Agriculture

for Secondary Schools

Student's Book
Form One

Tanzania Institute of Education

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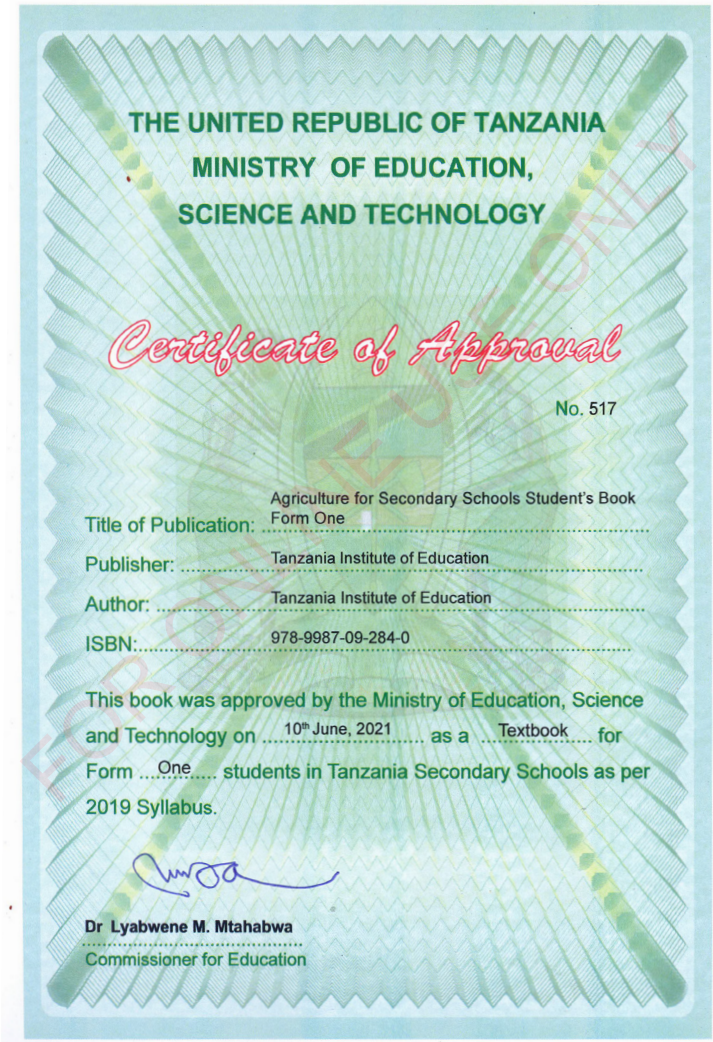

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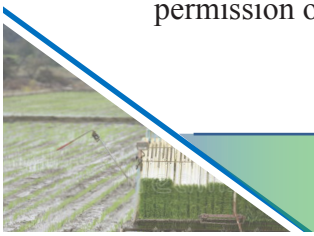

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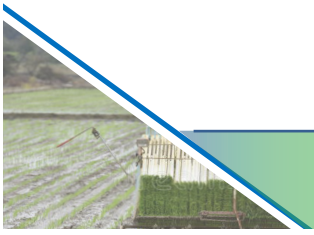

Preface

This book, *Agriculture for Secondary Schools* is written specifically for Form One students in the United Republic of Tanzania. The book is prepared as per the 2019 Agriculture Syllabus for Ordinary Level Secondary Education Form I-IV, issued by the Ministry of Education, Science and Technology.

The book is divided into thirteen chapters, which are: Introduction to agriculture, crop production, cropping systems and patterns, introduction to livestock production, livestock breeds, livestock farming systems, introduction to mechanisation in agriculture, farm tools and equipment, farm workshop, farm machinery, farm power, the concept of soil and physical properties of soils. In addition to the contents, the chapters comprise illustrations, activities and exercises. You are encouraged to do all the activities and attempt all the questions. This will enhance acquisition of the intended competencies for this level.

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Chapter One

Introduction to agriculture

Introduction

Agriculture provides the means of managing useful plants for the production of food and animals' feeds and generating income. In this chapter, you will learn the meaning and the branches of agriculture, relationship between agriculture and other subjects and application of agriculture in daily life. You will also learn the role of agriculture in the economy. The competencies developed in this chapter, will enable you to understand and appreciate the importance of agriculture in daily life.

The meaning and importance of agriculture

The term agriculture is derived from two Latin words "*ager*" and "*cultura*" Ager means "*land*" or "*field*" and cultura means "*cultivation*," which literaly means cultivation of land. *Agriculture is defined as the science and art of cultivating the land, growing crops and raising livestock. It involves managing, harvesting, processing, storing and marketing of products. It also includes the raising and managing bees, fish and man-made forests*. Agriculture is considered as the science, art and the business of producing crops and livestock.

Agriculture as a science: It uses scientific principles when developing agricultural technologies and innovation such as the use of genetic principles in developing improved crop varieties and livestock breeds. It also uses chemistry in manufacturing and application of fertilisers. Likewise, it uses biological knowledge in controlling and managing pests and diseases in crops and livestock.

Agriculture as an art: It embraces knowledge in a skilful manner and efficient way when performing physical farm operations such as handling of farm implements, animals and sowing seeds. Mental skills such as taking decision based on experience in matters relating to when and how to plough, how to adopt improved farming practises, how to select crops and how to practise cropping system are other aspects of agriculture as an art.

Agriculture as a business: Agriculture as a business is the way of life of farmers especially the rural population. In this respect, agricultural production aims at maximum net return through the management of land, labour, water and capital.

Generally, agriculture is the most important enterprise in the world as it helps people in meeting basic and other essential human needs such as food, clothing, shelter, medicine and recreation. It provides food and feeds for humans and livestock respectively. It also, provides raw materials for industries. Adequate agricultural production, promotes peace, prosperity, health, harmony and wealth of an individual and the nation at large. In Tanzania for example, the majority about 65 percent of the population are engaged in agriculture. They practise crop and animal farming in order to get produce and other useful products for home consumption and for sale to earn income.

Branches of agriculture

Agriculture is broadly divided into five areas. These are crop production, animal production, agricultural mechanisation, agricultural economics and soil science. These branches have been recognised as the major branches of agriculture because of their related activities and functions as elaborated hereunder:

(a) Crop production

This is the study of crops and their production, management, harvesting, processing and storage. The crops produced include maize, rice, orange, sisal, coffee, cassava, round potatoes and flowers.

(b) Animal production

This is the study of management of farm animals which includes selection, breeding, feeding, pests and diseases control. This is done for obtaining animal products such as meat, milk, eggs, skins or hides and other related products.

(c) Agricultural mechanisation

This is the study of use, maintenance and development of farm tools, equipment and machinery for the production of crops and farm animals.

(d) Soil science

This is the study of the classification, survey, conservation and management of soil for crop and animal production.

(e) Agricultural economics

This is the study of the supply and demand relationships in agriculture and the economics of agricultural production including financing and marketing understanding profits and losses, managing cooperatives, project development and evaluation.

Relationship between agriculture and other subjects

Agriculture subject is closely related to other subjects such as Physics, Chemistry, Biology, Geography, Business Studies, Home Economics and Mathematics in various ways as discussed hereunder:

(a) Physics

In Agriculture, we study Physics topics such as mechanics, heat and light. The knowledge from these topics is applied in agriculture. For instance, mechanics is a science that deals with physical actions of force on moving objects. In agricultural mechanisation, various actions are applied during farm operations such as cultivation, planting, weeding and harvesting. In these operations, mechanical energy is used. Most of the advanced agricultural operations are done by machines such as tractors, planters and harvesters. All these machines, tools and implements are made by using principles of physics.

(b) Biology

In Biology, we study about living things (including livestock, crop plants and pests), their characteristics and functioning of their body systems such as reproduction system and digestion system. This knowledge facilitates better understanding of production of crops, livestock and management of pests in agriculture. Also, genetics, which is studied in Biology, is applied in Agriculture during developing useful livestock breeds and crop varieties.

(c) Chemistry

The use of the principles of Chemistry enables a farmer to analyse and manage the soil. Soil management and analysis enable the farmer to know the types, forms and amount of fertiliser to apply. The manufacturing and application of agro-chemicals require the knowledge and skills of Chemistry. The availability and uptake of plant nutrients in plant roots depend on chemical reactions which are learnt in Chemistry subject. Both physical and chemical reactions which are taking place in the soil are very important for crop production.

