by mixing the following ingredients:

(i)	Crushed maize	60%
(ii)	Wheat bran or soya meal	10 – 30%
(iii)	Trace minerals	0.5%
(iv)	Dicalcium phosphate	0.5%
(v)	Vitamins	0.5%

Orphaned kids can also be adopted or given to foster mothers.

Weaners

Introduce hay fodder or lucerne fodder at 12 weeks of age giving more protein based plants.

- Dairy meal can also be given or an artificial grain mix, though the amount needs to be increased depending on the body weight. Between 1 and 2 kg of grain mix with at least 14% protein and 15% or 16% crude fibre.
- Water should always be given.
- The young goats should also be allowed to graze with other goats. If they are meat goats or if they are dairy goats, they should be put in a different pen and a hay rack suspended for them.

Adult goats

Adult goats feed on plant material which includes grass and leaves or twigs of various varieties and types of plants. However, this needs to be supplemented with waste products such as carrots, peelings of sweet potatoes, bananas, pods of legume plants. If forages are used then the forage has to be a mixed grass legume hay or pasture. A good mixture is that of grass and sweet potatoes or grass and clover. Pastures can be utilised continuously or on a rotational basis.

- Dry forage in form of hay or lucerne should be provided.
- Legume fodder such as calliandra, leuceana, sesbania, vetch, desmodium should be given on a routine basis.
- Dairy goats should be supplemented with dairy meal.
- Mineral lick and vitamins should be provided.

Other forms of feeding adults include:

(a) Flushing which involves giving both the buck and doe high quality feeds and in increased amounts around breeding time. This should be done 2 – 3 weeks

before breeding begins and continues for a further 3 weeks after mating.

(b) Steaming up. This is a practice of giving highly nutritious feed to a doe around the time of giving birth. In goats it is done 3 – 4 weeks before kidding.

Steaming up helps to:

(i) Provide nutrients to growing foetus.

(ii) Build energy for giving birth.

(iii) Improve milk production.

(iv) Promote good health of the mother.

(c) Feeding nursing does

- The does should be allowed to graze normally or browse normally however, it is important to give additional feeds which are rich in carbohydrates and proteins.
- Additional mineral supplements and vitamins are required.
- Also clean water should be provided.

5.6.2 Feeding cattle

(a) Feeding dairy cattle

Newborn calves are separated from their mother after birth and then fed artificially. They are fed on colostrum for the first 3 – 5 days. They are then fed on milk according to body weight until sixty days of age. Those calves not on mother's milk should be given milk replacers.

Calf starter pallets should be provided from one week of age. Starter rations are rich in minerals and vitamins.

The calf is fed with wilted lucerne and soft grass at the rate of 8 – 10% of the body weight.

Early weaning – The calf is weaned 4 – 5 weeks of age by reducing milk and increasing dry feed at a rate of 1.5% of body weight. Early weaning is carried out also to control scours. Hay or silage is given from 8 – 10 weeks to four months.

Late weaning – It is done at 9 – 10 weeks before solid feeds are introduced. This should continue to four months of age.

(b) Feeding heifers, bulls

They should be given solid feeds such as grass, legumes, concentrates and salts to encourage growth and early maturity at 15 months.

Grains, pastures and hay mixture should be given depending on body size.

(c) Feeding dairy heifers

Flushing is carried out by providing a high plan of nutrition between 15 and 18 months just before mating.

Steaming up is carried out by providing nutritious feed to gestating cows 60 days before calving to increase the growth rate of foetus, building milk reserves and general well being of the dairy cow.

(d) Feeding dairy cows

Enough pasture, concentrates, minerals and vitamins given at least 3 – 4 % of body weight. The dry matter of feeds in the form of napier grass provide dairy meal at the rate of 1 kg to 2 kg per day.

Provide adequate energy and protein concentrates for every 1.5 kg of dairy meal. A cow produces an extra 3 kg of milk. A cow producing 20 litres of milk is fed on 9 kg of dairy meal per day. Provide enough water to drink.

(e) Feeding beef cattle

The calves of beef cattle are left to stay with their mothers to suck until 4 – 5 months of age. Provide pastures, concentrates, minerals and vitamins from 3 months to 15 – 20 months of age.

Feed adult cattle with enough pasture, concentrates and water. Occasionaly, give grains to improve the nutritive quality of feeds. Provide enough water to drink.

5.6.3 Feeding sheep

Feeding lambs – Allow lambs to suckle colostrum for the first 3 – 5 days. The lambs should suckle at least 1 hour after birth.

Introduce dry feeds to lambs at 2 weeks of age. Give to the orphaned and abandoned lambs to foster mothers.

Reduce the quality of milk given between 45 and 60 days old.

Provide milk replacers if there are no other sources of milk.

Provide creep feed in form of creep pellets at 10 days of age. Give each lamb about 0.1 kg of creep pellets per day and increase to 0.5 kg by 45 – 60 days. Provide enough clean water to drink.

Weaning

Introduce solid feeds at 25 – 30 days of age by providing soft herbage, wilted lucerne and concentrates. Provide enough clean water for drinking and antibiotics in feeds to minimise attack by enterotoxemia disease.

Older sheep

Provide a high plane of nutrition with highly nutritious concentrates so that they can reach market weight early. This is when the lambs weigh between 30 and 40 kg depending on the breed. Rams are given more grains. The feeding of pastures is also allowed.

Feeding ewes

Flushing is done 4 – 6 weeks before mating to encourage twining and facilitates conception.

Steaming up is done 3 – 4 weeks before lambing to encourage growth of foetus and build energy reserves of the ewe. Enough water is provided during lactation.

5.7 Diseases of ruminants

Activity 5.10: Visit a farm where ruminants such as cattle, sheep and goats are kept and carry out the following activities:

(1) Find out the type of diseases that attack cattle, sheep and goats in the farm.
(2) Find out the symptoms, damages and how the diseases are controlled.

A disease is any condition which alters or changes the state of the body of an animal or its organs and, therefore, interrupts the proper performance of its functions.

5.7.1 Cattle Diseases

Cattle may be affected by the following diseases:

(a) Brucellosis

Also known as contagious abortion or Bang's Disease. The disease also affects goats, sheep, pigs and man.

Causative agent

This disease is caused by a bacterium of the *Brucella spp*. In cattle it is caused by *Brucella abortus*.

Brucellosis is a contagious disease which means it is spread through contact. It is also zoonotic thus can be transmitted to humans.

Symptoms

(i) Spontaneous abortion or sudden abortion of foetus or premature birth in later stages of pregnancy.

(ii) Retained placenta.

(iii) Barrenness and low libido in males. Males have swollen and inflammed testicles.

(iv) Brown, yellow, slimy, odourless discharge from the vulva occurs after abortion.

Fig. 5.30: Symptoms of brucellosis

Control

(i) Artificial insemination.

(ii) Affected animals should be culled and disposed of.

(iii) Vaccination of all young animals against brucellosis.

(iv) Avoid contact with aborted foetus for the farmer.

(v) Carry out blood test to determine the animals affected which should be disposed of and to detect the ones not affected.

(vi) Cleanliness of animal houses and milking equipment.

(vii) There is no effective treatment.

(b) Babesiosis

This disease is also known as red water. It is a vector-borne disease caused by protozoa and transmitted by blue tick and brown ear ticks. This disease also attacks sheep.

Causative agent

This disease is caused by a protozoa known as *Babesia spp* which attacks red blood cells. In cattle the protozoa is known as *Babesia divergens* and *Babesia bovis*.

Fig. 5.31: Animal suffering from Babesiosis

Symptoms

(i) High body temperature.
(ii) Lack of co-ordination.
(iii) Poor appetite.
(iv) Production of dark red or brown coloured urine.
(v) Nervous signs such as grinding of teeth.
(vi) Anaemia, swollen liver, pale tongue.
(vii) Non-productive cough and oedema of lungs.

Control

(i) Regular dipping and spraying livestock using recommended acaricides.
(ii) Treatment using tetracycline antibiotics.

(c) Tuberculosis

Tuberculosis is a bacterial disease that is highly infectious and zoonotic, transmitted to humans through milk and inhalation of spores.

Causative agent

This disease is caused by a bacteria known as *Mycobacterium bovis*. Although a variety of other species can cause tuberculosis.

Symptoms

(i) Soft chronic cough.
(ii) Difficulty in breathing.
(iii) Dullness.
(iv) Swelling of lymph nodes due to tubercles.
(v) Loss of appetite.
(vi) Fluctuating fever.

