Agriculture

Senior One

Student's Book

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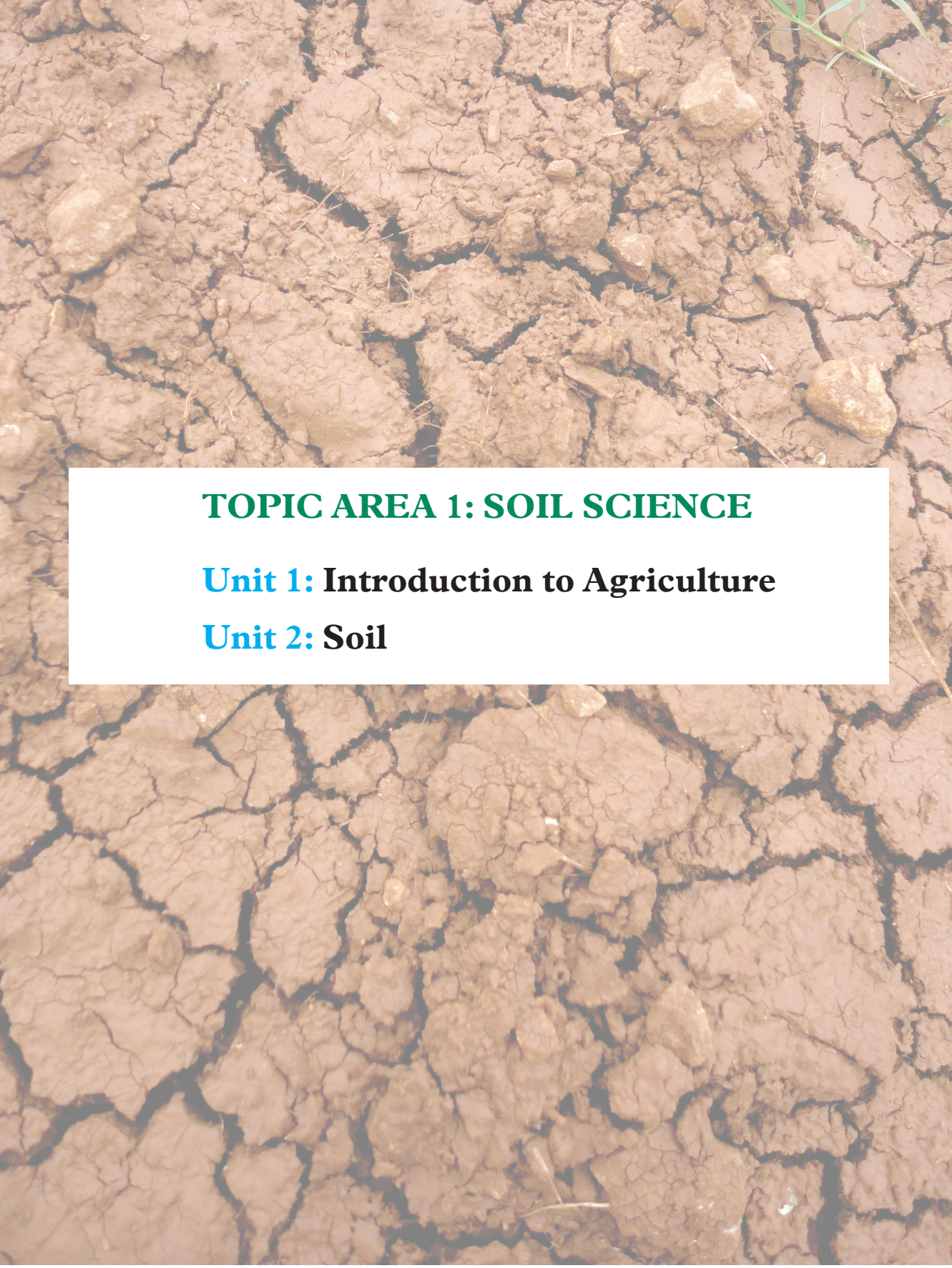

TOPIC AREA 1: SOIL SCIENCE

Unit 1: Introduction to Agriculture

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UNIT 1 Introduction to Agriculture

Introduction

The foods we eat every day are all deliberately produced at a given place. Examples include vegetables, meat, cereals, fruits and milk, among others. Some of them are produced in our country. Some are imported from other countries. You shall understand why foods are produced and why it is important to study Agriculture as a subject in this unit.

Discussion corner!

Look at the pictures below. What is happening in each picture? Do you think the activities in the pictures are of any benefit to us? Talk to your friend about this.

Key unit competency

After studying this unit, I should be able to:

a) Define the term Agriculture.
b) Explain correctly the importance of Agriculture.
c) Explain the branches of Agriculture and their relevance to human life.
d) Identify the different farming systems.

Unit Outline

1.1 Definition of Agriculture

Activity 1.1: Research Activity

Using textbooks and the internet, find out the meaning of Agriculture. Interact with your classmates to know what they have found out. Prepare a report and present to the rest of your class.

I have found out that…

Agriculture is the Art and Science of cultivating land, growing crops and rearing livestock.

The facts

Agriculture is regarded as an Art since it involves the application of human skills in processes such as milking, construction of farm structures, measuring land size and operating various farm machineries. As a Science, Agriculture requires application of various intellectual and practical skills. Examples are observation, experimentation and analysis.

Below is a chart showing the various agricultural activities in categories of art and science.

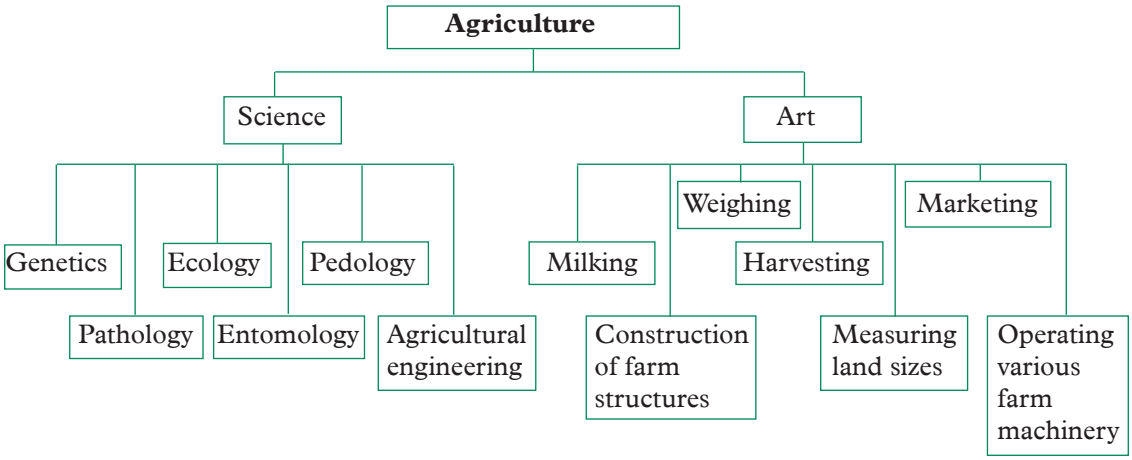


Fig. 1.1: Agriculture as an art and science subject

Money matters!

Agriculture is a major income earner for our country's economy. Therefore, let us have a positive attitude towards the subject as we aim towards having a more economically sustainable Rwanda.

Self-evaluation Test 1.1

1. Explain how Agriculture is being practised in your local environment.
2. Do you think those Agricultural practices are important? Why?

1.2 Socio-economic importance of Agriculture

Generally, Rwanda's economy relies heavily on Agriculture. About a third of Rwanda's Gross Domestic Product (GDP) is accounted for by Agriculture. In Rwanda, the Agricultural sector meets about 90% of the national food needs and it generates more than 70% of the country's export revenues. This subunit, seeks to appreciate the socio-economic importance of Agriculture to our households and country at large.

Activity 1.2

1. Go for a field trip to a nearby farm during the harvesting period. Ask as many questions as you can to the workers with the aim of understanding the various benefits of Agriculture. Note down the important points and prepare a report after the visit.
2. Try to think of other benefits that can come from practising Agriculture.
3. Do a class presentation to the rest of the class on your findings.

I have discovered that…

The socio-economic benefits of Agriculture can be presented in terms of:

- Food supply
- Source of employment
- Source of raw materials for industries
- Source of capital
- A recreational activity
- Foreign exchange earner
- Source of medicinal products

The facts

a) Food supply

Agriculture provides food needed to give us energy to engage in productive activities. The food comes from crops such as cereals, vegetables and fruits, and from livestock products, such as eggs, meat and milk. Proper feeding promotes good health. A healthy nation leads to enhanced productivity in all sectors. This ensures that development takes place.

Remember!

There is need to ensure that the agricultural sector is well-catered for; not only for the benefit of the farmers, but also for betterment of our nation's economy.

Activity 1.3

Visit a nearby agricultural market and list some of the most common agricultural produce being sold. Create a table and record the number of stalls in which certain foods are sold. Such foods can be vegetables, fruits or cereals (specify their names). From the results you will have obtained, come up with a bar graph.

Discussion corner!

From the graph in Activity 1.3 above, answer the following questions:

a) Which food is the most common in the market?
b) Which food is the least popular in the market?
c) Find out possible reasons for the answers in (a) and (b) above.
d) Give appropriate recommendations that can help to reduce the disparity.

b) Source of employment

As we have seen earlier, Agriculture accounts for a large part of Rwanda's Gross Domestic Product (GDP). This means that many Rwandans, especially those living in rural areas, are engaging, either directly or indirectly, in the agricultural sector. Direct involvement in the agricultural sector is when one actually works on the farms. This can be as a **farm manager** or any kind of casual worker in the farm. Indirect involvement can be when one works in a crop processing company or any other industry that uses agricultural produce. Those working in industries that manufacture farm inputs and other agrochemicals are also under the indirect employment category. From these, we draw that indeed Agriculture is a crucial industry. We should therefore be keen on learning more about agriculture; not just to be employed, but to be the ones creating employment opportunities for others.

Discussion corner!

Think of other agricultural activities you can come up with to expand the scope of farming carried out in your locality. Note them down and present them in class.

c) Source of raw materials for industries

The various industries present in our country play a major role in developing our economy. In most industries, raw materials are usually processed into more useful commodities. Since Rwanda is an agricultural country, most industries in the country are agriculture-based.

Examples of such industries are:

- Leather tanning factory in Gikondo.
- Inyange industries at Masaka that processes milk and fruits.

Fig.1.2 Inyange factory at Masaka, Kigali

- Food and fruit processing industry at Nyirangarama in Rulindo.
- Tea factories such as Pfunda in Rubavu, Mulindi in Gicumbi and Rubaya in Nyabihu.
- Breweries such as Bralirwa in Rubavu and Skol at Kigali.

Fig.1.3 Bralirwa industries

Quality check!

Ensure that you always buy products that have the mark of the Rwanda Bureau of Standards. Also, check that the date of manufacture and the expiry date are valid. In case of any discrepancies, alert the seller or any other appropriate authority.

- Sugar factories such as Kabuye in Gasabo.
- Rice processing units in Bugarama.

As in any other industry, it is also important for the participants of the agricultural

sector to forecast demand. In doing so, they will be able to tailor the products to suit the preferences of the consumers. Once this is achieved, it will guarantee more profits to the farmers and better products to the consumer.

d) Source of capital

Money matters!

Revenue from tax is essential for the development of our nation. We should therefore strive to promptly pay tax.

There are two forms of farming; **subsistence** farming and farming for **commercial** purposes. Subsistence farming refers to the kind of farming whereby the farmer only focuses on producing food for his/her household. Farming for commercial purposes on the other hand is mainly for business. The farmer sells produce from his/her farm in order to gain profits. From what they will have earned, the farmers will now be able to cater for their household needs and even have some extra cash to invest in other entrepreneurial ventures.

The government also gets revenue through the taxes levied on farmers. Such income enables the government to finance its recurrent expenditure and the various national development projects; such as provision of education facilities, health facilities, road construction among others.

e) Source of medicinal products

Various agricultural products, from both animals and plants, have been used since time immemorial to treat various ailments and diseases.

Despite the fact that today there is reduced use of herbs, some of these products are still being used as raw materials in the processing of the currently popular tablets and syrups.

Health check!

You should only take medicine that has been prescribed by a qualified doctor.

f) Foreign exchange earner

Activity 1.4: Research activity

Find out the meaning of the term foreign exchange. You can use textbooks in the library or the internet. Note down the meaning and discuss with your friends in the classroom.

I have discovered that...

The money that the government earns from exporting produce to other countries is what we call foreign exchange.

The facts

Agriculture is a major source of foreign exchange for Rwanda. It accounts for about 70% of the country's total export revenues. Some of the most valuable export crops in Rwanda include tea, coffee, fruits, vegetables, flowers (especially roses) and pyrethrum.

g) A recreational activity

Discussion corner!

Read this story

Uwase had a big compound in her home. She wondered what she was going to do to make her home more beautiful and welcoming. One day, she went to visit her friend Keza. Keza's home had beautiful flower gardens at almost every corner of the compound. It looked amazing. Uwase was impressed.

Study questions

1. What would you advice Uwase to do in her big compound?
2. What benefit is associated with Keza's home?

Apart from just providing food and all the other listed uses, agriculture can also be carried out solely for recreational reasons. An example would be when a farmer sets aside a small piece of land to plant flowers for beautification purposes. Flower gardens normally improve the general appearance of any given place. This can be done in private compounds, public places such as roads, schools, church compounds and hospitals. Also, fish ponds can be established to carry out fishing as a recreational activity.

Activity 1.5

With the help of your teacher, find places in your school compound that you can establish flower gardens. Look for appropriate plant seedlings and carefully plant them. You should be able to take care of those plant seedlings until when they are fully grown plants.

My environment, my life!

Agriculture is of great importance to our economy. However, we should avoid encroaching into forests in a bid to acquire land to carry out Agriculture. Our forests are equally important!

Self-evaluation Test 1.2

Study the table given below about a coffee farmer called Habimana then answer the questions that follow.

Habimana incurred the following expenses in his coffee farm in the year 2015.

Expenditure	Total cost per ha (in FRw)
Preparation of nursery bed	100,000
Buying of coffee seedlings	100,000
Treatment of seedlings	20,000
Preparation of the soil for planting	80,000
Planting	50,000
Mulching	100,000
Weeding	90,000
Treatment of pests and diseases of coffee	80,000
Harvesting	80,000
Total labour	200,000
Total cost of production per year	-
Total revenue per ha per year	-
Total profit per ha per year	-

1. Calculate the total profit per hectare per year that Habimana obtained; whereby the total number of plants per ha is 2500 and each plant produces 5kg (each kg costs FRw 200).
2. Discuss other means that Habimana can employ to increase his profit. Note them down and present them in class.

1.3 Branches of Agriculture

Activity 1.6: Research activity

Using reference books or the internet, find out the branches of Agriculture. Prepare a report and present it in class.

I have discovered that…

The branches of Agriculture are:

- Soil science
- Crop husbandry
- Animal husbandry
- Agricultural economics

- Agricultural engineering
- Horticulture

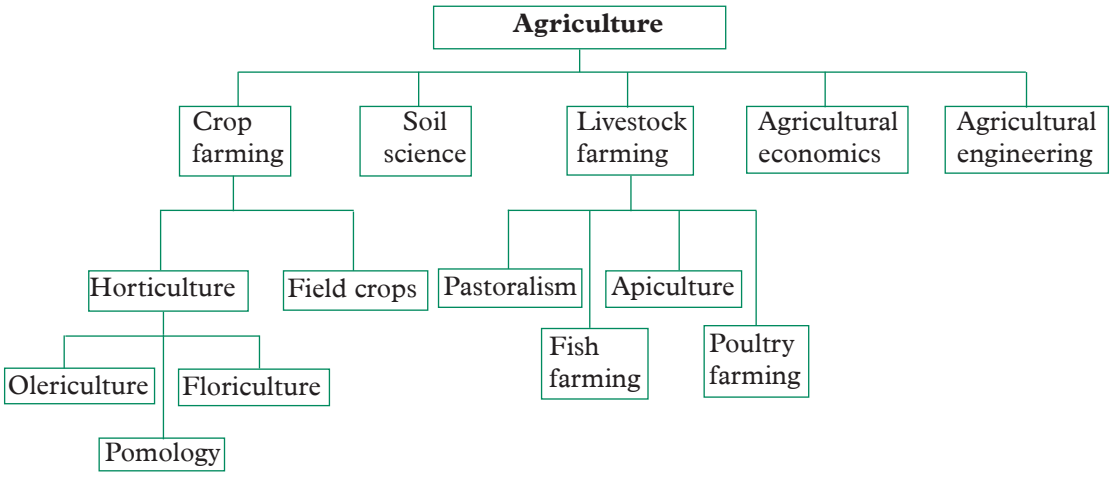


Fig. 1.4: Summary of branches of Agriculture

The facts

a) Soil science

This is the study of soil as a natural resource that occurs on the surface of the earth. The specific aspects of soil studied include soil formation, classification and mapping, physical, chemical, biological and fertility properties of soil among others. These properties are studied in relation to the use and management of soils.

b) Crop husbandry

Crop husbandry refers to all agricultural activities done to crops from the time crops are planted to the harvesting time. It also includes agricultural produce processing and storage. All these practices aim at ensuring that a crop is provided with the best conditions for optimum growth in the field. This ensures optimum returns in terms of quantity and quality of produce.

c) Animal husbandry

This refers to management and care of farm animals for a profit. It can also be defined as the practice of selectively breeding and raising livestock to promote desirable traits in them for sale, sports, pleasure or research.

In animal husbandry, genetic qualities and behaviours considered to be advantageous are further developed.

d) Agricultural economics

Discussion corner!

Read this story

Gatete grows plantains. His farm has grown bigger as compared to the one he had before. The produce is now becoming overwhelming. He needs better structures to help him get the best out of his farm. What should Gatete do?

Agricultural economics is an applied field of economics. It is concerned with the application of economic theories in improving the production and distribution of food and other agriculture-related materials.

Agricultural production involves the use of limited resources such as land, capital and labour. These resources are also known as **factors of production**. Each of these must be properly allocated in order to minimise costs while at the same time maximise revenue. This will in turn, result in high profits which is the sole objective of agricultural economics.

Activity 1.7

Visit to an agricultural farm

Visit a nearby farm and find out practices that farmers carry out to ensure that the limited resources used in Agriculture are well-utilised. Note them down and present them in class.

What I discovered...

Some practices that help to ensure that Agricultural economics is achieved include:

i. Application of principles of economics
ii. Proper accounting
iii. Proper record keeping
iv. Good marketing strategies

Money matters!

Money is the most valuable of all limited resources. It is important to learn to save money by all means. By making sure that we use the resources around us sparingly and not wastefully, we will be saving money!

e) Agricultural engineering

In this branch of Agriculture, engineering, science and technology are applied. Agricultural engineering mainly involves knowledge and usage of farm machines and equipment. It usually deals with the development of new systems and practices that aim at addressing problems of inefficiency facing the agricultural sector.

f) Horticulture

This is the branch of Agriculture that deals with the growing of **highly perishable crops**. Such crops require high level farm management skills, from planting time, to the time of harvest and also how the crop will be marketed.

Fig. 1.5: Some horticultural products

Activity 1.8

1. Visit a horticultural farm and find out the types of crops grown there.
2. Find out why the farmer chose to grow the crops. Are there any advantages of the crop over others?

What I have discovered...

Horticulture is divided into three main categories. These are:

- **Floriculture** – Growing of flowers.
- **Olericulture** – Growing of vegetables.
- **Pomoculture or pomology** – Growing of fruits.

Activity 1.9: Research Activity

Find out about some of the problems that farmers face. Find out possible solutions and present them in class.

The facts

Some of the problems that face the agricultural sector and their solutions include:

- **Inadequate capital for farmers** – Cooperative Societies have been established to help farmers obtain capital.
- **Unpredictable weather patterns** – Farming methods that are independent of weather patterns have been established through the use of irrigation systems and the green houses among others.

- **Crop pests and diseases** – Pesticides are used to deal with these problems.
- **Animal parasites and diseases** – Livestock can be sprayed using various chemicals to prevent them from succumbing to attacks by various external parasites and diseases. External parasites can be dealt with through the use of dewormers and other drugs.
- **Inadequate knowledge and lack of proper farming skills** – Farmers can be trained about the various farming techniques that will ensure that they have maximum output.
- **Inadequate awareness of proper farm inputs** – Farmers can be encouraged to use certified seeds, effective farming machines and to keep records of all these to ensure accountability.

Self-evaluation Test 1.3

1. Among all the named branches of Agriculture, which ones do you think can be applied in your school farm and why?
2. Why is floriculture popular in highlands?
3. Why is studying soil important to farmers?
4. Which three fields of study are combined with Agriculture in Agricultural Engineering?

1.4 Farming systems

Farming system refers to the way farm enterprises (resources) are organised and utilised. Different farm activities and enterprises are organised in various ways depending on the resources available to the farmer. These resources include land, capital, labour and human resource.

Activity 1.10

Field trip

1. Go for a field visit to a nearby farm and find out the various types of farming systems used.
2. Compare and contrast the various farming systems you have learnt about from your trip.
3. Come up with a report and do a presentation in the class.

I have discovered that…

Farming systems help farmers to organise and utilise their farm resources appropriately. The various types of farming systems are:

- Monocropping
- Intercropping

- Pastoralism
- Stall-feeding
- Intensive farming
- Extensive farming
- Large scale farming
- Small scale farming

The facts

a) Monocropping

This is the type of farming system whereby a single crop is grown on a large area. The farmer only grows one type of crop on the same piece of land throughout the farming season.

In Rwanda, tea, coffee, potatoes, sugarcane and pyrethrum are the main crops planted using the monocropping system.

Fig. 1.6: Monocropping of potato plants

Advantages of monocropping

(i) Operations like weeding, diseases and pests control and harvesting are easily carried out.
(ii) It is easy to mechanise field operations.
(iii) There is optimum utilisation of applied fetiliser and manure as a result of correct plant population establishment.

Disadvantages of monocropping

(i) Continuous growing of one crop may lead to depletion of a particular nutrient resulting in low crop yields.
(ii) It encourages build-up of pests and diseases.
(iii) It is difficult to control parasitic weeds on the crop, for example, the *Striga spp* in maize crops.
(iv) In cases of crop failure, heavy losses are occurred.
(v) There may be little profit realisation in cases of reduction in prices in the market.
(vi) Lack of soil cover encourages erosion especially when crops that grow upwards are planted continuously.

b) Intercropping

This involves the growing of two or three crops in association. All the crops are planted on the same piece of land. Examples of combinations of crops that can be grown using this system are maize, beans and finger millets. Intercropping can also be referred to as interplanting.

Fig. 1.7: Intercropping of maize and beans

Activity 1.11: Research Activity

Research on other crops that can be interplanted and list them down. What are the benefits of these?

Advantages of intercropping

(i) There are high crop yields per unit area.
(ii) It ensures ample soil cover especially when cereals are interplanted with legumes. This minimises soil erosion.
(iii) There is no total loss in cases of diseases and pests outbreaks. It is hence an insurance against total loss.
(iv) There is supplementation of nutrients in the soil especially when legumes are included.
(v) Some plants can even act as nurse crops for other crops. An example is the maize crop which acts as a nurse crop for bean plants.
(vi) Maximum utilisation of soil nutrients is ensured particularly when deep rooted plants are interplanted with shallow rooted plants.

Disadvantages of intercropping

(i) Carrying out of field practices, such as weeding, pests and diseases control becomes difficult.
(ii) It is not possible to mechanise the various field operations.
(iii) There is wastage of fertiliser since some of the crops planted may not respond to some given types of fertilisers. It will therefore require the farmer to apply different forms of fertiliser in order to cater for all the types of crops planted.

(iv) Use of herbicides becomes impossible since it may cause harm to some of the crops planted.

c) Pastoralism

Pastoralists are people who depend on livestock or the sale of livestock products for most of their income and for consumption. In this system, the livestock is mainly grazed on communally-managed or open-access pastures, and where there is at least some propensity of households or individuals to move seasonally with livestock. This is not common in the Rwandan culture.

Fig. 1.8: Pastoralism

d) Stall-feeding

Fig. 1.9: Stall feeding cattle

This involves keeping and feeding an animal in a stall, especially with an aim of fattening it. It is also known as **zero grazing**. Rwanda is one of the most densely populated countries in Africa.

With this condition every effort must be made both to increase agricultural output and to protect the soil from erosion. One of these efforts is to encourage stall feeding among farmers.

The idea of stall-feeding also enables production of manure for composting. The farmyard manure is used in the farms to increase the organic content of the soil. This helps to increase the permeability of soil and also improve the soil's water storage capacity, hence raising soil fertility, increasing yields and reducing erosion.

Self-evaluation Test 1.4

1. Draw a model of stall-feeding and give examples of livestock that can be kept under stall feeding.
2. How does stall feeding help small scale farmers?
3. What are the advantages of intercropping over monocropping?

e) Extensive farming

This system of farming involves use of large portions of land, normally with low capital, labour and management investment. There is also very minimal mechanisation.

Extensive farming is mostly carried out in marginal areas and wastelands.

Advantages of extensive farming

(i) It is cheap due to low capital input.
(ii) It requires less labour input.
(iii) It leads to proper utilisation of marginal areas and wastelands.
(iv) It does not require high level management skills.

Disadvantages of extensive farming

(i) It has low output due to the low investment in capital, labour and management skills.
(ii) The land is under-utilised; in terms of the available nutrients.
(iii) It cannot be practised in densely populated areas since it requires large portions of land.
(iv) It has low profit per unit area. This is because of the small amount of output obtained.

f) Intensive farming

The system is characterised by the use of a lot of labour, large sums of capital investment and high level management skills. In this system, **agricultural mechanisation** is practised and irrigation can also be applied where necessary.

A good example of a farming method that applies intensive farming is horticultural farming; which usually results in high returns per unit area.

Fig. 1.10: Intensive farming

Advantages of intensive farming

(i) There is maximum utilisation of land.
(ii) It can be practised in areas that are densely populated.
(iii) Due to the high level management skills involved, the intensive farming system often gives high yields and high quality produce.
(iv) It results in high income and high net revenue (profit).

Disadvantages of intensive farming

(i) In the event of failure-due to poor or ineffective management, or disease/pest attack, heavy losses can be incurred.
(ii) High initial capital is required.
(iii) High labour costs are incurred.
(iv) It requires high levels of skills and management.

g) Large scale farming

This entails the growing of crops and keeping of livestock in large hectares of land (usually over 20 ha). Large scale farming is mainly done for commercial purposes. Field operations are normally mechanised especially during land preparation, and in some cases, during planting and harvesting.

Large scale farming can either be intensive or extensive.

Advantages of large scale farming

(i) It results in high yields.
(ii) The farmer can take advantage of the economies of scale to increase profits.
(iii) It promotes foreign exchange earnings for the country.
(iv) It helps to create employment opportunities owing to the large labour force required where mechanisation is not possible.

Disadvantages of large scale farming

(i) A huge sum of capital investment is required for the purchase of farm inputs and machinery.
(ii) A lot of labour force is required, especially where mechanisation is not possible. This is for instance in coffee and tea harvesting.
(iii) High level management skills are required in order for good profits to be realised.
(iv) Heavy losses can be incurred in the event of disease and pest attack.
(v) It can only be practised where there are large tracts of land.

h) Small scale faming

Unlike in large scale farming, small scale farming is the growing of crops and keeping of livestock in a limited area of land. It is characterised by very minimal mechanisation. Most small scale farmers rely on their families for labour.

During high seasons, casual labourers can be hired to supplement the family labour. Due to limited arable land, the majority of farmers in Rwanda are small scale farmers. Small scale farming can be practised both for commercial purposes and also for subsistence purposes. It can also either be extensive or intensive.

Discussion corner!

Discuss about some of the reasons that can lead farmers to being small scale farmers.

The facts

Conditions that lead to small scale farming include:

(i) Lack of adequate land
(ii) Limited capital for large scale farming
(iii) Lack of market or incentives
(iv) Government policies

Advantages of small scale farming

(i) It requires low capital investment.
(ii) It has low labour requirement.
(iii) The farmer can decide to sell surplus produce to generate income for the family.

Disadvantages of small scale farming

(i) It has low output per unit area due to low investments in input and management.
(ii) It is less profitable compared to large scale farming.
(iii) The marketing of produce is difficult and unprofitable.

Fairness is my other name!

Land is a limited resource in Rwanda. We should therefore be mindful of others even as we buy out land so as to enhance peaceful coexistence with others.

Self-evaluation Test 1.5

1. Which farming system is the most economical and why?
2. Which farming system ensures maximum utilisation of land and how?
3. Among the farming systems, which one ensures high output and why?
4. Which farming system requires high level management and why?
5. Which of the farming systems do you think is the most appropriate for upcoming farmers? Why is this the case?

Remember the facts!

- Agriculture is the art and science of cultivating land, growing crops and rearing livestock.
- In Rwanda, the agricultural sector accounts for about 90% of the national food needs and it generates more than 70% of the country's export revenues.
- Agriculture has various branches. These include:
  - Soil science
  - Crop husbandry
  - Animal husbandry
  - Agricultural economics
  - Agricultural engineering
  - Horticulture
- Farming systems are ways in which farm enterprises are organised and utilised.
- Types of farming systems include:
  - Monocropping
  - Intercropping
  - Pastoralism
  - Stall-feeding
  - Extensive farming
  - Large scale farming
  - Small sale farming

Test your competence 1

1. Explain how agriculture affects human life.
2. Why is Agriculture a popular practice in Rwanda?
3. Discuss the various types of farming systems you have learnt about in terms of:
   (a) The number of crops grown.
   (b) The kind of product targeted.
4. Why would you spread awareness to your community against encroaching into forests so as to acquire land for agriculture?
5. What are some of the problems that farmers in your area face and what are the possible solutions you can give for these problems?
6. How would you recommend the structure of your school farm to be improved so that it becomes more effective?
7. (a) Which are the most commonly planted crops in your school farm and why?
   (b) Which farming system is being used to plant those crops in your school farm?

(c) Do you think the farming system being employed is appropriate? Give reasons for your answer.

8. Choose the single word used to describe growing of vegetables.
   A. Floriculture
   B. Pomoculture
   C. Arboriculture
   D. Olericulture

9. For horticultural farming to be successful there has to be a good transport system, electricity and high level farm management skills. Justify this statement.

10. Why do you think intensive farming is the most appropriate for horticultural farmers?

11. Referring to the branches of Agriculture, point out those that relate to the following subjects and also explain how they relate.
   (a) Physics
   (b) Chemistry
   (c) Home science
   (d) Biology
   (e) Economics

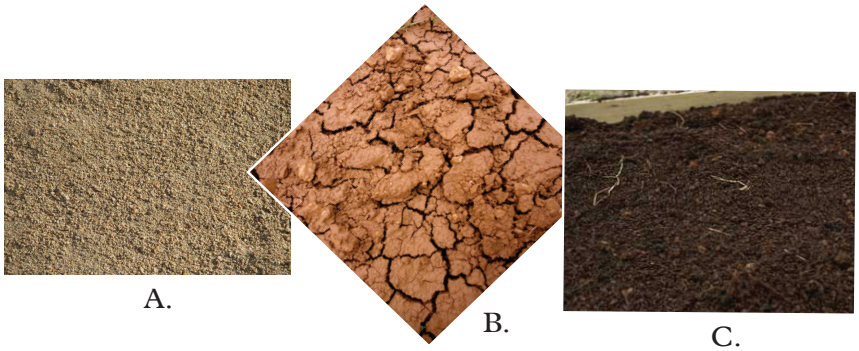
12. What do we call the type of farming where crops are grown and livestock are reared in large tracts of land?
   A. Extensive farming
   B. Intercropping
   C. Large scale farming
   D. Pastoralism

UNIT 2

Soil

Introduction

Agricultural practices are carried out on soil. This means we rely on land to do agriculture. It is therefore important for us to understand soil and its composition. Look at the pictures below. They show various types of soil. Which type of soil do you know? Which soil is suitable for farming?



A. B. C.

This unit is about soil and its importance in Agriculture.

Key Unit Competency

After studying this unit, I should be able to interpret soil formations, soil properties and the various types of soil.

Unit Outline

2.1 What is soil?

Activity 2.1: Research Activity

1. Find out the definition of soil and how it is formed. You can use the internet search engine and other reference books in the library.
2. Present your findings in class.

I have discovered that...

Soil refers to the loose natural material which form the uppermost layer of the earth's crust. Formation of soil from the parent material is referred to as soil genesis.

The facts

Soil is very important in our lives. It provides anchorage, nutrients and water to plants. The top soil, in particular, covers most of the earth's surface. It forms the fertile soil which contains minerals, organic matter and living things. It is good for farming. For this reason, this layer forms the basis of agriculture.

Self-evaluation Test 2.1

1. How does soil support plant growth?
2. What is top soil?
3. What are some of the components of soil?

2.2 Soil formation

Activity 2.2

1. Your teacher will show you a video on how soil is formed.
2. From what you have seen in the video, note down the processes of soil formation. Describe how they happen and write a report. Present your findings to the rest of the class.

I have discovered that...

Soil is formed by **weathering** of rocks through various physical, biological and chemical processes. The rock from which soil is formed is referred to as the parent material or **parent rock**. Minerals particles form the main bulk of soil. The organic portion of the soil forms a small but very important part.

The facts

Weathering refers to disintegration of rock particles to form soil. It takes several hundreds of years for a centimeter of soil to be formed. The weathering process is brought about by physical, biological and chemical agents. It is in turn influenced by climate changes, parent rock material, living organisms, topography and time. All these are referred to as **soil formation factors**.

The process of soil formation

Soil formation, or **soil genesis**, takes place through a process called **weathering**. Weathering is the breaking down and alteration of the parent rock near the surface to form soil.

The various forms of weathering include:

- Physical weathering
- Biological weathering
- Chemical weathering
- Transport and deposition

a) Physical weathering

Physical weathering, also known as **mechanical weathering**, involves disintegration of rocks into smaller fragments by physical agents. The agents include climatic factors such as rainfall (running water), temperature changes, moving ice (glaciers) and wind.

(i) **Wind** - When strong wind blows, it carries rock materials from the ground. These materials bounce on the ground and hit against each other hence breaking off into smaller fragments which form soil.

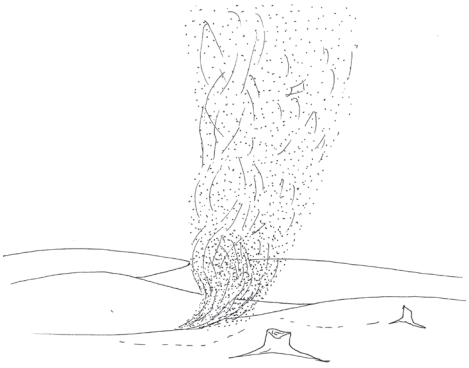


Fig. 2.1: Wind swirling soil particles

(ii) **Rainfall (running water)** - When it rains, the raindrops hit the ground with some force making rock particles to be loosened and broken down. Running water also carries small stones which hit against each other along the river bed or on the ground surface resulting in further breaking off and wearing out of rock particles. This is how **alluvial soils** are formed and deposited on river banks; and in later stages on river plains.

Fig. 2.2: Raindrops hitting a rock

(iii) **Moving ice (ice glaciers)** - Moving ice also known as **glacier**, depending on its size, has the capacity to cause rocks to rub over each other as they are carried along the ground. This causes breakdown of rock particles into small pieces. In other words, glaciers have a grinding effect on rock surfaces.

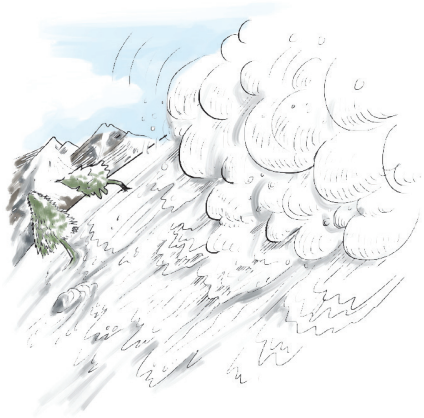


Fig. 2.3: Ice crashing against soil particles

(iv) **Temperature changes** - In places of high altitude; the temperatures are low and when water gets into the cracks, it freezes and becomes ice. As water freezes it expands hence exerting pressure on the crack. The water then melts as temperatures rise above 0°C, releasing the crack. When the temperatures drop again, the water refreezes and so on; eventually the rock breaks off due to the fluctuation in pressure.