(d) Geography

The agricultural activities are influenced by climate and weather condition. The knowledge and skills of climate and weather are learnt in Geography. Thus, the knowledge of Geography is important to farmers as it enables them to plan for farm activities and operations. Based on their understanding of climate and weather situations, farmers will be able to prepare their fields, plant, and harvest timely.

(e) Business Studies

Business studies enables a farmer to be in a good position of calculating some profits and losses in their farming activities. It also helps the farmer to be able to do some accounting operations and make informed decision before and when marketing his/her agricultural products.

(f) Home Economics

Home Economics is a broad field of study in which we learn how to manage household resources including proper storage and best use of food which we produce in agriculture. It also covers aspects of preparing meals in a manner that is nutritive and balanced for healthier family and community.

(g) Mathematics

In Mathematics we learn and perform some mathematical operations such as addition, substraction, multiplication and division. These operations are applied in Agriculture as well. For example, they can be used when determining the required number of chickens to be raised in a unit area of a given room. Also, it can be used when determining the appropriate ratios of a male to female animals such as, the number of cows and hens that can be served by one bull or cock respectively; and the amounts of constituents to be used in formulating animal feeds.

The application of Mathematics goes beyond determining the ratios of males to females in animal production; to determining plant population in crop fields. Many farmers get low yields because of failing to use the proper plant spacing in their fields. As a result, they either plant too many or too few of the required plant population. This in turn, leads to low crop yields. Proper plant spacing leads to proper plant population and finally to better yields. The number of plants in a piece of land is called plant population. It is expressed as the number of plants per unit area (plants/unit area). Plant population is obtained using the following formula:

$$\text{Plant Population (Plants/ha)} = \frac{\text{Farm area}}{\text{Area occupied by one plant}}$$

The area occupied by one plant is obtained by multiplying spaces between plants rows and spaces within rows.

The plant population can be obtained as indicated in the following example:

Example: A farmer possesses a piece of land measuring 10 000 m^2 and he/she is expecting to raise maize in the field by using a standard spacing of 90 cm between rows, and 30 cm between plants in a row. What will be the plant population for this piece of land?

Solution: The formula for plant population is given as:

$$\text{Plant Population (Plants/ha)} = \frac{\text{Farm area}}{\text{Area occupied by one plant}}$$

From the given information: Area = 10 000 m^2
Spacing = 30 cm plant to plant by 90 cm row to row

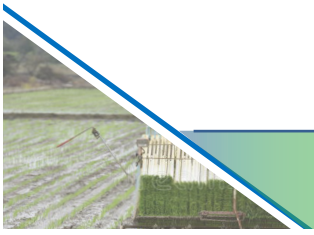
Since the area is in metres (m) and spacing is in centimetres (cm), change the centimetres into metres. The space of 30 cm plant to plant by 90 cm row to row, will now be 0.3m by 0.9m

$$\text{Plant population} = \frac{10\,000\ m^2}{(0.9\ m \times 0.3\ m)} = \frac{10\,000\ m^2}{0.27\ m^2} = 37\,037 \text{ plants/ha}$$

Thus, the plant population for this piece of land is 37 037 plants/ha.

(h) Language subjects

Likewise, language subjects such as English and Kiswahili (at certain circumstances) are very important since they are used as the media for communication during the process of learning and doing agricultural activities. Therefore, in studying Agriculture one needs to associate the knowledge learnt from other related subjects.



Activity 1.1

Work in groups to do the following activity:

1. Use a simple diagram/illustration to show how Agriculture as a field of study, relates to other subjects.
2. Visit some farms nearby your school or home. Observe various crops planted in those farms and write a brief report under the following guiding questions:
   (a) What types of crops did you observe?
   (b) Were the crops planted by considering any specific spaces? If not, what do you think was the reason?
3. Calculate the number of plants per hectare of maize, beans and coffee for spacing provided in the table. Fill the number of plants in the table provided in your right-hand side. Thereafter, present your work in class for discussion.

Crop	Spacing	Plant/ha
Maize	90 cm × 30 cm	
Beans	50 cm × 20 cm	
Coffee	2.7 m × 2.7 m	

Application of agriculture in daily life

Everyone needs to eat in order to survive. Food production therefore is very important in the family; and agriculture is the major activity which provides the means for food production. Agriculture has played a leading role in people's lives in Tanzania; this is because about 65 percent of Tanzanians are engaged in agriculture. Formerly, agriculture was perceived as crop and livestock farming alone. Currently, agriculture extends to fisheries, beekeeping, flowers and mushrooms farming and mixed skills such as plumbing, masonry and carpentry. The application of agricultural knowledge and skills in various fields enables the farmer to produce, process and market various agricultural products to consumers and eventually enabling him/her to earn money.

Activity 1.2

1. In a group, discuss how agriculture is applied in your area.
2. Summarise your discussion and present in class for discussion.

Exercise 1.1

1. From which two Latin words is the term "Agriculture" derived? Give the meaning of each word.
2. Outline five major branches of Agriculture.
3. Agriculture is important to both people living in rural and in urban areas. Discuss.
4. Giving examples in each case, explain how Agriculture relates to Biology, Mathematics, Chemistry and Geography subjects.

The role of agriculture in the economy

Normally, producers produce goods in order to satisfy the consumer's wants. "If there is no consumption, there will be no production." Therefore, consumption is the end of all production activities. Furthermore, consumption along with investments determines the level of income and employment. In agriculture, subsistence farming means producing for family use only. When there is agricultural improvement through various technological advancement including mechanisation, agriculture becomes more commercial and productive. When production meets family needs, it generates surplus, which in turn facilitates agricultural trade and revenue generation. The generated income can be used as a capital for further business investment. The investments from agricultural savings create further opportunities for agricultural development and contribute to the economy of the country through foreign exchange earnings. Thus, it is important to understand the concept of economy and development in agriculture, basic contributions of agriculture to the economy of a family, local community and the Tanzanian economic development.

The concept of economy and development in agriculture

The term economy can be explained as the larger set of inter-related production, distribution and consumption activities that aid in determining how scarce resources are allocated. Economic changes in Tanzania have direct relations to development in agriculture. The development in agriculture passed through certain distinct stages. At the beginning, farmers produced for family use only, that is subsistence agriculture. The increased technology in the production processes led to increased production among some farmers beyond what the family needed. The surplus in production necessitated a design of disposal mechanism. Creating a market for the product became necessary leading to semi-commercial economy whereby part of what produced was sold after meeting subsistence requirement.

In addition, introduction of commercial agriculture marked the turning point in agricultural transformation. Population growth and industrial revolution created more demand for agricultural raw materials for industries. The establishment of plantations and estates was seen as a solution to this problem. This led to a cash economy-system. The effect of cash economy to traditional agricultural pattern was observed in the growing of cash crops such as tea, coffee, sisal, pyrethrum and cotton. Specialisation in the production of food or cash crops increased, as the demand for such commodities increased with an increase of urban expansion. Due to increased production, farmers saved part of their income and invested in relatively large projects for future development. This led to improved standard of living. The term development in agriculture can be described as the advancement of agricultural production which aids the determination of the level of investments and consumption of the product.

Therefore, agriculture remains the major factor in the economy of Tanzania. Currently, about 65 percent of Tanzanians are directly engaged in agriculture. Among these, the majority live in rural areas where agriculture is virtually the main occupation and source of livelihood.

Contribution of agriculture to the economy of the family and local community

Agriculture is important to people's lives worldwide because it is the source of food to the family. Food production is an important aspect to the families and community as a whole. Thus, at a family level, agriculture provides the means of producing food and earn income. Through agriculture, a family can produce various products for its basic needs. In turn, these agriculture-based activities in the family contribute to the family economy and national development through the selling of surplus products to other people.

The contribution of agriculture to the wellbeing of the family cannot be overlooked because most families, especially in rural areas, depend on selling their agricultural products to get non-food requirements such as clothes and shelter. Therefore, agriculture is important in the economy of the family, the community and the nation as a whole in terms of food supply, source of employment, source of raw materials for industries, provision of market for industrial goods, source of income and improving the standards of living of the farmers. Some of these contributions are explained as follows:

(a) Food supply: The food eaten by the family is the product of agriculture. It is the duty of every head of the household to provide food for the family. Healthy family members can participate effectively in community development activities.

(b) Source of employment: Agriculture provides employment for those who are directly involved in the production of agricultural products. Also agriculture provides employment opportunities to people working on value addition sub sectors such as agro processing, transportation, storage and packing. Agricultural support sectors such as agricultural extension, training, research and input supply.