Fig. 5.32: A calf suffering from Tuberculosis

Control

(i) Proper ventilation in animal houses.
(ii) Avoid overcrowding livestock or keeping many livestock in a small space.
(iii) Screening of infected animals using blood tests and isolating them.
(iv) Pasteurisation of milk and meat inspection.
(v) Vaccination of young animals in areas endemic to the disease.
(vi) Proper disposal of carcasses.

(d) Bovine Anaplasmosis

Anaplasmosis is a vector-borne disease transmitted by blue ticks, contaminated surgical instruments and hypodermic needles which affects the red blood cells.
The other animals affected include sheep and goats.

Causative agent

This disease is caused by a protozoa known as *Anaplasma marginale* and *Anaplasma centrale*.

Symptoms

(i) Fever with high body temperature.

(ii) Anaemia which is indicated by paleness of gum and tongue.
(iii) Constipation.
(iv) Low milk production in lactating cows because milk flow to udder ceases.
(v) Jaundice.

Fig. 5.33: An animal suffering from Anaplasmosis

Control

(i) Regular dipping and spraying of cattle using recommended acaricide.
(ii) Treatment with antibiotics such as oxytetracycline.
(iii) Giving iron injections.
(iv) Control of mosquitoes and other biting insects.
(v) Using sterilised surgical instruments and hypodermic needles.

(e) East Coast Fever

East Coast Fever is a vector-borne disease transmitted by brown ear ticks. Also known as Theirelliosis. Local cattle breeds are fairly resistant.

Causative agent

This disease is caused by a protozoa known as *Theilevia parva*.

Symptoms

(i) Swollen lymph nodes around the base of the ears, shoulders and stifle joints.
(ii) Fever.
(iii) Animal produces a lot of saliva.
(iv) Animal produces a lot of tears from eyes.
(v) Difficulty in breathing and coughing.

(vi) Sight impairment.

Fig. 5.34: Animal showing profuse salivation

Control

(i) Regular dipping and spraying to control ticks using recommended acaricides.
(ii) Fencing to keep off unwanted animals and wildlife.
(iii) Treatment using recommended drugs.
(iv) Cross breeding with indigenous breeds which are more tolerant to the disease as compared to exotic cattle breeds.

(f) Heart Water

This is a vector-borne disease affecting cattle and is transmitted by the bont tick, and the East African bont tick. Local breeds are fairly resistant to the disease. It also attacks sheep and goats.

Causative agent

Heart water is caused by a protozoan *Ehrlichia ruminantium* formerly known as *Cowdria ruminantium*.

Symptoms

(i) Sudden rise in body temperature.
(ii) Loss of appetite.
(iii) Restlessness.
(iv) Difficulty in breathing and coughing.
(v) Neurological signs which include chewing movements, protrusion of tongue,

twitching eyelids, high stepping gait and mild in co-ordination.

(vi) Convulsions.

(vii) Death within one to two weeks.

(viii) Postmortem shows red to straw coloured fluid within the heart.

Control

(i) Regular dipping and spraying animals using recommended acaricides against ticks.

(ii) Treatment in early stages using antibiotics such as tetracycline.

(iii) Vaccination against heart water in calves between 5 and 8 weeks old.

5.7.2 Goat Diseases

Activity 5.11: Use the materials provided to carry out the following activities:

(1) Observe the symptoms of goat diseases.

(2) List the characteristics of the symptoms and damages of each disease observed.

Goats are hardy and fairly tolerant to most tropical diseases. They are commonly affected by the following diseases:

(a) Blue Tongue

Blue tongue is a contagious viral disease which is spread by biting insects particularly the midge. Animals also attacked include cattle and sheep.

Causative agent

Blue tongue is caused by a virus known as a blue tongue virus of the genus *orbivirus*.

Symptoms

(i) Fever.

(ii) Excessive salivation.

(iii) Swelling of the face, tongue and lips.

(iv) The tongue and lips appear blue to purple in colour.

(v) Nasal discharge with strained breathing.

(vi) Lesions in the foot leading to lameness.

Fig. 5.35: Animal suffering from blue tongue

Control

(i) Quarantine.
(ii) Vaccination.
(iii) Control of biting insects such as midge.

(b) Heart Water in Goats

This is a vector-borne disease affecting cattle and is transmitted by the bont tick, and the East African bont tick. Local breeds are fairly resistant to the disease. It also attacks sheep and cattle.

Causative agent

Heart water is caused by a protozoan *Ehrlichia ruminantium* formerly known as *Cowdria ruminantium*.

Symptoms

(i) High body temperature.
(ii) Anaemia which is indicated by paleness of the gums and tongue.
(iii) Constipation.
(iv) Low milk production in lactating because milk flow to the udder ceases.
(v) Jaundice.

Fig. 5.36: Goat suffering from Heart water

Control

(i) Regular dipping and spraying of goats using recommended acaricide.
(ii) Treatment with antibiotics such as oxytetracycline.
(iii) Giving iron injections.
(iv) Control of mosquitoes and other biting insects.
(v) Using sterilised surgical instruments and hypodermic needles.

(c) Vesicular Stomatitis

Vesicular stomatitis is a contagious viral disease that is also zoonotic. Has an incubation period of 28 days. Vesicular stomatitis is a notifiable disease. This disease also affects sheep, goats, horses and donkeys.

Causative agent

This disease is caused by a virus of the family *Rhabdoviridae*.

Symptoms and signs

(i) Excessive salivation.
(ii) Raised blister like lesions in the inner surfaces of the lips, gums, tongue and dental pad.
(iii) Blisters may also appear on the nostrils, vulva, teats and coronary band. The blisters break causing ulcers.
(iv) Lameness.
(v) Reluctance to eat due to wounds in the mouth.
(vi) High body temperature.
(vii) Drop in milk production in lactating does.
(viii) Affected animals may recover after some time.

Control

(i) Quarantine.

(ii) Isolation of infected animals.

(iii) Control of insect vectors and sterilisation of surgical instruments.

(iv) Using protective clothing when handling infected animals such as using gloves and facial masks.

(v) There is no effective treatment although the isolated animals may be reintroduced to the herd 21 days after the last lesion has healed.

(d) Caprine Arthritis Encephalitis

This is an infectious viral disease which mainly affects goats. The virus is mainly spread through colostrums and milk. It is transmitted through semen and mother to the kid while in the uterus. It is also important to note that the Saanen breed is highly susceptible.

Fig. 5.37: Caprine arthritic encephalitis

Causative agent

This disease is caused by a virus of the *lentivirus* group.

Symptoms

(i) Arthritis in any joints due to inflammation of the tendon sheaths resulting in big knees thus lameness.

(ii) Pneumonia.

(iii) Meningitis and neurological symptoms such as pressing head against the wall, wobbly gait and walking in circles.

(iv) Viral mastitis in does.

(v) Loss of hair around the neck.

Control

(i) Isolation of infected goats.

(ii) Feeding kids with artificial colostrums or cattle colostrums and milk.

(iii) Quarantine.

(iv) Notifying authorities.

(v) Screening affected goats and disposing of or culling them.

There is no treatment or vaccination currently available.

(e) Clostridial Infections

Clostridium is a bacterium that is naturally found in soils. A few species causes infections to various livestock and man. The primary mechanism in which these affect animals is through production of a toxin which affects the nervous system after being ingested or entering through a wound.

There are four diseases of clostridium that are important. These are:

1. Black Quarter
2. Botulism
3. Enterotoxemia
4. Tetanus

Black Quarter

This is a bacterial disease which is infectious and acute.

Animals that are affected also include:

(i) Cattle of between ages of 8 and 18 months.

(ii) Sheep (common after shearing).

Causative agent

This disease is caused by a bacteria known as *clostridium chauvei* and c*lostridium septicum*

The bacteria enters the body through a wound or contaminated water.

Symptoms

(i) Lameness and animal is forced to lie down in severe cases.
(ii) Affected quarter or leg gets swollen and produces a crackling sound when touched.
(iii) Body temperature rises.
(iv) Grunting and grinding of teeth.
(v) Animal stops chewing cud.
(vi) Death occurs suddenly.
(vii) Blood oozes from nose and mouth of dead animal which was infected.
(viii) Postmortem reveals the affected muscles of the leg appear dark and produce a bloody froth with smell of rancid butter.