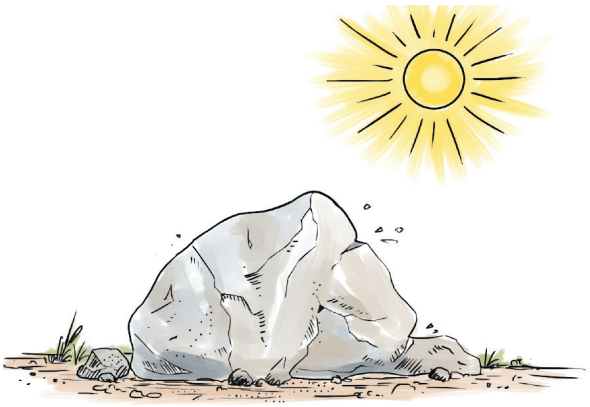


Fig. 2.4: A cracked stone due to temperature changes

(b) Biological weathering

Biological weathering involves the disintegration of rock and minerals due to the chemical and physical agents or organisms. Living organisms play a very important role in soil formation through various biological processes. Living organisms here act as agents of weathering. For example, when large animals such as cattle,

buffaloes, camels, elephants and human beings move, they exert pressure on the rocks causing small fragments of rock to disintegrate. Also, animals moving in large herds are very effective in breaking rocks or stones to form soil.

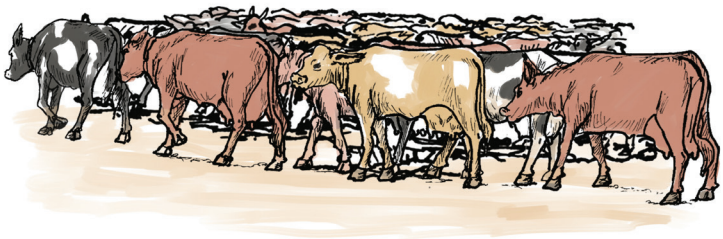


Fig. 2.5: Moving animals cause soil formation

Physical activities of human beings such as mining, cultivation, quarrying and construction of buildings, railways and roads on the earth's surface reduce the size of rocks into smaller particles.

Fig. 2.6: Quarrying cause breaking of rocks to form soil

Organisms living in the ground, including **moles** and **earthworms**, burrow the soil and break large soil particles into smaller pieces. In the course of their living, organisms produce fluids or wastes which have chemicals that can cause corrosion. Body fluids of most organisms contain ammonia, carbon dioxide and hydrogen. When these come into contact with rock surfaces in the presence of water, they cause substantial corrosion.

Roots of growing plants, on the other hand, penetrate small cracks in rocks and exert considerable pressure which eventually causes breakage of rocks. When these plants die, the roots decay leaving gaps in the rocks which are then occupied by water and air. These form acids which dissolve minerals from rocks and corrode the rocks weakening them so that they are easily broken into fragments by other agents of weathering. Roots produce acids in the soil during respiration. These acids dissolve minerals from rocks.

(c) Chemical weathering

Discussion corner!

What do you know about corrosive chemicals? Name them. Explain how they act.

Rocks which form the parent material where soil comes from are made up of chemical substances which in the course of time undergo changes that alter the composition of rocks. Chemical weathering is the actual decay or decomposition of rocks. It involves various chemical reactions which take place between rock minerals, water and certain atmospheric gases like oxygen and carbon dioxide.

Chemical weathering changes the chemical structure of the rock, making it unstable hence easy to disintegrate. Chemical weathering involves the following processes.

(i) **Carbonation** - This term describes the action of carbon dioxide on rock minerals. Carbon dioxide can dissolve in water to form a weak carbonic acid. This acid can dissolve some of the rocks, especially marble and limestone.

Chemical reaction

$$\underset{\text{(water)}}{H_2O} + \underset{\text{(carbondioxide)}}{CO_2} \longrightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

$$\underset{\text{(weak carbonic acid}}{H_2CO_3} + \underset{\text{(limestone) parent rock}}{CaCO_3} \longrightarrow \underset{\text{(calcium bicarbonate)}}{Ca(HCO_3)_2}$$

The resulting calcium bicarbonate is easily broken down since it is soluble in water. Therefore, limestone parent rocks form soils by this chemical weathering process.

(ii) **Oxidation** - This means the taking up of oxygen present in the air by an element or compound. It is important to note that oxygen also oxidises many elements. It usually occurs in compounds which contain mainly iron and sulphur. The oxides which are formed take up more space and help in rock disintegration. For example, oxygen oxidises iron from olivine rocks into ferrous oxide, ferric oxide and red ferric oxide producing red soils.

(iii) **Hydration** - This occurs when water combines with minerals present in the rocks. It causes softening of the original rocks, making them easy to break. The chemical composition of the rocks however, remains unchanged. When dehydration occurs, on the other hand, the rocks often revert to their original forms.

(iv) **Dissolution** - Water can dissolve any soluble minerals present in the rocks. When this occurs, the minerals that hold the rocks together are dissolved

and the rocks easily disintegrate. For example, in areas where there is a lot of industrial smoke being produced, the gases produced dissolve in water to form corrosive substances which can weather rocks. Some of the industrial gases produced are sulphur dioxide, hydrogen among others. When these gases dissolve in water, they form weak acids. These acids cause rocks to be brittle hence ready to weather physically.

(v) **Hydrolysis** - This occurs when the minerals in the rocks react with water. Chemical bonds in the minerals are broken by water, changing rocks from their original forms and making them easy to break. Hydrolysis best occurs where there is free movement of underground water.

Health Check!

Be careful when dealing with chemicals! Some can harm you.

(d) Transport and deposition (accumulation)

Wind acts as a transport agent and hence it can carry the weathered materials from one place to another. Where a lot of weathering materials are deposited, there are deep soils. However, where the materials were carried from will be left bare or with very shallow soils. Bacteria and fungi initiate breakdown of plant materials on the surface and within the soil. Also, arthropods such as mites, springtails and termites are chiefly responsible for more severe breakdown of plant tissues. Termites and earthworms mix organic matter with mineral fractions of the soil.

My environment, my life!

Let us by all means care for the soil; considering the long period of time taken for it to form.

Self-evaluation Test 2.2

1. Which human activities in your area do you think lead to soil formation?
2. How can we encourage soil formation and still discourage soil erosion?

2.3 Types of soils

Activity 2.3

Field trip

1. Go for a field excursion in your neighbourhood, or any appropriate place, and collect the various types of soil samples.

2. Describe the various types of soils you will have gathered.
3. Distinguish the various types of soils by touching (feel the various soil samples in between your fingers) and note down your inferences and conclusions. Use a table format.

The facts

The most common types of soils are **clay** soil, **loam** soil and **sandy** soil.

(a) Clay soils

Properties of clay soil

(i) They have more than 50% clay particles and between 0-45% silt and sand.
(ii) They have a very high water holding capacity but their ability to release this water to plants is much less compared to that of loam soil. This hence makes it difficult to cultivate crops in clay soils.
(iii) They are fine textured and smooth.
(iv) Clay usually forms extremely hard clods or lumps when dry and is extremely sticky and plastic when wet.

Fig. 2.7: Clay soil

(v) They have a crystalline and platy structure and expose a relatively large surface area which is responsible for their physical and chemical properties.
(vi) Clay soil has poor aeration and drainage but high capillarity. When wet, the clay particles expand and this impairs drainage. It therefore, makes them become heavy causing tillage operations difficult and expensive.
(vii) When containing the proper amount of moisture, it can be made into ribbons by squeezing between thumb and forefinger.
(viii) They have high nutrient absorption ability. This increases the amount of nitrogen causing the soil to have pH that is between neutral and alkaline.
(ix) Tubers and plant roots grown in such soils are greatly affected in their growth when the soil becomes dry.
(x) Lack of moisture may lead to hastened maturity in plants, making them yield less than expected.
(xi) The rate at which clay soils absorb water is low. Water therefore accumulates on the surface making them to be waterlogged. They can be improved by drainage.
(xii) This class of soil is particularly good for growing cotton and rice.

(b) Loam soils

Properties of loam soils

(i) These are medium–textured soils which contain 30–50% sand particles, 40% silt and 20% clay, with about 4% of organic matter.
(ii) They have good proportions of sand and clay in their composition.
(iii) They are the most productive soils for crop production as they contain good amounts of plant nutrients and organic matter.
(iv) They are high in soil water available for plant use and have a good water-holding capacity.
(v) They are easy to till and do not erode as easily as sand soil, hence most crops do well in loamy soils.
(vi) These soils can be improved by planting cover crops to maintain fertility and also by adding manures and fertilisers.

Fig. 2.8: Loam soil

(c) Sandy soils

Properties of sandy soils

Fig. 2.9: Sandy soil

(i) Sandy soils generally contain 80% sand particles, 10% silt and 10% clay and about 3% of organic matter.
(ii) They are usually well drained, coarse textured and moderately fertile.
(iii) They have a low water-holding capacity and capillarity, hence cannot retain enough water for plant use.
(iv) These soils are more prone to erosion than either clay or loam soils. This is mainly because sandy soils have a less stable structure on the surface.
(v) Deep rooted plants suited for arid regions can survive on sandy soils.
(vi) They are easy to cultivate but are not fertile. However, they can be improved by adding a lot of organic manure and fertilisers.

Quality check!

It is essential to establish the type of soil in a given area before growing any crops. Such knowledge will assist a farmer in planning what crops to grow and also the most appropriate type of fertiliser to apply.

Self-evaluation Test 2.3

1. Describe the type of soil in your area.
2. (a) Do you think the soil in your area is good for farming?
   (b) Which types of crops should be planted? Why?

2.4 Soil components

Discussion corner!

What do you think soil is made up of? Talk to your friend about this. Write a report and present it to class.

Soil constituents refer to the components that make up soil. They include the following:

- Mineral particles/inorganic matter or rock particles
- Soil water
- Soil air
- Organic matter (humus)
- Soil living organisms

The facts

(a) Mineral particles/inorganic matter

Mineral particles are also referred to as **inorganic matter**. It forms the main framework of soil in which plants anchor their roots. The inorganic matter of the soil is made up of particles of rocks formed from parent rock by the weathering process. The mineral constituents of these depend on the mineral composition of the parent rock from which it was derived. There are spaces between the particles which are filled with air and water.

Activity 2.4

Finding out the sizes and shapes of particles of various types of soil

Collect various soil samples from different places and observe them using a handlens or under a light microscope. Describe their shape. Draw the shapes in

your notebook. Compare and contrast the sizes of the particles. Comment on their suitability for use in growing crops.

The structures, texture and colour of the mineral particles are derived from the minerals found in the parent rock. Various soils are composed of particles of various sizes and shapes as shown below.

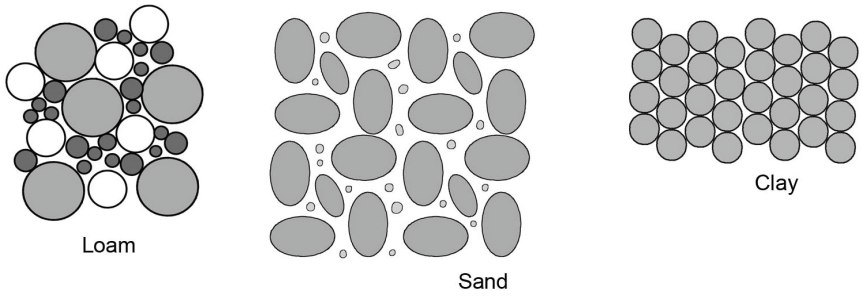


Fig. 2.10: Shapes of loam, sandy and clay soils as seen under a light microscope

(b) Soil water

Activity 2.5

Finding out if soil contain water

Apparatus/ materials

- A lump of soil
- Transparent plastic containers with leads
- Hand lens

Procedures

1. Dig out a lump of soil from a random location in your school compound.
2. Put the lump of soil in a transparent plastic container with a lid.
3. Place the container out in the sun and leave it for about 6 hours.
4. Observe the sides and lid of the container.

Discussion corner!

1. What do you see?
2. Why was the observation made?

The facts

Soil contains water which comes from precipitation (rainfall) or through irrigation. The amount of water in the soil is determined by factors such as the rate of precipitation, evaporation rate, the amount and type of vegetation cover, the water storage capacity, temperature, gradient of the land, type of soil and altitude.
Basically soil water exists in three forms, namely:

- Superfluous water
- Capillary water
- Hygroscopic water

(i) Superfluous water

This is water that exists in the large air spaces (macro-pores) between the mineral particles. It is held by gravitational force and can be made available to plants for use through the roots. This water is easily lost because it is loosely held by soil particles. Its amount varies inversely with the amount of air available. It is important to note that this water is not very useful to plants. Too much of it in the soil limits aeration and it also drains away a lot of nutrients hence causing leaching.

(ii) Capillary water

This is underground water available to plants through the roots and occupies the micropores. It is held with greater force by soil particles. It dissolves plant nutrients. It is also referred to as the available water since it leaves most of the macro-pores empty to allow aeration of the soil.

(iii) Hygroscopic water

This is water held strongly by the soil particles and exists as a thin film around the soil particles. This water is subject to forces created by soil particles and therefore it is not available to the plant. However not all soil particles have hygroscopic water. For instance sandy particles with weaker forces contain very little hygroscopic water whereas clay particles have a lot of hygroscopic water.

Activity 2.6

Finding out the percentage of water in a soil sample

1. Come up with a procedure to demonstrate the percentage of water in a given sample of soil. Your teacher may provide you with the following apparatus:
   - Soil sample
   - A porcelain dish
   - Bunsen burner
   - Stirring rod
   - Desiccators
   - Weighing balance
   - Tripod stand
   - Wire gauze
2. Record the steps you will need to follow, your results and conclusions.
3. Write a report and do a presentation to the rest of the class on your findings.

The facts

Sample procedure for investigating the percentage of water in a soil sample

1. Collect a sample of garden soil from a depth of about 20 cm.
2. Weigh the empty porcelain dish and record the weight.
3. Put some of the soil in the porcelain dish and weigh.
4. Heat the dish with its content in an oven at a temperature of about 105°C for about 1 hour.
5. While heating, the soil sample in the dish, it should be stirred to facilitate complete moisture evaporation.
6. The soil sample should be heated until a constant weight is obtained.

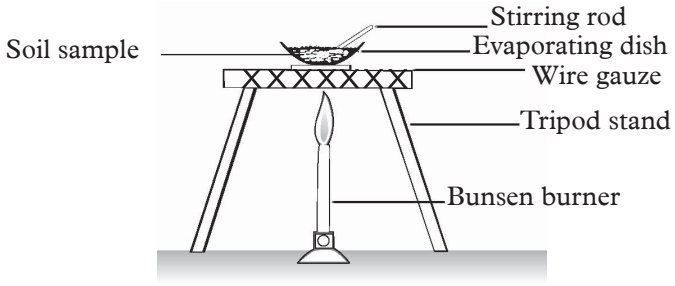


Fig. 2.11: Heating soil sample

The results of the procedure can be recorded as shown below:

- *Weight of empty dish = (a) g*
- *Weight of fresh unheated soil = (b) g*
- *Weight of dish + fresh unheated soil = (a + b) g*
- *Weight of dish + heated soil = (c) g*
- *Weight of evaporated water = (b – c) g*

Percentage of water in the soil can be calculated using this formula:

$$\text{Percentage of water lost} = \frac{\text{Mass of water lost}}{\text{Mass of fresh soil}} \times 100\% = \frac{(b - c) \times 100\%}{(b)}$$

I have discovered that...

Soil contains a certain percentage of water; hence water forms a substantial proportion of soil. However, the quantity of water in soil varies with different soils. For instance, sandy soil contains much less water compared to both clayey and loamy soils.

The facts

The following are importances of soil water:

(i) Water serves as a solvent for the plant nutrients (minerals) in the soil.

(ii) It is an essential raw material used in the process of photosynthesis by plants.
(iii) It is taken in by plants as a coolant in the process of transpiration.
(iv) Most of the protoplasm in plant cells is made up of water. It makes the plant cells turgid. The movement of this water within the plant cells makes the plant to stand upright (erect).

(c) Soil air

The air content of soil consists of oxygen, carbon dioxide, nitrogen and other rare gases. Soil air is located in soil pores separated by soil particles. The content and composition of soil air is determined to a large degree, by soil–water relationships. Air simply moves into the soil pores that are not occupied by water.

Table 2.1 Components of air in soil

Gas	Percentage
Nitrogen	78%
Oxygen	21.0%
Carbon dioxide	0.03%
Rare gases / inert gases	1%

The amount of air in the soil is inversely proportional to the amount of water in the soil pore spaces. The pore size and distribution is influenced by soil texture and structure. The air in soil has remarkable influence on plant growth and soil organisms; especially for respiration of plant roots. The presence of air in the soil leads to oxidation, which converts part of organic matter into nitrates; a form readily available to the plants.

When there is less oxygen in the soil, some plants may not do well. This is because their roots are not able to absorb water from the soil. Excess carbon dioxide in the soil can cause harm to plant roots.

A good soil for crop growing must contain an adequate amount of air. The air must circulate freely and continuously in order to keep oxygen at a level high enough for proper plant growth. For instance, there must be a balance between soil water and soil air for most crops to do well. It is important to note that the nitrogen in the soil must be converted into nitrates by the nitrogen–fixing bacteria for it to be available for plant use.

Activity 2.7

Determining the presence and percentage of air in soil

1. Find out how to establish the percentage of air in a soil sample. Your teacher may provide you with the following apparatus:

- A small tin (of known mass)
- A large graduated glass
- Trough
- Stirring rod
- Ruler
- A knife
- 500 cm^3 graduated cylinder
- Hammer
- A nail

2. Record the steps you will follow, your observations and conclusions.
3. Write a report and make a presentation to the rest of the class.

The facts

Sample procedure for investigating the presence (percentage) of air in a soil sample

1. Fill a tin of known mass, for example a 300 g jam tin, with water and transfer the water into the 500 cm^3 cylinder.
2. Then fill the tin with garden soil and use a ruler to cut clean the soil in the tin so that it fills just up to the brim.
3. Place the tin with soil carefully into the water in the graduated cylinder. The tin should be placed upside down without pouring the soil out.
4. Record the final volume of the soil and water in the cylinder.

Note: It is important to note that the volume of the soil in the tin is equal to the volume of the tin. This experiment could be repeated with different soil types such as clay and loam.

5. Put some soil in glass of water as shown below. Note your observations

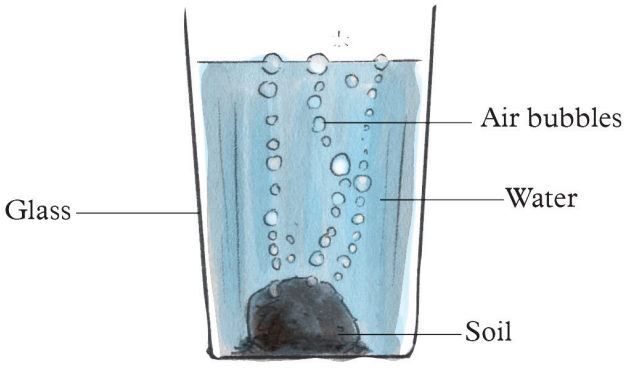


Fig. 2.12: Finding out presence of air in soil

I observed the following:

- When the small tin with soil was placed in the water the level of the water rose.
- Bubbles of air were also seen escaping from the small tin through the holes at the base of the tin.
- While the bubbles were escaping the level of the water was dropping.

The results of the procedure can be recorded as shown below:

Volume of soil in cylinder = (a) cm^3

Original volume of water in the cylinder = (b) cm^3

Volume of soil and water in the tin = (a+b) cm^3

New volume of soil after air has escaped = (c) cm^3

Percentage of air in the soil can be calculated as shown below:

$$\text{Percentage of air lost} = \frac{\text{Volume of air lost}}{\text{Volume of fresh soil}} \times 100\% = \frac{(a - c) \times 100\%}{(a)}$$

I have discovered that...

Soil contains a certain percentage of air. Hence air is a component of soil. The percentage of air in any given soil depends on the type of soil.

The facts

The following are the importance of air in soil:

(i) Air is required for plant respiration.

(ii) Oxygen in the soil combines with many elements in the soil so that they become available to plants. For example oxygen combines with nitrogen to form nitrates which are used by plants.

(iii) Plants and animals that occupy spaces in soil require oxygen for respiration. These organisms are useful in the process of soil formation.

(d) Soil organic matter

Soil organic matter is derived from partially decayed and totally decomposed plant and animal remains. Organic matter that has totally undergone decomposition is called **humus**. Humus may be dark or brown in colour and is very rich in plant nutrients. It is usually found at the top of the soil profile. Due to its dark colour, humus absorbs and retains a lot of heat. Therefore, soils rich in humus are relatively warm.

The process of breaking down organic matter releases carbon dioxide into the atmosphere. Other substances such as sulphates $(SO_4)^{2-}$, phosphates $(PO_4)^{2-}$, nitrates $(NO_3)^-$ and other nutrients are oxidised and released into the soil for plant use. Humus also cointains important minerals such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and ammonium $(NH_4)^+$ ions which are released to plants for their nutrition. It is important to note that a good supply of humus in the soil increases the amount of water absorbed and its availability in the soil.

Activity 2.8

Determining the percentage of organic matter in soil

1. Come up with a procedure to find out the percentage of organic matter in various soil samples. Your teacher may provide you with the following materials and apparatus:
   - Silica dish/porcelain dish
   - Fresh garden soil
   - Weighing balance
   - Tripod stand
   - Bunsen burner
   - Wire gauze
   - Stirring rod
   - Desiccator
2. Record the steps you will have followed and your results.
3. Write a report and do a presentation to the rest of the class.

The facts

Sample procedure for investigating the presence (percentage) of organic matter in a soil sample

1. Weigh the empty silica dish and record the mass.
2. Collect fresh samples of garden soil from a depth of about 20 cm where there is a high likelihood of getting a good supply of humus.
3. Put the collected soil sample in the dish and record the mass.
4. Heat the soil sample in an oven at a temperature of about 105°C for two hours.
5. Allow the moisture in the soil to evaporate.
6. Cool the sample in desiccator-this is to prevent more moisture from being added into the soil.
7. Weigh the cooled soil sample and record the new mass.
8. Heat the cooled soil sample strongly over a Bunsen burner noting any change in appearance of the soil during the heating process. The heating will remove

the humus in the soil, converting it to gases. The gases then escape into the atmosphere.

9. Cool the dish and soil sample in the desiccator.
10. Weigh it and record the new mass. (Note:This heating, cooling and weighing is repeated until a constant weight is obtained.)

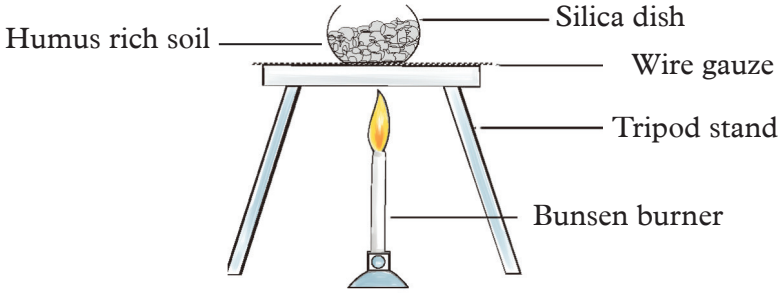


Fig. 2.13: Strongly heating humus-rich soil

The results of the procedure can be recorded as shown below:

- *Mass of silica dish = (a) g*
- *Mass of fresh soil = (b) g*
- *Mass of burnt soil = (c) g*
- *Mass of strongly burnt soil = (d) g*
- *Mass of humus removed = (c – d) g*
- *Percentage of humus in the soil can be calculated as shown below:*

$$\frac{\text{Mass of humus} \times 100\%}{\text{Mass of fresh soil}} = \frac{(c - d) \times 100\%}{(b)}$$

I have discovered that...

There is always a percentage of humus in a given soil sample. Hence soil contains organic matter or humus.

The facts

The following are the importance of organic matter in soil:

(i) It is a major source of most plant nutrients such as nitrates, phosphorous, sulphur and calcium.

(ii) Organic matter provides food for micro-organisms in the soil. These micro-organisms promote the process of soil formation.

(iii) Organic matter in the soil absorbs moisture and acts as a sponge, resulting in moisture retention.

(iv) Organic matter binds soil particles together. It helps to maintain the structure, workability, aeration, water penetration and increases the water holding capacity of the soil.

(v) Organic matter has a texture that helps increase the water holding capacity especially in sandy soils.
(vi) The dark colour of humus makes it absorb and retain more heat in the soil thereby moderating soil temperature.

(e) Soil living organisms

Living organisms are a very important component of the soil. In fact, soil contains a variety of living organisms. They range from micro-organisms such as bacteria and fungi to insects, earthworms and rodents. These micro-organisms live in the micro-pores in the soil particles whereas the larger organisms burrow into the soil. When, larger organisms such as earthworms burrow into the soil, they make it well aerated and loose. On the other hand, micro-organisms such as bacteria, fungi and protozoa help in the decomposition of organic matter. Some bacteria, such as those of the rhizobium group, live in the roots of leguminous plants. They help in converting soil nitrogen into nitrates. These nitrates are later absorbed by plants. However, some of these micro-organisms may damage crops by causing diseases. Examples are bacterial and fungal diseases that attack crops.

Activity 2.9

Determining the presence of living things in a soil sample

1. Come up with a procedure of an experiment to show presence of living organisms in soil. Your teacher may provide you with the following apparatus and materials:
    - Fresh garden soil
    - Porcelain dish
    - 2 conical flasks
    - Rubber corks
    - Bunsen burner
    - Strings
    - 2 muslin bags
    - Lime water
    - A tripod stand
2. Record the steps you will follow, your observations, reasons and inferences.
3. Write a report and do a presentation to the rest of the class.

The facts

Sample procedure for investigating the presence of living organisms in a soil sample

1. Collect a sample of fresh garden soil.

2. Place half of the collected soil on a porcelain dish and heat it until you are sure that all the living organisms are dead. Then let it cool.
3. Place the other half of the fresh garden soil in a muslin bag and suspend in the first conical flask containing lime water as shown in Fig. 2.14 A.
4. Place the heated soil in another muslin bag and suspend it in another conical flask which has lime water as well. See Fig. 2.14 B.
5. Leave the set up to stand for about 4 hours then make your observations.

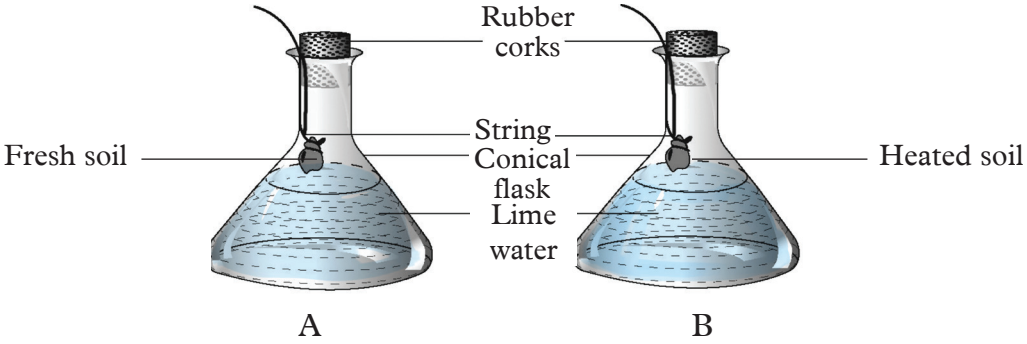


Fig. 2.14: Investigating presence of living organisms in soil

I have observed that:

Lime water in conical flask A turns milky while lime water in conical flask B remains clear.

The lime water in conical flask A turns milky because living organisms present in fresh soil exhale carbon dioxide during respiration. This is what forms the white precipitate when it comes into contact with lime water.

$$\underset{\text{(lime water)}}{Ca(OH)_2} + \underset{\text{(carbon dioxide)}}{CO_2} \longrightarrow \underset{\text{(white precipitate)}}{Ca(HCO_3)_2}$$

The lime water in conical flask B remains clear. This is because the soil living organisms in that soil sample were burnt to death during heating; hence no carbon dioxide was present to turn the lime water milky.

What I have discovered!

- Garden soil usually contains living organisms which respire actively.
- These organisms take in oxygen and exhale carbon dioxide.

Importance of living organisms in the soil

(i) Living organisms help in soil formation by physically breaking down the soil particles.

(ii) The micro-organisms assist in the decomposition of organic matter in the soil.

(iii) The larger organisms on the other hand burrow the soil and in the process they aerate it.

(iv) Certain micro-organisms such as the rhizobium bacteria help fix free nitrogen in the atmosphere into nitrates. This makes it available to plants.

My environment, my life!

We should avoid burning soil and using harmful chemicals on it. These might cause harm to the living organisms in soil.

Self-evaluation Test 2.4

1. Given the following information:
   Weight of empty dish = 15 g
   Mass of dish + fresh soil = 45 g
   Mass of dish + heated soil = 40 g
   Calculate:
   (a) Mass of unheated soil only.
   (b) Mass of heated soil only.
   (c) Mass of evaporated moisture.
   (d) Percentage of water in the soil.
2. Given the following information:
   Mass of silica dish + fresh soil = 36 g
   Mass of silica dish + burnt soil = 35 g
   Mass of silica dish + strongly burnt soil = 33 g
   Calculate the percentage of humus that was in the original soil sample.
3. What is the significance of soil living organisms in the soil?
4. Why would it be important to establish the percentage of organic matter in a soil?

2.5 Soil profile

Activity 2.10(a)

Field trip

1. Go out into the field. With the help of your teacher, find a hole that has been recently dug. Observe, from the wall of the hole the various layers of soil. You can also visit a quarrying site to observe these layers.
2. Make a drawing of what you have seen in your notebook.
3. Back in your class, compare the layers you drew with the chart provided by the teacher. Did you get the layers right?

I have discovered that...

Soil profile is the vertical arrangement, or a cross-section of soil layers from the ground level (surface) to the parent rock. These layers are known as **horizons**. The horizons differ in properties such as colour, texture, structure, porosity, organic matter content and chemical composition.

The facts

Soil profile can help to determine whether the soil is mature or recently formed. This depends on the number of horizons present. From the soil profile, we can also determine the origin of the parent material involved in soil formation. Every soil type has its own way of formation. The horizons in a soil profile are:

- Top soil
- Subsoil
- Substratum (weathered rock)
- Parent rock (bedrock)

These layers can also be named as horizons A, B, C and D respectively, as shown in the diagram below.

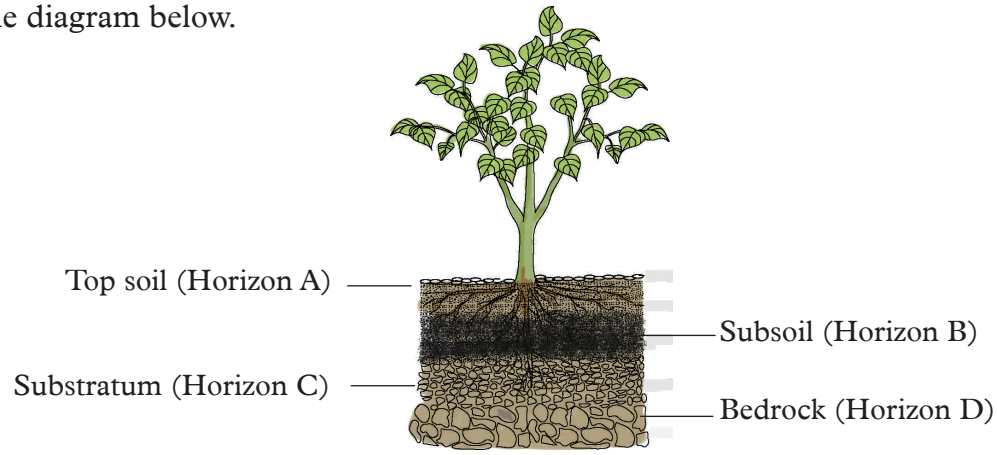


Fig. 2.15: Soil profile

Characteristics of the horizons in the soil profile

(i) Horizon A (Top soil)

This is the uppermost soil layer which lies beneath the superficial layer (surface) and marks the beginning of the mineral soil. It is commonly known as the top soil. It is characteristically dark in colour due to its high humus content. It is well aerated and contains active living organisms which break down and decompose organic matter into humus. Most plant roots and nutrients are found here. This zone is permeable to air and water and it is also well-drained.

(ii) Horizon B (Subsoil)

This is the layer found immediately below the top soil (Horizon A) and is also referred to as subsoil. Tap roots of large plants reach to this layer. The base of this layer is more compact and less aerated than their top soil. It also contains an impermeable layer called a hard pan. This hard pan impedes drainage and may prevent root penetration. There are clay deposits in this zone because of the downward movement of clay colloids. Sometimes minerals are leached from the subsoil and accumulate here, hence the subsoil layer is also referred to as layer of accumulation.

(iii) Horizon C (Substratum or weathered rock)

This layer is also referred to as substratum or weathered rock. This layer is found beneath the subsoil and is partly made of weathered rock with no humus. Tap roots of large trees may reach this layer and draw water from it during the dry season. The layer is hard, therefore impermeable to water. During erosion, most parts of the horizon A and B are washed away to expose this layer.

(iv) Horizon D (Bedrock)

This layer is found below the weathered rock and is also referred to as the **parent rock** or bedrock. This layer is completely impermeable to water and air. Soil is formed from this rock. The entire soil profile is from this horizon. Water table is found in this layer.

Activity 2.10 (b)

Having learnt about the various layers of soil, refer to the diagram you drew in Activity 2.10(a) and label it (name the various layers you have learnt about correctly). Recognise the most important layer and explain why it is important.

Influence of soil profile on crop production

a) The suitability of a soil for agricultural production can be determined by the depth of the soil profile. Farmers look at how deep the soil profile is to decide what crops to grow and how best to cultivate the land.

b) Soils on steep slopes have their top fertile layers washed away. This type of soil has very thin or shallow top layers. Erosive agents especially water can easily wash it away. This makes such soils less fertile and they therefore cannot support growth of healthy plants.

c) A deep soil having a well developed profile has great potential for agriculture. It is able to hold more moisture for plant use than a shallow one.

d) A loosely packed subsoil layer allows easy penetration of roots, drainage and aeration. It also ensures that erosion does not take place and reduces the

degree of run-off. This layer must also be fairly deep. The maintenance of the top soil and subsoil ensures that fertile soils are available for plant growth.

e) Most of the soil nutrients are contained at the top soil. This is vital to plants since most soil organisms, such as soil microbes and plant roots spread here.

f) The top soil is usually better aerated. It has therefore more active micro-organisms which decompose the vegetable matter into humus.

g) The nature and composition of the mineral components of the bedrock have influence on the mineral components of the whole soil. Thus the mineral nutrients that a soil is able to supply to the plant largely depends on the mineral composition of the parent rock. If, for example, the parent rock lacked in some minerals, then the soil formed from it will also lack those same minerals.

h) Crop production is influenced by root penetration into the subsoil and by the amount of moisture and nutrients held there. An impermeable subsoil will restrict root growth and penetration.

i) The topography on which the soil develops greatly influences its properties. Soils that develop from slopes have shallow horizons A and B than soils developing from level topography. Soils on level grounds are darker in colour than soils on steep slopes.

My environment, my life!

We should all actively participate in activities that help to reduce soil erosion.