(c) Improving living standards of the community: The use of opportunities available in the agricultural sector enables the farmers to improve their living standard and become more useful citizen for the development of the country.

(d) Source of income to the family: Agricultural products are the major sources of domestic and international trade as they provide revenue for the family. The increased agricultural production enables farmers to pay for various services including taxes. The government uses these taxes to facilitate national development by financing services and projects like: education, health, manufacturing industries, roads, communication and electrical power supply.

Activity 1.3

Perform the following tasks:

1. In a group, survey a community around your school and do the following:
   (a) Observe and identify various agricultural activities being undertaken by the community members; and
   (b) State how the activities contribute to the improvement of life standard of the individuals.
2. Choose one agricultural enterprise of your interest which you would like to engage in for your income generation. Give reasons why you are interested in the chosen enterprise.
3. Present your work in class for discussion.

The importance of agriculture to Tanzanian economic development

Agricultural and Industrial sectors are the basic criteria for the country development. The development of these two sectors leads to the development of other sectors such as education, health, transportation, mining and communication. Tanzania has a total of 94.5 million hectares of land of which 44 million hectares are classified as arable land. The 2016/17 Annual Agriculture Sample Survey report shows that only 33 percent of the arable land was under cultivation by 2016.

The sample survey also indicates that about 29.4 million hectares are potential for irrigation of which 2.3 and 4.8 million hectares are regarded as having high and medium potentials respectively. Although the area under irrigation has been on the increase, by 2016 the area under irrigation was 460 000 hectares only which is less than 20 percent of the high potential area for irrigation and less than 5 percent of the cultivated land. The report further indicates that of the 50 million hectares suitable for livestock keeping, only 26 million hectares were under use while the rest cannot be used mainly due to tsetse fly infestation. Tanzania is the second largest country in livestock population in Africa after Ethiopia.

According to the Bank of Tanzania Annual Report-2020, in the year 2019, agricultural sector contributed about 28.6 percent of the national income (Gross Domestic Product) and it was projected to increase to over 30 percent by 2023. Agriculture employs about 65 percent of the total population of Tanzania and contributes about 96 percent of the national food requirements. Moreover, the sector is a source of raw materials for agro-processing industries. Agricultural production in the country is dominated by smallholder farmers who represent most of the rural families. In 2016 about 42 percent were engaged in both crop and livestock keeping, 56 percent were engaged in crop growing only and 2 percent were engaged in livestock keeping only.

The importance of agriculture to Tanzanian economic development can be summarized as follows:

(a) Livelihood of the people: Agriculture is a source of food to the whole community. Therefore, it is the duty of every nation to ensure that her people have sufficient food because a well-fed nation is a healthy one. The nation with healthy population can fully participate in economic development activities.

(b) National economy: Agricultural sector is the key contributor to the national economy. In 2019 for instance, the Tanzania economy continued to be among the fastest growing economies in sub-Saharan Africa with a Gross Domestic Product (GDP) growth of 7.0 percent. The main growth drivers were agriculture, construction, mining and quarrying, transport and storage activities. Agriculture activities accounted for the largest share (26.5 percent) of the GDP, followed by construction (14.3 percent), trade and repair (8.8 percent) and manufacturing (8.5 percent).

(c) Employment: The agricultural sector employs the majority of Tanzanians including those engaged in farming and in processing industries. Generally, economic development occurs when there is expansion of industrial sector which is mostly contributed by the expansion of agricultural sector.

(d) Source of raw materials for industries: Most of the agricultural products require some processing before they are eventually utilised. The sector contributes about 65 percent of raw materials for domestic industries. For example, cotton, sisal, coffee, tea, hides/skins and wool require to be processed before they eventually reach the consumers. Processing increases the value of agricultural products thereby increasing the national wealth. The main industries in East Africa are therefore, based on agricultural raw materials. These include maize mills, rice mills, canning factories, breweries, leather tanning and milk processing industries.

(e) Provision of market for industrial goods: People engaged in agricultural sector are in turn, serving as a large consumer market for the industrial products such as fertiliser, pesticides, agricultural tools and machinery, building and construction materials, bicycles, trucks, lorries, boats and many others.

Activity 1.4

Perform the following tasks by searching for information in the library, internet or other sources:

(a) Find out the current economic growth of Tanzania.
(b) Find out the leading sectors in contributing to the Tanzanian economy.
(c) Present your findings in class for discussion.

Exercise 1.2

Answer the following questions

1. How agriculture development relates with economic development in Tanzania?
2. Outline the importance of agriculture in economic development of any nation.
3. Discuss how agricultural skills can be applied in your daily life?
4. Briefly explain the relationship between agriculture and industrial development.

Chapter Two

Crop production

Introduction

Human beings depend on various crops including grains, vegetables, and fruits to survive. In this chapter, you will learn about the meaning of crop and crop production, types of agricultural crops and importance of agricultural crops. The competencies developed from this chapter will enable you to apply the knowledge of crop production in your daily life.

The concept of crop production

All plants which are cultivated and managed in the farms are termed as agricultural crops. On the one hand, a crop is a plant that is grown for a specific purpose, be it for food, business or both. On the other hand, crop production can be explained as an art and science of growing plants for food and other purposes. Crop production include land preparation, planting, fertiliser/manure application, diseases and pest control, irrigation and harvesting as well as processing and storage. Through crop production, human beings obtain different crop products. These include grains, fibres, spices, oil, medicines, beverages, forages for livestock and ornamentals for decorations. The useful parts of crops may either be roots, stems, leaves, flowers, seeds or fruits. Each crop plant is grown by human beings for the production of one, two or several of these products.

Classification of agricultural crops

Agricultural crops are classified into different types or groups. This is done so as to be familiar with the crops, understand their soil and water requirements, adaptability of crops, the growing habit of crops, climatic requirement of different crops, recognise the economics of the crop plant and its uses and recognise the growing season of the crop. Therefore, a well-defined system of crop classification is important in crop production and agriculture in general. Crops can be classified in various ways, these include classification with respect to their uses, their characteristics (descriptive) and botanical basis. In this context, three approaches of classifying crops are elaborated in the following sections.

Use-based classification of crops

According to their uses, crops are classified into different categories as described hereunder:

(i) **Cereal crops:** These are crops grown for their edible seeds or grains. Cereals crops include maize, sorghum, wheat, millet, oat, barley, rice and rye.

(ii) **Pulses:** These are crops which belong to the family leguminoseae and are grown for their edible seeds. These crops include peanut or groundnut, bambara-groundnut, common bean, cowpea, soya bean, lima bean, mug bean, chick pea, pigeon pea, broad bean and lentil.

(iii) **Oil crops:** These include crops which bear the seeds which contain some useful oils such crops include soya bean, peanut or groundnut, sunflower, sesame or simsim, castor bean, palm and cotton.

(iv) **Root/Tuber and stem crops:** These include crops which store food in roots or stems, for example cassava, sweet potato, yams, potato, cocoyam, carrot, and sugar beet and sugar cane.

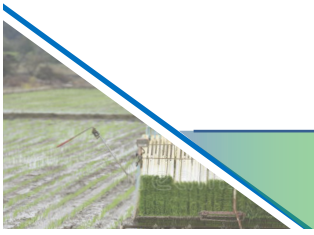
(v) **Fibre crops:** These are grown for their fibre. They include crops such as cotton, sisal, jute and kenaf.

(vi) **Forage crops:** These are crops grown for their vegetative parts used for feeding livestock. They include grasses, legumes and other cultivated pastures.

(vii) **Vegetable crops:** These are crop plants grown for their roots, seeds or pods that are used as vegetables. They include tomatoe, onion, egg plant, okra, cucumber, beet root, radish, cauliflower, pumpkin and green bean.

(viii) **Beverage crops:** These are crops grown for their leaves, seeds (beans) that are used for making refreshment drinks. Examples of beverages crops grown in Tanzania are coffee, tea and cocoa.

(ix) **Rubber or latex crops:** These are crops which are grown for their milky sap called latex. Latex is used in manufacturing different types of rubber products. Example of rubber crop is a rubber tree.



(xi) Biofuel crops: These are special crops grown for the production of fuel, which is used as additive or replacement for petroleum products, for example, jatropha.

(xii) Spice crops: These are crops grown for the production of aromatic substances used primarly for food flavouring and for other purposes such as food preservation. They include ginger, turmeric, peppers, cloves, cardamom, cinnamon, coriander and lemon grass.