Fig. 5.38: Black quarter in sheep

Control

(i) Vaccination using Blanthrax vaccine which also controls anthrax.
(ii) Treatment using antibiotics such as penicillin and tetracycline.
(iii) Use of antitoxin serum against the black quarter toxin.
(iv) Carcass should be buried deep in soil at least 2 m or burnt completely to ashes.

Botulism

Botulism is a rare but fatal condition caused when toxins from the botulinum bacteria affect livestock. The botulism bacteria is ingested leading to the condition.

Other animals also affected include cattle and sheep.

Causative agent

This disease is caused by a bacterium known as *clostridium botulinum*. It has an incubation period of 8 – 36 hours.

Symptoms

(i) Severe abdominal pains.
(ii) Difficulty in breathing.
(iii) Difficulty in swallowing and animal stops chewing cud.
(iv) Paralysis of the hind limbs.
(v) Diarrhoea.
(vi) Unco-ordinated gait.
(vii) Drooling of saliva.
(viii) Paralysis and eventually death.

Control

(i) Vaccination against botulism.
(ii) Observe hygiene when preparing animal feeds such as silage and hay.
(iii) Clinical care for affected animals.
(iv) Burning of affected carcasses.
(v) Cleaning and disinfection of affected animal houses.

Enterotoxemia

This is also known as an overfeeding disease or pulpy kidney in goat and sheep production. This is an acute and infectious disease that is introduced in livestock through feeding contaminated food. This disease also affects cattle and sheep.

Causative agent

This disease is caused by bacterium called *clostridium perfringes* commonly found in soil and intestinal track of mammals.

Symptoms

(i) Diarrhoea.

(ii) Dehydration.
(iii) Rapid mortality in lambs and kids.
(iv) Convulsions and wide opening of the eyes.

Fig. 5.39: Goat suffering from enterotoxemia

Control

(i) Vaccination against enterotoxemia.
(ii) Disinfection of animal houses, feeding and watering troughs.
(iii) Hygiene standards should be maintained.

5.7.3 Diseases of Sheep

Activity 5.12: Use the materials provided and or internet to carry out the following activities:

(1) Observe the symptoms of the different diseases that attack sheep.
(2) Note their characteristics and damages.

Sheep are commonly affected by the following diseases:

a) Blue Tongue

Blue tongue is caused by a virus known as blue tongue virus of the genus *Orbivirus*.

Symptoms

(i) High fever with high body temperature.
(ii) Excessive salivation.
(iii) Swelling of the face, tongue and lips.
(iv) The tongue and lips appear blue to purple in colour.
(v) Nasal discharge with strained breathing.

Fig. 5.40: The tongue protruding due to swelling

Control

(i) Use of quarantine.
(ii) Vaccination.
(iii) Control of biting insects such as midge.

(b) Cryptococcosis

This is a fungal disease that affects livestock and also human beings. It is, therefore, a zoonotic disease. It also affects cattle and goats.

Causative agent

The disease is caused by a yeast like fungus known as *Cryptococcus neoformans*. Sheep get exposed to the disease through inhalation and, therefore, affects the lungs.

Symptoms

(i) Ulcerative lesions in the nose.
(ii) Congested or cloudy conjunctiva.
(iii) Enlarged lymph nodes.
(iv) Difficulty in breathing which is rapid and laboured.
(v) Grunting and gaggling sounds when breathing and coughing.
(vi) Loss of appetite.
(vii) Dehydration.
(viii) Loss of hair or wool.
(ix) Death in severe infections.

Fig. 5.41: Loss of hair/wool

Control

(i) Killing and disposing of infected sheep.
(ii) Treatment using systemic fungicides and antibiotics.
(iii) Management of skin lesions within the nose.
(iv) Isolation and treatment of sick animals.
(v) Wearing protective clothing when handling sick sheep to prevent spread to other animals and the farmer.

(c) Vesicular Stomatitis

Vesicular stomatitis is a contagious viral disease that is also zoonotic when man handles infected animals or their product. Has an incubation period of 2 – 8 days. Vescular stomatitis is a notifiable disease.

It also affects cattle, goats, horses and donkeys.

Causative agent

It is caused by a virus of the family *Rhabdoviridae*.

Symptoms

(i) Excessive salivation.
(ii) Raised blister like lesions in the inner surfaces of the lips, gums, tongue and dental pad.
(iii) Blisters may also appear on the nostrils, vulva, teats and coronary band. The blisters break causing ulcers.
(iv) Lameness.
(v) Reluctance to eat due to wounds in the mouth.
(vi) High body temperature.

(vii) Drop in milk production in lactating ewes.

(viii) Affected animals may recover after some time.

Fig. 5.42: Vesicular stomatitis in sheep

Control

(i) Quarantine.

(ii) Isolation of infected animals.

(iii) Control of insect vectors and sterilisation of surgical instruments.

5.8 Sanitation in ruminant farms

Activity 5.13: Visit a ruminant livestock farm near your school and carry out the following activities:

(1) Find out the daily activities carried out in the farm to ensure proper sanitation.

(2) Prepare a routine plan for the whole day for a dairy cattle farm, goat farm or sheep farm.

(3) Discuss the routine activities carried out when managing ruminant livestock.

Sanitation

Sanitation is an important routine practice in farms. Sanitation involves the removal of dirt and other refuse which would be a likely predisposing factor of some livestock disease.

Sanitation rules in a ruminant farm include:

1. Proper housing and hygiene

   All animal houses should meet the recommended structural requirements such as:

   (a) Well ventilated but free from drought winds.

   (b) Have adequate spaces.

   (c) Allow proper drainage and deposition of faecal waste.

   (d) Be leak-proof.

(e) Be well lit.
(f) Easy to clean.
(g) Free of parasites.

2. Use of antiseptic and disinfectants

To prevent diseases, the livestock house should be disinfected using recommended antiseptic and disinfectants such as formalin, chlorine water and soap or detergents.

3. Proper disposal of carcasses and waste

All carcasses from sick animals should be buried deeply in soil or burnt completely to prevent spread of diseases. Droppings and other wastes are possible carriers of disease-causing organisms and internal parasites. They should be put in a compost pit or heap and covered with soil.

4. Isolation of sick animals

This is a preventive measure where all animals showing clinical symptoms are separated from the rest of the herd to prevent spread of infectious and contagious diseases. Isolation should continue until the animal recovers.

5. Imposition of quarantine

Quarantine involves restriction of movement of animals and their products from one farm to another or one region to another. Quarantine is imposed when a notifiable disease is present. It prevents spread of such diseases. During quarantine other measures such as vaccination or treatment are employed.

6. Slaughtering and burning infected animals

Some livestock diseases are notifiable and dangerous. To prevent disease spread, all sick animals are slaughtered and burned or buried deeply in the soil. In some cases, the whole herd is slaughtered to prevent disease spreading.

7. Proper nutrition

Always provide clean and fresh food to livestock to prevent some diseases like botulism. Provide clean water which prevents spread of some diseases through water. A high plan of nutrition gives the animal energy and helps to control nutritional deficiency disorders.

8. Provision of clean equipment

Feed and water troughs should be cleaned everyday to prevent spread of contagious diseases. All surgical equipment such as hypodermic needles and syringes should be sterilised before use. Animal handling equipment such as milking machines, burdizzo and hoof trimmers should be cleaned thoroughly before use to prevent spread of diseases.

Unit Summary

- Ruminants are herbivorous animals that chew cud.
- Their digestive system consists of four stomach chambers, the rumen, reticulum, omasum and abomasum. Ruminant species kept in Rwanda include cattle, sheep and goats. These may be originated locally or imported from other continents to boost production. The ruminant breeds in Rwanda are kept for meat, milk and wool production.
- Cattle breeds kept in Rwanda include Ankole, Friesian and Jersey.
- Cattle provide milk and meat. Goat breeds kept in Rwanda include local sheep, Alpine, Boer, Ethiopian galla and Saanen, among others. Goats provide meat and milk. Sheep breeds kept in Rwanda include local sheep, mountain white, merino, corriadale and dorper. Sheep provide meat and wool.
- When siting ruminant shelter, the following factors are considered; location of the homestead, accessibility, drainage, security, direction of prevailing wind, farmer's tastes and preferences, nearness to sources of water and electricity.
- When constructing a livestock shelter, the materials to be used should be durable, affordable, suitable for the enterprise, climate strong and easy to work.
- When constructing a goat shelter the following factors are considered: age group of the animal enterprise, environmental conditions, drainage and skills of the farmer.
- A goat shelter needs to be spacious, free from cold winds, well ventilated, easy to construct and less dependent on support for farmer when carrying out routine practices. The following materials are required when constructing a goat house: timber, plywood, concrete, iron sheets and nails.
- The selection criteria for sheep include a natural base width, muscle volume and style balance, growth potential and age. Cattle are selected on the basis of their production enterprise which include head, topline legs, main body and ribs, humps and hooves walking gait, fat, muscle, teat size and fertility.
- Ruminant fodder includes grass and legumes. Grass fodder include napier grass, Guatemala grass and Sudan grass. Legume fodder include lucerne, desmodium, vetch, leuceana and sesbania.
- Concentrates provide energy and proteins to livestock. Energy concentrates include molasses ground grains, protein concentrates include animal based products such as blood, bone and milk. Plant based protein concentrates include beans and various oil seed cakes. Minerals and vitamins are provided in form of mineral licks and vitamins premixes. These supply essential elements for proper growth.