Self-evaluation Test 2.5

1. Explain how we can ensure that soil profile is well maintained.
2. How important is the top soil to plant growth?

2.6 Soil properties

Soil properties can be explored from three perspectives. They include:

- Physical properties
- Chemical properties
- Biological properties

a) Physical properties of soil

Activity 2.11

Collect various soil samples from different areas in your locality. For each of the samples:

1. Observe the colour and record.

2. Pass the soil particles in between your fingers to feel how smooth or rough they are and record.
3. Use a hand lens or light microscope to observe how the aggregate soil particles look like. Draw the shapes of the various soils in your notebook.

What I have discovered

The physical properties of soil include:

- Soil colour
- Soil texture
- Soil structure

The facts

(i) Soil colour

Soils tend to have distinct variations in colour when looked at horizontally and vertically as well. This property can help identify the nutrients in the soil. It also gives information on the present condition of the soil system. Soil colour is determined by the minerals present in the parent rock, the amount of organic matter and the amount of iron in the soil. If a soil was formed from a rock containing a lot of iron compounds, it tends to be brownish or reddish in colour. Such soils are rich in oxidised iron.

Soils rich in organic matter are usually black in colour. This is due to the presence of humus and other substances in the soil such as peat and more or less decomposed plant residues. The amount of water present may also determine the type of reactions that take place in the soil. It may also determine the colour of the soil. For example, soils which have a lot of water are poorly drained and they tend to develop a greyish colour. In arid areas, soils develop a high concentration of solute salts. They do not have organic matter and are generally whitish-yellow in colour. The combination of iron dioxide and organic content gives many soil types a brown colour.

It is important to note that soil colours influence soil temperature. Dark soils absorb and retain more heat than light coloured soils. High temperatures affect the activity of soil micro-organisms. Soil micro-organisms will be more active in high temperatures. Under such conditions, the decay of organic matter is usually faster than it is in low temperatures.

(ii) Soil texture

The term soil texture refers to the relative proportions of the various sizes of mineral particles in soil. More appropriately, soil texture is a term commonly used to designate the proportionate distribution of the different sizes of mineral particles in a soil.

Soil texture can also be defined as the coarseness or fineness of a soil sample when felt between fingers. Some particles are large and therefore coarse in texture while others are small. The small particles are fine to the feel between the thumb and the index finger hence giving a fine texture.

Table 2.2 Classification of soil particles according to their texture and water retention abilities

Soil particles	Diameter (mm)	Water retention ability
Clay	Less than 0.002 mm	Very high
Silt	0.002 mm to 0.02 mm	High
Fine sand	0.02 mm to 0.2 mm	Medium or average
Course sand	0.2 mm to 2 mm	Low
Granule large stones	Greater than 2 mm	Very low

Soil textural classification

Most soils do not consist entirely of particles of the same size. Most soils are a mixture of sand, silt and clay particles. The texture of the soil determines its ability to absorb and retain water and soil nutrients. The following are the classes of soil according to their texture:

- Clay soil
- Sandy clay
- Sandy loam
- Clay loam
- Loam soil
- Silty loam
- Silty clay

These classes can be obtained using the textual triangle see fig 2.16. Follow any two component percentages to find the name of the soil type.For example, for a soil that is 75% silt and 50% clay. Find 50% along the bottom (clay) line. Follow the slanted (dotted) line until you reach the horizontal line for 75%. The soil type is clay loam.

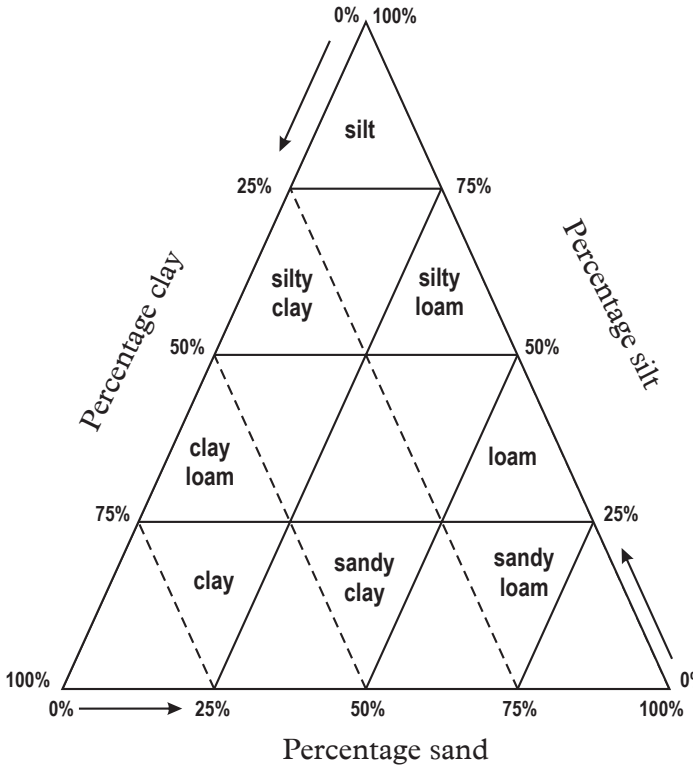


Fig. 2.16: Textural triangle

Activity 2.12

Demonstrating that soil is made up of differently sized particles

1. Come up with an experiment to demonstrate that soil is made up of differently sized particles. Your teacher may provide you with the following materials and apparatus:
   - Garden soil
   - Water
   - Sodium carbonate
   - A 250 cm^3 measuring cylinder
2. Record the steps you followed, the observations and results you obtained.
3. Write a report and do a presentation to the rest of the class.

The facts

Sample procedure for investigating the sizes of various soil particles

1. Collect fresh garden soil.
2. Put about 50 g of the soil in the 250 cm^3 measuring cylinder.
3. Add sodium carbonate about four times the volume of water to help in dispersion of the soil particles.
4. Cover the mouth of the cylinder with your hand and shake vigorously for about two minutes.
5. Place the cylinder on the bench for about one hour or more to allow the contents to settle down.

I observed that...

The soil in the cylinder settles in various layers as shown in figure 2.17 below.

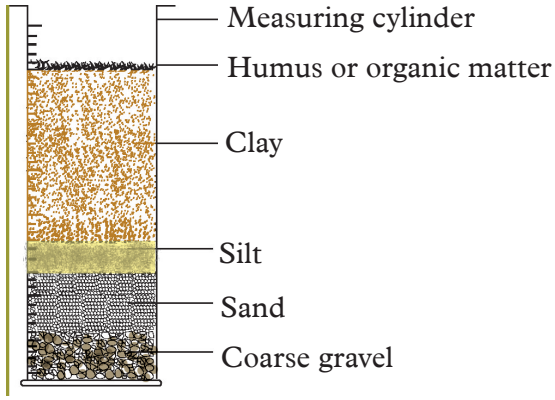


Fig. 2.17: Separation of soil particles

- The heavy, coarse gravel settled first.
- Followed by sand, silt and clay.
- The humus and other organic matter remain floating on the water.
- The depth of each layer can be assessed by reading from the marks on the measuring cylinder.

I have discovered that...

Garden soil is a mixture of particles of different sizes.

Activity 2.13

Determining size of particles of different types of soil

1. Perform an experiment to determine size of particles of different types of soil. Your teacher may provide you with the following apparatus and materials:
   - Sieves of different mesh diameters

- Garden soil
- Containers
- Weighing balance

2. Record the steps you followed, the observations and the inferences made.
3. Write a report and do a presentation to the rest of the class.

The facts

Sample procedure of an experiment to determine sizes of different soil types

1. Collect fresh garden soil.
2. Place a known amount of soil into a container.
3. Crush the soil lumps without breaking the particles.
4. The crushed soil should be passed through the sieve with the largest mesh diameter (2.00 mm) and shaken vigorously.

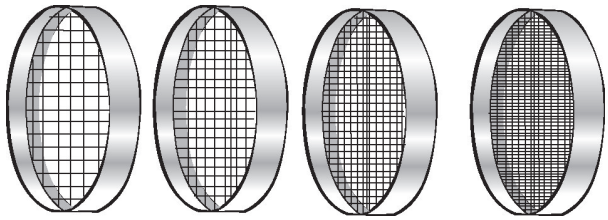


Fig. 2.18: Sieves of different mesh diameters

5. Observe the sizes of the soil particles that remain on the sieve and record.
6. Repeat the process using the other sieves with mesh diameters of 0.2 mm and 0.02 mm (always using the soil that passes through the previously used sieve).

I have observed that...

Some larger soil particles are always left on the different sieves used. The soil particles left on the first sieve of mesh diameter 2.00 mm are called **gravel**; from the second sieve (0.2 mm), **coarse sand** particles; from the third sieve (0.02 mm), **fine sand particles**; from fourth sieve (0.002 mm), **silt particles** and whatever particles pass through the smallest sieve (0.0002 mm) are **clay particles**.

Note: The proportions of the various soil particle sizes can be calculated based on the original mass of soil sample.

I have found out that…

- Soil is made up of differently sized particles.
- Gravel particles are fairly large and heavy because they contain a lot of iron.
- Sand particles are coarse textured and are very well aerated. When wetted and felt between the fingers, sand particles are coarse and gritty.
- Silt particles are smooth and powdery. They normally increase the water holding capacity of the soil. Therefore the higher the amount of silt in a soil, the greater the amount of water available for plant use in that soil.
- Clay particles are fine and colloidal in nature hence their rate of water absorption is very good. Clay particles are closely packed together and contain very small and few air spaces. They feel smooth, sticky and plastic when wet and can easily be molded. They form very hard lumps when dry. Such particles remain suspended in water for a very long time.

Activity 2.14

Determining the water-holding capacity of a given soil

1. Carry out an experiment to find out the water-holding capacity of various soil samples. Your teacher may provide you with the following apparatus and materials:
   - Measuring cylinders
   - Funnels
   - Water
   - Cotton wool
   - Sandy soil
   - Clay soil
   - Loam soil
   - Stop watch
2. Record the steps you will have followed, your results and conclusions.
3. Write a report and make a presentation to the rest of the class.

The facts

Sample procedure for investigating the water holding capacity of various soil samples

1. Dry the soil samples in the sun.
2. Crush all the soil samples except sandy soil.
3. Plug the funnels with equal amounts of cotton wool.
4. Place equal amounts of the three different types of soil into each of the funnels.

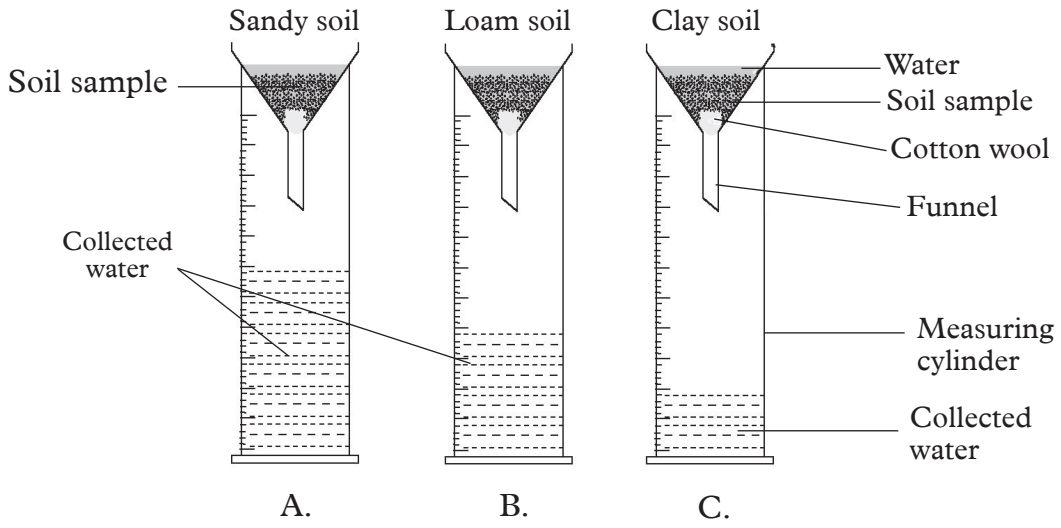


Fig. 2.19: Determining water-holding capacities of different soils

5. Place each funnel onto a separate measuring cylinder as shown above, and then quickly pour 20 cm^3 of water into each of the funnels. (The water should be poured into each of the funnels simultaneously as a fourth learner starts the stop watch.)
6. Record the time taken for any known volume of water to drain through each of the soil types in each measuring cylinder. (Once the stop watch has been stopped, the funnels must be removed from each of the measuring cylinders so that no more water drains in. Label the respective measuring cylinders with the type of soil).
7. Note the volume of water collected from each set up. In which soil was most water collected?

I observed that...

- After about half a minute, the first drop will come from the funnel containing sandy soil.
- In the funnel containing loam soil, the first drop was seen after about one minute while the first drop from clay soil took about five minutes to drip into the measuring cylinder.

Conclusion

- Clay soil is least porous of the three types of soil while sandy soil is the most porous.
- It can also be said that sandy soil has low water-holding capacity while clay has the highest water-holding capacity.
- Loamy soil has an average porosity and water-holding capacity.
- Soils found in low-lying areas and depressions which are characterised by dull

colours and fine textures usually range between imperfectly drained and poorly drained.

Activity 2.15

Comparing capillarity in different soils

1. Come up with an experiment to compare the capillary action of different soils. Your teacher may provide you with the following apparatus and materials:
   - Long capillary tubes
   - Trough
   - Water
   - Samples of sandy, clay and loamy soils
   - Cotton wool
   - Stop watch
   - A ruler
   - A clamp
2. Note down the steps you followed, and the observations and inferences you made.
3. Write a report and do a presentation to the rest of the class.

The facts

Sample procedure for an experiment to compare the capillarity action of different soils

1. Collect the three types of soil, sandy, clay and loam and ensure they are adequately dried.
2. Crush the loam and clay soil samples to fine particles except the sandy soil.
3. Plug one end of each capillary tube with cotton wool.
4. Put the samples of sand, loam and clay soils labelled A, B and C respectively in separate capillary tubes.
5. Using a clamp, hold the tubes upright in the water trough as shown in Fig 2.20.
6. Put water into the trough to a depth of 5 cm.
7. Remove the tubes from the trough after about 3–5 minutes and measure the height of water in every tube.
8. At least six readings should be taken.
9. Leave the experiment to stand overnight. Examine the height to which the water has risen in each kind of soil after 24 hours.

10. Plot the results on a graph; mark the time in minutes along the horizontal axis and water height in centimeters along the vertical axis.
11. Plot the graphs for each of the three samples on the same axes.

Note: By comparing the three graphs, we can deduce the relationship of size of soil particles to capillarity action represented by the height of the water.

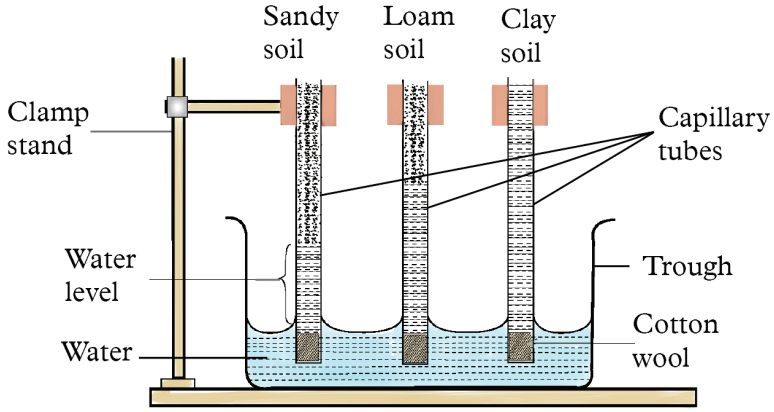


Fig. 2.20: Determining capillarity action of different soils

I observed that…

- After some time, water rose up through the three tubes by capillarity action. The water rose fastest in clay soil followed by loamy soil within the first few minutes. After about 2 hours, the level of water in the clay soil was highest followed by loam soil and then sandy soil.
- The water stopped rising first in sandy soil and it stopped rising last in clay soil.

Conclusion

- Clay soil has the highest capillarity of the three soil types.
- Loam soil has average capillarity. It is therefore good for crop production.
- Sandy soil has the lowest capillarity.

Money matters!

Care should be taken when using the various laboratory equipment in a bid to minimise damage.

(iii) Soil structure

Soil structure refers to the physical appearance of soil in terms of how the individual soil particles are arranged, packed and aggregated. It is a term used to describe the overall arrangement or grouping of soil particles. Aggregated soil consists of many soil particles held or cemented together. They form natural units of compound

particles/clusters or aggregates. The consistency of the soil changes with the amount of water present in the soil. Soil aggregates are often separated from adjoining surfaces by lines of weaknesses.

When a soil sample is dry, its consistency is described as loose, soft, hard or very hard. When moist, its consistency is loose, friable or firm. Wet soils are sticky and plastic. This is especially true of clay soils. Soil organic matter is important in soil aggregation due to its binding effect.

Types of soil structures

Activity 2.16

Go out into the field and collect soils from different places. (Be careful not to crush the soil samples). Label the soils depending on where they were obtained. Carry the soil samples carefully back to class. Observe the soil under a hand lens. Draw the various shapes of soil structures observed. Comment on the shapes of the structures and where the soil sample was obtained.

The facts

There are various types of soil structures. They are categorised according to the arrangement of the particles and the pore spaces in the soil. Soil structure depends on the kind and extent of **aggregation**. Aggregation is influenced by climate, living organisms, topography, parent material and time. Clay particles and humus influence soil structure by the way they cement or build the different soil particles into bigger and more stable aggregates. Secretions from plant roots may influence soil structure as well. The most common types of soil structures are:

- Crumb soil structure
- Granular soil structure
- Single–grained soil structure
- Prismatic and columnar soil structure
- Platy (plate-like) soil structure
- Block soil structure

(a) Crumb soil structure

The soil particles here appear irregular in shape, small and rounded. They are not closely fitted together; that is the soil particles loosely adjoin with other aggregates. This soil is therefore soft, porous and permeable, yet it retains moisture. They are normally found on horizon A.

Fig. 2.21: Crumb soil structure

(b) Single–grained soil structure

This is an elementary structure which forms no aggregates meaning that particles are not cemented together. This structure is relatively non-porous with small and spherical particles mostly found at the top soil of sandy soils, arid climates and alkaline soils.

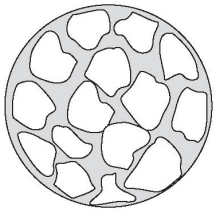


Fig. 2.22: Single-grained soil structure

(c) Granular soil structure

The soil grains appear irregular in shape and aggregates are rounded with smoother edges. The aggregates are loosely held together and when wet, the grains are highly porous. This is because the spaces in between are not readily closed. This structure can be found in the top soil horizon of cultivated soils and in the subsoil horizons of soils under grasses or bushes. The granular soil structure is the only arrangement influenced by practical methods of tillage. It contains organic material and a high water retention capacity.

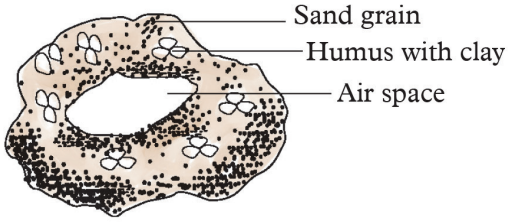


Fig. 2.23: Granular soil structure

(d) Platy soil structure

The aggregates here appear in thin horizontal plate-like layers. It is actually a soil structure whose aggregates are arranged on top of one another in relatively thin horizontal plates, as in leaflets. The plates often overlap and impair permeability. This impedes drainage and root penetration. Soils with such structures are poorly drained and are not suitable for growing crops. The structure is mostly found at the top horizon of soils in forests and it is mainly found in clayey soils.

Fig. 2.24: Platy soil structure

(e) Prismatic structure

The soil particles in this structure are cemented in vertically oriented pillars. The tops of the pillars could be shaped in such a way that they are level, plane and clean cut. This is what gives the structure the name prismatic.

Soils with such a structure are normally located in the subsoil horizons of arid and semi-arid lands.

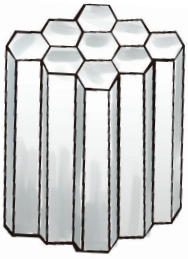


Fig. 2.25: Prismatic soil structure

(f) Columnar structure

When soil aggregates are arranged vertically but with flat rounded tops, they are said to have a columnar structure. The columns are similar to those in the prismatic soil structure; apart from the rounded tops. They are also found in the subsoils of arid and semi arid areas.

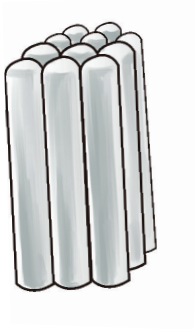


Fig. 2.26: Columnar soil structure

(g) Block soil structure

The aggregates are arranged in rectangular blocks. The aggregates easily fit together along vertical edges. They make penetration of plant roots difficult because their angular edges fit closely. They are moderately permeable, poorly aerated and drained. The blocky structure is common in finely textured subsoils.

Fig. 2.27: Block soil structure

Activity 2.17

Having learnt about the various soil structures, refer to the ones you had drawn in Activity 2.16. Identify and name the various soil structures you had drawn.

Influence of soil structure on crop production

- A good soil structure ensures a good balance between soil water and air since soil structure influences the pore spaces in the soil. In fact the amount of air and water present in a soil sample depends on the pore spaces available. This implies that soils with closely packed particles are poorly aerated and drained.
- A good soil structure aids drainage thereby avoiding waterlogging. Remember that most crops do well in well aerated and drained soils except for a few such as rice, which do well in waterlogged soils.
- A good soil structure also ensures adequate water retention for the plants.

It also reduces accumulation of carbon dioxide in the soil through proper aeration.

- Use of heavy machinery on wet soils destroys the structure thus decreasing permeability and aeration. This results in high incidences of surface run-off and erosion.
- Soil structure influences the water-holding capacity of a soil. A good soil should hold enough water for plant use. A soil which cannot retain water, though fertile, may not be good for crop production as there will be no water available for plant use.
- Soil living organisms respire and produce carbon dioxide which must be removed from the soil so that it does not build up to toxic levels. This is facilitated by free circulation of air. The structure should allow free circulation of air by having enough pore space, which can be occupied by air as in granular or crumby soil structures. In such soils, the plant roots and microorganisms can get the oxygen they need while carbon dioxide is expelled easily.
- Waterlogged soils may result from structures whose particles fit closely together. For example soils with platy structure have a higher capacity for holding water, hence such structures may be good for crops such as rice.

My environment, my life!

After using the soil samples, ensure that they are returned to the places where they were found!

b) Chemical properties of soil

Chemical properties of soil are influenced by the following factors:

- The level of organic matter in the soil
- The amount of rainfall or precipitation
- The mineral rock from which the soil particles have been derived

On decomposition, organic matter in the soil releases organic acids, like carbonic and nitric acids, which make the soil acidic. In high rainfall areas, soils tend to be acidic due to excessive leaching of bases like potassium hydroxide, calcium hydroxide and magnesium hydroxide. Soils derived from rock particles rich in minerals, such as aluminum, are usually acidic.

The four major chemical properties of soil include:

- Soil pH
- Salinity
- Cation Exchange Capacity (CEC)
- Carbon: Nitrogen ratio

(i) Soil pH

Soils may generally be referred to as either **acidic or basic**. One of the most important chemical properties of soil is pH. Soil pH is a measure of the degree of acidity or alkalinity of a soil solution. It is expressed as the potential hydrogen, which is the hydrogen ion (H^+) concentration in a soil solution.

Soil pH can be measured in two ways:

- Using a **universal indicator** solution: This solution results from the mixing of several acidic-base indicators put together. When this is added to a soil solution, the colour change is matched with the colours on the pH chart.

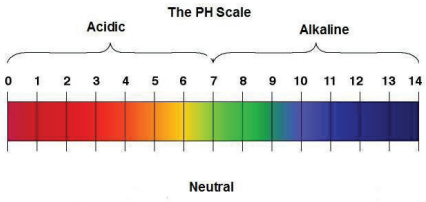


Fig. 2.28: pH chart

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

The pH scale shown above runs from 0–14 corresponding to hydrogen ion concentration with pH 7 being the neutral point. The values in the pH scale that fall above 7 are alkaline while those less than 7 are acidic. This means that the lower the pH, the more acidic a soil solution is; that is solutions with low pH values are strongly acidic while those with high pH values are highly alkaline.

Activity 2.18

Determining soil pH using the Universal indicator

1. Conduct a research in the library or by using the internet and find out how the universal indicator solution is used to determine soil pH. Note down your findings.
2. Having known how the Universal Indicator solution is used, come up with an experiment to determine the pH of various soil samples. Your teacher may provide you with the following apparatus:
    - Test tubes
    - Universal indicator solution
    - A pH chart
    - Barium sulphate powder
    - Soil samples
    - Distilled water
3. Record the steps you will follow, the observations and readings, and note down the inferences you make.
4. Write a report and share with the rest of the class members.

The facts

A sample procedure for determining the soil pH of various soil samples:

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

I have discovered that…

Various soil samples collected from different places have varying pH values. Various plants also have preferences for soils with specific pH values.

(ii) Salinity

Soil salinity refers to the concentration of salts in a soil solution. This can be pronounced at the top soil surface. Salt solutions can move to the top soil surface by capillarity from the salt laden water table. They then accumulate due to evaporation of water. Salt can also accumulate due to human activities, such as use of potassium fertilisers, which accumulates phosphate salts. As soil salinity increases, it results in soil degradation.

Activity 2.19

Determining soil salinity using a salinity meter

1. Perform the experiment below to determine the salinity of soil in an area of your choice. You may be provided with the following apparatus:
   - Soil sample
   - Distilled water
   - Weighing scale
   - Measuring cylinder
   - Jug or any container
   - Salinity meter
2. Follow the steps below:
   (i) Take a sample of soil and leave it to dry in the sun.

(ii) Crush the soil lumps after drying. Use a wide and heavy blunt object, such as a hammer.
(iii) Place 50 g of the dried soil in the jug and add 250 cm^3 of distilled water.
(iv) Shake the content vigorously for about 3 minutes to enable salts in the soil to dissolve in the water.
(v) Allow the solution to settle for at least 1 minute.
(vi) Place the salinity meter in the solution and read the display.

Note: Do not dip the salinity meter into the soil settled at the bottom of the container. Soil salinity can also be tested by use of a conductivity meter.

3. Carry out research on the internet and find out how the conductivity meter is used. Note down the steps to follow and use it to measure soil salinity. (The conductivity meter will be provided by your teacher.)

We are all equal!

In your respective groups, let every member play some role. Do not discriminate against some members of the group!

(iii) Cation exchange capacity of soil (CEC)

Cation exchange capacity of a given soil refers to the total capacity of a soil to hold exchangeable cations.

Factors influencing Cation Exchange Capacity of soil

- Nature of clay minerals in the soil-for example a CEC increases with the amount of clay and it also varies with the type of clay.
- Texture of soil-that is finer textured soils have more mineral colloids than coarse textured ones.
- Organic matter – the higher the humus content the higher the CEC. The type of humus compound is also important. For example, humus which has been developed from monocotyledonous leaves are better.
- Soil pH – The higher the soil pH, the higher the CEC.

Note:
- The availability of a certain cation to plants will depend very much on the proportion of that cation in the cation exchange capacity of the soil.
- The replacement of cations by others is known as **cation exchange.**

Importance of Cation Exchange Capacity of a soil (CEC)

- Cation Exchange Capacity of a soil is described as a measure of how much nutrients a soil can hold rather than how fertile a soil is. However, it is very much correlated with natural soil fertility because it indicates the degree of weathering.

- CEC guides a farmer on the level of fertilisers and liming to apply. Nutrients should be applied to the soil in amounts which the soil can hold not in big surpluses which will leach away without being taken up by plants.
- On the other hand a soil with a high CEC requires high fertiliser application and or liming before nutrients can be available to plants.

(iv) Carbon: Nitrogen ratio

Carbon is an essential constituent of all living things. It occurs naturally in the atmosphere in form of carbon dioxide whereby it constitutes 0.03% of air by volume. Atmospheric carbon dioxide is the major source of carbon required by plants. The various processes contribute to the circulation of carbon in the atmosphere. These processes include those that use carbon from the atmosphere and those that replenish carbon into atmosphere.

Nitrogen is one of the most important elements needed for plant growth. It occurs naturally in the atmosphere in form of nitrogen gas (N_2); it constitutes 78% of air by volume. However, it is not available to plants in this free gaseous form. The various processes which contribute to the circulation of nitrogen in the atmosphere include those that use nitrogen from the atmosphere and those that replenish nitrogen into the atmosphere.

Therefore, the Carbon: Nitrogen ratio through its selective influence on soil organisms, exerts a powerful control on nitrification and the presence of nitrogen in the soil. The nitrogen in the soil may be used by the soil micro-organisms and higher plants, or it may as well be lost through leaching, or it may escape into the air in volatile form. For purposes of encouraging the useful microbial activity in the soil, it is important to maintain a good balance of the C:N ratio in the soil.

(c) Biological properties of soil

Living organisms are found almost everywhere on earth. These living organisms have both positive and negative effects on their surroundings. Living organisms may include pests, parasites, decomposers, pathogens, predators, pollinators and nitrogen-fixing bacteria. The main soil micro-organisms you shall learn about in this section are bacteria.

The following are the two major categories of bacteria that are important in soil:

- **Symbiotic bacteria** – Found in nodules of leguminous plants such as beans. They mainly include rhizobium bacteria.
- **Non-symbiotic bacteria** – Found in the soil which include azotobacter bacteria.

Apart from decomposing organic matter, bacteria perform other useful functions like fixing free atmospheric nitrogen into the soil for plant use. This is done by the rhizobium bacteria. Nitrogen is converted into nitrates which are absorbed by plants. Some micro-organisms damage crops by causing bacterial and fungal diseases in plants. Nematodes live as parasites in plant roots and interfere with the nutrient and water uptake.

Clostridium and azotobacter are two genera of anaerobic soil bacteria that are dependent on plants for their activities. They can fix atmospheric nitrogen to nitrogenous matter. When these micro-organisms die, they decompose and release the nitrogen compounds into the soil for use by crops.

On the other hand, soil nitrogen may also be lost in form of ammonia, nitrogen gas or oxides of nitrogen. This may be due to the activity of certain denitrifying anaerobic bacteria which can oxidise ammonium on to ammonia gas; nitrates and nitrous acid are reduced to nitrogen and oxides of nitrogen such as nitrogen oxide.

Self-evaluation Test 2.6

1. How does the soil in your area behave when it rains? What does that say about its water-holding capacity?
2. Why should a prospective farmer be keen on investigating the properties of soil in a land he/she is intending to cultivate first before embarking on any farming?

2.7 Soil sampling and testing

Soil sampling is the process of random collection of a small quantity of soil from a defined area of land. The soil then acts as a representative sample for laboratory testing and analysis. The defined area of land where the sample is taken from is known as a **sampling unit**. Such a chosen area should be uniform in terms of slope, drainage, soil texture, soil colour, fertiliser usage and history of cropping. Soil is sampled in order to be tested for nutrients and soil pH. An analysis of the samples gives information about the **fertility status** of the soil. In fact, sampling should be done when crops show deficiency symptoms or whenever yields start to drop.

(a) Soil sampling methods

There are two methods of soil sampling which are usually used:

- The traverse method
- The zigzag method

(i) The traverse method

This is where the sampling follows a line along diagonals of the field or a sampling unit. It is also referred to as the **diagonal method**.

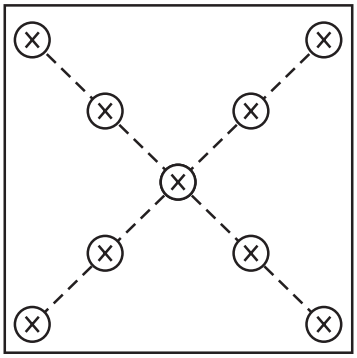


Fig. 2.29: Traverse or diagonal method

(ii) The zigzag method

This is where the sampling forms random zigzag patterns in the sampling unit. Here locations are arranged in such a way that they are in a zigzag form as shown below.

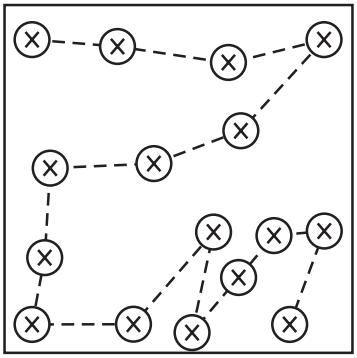


Fig. 2.30: Random or zigzag sampling method

When sampling, the following areas should be avoided:

- Places where manure or organic matter have been heaped
- Fence lines or boundaries which may not give representative sample.
- Places near trees
- Swampy areas
- Dead furrows
- Footpaths in the field
- Ant-hills in the field
- Areas between slopes and the bottom line

(b) Soil sampling procedure

When collecting a soil sample the following procedure should be followed carefully in order to get reliable results and a good representative sample.

1. Clear sampling unit of any vegetation by scrapping it off.
2. Make a vertical cut to a depth of 15-25 cm for crop land and 5 cm for top soil and 25-30 cm for subsoil.
3. Take a slice from the vertical cut, preferably using a soil auger.
4. Put the soil obtained from each site, for both topsoil and subsoil layers, in a clean container.

Note: The above steps can be done on 10-20 sites depending on the sampling method being used.

5. Remove any foreign materials from the collected soil samples.
6. Dry the soil samples and crush them into smaller particles or colloids.
7. Use the quartering technique to arrive at a small quantity of each representative sample.
8. The samples should then be packed in sampling envelopes and dispatched to the laboratory with the following information given:
   - Name and address of the farmer or locality of the farm
   - History of fertilisers or manure use
   - Crop to be grown
   - History of land use
   - Special features on the land
   - Date of sampling

Activity 2.20

Perform a soil sampling procedure on your school farm. Record your results and present them in class.

(c) Soil pH

Soil pH, as we have seen previously, is a measure of the degree of acidity or alkalinity of a soil solution.

Testing soil pH

From our previous discussions, we saw that soil pH can be determined accurately. We only used the Universal indicator solution as one method of testing for soil pH. However, here we shall explore more ways of determining soil pH. It is important for farmers to understand the pH status of soil in their prospective and even present pieces of land to avoid disappointments.
The following are some alternative methods of determining soil pH.

(i) Using a pH meter

The pH meter is an expensive equipment only found in research stations, colleges, universities and some teacher training colleges. This method is also known as glass

electrode method. The pH meter consists of a thin-walled bulb of special glass which contains dilute hydrochloric acid, into which a platinum wire is dipped to make an electrical contact.

This arrangement is sensitive to the hydrogen ion concentration of the solution to which it is immersed. The pH meter method is accurate. However, the set up is expensive hence it is only limited to research work.

Fig. 2.31: A pH meter

(ii) Using colour indicators

In soil pH testing, the colour indicators that can be used include the following:

- Litmus paper
- Universal indicator papers (pH papers)
- Colour indicator dyes

Some of the procedures of determining soil pH using colour indicators are outlined below:

Universal indicator method

1. Place a little soil on clean porcelain plates.
2. Pour 1–2 cm^3 of the indicator on the soil.
3. Wash the soil with the indicator and allow the liquid to drain away from the soil into a clean part of the porcelain.
4. The colour of the solution is observed against the pH colour chat and the acidity or alkalinity of the solution estimated.

Using universal indicator papers

1. A small quantity of soil sample is taken and added to about 25 cm^3 of distilled water which has been boiled to expel dissolved carbon dioxide.
2. The mixture is shaken thoroughly and a piece of the pH paper is then dipped.
3. The colour change of the pH paper is checked against the pH chart to give the correct pH value.

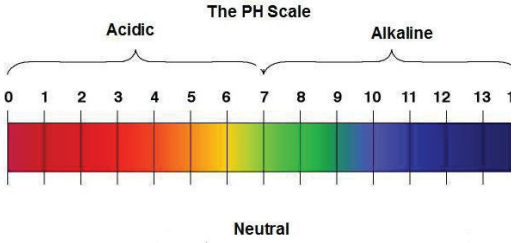


Fig. 2.28: pH chart

Using a commercial soil testing kit

1. A small quantity of soil sample is taken and shaken with distilled water to make a soil solution.
2. A few drops of commercial indicator are added to the solution.
3. The colour of the soil solution is then compared with the colours on the colour chart.

Note: The basis of this method is the fact that different indicators change colour at different pH values.