(xiii) Ornamental crops: These are crops which are grown primarily for decoration or landscaping due to their attractive flowers or foliage. Examples include hibiscus, roses and bourganivillia.

(xiv) Medicinal crops: These are crops grown for their organic compounds with pesticidal or anti-microbial properties. They include pyrethrum, moringa and neem.

Activity 2.1

Visit some nearby crop fields, gardens or agricultural markets and collect various crop plants or their parts then classify them basing on the following categories:

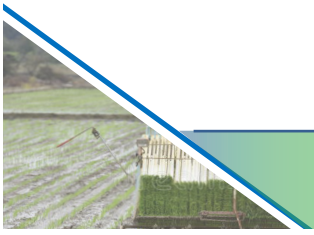
(a) Medicinal crops;
(b) Oil crops;
(c) Fibre crops;
(d) Cereal crops;
(e) Pulses; and
(f) Root/tuber crops.

Thereafter, write a report and present it in class for discussion.

Plant characteristics-based classification of crops

According to plant characteristics, crops are classified based on different criteria such as life span or life cycle, mode of reproduction, mode of pollination and growth habit as described in the following subsections.

Life span: According to life span, crop plants are classified into annual, biennial and perennial crops. Annual crops are those crops which have life span not exceeding one year. Examples of annual crops are paddy, maize and common bean.



Biennials crops are those crops which have lifespan of more than one year but not exceeding two years. An example of biennial crops is a cowpea.

Perennial crops are those crops which have life span exceeding two years. Examples of perennial crops are banana, coffee and tea.

***Mode of propagation*:** According to plant propagation, crop plants are classified into two major categories sexual and asexual propagated plants. Sexually propagated plants are those which are developed from seeds. Examples of sexually propagated crop plants are palm tree, maize and pawpaw.
On the other hand, asexually propagated crop plants are those crop plants developed using other plant parts than seeds or spores. Example of asexually propagated plants are cassava, sweet potato, banana and sugar cane.

Mode of Pollination: Based on the mode of pollination, crop plants can be divided into self-pollinated and cross-pollinated crops. In self-pollinated crops, both pollen and embryo sac are produced in the same floral structure or in different flowers but within the same plant. Typical examples include rice, most pulses, okra, tobacco and tomato. For the cross-pollinated crops, the pollen transfer is done from one flower to the stigma of another flower in a separate plant. Typical examples include, maize and many grasses, avocado, grape and mango.

***Growth habit**:* Based on growth habit, crop plants can be classified into herbs, for example carrot and ginger; vines, for example grapes and sweet potatoes; shrubs, for example tea and roses; and trees.

Activity: 2.2

In a group, walk around the school compound or field/garden and collect different crop plants. Put them into groups of annual, biennial and perennial crops.

Share your findings in class for discussion.

Botanical classification of agricultural crops

Botanical classification of crops is based upon similarity of crop plant parts and flower structure. Field crops belong to the spermatophyte, or seed plant division of plant kingdom, which comprises plants that are reproduced by seeds. Within this division, the common crop plants belong to the subdivision of angiosperm, which are characterised by producing seeds which are enclosed in ovaries. The angiosperm is then divided into two classes, which are monocotyledons and dicotyledons. Crops such as maize, wheat and sugar cane are monocotyledons while crops like beans, coffee, cucumber and cow peas are dicotyledons.

Each of these two classes is still divided further into orders, families, genera, and species. Some families are briefly explained in the following section.

The grass family: This is also termed as gramineae (poaceae) family. It includes all cereal crops and most of the cultivated forage crops. They are either annuals or perennials. They are almost all herbaceous plants, usually with hollow cylindrical stems closed at the nodes. The stems are made of nodes and internodes and they have fibrous roots.

The legume family: This is also termed as leguminoseae family. Their leaves alternate on the stems and are stipulated with netted veins and are mostly compound. They have taproot system. Their roots have nodules which are caused by Rhizobium bacterial activities.

Other crop families: Some of these are Malvaceae family, which includes crops such as cotton; Solanaceae family, which includes crops such as round potato and tobacco; and Compositae family, which includes crop such as sunflower.

The example of botanical classification of maize and common beans is provided hereunder:

Taxonomic unit	**Maize**	**Common bean**
Kingdom	Plantae	Plantae
Division	Spermatophyte	Spermatophyte
Subdivision	Angiosperms	Angiosperms
Class	Monocotyledons	Dicotyledons
Order	Herbaceous	Herbaceous
Family	Gramineae	Leguminoseae
Genus	*Zea*	*Phaseolus*
Species	*mays*	*vulgaris*

With botanical classification, each crop has its distinct scientific name. The scientific name has two parts. The first part represent the genus and the second part, represents the specific epithet. When writing a scientific name of a crop plant, the generic name must start with a capital letter. The specific epithet begins with a small letter. Then, the two parts of a name must be underlined separately. In published documents such as books, the scientific names should be written in italics. For example, the scientific name of a maize plant is Zea mays when hand written or *Zea mays* when typed. Likewise, the scientific name of a common bean is written as Phaseolus vulgaris or typed as *Phaseolus vulgaris*.

Activity 2.3

Visit a school farm or a garden nearby your school or home and collect ten different crop plants. Then do the following tasks:

1. Observe the characteristics of the plants you have collected and group them into monocots and dicots;
2. Present your work in class for discussion.

Importance of agricultural crops

The following are the importance of agricultural crops.

(a) Source of food

Agricultural crops are the world's leading source of food since they supply carbohydrates, protein, lipids, minerals and vitamins which are very essential for life. The availability of enough food to meet all the nutritional requirement reduces the incidences of food insecurity and malnutrition.

(b) Source of livelihood

Different groups of people in Tanzania including crop producers, processors, transporters and traders derive their livelihood from agricultural crops.

(c) Source of savings

When a farmer produces in excess, the excess may be sold for saving.This can be used to invest in other enterprises.

Exercise

1. What does the term crop production mean?
2. Discuss the contribution of agriculture in the building of an industrialized country.
3. Your family and the community that surround you need food every day. What can the family and the community do to ensure that food is sufficiently available?
4. Think of an "imaginary world" in which all people have money in surplus but very few of them are engaged in crop production. Discuss your ideas in class of what you think will occur.

Chapter Three

Cropping systems and patterns

Introduction

Knowledge and skills in cropping systems help you to understand various systems in raising crop plants for various purposes. In this chapter, you will learn the meaning of cropping system, criteria used to classify cropping systems and the major cropping systems in Tanzania. The competencies developed from this chapter will enable you to apply the knowledge of cropping systems in agricultural production.

Meaning of cropping system

Farmers in Tanzania use different systems and patterns in planting and managing crop plants in the field. Cropping systems therefore, is defined as a combination of crops that are grown by a farmer during a particular cropping season or various cropping seasons. The way farmers plant and manage crop plants has an impact on crop yield. A good cropping system is one of the factors for good yield. The choice of a cropping system depends on climate, soil and water availability.The choosen system should be the one that leads to maximum productivity.

Cropping system is an important component of a farming system. It represents a cropping arrangement used in a farm and their interaction with farm resources, other farm enterprises and the available technology, which determine their make-up. In each cropping system, farmers grow crop plants on the field using various patterns.

Criteria used to classify cropping systems

A farmer may have different combinations of crops on the farm and use different ways to manage them. For example, a farmer may grow vegetables closer to the house. At the same time, she/he may decide to grow some common beans far away from home.

The cropping systems are classified using the following criteria: the choice of crops to be grown, the capacity of plants of using nutrients in the soil, the growth habit of the plant and the nature of plant roots. These criteria are explained hereunder.

(a) Nature of crops

The choice of the crop to be grown in a piece of land using a selected cropping system depends on the compatibility of crops to be combined.

(b) Capacity of plant in using soil nutrients

Some plants such as legumes improve soil fertility by fixing nitrogen from the atmosphere in to the soil. Cereals and other plants can use this if they are grown as the next crop in the rotation.

(c) Growth habit of the crop plants

Most cereals do not cover the soil well because they have upright stem and are normally planted far apart. Legumes such as groundnuts, cowpeas, beans and some creeping grasses such as guinea grass, cover the ground very quickly after establishment. If their main use is to provide cover, we call them cover crops; if their main use is to provide food, we call them food crops.