- Methods of feeding goats include creep feeding or feeding young goats, weaning, flushing, steaming up and fattening.
- Cattle diseases include brucellosis, babesiosis, thereliosis or East Coast fever, heart water and enteric fever. Goat diseases include blue tongue, heart water, vesicular stomatitis, caprine arthritis encephalitis and clostridial infections.
- Sheep diseases include blue tongue, cryptococcosis, heart water, vesicular stomatitis. It is important to observe strict sanitation in livestock production to prevent spread of livestock diseases and ensure clean products, healthy farmer and healthy population.

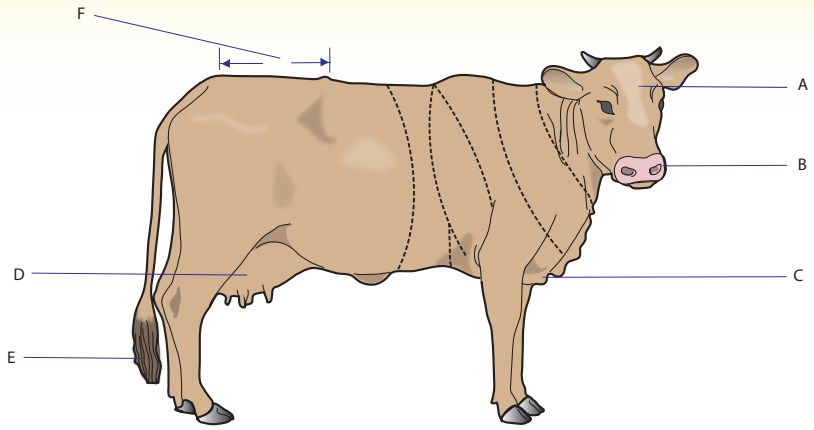
Key Terms

1. **Oxen** – Castrated male cattle used in providing power when pulling carts or ploughs.
2. **Wealth** – The assets owned by an individual.
3. **Lactation period** – A period when a cow produces milk after birth until it is dried up.
4. **Butter fat content** – The proportion of butter fat in milk.
5. **Exotic** – Imported from Europe or temperate countries.
6. **Polled** – Without horns.
7. **Native/indigenous** – Originated or found locally.
8. **Staple length of wool** – The quality measure of the length of wool.
9. **Concrete** – A mixture of cement, sand and gravel mixed with water and used for building.
10. **Infectious** – A disease caused by micro-organisms and can easily be spread from one animal to another.
11. **Contagious** – A disease which is spread through contact with the disease-causing agent.
12. **Paralysis** – Inability to co-ordinate the body due to damages in the nervous system.
13. **Vaccine** – A weakened disease-causing agent introduced to animals to stimulate the body to produce antibodies.
14. **Neurological signs** – Deviation from the normal behaviour caused by the nervous disorders.
15. **Fever** – Change in temperature.
16. **Isolation** – Separation of a sick animal from a healthy one to prevent the spread of diseases.
17. **Anaemia** – Loss of red blood cells.

18. **Constipation** – Inability to digest.
19. **Cross breeding** – Breeding two animal breeds of the same species which are not related.
20. **Dehydration** – Loss of water from the body.
21. **Tick** – An external parasite that transmits diseases to livestock.
22. **Acaricide** – A chemical used to control ticks.
23. **Antibiotic** – A chemical used to treat bacterial diseases.
24. **Ad-libutum** – Without a measure.
25. **Abbatoir** – A livestock slaughter house.
26. **Slated floor** – A wooden floor with small spaces between timber slabs to allow passage of droppings in goat houses.
27. **Tropical diseases** – Diseases commonly found within the tropic.
28. **Fodder** – Crop grown and harvested for livestock.
29. **Concentrates** – Feed containing high fibre content, high protein content and low fibre content.
30. **Hand feeding** – Feeding of young animals using milk bottles or buckets.
31. **Laxatives** – Substances that loosen stool and increase bowel movement.
32. **Weaning** – Introduction of solid feeds to young animals.
33. **Quarantine** – Restriction of movement of livestock or their products during a disease outbreak.
34. **Zoonotic** – A disease which is transmissible between man and livestock.
35. **Tubercles** – Swellings in body organs due to tuberculosis infection.

Revision Questions

1. What is a ruminant animal?
2. Name ruminant livestock kept in Rwanda.
3. State three importance of keeping ruminant livestock.
4. The following diagram is an illustration of a cow. Study it and name the parts labelled A, B, C, D, E and F on the diagram.



5. State the external characteristics of the following goat breeds:
   (a) Local goat
   (b) Alpine
   (c) Saanen
   (d) Ethiopian Galla
   (e) Boer

6. Describe the external characteristics of the following sheep breeds:

(a)

(b)

7. Explain the factors to consider when siting livestock structures.
8. Outline the procedure of constructing a goat shelter.
9. State the selection criteria for the following ruminant breeds:
   (a) Dairy goats
   (b) Meat goats
   (c) Sheep for mutton
   (d) Dairy cattle

10. List three grass fodder crops.
11. List three legume fodder crops.
12. What is a concentrate as used in livestock feeding?
13. State the importance of feeding a young goat with colostrums.
14. Describe weaning in young goats.
15. Make a feeding plan for an adult goat.
16. List the causes of diseases in livestock.
17. State the causes of the following livestock diseases:
    (a) Brucellosis in cattle
    (b) Babesiosis in cattle
    (c) Tuberculosis in cattle
18. Identify the disease shown by each photograph below:

(a)

(b)

19. State the control of the following livestock disease:
    (a) East Coast fever
    (b) Black Quarter
    (c) Cryptococcosis
20. Describe four sanitation rules in a ruminant farm.

UNIT 6

LIVESTOCK PRODUCTS

Introduction

Globally there is a rapid increase in the production and consumption of livestock products and which is expected to continue growing. However, increasing productivity, especially in the small to medium production system, is limited by lack of proper marketing channels. As a result, losses and wastage are incurred. Interventions in terms of proper handling, value-addition and preservation technologies are required. This does not only increase the shelf-life of these products, but also increases income generation for the small and medium livestock keeper.

This unit addresses how livestock products, and by-products from cattle, pigs, poultry and rabbit can be preserved. The pictures below show fresh and preserved livestock products with some contrast of how some of these products can get spoilt.

Fresh beef meat

Decomposing meat infested with maggots

Packaged ultra-treated milk

Fresh milk

Smoked sausages

Sun-dried hide

6.1: Importance of preservation of livestock products

Activity 6.1: Observing destroyed and fresh products

Use the products exhibited to carry out the following activities:

(1) Observe the characteristics of the destroyed (meat. milk, skin, ice cream and blood) livestock products and fresh livestock products displayed.

(2) Compare the characteristics of the destroyed livestock products with fresh livestock products displayed.

(3) Record your observations in table 6.1 below and discuss your findings.

Table 6.1: Comparison between characteristics of the destroyed and fresh livestock products

Characteristics	Destroyed products	Fresh products
Colour		
Smell		
Texture		
Appearance/Looks		

(4) Using your experience, find out the importance of preserving livestock products.

Preservation is the process of preventing deterioration of products. Livestock products such as meat, milk and eggs form a major component of the economy of any nation as source of food. Most livestock products, like other agricultural products, are highly perishable, meaning that they easily go bad. They should, therefore, be kept properly in order to maintain their quality.

The preservation of livestock products is important for the following reasons:

(i) To increase their shelf-life

Shelf-life is the period of time that a product remains in good condition under storage.