Using litmus papers

Although litmus papers can also be used, they only indicate whether a solution is acidic or alkaline and cannot give specific pH values. Remember that use of litmus papers is the simplest pH testing method. The litmus papers exist in two colours; **blue** to test for acidity and **red** to test for alkalinity. If the solution is acidic, blue litmus paper turns red, while the red litmus paper remains red. If the solution is alkaline, the blue litmus paper remains blue while the red litmus paper changes to blue. Litmus paper colour remains the same in neutral solutions. The limitation of this method is that the pH value is not known.

Self-evaluation Test 2.7

1. Select three areas that should be avoided during soil sampling and justify why they should be avoided.
2. Which method or instrument of determining soil pH is the best according to you and why?

Remember the facts!

- Soil refers to the loose natural material on the uppermost layer of the earth crust.
- Formation of soil from the parent material is known as soil genesis.
- Soil is formed by weathering of rocks through various physical, biological and chemical weathering processes.
- The common types of soils are clay soil, loamy soil and sandy soil.
- The quantity of water in any soil sample depends on the type of soil it is.
- Soil contains a certain percentage of air. Air is a component of the soil.
- Humus is normally made up of organic matter.
- Soil usually contains living organisms which respire actively.
- We should avoid burning soil and using harmful chemicals on soil. These might cause harm to the soil living organisms.
- Soil profile is the vertical arrangement or a cross-section of soil particles in different layers from ground level. The layers of the soil profile are called horizons.

- Physical properties of soil include:
  - Soil colour
  - Soil texture
  - Soil structure
- Soil is made up of particles of different sizes. They include:
  - **Gravel:** fairly large and heavy.
  - **Sand:** coarse-textured and very well aerated.
  - **Silt:** smooth and powdery.
  - **Clay:** fine and colloidal.
- Soil structure refers to the physical appearance of soil in terms of how the individual soil particles are arranged, packed and aggregated.
- Soil pH is a measure of the degree of acidity or alkalinity of a soil solution.
- Various plants have preferences for specific pH values.
- Cation exchange capacity (CEC) of a given soil refers to the total capacity of a soil to hold exchangeable ions.
- Soil sampling is the process of random collection of a small quantity of soil from a defined area of land. The soil will then act as a sample for laboratory testing and analysis.

Test your competence 2

1. Explain what happens during soil genesis in your own words.
2. Distinguish between the three types of soils described in this unit and give the appropriate uses of each type.
3. (a) How does the water-holding capacity of a soil relate with texture?
   (b) How does this affect crop farming?
4. Explain the factors which determine the amount of soil water in any given type of soil.
5. We must avoid burning soil and using dangerous chemicals on it. Explain why.
6. Explain some of the activities which you think can lead to increased soil salinity.
7. How does carbon:nitrogen ratio affect plant growth?
8. Which activities do you think can destroy the physical soil structure and how?
9. (a) Why is sandy soil more erodible than clay soil?
   (b) What are some of the things you can do to prevent soil erosion?

10. Mutesi has just acquired a piece of land which she plans to cultivate. However, the piece of land is largely dominated by sand soil. Explain what advice you would give Mutesi so that she can improve the soil fertility of the piece of land.

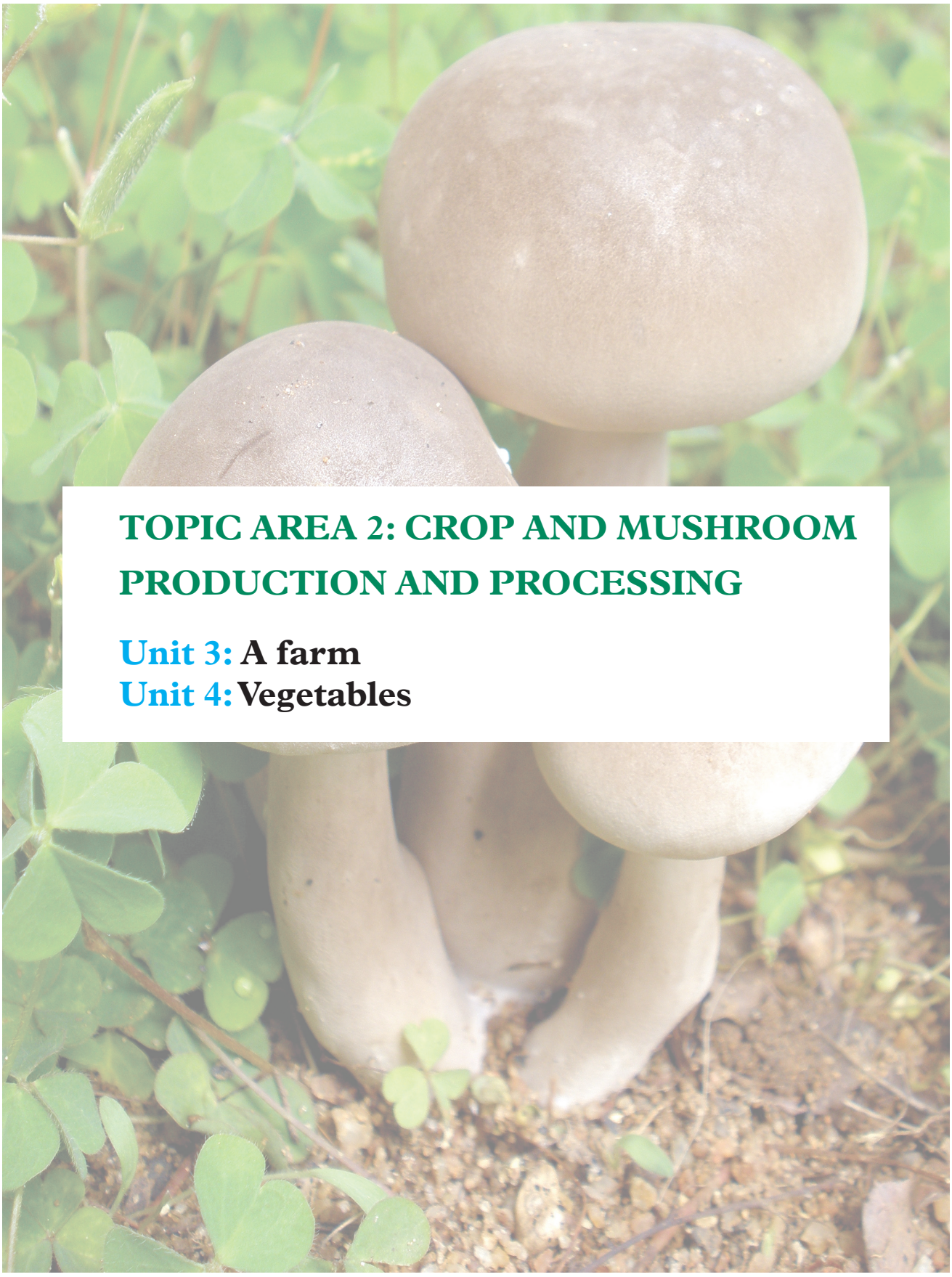
11. Which soil structure is likely to encourage waterlogging?

    A. Single-grained soil structure

    B. Platy soil structure

    C. Crumb soil structure

    D. Granular soil structure



TOPIC AREA 2: CROP AND MUSHROOM PRODUCTION AND PROCESSING

Unit 3: A farm
Unit 4: Vegetables

UNIT 3

A farm

Introduction

In agriculture, there are so many tools and machines that can be used to facilitate various agricultural activities. Each of the agricultural tools and implements are usually used for specific operations. These tools can be used both during crop production and livestock production. All of them have an important role to play in the improvement of agricultural operations.

Discussion corner!

Look at the photographs below. Can you say what is going on in the photographs? What would happen if the tractors were not used? What impact would that have on farm productivity?

B.

A.

This unit is about farm tools and machines. It should empower you to use and appreciate farm tools and machines in your daily life.

Key Unit Competency

After studying this unit, I should be able to:

a) Classify farm tools.

b) Use small farm tools safely.

Unit Outline

3.1 Identifying small farm tools.

3.2 Categories of farm tools, their uses and maintenance practices.

3.1 Identification of small farm tools

Activity 3.1

1. Go for a field trip to a multipurpose farm and find out why farmers use farm tools.
2. Observe the various farming tools used. Find out how they are used, their names, types and classes.
3. Draw the tools you have seen at the farm in your note book.

Safety check!

Care should be taken when handling farm tools. Always hold them far away from yourself and your classmates. If not properly handled, some farm tools can cause serious injuries.

I have discovered that...

Some of the reasons why farmers use farm tools and equipment are:

(i) To increase efficiency and to make farm operations easier.

(ii) To minimise injuries to farm animals. This mostly applies to livestock production tools.

(iii) To enhance production process.

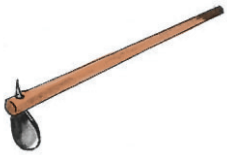
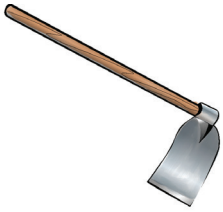
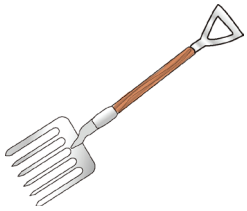
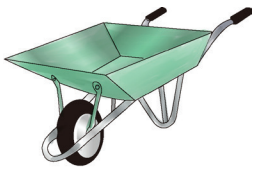
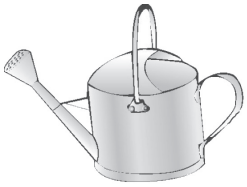
Quality check!

Find out from your teacher whether the farm tools used at your school are the genuine ones. Observe these tools closely to avoid future purchase of counterfeit farm tools which may lead to injuries or damage to crops.

The facts

Some common farm tools are given in Table 3.1. Which ones do you know?

Table 3.1: Common farm tools

 A	 B	 C	 D
 E	 F	 G	 H
 I	 J	 K	 L
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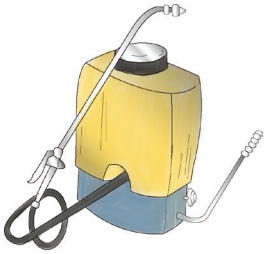
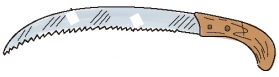
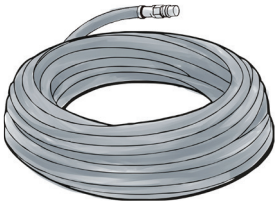
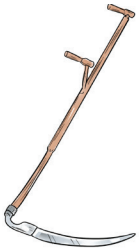
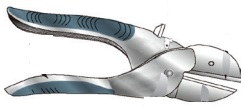
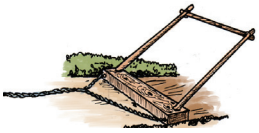
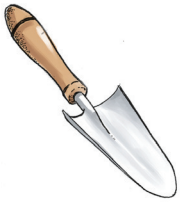
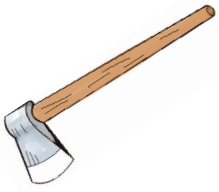
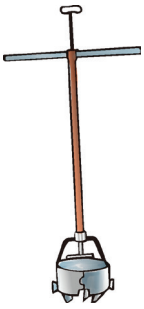
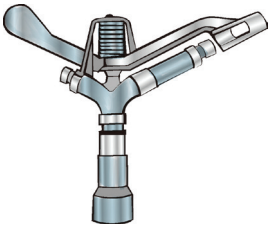
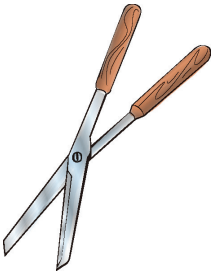
 Q	 R	 S	 T
 U	 V	 W	 X
 Y	 Z	 A_2	 B_2
 C_2	 D_2	 E_2	 F_2

Money matters!

The cost of purchasing farm tools is quite high. Therefore, we must handle the tools with care to avoid damaging them.

3.2 Categories of farm tools, their uses and maintenance practices

Activity 3.2

1. Find out the names of the farm tools in Table 3.1.
2. Categorise the tools as either farming tools or gardening tools.
3. Discuss the uses and maintenance practices of each of the tools. Note them down and present them in class.

The facts

The two major categories of farm tools are:

- Gardening tools
- Farming tools

A. Gardening tools

These are small farm tools used for carrying out general gardening activities. This mostly entails crop production at a very small scale level.

These gardening tools include the following:

(i) Machete

It is mainly used for cutting down small trees and grass used to feed livestock. It is also used to clear land before cultivation.

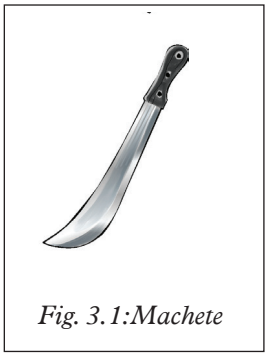


Fig. 3.1:Machete

Maintenance practices

- Store properly in the tool store.
- Paint the metallic part to prevent rusting during long periods of storage.
- Repair worn out or broken handle.
- Sharpen when blunt using of a file.

(ii) Axe

It is used for:

(i) Cutting tree stumps.

(ii) Felling big trees during initial stages of land preparation.

(iii) Splitting trees into logs for construction of farm structures and firewood.

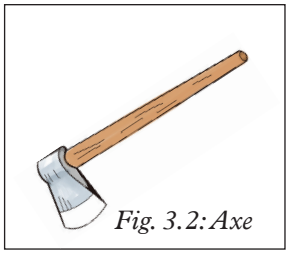


Fig. 3.2: Axe

Maintenance practices

- Replace worn out handles.
- Paint the metallic part to prevent rusting.
- Store properly in the tool store.
- Sharpen regularly to maintain efficiency.

(iii) Pick axe

It used for:

(i) Digging out stony grounds and hard soil.

(ii) Uprooting tree stumps before ploughing.

(iii) Cutting tree roots during land preparation.

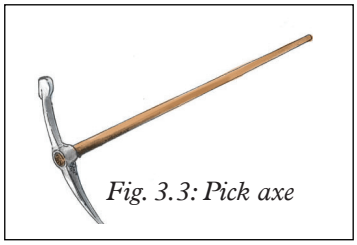


Fig. 3.3: Pick axe

Maintenance practices

- Replace the handle when worn out.
- Paint the metallic part to prevent rusting.
- Proper storage in the tool store.
- Fix loose handle properly.

(iv) Digging hoe (hand hoe)

It is used for:

(i) Cultivation of land when preparing seedbed and during weeding.

(ii) Digging foundations of farm structures and buildings.

(iii) Preparing planting furrows and holes.

Fig. 3.4: (a) Digging hoe

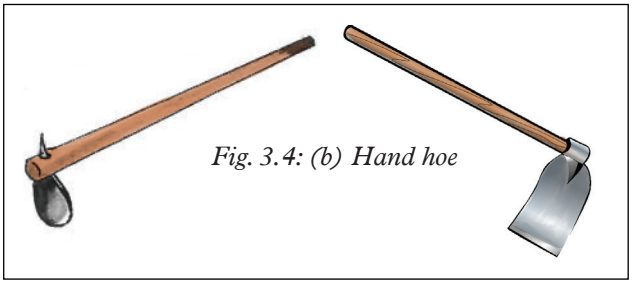


Fig. 3.4: (b) Hand hoe

Maintenance practices

- Regular cleaning after use.
- Proper storage in the tool store.
- Paint the metallic part to prevent rusting.
- Sharpen regularly to maintain efficiency.
- Replace incase of broken handle.

(v) Wheelbarrow

It is used for transporting small loads like sand, bags of seeds or seedlings (during transplanting), bags of fertiliser, among others within a short distance.

Maintenance practices

- Tighten loose nuts and bolts.
- Grease or oil the wheel and moving parts to facilitate smooth running of the wheel.
- Apply old engine oil or paint the metallic part to prevent rusting.
- Store properly under a tool shed.
- Repair any worn out or broken parts.

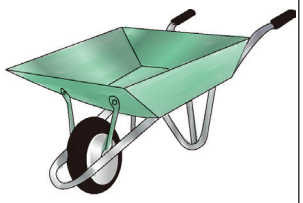


Fig. 3.5:Wheelbarrow

(vi) Rake

Fig. 3.6: Rake

It is used for:

(i) Collecting uprooted plant roots and stems when preparing a nursery seedbed for vegetable crops.

(ii) Breaking large soil clods, removing stones and other rubbish to obtain a fine tilth for tiny seeds.

(iii) Leveling and finishing of the seedbed.

Maintenance practices

- Paint the metallic part to prevent rusting.
- Replace any worn out or broken handles.
- Repair any broken or bent teeth.
- Store in a cool store.

(vii) Tape measure

It is used for measuring distance and length.

Maintenance practices

- Proper storage in the tool rack.
- Clean the tape in case it comes into contact with dirt.

(viii) Garden trowel

Fig. 3.7: Garden trowel

This is a pointed scoop-like tool. It is used for:

(i) Loosening the soil.

(ii) Digging small shallow holes.

(iii) Lifting out seedlings from the nursery bed during transplanting.

Maintenance practices

- Store properly in the tool rack.
- Apply old engine oil to prevent rusting.
- Clean after use.
- Replace broken wooden handles.
- Ensure it is firm.

(ix) Garden fork

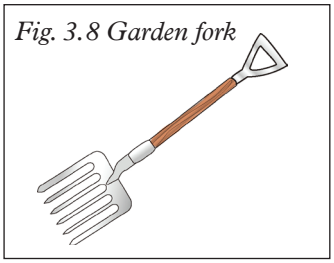


Fig. 3.8 Garden fork

It is used for:

(i) Weeding nursery or carrot fields.

(ii) Preparing holes for transplanting seedlings.

Maintenance practices

- Repair any broken handles.
- Store properly in a tool shed.
- Paint the metallic parts to prevent rusting.

(x) Watering can

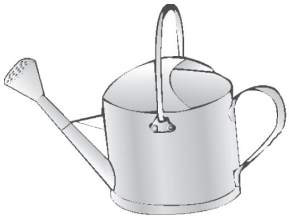


Fig. 3.9: Watering can

It is used for watering seedlings in seed boxes, potted plants, nursery beds and transplanted seedlings.

Maintenance practices

- Clean after use.
- Paint the body (tank) to prevent rusting (for metallic watering cans).
- Remove the rose, unblock the perforations and return in place.
- Proper storage in the tool store.
- Repair leaking tank and any other damaged parts, such as the handle.

(xi) Shovel

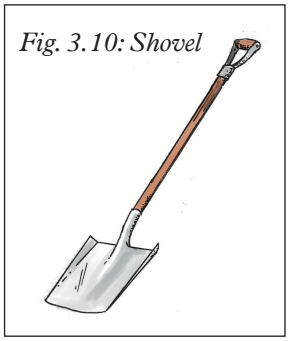


Fig. 3.10: Shovel

It closely resembles the spade, but it has a tray-like blade.

It is used for scooping loose soil, fertilisers, seeds and sand.

Maintenance practices

- Replacing worn out handles.
- Applying oil on the metallic parts to prevent rusting.
- Store properly in a dry place.

(xii) Slasher

Fig. 3.11: Slasher

It is used for clearing shrubs.

Maintenance practices

The handle must be well fixed and the blade must be kept sharp.

(xiii) Billhook

Fig. 3.12: Billhook

It is used for cutting banana leaves.

Maintenance practice

The handle must be well fixed and the blade must be kept sharp.

(xiv) Grafting knife

Fig. 3.13: Grafting knife

Used for grafting woody plants.

Maintenance practices

- The blade must be well-fixed on the handle.
- The blade must be kept sharp.
- The blade must also be painted to reduce rusting.

(xv) Secateurs

It is used for pruning crops like coffee and cutting flowers. (Pruning involves cutting unwanted branches and suckers.)

Maintenance practices

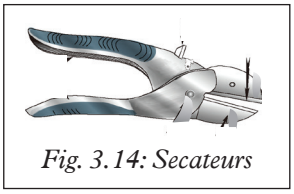


Fig. 3.14: Secateurs

- Replace broken handles.
- Paint the metallic parts to prevent rusting.
- Store properly in a tool cabinet.
- Grease or oil the pivot for easy movement.
- Replace the worn out parts.
- Sharpen the edges.

(xvi) Leveling board

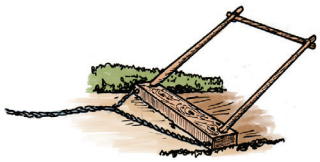


Fig. 3.15: Leveling board

It is used for leveling a prepared seedbed especially in rice fields.

Maintenance practices

- Clean after use.
- Store properly in a tool rack.

Activity 3.3: Research activity

1. Find out other garden tools that are not in this list.
2. Give their uses and maintenance practices.
3. Discuss with your group members and do a class presentation of your findings.

B. Farming tools

These are tools used for performing various farming activities. These activities may entail both crop production and livestock rearing. The following are some examples of farming tools.

Note: Some gardening tools can as well be used as farming tools.

(i) Forked hoe

Fig. 3.16: Forked hoe

It is used for:

(i) Removing underground perennial weeds, such as couch grass.

(ii) Digging hard, stony, wet or muddy soils.

(iii) Harvesting tuber crops such as Irish potatoes.

Maintenance practices

- Clean after use.
- Oil the metallic parts to prevent rusting.
- Replace broken handle.
- Straighten bent prongs.

(ii) Spade

It is used for:

(i) Digging in place of a hoe, for instance in coffee plantations where use of a hoe may damage coffee roots.

(ii) Removing soil when digging holes and applying manure.

Fig. 3.17: Spade

Maintenance practices

- Clean after use.
- Store properly in the tools store.
- Apply oil on the metallic parts to prevent rusting.
- Replace any broken handles.

(iii) Spring balance

It is used for weighing farm produce and farm inputs like seeds.

Fig. 3.18: Spring balance

Maintenance practices

- Proper storage in the tool rack.
- Paint to prevent rusting.
- Lubricate the inner springs by applying oil or grease.

(iv) Soil auger

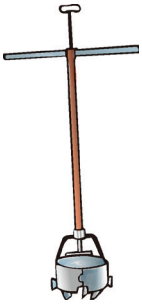


Fig. 3.19: Soil auger

It is used for:

(i) Soil sampling that is done during soil analysis and testing.

(ii) Digging holes for fixing fence posts.

Maintenance practices

- Clean after use.
- Paint to prevent rusting.
- Sharpen the cutting edges.
- Replace any damaged handles.

(v) Knapsack sprayer

It is used for applying agrochemicals such as foliar fertilisers, herbicides and pesticides to crops efficiently, economically and safely.

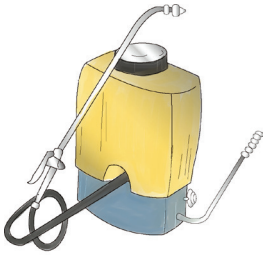


Fig. 3.20: Knapsack sprayer

Maintenance practices

- Wash thoroughly after use and keep in a safe place.
- Oil or grease the moving parts.
- Remove dirt, soil and small stones from the sieve regularly.
- Check the nozzle regularly to unblock when blocked.

(vi) Sprinkler

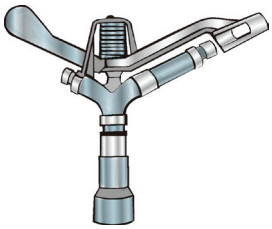


Fig. 3.21: Sprinkler

It is used for applying water to crops in overhead irrigation.

Maintenance practices

- Unblock the nozzles when blocked.
- Clean after use.
- Store properly in a dry place after use.
- Repair worn out or broken parts.

(vii) Hose pipe

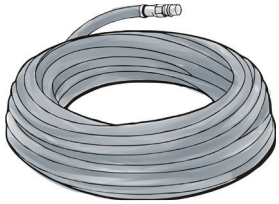


Fig. 3.22: Hose pipe

It is used for conveying water from one point to another.

Maintenance practices

- Clean after use.
- Store properly in a tool shed.

(viii) Garden shear

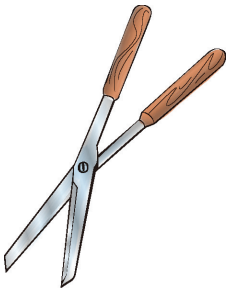


Fig. 3.23: Garden shear

It is used for trimming hedges and shrubs in the farm.

Maintenance practices

- Clean after use.
- Store properly in a tool cabinet.
- Paint to prevent rusting.
- Grease or oil the moving parts to avoid friction.
- Sharpen the blades regularly.

(ix) Pruning saw

It is used for pruning perennial crops like coffee, citrus and passion fruits and pollarding trees.

Maintenance practices

- Replace broken handle.
- Paint the metallic part to prevent rusting.
- Set the teeth by use of a saw set so that it is in good condition.
- Store properly in a tool cabinet.

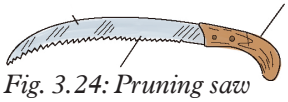


Fig. 3.24: Pruning saw

(x) Meter rule

It is used for measuring out distances such as when planting, to determine spacing or when marking small plots in the farm.

(xi) Manure fork

It is mainly used for moving heavy loads of manure or compost.

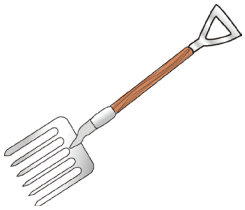


Fig. 3.25: Manure fork

Maintenance practices

- Clean after use.
- Handle must be well fixed and replace broken handles.

(xii) Hayfork

The tool is used to manually move hay.

Maintenance practices

- Clean after use.
- Store properly in a tool rack.

(xiii) Sickle

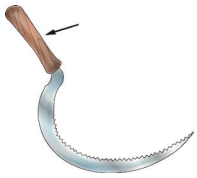


Fig. 3.26: Sickle

It is a hand-held agricultural tool with a curved blade. It is typically used for harvesting grain crops or cutting succulent forage chiefly for feeding livestock.

Maintenance practices

- Clean sickle after use.
- Store properly in a tool rack.
- Handle must always be well fixed onto the blade and broken ones replaced.

(xiv) Rake maker

Used for curving various angles on rakes. It can also be used in repairing rakes.

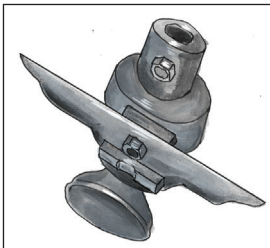


Fig. 3.27: Rake maker

Maintenance practices

- Grease or oil regularly to prevent rusting.
- Store in a dry place, in a tool rack.

(xv) Lactodensimeter

It is a form of hydrometer for finding out the density of milk. It hence helps in discovering whether milk has been mixed with water or if it has had some of the cream removed.

Fig. 3.28.: Lactodensimeter

Maintenance practices

It should be cleaned and disinfected after use.

(xvi) Scythe

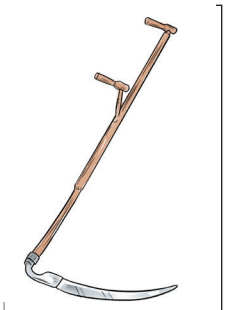


Fig. 3.29: Scythe

An agricultural implement consisting of a long, curving blade fastened at an angle to a handle, for cutting grass and grain by hand.

Maintenance practices

- The blade must always be well-fastened and sharpened.
- Broken handles must be replaced.

(xvii) Milk can/ Milk pots

Fig. 3.30: Milk can

They are used for:

- Storing milk.
- Transporting milk.

Maintenance practices

- Clean and disinfect after use.
- Store properly in a clean and dry place.

Fig. 3.31: Milk pots

(xviii) Milk churn

This is an instrument used for separating butter from milk by shaking.

Maintenance practices.

- It should be washed immediately after use.
- Store in a clean and dry place.

Fig. 3.32: Milk churn

(xix) Flail

Fig. 3.33: Flail

This is an agricultural tool used for threshing to separate grains from their husks.

Maintenance practices

- Lubrication of the moveable part.
- Repairing of any broken parts.

(xx) Strimmer

It is a tool which uses a flexible monofilament line, instead of a blade, to cut grass (or other plants) that are near objects or on steep or irregular terrain.

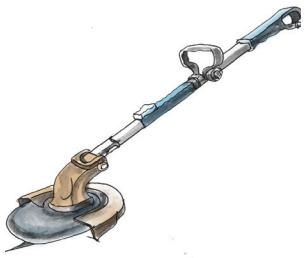


Fig. 3.34: Strimmer

Maintenance practices

- The cutting head can be sharpened occassionally when blunt.
- The shaft and handle can be repaired if spoilt.

Activity 3.4

1. Go into the school farm and practise using some of the small farm tools you have learnt about. (Also, depending on the season, you can help in the various farm operations using the appropriate tools).
2. Once you have completed the farm practices, perform the maintenance practices to be done on each of the tools used. (If a tool happens to have been damaged, inform your teacher so that it can be repaired.)

Activity 3.5: Research activity

1. Name other farming tools you know that are not in the list above.
2. State their uses and maintenance practices

Remember the facts!

- Farmers use farm tools and equipment mainly for the following reasons:
  - To increase efficiency and to make farm operations easier.
  - To minimise injuries to the farm animals.
  - To enhance production.
- We must be careful to use only genuine farm tools to avoid injury and damage to crops.
- Gardening tools are small farm tools used for carrying out general gardening activities.

- Farming tools are used for performing various farming activities such as crop production and livestock rearing.
- For the farm tools to last and serve for long, they must be used appropriately and maintained accordingly.
- I should make every effort to learn how to use farm tools and know how to maintain them appropriately.

Test your competence 3

1. (a) What are some of the common farm tools you use in your school farm?
   (b) Classify these tools into farming and gardening tools.
   (c) What can you do to ensure that each of the farm tools you have named in 1(a) above last for long and functions as required?
2. Why should a lactodensimeter and a milk churn be disinfected after use?
3. Farm tools with moving parts must be oiled. Explain why this is necessary.
4. Neza keeps some four dairy cows in her backyard. What are some of the tools that you will find in her store room and what will be their use?
5. A safe distance from other learners should be maintained when handling both sharp and blunt farm tools. Name some of these tools and explain how best they can be handled to avoid injury and damage to the tool.
6. Which of the following tools cannot be used during nursery preparation?
   A. Digging hoe B. Garden shear
   C. Manure fork D. Watering can
7. Why is it important for tools to be cleaned and kept at a specific designation?
8. Mugwaneza wants to plant maize on a piece of land that he has newly acquired. What tools should he purchase which he shall use from the time of land preparation all the way to the harvesting period?
9. Keza wants to have a small flower garden at the front part of her house. Mention the tools which she will require and explain their uses as well.
10. Which one of the listed maintenance practices will not help in improving the efficiency of a rake?
    A. Sharpening B. Fixing handle
    C. Replacement D. Proper storage

UNIT 4 Vegetables

Introduction

We eat a lot of vegetables in our households. They mainly give us vitamins.

Discussion corner!

1. What are your favourite vegetables? Why do you like them?
2. Do you know where and how they are grown?

3. Look at the picture above. Which vegetables do you know?

In this unit, you will learn the various classes of vegetables, their importance, how they are grown and how they are preserved.

This will prepare you in life to be able to cultivate vegetables and maybe use them as a source of income.

Key Unit Competency

After studying this unit, I should be able to cultivate and preserve vegetables.

Unit Outline

4.1. Definition and importance of vegetables

Activity 4.1: Research Activity

1. Find out the various examples of vegetables in your home area.
2. Using the Internet, find out the importance of vegetables. Note them down and present them in class.

The facts

A vegetable is any part of a plant that is consumed by human beings as food in a savoury course or meal.

Examples of vegetables include:

- Cucumber
- Carrots
- Green bananas
- Tomatoes
- Irish potatoes
- Cauliflower
- Onions
- Cabbages
- Spinach
- Kales
- Lettuce

Fig. 4.1: Some common vegetables in Rwanda

The importance of vegetables can be looked at from the following perspectives.

(a) **Improving human health**

- There is a reduced risk of susceptibility to many chronic diseases for people who eat vegetables daily. Vegetables provide **many nutrients** including potassium (which helps to maintain a healthy blood pressure); fiber and folic acid (help the body to form healthy red blood cells).
- **Dietary fibers** from vegetables help reduce blood cholesterol levels and it also lowers the risk of heart diseases.
- Consuming a diet rich in vegetables may **reduce risk** of stroke, cancer, heart attack and diabetes.

(b) **A source of income** - Large-scale growing of vegetables can earn the farmer money to sustain his/her family.

(c) There is also **improvement of soil** through crop rotation. They also provide fodder to domestic animals.

(d) Vegetable farming is a **source of both direct and indirect employment**.

Cultivation of vegetable crops involves intensive operations; starting from sowing to marketing. It provides more and regular employment opportunities especially in rural areas.

(e) Vegetables also have an **industrial importance**. Due to their highly perishable nature, vegetables demand comprehensive planning for movement, storage, processing and distribution of vegetable products. Success in the vegetable industry as a commercial proposition largely depends on allied enterprises like storage, processing, marketing, maintenance and service industries, so encourage vegetable farming.

(f) Vegetables are a **source of medicine**. In this regard, many of the vegetable crops possess high medicinal value for curing certain diseases.

Health check!

The sick, especially those suffering from HIV and AIDS, should be encouraged to eat a lot of vegetables. Vegetables help to prevent opportunistic infections!

Self-evaluation Test 4.1

1. How are vegetables important to our health?
2. Name vegetables in your community that are used as medicine.

4.2 Classification of vegetable crops

Activity 4.2

Classify the vegetables you listed in Activity 4.1. Use any applicable criteria you know.

The facts

Discussed below are some of the criteria that can be used to classify vegetables.

(a) Based on edible parts

From roots to leaves to stems to fruits, different parts of various vegetable plants are consumed. On that basis vegetables can be classified.

Table 4.1 gives examples of vegetables classified according to their edible parts.

Table 4.1: Vegetables with their edible parts

Edible part	Examples of vegetables
Leaf	Amaranthus, cabbage, kale, lettuce, spinach.
Flower	Broccoli, cauliflower.
Seed	Cow peas, garden peas, soybeans.

Edible part	Examples of vegetables.
Fruit	Tomato, cucumber.
Bulb	Onion, garlic.
Tuber	Irish potato, carrots, radish.
Stem	Asparagus.

Discussion corner!

1. Which of these vegetables do you know? Which ones do you use in your community?
2. Find out the importance of each vegetable. Write a report and present to class.

(b) Based on botanical names

This method of classification is based on botanical relationships of crops.
In Biology, you learnt about the various ranks of classification.

Discussion corner!

1. Find out about the various ranks of classification.
2. Which is the largest and which is the smallest rank?
3. Which characteristics are used to put organisms in those groups?
4. Write a report and present in class.

I have discovered that...

The various ranks of classification are:

- Kingdom
- Division or phylum
- Class
- Order
- Family
- Genus
- Species

Kingdom is the largest group while species is the smallest.

When classifying vegetables based on botanical names, the class order or family name of the plant is used.

The facts

Table 4.2 summarises the various categories of vegetables based on their botanical names.

Table 4.2 Botanical classification of vegetables

Vegetable family	Description	Examples of vegetables
Monocotyledons		
Alliaceae	Members have corms, bulbs or underground stems. Most have long thin leaves.	Onion and garlic

Vegetable family	Description	Examples of vegetables
Gramineae	Members have hollow stems with leaves that are nearly alternate.	Sweet corn
Liliaceae	Members have large flowers with parts arranged in threes. Their leaves are linear and have parallel venation.	Asparagus
Dicotyledons		
Mustard (*Cruciferae*)	Members have flowers with four petals. Almost all members are annual or perennial with alternate estipulate leaves.	Cabbage, turnip, mustard, peppergrass, radish, cauliflower, broccoli and kale.
Leguminosae	Members have leaves that are placed alternately up the stem. Their leaves have five petals.	Soya bean, peanut, kidney bean, peas.
Cucurbitaceae	Most members have hairy and pentangular stems. They have large, yellow or white flowers.	Pumpkin, squash, cucumber.
Umbeliferae	Members are mostly aromatic plants with hollow stems. Most of them are annual, biennial or perennial.	Carrot, coriander, celery, celeriae .
Solanaceae	Members produce alkaloids. Some alkaloids are desirable to animals while others are toxic.	Tomato, egg plant, capsicum.