(d) Roots nature of the crop plants

Crops have different root systems. Some plants are deep rooted and others are shallow rooted. Thus, a good cropping system should involve both shallow and deep rooted crops for optimal utilisation of soil nutrients.

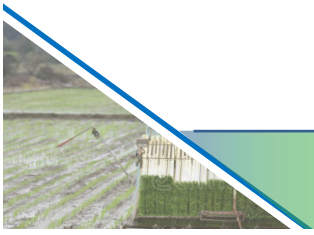
Activity 3.1

Work in a group to perform the following activities:

(i) Think about crops that are grown in your area or nearby areas then,
(ii) Identify possible combinations of crops that can be grown together;
(iii) Discuss whether the combinations you have identified above are applied by farmers in your area;
(iv) Present your group work in class for discussion.

Cropping systems in Tanzania

Farmers in Tanzania can use different cropping systems. They may decide to grow either a single or more than one crop on a piece of land per season. When deciding for a combination of crops, the farmer can further choose the patterns or sequential arrangement of the combined crops in that particular field. The cropping systems commonly used in farming are classified as mono-cropping, inter-cropping, mixed cropping and crop rotation.



Mono-cropping

This is the practise of growing one type of crop on a piece of land over a long time. It is also called monoculture. Sometimes this system is referred to as continuous cropping or pure stand cropping. In this system, a farmer can apply the recommended cultural practises efficiently because only one type of crop is grown at a time. The cultural practises include application of the right type of fertilisers, insecticides, fungicides and weed killers. However, the system is risky because only one type of crop is grown in the field. Therefore, if the crop fails because of unsuitable weather, insect pests and diseases infection, the farmer is likely to get poor harvest. Also, if a farmer uses this cropping system for many seasons without applying manure and or fertilisers, soil fertility may decrease. When the soil loses its fertility because of continuous cropping, yields become poor and may require applying manure, fertiliser or practising crop rotation.

The following are some principles that must be adhered to when practising mono-cropping in the farm:

(a) Consider the fertility of the soil. When a farmer wants to use this system, it is advised to select a fertile land.

(b) Consider moisture level of the soil in relation to water requirement of the targeted crop.

Advantages of mono-cropping

(i) It is convenient for mechanisation.

(ii) It facilitates efficient farm managerial practices, which may lead to high yields.

Disadvantages of mono-cropping

(i) Sometimes, fertility and productivity of the soil are lowered if proper soil management practises are not applied.

(ii) Soil structure may deteriorate.

(iii) May increase infestation of insect pests, diseases and weeds.

Mixed cropping

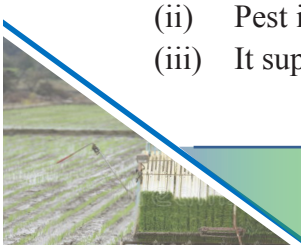
This means growing two or more crops simultaneously in the same field at the same time. In this system, there is no distinct row arrangement.

Advantages of mixed cropping

(i) It reduces the risk of crop failure due to environmental stress.

(ii) Pest infestation of crop is greatly reduced.

(iii) It suppresses weeds.



(iv) If legumes are included in the mixture, it increases soil fertility.
(v) If well managed, mixed cropping may increase the yield of both crops due to complementary effects of each crop.

Disadvantages of mixed cropping

(i) Application of fertilisers to the specific crops is difficult.
(ii) It is difficult to spray pesticides to the individual crops.
(iii) Competition among the resources may occur.
(iv) Time consuming during harvesting.
(v) Weeding process becomes difficult.

Inter-cropping

It is a cropping system whereby two or more crops (the main crop and the inter-crop (s) are simultaneously grown on the same piece of land with distinct row arrangement. The main crop is planted first at the recommended spaces followed by the inter-crop (s). For example, a farmer may decide to inter-crop the following crops:

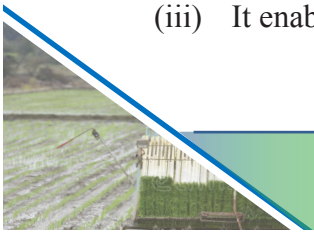
(a) Maize with pigeon peas.
(b) Sorghum with pigeon peas.
(c) Cotton with green gram.
(d) Pigeon pea with groundnut and sunflower.

In this system, in addition to the yield of the major crop, some extra crop yields are obtained. Therefore, the intercrop is like a bonus crop to the farmer. For example, when groundnut is inter-cropped with maize, a farmer gets the yields from groundnut and maize. The following are factors to consider when planning for inter-cropping:

(i) Ensure that maturity of intercrop does not concide with that of the main crop.
(ii) The intercrop should preferably be a legume for maintaining fertility and productivity of the soil.
(iii) The crops should have different growth habits and nutrient requirements in order to have minimum competition.

Advantages of inter-cropping

(i) It helps to improve soil fertility and soil productivity.
(ii) It maintains higher crop yields.
(iii) It enables better utilization of available resources.



(iv) It helps to prevent soil erosion.
(v) It reduces the incidence of insect pests, diseases and weeds.
(vi) It improves the soil structure and water holding capacity of soil.

Disadvantages of inter-cropping

(i) Mechanisation is difficult.
(ii) Competition for the resources may occur if not done properly.
(iii) Time consuming for such operations as weeding and harvesting.

Crop rotation

Crop rotation has received considerable attention in agriculture as it is one of the key principles of soil conservation. Crop rotation is defined as the practice of growing different types of crops sequentially on the same piece of land in successive seasons or years. Crop rotation aims at improving soil fertility, controlling weeds, insect pests and diseases. Figure 3.1 represents an example of crop rotation.

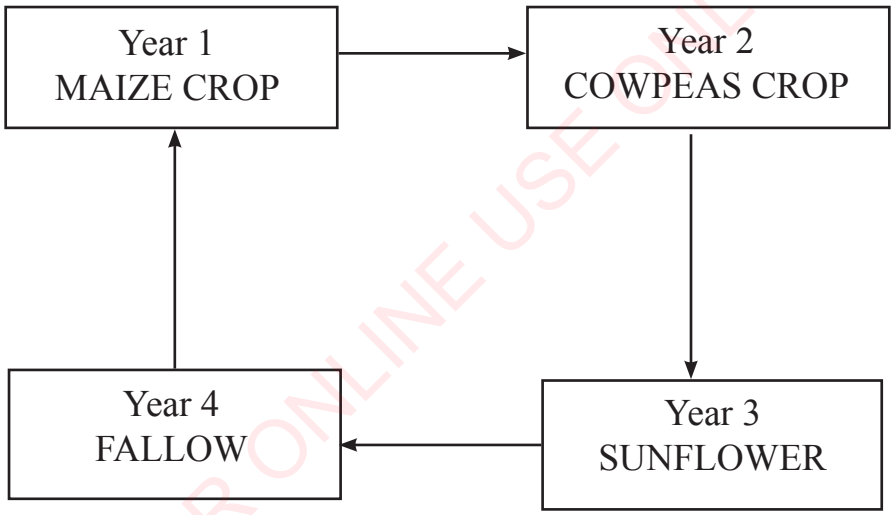


Figure 3.1: Crop rotation

When planning for crop rotation system, it is important to take into consideration the following principles:

(a) Feeding habits of crops: Heavy feeder crops are the crops that absorb a lot of nutrients, while, light feeder crops are those crops that absorb nutrients in small amounts from the soils. When practising crop rotation, it is important to interchange heavy feeders with light feeders in the successive seasons or years.

(b) Include crops of different families: Crop plants of the same family are normally attacked by the same diseases and insect pests. When crop plants of the same family are grown continuously on the same field, there is a risk of increased incidence of insect pests and diseases. Farmers should prevent this from happening by rotating crops of different families in successive seasons or years.

(c) Consider root system of the crop plants: Some plants have short roots which can use nutrients from surface soils. Such plants are shallow rooted crops. Other crop plants have long roots which penetrate deeper into the soils searching for nutrients. Such crops are called deep rooted crops. For maximum yields, farmers are advised to alternate deep rooted with shallow rooted crops.

(d) Consider the growing habit of the crops: Different plants have different growing habits. Some plants cover the soil fully, others do not. Plants that cover the soil fully include common beans, groundnuts and sweet potatoes. Plants which do not cover the soil fully include millet, maize and sorghum.

The following are some advantages of crop rotation:

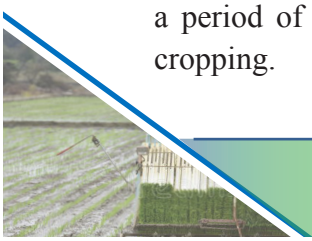
(i) *It improves the soil structure:* Some crops have strong, deep roots. They can break up hardpans, deep layers of soil and their penetration into the soil, creates tiny holes that allow free air and water movement.