(ii) To lower the activity of micro-organisms and, therefore, prevent rotting of products.
(iii) To add value to the products – Processed livestock products fetch higher prices in the market hence high profits.
(iv) To add flavour to the food – Processed livestock products improve in smell, taste, appearance, colour and texture.

General methods of preserving livestock products

The following are the general methods of preserving livestock products:

(a) Drying

This is a method of preservation where water is removed through evaporation. The evaporation may be done through sun drying or by use of an air current (air drying). Drying inhibits the growth of micro-organisms that cause spoilage of the products. It is one of the oldest methods of preservation. It is used for preserving meat, fish, hides and skin.

(b) Salting

This is a method of preservation where dry table salt is applied on the surface of the product. The salt removes water from the product by osmosis. Salting inhibits the growth of pathogenic organisms such as bacteria and fungi as they get dehydrated by the high salty environment and die or become temporarily inactivated. It is one of the oldest method of preservation and is used for the preservation of meat, fish, hides and skin.

Fig. 6.1: Salting meat

(c) Smoking

This is a method of preservation where the product is exposed to smoke from a

burning material usually wood. This method is usually applied on food products. Besides preserving the food, smoking also adds flavour to it. This method is used on meat, fish and cheese.

Fig. 6.2: Smoking meat

(d) Cooling or refrigeration

Cooling is a method of preservation where ambient temperatures are lowered to levels where microbial activities are greatly reduced. This may be done through refrigeration or use of any other coolant such as water to conduct heat away from the product. This method is used for preserving food substances such as meat, milk and fish.

(e) Heat treatment

This is the preservation of livestock products by the application of heat to the product. It includes heat treatment measures as boiling of food, milk (pasteurisation), cooking and wasting of meat. Very high temperatures destroy micro-organisms that cause food spoilage.

(f) Freezing

This is a method of preservation where the growth of micro-organisms is slowed down by very low temperatures of about -23°C. The frozen water is also not available to the micro-organisms and this further reduces the activity of micro-organisms.

Fig. 6.3: Freezing meat

(g) Canning

In this method of preservation, food is cooked and sealed in a sterile container. It is then boiled to kill any remaining bacteria. This method is used for preserving meat and milk products.

(h) Fermentation

The carbohydrates in the food are converted into alcohol and organic acids, for example, lactic acid. Lactic acid prevents further action by micro-organisms thus preserving the food. Fermentation is brought about by beneficial micro-organisms under anaerobic conditions. This is an old method of food preservation. It is used to preserve meat and milk products.

(i) Sugaring

This is a method of preserving meat where sugar is applied in form of honey, syrup and solids. The sugar then absorbs water in the products through osmosis. This lowers the activity of the micro-organisms which destroys the product. Sugar also promotes the growth of favourable micro-organisms such as lactobacillus which produce lactic acid. Lactic acid prevents growth of unwanted micro-organisms.

(j) Jellying

This is a method of preservation where the material to be preserved is kept in a substance that solidifies to form a gel, for example, gelatin. It is used in the preservation of meat.

(k) Use of chemicals

This is the use of chemicals to preserve livestock products. It is commonly used in the preservation of food materials such as meat, hides and skin. Common chemicals used in food preservation include sodiumbenzoate, sodium nitrite and sulphur (IV) oxide. These chemicals inhibit the growth of micro-organisms that spoil food.

(l) Pickling

This is the use of an edible anti-microbial liquid to preserve food. Examples of such liquids include brine (strong salt solution), vinegar and vegetable oils such as olive. This method is used in storing meat and eggs.

Fig. 6.4: Pickling

(m) Vacuum packing

This is the storing of food in a vacuum environment usually in an air-tight bag or bottle. The vacuum condition deprives micro-organism of oxygen thus reducing their activity. This method is used for preserving cheese.

Fig. 6.5: Vacuum packing

6.2 Preservation of cattle products and by-products

Activity 6.2:

(1) Visit a livestock product processing industry and a dairy to observe different operations carried out to preserve livestock products in the industry and the dairy.

(2) Watch a video showing different methods of preserving cattle products and by products then carry out the following activity:

Discuss the different methods used to preserve different cattle products and by-products.

Products obtained from cattle include, meat, milk, ice cream, cheese and yoghurt, while the by-products include hide, tallow, gelatin, leather, blood, horns and bones. Most of these products are perishable and require preservation.

6.2.1 Preservation of cattle products

(a) Meat

After dressing of the carcass, meat is cut into thin strips or flat pieces while fresh and then preserved as follows:

(i) Drying – The strips of meat are sun-dried or open air dried to reduce moisture content which discourages growth of bacteria hence spoilage. The disadvantage of this method is contamination of meat with dust and insects.

(ii) Curing – The dried meat strips may be cured through salting, sugaring and smoking. Curing removes excess water from the meat reducing microbial spoilage. Sugaring is done where sweet meat products are required. Smoking removes water and adds flavour to the meat.

Fig. 6.6: Preservation of beef through salting

(iii) Boiling or cooking – Cured meat can be cooked or boiled before consumption. Raw meat is cooked or boiled and packed in sterile containers. The containers are further sterilised.

(iv) Freezing and refrigeration – Pieces of raw meat or raw meat strips are put in a freezer where temperatures are low to inactivate the activities of micro-organisms.

Fig. 6.7: Preservation of meat through refrigeration

(v) Fermentation – The meat to be preserved is first crushed to form minced meat and mixed with spices, vinegar and wine and packed in nature edible cellulose casing and hung to dry.

(b) Raw milk

Milk is a highly perishable animal product. Raw milk is preserved through the following methods:

Fig. 6.8: Raw milk

(i) Pasteurisation

Involves heating milk to a temperature of 50°C – 60°C and then cooling rapidly. The pasteurised milk is then packed in sterile containers such as tetra pack and bottles.

Fig. 6.9: Pasteurisation plant

(ii) Use of chemicals

Chemicals such as hydrogen peroxide, sodium thiocynate and sodium bicarbonate are used to preserve milk. They inhibit the growth of anaerobic bacteria thus increasing the shelf-life of milk.

Fig. 6.10: Peroxide

(iii) Cooling and freezing

Raw milk is subjected to low temperature to minimise the activity of micro-organisms and their multiplication. This is a common method of milk preservation of raw milk and homogenised milk at the shop shelves.

Fig. 6.11: Milk cooling tank

(iv) Boiling

This is the most common method of preserving raw milk. When milk is heated at 100°C most of the bacteria which cause milk spoilage are killed. This increases the keeping quality and shelf-life of milk. It is a common method of preserving milk at home.

Fig. 6.12: Boiling milk

(v) Ultra heat treatment

This milk is heated at a temperature between 130°C and 135°C for a second and immediately packed and cooled. The milk quality is maintained. This temperature also kills micro-organisms such as *Bacillus tuberculosis* and *Brucella arbotus* found in fresh milk.

Fig. 6.13: Preservation of raw milk through ultra-heat treatment/Tetra pack

(c) Ice cream

Newly churned ice cream should be chilled immediately and stored in a freezer as far back as possible. This makes it remain firm and keeps the ice crystals small. It should be stored in an airtight container. It should only last for a week or two to keep its flavours and texture.

Fig. 6.14: Ice-cream

(d) Cheese

In the preservation of cheese, the following is important:

(i) It should not be wrapped tightly to allow the pungent ammonia smell to come out.

(ii) Cheese should be wrapped in cheese bags or cheese paper which is porous and allow cheese to breath. If cheese is wrapped in plastic bag, it will take the flavour of the plastics.

(iii) The paper should always be replaced after unwrapping. Softer cheese should be kept in brine solution. The solution should be replaced every few days to prevent contamination.

(iv) Cheese cuts should be rubbed in a light coat of olive, canola or vegetable oil and stored in air tight container to prevent molds. Cheese is also preserved through refrigeration.

Fig. 6.15: Cheese

(e) Yoghurt

Yoghurt is preserved through refrigeration. Rapid cooling of yoghurt inactivates further bacteria, action to stabilise lactic acid. Yoghurt will keep for about 10–21 days if held in a refrigerator at 4.4°C or lower. Yoghurt may also be salted and dried to preserve it.

Fig. 6.16: Yoghurt

6.2.2 Preservation of cattle by-products

Cattle by-products include: hide, tallow, gelatin, leather, blood, horns and bones.

Hide

The hide is preserved through curing and drying up.

The table below shows different cattle by-products. Discuss it in groups and then complete the table by filling in the methods used to preserve each by-products.