(c) Based on hardiness

Vegetables can be grouped as either hardy or tender on the basis of tolerance to frost; low temperatures etc. The following table shows some examples of vegetables classified according to their hardiness.

Table 4.3: Vegetable classifications

Hardy	Semi hardy	Tender
Asparagus	Beet root	Tomato
Cabbage	Carrot	Cucumber
Garlic	Cauliflower	Cucurbit
Onion	Lettuce	Irish potato
Peas	Celery	Amaranthus
Radish	Sweet potato	Cowpea

Self-evaluation Test 4.2

1. Come up with another way in which you think vegetables can be classified.
2. Why do you think it is important to classify vegetables in this way?

4.3 Nursery establishment

Activity 4.3: Research Activity

1. Find out the meaning of the word nursery in relation to agriculture.
2. What is the importance of a nursery?
3. How can we establish a nursery?

I have discovered that…

In Agriculture, a nursery is a place where plants are raised with special care until they are ready or mature enough for transplantation into the field (seedbed).

The facts

Every farmer who grows seedlings should aim at producing healthy uniform plants that will be able to establish in the field quickly. A wide range of vegetable crops are delicate at a young age. They are therefore raised in nurseries. Examples include cabbages, onions, tomatoes, eggplant, lettuce, celery, broccoli and cauliflower.

(a) Types of nurseries

There are two main types of nurseries:

- **Temporary nurseries** – In such nurseries, seedlings are planted for a while after which they are removed and relocated to the bigger field.
- **Permanent nurseries** – Here, plants normally grow for all their lives.

Activity 4.4

1. Go for a field visit to an established farm and observe the nurseries. Are they temporary or permanent?
2. Enquire from the farmer some of the factors that led him or her to choose that particular place as a nursery site.

(b) Selection criteria for a nursery site

The site selected as nursery site should:

- Be levelled and protected from wind.
- Be reasonably well-drained to avoid problems that come from waterlogging.
- Be free of stones.
- Have a nearby reliable source of water.
- Be fertile.

The facts

The following are the major criteria used in the selection of a nursery site.

a) **Soil type** – The site must have good soil that supports the growth of the seedlings. The soil must have enough organic matter and it should respond well to fertiliser and manure.

b) **Climate** - Weather conditions are very crucial in nursery establishment. This should be considered with regard to the crops that are to be grown in the nursery.

c) **Water** - The availability of water is an important factor to consider in the nurturing of seedlings. The total amount of water a seedling receives will affect its cropping and quality. Irrigation is necessary in the dry season and during drought.

d) **Planting material** - It is important to plant varieties suitable for your particular area. It is also important to have healthy planting material. The success of the nursery depends on this.

e) **Market** - For commercial purposes, it is very important to have access to the market. A farmer should be able to satisfy the demands of the market.

Activity 4.5

Go into your school farm and choose a suitable site to establish a nursery. Consider all the factors you have learnt above.

Self-evaluation Test 4.3

Why is it necessary for some plants to be grown in nurseries first before being taken to the main field?

(c) Nursery preparation for vegetables

Nursery preparation refers to the process of making the soil suitable for sowing. The soil should be fine, moist and firm to allow effective germination and be an excellent medium for seedling growth.

Discussion corner!

In groups, find out:

1. The conditions of a good nursery.
2. What you need to do to prepare a nursery.
3. How to prepare a good nursery.

Write a report and do a presentation to the rest of the class.

I have discovered that...

Nursery preparation is necessary to facilitate proper germination and seedlings growth.

Prior to seeding, the nursery should be levelled and worked on to obtain a fine textured soil free of clods and debris.

Enough of well decomposed farm yard manure should be mixed thoroughly in the soil.

Remember, after a proper nursery preparation:

- There must be no weeds in the nursery.
- Insects and pests must be exposed to natural hazards and predators.
- Proper support for the growing seedlings must be available.
- The applied fertiliser must offer balanced nutrients to the seedlings.
- An optimum supply of soil moisture must be available to seedlings.
- Good soil aeration must be facilitated.

The facts

Operations involved in nursery preparation

1. **Ploughing (digging)**
   This turns the soil from lower layers to the surface exposing the insects in the soil to predators and natural hazards.

   This also exposes the weed seeds to the birds and insects. Simultaneously, it mixes the soils of different layers and ensures that the nutrients are well distributed in the soil.
2. **Clod crushing**
   Clod crushing is required to break the soil particles into finer grains which can facilitate well mixed nutrients, well aerated soil mass and good water holding capacity. Fine soil particles allow the seeds and roots of the seedlings to get good contact with the soil particles.
3. **Manure and fertiliser application**
   Application of manures and fertilisers replenishes nutrients that are removed during previous growing season, erosion and leaching.
4. **Irrigation** is necessary firstly to facilitate the germination of unwanted seeds so that they can be removed during land preparation. Secondly irrigation facilitates other field preparation operations like ploughing or digging which otherwise is difficult in hard, dried soils.
5. **Bed preparation**
   Bed preparation ensures ease of carrying out cultivation operations like sowing and transplanting, and later in the intercultural operations. The width of a bed should be between 100 - 120 cm and the length should be between 1.5- 15 m. This width facilitates weeding and watering without trampling the bed. The bed should be kept raised at about 15 cm so as to provide proper drainage of excess water.

Activity 4.6

Go back to the piece of land you had chosen in Activity 4.5 and now prepare a nursery in your school field. Consider all the factors you have learnt above.

(d) Sowing methods

Sowing methods refer to the means through which farmers plant seeds.

Discussion corner!

Discuss the various methods you can use to sow seeds assuming you are a farmer. Which is better? Why?

The facts

The common practice is to **broadcast** seeds in the nursery bed. The other method is line sowing. **Line sowing** is preferred because it allows checking to ensure proper germination. It also facilitates weeding, hoeing and plant protection operations. Follow these steps when sowing seeds in a nursery.

1. **Preparation of seebed.** This involves digging, harowing and mixing manure with soil followed by leveling.

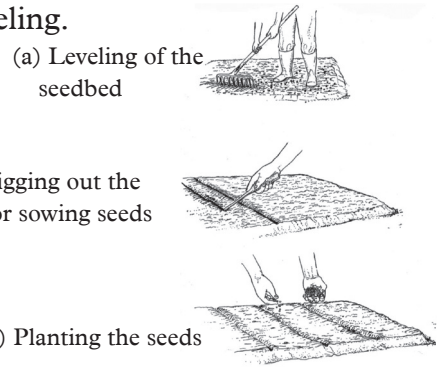


Fig. 4.3: Some steps of sowing seeds in a line

2. Digging out rows in readiness for sowing.
3. Planting the seeds. This involves dropping the seeds in the rows then covering them with soil.
4. Mulching to protect the seeds from being displaced by rain water.
5. Watering the seeds.
6. Constructing a shade to protect seedlings from direct sunlight and rain drops.

The rows are usually about 5 cm apart. Small seeds are sown mixed with a little sand and are then covered with soil. The soil covering should be lighter in heavy soils. A general rule in this method is to sow seeds 2-3 times their own thickness deep. If seeds are sown too deep, nutrient reserves will be exhausted before the plant emerges; or the emerging plants will be weak, or they will be liable to death. If sown too shallow, then the seeds are likely to be eaten by birds or washed away by

running water. Spacing allows for seed losses. However, if one thinks that the seed losses may be higher than normal, then a test for seed viability beforehand becomes necessary.

How to construct a nursery bed shade

After sowing the seeds, the nursery bed should be thoroughly watered and a shade erected over it. The following materials are required to make a seed bed shade:

- Y –shaped sticks about 100 cm long
- 4-6m long slender sticks.
- Twigs and leaves of plants.

Procedure

1. Dig 4 holes at the corners of the nursery bed. You can add two more holes for support.
2. Put the Y -shaped sticks into the dug holes.
3. Then place the long slender sticks on the Y shaped sticks.
4. Finally place the twigs and leaves over the slender sticks as shown in Fig 4.4. These will provide the shade. The shade made should be between 75 cm and 90 cm above the bed.

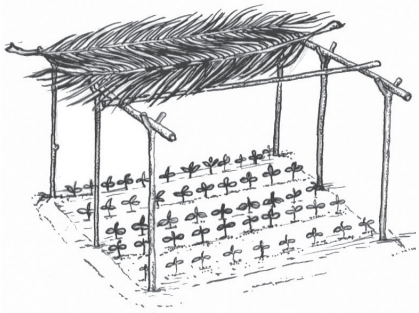


Fig. 4.4: A shade over a nursery bed

A week before transplanting, the seedlings can be exposed to full sunshine and moisture stress. This ensures that the seedlings are sufficiently hardened for field settings.

Activity 4.7

1. Now sow seeds in your prepared nursery bed then prepare a shade as explained above.
2. Monitor your seedlings frequently to ensure normal growth.

Money matters!

Sow the seeds sparingly. Consult your teacher so as to know the right number of seeds to be sown per hole.

Self-evaluation Test 4.4

What advice would you give to a farmer who does not pay attention to the number of seeds he or she puts in each hole when planting?

(e) Nursery activities

Activity 4.8: Research Activity

1. Find out with your friend the various activities that should be done in a nursery.

What is the significance of each activity?
2. Assuming that the activity was not done, what will happen? Why?
3. Write a report and do a presentation to the rest of the class.

The facts

Fig. 4.5: Watering seedlings

The main nursery practices include:

- **Harrowing** – This is turning of soil using a hoe to improve aeration.
- **Earthing up** – Piling up soil to form raised ground. This prevents the seedlings from being swept away by running water.
- **Sowing** – Planting seeds in the seedbed for them to germinate into seedlings.
- **Watering or irrigation** – Supplying water to young seedlings so as to prevent them from drying up.
- **Mulching** – This is putting grass or other plant materials between lines of growing seedlings to prevent loss of soil moisture.
- **Thinning** – This is removing excess seedlings to allow fewer to grow healthy.
- **Weed control** – Removing weeds as they grow. This prevents them from interfering with growth of seedlings.
- **Pest and disease control** – This is aimed at removing all insects that may destroy the seedlings and protecting them from diseases.
- **Hardening off** – This is an operation carried out to acclamatise seedlings to normal growing conditions before transplanting.
- **Shading** – This is putting up a shade on the nursery to prevent adverse conditions from influencing the seedlings. At this stage, seedlings are very delicate hence need special care.

Once the seedlings are grown and have been hardened off, they can be transferred to the main field. This is called **transplanting**.

(f) Fertiliser application on vegetables

Proper application of fertiliser on a vegetable garden is an important aspect towards successful vegetable growing. The amount of fertiliser applied generally depends on the type of soil and particular crops being grown. Soil fertility requirements differ between growing seasons and among different soil types. The requirements in fertiliser for root vegetables, like carrots, is not the same as that of vegetables in the cabbage family, for example. With regards to soils, those that are rich in organic matter (mostly dark in colour) may not require much fertiliser.

Organic matter improves the soil in many ways. It also helps to release various minerals and nutrients that plants require. The two main categories of fertiliser that

are mostly applied are organic fertilisers, an example being the compost manure, and chemical fertilisers.

Chemical fertilisers are mainly of four types:

(i) **Nitrogenous fertilisers:** Examples are ammonium sulphate $(NH_4)_2SO_4$, calcium cyanide $Ca(CN)_2$, Urea (NH_2CONH_2) etc.

(ii) **Phosphatic fertilisers:** Examples are (triple superphosphate) $Ca.(H_2PO_4)_2.H_2O$, Diammonium phosphate (DAP), phosphatic slag, etc.

(iii) **Potash fertilisers:** Examples are potassium nitrate (KNO_3) potassium sulphate (K_2SO_4), etc.

(iv) **Mixed fertilisers:** These are made by mixing two or more fertilisers in suitable proportions. An example is NPK (contains nitrogen, phosphorus and potassium in the ratios 17:17:17 for nitrogen, phosphorus and potassium respectively).

Fig. 4.6: NPK fertiliser

4.4 Land preparation and cultivation of vegetables

Before transplanting vegetable seedlings, there is need to prepare the field where the vegetables will grow.

Discussion corner!

In your groups, discuss about what you need to do before transplanting vegatable seedlings. Why are these activities necessary? Prepare a report and present to the rest of the class.

The facts

a) Land preparation

This involves four processes

i) **Land clearing** – This involves removing obstacles such as trees or other structures before cultivation. It can be done by clearing forests or burning. Chemical methods can also be used.

My environment, my life!

When clearing land for farming, we should avoid burning as much as possible. We should also cut down trees only if it is absolutely necessary. We however should replace the cut down trees by planting two for every one cut elsewhere.

ii) **First ploughing** – This is the initial tilling of the land. It involves breaking the ground using either a hoe, forked hoe or ox ploughs. In mechanised farms, tractor-drawn ploughs are used.

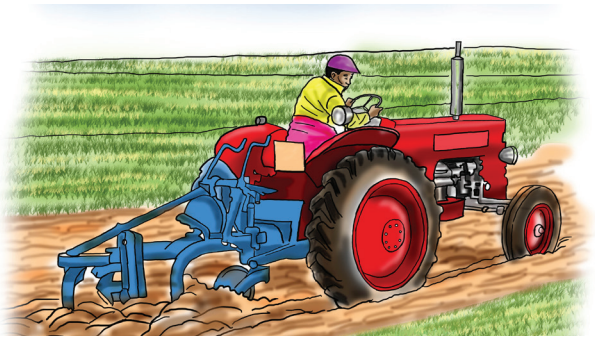


Fig. 4.7: First ploughing using a tractor

This opens up the ground, improves aeration and water penetration.

iii) **Second ploughing** – This is meant to further break huge boulders of soil into finer particles. This way, seedlings can grow without difficulties. It is also known as **harrowing**. It can be done more than once depending on the nature of the soil where the farm is. Harrowing creates suitable **tilth** that is ready to receive seeds or seedlings.

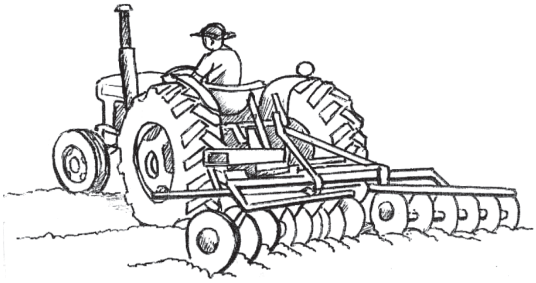


Fig. 4.8: Harrowing

iv) **Leveling** – This is the practice of dragging soil using a leveling board or rake to ensure that the soil is level. This practice helps to improve the chances of survival of the transplanted seedlings. It also ensures that when irrigation is done, there is uniform supply of water and that the roots of growing seedlings penetrate the soil without difficulties.

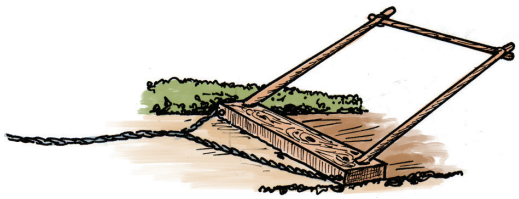


Fig. 4.9: Leveling of soil

b) Planting

The method of planting chosen depends on the type of vegetables and the field. The two common methods are:

i) **Direct planting** –This is where seeds are sown directly on the prepared field. This method may not be appropriate in vegetable farming.

ii) **Indirect planting** – This method involves sowing seeds in a nursery then tranplanting them onto the main field. It is the most common practice in vegetable farming.

c) Maintenance activities of vegetables in the field

Activity 4.9: Research Activity

Find out the field practices that should be done in a vegetable farm. Why are those practices important? Write a report and do a presentation to the rest of the class.

The facts

Some maintenance practices to carry out in a vegetable farm are:

- Transplanting
- Weeding
- Gapping
- Watering/irrigation
- Pests and diseases control
- Howing and horrowing
- Earthing up
- Top dressing
- Thining plant
- Mulching

(i) Transplanting

Most vegetables grow better when transplanted. Examples are cabbages, tomatoes and chili. Others do better when directly sown into the fields. These are mainly root crops. There are other vegetables which can either be directly sown or transplanted depending on circumstances.

Rules for transplanting

- Transplanting should be done as soon as seedlings are about 4 to 8 weeks old, 10 to 15 cm tall and have formed about 3 to 4 true leaves.
- The nursery bed should be watered 24 hours before uprooting the seedlings for transplanting so that they may not suffer from desiccation and minimise root damage.

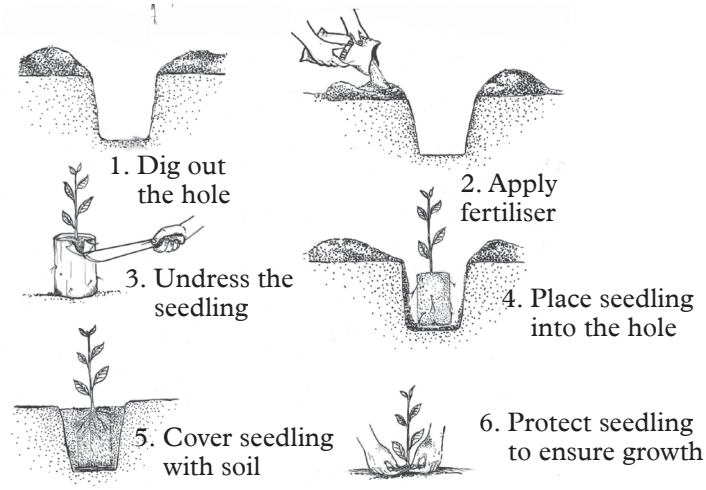


Fig. 4.10: Steps of transplanting seedlings

- The seedlings should be dug up not pulled out.
- When the seedlings are uprooted they experience transplanting shock. Therefore, it is essential to water plants immediately after transplanting and until the plants have recovered.
- Always transplant under cool conditions so that plants may establish themselves in the cool weather, especially in the night. This also helps to ensure that plants recover from the shock of transplanting before sunrise.
- Avoid seedlings which have grown too tall. Such seedlings become weak and they may start flowering very early.
- During transplanting, care should be taken to protect seedlings against wilting. This can be done by frequently sprinkling water on them and covering the roots with moist soil or leaves.
- Setting the seedlings to a depth of first true leaves when transplanting is known to result in early fruiting and larger fruit size in some crops.

Activity 4.10

1. Prepare the now grown seedlings from your nursery in Activity 4.7 for transplanting. Then carefully transplant the seedlings onto the larger farming field.
2. Keep watching and taking care of the plants until maturity.

Self-evaluation Test 4.5

1. Explain transplanting shock and how it relates with time of transplanting.
2. Why is it a bad sign when plants start flowering too early?

(ii) Irrigation or watering

Irrigation refers to artificial application of water. Irrigation is done to supplement the available soil water. Water is very essential to plants since it helps to keep the plant body cool and it also facilitates nutrients uptake by the roots of plants. Vegetables are normally between 80 to 95 percent water. Therefore, they require plenty of water during their growing period.

General rules for irrigation

- Always water before water stress symptoms occur.
- Water when the atmosphere is cool.
- Apply water on soil surface and not on to the plants. This helps to reduce risk of diseases such as blight.
- The amount of water to be applied at a given time will depend on the soil moisture content and the water-holding capacity of the soil.

My environment, my life!

Irrigation or watering of plants should only be done when necessary. Water is a natural resource which should not be wasted!

Self-evaluation Test 4.6

1. How can one determine the moisture content and water-holding capacity of a given soil?
2. How will the farmer apply this information during irrigation?

(iii) Weeding

Weeds reduce yield and quality of vegetables through direct competition for light, water and nutrients. They also interfere with harvesting operations. Weeds also harbour pests and diseases which can infect or infest the vegetables. Weed competition is very critical and major emphasis of control should be done in the early stages of plant growth. Incorporation of several of the following management practices into vegetable production increases the effectiveness of controlling weeds.

- Crop competition
- Crop rotation
- Mulching
- Mechanical control
- Use of herbicides

(iv) **Hoeing and harrowing**

Hoeing is the opening of soil in standing crops with the help of a hoe or a pointed stick. Hoeing facilitates breaking of the soil crust (in some soils), aeration of the soil, movement of water in the soil mass and bringing the needed nutrients closer to the roots of the crops. However, hoeing should not be too deep thereby injuring the roots of the crop.

(v) **Earthing up** - Piling up of the soil on the standing crop is called earthing up. This operation is required for tuber and root crops. It facilitates the growth and development of roots and tuber crops.

(vi) **Top dressing** - Addition or application of fertilisers in the standing crop is termed as top dressing. Top dressing is done to provide nutrients when needed most. It helps to avoid the loss of nutrients through leaching.

(vii) **Thinning plants** - This is eliminating excess plants to let few remain. This reduces crowding and ensures that the crops grow healthy.

(viii) **Gapping** - This refers to replacing seedlings that dried up after transplanting. The seedlings may have dried because of harsh environmental conditions or pests and diseases. Gapping should be done after it has rained.

(ix) **Mulching**-This is covering of the soil with organic matter like grasses and crop residues or with artificial materials like plastic sheet.

Fig. 4.11: Mulch in cabbage plantation

Mulching helps:

- To prevent loss of soil water and moisture.
- To raise soil temperature.
- To reduce growth of weeds.
- In adding organic matter, if the mulching material is biodegradable.
- To reduce leaching of soil nutrients.

All these help to improve soil fertility.

(x) **Pest and disease control**

All vegetables will be attacked by some pests and diseases at some stage. The pests that affect vegetable crops can be put into various groups.

Activity 4.11: Research Activity

Find out which pests and diseases attack vegetables. How can they be controlled? Write a report and do a presentation to the rest of the class.

The facts

Examples of vegetables pests are:

- Soil insects-Examples are cut worms, white grubs, red ants, wire worms, etc.
- Stem and foliage feeders-Examples are caterpillars, loopers, diamond back moth, beetles, etc.
- Mites and sucking pests-Examples are aphids, whiteflies, plant hoppers, thrips, bugs, etc.
- Insects that consume seeds, pods and fruits-Examples are pod borers, fruit borers and fruit flies, etc.

Similarly, the diseases that attack vegetables can be grouped as follows:

- Root diseases - examples include club roots, damping off, root rot, wilts, etc.
- Foliage diseases - examples are blights, rusts, leaf spots, etc.

- Fruit diseases - examples include fruit rots, anthracnose, fruit blight, etc.
- Vascular diseases such as wilts.

These diseases could be caused by either **fungi**, **bacteria**, **viruses** or **nematodes**. Often, unfavourable conditions can also cause diseases.

Control measures for pests and diseases

Any practices which produce strong and healthy seedlings will reduce the risk of pest and disease attack.

- Maintain high **soil fertility** and use **adequate manures** to maintain good soil structure. These will provide soil aeration and a good supply of micronutrients.
- Use only **healthy seeds** and seedlings of the desired variety.
- Varieties with **resistance** to pests or disease should be emphasised.
- Crop rotation should be done to prevent build up of soil-borne pests. This also ensures efficient use of nutrients.
- Practise **good crop hygiene**. Remove crop debris and weeds that may act as alternative hosts for pests and diseases. Destroy diseased plants, collect insect infested fallen fruits and bury them.
- **Monitor** your crops regularly for early detection of problems. Small numbers of pests especially egg masses and larvae can be destroyed by hand.
- Finally, most crop pests and diseases are controlled through **spraying** using appropriate chemicals.

Activity 4.12

1. Having learnt the various maintenance practices, carry out the necessary vegetable maintenance activities on your seedlings.
2. Look out for any pest or disease attacks. Early prevention is better than cure.
3. Once the signs of maturity have been observed, harvesting can be done.

My environment, my life!

When spraying chemicals, we should follow manufacturers instructions. We should also avoid excessive use of chemicals.

Self-evaluation Test 4.7

1. From the aforementioned nursery maintenance practices, which ones help to discourage pests and diseases and how ?
2. You have been invited to speak to farmers about the advantages of using healthy seeds and seedlings. Highlight the main points of your speech.

3. Come up with a duty roster to ensure that each member of your class has a specific role to play every day on your nursery project.

4.5 Harvesting indicators of vegetables

Discussion corner!

1. Work with your friends in a group.
2. Find out what factors to look out for in order to know that vegetables are mature to harvest.
3. Choose a group leader to take notes.
4. The group leader should do a presentation to the rest of the class on behalf of the group.

The facts

When vegetables are ready for harvesting, there are a number of things to look out for to know the right time to harvest. The three main ones are: days of **maturity**, **size** and **colour**.

(a) Days of maturity

There may be no clear difference between the terms '**ripe**' and '**mature**'. Produce that is ripe is mature and ripe produce is ready for sale and use. Produce that is mature may or may not be ripe but will ripen if the right conditions are provided. The best example is the mature green tomato. These tomatoes are harvested when they are green but after some time, when under certain conditions, they eventually turn red and soften, such tomatoes are said to be ripe.

(b) Colour

Many vegetables turn colour as they mature; tomatoes and peppers are examples. These colours may vary from one vegetable to another. Also vegetables ready for picking commonly have a shiny, healthy look. If the skin of the crop is dull, the peak time for harvest may have passed, etc.

(c) Size

Most vegetables are ready for harvest when they reach a useable size; depending on the type of vegetable.

Quality check!

Do not delay harvesting while waiting for a vegetable to grow bigger. The nutritive value of the vegetable may end up being lost. Also when buying vegetables, always go for quality not price.

The table below summarises the various characteristics considered when harvesting various vegetables.

Table 4.4: Things to look out for in various vegetables that are ready for harvesting

Vegetable	Harvesting indicators considered			Observations/ Comment
	Days to maturity	Size	Colour	
Tomato	70-90	Varies with variety	Red, orange, yellow	Harvest fully ripe for best flavour
Onion	100-120	Varies with variety	White, yellow, red	Harvest when tops fall over and begin to dry
Lettuce	45-60	4 cm long	Green	Harvest outer leaves, Start harvesting when the leaves are big enough, early in the morning when the leaves are crisp and full of moisture. ***Note***: Hot weather leads to bitterness.
Pumpkin fruit	80-100	Varies with variety	Light to dark green or striped	Harvested when belly turns from white to creamy yellow
Pepper hot	60-90	1-3 cm long	Red, purple, yellow, green	Use gloves when harvesting
Spinach	45-60	6-8 cm tall	Green	Harvest the entire crop when plants begin to show signs of bloting.
Peas	55-85	3 cm long pods	Bright green	Harvest when pods are long and thin, just as the seeds begin to develop
Garlic	90	2-3 cm long	White, reddish	Harvest when foliage topples over and dries

Other factors, which are external also have an impact on the quality of the vegetables. Among them are the time of the day that is most suitable for harvesting. For this case, it is mostly recommended that harvesting of vegetables be done during the coolest time of the day, which is usually *early morning* or late *in the evening*. The shelf-life of produce is closely tied to its respiration rate. The higher the respiration rate, the shorter the shelf-life of the product. The respiration rate is also directly related to the air and produce temperature.

At high temperatures, the respiration rate is high, so the shelf life of produce is reduced. Keeping the produce's temperature low increases shelf-life. Optimum storage temperature and harvest temperature differences should be kept to a minimum. By harvesting during the cool times of the day, this will be accomplished; hence shelf-life will be prolonged.

Activity 4.13

Observe your vegetables and see whether they have matured yet or not. Consider the harvesting indicators you have learned in class.

4.6 Preservation of vegetables

Activity 4.14: Research Activity

Find out how people preserve vegetables in your community. How about modern methods of vegetable preservation? Comparing the two, which ones are more effective? Why? Write a report and present it to class.

The facts

Vegetables should be prepared for preservation as soon as they are harvested. This should be within 4 to 48 hours after time of harvesting. The likelihood of **spoilage** (any change in food that causes it to lose its desired quality, eventually becoming inedible) increases rapidly as more time passes by.
Some of the methods of preserving vegetables are discussed below.

1. Blanching or pre-cooking

This is done by immersing vegetables in water at a temperature of 90-95°C. Exposing them to steam is also recommended. The result is that fruits and vegetables become somewhat soft and the enzymes are inactivated. **Blanching** is done before a product is dried in order to prevent unwanted colour, odour changes and an excessive loss of vitamins.

Note: Fruits that do not change colour generally do not need to be blanched. Onions and leek are not at all suited for blanching.

The relevant examples of vegatables that require blanching are:

- Peas and beans before canning in order to inactivate enzymes.
- Irish potatoes to prevent browning when making French fries.
- Green beans before cold storage.
- Cabbages.
- Carrots.
- Pea pods.

2. Preserving by heating

One of the most common and effective ways of preserving fruits and vegetables is to prepare them and place them in air-tight containers, which are then heated. The high temperatures ensure that microorganisms are killed and the enzymes are inactivated.

Some examples of food preserved by heating include:

- Canned cabbages.
- Canned green beans.
- Canned bean pods.
- Canned green peas.
- Canned carrots.
- Canned pea pods.

Advantages

- Most microorganisms are destroyed so there is a low chance of spoilage.
- After being sterilised and stored, the food can be kept for longer and more safely.

Disadvantages

- Heating requires the following which makes it expensive:
  - Heat-resistant storage containers such as cans or glass jars (which can be difficult to get). The latter are preferred because they canbe reused.
  - Cooking utensils, such as a steamer.
  - Fuel
- The costs above will have to be represented in the final cost of the product.
- This method is labour intensive.
- It requires access to abundant clean water.
- Heated fruits and vegetables have a lower nutritional value as some nutrients are destroyed by heat for example vitamins.

3. Pasteurisation and sterilisation

This is done to prepare food items for storage in glasses, bottles or tins.
Glass bottles and jars can be used for sterilisation and pasteurisation. They are normally reusable. However, they are also breakable and when transparent, they do not protect food from the negative effects of light. This problem can be solved by storing the filled bottles and jars in a dark place. Glass bottles, those previously used for soft drinks or beer for example, are well suited for heating and storing fruit pulp, puree or juice. They have to be sealed with a metal screw cap. Their volume can vary from 0.2 to even 2 litres.

- **Sterilisation** refers to heating above 100°C. It can be done in a pressure cooker or an autoclave (large pressure cooker).
- **Pasteurisation** is a mild heating treatment at temperatures of up to 100°C (which is the boiling point of water at elevations of up to 300 m above sea level). This method causes only a slight decrease in taste and nutritional value. The enzymes are inactivated and most, but not all, bacteria are killed. Pasteurised products therefore spoil faster than sterilised products. To prevent the surviving spore-producing microorganisms from multiplying, the produce should be stored in temperatures below 20°C.

Quality check!

Always remember to check the date of expiry and that of manufacture on any product you buy that have been pasteurised. This will largely help in avoiding cases of food poisoning.

4. Drying

This is one of the oldest preservation methods. The moisture level of agricultural products is decreased to 10-15% so that the microorganisms present cannot thrive and the enzymes become inactive. Further dehydration is usually not desired, because the products then often become brittle. To ensure that the products do not spoil after being dried, they have to be stored in a moisture-free environment.
The final quality of the dried product is determined by many factors. They can however be divided into four groups:

a) Quality of the product to be dried.
b) The preparation of the product.
c) The drying method used.
d) The packing and storage conditions.

5. Use of preservatives

Fruits are sometimes treated with smoke from burning sulphur or are dipped in a sulphite or thiosulphate-salt solution to prevent browning.

Taste and vitamin C content are also better preserved with these treatments. The residual sulphite in the product can, however, be dangerous in high concentrations and can also affect the taste.

6. Pickling

This is done by dipping the food in vinegar. This method of preserving vegetables can be done with cabbages, beets, onions, cucumber and fruits such as lemons and olives. To obtain a product that can be stored, the food first has to be salted and heated before being put into vinegar.
We can remove water (drying), increase the acidity, or first heat the product (to kill the bacteria) and then store them in air-tight containers to prevent oxygen from entering (bottling or canning).

7. Freezing

This is another age-old method of preservation.Vegetables are kept at very low temperatures (-40°C) after having been collected and washed properly. However, frozen vegetables do not have the same properties as fresh ones because many vitamins are lost in the process.

8. Fourth generation vegetables

These are vegetables preserved in vaccum plastic bags or trays ready to be consumed directly. Before this is done, vegetables are very well cleaned and chopped. The oxygen is removed and the product is packed in nitrogen gas. This prevents the survival of microorganisms. These products are normally fresh and can be eaten as salads; oil and salt may be added.
There are a wide variety of vegetables in the market stored using this method. They include lettuce, endives, carrots and celeries.

9. Fermentation of vegetables

During fermentation of raw vegetables, **lactic acid bacteria** develop, transforming the natural sugars present and the added sugar into an acid. In general, a low salt concentration of 3-5% is used to prevent the growth of spoilage bacteria; while lactic acid bacteria are developing. The characteristic flavour and texture of fermented vegetables is produced by the action of lactic acid bacteria.

Vegetables must be kept submerged in the liquid to prevent contact with air, which can cause decomposition. Due to action of yeasts and moulds during the fermentation process (2 to 3 weeks), the salt becomes diluted due to water drained from the vegetables, therefore salt must be frequently added to maintain the concentration at 3-5%.

10. Vaccum packaging

Vacuum packaging extends the shelf-life of vegetables for long periods. This technique relies on the withdrawal of air from the package with a suctioning machine. Removal of air retards the development of enzymatic reactions and bacterial spoilage. Vacuum packaging and gas flushing establish the modified atmosphere quickly and increase the shelf-life and quality of processed products. For example, browning of cut lettuce occurs before a beneficial atmosphere can be established by the product's respiration. In addition to vacuum packing, the specifications of handling must be taken into account, especially the time delays and temperature fluctuations.

11. Canning (Tinning)

This is a food preservation method in which processed food is sealed in airtight containers. It is a reliable method as it increases the shelf-life of food to up to five years. The canning process involves placing foods in jars or similar containers and heating them to a temperature that destroys micro-organisms that cause food to spoil. Heating drives out air out of the jar and as it cools, a vacuum seal is formed. The vacuum seal prevents air from getting back into the product hence preventing the entry of microorganisms.

Activity 4.15

Perform a vegetable preservation experiment using any method that you know. (This should be done in the Biology laboratory.) Use the vegetables that you will have harvested from your school farm.

Safety check!

Be careful as you interact with fire and any chemicals in the laboratory. Ensure that you do not cause any harm to your partner and also to yourself. Handle the equipment you will be using with care!

Self-evaluation Test 4.8

Classify the various vegetables with their most appropriate methods of preservation.

Remember the facts!