(ii) *Increases soil fertility:* Legumes such as groundnuts and beans fix nitrogen in the soil. Also, when their green parts and roots decay, they release nitrogen which can be used by othe crop plants in the successive cropping seasons.

(iii) *Helps to control weeds, insect pests and diseases:* Planting the same crop season after season encourages the building up of certain weeds, insect pests and diseases. Planting different crops breaks their life cycle and prevents them from multiplying.

Cropping patterns

In cropping systems, sometimes a number of crops are grown together using a certain pattern or are grown separately at short intervals in the same field. The term cropping pattern refers to the arrangement of crop plants and crop sequences in relation to each other in the field and the management techniques used on a period of growing season. Cropping patterns include broadcasting and row cropping.



In cropping systems, sometimes a number of crops are grown together using a certain pattern or they are grown separately at short intervals in the same field. The term cropping patterns refers to the arrangement of crop plants and crop sequences in relation to each other in the field and the management techniques used on a period of growing season.

Broadcasting: This is the pattern of cropping whereby the seeds are planted by scattering on the field so that there is no specific distance between them. Broadcasting is commonly used for crops with very small seeds, which cannot be easily counted and managed during planting. This can be done by hand or by a machine called broadcaster. In this method, it is difficult to determine the plant population. This also makes it difficult for some farm operations such as weeding, fertilisation and harvesting to take place. Likewise, individual plants may compete for essential requirements because they may be too close to each other.

Row cropping: This is a pattern of cropping whereby seeds are planted on the field in such a way that there is a systematic distance between plants. It is commonly used for crops with large seed sizes which can be counted and easily managed in individual holes during planting. The distance between one plant and another is called spacing. Spacing is of two dimensions: the first, is the distance between rows of the plants and the second, is the distance between plants within rows. The distance between rows is called inter-row spacing and the distance between plants within the row is called intra-row spacing. When a farmer uses row cropping in the farm, it is easy to have an optimum plant population on the field. Sowing seeds in rows may be done by hand or by machine called planter.

Activity 3.2

1. In a group, visit your school/home or any nearby field crops, observe the crops in the field, then write a report on:
   (a) Types of crops grown in the field;
   (b) The cropping system used; then
2. Present your work in class for discussion.

Exercise

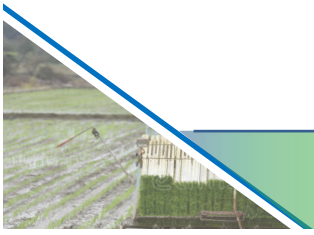
1. Describe the difference between cropping system and cropping patterns as applied in crop production.
2. State four cropping systems and two cropping patterns commonly used by farmers in your community.

3. (a) Use examples to describe the concept of crop rotation.
   (b) Why do you think it is important to practise crop rotation in crop production?
   (c) Describe four principles to be followed when practicing crop rotation.

4. (a) Discuss the inter-cropping and mixed cropping systems and state the advantages of each.
   (b) State four principles to be followed when practicing inter-cropping.
   (c) How does inter-cropping differ from mixed cropping?

5. (a) Which features differentiate row-cropping from broadcasting cropping patterns?
   (b) Which types of crops are suitable for broadcasting, and which ones are suitable for row cropping?

6. (a) Explain the meaning of the concept *inter* and *intra* row spacing.
   (b) Why is it important to consider inter and intra row spacing when planning to grow a certain crop?



Chapter Four

Introduction to livestock production

Introduction

In this chapter, you will learn the concept of livestock production as well as classes and types of livestock. The competencies developed from this chapter will enable you to practice livestock production in an effective and efficient manner for income generation and food production.

The concept of livestock production

Historically, human kind has been associated with wild animals. These animals have been used as a source of food, clothing and shelter. Hunting of wild animals was the sole means for human to get animal products. As time went by, hunting became unpredictable. As a result, human being started to select some animals for domestication. Domestication is the process of adapting wild animals for human use.

Today, human beings have understood animals and adopted various practices to suit their life needs. Due to the development of science and technology and an increase in population, the uses of animals have expanded from merely being a source of food, shelter and clothing to becoming a source of income, farm power, recreational, social and cultural uses.

Currently in Tanzania, people in both rural and urban areas keep different animals for various purposes, including home consumption and commercial use. The common name used for animals kept by human being is livestock. The term livestock is the combination of two words; "*live*" and "*stock*". live means "*living*" and stock means "*keep*". Livestock production therefore, is an art and science of keeping animals for the production of a wide range of products and services.

It is a science because it involves a scientific investigation, research, and systematic generation of knowledge. It is also a science because some of the livestock field operations are scientific. This includes breeding, which involves Genetics in selecting suitable breeds; Entomology, which is a science of insects; Parasitology, which deals with the study of parasites; and Pathology which deals with animal diseases.

It is an art because it involves creativity and improvisation to ensure that designing of structures and production system patterns is done skilful to make them more attractive.

The importance of livestock

Livestock production is the second income generating activity after crop production in the agricultural economy of Tanzania. Livestock production plays a multidimensional role in providing livelihood support to the population. Apart from contributing to national economy in general, livestock sector also provides employment and income generating opportunities to individuals. Therefore, the importance of livestock production in economic development can be summarized as follows:

(a) Source of income and employment: Livestock production sustains farmer's life by creating direct and indirect employment. This is possible when either a livestock keeper sells the product to get an income or when one works in the livestock farm or engaged in the industry of processing, transporting and marketing of livestock products such as meat, milk, eggs, hides and skin.

(b) Source of food: Livestock is an important source of foods rich in proteins, vitamins and minerals, for example meat, milk, egg and other products. Generally animal protein has relatively high nutritional value than plant protein.

(c) Source of raw materials: Livestock provides raw materials for industries. For example, skins and hides are used in leather industries for making shoes, bags and belts and wool is used in clothes industries. Hides and skin are the by-products of a slaughtered and dressed carcass of large and small animals respectively. Also, wool and mohair are obtained from long hairs bearing sheep and goats respectively.

(d) A means of transport: Donkeys, horses and bulls are used for transportation. In some areas of the country, these animals are used for transporting agricultural products from the farm to the home and from home to the market. Similarly, they can also be used for transportation of inputs from home to the farm.

(e) Provision of farm power: In some parts, especially in rural areas, draught animals such as camels, oxen and donkeys are highly utilised by farmers in ploughing their fields. For example, they are used to draw oxen plough.

(f) Provision of manure and fuel: Faeces of animals when decomposed enough can be used as manures. They can also be a source of fuel for example dry dung and biogas, which can be used in cooking and lighting.

Classes and types of livestock

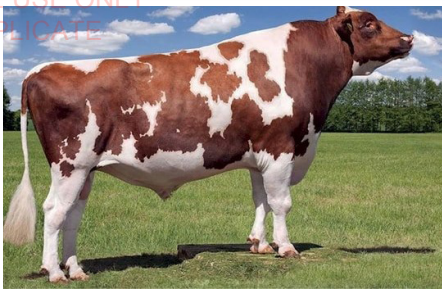
The word 'class' as used in this section means a set or category of animals having the common characteristics or attributes and are differentiated from other categories of animals by their kinds, types or qualities. While the word 'type' describes various animals differentiated by types of products and appearance. In Tanzania, most households keep at least one of the classes of animals for home or commercial use. Classes of animals that are commonly kept include cattle, poultry, rabbit, goats, pigs and sheep. Figure 4.1 shows some representative members of the classes of livestock.

Figure 4.1: Some classes of livestock

Cattle

Cattle are large ruminant animals, with cloven hoofs and some with horns which are domesticated for meat, milk and draught power. Cattle, which are kept for meat only, are called beef cattle. This type of cattle can be slaughtered after reaching the desired size and weight. Cattle, which are kept for milk production are referred to as dairy cattle. While those kept for both meat and milk are referred to as dual purpose cattle. Some bulls are castrated and trained specifically for performing farm operations, these are called oxen. Therefore, cattle have been grouped in four categories: dairy, beef, dual purpose and draught cattle (oxen). Figure 4.2 shows the four types of cattle.