Table 6.2: Cattle by-products

Cattle by-products	*Method of preservation*
(a) Tallow	
(b) Gelatin	
(c) Leather	
(d) Blood	
(e) Horns and bones	

(i) Curing

Curing of the hide is done by application of salt, which is referred to as salting. Salting is done in the following ways:

- Wet salting
  The fleshed and washed hide are left in a cool room for several hours so that they can lose heat. They are then spread with the flesh side up on a wooden platform which is about 10 cm high. The flesh side is then covered with layers of salt. Salt absorbs moisture from the hide and, therefore, decomposition cannot occur. The salt is then shaken off from the hide.
- Brining
  The washed hide is soaked in a drum containing brine overnight. After which is air dried or sun dried.
- Dry salting
  A layer of salt is applied on the flesh side of the hide after flaying. Salt prevents decomposition which may occur during the first few days of hide curing. It is then suspended on a frame to dry.
- Quick drying
  A lot of salt is rubbed vigorously on the flesh side of the hide, immediately after flaying. The salt is applied at the rate of 2 kg per hide. The hide is then folded and rolled like a blanket. It is placed under a heavy weight for about two days. It is then unfolded and suspended by a frame to dry.

(ii) Drying

Hides are dried by suspending them in a frame in such a way that there is free air circulation from all the sides. The frames measure 2.7 m × 3.1 m for large hides and 2.7 m × 2.4 m for the smaller hides. The distance between the frames should not be less than 23 cm in order to allow free circulation of air and permit the operator to pass between them. The hides are laced on the frames with sisal strings, bark or skin straps. Avoid using the wire for lacing because it is not elastic and can tear the hole out. It may also rust leading to formation of stains during tanning.

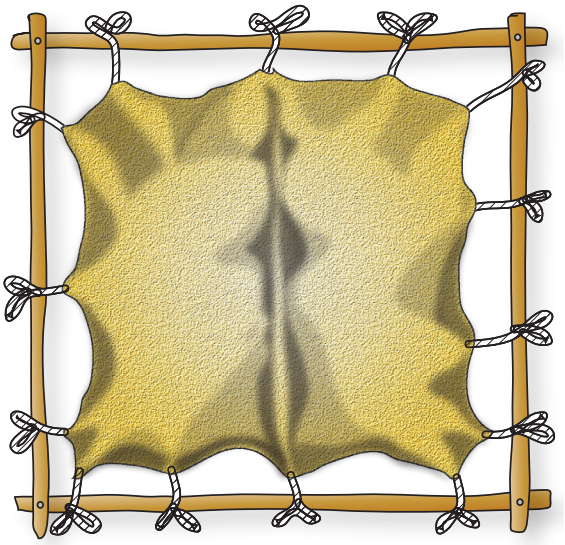


Fig. 6.17: Frame drying of a hide

6.3 Preservation of pig products and by-products

Activity 6.3: Using search engine or library textbooks, explain the methods of pig products and by products preservation.

Pig products include; meat (pork and bacon) and pig fat known as lard, while pig by-products include suede and gelatin.

6.3.1 Preservation of pig products

(i) Preservation of Pork

After dressing the pig carcass, the meat is cut into slabs of between 4 and 6 inches. The meat is then cured by applying salt and sugar mixture. The pieces of meat are well coated with the mixture. The meat is then kept in a crock or jar which is covered tightly with cheese cloth. The containers are then kept in a freezing condition of about

3.0 – 3.5°C for at least a month. The pork may also be preserved by brining. This is done by packing the pieces of meat in a sterilised crock or jar and covering with a brine made up of water, salt and brown sugar. Ensure that the salt and sugar mixture is properly dissolved in water. Cover the container and store for a week at about 3°C.

Fig. 6:18: Preservation of pork through curing

(ii) Preservation of Bacon

Bacon is meat obtained from a pig. The following methods are used to preserve bacon:

(a) Salting: Either in brine or in dry salt, cold drying, boiling and smoking.
   (i) Salting involves putting bacon in either dry salt or brine which dehydrate the meat killing bacteria. This process involves cleaning the raw meat then covering it in salt for about one month while it is gradually pressed. Pressing is done to remove all the fluids and blood. Spices and herbs are also added.
   (ii) Smoking involves cutting small pieces of bacon which are then placed over a smoky flame. This kills bacteria and also improves the quality of bacon.
   (iii) Cold drying involves salting then hanging the bacon in cold wind for approximately one month. Cold drying dehydrates the meat and kills micro-organisms which causes spoilage.
   (iv) Boiling involves heating of pork in brine or lard to kill micro-organisms using high temperature.

(b) Use of chemicals: Nitrates are added to ground bacon. These chemicals kill micro-organisms and provide a hostile environment which prevents the growth and multiplication of bacteria. Nitrates also make the meat have a distinctive pink or red tinge and imparts a flavour.

(c) Fermentation: The bacon is first crushed to form minced meat. Bacon is mixed with a variety of ingredients which include garlic, salt, spices, vinegar and wine. The meat is allowed to ferment for one day. Then is packed in a natural edible cellulose casing and hung to dry.

(iii) Preservation of Lard

Lard is fat derived from pig meat. It is preserved through heating and cooling. The fat is chopped into small pieces and then heated until melting takes place. The meat particles are removed through decanting. The lard is put in bottles while still hot and sealed. It is allowed to cool.

Fig. 6.19: Lard

6.3.2 Preservation of pig by-products

Pig by-products include suede and gelatin. For each by-product listed in the table below, fill in the methods of preservation.

Table 6.3: Methods of preserving pig by-products

Pig by-products	***Method of preservation***
(a) Suede	
(b) Gelatin	

6.4 Preservation of poultry products

Activity 6.4: Using library textbooks and search engine carry out the following activities:

1. Find out how poultry products and by-products are preserved.
2. Poultry products include meat and eggs. If the meat is from the domestic fowl(chicken) it is known as chicken. Discuss and indicate the methods of preserving poultry products by filling in the table below:

Table 6.4: Methods of preserving poultry products

Poultry products	Methods of preservation
1. Meat	
2. Eggs	

6.5 Preservation of rabbit products

Activity 6.5: Use the references provided (text books, dictionaries and internet) to discuss the methods of preserving rabbit products and by-products.

Rabbit products include meat and fur. Discuss the methods of preserving rabbit products and indicate by filling in the table below:

Table 6.5: Methods of preserving rabbit products

Rabbit products	Methods of preservation
1. Meat	
2. Fur	

Unit Summary

Preservation of livestock products is a very important and necessary practice in livestock production. Most of the livestock products get spoilt by micro-organisms and oxidation after they are obtained from the livestock. This is due to lack of proper preservation measures. Preservation measures aim at reducing the activities of micro-organisms and preventing oxidation of products.

Preservation measures taken either kill the micro-organisms or inhibit their activities. This may be achieved through the following measures:

(i) Raising the temperatures to high levels which destroy the micro-organisms through cooking, boiling or roasting the products.

(ii) Lowering the temperature levels that inactivates the micro-organisms through cooling, refrigeration and freezing.

(iii) Preventing micro-organisms from getting water for survival, through drying, freezing, salting, sugaring, smoking and use of honey.

(iv) Preventing micro-organisms from getting oxygen by use of honey, vacuum packing, freezing, smoking and refrigeration.

(v) Dehydrating the micro-organisms by salting and sugaring.

Key Terms

1. **Preservation** – Process of preventing deterioration of products.
2. **Perishable** – Gets destroyed easily through decomposition.
3. **Shelf-life** – Period of time that a product can remain in good condition under storage.
4. **Micro-organisms** – Organisms that are too small to be observed through the naked eyes.
5. **Pathogens** – Organisms that cause diseases.
6. **Salting** – Application of dry salt on the surface of a product to preserve it.
7. **Smoking** – Exposing a product to smoke in order to preserve it.
8. **Drying** – Removal of water from a substance/product through evaporation.
9. **Refrigeration** – Removal of heat from a substance under controlled conditions.
10. **Cooling** – Lowering the temperatures of substance.
11. **Freezing** – Lowering the temperatures of a substance to a point where water solidifies.
12. **Canning** – Preservation of cooked food in sealed containers.
13. **Anaerobic respiration** – Breakdown of carbohydrates in the absence of oxygen.
14. **Fermentation** – Preservation by allowing the sugars in a food substance to undergo anaerobic respiration where the acids or alcohol produced protects the food from further spoilage by micro-organisms.
15. **Sugaring** – The application of sugar to the surface of a substance to withdraw water by osmosis.
16. **Jellying** – Preservation of a food material in a substance that later on solidifies to form a gel.
17. **Pickling** – Preservation of food in an anti-microbial edible liquid, for example, olive oil.
18. **Vacuum packing** – Preservation of food in an airtight bag or bottle.
19. **Tallow** – Fats from cattle meat.
20. **Lard** – Fats from pig meat.
21. **Gelatin** – A translucent flavourless food substance derived from animal products.
22. **Pork** – Fresh pig meat.
23. **Bacon** – Processed pig meat that has been preserved through salting or brining.
24. **Suede** – Leather from pig skin.
25. **Beef** – Cattle meat.