- A vegetable is any part of a plant that is consumed by human beings as food in a savoury course or meal.
- The following are some benefits of vegetables:

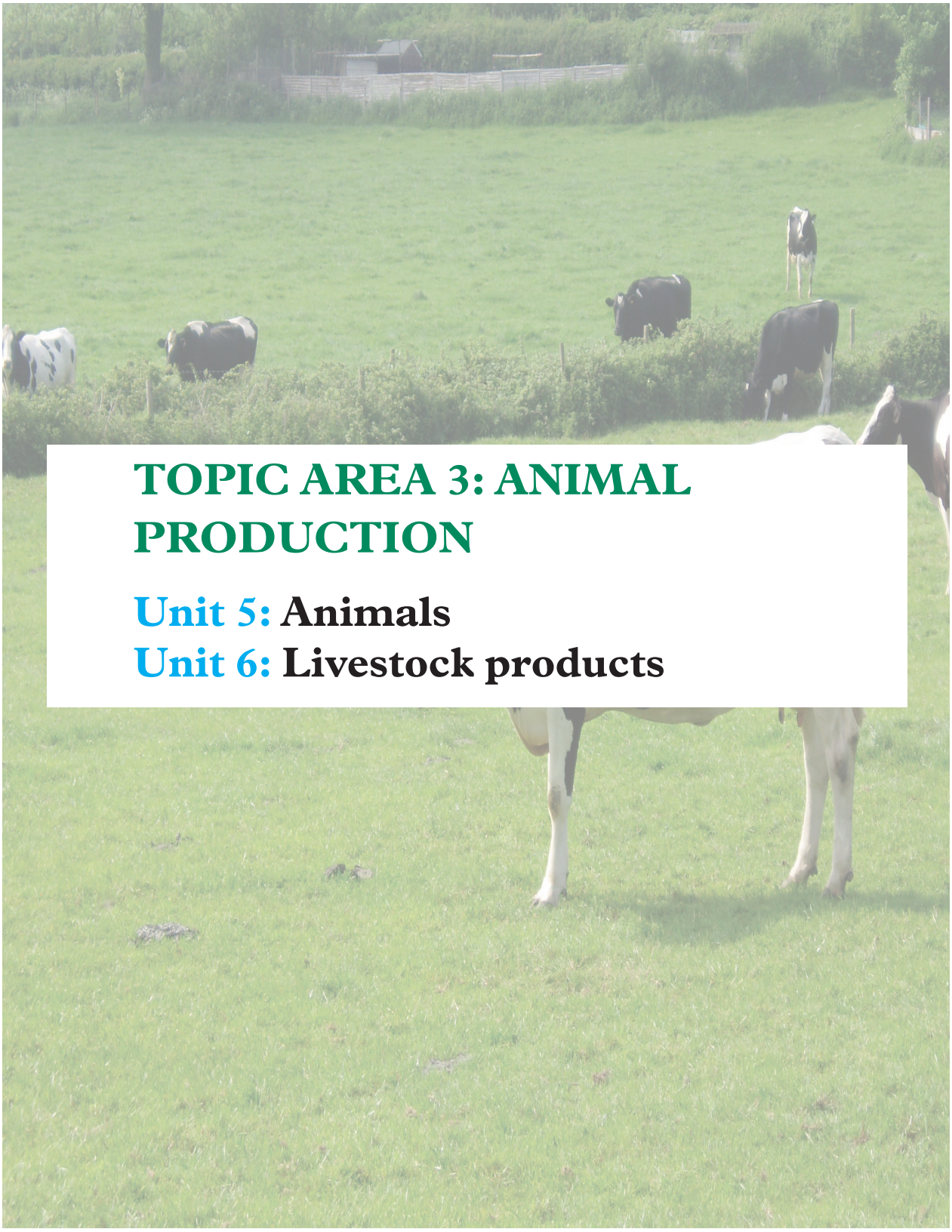
  - Improving human health
  - A source of income
  - Improving soil fertility when incorporated in crop rotation programmes
  - A source of employment
  - Industrial importance
  - Medicinal value
- The three major ways of classifying vegetables are based on:
  - Edible parts
  - Botanical classifications
  - Hardiness
- A nursery from the agricultural point of view is a place where plants are raised with special care until they are ready for transplanting into the field.
- The following are the major types of nurseries:
  - Temporary nurseries
  - Permanent nurseries
- Some of the major criteria used in selecting a nursery site are:
  - Soil type
  - Climate
  - Water availability
  - Planting material
  - Availability of market
- Nursery preparation refers to the process of making the soil suitable for sowing and transplanting of seedlings.
- Some of the operations involved in nursery preparation include:
  - Irrigation
  - Hardening off
  - Pest and disease control
  - Earthing up
  - Mulching
  - Thinning
  - Shading
  - Harrowing
  - Manure and fertiliser application
- Sowing methods are the modes by which farmers plant seeds. This can be direct or indirect through transplanting.
- The two main nursery activities are:
  - Transplanting
  - Irrigation or watering
- Maintenance activities of vegetables are those activities that help in ensuring

that the seedlings in the field grow healthy and strong. They include:
  - Weeding
  - Hoeing and harrowing
  - Earthing up
  - Top dressing
  - Thinning
  - Gapping
  - Mulching
- Vegetables are also attacked by some pests and diseases. They should be controlled before they cause damage.
- Harvesting indicators for vegetables include days of maturity, size and colour.
- Vegetables should be prepared for preservation as soon as they are harvested. Examples of preservation methods are:
  - Blanching or pre-cooking
  - Preserving by heating
  - Pasteurisation or sterilisation
  - Drying
  - Use of preservatives
  - Prickling in vinegar or acetic acid
  - Freezing
  - Fourth generation vegetables
  - Vacuum packaging.

Test your competence 4

1. Why is classifying vegetables important?
2. Why is it important for some vegetables to be planted in nurseries first before being taken to the field?
3. Name some farm tools that can be used in the operations performed during nursery preparation.
4. Why is weeding an important operation in nursery preparation?
5. What are some of the irrigation or watering methods you know that can help save on water?
6. Of the listed, what is not important when considering a site for a nursery?
   A. Soil type
   B. Type of plant
   C. Topography
   D. Proximity to water
7. Transplanting is a very delicate process. Explain.
8. Mutoni wants to minimise pest and disease attack on the seedlings in her nursery. What would you advise her to do?

9. The nutritive value of vegetables is important. How can we ensure that the nutrients in vegetables are **not** interfered with?
10. Ntwali wants to preserve vegetables to be sold in the next two weeks. Which preservation methods would be most appropriate for storing vegetables for this long?
11. Mugwaneza bought tinned vegetables only for him to reach home and find them spoilt.
    a) What was Mugwaneza's mistake and what should she have done at the shop?
    b) Describe the method that may have been used to preserve the tinned vegetables.
12. Which of the following is not done during nursery bed preparation?
    A. Top dressing
    B. Ploughing
    C. Fertiliser application
    D. Clod crushing



TOPIC AREA 3: ANIMAL PRODUCTION

Unit 5: Animals
Unit 6: Livestock products

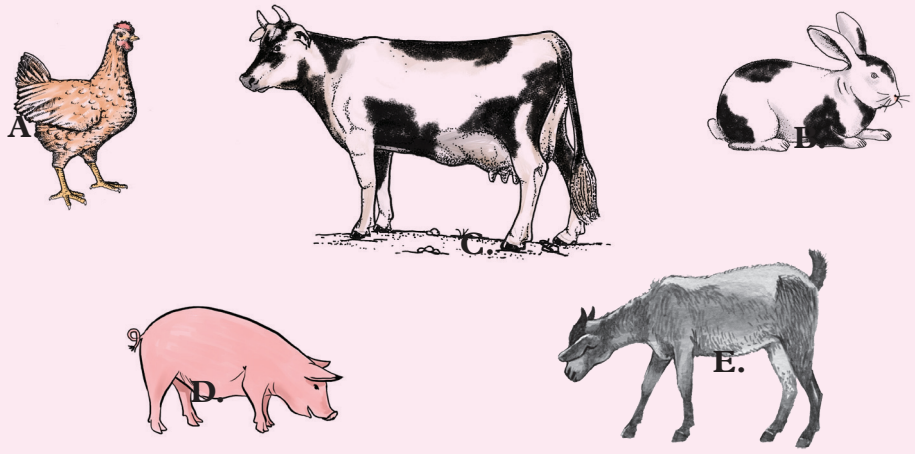
UNIT 5 Animals

Introduction

In Rwanda, rearing of non-ruminants such as rabbits has continued to be dominated by smallholder farmers and very few big farmers. This is of great concern because these animals can be a source of income through their products. Their wastes (manures) can also be used as manure in the farms.

Discussion corner!

Which animals do you know in the pictures shown below?



How are the animals important to us? Given a chance, which animal(s) would you keep? Why?

Key Unit Competency

After studying this unit, I should be able to:

a) Identify non-ruminant species and breeds.
b) Successfully conduct rabbit rearing.

Unit Outline

5.1 What are non-ruminants?

Activity 5.1

Your teacher will take you for a field visit to a farm that keeps non-ruminants. Observe the various types of non-ruminants present. Identify them (with the help of the farmer) and note down their characteristics.

The facts

Non-ruminants are also called **mono-gastric** animals. The animals have one stomach and they swallow food once without regurgitation. Examples of non-ruminants are dogs, cats, pigs, rabbits and poultry. Name five other non-ruminants that you know.

5.2 Non-ruminant species and breeds

The non-ruminants that you will learn about at this level which are commonly reared in Rwanda are:

- Poultry
- Pigs
- Rabbits

a) Breeds of poultry

Activity 5.2: Research Activity

1. Using the internet search engine and other text books, find out the various breeds of poultry in Rwanda.
2. Your teacher will now show you a video on poultry keeping. Watch the video and note down the characteristics of various breeds of poultry.
3. Discuss in groups the characteristics of the breeds.
4. Write down the main points and do a presentation to the rest of the class.

The facts

Poultry refers collectively to domesticated birds. They include chicken, ducks, guinea fowls, geese and turkeys among others. However, in this unit, you shall only learn about chicken as a representative of the **poultry family**.

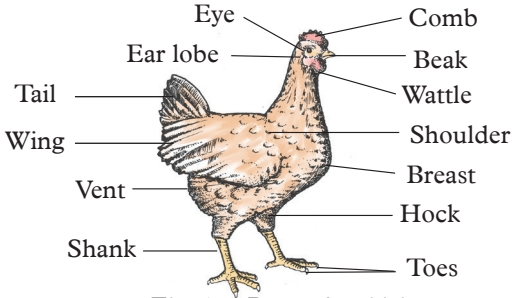


Fig. 5.1: Parts of a chicken

Chicken can be kept for meat, eggs or both. The common breeds of chicken reared in Rwanda are:

(i) Rhode Island Red

It is a dual purpose breed meaning it is reared for both meat and eggs.
It is the most popular of all dual purpose breeds of chicken.

Fig. 5.2: Rhode Island Red

- Rhode island red originated from America.
- The bird lays brown-shelled eggs.
- It has good quality carcass.
- They are mostly docile hence easy to manage.
- The bird has a broad deep angular body.
- Cocks weigh 4.0 kg while hens weigh 3.5 kg.
- It also has well-formed breasts that protrude forwards while the back is flat.
- Their main disadvantage is their yellow skin which is normally unpopular with consumers.

(ii) Sussex

Fig. 5.3: Light sussex

The most common type of Sussex is the **Light Sussex**. It is a **broiler** meaning it is kept for meat.

- Its origin is Great Britain.
- Cocks weigh 5.0 kg while hens weigh 3.0 kg on average.
- They have a high meat conversion rate.
- They lay small tinted eggs.
- They have a large body with good deep and broad shoulders.
- The breast is well developed with excellent meat qualities.

Health Check!

Chicken give white meat which is very good for those suffering from various ailments, especially HIV and AIDS.

(iii) Derco

It is a French hybrid. It shows slow growth when compared with other exotic chicken breeds. It also shows a high potential of crossbreeding with other chicken breeds.

Fig. 5.4: Derco

(iv) Local breeds

This is the most common breed in Rwanda. It is a multi-purpose breed that is very hardy.

It lays between 40 and 100 eggs per year and the adult weight is reached in more than 10 months. The breed combines the needed quality of production and resistance to diseases. It adapts very well to the local conditions and is easy to manage.

Fig. 5.5: Local breed of chicken in Rwanda

(b) Breeds of rabbits

Activity 5.3

1. Using the internet search engine and text books, find out the various breeds of rabbit.
2. Your teacher will now show you a video on rabbit rearing. Watch the video and note the characteristics of various breeds of rabbits.
3. Write down the main points and do a presentation to the rest of the class.

The facts

Rabbits are mainly kept for meat and fur or hair. Their skin is also used in making soft upholstery such as seat covers.

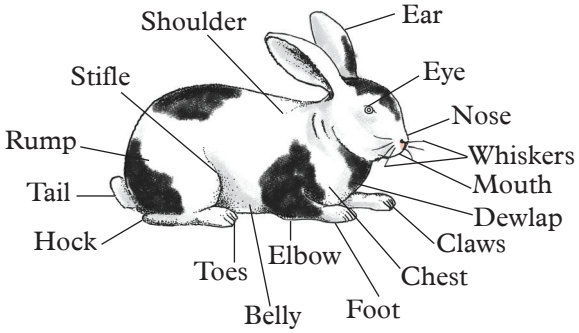


Fig. 5.6: Parts of a rabbit

The common breeds of rabbits reared in Rwanda are:

(i) Angora

This is a domestic rabbit bred for its long, soft fur. The Angora breed is one of the oldest of the domestic rabbit breeds. The breed has poor body conformation and its average weight is 2.5 kg.

Fig. 5.7: Angora

(ii) California white

Fig. 5.8: California white

- It is white with black or dark brown ears, eyes, nose and feet.
- Adult bucks weigh 5.0 kg while adult does weigh 3.5 kg on average.
- It is very prolific and is widely used for cross breeding.
- It is kept for meat.

(iii) New Zealand white

- It is white with pink eyes.
- Bucks are blocky and compact. They weigh 5.0 kg on average.
- Does on the other hand weigh 4.5 kg on average.
- They have a long body and a wide back.
- The breed is prolific and fast growing.
- The breed is mainly kept for meat.

Fig. 5.9: New Zealand white

(iv) Local breeds of rabbits

The local breed of rabbits has the following characteristics:

- It is black with white patches and pink eyes.
- They have a short body.
- They weigh 2.0kg on average.
- The breed is not prolific and gives birth to few young ones.
- The breed is slow-growing but resistant to

many rabbit diseases.

Fig. 5.10: Local breed of rabbits in Rwanda

- They are reared mainly for both meat and skins.

(c) Breeds of pigs

Activity 5.4

1. Using the internet search engine and text books, find out the various breeds of pigs.
2. Your teacher will now show you a video on pig production. Watch the video and note the characteristics of various breeds of pigs.
3. Write down the main points and do a presentation to the rest of the class.

The facts

Pigs are reared for either **pork** or **bacon** production. Pork is meat from a young pig weighing 45-50kg and at 4 months. The meat is not salted. Bacon is meat from an old pig weighing 110kg live weight, slaughtered at 7 months. Bacon is salted and is normally obtained from the back and sides of the pig.

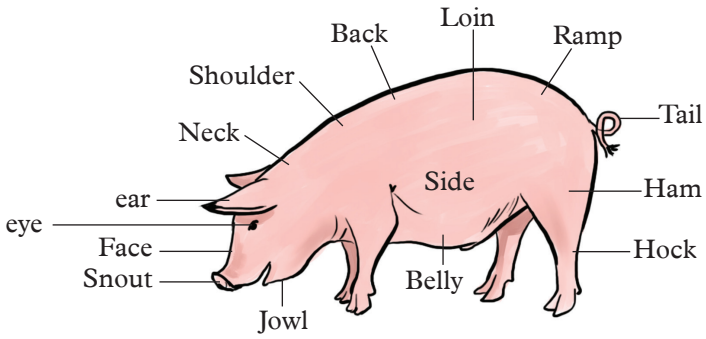


Fig. 5.11: Parts of a pig

The common pig breeds reared in Rwanda are:

(i) Large white

Large white originated from York shire, Britain. It is widely reared in many parts of Rwanda. It is mainly kept for pork.

- It is long, large and white in colour.
- It has erect ears.
- It has a dished face and a snout.
- It is the most prolific of all the pig breeds.
- It has good mothering ability and it is a high milker.

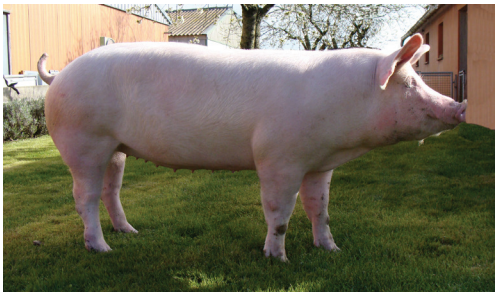


Fig. 5.12: Large white

- It is susceptible to sun burn.
- It matures late.
- It is a good converter of feeds into meat.
- It is fairly hardy.
- It has strong hind legs.
- It has a sagging back and a level underneath.

(ii) Landrace

This breed originated from Denmark. It is kept for bacon production.

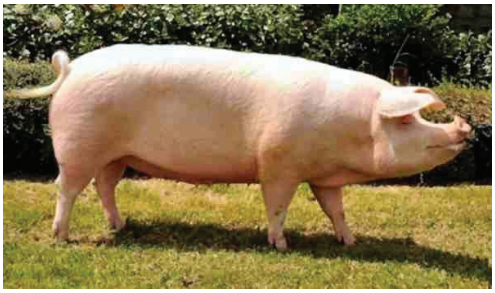


Fig. 5.13: Landrace

- It is white in colour.
- It is longer than the large white.
- Its ears are long and they droop over the face.
- It is as prolific as the large white.
- It also has good mothering ability.
- It requires high level management skills.
- It has a sagging back and weak hind legs.
- It has a straight snout.

(iii) Pietrain

This breed was introduced in Rwanda by Brother Cyrile. Some were imported by the government of Rwanda. Their number in Rwanda is restricted in different parts of the country. Its origin is Belgium.

- It is medium-sized.
- It is white in colour with round black spots and characteristic rings of light pigmentation that have white hair.
- Their ears are erect.
- It is renowned for its very high yield of lean meat.
- It has good mothering abilities.
- It matures fast and it is also a good converter of feed into meat.

Fig. 5.14: Pietrain

(iv) Local or traditional pig breeds

Fig. 5.15: Local breed of pig in Rwanda

The traditional pig breed in Rwanda is small-sized, hardy and with low productivity. It also has low exigencies, which fits perfectly in an environment with scarce resources and low level management capacity.

Local pigs are of different colours (mainly black or spotted) and are available in various sizes. It is obvious that there has been crossbreeding taking place in the past but it is hard to assess how much and whether there are still pure traditional pigs.

Money matters!

Rearing of pigs may not be acceptable in some communities. It is therefore wise to do a thorough market research to see whether the pork or bacon produced will sell or not.

Self-evaluation Test 5.1

1. What is a non-ruminant animal?
2. Which non-ruminants are reared in Rwanda?
3. Draw and label a:
   a) Hen b) Rabbit c) Pig
4. What are some of the advantages and disadvantages of keeping local or traditional breeds of the above mentioned non-ruminants?

5.3 A rabbit hutch

Activity 5.5: Research Activity

1. What is a hutch?
2. Go for a field visit to a rabbit farm and observe the available rabbit hutches, the materials they are made of and how the materials are arranged.
3. Afterwards, research and discuss the standards used and the different operations involved in the construction of a rabbit hutch.
4. Write a report and do a presentation to the rest of the class.

The facts

Rabbits are kept in structures called **hutches**. Rabbit hutches can be constructed in two ways.

1. One structure consisting of **several hutches**. The structure is normally immobile, i.e., cannot be moved. The food is brought to the rabbits while they are in the hutch.
2. **Single hutches**. Here, the hutches can be moved from place to place. The rabbits feed on the grass that sticks through the wire part of the floor of the hutch.

The following are the necessary materials required in the construction of a hutch: timber, iron sheets, nails and iron wire nets.

Fig. 5.16: A rabbit hutch

Each hutch should measure 120 cm by 60 cm by 60 cm. A hutch for the doe should have a **nesting box** besides feed and water troughs. They also have resting and sleeping areas. The floors of the sleeping and nesting boxes should be wooden. The rest of the floor can be made of a wire netting of 1cm mesh or slats spaced 1cm apart. The nesting box should measure 38 cm by 25 cm by 20 cm.

In hot areas, the wall should be made of a wire netting. In cool areas, only the front wall is to be covered with a wire net to let in light and allow for ventilation.

Note: All hutches should be raised 1 m above the ground.

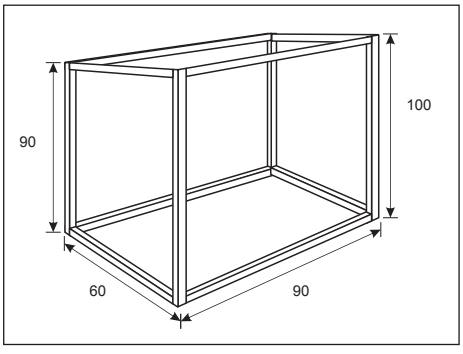
Steps to follow when making a rabbit hutch

The example given here is that of one rabbit hutch. Feel free to vary the size according to the number of rabbits you want to rear.

Step 1: Site selection

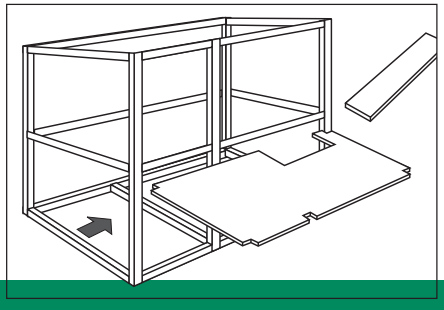
Hutches are typically made of exterior grade ply-wood for placement outdoors. Choose a covered location that will protect the hutch from harsh weather and from predators. Remember: It is hard for rabbits to endure high temperatures.

Step 2: Build the frame



The first step is to build the outer frame. The dimensions of the frame for one rabbit are as shown besides. Remember, the front part should be taller to allow slanting of the roof. This ensures that rain water fall off easily when it rains. Use a spirit level to check that all the corners are straight and properly aligned.

Step 3: Fit a floor panel

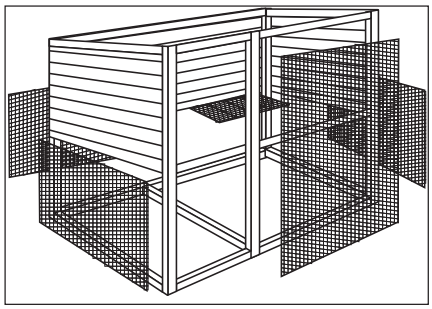


To prevent your rabbit from escaping by digging a rabbit hole, fit a floor panel in the rabbit hutch. If you do not mind your rabbit digging into the ground, put a strong wire gauze under the ground (about 20 cm deep). This way, your rabbit will have the freedom to dig, but won't be able to

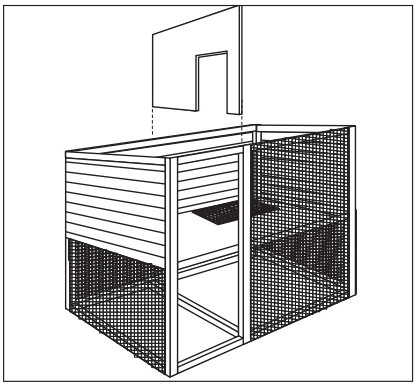
escape.

Step 4: Make the sidewalls

Make the sidewalls of the rabbit hutch by screwing the planks of wood to the frame. You can also nail the wood onto the frame. You can then fix wire gauze to the openings using staple nails.



Step 5: Fit the interior panel

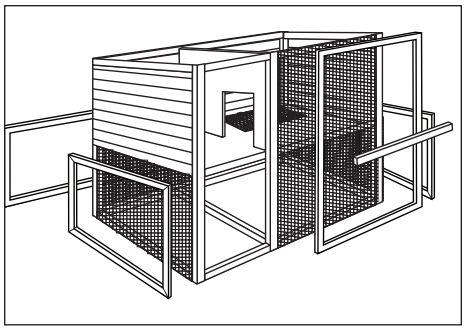


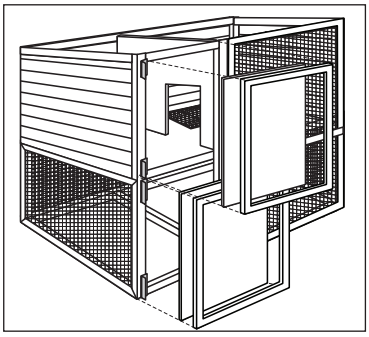
The interior panel is intended to serve as a night shelter. Make an opening in the panel that's big enough to let your rabbit go in and out.

The interior panel can also have the nesting boxes. Water and feeding troughs can be placed at the front panel.

Step 6: Fit the finishing strips

Finish the outside of the hutch with decorative strips to cover the sharp edges of the gauze. Check that all the corners are straight and properly aligned.





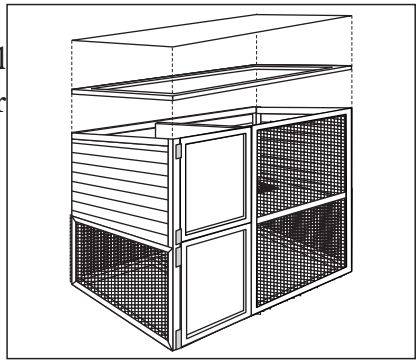
Step 7: Make the doors

Make the doors as shown in the drawing. Use two galvanised or stainless steel hinges on both doors. Fit bolts on the upper and lower doors.

Step 8: Finish the roof

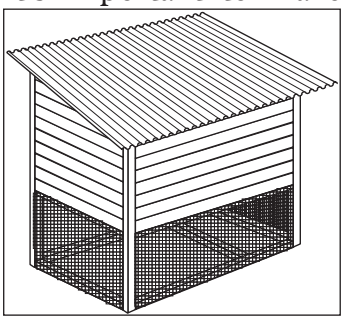
Make a roof frame from beams of the right size,
so the outside of the rabbit hutch covers the frame. Make the roof panel from a piece of 12 or 18 mm shuttering plywood or waterproof plywood.

Screw the roof panel to the frame with two hinges. Make sure the roof panel overlaps by at least 5 cm all round, and by 10 cm at the front. That prevents water entry, so the inside of the rabbit hutch stays dry.



Step 9: Make the roof water-proof

It's important to make sure that the roof of the rabbit hutch is waterproof, so cover it with self-adhesive bitumenised roofing. You can also use iron sheets or polythene bag to cover the roof as shown.



Your rabbit hutch is now ready for use but before that, put saw dust and soft grass on the floor. This offers a soft ground for the rabbit to sleep and play.

Activity 5.6

Construct a standardised hutch, considering the steps shown above.
Work in groups and:

1. Come up with a plan of action.
2. Execute the plan.
3. Look back and discuss the challenges encountered.
4. Discuss how you would avoid these challenges in future projects.

Money matters!

Strive to be creative, especially when it comes to the materials. Find locally available materials and use them skillfully (consult your teacher when stuck). Only when necessary should you buy the materials!

Self-evaluation Test 5.2

1. In which two ways can rabbit hutches be constructed?
2. Name the materials necessary for the construction of a rabbit hutch.
3. Why should the roof of a rabbit hutch be slanting?
4. What can you do to prevent your rabbits from digging rabbit holes?
5. What is the use of saw dust and soft grass on the floor of a rabbit hutch?

5.4 Feeding rabbits

Activity 5.7

Go for a field trip again to the rabbit farm, or any other appropriate one to find out how rabbits are fed. You should note down the following:

(a) Appropriate ingredients for a rabbit diet.
(b) The different possible diets for a rabbit as per its age and body weight.
(c) The feeding plan for a rabbit for a week.

The facts

Rabbits feed on a wide range of foods. These include:

- **Greens** such as cabbages, kales, vines and Napier grass.
- **Root tubers** such as carrots, cassava and turnips.
- **Concentrates** such as dairy meal, dairy cubes and fish meal. These should be fed to pregnant and nursing rabbits. Some salt licks should also be provided.
- Plenty of water.

Young rabbits should start eating solid food at the age of 2½-3 weeks.

Feeding should be done in the mornings and evenings, but water should be available all the time.

Feeding plan for rabbits

For good rearing, rabbits must have at their disposal enough food and water. One healthy rabbit consumes food that is 50% of its body weight per day but this should not exceed 2kg of feeds. For rabbits with more than 4kg body weight include concentrates of these feeds. This should be put in a rack near the litter.

Below is a general feeding plan for rabbits right from birth:

- From weaning time to one month after weaning: 50 g per day per rabbit.
- At 2 months after weaning-75g per day for each rabbit.
- At 3 months after weaning-100g per day for each rabbit.
- Rabbit at the age of over 3 months-100g per day for each rabbit.
- Nursing rabbits-300-400g per day, according to the number of young rabbits.

Activity 5.8

1. Consider the feeding plan you have learnt about in class and plan the types of rabbits you will want to bring into your rabbit hutch(es).
2. Organise with your teacher to purchase the food and the rabbits as well.

Note: This may take time, therefore plan early.

We are all equal!

Listen to each other's opinions and ensure that you agree on the most convenient types of rabbits to rear. You can consider resources such as food and the available room. Also, allowing all members of the group to share their opinions will create a sense of ownership for the rabbit rearing project.

Self-evaluation Test 5.3

1. Young rabbits start feeding on solid foods much later (after 2½-3 weeks). Why is this so?
2. Name some of the locally available foods that you can feed your rabbits on.
3. Why do you think feeding should only be done in the mornings and evenings?

5.5 Rabbit diseases, pests and enemies

Activity 5.9

1. Your teacher will show you a video displaying the different rabbit diseases and enemies. From the video, note down the following:
   (a) The names of the various diseases and enemies of rabbits.
   (b) The characteristics (symptoms and signs) of each disease.
   (c) The causes or any predisposing factors of the rabbit diseases and enemies.
   (d) Prevention and curative control methods.
2. After the video, discuss what you will implement in your rabbit hutch to ensure that your rabbits stay healthy.
3. Write a report and choose one group member to make a presentation to the rest of the class.

The facts

Some of the common diseases and pests that attack rabbits are given in the table that follows.

Table 5.1: Diseases and pests, their signs and symptoms and control measures.

Disease	Cause	Signs & symptoms	Control and prevention
Myxomatosis	myxoma virus	Swelling of the eyes, mouth and anal area. Skin hemorrhage. Lethargy or general body weakness Loss of weight. Difficulty breathing. Seizures or other central nervous system (CNS) signs like spasms of the back muscles. Death typically occurs within 1-2 weeks.	Vaccination Quarantine Due to the serious nature of this virus, most rabbits do not survive. Treatment is instead focused on making the rabbit as comfortable as possible.
Pneumonia	Bacterial, fungal, viral or parasitic infection	Anorexia Weight loss Lethargy Fever Sneezing Excessive salivation Exercise intolerance Nasal discharge Eye discharge Facial abscesses Difficulty breathing	If you suspect pneumonia in your rabbit you must take it to the veterinarian immediately, as untreated cases can become fatal. Culling to prevent spread of disease.
Ringworms	Fungi	Fur falls off the body of the rabbit.	Fungicide can be dusted all over the body of the rabbit and worked down to the skin.

Disease	Cause	Signs & symptoms	Control and prevention
Pasteurellosis	Caused by bacterium known as *Pasteurella multocida*	Upper respiratory tract infection signs which include: - watery nasal discharge - sneezing and then a thick, whitish to yellowish nasal discharge Rabbit produces loud snuffling or snoring sound due to the fluid and mucous in their nasal tracts. Conjuctivitis, causing discharge from the eyes and ear. May cause torticollis or twisting of the neck and inability to stand.	Strict sanitation. Quarantine for infected rabbits. Good housing. Treatment using antibiotics.
Coccidiosis	Protozoa parasite	Reduced appetite, depression, abdominal pain and pale watery mucous membranes, but they can be absent in older rabbits. Inspection of the faeces often reveals blood and threads of mucus. Young rabbits show retarded growth due to effects on the kidney and the liver in particular.	Avoiding overcrowding. Ensuring proper hygiene in the rabbit hutches.
Mites Infestation	Parasite	Severe itching and scales on the body and ears.	Clean conditions can help to control the pest. Use mange mite dust on infested rabbits.
Bloat	Abnormal accumulation of gas in the stomach	Stomach feels hard. Rabbit stomach looks like a balloon. Difficulty in breathing. If left unattended it may lead to death of rabbits.	Avoid overfeeding of rabbits. Provide roughages. Seek veterinarian advice.
Constipation	Changes in eating habits, not drinking enough water	Difficulty in emptying the intestine	Provide enough fibre and plenty of water.

Self-evaluation Test 5.4

1. From the listed pests and diseases, which ones do you think you can control through having good hygienic practices?
2. What is quarantine?

3. Which rabbit disease leads to a watery, whitish to yellow nasal discharge?
4. What causes retarded growth in young rabbits suffering from coccidiosis?

5.6 Farm sanitation rules for rabbit rearing

Activity 5.10

1. Visit a rabbit farm once again and inquire about the sanitation practices they conduct in the rabbit hutches.
2. Find out why the practices are important.
3. Write a report and do a presentation to the rest of the class.

The facts

To have the highest output from rabbit keeping, proper sanitation measures should be taken in the farm. These help to ensure that the rabbits are growing healthy and strong. This way, their rate of reproduction is high and they have quality meat for sale.

The following are some of the sanitation practices that can be performed in a rabbit hutch.

a) Good ventilation: A properly designed ventilation system. This is important because it:

- Removes excess moisture from the hutch.
- Removes harmful gases from the hutch.
- Ensures that the temperatures in the hutch are at favourable levels.
- Ensures proper air circulation.
- Discourages harbouring of disease-causing organisms.

b) Lighting - Indoor housing facilities for rabbits should have ample light. Both natural light and artificial light should be available. These should allow for routine inspection of the rabbits.

c) Shelter from sunlight – Outdoor housing facilities should provide each animal with a section of shade that protects it from direct exposure to the sun. When sunlight is likely to cause overheating or discomfort, sufficient shade should be provided to all rabbits.

d) Shelter from rain – Rabbits kept outdoors should be provided with access to shelter when it rains.

e) Protection from predators – Outdoor housing facilities for rabbits should be fenced or enclosed to minimise the entry of predators.

f) Provide a good drainage system. A suitable method should be provided so as to rapidly eliminate excess water or any fluids.

g) Proper waste disposal – There should be regular disposal of animal and food wastes, replacement of beddings, removal of dead animals and debris. This will help to minimise vermin infestation, contamination, odours and disease hazards.

h) Cleaning of primary enclosures – primary enclosures should be kept reasonably free of excreta, hair, cobwebs and other debris through periodic cleaning. Thorough cleaning should be done regularly.

i) All watering receptacles should be sanitised-with an aim of preventing algae build up and contamination.

j) Supplies of feed can be stored in sealed containers-or any other containers that protect the feeds against insect and rodent infestation and/or contamination.

Self-evaluation Test 5.5

1. Why is good lighting and ventilation important for rabbits in a rabbit hutch?
2. Why is it important to regularly dispose of waste from a hutch?
3. Which diseases and pests can be brought about by poor sanitation in a hutch?
4. Overfeeding rabbits can be fatal to them. Explain why.

Project Work

1. Begin a rabbit keeping project with your friend. Ensure that you observe all the rabbit keeping best practices.
2. Do the following:
   - Write a plan for the project. This should include what you require and the costs involved and how to get the money for the start up.
   - Execute the plan.

Remember the facts!

- Non-ruminants are also called mono-gastric animals. Such animals have one stomach and they swallow food once without regurgitation.
- The most common non-ruminants reared in Rwanda are poultry, pigs and rabbits.
- Poultry refers collectively to domesticated birds.
- Chicken can be kept for meat, eggs or both.
- The following are common breeds of chicken kept in Rwanda:
  - Rhode Island Red
  - Light sussex
  - Derco
  - Local breeds of chicken
- Rabbits are mainly kept for meat and fur or hair.

- The following are some common breeds of rabbits in Rwanda:
  - Angora
  - California white
  - New zealand white
  - Local rabbit breed
- Pigs are reared for either pork or bacon production.
- Pork is meat from a young pig weighing 45-50 kg and at 4 months age.
- Bacon is meat from an old pig weighing 110 kg and at over 7 months of age.
- Some common pig breeds reared in Rwanda are :
  - Large white
  - Landrace
  - Pietrain
  - Local or traditional pig breeds
- The structure in which rabbits are kept is called a hutch.
- The necesarry materials required in the construction of a hutch are timber, iron sheets, nets and iron wire nets.
- All hutches should be raised 1m above the ground.
- Some of the foods that rabbits feed on are cabbages, kales, vines and nappier grass. They also eat roots such as cassava, carrots and turnips. Also, concentrates such as fish meal or dairy meal are good sources of proteins for rabbits.
- Diseases and pests reduce the growth rate in rabbits and they may sometimes even lead to death. Appropriate measures should be put in place to prevent or control them.
- To have the highest output from rabbit keeping, farm sanitation needs to be observed.
- Some of the essential sanitation practices include :
  - Good ventilation
  - Shelter from rain
  - Proper lighting
  - Protection from predators
  - A good drainage system
  - Proper waste disposal
  - Cleaning of primary enclosures
  - All watering receptacles should be sanitised
  - Supplies of feed can be stored in sealed containers.
- When coming up with a rabbit farming project, you should write a plan, determine the type of rabbits to rear and execute the plan. You should later look back and determine the challenges encountered and come up with ways of addressing them in the next project.