(a) Female dairy cattle



(b) Male dairy cattle

(c) Beef cattle

(d) Oxen

(e) Female dual-purpose cattle

(f) Male dual-purpose cattle

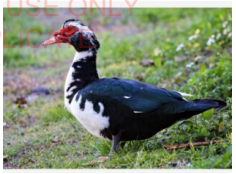
Figure 4.2: Types of cattle kept in Tanzania

Poultry

Poultry represents all domesticated birds including chicken, ducks, guinea fowls, geese and turkeys. Out of these birds, chickens are very popular and are kept by most of households in Tanzania for food and commercial purposes. Chicken may be local or exotic breeds, they are normally kept for eggs and meat production. Chiken kept for laying eggs are called layers, while those kept for meat are called broilers. Layers start laying eggs approximately from five to six months, while chicken kept for meat can be ready for slaughtering from five to seven weeks depending on the breed, feeding and other management practises. Also, there are chickens which are kept for both eggs and meat production. These are called dual purpose chicken. Figure 4.3 shows types of poultry commonly kept in Tanzania.


(a) Chicken


(b) Turkey


(c) Duck

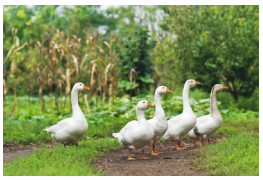

(d) Geese

Figure 4.3: Some types of poultry

Goats

A goat is a small hardy domesticated ruminant animal. They are generally kept for meat, milk and hair production. Goats are characterised by small body size and short tail. Some breeds have backward curving horns. Goats are kept by many people both in urban and rural areas for meat production. Those kept for milk are called dairy goats, those kept for meat are called meat goats and goats kept specifically for hair production are called mohair goats. Milk from goat has higher nutritional value compared to milk from cattle. Figure 4.4. shows types of goats.


(a) Meat goat


(b) Dairy goat

Figure 4.4: Types of goats raised in Tanzania

Sheep

A sheep is a domesticated ruminant animal with a thick woolly coat, characteristically small in body size with short and wider tail. Sheep are kept for meat and wool production. Sheep kept for meat is called mutton sheep and that kept for wool is called woollen sheep. Figure 4.5 shows sheep kept for meat and wool, respectively.

(a) Mutton sheep

(b) Woolen sheep

Figure 4.5: Types of sheep

Pig

A pig is a non-ruminant domesticated hoofed animal with spaced thick hair, long and flat snout. Most people in Tanzania keep pigs for meat production. Depending on slaughter weight, pigs are categorised into four groups. These are porkers, cutters, baconers and heavy hog. Porker is the pig slaughtered at the weight of between 50-70 kg; cutter is the pig slaughtered at the weight of between 71-80 kg; and baconer is the pig slaughtered at the weight of between 81-95 kg. A heavy hog is the pig slaughtered at the weight of between 110-130 kg. Sometimes pigs are kept for producing fat which is commonly called lard. The pig kept for this purpose is called larder. Figure 4.6 shows a baconer and porker categories of pigs.

(a) Baconer

(b) Porker

Figure 4.6: Some pigs

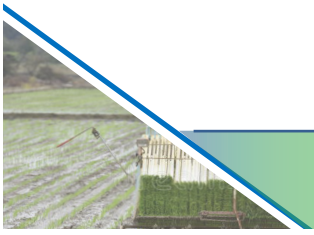
Activity

1. In groups, by considering the classes and types of livestock found in your area, discuss the importance of keeping animals.
2. Visit a school farm or any nearby livestock farm. Identify classes and types of livestock being kept.
3. Share your observation in class for discussion.

Exercise

Answer the following questions

1. Explain the importance of keeping livestock.
2. State at least six classes of animals commonly kept by livestock keepers in Tanzania.
3. Mention at least two types of each class of the following animals:
   (a) Cattle;
   (b) Poultry; and
   (c) Goat.



Chapter Five

Livestock breeds

Introduction

In chapter Four, you were introduced to livestock production. In this chapter, you will learn about the concept of livestock breeds. You will also learn various breeds of cattle, poultry, pig, goat, sheep and rabbit. The competencies developed from this chapter, will enable you to select and raise suitable livestock breeds for income generation and other uses.

The concept of livestock breeds

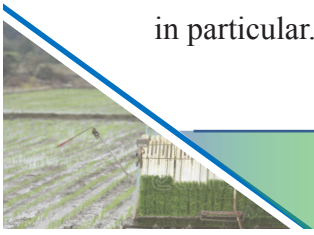
As used in livestock, a breed is a specific group of domestic animals, which are genetically related by their origin from common ancestors. Members of the same breed have similar appearance, behaviour and other characteristics that distinguish them from other animals of the same species. There are exotic and indigenous breeds of livestock. An indigenous breed is a group of animals originating in, and have adaptive characteristics of a particular country or region. Generally, indigenous breeds of Tanzania are very resistant to diseases and severity of local environmental conditions such as high temperature and humidity. However, indigeneous breeds are characterised by low production levels, low growth rates and small body sizes. On the contrary, an exotic breed is a group of animals of foreign origin. Exotic breeds in the tropical region in general are characterised by large body size, high production level, and high growth rates but are less resistant to diseases and severity of local environmental conditions such as high temperature.

Breeds of cattle

There are several and diverse types and breeds of cattle kept in Tanzania. Some cattle are indigenous or native and others are exotic. The indigenous breeds are produced naturally within the region (East Africa) and the exotic cattle were introduced from outside East Africa. The indigenous and exotic breeds of cattle are elaborated in the following sections.

Indigenous breeds of cattle

There are three main types of indigenous breeds of cattle in East Africa, Tanzania in particular. These include Zebu, Ankole and Nganda.



Zebu cattle: This breed originates from Northern Kenya and Uganda. It is commonly called Bos-indicus. It includes such breeds as Boran, Nandi, Bukedi, Masai and Tanzania Short Horn Zebu. Boran zebu is the largest group with the fastest growth rate and highest milk production. However, the Boran cattle are not resistant to tick borne diseases such as East Coast Fever, Anaplasmosis and Black quarter. Despite that Boran produces higher yield of milk, they are mainly kept for beef. Figure 5.1 shows a Boran cattle.

Figure: 5.1: Boran cattle

Ankole cattle: This breed of cattle originated from Rwanda, Burundi and Western Uganda. The Ankole breed is sometimes called Bunyoro, Kigezi and Bahima; these names represent areas of origin. Ankole group of cattle belongs to a larger group known as Sanga, which is a cross breed between longhorn humpless and the humped Zebu cattle. The characteristics of Ankole breed include: long and thick well-developed horns, less resistant to some of the diseases such as tuberculosis, poorly developed hump and dewlap, flat sided body, rusty-red coat, which is solid in colour or spackled and relatively large in size. Figure 5.2 shows the Ankole cattle.

Figure 5.2: Ankole cattle

Nganda cattle: This breed is a cross breed between Bukedi zebu and Ankole breeds. They are found in central Uganda. They have been selected for both milk and meat production. The breed is characterised by features from parent cattle such as Ankole and Bukendi Zebu. Figure 5.3 shows the Nganda cattle.

Figure: 5.3: Nganda cattle

The exotic dairy breeds of cattle

These breeds were introduced in East Africa, particularly in Kenya and

Tanzania, by European settlers in the 19th century. Exotic dairy breeds are in two groups: the European temperate breeds, which belong to a class of Bos-Taurus (humpless cattle) and breeds of Pakistan origin represented by Sahiwal and Sindhi, which belong to a class called Bos-Indicus, (the humped cattle). The most common temperate dairy breeds found in East Africa and Tanzania in particular are Friesian, Ayrshire, Guernsey and Jersey.

These breeds have a significant contribution to the rapidly expanding dairy industry in Tanzania. They have for a long time been bred for milk production. Various organisations have shown an interest in ensuring that the breeds' characteristics are preserved. However, temperate exotic breeds are limited to highland areas where the climatic conditions are much more similar to that of their place of origin. They are not adaptive to local environmental conditions especially high temperature which causes heat stress and makes them eat less and thus produce less milk. Also, various research works show that high temperature affects the reproductive ability of bulls causing them to underperfom in high temperature areas than they do in temperate climatic conditions. These exotic dairy breeds are described in details hereunder.

Friesian cattle: They originate from Holland in Europe. Their characteristic features include black and white markings, larger in size than the size of other dairy breeds. They produce up to 4,550 litres of milk per lactation period with relatively fat content of about 3.3-3.75 percent. Figure 5.4 shows a female and a male Friesian cattle.