Revision Questions

1. What is preservation?
2. State five importance of preserving livestock product.
3. State five indicators that help to determine whether a product is fresh or destroyed.
4. The following are various livestock products and by-products. Study them carefully and then group them into products and by-products. Hide, raw milk, eggs, fur, tallow, yoghurt, pork and suede.
5. Explain one factor which is common in the following methods of preserving livestock products; salting, sugaring, drying and freezing.
6. Describe five methods of preserving cattle meat.
7. Explain the following methods of preserving livestock products:
   (i) Fermentation
   (ii) Use of honey
   (iii) Pickling
8. Carry out the preservation of hides using frame drying method.
9. The photograph below illustrates a method of preserving meat. Study it and identify the method of preservation.

10. Name two rabbit products.
11. Give two advantages of smoking as a method of preservation.
12. The following are methods of preserving livestock products.
    (i) Canning
    (ii) Salting
    (iii) Pickling
    (iv) Cooling

    Which of the following sets are methods of preserving eggs?
    A. (i) and (ii)
    B. (ii) and (iii)
    C. (iii) and (iv)
    D. (i) and (iv)

UNIT 7

PROBLEMS AND SOLUTIONS OF AGRICULTURE

Introduction

The agricultural sector in Rwanda, like any other in the world, has its own challenges. However, efforts are being made to address these challenges in order to improve agricultural production in Rwanda.

This unit highlights some of the problems facing agriculture in Rwanda and their possible solutions. The following figures give an overview of the unit:

Ox-ploughing

Hand digging

Combined-harvester

Maize sheller

Maize planter in action

7.1 Problems facing agriculture in Rwanda

Activity 7.1: Use the references provided to carry out research on the problems facing agriculture in Rwanda. Alternatively, watch a video show on problems facing agriculture in Rwanda.

The agricultural sector in Rwanda is faced with a lot of challenges or problems.

(a) Land shortage

Land sizes per unit holding in Rwanda are generally small. This is attributed to high population density. The other reason is that most of the Western, Northwestern parts of the country and parts of Central Rwanda are mountainous. Rwanda has an area of 26,336 km^2 of land. The total arable land in Rwanda is about 1.4 million hectares which is 52% of the total land. However, the actual cultivated land exceeds 1.6 million hectares. Another 0.47 million hectares are under permanent pastures, meaning that well over 70 % of the country's total land surface is exploited for agriculture (ROR 2008).

(b) Lack of capital

Capital includes all the man-made assets used in the production of desired goods. According to Rwanda statistical year book 2015, about 39.1% of the people of Rwanda live below the poverty line and, therefore, are not able to invest heavily in farming.

Farming methods remain at subsistence levels. Most of the farmers use hand tools and simple mechanisation using animal-drawn implements for cultivation in large-scale. Mechanisation is limited to a few commercial farms that can afford them.

(c) Pests and diseases

Pests and diseases in both crop and livestock remain a major challenge in agricultural production in Rwanda. This reduces farm outputs greatly. This is attributed to lack of the necessary information and capital in the control of pests and disease and conducive environment for the multiplication of pests and disease causing organisms. Common livestock parasites include: ticks and internal parasites while diseases include: the tick-borne diseases for East Coast fever. Others include foot and mouth disease, rinderpest and Newcastle in poultry.

Fig. 7.1: (a) Tick

Fig. 7.1: (b) Tape worm

(d) Unstable prices

The prices of both farm inputs and products keep on changing from one season to another. This poses a challenge in the planning for the production as farmers are not certain of the profit or gross maximum to be realised. This creates the problem of risks and uncertainties. A wrong choice of an enterprise may result in farmers getting very little and this discourages them in the following season.

(e) Rainfall distribution

Rwanda has two main rain seasons. The first one occurs between the months of February and June and the second one between the months of September and December with an average annual rainfall of about 1231 mm (*source: Rwanda statistical year book, 2015*). Most of this rainfall occurs in the Western and Northwestern parts of Rwanda while the Southeastern and Eastern parts of the country receives relatively low rainfall. These are two dry spells in Rwanda, one between June and September. There is less rainfall and a short one between December and February.

(f) Bad attitude towards agriculture

Most educated people and especially the youth regard agriculture as a dirty job meant for the illiterate. They prefer the white collar jobs available in urban areas. They do not consider agriculture as a career or take it as a business. The situation is made even worse by the low wages in agricultural sector compared to the industrial sector. This has made agricultural production to remain generally low for a long period of time in Rwanda.

(g) Malnutrition

Lack of food and proper balanced diet leads to a weak population which cannot provide physical labour to the sector. Lack of necessary labour leads to poor agricultural production.

(h) Lack of market for agricultural goods

Some farmers are not aware of the existing markets of their products and the prices offered in these markets. They lack important market information and, therefore, end up being exploited by the middlemen. Sometimes farmers produce more than the market demands leading to lack of market for their products. This discourages them from producing more.

(i) Lack of proper storage facilities

Agricultural goods are seasonal but their demand is distributed throughout the year. They are also highly perishable. A lot of agricultural products go to waste during this stage due to lack of proper storage. Most farmers construct granaries which are very small and inadequate. The crop products are destroyed by storage pests in these structures or get destroyed through rotting due to leaking roofs.

(j) Poor transport facilities

Farmers lack the means to transport their products to the markets in the urban areas due to the high poverty levels. As a result, farmers sell their products at the farm level. This leads to exploitation by middlemen who will not let the farmers know the true market situation. Some farm products end up going bad altogether in the farm due to lack of proper transport.

7.2 Solutions to problems facing agriculture in Rwanda

Activity 7.2: A visit to a field day organised by an agricultural institution or agricultural research institute to find out how farmers respond to challenges they face while farming in Rwanda

Various efforts have been made in an attempt to solve the problems facing agriculture and alleviate the economy of Rwanda which is based in Agriculture. Research is also going on to find out solutions to the problems facing Agriculture in Rwanda.

The following are possible solutions to the problems facing agriculture in Rwanda:

(a) Intensive agriculture

This problem can be solved through the following:

(i) *Use of intensive farming systems* – This is to ensure increased production per unit area. Some of the intensive systems include:

- Zero grazing – This is the rearing of livestock especially dairy cattle and goats in structures known as zero grazing stalls or units. The structures have provisions for feeding, milking and sleeping. Due to the reduced movements and proper feeding, zero grazed animals produce more milk compared to those on the free grazing. However, the system is labour demanding and require heavy capital investment.
- Use of green houses – Green houses are structures in which the environmental conditions such as temperature, relative humidity, soil fertility, wind, carbon (IV) oxide concentration of a place are regulated to create a micro-climate where crops which under normal conditions would not grow in a particular area are grown. High value horticultural crops such as tomatoes and cabbages are grown in green houses. The green houses are used to grow crops in off seasons because they do not rely on rainfall, instead the crops are irrigated.

Other methods of intensive farming include; irrigation, use of fertilisers and growing high value crops such as vegetables, flowers and fruits.

(ii) *Use of improved livestock* – These animals are developed by upgrading local animals with the exotic ones through artificial insemination.

(iii) *Use of improved seeds* – These are high yielding, early maturing consumables. These are developed in research stations.

(iv) *Use of modern farming techniques* – Modern farming techniques such as spraying crops against diseases and pests, vaccinating livestock against diseases and irrigating crops can enhance the chances of high production and reduce the amount of risk. However, adopting these modern methods involves extra costs.

(v) *Improving land tenure systems* – It is used to consolidate land and reduce land fragmentation. This increases land sizes under one holding and encourages large-scale farming and mechanisation of farming activities.

(b) Provision of capital

This problem can be solved through the following ways:

(i) Forming co-operative societies – Under co-operatives, farmers pool resources together and enjoy economies of scale.

(ii) Borrowing capital – Borrowed capital is known as credit or loan. Farmers should be able to access capital from commercial banks, co-operatives and other credit giving institutions. The institutions should make borrowing terms easy to the farmer.