Test your competence 5

1. Which ones of the following are not ruminants?
   A. Cows B. Goats C. Pigs D. Sheep
2. Between ruminants and non-ruminants, which ones would you prefer to rear and why ?
3. Keza wants to raise pigs for small scale pork production. Which breeds would be most appropriate for her and why ?
4. Of the three breeds of rabbits discussed, which one would you prefer keeping and why?
5. Mention some of the sanitation practices you can perform in a hutch to prevent spread of diseases.
6. Which rabbit breed fits the description below?
   (i) Widely used for crossbreeding.
   (ii) Is white with dark brown ears, eyes, nose and feet.
   (iii) Is mainly kept for meat.
7. Mention some of the tools that will be used in the construction of a hutch and their uses.
8. Come up with a weekly feeding plan for 2 weeks old rabbits. (Hint: The foods in the plan must be balanced)
9. Which is the best method of dealing with sick rabbits in a hutch? Explain.
10. How can a rabbit farmer ensure that his rabbits are well protected from predators ?
11. What are some of the important things a rabbit farmer should observe in feeds before giving it to the rabbits?
12. Ngabo is a prospective rabbit farmer. He is looking for a piece of land that would be most suitable for his venture. Explain some of the factors he should consider before settling on any given piece of land.

UNIT 6 Livestock products

Introduction

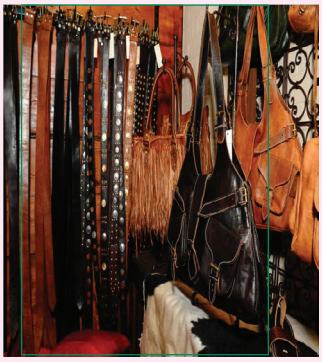
Up to this point, you have learnt about the various species of livestock and how useful they are to the farmers. In this unit, focus shifts to livestock products and their importance in our lives. Therefore, this unit prepares you to appreciate the various animals and the benefits we derive from them. At the end, you should be able to start a farm and earn a living by selling livestock products.

Discussion corner!

Are you familiar with any livestock products? Which ones are they? Which are your favourite? Now look at these pictures.

A.

B.



D.

C.

- What can you see? From which animals are the products obtained?

Key Unit Competency

After studying this unit, I should be able to differentiate livestock products and by-products.

Unit Outline

6.1 Cattle products and by-products

Activity 6.1: Research Activity

1. Use the internet search engine or textbooks to find out:
   - The various cattle products.
   - The by-products of cattle.
   - Their significance.
2. Write a report and present it to the rest of the class.

The facts

We get these things from cattle:

- Meat (beef)
- Milk
- Hides and skin (leather)
- Bones and horns
- Blood
- Ham

a) Meat

Meat from cattle is called **beef**, while meat from sheep or goat is called **mutton**. By far, beef is the most popular meat. Meat farmers normally aim at producing heavy animals to reach the suitable market weight within the shortest period possible. Nevertheless, most of the beef in our country is produced from mature bulls, culled cows and oxen. Therefore, timing of market age is not as critical as in a feedlot beef system. It is important to note that beef is one of the most popular delicacies in the whole world. Beef forms a good source of proteins and minerals like iron, cobalt among others.

Fig. 6.1: Meat in a butchery

Qualities of good beef

Activity 6.2 : Research Activity

Find out about qualities of good beef in the library with your friend. You can also search the internet. Write a report and do a presentation to the rest of the class.

The facts

The following are some of the qualities that one should look out for when determining the quality of beef.

Tenderness of meat – such beef is likely to be obtained if cattle are slaughtered at a young age. The nutritional value of the feeds given to the animal also affects tenderness of beef. The market prefers tender meat to tough meat.

Colour of meat – Most consumers prefer a cherry red colour of beef.

Flavour of the meat – Beef flavour is simply a blend of odour and taste. This becomes more prominent as the animal ages.

Leanness of the meat – Most modern consumers of beef prefer lean meat with little fat or a well marbled meat.

Juiciness of beef – The fat cover or spread on meat and marbleness normally increases the juiciness of beef. Well marbled meat and thorough mixing of fat with the lean meat makes a delicious meal.

Self-evaluation Test 6.1

1. How do we call meat from cattle?
2. Which types of cattle give us beef?
3. Give three qualities of good beef.

b) Milk

Activity 6.3

Visit a supermarket or a nearby well stocked shop. Find out the various milk products sold there. List them in your note book. Find out the difference between them. Discuss with your friends in a group the advantages and disadvantages of each product. Write a report and do a presentation to the rest of the class.

I have discovered that...

A number of products are obtained when raw milk is processed. They include:

- Homogenised and pasteurised milk
- Ultra-heat treated (UHT) milk
- Skimmed milk
- Cream
- Cheese
- Curd
- Butter
- Ghee
- Powdered milk
- Yogurt

- Ice cream
- Condensed milk

Fig. 6.2: Common milk products

The facts

i) Homogenised and pasteurised milk

To increase the storage quality and safety of milk as a food, some of the dairies in existence now process and distribute homogenised and pasteurised milk for the consumers. **Homogenisation** is the mechanical breaking of fat globules in the milk into smaller fat molecules which are then distributed evenly in the milk. **Pasteurisation**, on the other hand involves heating the milk and then cooling it immediately. This process destroys most of the harmful bacteria in the milk. This milk is marketed as whole milk. This is the most common type of milk in the market.

Fig. 6.3: Pasteurised milk

ii) Ultra-heat treated (UHT) milk

This is long lasting milk which is most appropriate in areas where fresh milk is not accessible. This kind of milk is usually subjected to heating between 130°C and 135°C for one second and then immediately cooled and packed. UHT milk has a long shelf life and is usually marketed as whole milk to the consumers. It is also very common in Rwanda especially in rural areas where refrigeration is not possible due to absence of electricity.

iii) Skimmed milk

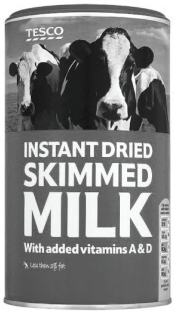


Fig. 6.4: Skimmed milk

Skimmed milk is what is usually left after cream is removed from whole milk. Skimmed milk is low on fats and rich in proteins, minerals and vitamins. Some farms and dairies prefer to separate cream from milk since they sell cream separately and sometimes use skimmed milk to feed calves. This milk is therefore used to manufacture fat-free milk powder as food for both livestock and human beings. Skimmed milk is therefore, the part of the whole milk which is left after cream has been removed.

iv) Cream

Cream is the milk fat that has been separated from the whole milk either mechanically or by use of a machine separator or by hand.

A milk separator is used to separate cream from whole milk, leaving behind skimmed milk. The plates in the milk separate the solid fats from liquid milk.

v) Butter

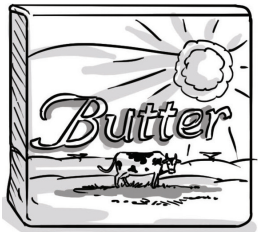


Fig. 6.5: Butter

Butter is made from cream. Butter is one of the most popular milk products. It is obtained by churning the cream in a milk churn. This process leads to the separation of milk fat from the non-fat solids. This process also reduces the moisture content and air bubbles in the butter. Butter contains about 80% fat, 15-20% water and 1-1.5% of milk non-fat solids.

vi) Ghee

Ghee is prepared by either heating cream or butter in order to remove moisture and non-fat solids. Ghee contains 100% fat and is mainly used for cooking. This milk product is prepared by subjecting cream or butter to intense heat or high temperatures to drive away moisture and non-fat solids.

vii) Powdered milk

Fig. 6.6: Powdered milk

This milk product is usually prepared by subjecting whole or skimmed milk to high temperatures, i.e., drying and hence converting the milk into powder. If whole milk is used, it produces a full cream powder while if skimmed milk is used, a fat-free powder is produced. The powdered milk can be reconstituted to liquid form by dissolving it in water.

viii) Curd

Curd is produced by allowing whole or skimmed milk to stand unprotected for some hours. It will then coagulate and change to a semi-solid form. If it is left to stand for a longer period, the semi-solid form solidifies and floats on top of a clear liquid that forms after coagulation. This solid curd is consumed by human beings plain or flavoured with sugar, salt, fruit juices and food dyes which may be added to make it look appetising.

ix) Cheese

Fig. 6.7: Cheese

Cheese is prepared by compressing milk curd until the water is out completely. When this is done the curd becomes smaller and elastic in texture; hence cheese is a consolidated curd. Acids, enzymes and salt are added to the curd at various stages of cheese preparation. Thereafter, the cheese is then cured for sometime before it is sold for consumption.

x) Yogurt

This is thickened flavoured milk and it is slightly acidic. The thickening is done by adding certain bacteria and food flavours like vanilla or strawberry to the milk. Yogurt is normally made by putting or injecting certain strains of bacteria culture in milk to allow it to ferment. It is then warmed to a controlled temperature for a short period of time. The milk is then cooled to stop further fermentation.

xi) Ice cream

Ice cream is a frozen food normally eaten as a snack or dessert. It is made from dairy products such as milk and cream combined with fruits and other ingredients. These other ingredients may include flavourings and colourings.

Fig. 6.8: Ice cream cones

Quality check!

Milk salve is usually applied on the teats of cows after milking to avoid cracking of the teats. It should never be applied during or before milking, since it may contaminate milk and also encourage pulling and stripping of teats during milking.

Self-evaluation Test 6.2

1. Why do you think milk is a common delicacy in our country?
2. Arrange the milk products below starting with the one with the longest shelf life to the one with the shortest.
   Shelf life: *Pasteurised milk, UHT, raw milk, whole milk*.
3. Distinguish between:
   a) Skimmed milk and whole milk b) Butter and ghee
   c) Curd and cheese
4. How would you prepare yogurt given a jug of raw milk?

c) Hides and skins

Activity 6.4

Your teacher will take you to a leather tanning factory. While at the factory, find out:

1. How skins and hides are being tanned into leather.
2. The sources of the skins and hides.
3. How the leather is used after tanning.

Write a report and do a presentation to the rest of the class.

The facts

Skins and hides can be obtained from cows, goats, rabbits and other domestic animals. They can also be obtained from wild animals such as snakes, crocodiles and elephants.

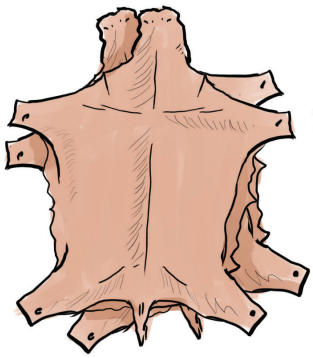


Fig. 6.9: Hides

They are obtained after slaughtering the specific animal and removing the meat. Skins come from smaller animals like sheep and goats. Hides come from big animals such as cattle. Both hides and skins are processed into **leather**. The process is called **tanning** and is done in tanning factories. An example of a tanning factory is Rwanda Leather Industries Limited located in Kigali.

Fig. 6.10: Hide of a cow

After tanning, the leather is used to make products such as shoes, belts, bags or luggage boxes, purses, garments among others.

A good hide can be produced by taking pre-slaughter care of animals, avoiding damages in the slaughter house and by proper treatment after slaughtering the animal.

Money matters!

It is possible to start a tanning business in your village where skins and hides of all slaughtered animals can be taken for pre-processing before being taken to a leather processing factory. This can be a business opportunity after your school life. Visit Rwanda Development Board (RDB) for more information!

Other cattle by-products

Besides meat, hides, skins and milk, cattle also can give us the following by-products:

- **Meat meal** – for feeding livestock.
- **Sterilised bone meal** – for feeding livestock.
- **Blood meal** – for feeding livestock.
- **Hoof and bone meal** – for fertiliser making. Hooves and bones can also be used to make other products like buttons, etc.
- **Liver meal** – for feeding animals.
- **Tallow** – this is a byproduct obtained by **rendering** fatty waste beef or mutton. Rendering refers to the process of converting waste animal tissue into value added materials that can be used elsewhere. Tallow can be used in making soap and animal feeds.
- **Gelatin** – This is the material used mainly as a **gelling** agent in food, pharmaceutical or cosmetic industries. It is obtained from byproducts of meat and leather.
- **Manure** – used to improve soil fertility.

Self-evalation Test 6.3

1. Name other cattle products and byproducts you know of in your community.
2. State what they are used for.

6.2 Pig products and by-products

Pigs are quick growing animals which are efficient at converting food into meat. They however require high level management skills and controlled conditions for good performance.

Activity 6.5

Visit a nearby abattoir and observe pigs being slaughtered. Note the various steps followed and the products obtained. Find out where the products are taken after slaughtering of the pigs.

The facts

Pigs give us the following products:

a) **Pork** – Pork is fresh pig meat usually produced by lightweight pigs known as "porkers" at the age of 4 months.

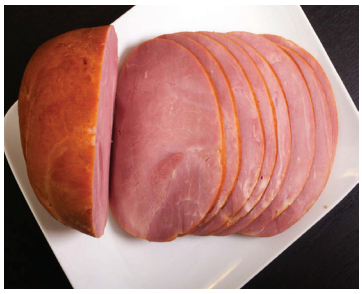
b) **Bacon** – Bacon is pig meat which is factory processed and cured after grading to very strict standards. It is usually produced by heavyweight pigs at 7 months age and above.

c) **Processed pig products** – There are a number of factory processed pig products especially from very heavy and culled pigs usually referred to as **larders**. The products of such manufacturing processes include lard, sausages, pies and hams.

(d) **Lard** is oil from fat tissue of a pig obtained after cooking or boiling the skin.

(a) Pork chops

(b) Pork sausages



(c) Ham

Fig. 6.11: Pork products

Activity 6.6

Visit a nearby supermarket and record as many pig by-products as you can. What is the difference between them?

Self-evaluation Test 6.4

1. State the advantages of rearing pigs compared to livestock.
2. Give some disadvantages of rearing pigs.
3. What precautions should be taken before slaughtering pigs?

6.3 Poultry products and by-products

Poultry keeping is a wide spread practice worldwide. Most poultry are normally kept for both domestic use and for commercial purposes. They produce eggs and meat which are high protein foods. Among the poultry groups of birds, domestic fowl is widely distributed. The most common domestic fowl is **chicken**. They are kept for both meat and egg in Rwanda.

Activity 6.7

Visit a nearby supermarket and find out the various poultry products that are stocked. Come up with a list and do a presentation to the rest of the class.

The facts

Chicken eggs

Chicken eggs meant for consumption are also known as **table eggs**. Fertilised eggs are mainly produced for breeding purposes although they can also be sold as table eggs.

Successful marketing of eggs depends on the way the eggs are graded, handled and their general quality. The following factors should therefore be considered when preparing the table eggs for marketing.

a) Egg collection

Eggs should be collected at least 2–3 times in a day from the laying nests or boxes. This regularity of collection prevents accumulation of eggs; which would otherwise lead to high rate of breakages. Eggs should be collected using clean containers as well.

b) Sorting of eggs

Eggs should be sorted to separate those with cracked shells or any other physical deformities from the good ones.

c) Grading of eggs

In large commercial egg-production plants, the collection of eggs is done using a conveyor belt, especially in a battery cage system. The sorting out is done automatically by a weighing device.

Fig. 6.12: Eggs on a conveyor belt

However, under small scale or the deep litter system of keeping layers, the grading is done manually by considering the sizes of eggs. In most areas, the eggs have three major grades depending on size:

- Large size eggs are those weighing 65 g and above.
- Medium sized eggs are those weighing 55–65 g.
- Small size eggs are those weighing 45–55 g.

It is important to note that pullet eggs are normally less than 45 g and should be sold locally in the farm.

The following features should be considered during sorting and grading of eggs:

i) ***Cleanliness of eggs*** - Eggs for sale should be clean. Eggs command the highest prices in the market when they are clean. Farmers should therefore, ensure that they are as clean as possible. Dirty eggs should be wiped with a clean piece of cloth.

ii) ***Shape of eggs*** - Good quality eggs should have an oval shape. Round or long eggs are mostly rejected. They are also prone to breakage during transportation because they do not fit well into the egg trays.

iii) ***Colour of eggs*** - Since eggs usually have two shell colours, white and brown, it is important to group them according to colour instead of mixing them up. This is because different consumers may prefer either of these two coloured eggs.

iv) ***The candling quality*** - The internal qualities of an egg are determined by **candling**. Eggs of high candling quality are preferred by consumers. Through candling, one is able to determine eggs with cracked shells, double yolks, centralised air space (cell) and blood or meat spots in the albumen or yolk. Fresh eggs should have small air spaces.

Fig. 6.13: Egg candling

Note: Eggs with any of these abnormalities should be discarded.

d) Packing of eggs

Fig. 6.14: Egg trays

The eggs should be well packaged in egg trays with their small ends facing downwards so that the air space keeps to the big upper end. The common egg trays normally carry 30 eggs each. The egg trays are then placed in carton boxes to a **maximum of ten trays** per carton. This makes transportation easier. Eggs should then be kept in a cool place before sale or use.

e) Marketing of eggs

Small scale farmers sell their eggs either through co-operative societies or directly to shopkeepers and to consumers. Large-scale farmers, on the other hand, either make individual contracts to sell their eggs to **hotels** or sell through the **co-operative societies**.

It is important to note that eggs should be sold soon after they are collected due to their short shelf-life. Eggs should be marketed at least twice a week so as to give the consumers fresh eggs. The price of eggs is usually determined by the market forces of supply and demand.

Chicken meat

Chicken kept for meat supply are referred to as **broilers**; they are also known as table birds. In rural areas of Rwanda, the table birds are sold alive because this provides a fresh source of chicken meat to the people. In urban centres, towns and cities, dressed chicken meat is made available in supermarkets; where it is stored in deep freezers. The meats are dressed after slaughtering in slaughter houses.

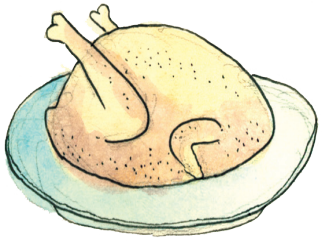


Fig. 6.15: Chicken meat

The birds reared for meat are either hybrid broilers or indigenous breeds. Indigenous breeds are largely marketed in the rural areas while broilers are sold in the big towns; mainly in hotels, restaurants, supermarkets and also in fast-food eating outlets.

Activity 6.8

1. Visit a nearby poultry farm and find out the following:
   (a) How eggs are sorted, graded and packaged.
   (b) How eggs are marketed.
   (c) How broiler meat is processed before marketing.
   (d) How eggs are packed in trays ready for marketing.
2. Carry out practical activities in egg candling and cleaning of dirty eggs for marketing.
3. Visit a broiler poultry farm and observe the slaughtering and processing of the products and the marketing procedure.

Self-evaluation Test 6.5

1. Mention the differences between broilers and layers.
2. Why should we keep eggs clean?
3. Why should care be taken during egg collection?
4. Explain egg candling and what it is used for.

6.4 Rabbit products

Activity 6.9: Research Activity

1. Work with your friends in a group.
2. Find out the various rabbit products and byproducts.
3. Come up with a list describing each.
4. What is each product used for?
5. Write a report then do a presentation to the class.

The facts

The main products that we can get from rabbits are:

- Meat
- Fur
- Skin

Meat is the main aim of rabbit production venture in Rwanda. This can either be done for commercial purposes or for subsistence use.

There are two byproducts that are usually acquired from the skin: the pelt and the shorn hair.

a) Rabbit skins

b) Rabbit meat

Fig. 6.16: Rabbit products

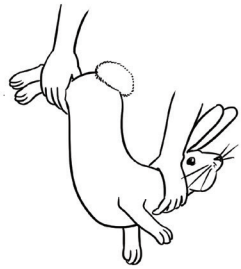
These can be used in the textile industry to come up with bags and even clothes. Waste from rabbits can be used as fertiliser as well. Before getting these products, the rabbit has to be slaughtered and skinned.

a) Slaughtering of rabbits

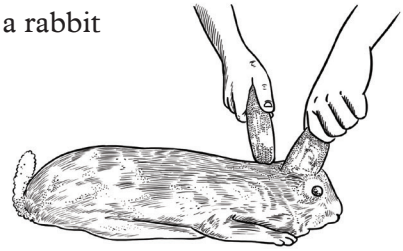
To obtain good quality rabbit meat, the rabbit should be slaughtered properly.

Note: Feeding of rabbits should be stopped 6–12 hours before slaughtering.

The rabbits are first killed by dislocating the neck while holding the hind legs firmly with one hand and the head with the other. See figure 6.17. A sharp pull on the head with a downward twist will kill a rabbit. You can also kill a rabbit by hitting it hard at the back of its head, at the base of the skull, with a blunt object such as a hammer or piece of wood, in order to break the spine. This is the simplest method of killing rabbits. In modern slaughterhouses, they are normally killed with a spanner.



a) Twisting the neck of a rabbit



b) Hitting the head with a blunt object

Fig. 6.17: Ways of killing a rabbit

b) Dressing a rabbit carcass

This involves skinning the rabbit and packaging the meat for sale. After killing the rabbit, it should be skinned while its body is still warm. The carcass is then hung with hooks, as shown in the diagram below, on a frame or a hoist with the head facing down to drain the blood and other body fluids.

For hairy rabbits, the hair is removed from the body so that the skin can be reached.

This process of skinning involves making cuts as explained below:

- A straight cut from the anus to the neck along the centre line of the belly is made.
- A circular cut around the hock of each of the hind legs.
- A cut similar to the one above around each of the elbows of the forelimbs.
- One straight cut on the inside of each of the hind legs from the hock to the udder or scrotum.
- A cut similar to the one above, now on the inside of each of the forelimbs from the elbow to the breastbone.

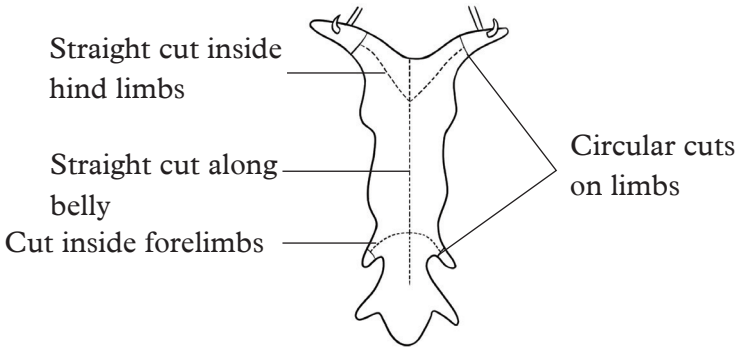


Fig. 6.18: Dressing a rabbit

Skinning of the carcass commences immediately after the cuts are made.

The skin of the forelimbs, hind legs and the rear parts of the body is initially removed gently. It is then held firmly at point of the rump and peeled off completely from the body by pulling it gently, using fingers or a knife where necessary.

Once the animal is skinned, the belly is opened and the content (offal) is removed. As the content is being pulled out make sure that the gall bladder does not burst.

The liver and the kidney should however, be left in the carcass. The carcass is now ready for fresh cooking. The hind feet and head are then cut off.

If the carcass has to be preserved, then it should be kept hanging for about 12 hours, in a clean environment so that all the body fluid drains out completely.

The skin may then be either stripped over a wire loop or opened and nailed onto a board for drying.

C) Marketing rabbit products

Rabbits produced in Eastern Africa are either consumed on the farms or sold locally. There is no elaborate marketing process for rabbits yet. Rabbits can be slaughtered for the table at two months of age. During the last month to slaughtering, the protein feeds should be increased while the green feed is reduced so that the rabbit can fatten up quickly.

Quality check!

Always buy products that have the mark of the Rwanda Bureau of Standards. Also check the dates of expiry and those of manufacture in products to ensure they are safe for use.

We can also obtain fur from rabbits. Rabbit fur can be used to make things like socks, sweaters, scarfs, blankets and jackets.

Activity 6.10

1. Go for a visit to a local slaughter house or a rabbit farm and observe how the rabbit carcass is being prepared for marketing. Write down the main points.
2. Practice slaughtering or dissecting a rabbit in the laboratory.

Self-evaluation Test 6.6

1. What is the work of the Rwanda Bureau of Standards?
2. (a) What products can be obtained from rabbits?
   (b) Mention the uses of the products you have mentioned in 2 (a).
3. Give the two methods that can be used to kill rabbits.

Remember the facts!

- Meat from cattle is called beef while meat from sheep or goat is called mutton.
- Beef is a good source of proteins and mineral salts like iron, cobalt among others.
- Good beef should:
  - Be tender
  - Have good colour
  - Have good flavour
  - Be lean
  - Be juicy

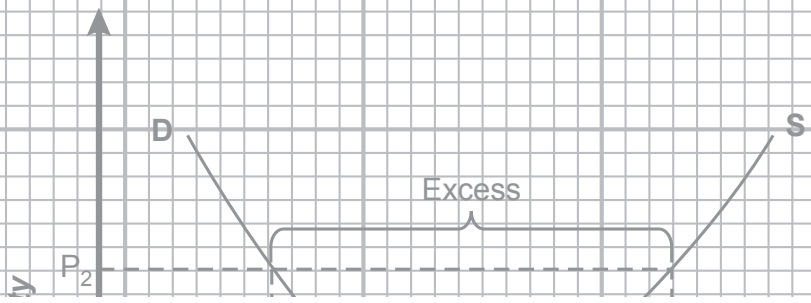
- Products obtained after processing raw milk include:
  - Homogenised and pasteurised milk
  - Ultra-heat treated (UHT) milk
  - Skimmed milk
  - Cream
  - Cheese
  - Curd
  - Butter
  - Ghee
  - Powdered milk
- By-products of beef include:
  - Hides and skins
  - Meat meal for livestock feeding
  - Blood meal for livestock feeding
  - Hoof and bone meal for fertiliser making
  - Liver meal for animal feeding
- Pigs are quick growing animals that are efficient at converting food into meat.
- Pigs provide pork and bacon.
- Processed pig products include lard, sausages, pies and hams.
- Poultry can be reared for both domestic consumption and for commercial purposes.
- Chicken eggs meant for consumption are also known as table eggs.
- Successful marketing of eggs depends on the way the eggs are graded, handled and their general quality.
- The following features should be considered during sorting and grading of eggs:
  - Cleanliness of eggs
  - Shape of eggs
  - Colour of eggs
  - The candling quality
- The main rabbit products are meat and fur.
- Rabbits produced in Eastern Africa are either consumed on the farms or sold locally.
- Rabbits can be slaughtered for the table at 2 months of age.

Test your competence 6

1. Among the listed, which one would you highly recommend to a patient suffering from HIV and AIDS?
   A. Chicken meat
   B. Ghee
   C. Eggs
   D. Powdered milk
2. Which cattle products and byproducts are the most common in your locality and why? (Give a reason for each product and byproduct you give.)
3. Between pigs and cattle, which ones do you think are most profitable and why?
4. Mulekatete eats bacon and milk produced at her home every day she goes to school. Which are these animals kept at her home?
5. The more you give, the more you get. How true is this statement with regard to animal farming?
6. Mihigo likes drinking milk directly from the cow. What is wrong with this habit and what would you advise Mihigo?
7. Match the products and byproducts in A below with the animals that produce them in B. (Where a product is produced by more than one animal, indicate all of the animals responsible.)

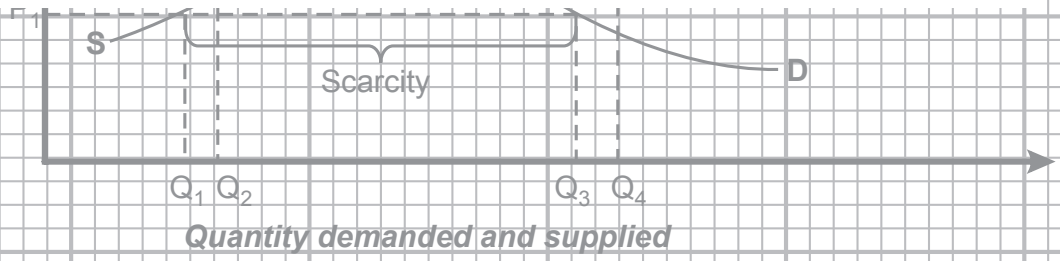
A	B
Mutton	Sheep
Fur	Rabbit
Beef	Cattle
Pork	Pig
Hides	Poultry
Lard	
Eggs	
Milk	
Wool	
Ghee	
Skins	

8. When buying livestock products and byproducts from the shops and supermarkets, it is important that you check the dates of manufacture and expiry. Why is this important?
9. Niriniri is allergic to all kinds of meat. Which one of the following products can't she take?
   A. Lard B. Ham
   C. Cheese D. Ghee



TOPIC AREA 4: AGRICULTURAL ECONOMICS

Unit 7: Principles of farm economics



UNIT 7 Principles of farm economics

Introduction

Farming can be a good business venture that can act as a source of income for many people. It is therefore important for us to familiarise ourselves with farming practices that can earn us most money. These will enhance progress in the agricultural sector and our economy as a whole. Knowledge of agricultural economics is therefore necessary to assist farmers to operate farming businesses at a profit.

Discussion corner!

Look at the pictures below. What is going on in the pictures? Describe the relationship between A, B and C.

A.

B.

C.

Which of the business ventures in agriculture can bring more money? How can we manage the business?

Key Unit Competency

After studying this unit, you should be able to explain the main elements of agricultural economics, particularly the influence of demand, supply and diminishing returns on production and prices.

Unit Outline

7.1 The laws of demand, supply and price

Activity 7.1: Research Activity

Using textbooks or the internet, find out what the laws of demand, supply and price are. Take down notes on how they relate to farm economics. Interact with other class members and see what they have found out.

The facts

In a market place, buyers come into contact with sellers so as to exchange goods and services. The buyers or consumers, in this case, demand goods from sellers who supply them. This contact between the buyers or consumers and the sellers in a market situation brings about what is known as **market forces**. These forces operate in a free market to determine the prices of goods or services. Hence market forces involve demand, supply and pricing.

(a) Theory of demand

Demand is the quantity of goods or services which the consumers are willing and able to buy at a specific period of time. Demand is concerned with what consumers are actually able to buy (what they can afford and have money to buy) rather than what they would like to buy. Demand changes with the change in the price of goods in the market at a given time. For instance, demand is low when the price of a good is high and vice versa. In other words, when prices are high, consumers will buy fewer goods than when prices are low.

Discussion corner!

Study the graph below with a friend and discuss what you think it implies. Note down your conclusions and inferences.

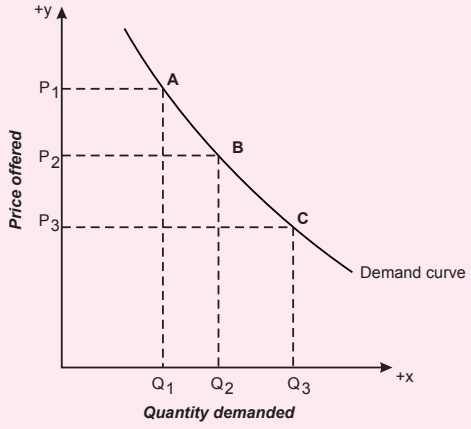


Fig 7.1: Relationship between demand and price

NOTE: Demand is not same as "want". A **want** is mainly a desire for something; one may not necessarily have the means of acquiring. Whereas, a **demand** is the

ability to purchase that good at a given price. This concept leads to the theory of demand which states that the **quantity of a good or service demanded varies inversely with the price**. The higher the price, the less the quantity demanded and the lower the price, the more the quantity demanded.

This type of demand, which involves payment for the required goods, is known as **effective demand** and it is controlled by one's purchasing power, which is determined by their income.

Demand is mainly determined by price. However, there are other circumstances that may influence demand even if the price remains the same. These include the following factors.

Factors influencing demand for a commodity

(a) Income of consumers

A change in the income of consumers will result in a change of the purchasing power and subsequently a change in demand for certain goods and services. Consumers with high income buy more compared to those with low income. As the income rises, the demand for some foods like meat, fish, rice, butter and others may rise, while for other foods like maize meal, cassava and potatoes, it may fall.

(b) Tastes and preferences of the consumers

Demand is affected by the various tastes and preferences of consumers. For instance, a change in consumers taste in favour of one product can bring about a shift in demand for that product.

(c) Change in population

A change in population levels and a change in the structure of the population will affect the total demand for goods and services. A general increase in the population increases the number of mouths to feed. Hence, for a product like maize flour, increase in population increases its demand.

(d) Prices of related goods (substitutes)

The demand for one product may sometimes often depend on the price of another related product. For example, the demand for margarine may increase when the price of butter (which is the main substitute of margarine) increases.

(e) Price expectations

Expectations about future prices play an important role in determining the demand of any given product. If in future the prices of certain commodities are likely to go up, then the demand of such goods may go up currently; the vice versa is also true.

(f) Beliefs, customs and taboos

These will influence the total demand for a given good or service. In some communities, their religious beliefs forbid them from consuming certain food items; for example pork among Muslims.

(g) Advertisement

Advertisement promotes the sale of a given good or service, subsequently increasing its demand. It serves the purpose of informing the prospective consumers of the existent good and services. The consumers hence become aware that they need the particular goods or services which leads to an increase in their demand.

Quality Check!

Advertisements can be very convincing. However, at times, they may not necessarily publicise the truth. It is therefore important that you get the right information about any product before you decide to buy it.

(h) Government policies and regulations

Policies, such as taxation, imposed by the government on certain goods, may increase or decrease the prices of certain goods and services in the market. This may consequently lead people to either drop or increase consumption of these goods.

Money matters!

Before one starts any business, thorough research of the market must be done to establish the goods and services that are in demand at any given place. This will help in ensuring that maximum returns are obtained.

Demand schedules and demand curves

(i) Demand schedules

A demand schedule is a series of quantities of a given commodity that a particular individual or a particular population is willing to purchase at different prices within a given period of time. A demand schedule can be prepared for an individual or for a population in a certain market. When a demand schedule is drawn separately for each individual in the market, it is referred to as **individual's demand**. On the other hand, if the individual demands for all the people in the market are added together, they give the **total market demand**. The total market demand is very important since it determines the prices at which commodities are sold.

Consider the tables below.

Table 7.1 Demand schedule for oranges by individual A

Price	Quantity demanded
4	22
8	18
12	12
16	8
20	4

Table 7.2 Demand schedule for oranges by individual B

Price	Quantity demanded
4	30
8	25
12	18
16	12
20	9

An individual demand schedule shows the quantities of oranges demanded at various prices within a period of five days.

Table 7.3 Market demand schedule for oranges

Price	Quantity demanded
4	52
8	43
12	30
16	20
20	13

The market demand schedule shows the total quantities of oranges bought by individuals A and B in the market at various prices within a period of five days. When a market demand schedule is derived from summing up the two individuals' demands, it is referred to as **horizontal summation**.

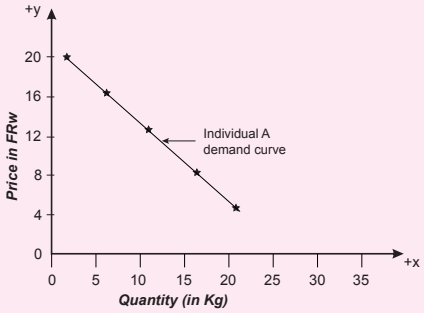
(ii) Demand curves

When the quantities demanded are plotted against their prices on a graph, they produce a **demand curve**. The following are samples of demand curves.

Discussion corner!

Study the graphs and note down your conclusions and inferences.

a)



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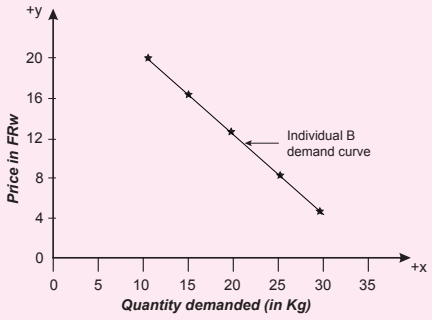

c)

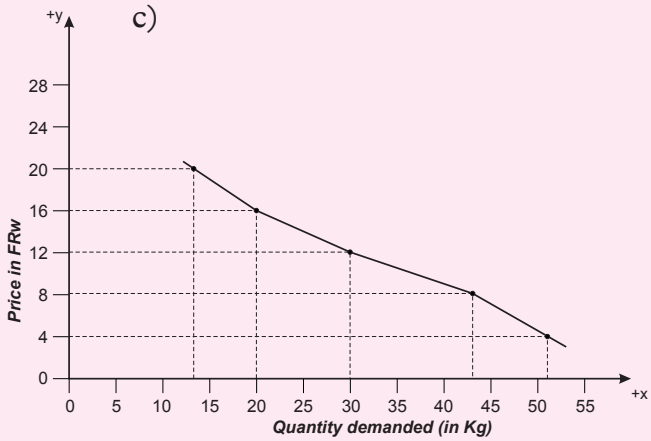

Fig 7.2: Demand curves

The price of the commodity is indicated on the y-axis while the quantity of the commodity demanded is indicated on the x-axis.