(iii) Government subsidies on farm inputs and outputs – The government can subsidise on farm inputs by reducing tax on agricultural inputs such as fertilisers, seeds and agrochemicals. This will reduce the prices of these farm inputs thus reducing production cost. It can also reduce excess supply by buying farm produce at a high price and then later on selling the produce to recover its money.

(c) Plant protection

This can be achieved through the following:

(i) Supplying agrochemicals at prices that farmers can afford.

(ii) Planting resistant crop varieties.

(iii) Providing extension services to farmers either by "visit and train" or organising field days.

(d) Maintaining stability in the commodity prices

Changes in commodity prices emanates from the market forces of supply and demand and as long as supply and demand keep on changing the prices of commodities will also keep on changing. The solution to the problem of fluctuating commodity prices will have to do with either minimising the effect or regulating supply. This problem can be solved through the following ways:

(i) **Contracting** – Farmers may enter into contract with consumers to supply certain goods over a specified period of time at an agreed price. Such a contract guarantees them a constant and fixed market for their produce. The only disadvantage is that should the prices rise, the farmers would not benefit.

(ii) **Diversification** – The agricultural sector should be diversified by producing various products so that while the prices of some products may be going down, the prices of others may be going up thus neutralising the effect of fluctuations of commodity prices.

(iii) Operating a buffer stock and stabilisation fund scheme to take care of shortage in production.

(iv) Signing international agreements on crop production, for example, the International Coffee Agreement to keep prices stable.

(e) Irrigation

Rwanda happens to have very many fresh water lakes and rivers. The rivers Nyabarongo and Akagera which forms part of the upper Nile drains their waters into Lake Victoria, a fresh water lake. Rusizi River drains the western region of Rwanda.

This water can be used for irrigation. Swampy areas in the eastern regions are already being utilised in food production. Other water harvesting methods can be devised to ensure as much water as possible is harvested for agricultural production.

(f) Attitudinal change towards Agriculture

This can be achieved through:

(i) Sensitisation of the people of the opportunities existing in agriculture so that they can view agriculture as a business.

(ii) Improve wages and provision of incentives in the agricultural sector so that they can be at the same level with those in other employment sectors and, therefore, attract more people into the farms.

(iii) Educating young people in schools on the importance of agriculture to the economy of Rwanda. The introduction of agriculture in the lower secondary education in Rwanda is a step in the right direction. It will go a long way in orientating the youth towards agriculture.

(g) Construction and maintenance of feeder roads

The government should ensure that all feeder roads to agricultural productive areas are accessible during the wet season by making them all weather roads.

(h) Searching proper markets

This can be achieved through:

(i) Carrying out market research to find out more markets of the agricultural products.

(ii) Venturing in across the border markets that have been created by the integration of the East Africa countries into the East African Community in which Rwanda is a member.

(iii) Formation of co-operative societies to sell goods on behalf of the members.

(iv) Use of the marketing boards to assist farmers market their produce.

(i) Improving storage facilities

Through the construction of good and improved storage facilities, farm products can be stored for a long period awaiting good market prices. The stores should be made rodent-free and leak-proof. The crop products stored should be properly dried and dressed with chemicals to keep off storage pests.

(j) Provision of better transport facilities

This can be done through the following ways:

(i) Forming co-operatives to pool resources together to acquire means of transport.

(ii) Providing credit facilities to individual farmers to enable them acquire means of transport for their produce to the markets.

(iii) Marketing boards can also provide transport for their respective crop produce grown by farmers.

Unit Summary

The agricultural sector in Rwanda has a lot of challenges and problems. However, these problems are not unique to Rwanda but are common anywhere in the world where agriculture is practised. The difference lies in the way different people or countries respond to the challenges. Some of the problems facing agriculture in Rwanda include:

- Shortage of land.
- Lack of capital.
- Pests and diseases.
- Unstable prices.
- Poor rainfall distribution.
- Bad attitude towards agriculture.
- Poor road network.
- Insufficient market for agricultural goods.
- Lack of proper storage facilities.
- Poor transport facilities.

These problems can be solved through various means and approaches.

The following solutions should be find out to solve enumerated challenges:

- Use of intensive farming systems which include zero grazing, the use of green house, the use of improved livestock, seeds, modern farming and irrigation systems.

- Provision of capital by forming cooperative societies, borrowing capital and getting government subsidies of farm inputs and outputs.
- Plant protection by supplying of agroclinicals, planting resistant crop varieties and providing extension services to farmers.
- Searching proper market, improving storages facilities, prices and maintaining stability in commodities.
- Attitudinal change towards agriculture.
- Construction and maintenance of feeder roads and provision of better transport facilities.

Research is going on to come up with new methods of handling the challenges facing agriculture in Rwanda

Key terms

1. **Field day** – A day set aside when farmers meet in a demonstration farm and taken through various methods of carrying out agricultural activities by agricultural experts or officers.
2. **Capital** – All man-made assets used in the production of goods and services.
3. **Animal-drawn implements** – These are implements that are pulled by trained animals while working.
4. **Extension service** – Advice given to farmers by experts.
5. **Visit and train** – A method of giving extension service where agricultural officers visit farmers in their farm and advise them on how to carry out agricultural activities.
6. **Mechanisation** – Use of machines in carrying out agricultural activities.
7. **Intensive farming** – System of farming that involves heavy capital investment.
8. **Seed dressing** – Covering or coating of seeds with a pesticide or insecticide to protect from damage by pests and diseases.
9. **Pests** – Living organisms that cause damage to crops. A parasite is an organism that derives its livelihood from another (a host) causing damage to it.
10. **Parasite:** A living organism that derive its livelihood from another and couses damage to it.
11. **Supply** – Quantity of goods that sellers are willing to sell at a specified price in a given market and time.
12. **Demand** – Quantity of goods that consumers are willing and able to buy at a specific price in a given market and time.

13. **Perishable** – Easily damaged.
14. **Middlemen** – These are traders who move from one farm to another buying agricultural goods from farmers.
15. **Zero grazing** – Rearing of livestock in structures known as stalls.
16. **Green houses** – These are crop production structures in which high value crops are grown under controlled environmental conditions.
17. **High value crops** – Highly perishable crops that fetch high prices when fresh, for example, tomatoes, cabbages, onions and melons.
18. **Land tenure system** – System of land ownership.
19. **Large-scale farming** – System of farming carried out on a large piece of land which is over 20 hectares.
20. **Hybrid seeds** – Seeds developed by crossing two or more pure lines of crops.
21. **Upgrading** – The improvement of local animals by crossing with exotic animals for high production.
22. **Co-operative** – Organisation of people who have joined together voluntarily with a common purpose for mutual benefit.
23. **Borrowed capital** – Credit or loan or borrowed funds.
24. **Buffer stocks** – Agricultural produce that are stored only to be released during time of scarcity to offset shortage and stabilise prices of commodities.
25. **Stabilisation fund** – A fund set aside by the government to import agricultural commodities in the event of a shortage so as to stabilise the price of the commodity.
26. **Diversification** – Allocating resources in more than one enterprise so that should one enterprise fail the farmer benefits from the other.
27. **Enterprise** – A single unit of production.
28. **Agrochemicals** – Chemicals used in agricultural production such as pesticides, herbicides and insecticides.
29. **Government subsidies** – These are government incentives given to farmers to motivate them to produce more and, therefore, prevent the shortage of an agricultural commodity.
30. **Contracting** – Entering into an agreement between two parties that is legally binding.
31. **Farm inputs** – Capital used in agricultural production, for example, seeds, fertilisers and agrochemicals.
32. **Marketing boards** – These are statutory bodies established by an Act of Parliament to oversee the production and marketing of a particular produce.

33. Gross margins – Profit realised from the sale of produce when the fixed costs are not considered.

Revision Questions

1. State five problems facing agriculture in Rwanda and give one possible solution in each case.
2. Describe two ways by which farmers can intensify farming.
3. What is the meaning of the following terms:
   (a) Mechanisation?
   (b) Diversification?
   (c) Zero grazing?
4. Differentiate between supply and demand as used in agriculture.
5. (a) What is borrowed capital?
   (b) Give two sources of borrowed capital.
6. (a) What is government subsidy?
   (b) Give two ways in which government gives subsidy to farmers.
7. Give two ways in which extension service may be provided to the farmers.
8. (a) What is an enterprise?
   (b) Give two examples of agricultural enterprises.

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