When the demand schedules are plotted against the price of the commodity, the resulting demand curve shows a **straight line**. This is not usually a practical case; it is only meant for ease of understanding. Such curves slope downwards from left to right. This is because the quantity demanded of any commodity is likely to be higher when prices are low and vice versa; assuming other factors are constant. The following figure shows such a curve.

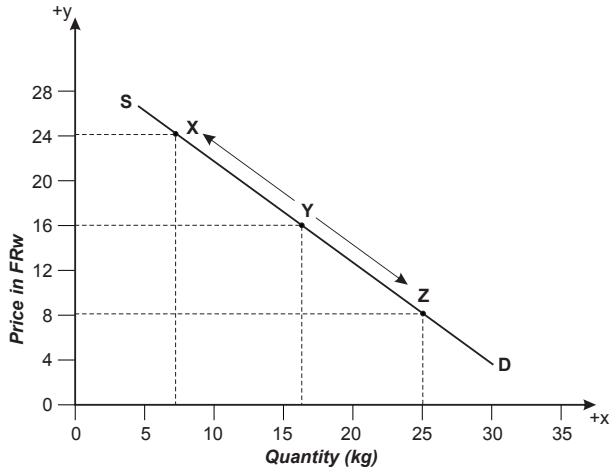

Fig. 7.3: Movement along the curve

When there is a change in price of the commodity, the quantity demanded also changes. This is shown on a demand curve as a movement along (up or down) the curve.

A fall in price, for example from FRw.24 to FRw.8 will result in a movement along the demand curve from point X to point Z. This will result in a rise in quantities demanded from 10kgs to 25kgs. The demand curve hence remains in its original position and does not shift. Change of prices will therefore only lead to a rise (extension) or a fall (contraction) in the quantities demanded.

(b) Theory of supply

Supply is the quantity of goods or services a seller (producer) is willing to sell or is able to sell or offer for sale at a given price, market and time. **The higher the price of a particular good or service, the more of it will be offered to the market for sale.** It should be noted that supply does not mean the same as total production or output. Instead, it refers to the quantity of output which particular prices attract to the market. This marketing concept leads to the theory of supply. It states that **"as the prices of goods or services increase, the corresponding quantity of goods or services offered for sale increase and vice versa"**. Supply is mainly influenced by price. However, there are other factors that may influence the supply of any given item.

Factors influencing supply of a commodity

(a) Price expectation

A change in the expectation of the price of a given product in future can affect the

producer's current willingness to supply. In other words, some farmers may choose to withhold part of their current produce from the market; if they anticipate a rise in the price of the produce in the near future. This is called **Guarding.**

Fairness is my other name!

Hoarding of produce is illegal. This usually leads to an artificial rise in demand levels hence a hike in prices. In as much as the farmers may benefit, this is not a fair way of making profits. Hoarding should therefore be discouraged!

(b) Prices of related goods

If the prices of other related products increase, then the demand for the product whose price has not increased will rise. This will then call for an increase in supply of the product with a lower price. For instance, if the price of bread decreases in comparison with the price of cakes, the suppliers will increase the supply of bread in the market and reduce the supply of the cakes. This concept can also apply to other products known as **joint products**; like hides and beef. Under such situations, an increase in the output of hides is accompanied by an increase in beef production.

(c) Number of sellers in the market

If a certain product is sold by many sellers in any given market, the product is said to be in high supply.

(d) Cost of production

The prices of inputs used to produce a certain product have a direct relationship to its level of supply. For example, if the costs of fertilisers and seeds are low, then more farmers will be able to buy them. This means that more farmers will be able to apply these onto their crops which will lead to increase in yields. Increase in yields will consequently translate into increase in supply.

(e) Transport system

Improved and efficient transport will facilitate the delivery of farm produce to the market and hence support and increase supply.

(f) Government policies and regulations

If the government increases tax on a particular commodity say fertiliser, then this will automatically increase the price of the commodity produced using it. Farmers may cease to apply fertilisers and then production will definitely drop. Policies of the government such as taxation, therefore, affect supply of agricultural products in the market. Certain taxes, like customs duty and sales taxes are viewed as additions to cost of production and could affect supply.

(g) Weather changes

The type of weather can influence agricultural markets. Favourable weather conditions lead to increased production of goods which means that more goods will be available for sale. Unfavourable weather conditions, on the other hand, will result in low supply of certain goods.

(h) Technology in modern agricultural practices

Modern techniques of production lead to increased production of goods hence increased supply. For example, farmers using machines for milking and combined harvesters realise higher yields than farmers who use traditional methods.

(i) Time lag for certain commodities

It should be noted that the time span between the production process and the availability of some agricultural products may sometimes be too long. For example, coffee may take three years from planting to the time the first harvest is obtained. The supply situation in the market during this period of waiting might be affected.

Supply schedules and supply curves

i) Supply schedule

A supply schedule is a series of planned production rates that depend on the price of a product. In other words, it is a list of the quantities of an item that will be produced or sold at all probable prices. It shows in a tabulated form the quantities of a specific product, such as tomatoes, the producers are willing to bring to the market at different prices over a given period of time.

Table 7.4 Supply schedule for tomatoes

Price per unit (100 kg/unit)	Quantities of tomatoes supplied (100 kg/unit)
20	2
40	4
60	6
80	8
100	10

ii) Supply curve

The supply schedule given in Table 7.4 can be converted into a supply curve. The price quantity combinations from the table are plotted against each other in a graph and the points are joined to give a supply curve for tomatoes in the market.
The following figure shows the supply curve.

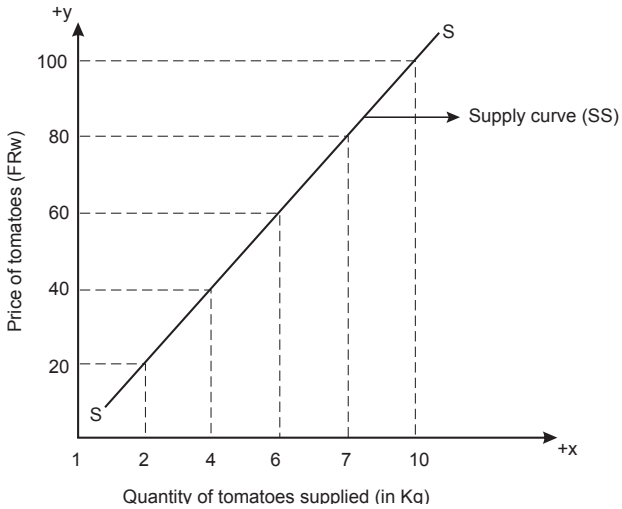

Fig 7.4: Supply curve

(c) Price theory

Activity 7.2

In your group, divide yourselves into two or more subgroups. Assign to each subgroup a packet of sweets. Plan to sell the sweets in each packet at different prices per subgroup to your fellow students around the school. At the end of the day, find out which subgroup sold the most. Discuss how the different prices of the sweets may have affected the sale.

Price

Price is the amount of money paid in exchange for goods bought or services rendered. The price of a commodity should be reasonable enough to cover the production costs and have a margin to reward the producers for their investments. It should also be affordable to the consumers, without having to strain their financial capabilities.

Money matters!

Always be careful to purchase only what you really need. Avoid living beyond your means.

Pricing

Pricing is the process of determining the most suitable price of a commodity or a service. The following are some of the ways of determining prices.

i) The market forces of demand and supply will determine the price of a

commodity. When the demand and supply curves are plotted on the same axis, the place where the two curves intersect is where the price is most reasonable, as shown in the graph below.

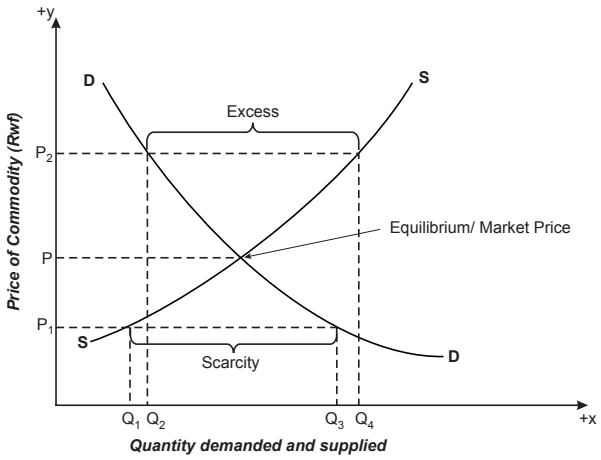

Fig 7.5: Relationship between demand and supply in determining price

The point of intersection of the two curves produces the **equilibrium price**, which is subject to change if the levels of demand or supply change.

ii) The quality of the produce will also determine the selling price.

iii) The manufacturers and processors of agricultural produce determine the price of their products in a bid to cover the costs incurred during processing. This must be covered in the final price of the product.

iv) The government on the other hand sometimes controls the pricing of goods and services. This helps to ensure that farmers benefit from their produce such as tea, cotton, coffee, milk, pyrethrum, sisal and other cash crops.

Equilibrium price

The equilibrium price is attained when the quantity of goods supplied equals the quantity of goods demanded. It is important to note that consumers are able and willing to buy the largest quantity of a given good at its lowest price. Producers, on the other hand, are willing to sell the largest quantity at the highest price. These two groups of people must, therefore, come to an agreeable price which will leave each one of them happy, if not completely satisfied.

Price control

If traders are left to decide on prices outside on their own, they could collude to fix them very high. Also, consumers may prefer very low prices. The government, therefore, intervenes from time to time and fixes the minimum and maximum farm gate and consumer prices. If farmers feel thet the prices are too low they may need to co-operate and lobby better prices from the government.

Price control is mainly done to keep down the cost of living. Some circumstances may force the government to change the prices of some essential farm produce. In most cases, increasing the produce prices helps to encourage farmers to produce more. On the other hand, if the produce prices are lowered, it may prompt the farmers concerned to either produce less or abandon the affected enterprise all together and shift to more profitable ventures. Nevertheless, the government sometimes may give the producers subsidy by reducing the costs of production inputs or by fixing prices of related products.

Self-evaluation Test 7.1

1. Explain how price affects demand and supply.
2. Describe the theory of demand.
3. What is the significance of advertisements in any market?
4. List and explain five factors that can influence the supply of milk.

7.2 The law of diminishing returns .

Activity 7.3

A farmer planted maize in his one hectare piece of land using 30 kg bags of NPK fertilizer. His harvest was 10 (90kg) bags. He decided to increase the amount of fertilizer used by 1 bag in every subsequent season and compare the yields obtained . His records were as shown in Table 7.5 below.

Table 7.5 Yields of maize at various levels of NPK fertiliser

Land area (Fixed quantity)	Amount of NPK applied (in 30kg bags)	Total produce (in 90 kg bags)	Marginal produce (in 90kg bags)	Average produce (maize in 90kg bags)
1 hectare	1	10	0	$\frac{10}{1}$ = 10
1 hectare	2	27	27-10 = 17	$\frac{27}{2}$ =13.5
1 hectare	3	42	42-27 = 15	$\frac{42}{3}$ =14
1 hectare	4	56	56-42 = 14	$\frac{56}{4}$ =14
1 hectare	5	63	63-56 = 7	$\frac{63}{5}$ =12.6
1 hectare	6	65	65-63 = 2	$\frac{65}{6}$ =10.8
1 hectare	7	65	65-65 = 0	$\frac{65}{7}$ =9.3
1 hectare	8	60	60-65 = -5	$\frac{60}{8}$ =7.5

1 hectare	9	52	52-60 = -8	$\frac{52}{9}$ =5.8
1 hectare	10	42	42-52 = -10	$\frac{42}{10}$ =4.2

The data above can be plotted to obtain a graph as shown below.

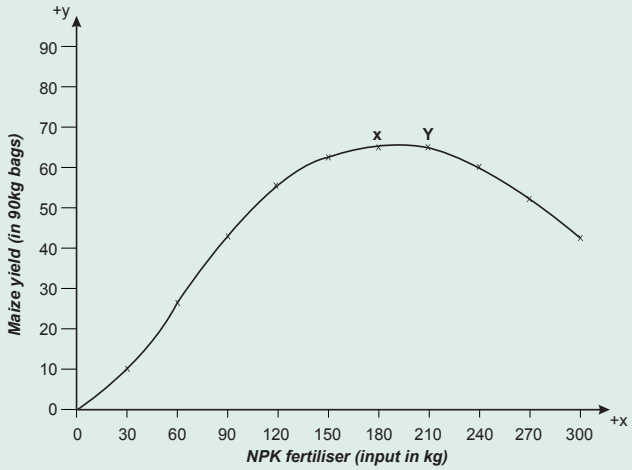

Fig 7.6: Graph showing of the law of diminishing returns

1. What is the cause of the increase in the total production from when 1 bag to 6 bags were added.?
2. Why at the level when 3 bags were added, there wasn't increase in average production?
3. With reference to the graph what caused the decrease in the maize yield?

In production economics, there are several laws and principles which help us to predict the outcomes of a given production process. Production is the process of altering the condition or form of something in space and in time to become more useful or valuable. The same laws also enable us to understand different phenomena in production as well as guiding the farmer in decision making. This therefore, leads us to the definition of this law. It states that *"if successive units of one variable input are added to fixed quantities of other inputs, which are held constant, a point is eventually reached when the additional (and average) product per additional unit of input will decline"*

As shown in the graph, the first addition of 30kg of NPK fertiliser results in an output of 10 bags of maize. The second addition of NPK results in an additional increase of 17 bags to 27. This means that each additional unit of input (30kg of NPK fertiliser) leads to a larger increase of output than the preceding one. This continues up to a point when the total output starts to increase at a decreasing rate. For instance, the third and fourth additions of fertiliser are seen to result in additional increases of 15 and 14 bags to 42 and 56 bags respectively. From this point, it can be observed that there is a trend of declining output per additional

unit of fertiliser. This is where the law of diminishing returns starts to apply. This trend of declining output continues up to a point when the additional output per additional input is zero as represented by points X-Y in the graph. This means that there is no increase even with addition of more fertiliser i.e the maize yield remains constant at 65 bags. At point Y on the graph, the maximum level of output is reached and there is no further increase in output after this point. Any further addition of NPK fertiliser thereafter results in a decline of output.

Note: The law of diminishing returns warns that in production, if variable inputs of one resource are applied beyond a certain limit, a point is eventually reached where total production begins to decline. This law hence helps the farmer to establish the most profitable point at which to produce.

Self-evaluation Test 7.2

Come up with instances whereby the law of diminishing returns can be applied.

7.3 Product relationships

Activity 7.4: Research Activity

Find out from text books and the internet the various product relationships. Also find out how they manifest in agricultural production. Discuss your findings and come up with a presentation to the rest of the class.

What I have discovered...

In the concept of profit maximisation-which is combining enterprises with the aim of maximising revenue, the aim of any producer is to obtain as much revenue as possible while at the same time trying to minimise the cost of production. It is normally assumed that when the maximum net revenue is obtained, profit is maximised. The following are examples of product relationships:

- Substitute products
- Competitive products
- Complementary products

The facts

a) Substitute products

Two resources are said to be substitutes when change in price of one leads to a change in demand for the other.

Principle of substitution

The principle of substitution concerns substituting inputs to obtain the least cost when combined to produce a given amount of output. Some inputs can substitute

each other without affecting the level of output.For example, a famer can substitute maize for barley, maize for oats, grain sorghum for maize, wheat for barley; protein supplement for concentrates among others.The bottom line is that if cheaper input can be used, then it should substitute the existing more costly input (as long as quality is not largely affected).

b) Competitive products

These kinds of products are the most common in agricultural production. In such situations, when the production of one item is increased, then the production of another related item is bound to be reduced. It usually occurs where the available resources are limited. For instance, if the products listed below are provided, and the amount of land available is limited, the following are bound to occur:

- **Wheat and maize** - If the wheat acreage is increased then the maize acreage has to be reduced.
- **Dairy and beef cattle** - If the number of dairy cattle is increased, then there should be a reduction in the number of beef cattle.
- **Wool sheep and mutton sheep** - An increase in wool sheep must be corresponded by a reduction in mutton sheep.

Self-evaluation Test 7.3

1. Mention other competitive products you know.
2. Explain the ways in which the products would compete in a given situation.

c) Complementary products

Goods whose use are interrelated with the use of another good, such that the demand for one generates demand for the other are said to be complementary. If the price of one good falls and people buy more of it, they will usually also buy more of the complementary good, whether its price also falls or not. Similarly, if the price of one good rises, leading to low demand, it may reduce the demand for the paired good as well.

An example of complementary products are **seed** and **fertiliser**. Planting seeds is an activity which calls for the use of the complementary item, the fertiliser.

Self-evaluation Test 7.4

1. Of the three mentioned product relationships, which one would bring higher profits on a good season? Explain how.
2. Give examples of complementary products you know.
3. Differentiate competitive and complementary products.

7.4 Farm records

Activity 7.5

Visit a farm and enquire from the farmer the various farm records he or she keeps.

A farm record is a form of stored information in a farm which may be useful at a later date; when decision-making and planning become necessary.

It may also be described as a record of financial transactions made in a systematic way, covering a specified period of time. The main objectives of keeping records are to provide the farmer or manager with information about the following:

- The economic situation of the farm
- The production capacity of the farm

It is important to note that modern farming, like other business operations, has nowadays become more complex, with a large number of financial transactions and many other external operations. Majority of farmers keep farm accounts and records of these transactions. No single farmer can be able to memorise all activities that take place in the entire farm. It is therefore important that good and accurate records are kept in details as soon as the various transactions are done.

It is important to keep farm records so as to avoid loss of important information. If kept properly, such records can enable the farmer to find out, at any time the exact financial position of the farm business. This will make it possible for the farmer to know the losses or profits made from the farm over a given period of time.

Reasons for keeping records

1. Farm records show the **history of the farm** thus providing a basis for improvement in productivity. They indicate what has happened on the farm for the period during which they were kept.
2. They help to show the **transactions** that occur from day to day on the farm.
3. They help in **management analysis** and making **business decisions**. Such decisions are normally meant to improve the profitability of the farm business.
4. Farm records help in **comparing the performances** of different enterprises within the farm as well as with those of neighbouring farms. This assists in revealing any existing weaknesses in the farm.
5. Farm records also help in **settling disputes** among heirs to an estate, especially when a farmer dies without leaving a will.
6. Farm records help in giving an **accurate assessment** of income tax to avoid over and under taxation.
7. Farm records may also help a farmer to make **insurance claims**; for example in cases where insured crops fail.

8. In cases where farmers work on a co-operative basis, records help to show **bonuses and losses** at the end of the production season.
9. Farm records provide information used in **farm planning** and **budgeting** of various farm operations.
10. Farm records help to provide accurate information in case the farmer wants **credit or loans**. Good records indicate, among other things, the financial state of the farm and how the farmer manages the farm.
11. Farm records show the **productivity** of the farm as a business and the credit worthiness of the farmer. Records will also help in determining the **value** of the farm in order to indicate the actual value of all the present assets and liabilities. In addition to this, they also give information to local investors.
12. Farm records also assist the farmer to determine the **profitability** of the farm business. They help in early detection of losses or theft on the farm.
13. Farm records also help in providing **labour information** necessary for calculating payment rates of farm workers including their terminal benefits and pensions when they retire.

Money matters!

Records are a good way of keeping us accountable and hence able to keep ourselves in check concerning our spending and how much we are making.

Types of farm records

There are many types of farm records which can be kept by farmers. These depend on the particular situation of an individual farmer, such as the type of enterprises one is undertaking. The following are some types of records which may be found in various farming enterprises:

- Production records
- Inventory records
- Income statement: (profits and losses)
- Health records
- Breeding records
- Field operations records
- Marketing records

a) Production records

These types of records will show the total yield from each enterprise and also the yield per unit of the enterprise. For example, in crop production such records will show the total number of bags of maize, beans, potatoes and others from the whole farm and from each hectare of land. For livestock, production records will depend on the type of animal kept. For instance in dairy cattle, such records will include

total amount of milk produced in litres from a herd and also from individual cows per lactation period.

Table 7.6 Sample of a crop production record

Crop	Size of farm (in ha)	Seed rate per ha	Date of planting	Date of harvesting	Yield in bags per ha	Special notes
Maize	5 Ha	30 kg	10/03/2015	28/07/2015	50 bags	DAP fertilisers used at planting
Beans	5 Ha	20 kg	18/03/2015	06/06/2015	25 bags	Interplanted Chemical control of bean flies done

Properly kept crop records should include some of the following information in reasonable details.

- The size of land under the crop
- The date of planting and harvesting
- The type and rate of seed used
- The type of fertiliser applied
- The amount of fertiliser used and time of application
- The total yield obtained
- The number of weeding operations
- The labour cost for various operations
- The application of herbicides, insecticides (If any) and the costs involved

Table 7.7 Sample of a dairy production record

Month of _____ Year _____											
Name or number of cow	**Days of the Month**										
	1		**2**		**3**		**4**		**Up to last date of month**		**Total**
	6pm	**6pm**	**6pm**	**6pm**	**6pm**	**6pm**	**6pm**	**6pm**	**6pm**	**6pm**	
Mawingo (8)											
Marula (12)											
Kawenze (5)											
Totals											

b) Inventory records

For any business enterprise, it is important to prepare an inventory of all farm assets and liabilities. This refers to a physical count of everything that the farm owns and all that it owes others. Inventory records are basically divided into two groups. There are inventory records on consumable goods and those on permanent goods.

Consumable goods include items like animal feeds, fertilisers, seeds, chemicals such as drugs, insecticides, herbicides and others. It also includes construction materials such as cement, sand and sisal strings.

Table 7.8 Sample of a consumable goods inventory

Receipts			Issues			
Date	Commodity Item	Quantity	Date	Issued to	Quantity	Balance stock

Table 7.9 Sample of a permanent goods inventory

Date	Commodity/ Item	Quantity	Written Off	Balance in Charge	Comment

c) Income statement: profit and loss account

This is a financial statement showing the income (revenue) generated and expenses incurred on the farm during a financial period. It also shows the opening and closing valuation. Opening valuation is the monetary value of the farm at the beginning of a financial period. The opening valuation is usually the closing valuation of the preceeding financial period. It provides evidence on whether the business made a profit or loss.

The following are some of the benefits of having income statement records:

- An income statement can be used to compare the results for the same farm in different years or seasons.

- It can also be used to compare the results between different farms with the same production enterprise.
- With a more detailed analysis, it is possible to gain some insights on why the net farm income has been low or high.

Example

The following business transaction information was extracted from Habiyambere's Farm Financial documents on 31/12/2015.

Depreciation of tractor	FRw	6,000.00
Opening valuation	FRw	8,000.00
Casual wages paid	FRw	6,000.00
Dairy meal bought	FRw	5,000.00
Tools and equipment	FRw	12,000.00
Bought fertilizer	FRw	10,000.00
Milk sale	FRw	20,000.00
Beans sale	FRw	15,000.00
Sale of bull calves	FRw	2,000.00
Sale of maize	FRw	16,000.00
Closing valuation	FRw	5,000.00

The income statement for the above records is as follows:

Table 7.10: Sample income statement

Purchases and Expenses		**Sales and Receipts**	
	FRw		FRw
Opening valuation	8,000	Milk sales	20,000
Casual wages	6,000	Sale of bull calves	2,000
Tools & Equipment	5,000	Maize sale	16,000
Depreciation of Tractor	12,000	Beans sale	15,000
Fertilizers	6,000		
	10,000	Closing valuation	5,000
Total	**47,000**		
Profit	11,000		
	58,000		58,000

At the end of the production year, Habiyambere made a profit of FRw 11,000.

d) Health records

It is very important that every farmer keeps their livestock in good health. When livestock are in good health, a farmer is reassured of better production which in turn means more profit to the farmer. Such records are specific to livestock production and are normally kept to show the health condition or status of the animals on the farm. With these records intact, a farmer is able to plan the right course of action to take. Considering that livestock suffer from various diseases and are attacked by numerous parasites. Such records will also assist the farmer in calculating the actual cost of treatment. They are also useful during selection and culling of animals on health grounds.

Table 7.11 Sample of a health record

Date of treatment	Animal affected	Disease symptoms	Kind of treatment given (e.g drug)	Cost of treatment	Other operations			Remarks
					Vaccination	Dosing/ Dusting	Dipping	

e) Breeding records

Breeding records are more relevant to livestock production. They will therefore help the farmer in planning the livestock breeding programmes and also to select the best animals within the herd or flock.

It is important to note that each species of livestock has unique breeding aspects to be recorded and the format used will therefore vary with the individual farmer.

Table 7.12 (a): Sample of a dairy cattle breeding record

Name/No. of Cow	Name / No. of Bull/Sire	Date of Service	Date of pregnancy diagnosis and result	Expected Date of Calving	Actual date of calving	Sex of calf	Weight of calf at birth	Remarks

Table 7.12 (b): Sample of a breeding record of a sow

No. of sow	Date of service	Boar used for service	Expected farrowing date	No. of piglets farrowed	Av. Wt of Piglets at birth	No. of Piglets weaned	Av. Wt at weaning	Remarks

Table 7.12 (c) Sample of a breeding record for sheep

No. of ewes	Tapping period	Time of lambing	No. of lambs born	Lambing % of the flock	No. of lambs disowned	Remarks

e) Field operations records

Field operations records are used in recording activities like land preparation, planting and harvesting; carried out on crop production. Details of operations on each of the crop fields should be accurately kept. Such records will enable the farmer to manage the fields properly as well as determining how profitable each enterprise is.

The following are some of the necessary details that should be included in field operations records:

- The size of land or acreage of the field
- Date of seedbed preparation
- Date of planting

- Types of crop and variety planted
- Seed rate used
- Type and amount of fertilisers applied
- Dates of fertiliser application
- Dates of weed control
- Dates of operations such as pruning, spraying to control pests and diseases
- Date of harvesting
- The yield per hectare

g) Marketing records

Farmers like all other business people in Rwanda are profit motivated. Therefore, whatever they produce should in one way or another, go through the market. Records therefore need to be kept concerning how these products perform in the market.

Money matters!

The networth of a business can be defined as the total worth of the business or net capital. It is the balance that is left after the owner of the business has met all the liabilities. The business is considered solvent if it is able to meet all the liabilities and still have some capital left at the end of an accounting period.

Self-evaluation Test 7.5

1. What types of records would a rabbit rearing farmer need to keep?
2. Draw a sample weekly production record for a dairy cow. The record should be able to capture daily milk production amounts of one cow.

7.5 Farm budgeting

Activity 7.6: Research Activity

Visit your library and read about budgeting and its importance. Write a short report and share with members of your class.

Whether a farm is being run on large scale or small scale levels, proper planning, effective co-ordination and dynamic control of the farm operations is vital. Planning and budgeting are, therefore, important and effective managerial tools for attaining desirable goals on the farm.

Planning involves the establishment of objectives and what is required to attain them. They may include both long term and short term plans for the entire business and also for each subdivision on the farm.

After planning is completed, it is necessary to organise the available factors of production in such a way that the expected results can be attained. Planning

involves drawing up detailed divisions relative to such items as the size of the farm, state of the environment, farmer's objectives and preferences, possible production enterprises, production schedules, labour costs and requirements, input material costs and requirements, expense limitations, capital conditions, existing market conditions, inventory levels and the present financial plans.

Farm budgeting and planning practically overlap each other to such a degree that it is difficult to discuss one without mentioning the other. For example, when a planning function is performed, the basis for a good budget is laid.

A farm business is an estimate of the future income and expenses of a proposed plan. The process of estimating the future results of a farming plan is known as **farm budgeting**.

There are two common types of budgets that are prepared for farm businesses. They are partial and complete budgets.

(a) Partial budget

A partial budget represents financial effects on minor changes in a farm organisation. Some of these changes include a change of size of land under a given crop, change of production techniques among others.

A partial budget is prepared as an effort to find solutions to questions such as:

- What would happen if a farmer replaced one enterprise with another?
- What would happen if a farmer expanded an enterprise?
- What would happen if a farmer introduced new production techniques such as changing from hand milking to machine milking or rotational grazing to zero grazing?
- In partial budgeting, the planner should ask the following four guiding questions:
  - *What extra cost is the farmer going to incur as a result of the proposed change?*
  - *What revenue is to be foregone as a result of the proposed change?*
  - *What extra revenue is to be earned from the proposed change?*
  - *What costs are to be saved as a result of the proposed change?*

After finding the answers to the above questions, the farmer establishes whether the proposed change will result in a gain or a loss. If there will be a gain, the change will be worthwhile, but if there will be a loss, then the change should be abandoned and other proposals tried.

Example

A farmer in Gisenyi area has 4 ha of arable land, 1.5 ha of which are under a crop of wheat, 0.8 ha are under a crop of maize, 0.3 ha under fodder crop and the rest either under improved grass or natural grass. The farmer wishes to know whether

replacing 0.3 ha of the piece of land under maize with Irish potatoes the following season would be worthwhile. The following are some of the proposals the farmer had on the new project:

The fertiliser rate would have to increase from 2 bags per ha for maize to 2.5 bags per ha, for potatoes and extra 40 man-days of casual labour per ha would be necessary as a result of the change.

Average yields of maize and potatoes are 56 and 90 bags per ha respectively. The prices are FRw.220 per bag of maize and FRw.162 per bag of Irish potatoes. Seed costs are FRw.110 per 10 kg of maize and FRw.200 per 50 kg of potatoes. Fertiliser costs are FRw.300 per 50 kg bag. Labour is paid at FRw.20 per man-day. The farmer would require 10 bags of potato seed and 1 bag of maize seed to cover 0.3 ha.

Table 7.13: Partial cost budget calculation

Debit(-)	**FRw**	**Credit(+)**	**FRw**
Extra cost on potatoes		Extra revenue	
Fertilisers	225	Yield =	4,374
2.5 x 0.3 x 20		90 x 0.3 x 162	
Labour : 40 x 0.3 x 20	240		
Seed: 200 x 10	2,000		
Sub-total	**2,465**	**Sub-total**	**4,374**
Revenue forgone	3,696	Cost saved	
Maize yield 56 x 0.3 220		Maize Seed =1	110
		Fertiliser 2 x 0.3 x 300	180
Sub-total	3,696	Sub- total	290
Total	**6,161**		**4,664**

From the above information, one can deduce that: (extra revenue + cost saved) – (extra + revenue forgone) is (4,664 – 6161) = -1497

The result i.e FRw-1497 indicates a loss. The farmer should, therefore, not replace maize with Irish potatoes because the farmer will definitely incur a loss.

(b) Complete budget

A complete budget is necessary where a farmer wants to start a new business. Both the variable costs and the fixed costs are all likely to be affected. This would involve a major change in the farm business operations.

A complete budget covers every item of expenditure and income. In this type of budget, estimates must be made of both the variable and the fixed costs that are likely to be incurred. The preparation of a complete budget requires that budgeting

should be done for all possible alternatives. Nevertheless, it is practically impossible to budget for all the alternatives. The farmer should, therefore, use skill in choosing the best plan with minimum use of time and money.

Preparation of a complete farm budget

The following guidelines should be followed when preparing a complete budget.

1. *Formulation of farm goals*

Here, for instance, the farmer may state reasons for setting up the farming business.

2. *Taking the farm inventory*

Here, the items listed in an inventory should include farm buildings, processes of land improvement such as irrigation, fencing, and breeding stock, and human labour, funds available, sources of power, machinery and equipment. All these should be described in details.

3. *Planning for resources*

Here one shows how resources such as land, labour and capital will be utilised.

4. *Estimating income and expenditure*

This is done by preparing a statement of income and expenditure based on existing prices and costs.

5. *Estimating production*

Analysing the input-output relationships that exist in the farm.

6. *Analysing existing production weaknesses in the farm*

Here the farmer will have to determine what to eliminate first in order of importance.

7. *Making a number of alternative farm plans and choosing one for adoption*

Putting the best chosen plan into operation and supervising its implementation.

Self-evaluation Test 7.6

Ingabire has acquired a farm of reasonably high agricultural potential in Rwamagana area. The farm is 30 ha, all arable. The general environmental conditions and assessment indicate that the following enterprises can be successfully carried out:

- Dairy cattle rearing

- Maize growing
- Tea growing
- Pyrethrum growing
- Poultry keeping
- Potato growing
- Growing of wattle trees
- Vegetables farming

Having considered her objectives and preferences, as well as the marketing prospects for all the possible products, Ingabire chose to carry out the following enterprises:

- Dairy cattle rearing
- Maize production
- 200 egg laying hens
- Pyrethrum growing
- Vegetables

Draw up a complete budget for Ingabire.

Activity 7.7

Mention things that one should consider in coming up with a good budget for a rabbit farm.

Remember the facts!

- Farming is a business just like any other.
- In the market, buyers come into contact with the sellers so as to exchange money for various goods and services.
- Demand is the quantity of goods and services which consumers are willing and able to buy at a specific period of time.
- The theory of demand states that the quantity of a good or service demanded varies inversely with its price.
- Demand is mainly determined by price.
- Factors which may influence demand for a commodity include:
  - Income of consumer
  - Tastes and preferences of consumers
  - Change in population
  - Prices of related goods (substitutes)
  - Price expectations
  - Advertisements
  - Beliefs, customs and taboos
  - Government policies and regulations

- A demand schedule is a series of quantities of a given commodity that a particular population is willing to purchase at different prices within a given period of time.
- Several demand schedules make up a market demand.
- Supply is the quantity of goods or services a seller is willing to sell or is able to offer for sale at a given price, market and time.
- The supply theory states that as the prices of goods or services increase, the corresponding quantity of goods or services offered for sale increases and vice versa.
- Factors that tend to influence the supply of a commodity include:
  - Price expectation
  - Prices of related goods
  - Number of sellers in the market
  - Cost of production
  - Transport system
  - Government policies and regulations
  - Weather changes
  - Technology and modern agricultural practices
  - Time lag for certain commodities
- A supply schedule is a series of planned production rates that depend on the price of a product.
- Price is the amount of money paid in exchange for goods bought or services rendered.
- Pricing is the process of determining the most suitable prices for various goods and services.
- Equilibrium price is attained when the quantity of goods supplied equals the quantity of goods demanded.
- The law of diminishing returns states that if successive units of one variable input are added to fixed quantities of other inputs, which are held constant, a point is eventually reached when the additional (and average) product per additional unit of input will decline.
- The following are examples of product relationships:
  - Joint products
  - Complementary products
  - Competitive products
- A farm record is a form of stored information in a farm that may be useful at a later date, when decision making and planning become necessary.
- Farm budgeting is the process of estimating future income and expenses of a farm plan.

Test your Competence 7

1. Explain how market prices relate with the demand and supply of tea in a given market.
2. Explain four factors that may influence the changes in supply of beef in a given market.
3. How can knowledge of the law of diminishing returns enable Mugisha to gain the most from his coffee farm?
4. What are the benefits of price control on the economy of Rwanda?
5. What is:
   a) Farm planning?
   b) Farm budgeting?
6. How can equilibrium price be achieved in a market with demand for broilers?
7. How will rainy weather affect the supply of maize grains?
8. How can government policies and regulations be made in such a way that they cater for upcoming farmers hence encouraging farming as an economic activity?
9. How has the advent of new technologies in the farming practice affected farming as a business?
10. Which of the following do you think will least affect the demand for milk?
    A. Drastic change in population
    B. Weather conditions
    C. Advertisement
    D. Income of consumers

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