(i) Female

(ii) Male

Figure 5.4: Friesian cattle

Jersey cattle: This breed originates from Jersey Island in Europe. Their characteristic features include: brownish colour, wedged body and relatively small size. They produce up to 3,180 litres of milk per lactation period with relatively low butter fat content of about 4.95 percent. Figure 5.5 shows jersey cattle.

(i) Female

(ii) Male

Figure 5.5: Jersey cattle

Activity: 5.1

1. Work in a group to compare and contrast breeds in Figure 5.4 and 5.5 with other dairy breeds in terms of body structure, colour and udder.
2. Share your observations in class for discussion.

Guernsey cattle: This breed originates from Guernsey Island in Europe. Their characteristic features include: brownish-red and white markings, strong back, wide rump and deep barrel with strongly attached udder. They produce up to 2,500 litres of milk per lactation period with butter fat content of about 4.6 percent. Figure 5.6 shows a Guernsey cattle.

(i) Female

(ii) Male

Figure 5.6: Guernsey cattle

Ayrshire cattle: This breed originates from Scotland, Europe. Their characteristic features include: medium body size, white and brownish markings on skin. They produce relatively more milk than Guernsey do with butter fat content of about 3.8 percent. They are more tolerant to drought condition than Guernsey cattle. Figure 5.7 shows Ayrshire cattle.

(i) Female (ii) Male

Figure 5.7: Ayrshire cattle

Sahiwal cattle: This breed originates from Pakistan. Their characteristic features include: reddish or brownish colour, short legs, large udder and large ears pointing upward. They produce up to 2,000 litres of milk per lactation period with butter fat content of about 4-5 percent. They are resistant to drought condition and can withstand tropical temperatures. Figure 5.8 shows Sahiwal cattle.

(i) Female (ii) Male

Figure 5.8: Sahiwal cattle

Activity 5.2

1. Observe Figure 5.6 to 5.8 and compare with other breeds above in terms of colour and structure.
2. Discuss the importance of various breeds of cattle learnt in class.
3. Visit some nearby livestock farms, observe and compare various breeds of cattle in terms of colour and body structure.
4. Write a summary and present it in class for discussion.

The indigenous beef cattle

Most of beef cattle kept by livestock keepers in Tanzania are indigenous breeds of Zebu type. There are two groups of Zebu type, which are Small East African Short horned Zebu and Boran. These are described hereunder.

***Small East African Short horned Zebu**:* Their characteristic features include: prominent hump, marked similarity in conformation including coffin-shaped head, with large surface area per unit body weight, relatively small in body size with adult weighing 350 kg on average and appear in brown, black and white colours. They are well adapted to Tanzania's local environmental conditions.

Boran cattle: Their characteristic features include: appearing in different colours such as black, grey, fawn, brown and mixed colours; having fine and soft hair, having faster growth rate than is the case with Short-horned Zebu; resistant to most of the tropical diseases and produce better meat quality than do the East African Short horned Zebu.

Exotic beef cattle breeds

Exotic beef cattle breeds are those meat breeds, which were imported from outside the East African countries. These breeds produce high quantity of meat than do indigenous cattle. The breeds are sometimes called conventional breeds of beef cattle. The common exotic breeds include: Aberdeen Angus, Hereford, Santa Gertrudis, Brahman, Galloway, and Charolais. These breeds are described hereunder.

Aberdeen Angus cattle: This breed originates from Scotland. Their characteristic features include: solid black or red appearance, though others may be white in colour; naturally polled (have no horns); relatively fast growth rate; and an average body weight of 700 kg at maturity.

Hereford cattle: This breed originates from England. Their characteristic features are: white face with red colour in the rest of their body, a relatively fast growth rate, and an average body weight of 1 000 kg at maturity.

Santa Gertrudis cattle: This breed originates from America. Their characteristic features include: varied colour, relatively large body size, fast growth rate and early maturity. They survive in poor pastures and have an average body weight of 1 200 kg at maturity.

Brahman cattle: This breed originates from USA. Their characteristic features are: varied colour, relatively large size with large developed dewlap and hump; fast growth rate. They can tolerate high temperatures and have an average body weight of 1 200 kg at maturity.

Galloway cattle: This breed originates from Scotland. Their characteristic features are: black and/or brownish colour, they have long hairs.

Charolais cattle: This breed originates from France. Their characteristic features are: large body size, creamy colour and grows fast under good management. They have an average body weight of 1 000 kg at maturity.

Dual purpose breeds of cattle

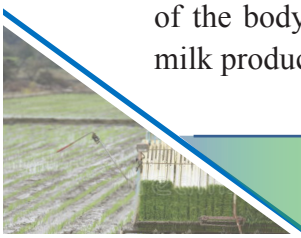
These are types of breeds kept for both meat and milk. Examples of dual purposes breeds are Mpwapwa, Sahiwal, Red pol and Simmental which are described in the following sub-sections:

Mpwapwa cattle: This breed originates from Mpwapwa, Tanzania. Their characteristic features are: mostly brownish in colour, big ears facing downwards and long face, which is slightly protruding outside.

Sahiwal cattle: This breed originates from Pakistan. Their characteristic features include: reddish or brownish colour, short legs, large udder and large ears pointing upward. They produce up to 2 000 litres of milk per lactation period with butter fat content of about 3.7 percent. They can withstand tropical temperatures.

Redpoll cattle: This breed originates from Europe. Their characteristic features include: red colour, lacking horns (pooled); and being of medium sized body with an average body weight of 450 kg at maturity.

Simmental cattle: This breed originates from Switzerland. Their characteristic features include: having light red with white head and white patches on the parts of the body, well muscled, long and deep bodied, good temperanent and high milk production.



Activity 5.3

1. Visit a nearby cattle farm or a ranch and observe the characteristics features of the raised cattle, compare these features with the features of the breeds you have studied from this chapter.
2. Discuss your observation in a group; then
3. Present your group work in class for discussion.

Breeds of poultry

Popular domesticated birds are chicken, ducks, geese and turkeys. Of these, chicken is the commonly kept by most people for home use and business purposes. Chicken originated from wild fowl of the genus *Gallus*. The Red Jungle Fowl (*Gallus gallus*) is the wild ancestor of all the domestic chicken and is one of the four fowls species. Others are: Grey Jungle Fowl (*Gallus sonneratti),* Ceylon Jungle Fowl (*Gallus lafayetti) and* Java Jungle Fowl (*Gallus varius).* Due to its popularity and economic importance, chicken, which include indigenous and exotic breeds, are discussed in detail in the following sections.

Indigenous chicken

Most of Tanzanians both in rural and urban settings keep indigenous chicken which are also known as local chicken. Indigeneous local breeds differ from one another in terms of colour, body size, growth rate and ability to lay eggs. They have feathers of different colours: white, black, red, or mixture of colours. They are characterised by small body size and generally grow slowly compared to exotic breeds. Hens lay few eggs which are small in size. Figure 5.9 shows examples of indigenous chicken.

Figure 5.9: Indigenous chickens

The indigenous or local breeds of chicken in most cases are kept for meat production. However, their eggs are preferred by most consumers and are sold at a relatively high price than is the case with exotic breeds. Its meat is very delicious and of high quality. Indigenous local chicken are mostly preferred and highly demanded by consumers.

Exotic breeds of chicken

The exotic chicken breeds are those which have been introduced into Tanzania from outside the country and are divided into two groups: pure breed and hybrid. Generally, most of them are white, black or brown in colour. They are

characterised by large and heavy body size. If properly managed they grow very fast. Hens lay large sized eggs, which are uniform in size. Also, their meat is normally tender. Figure 5:10 shows the pure and light exotic breeds of chicken.

(i) Rhodes Island Red (ii)White Leghorn (iii) New Hampshire Red (iv) Urpington

Figure 5.10: Exotic breeds of chicken

Pure breed: Pure breed is one of the exotic breeds obtained from selectively mating of a series of hens and cocks to transmit a desirable trait. The main group of pure breed includes the heavy breed and the light breed. Specifically, heavy breed is kept for both meat and egg production whereas the light breed is for egg production only.

(i) Heavy breed

This is a breed, which is been bred mainly for meat production. It produces high quality meat and has high feed conversion rate, they go broody and are bigger in size. They are sometimes called broilers. Examples include: Light Sussex, Cornish White, Cornish Dark, Black Giant, Black Autralorp, New Hampshire Red and Orpington.

(ii) Light breed

This type of breed is described as being flighty. The chicken in this breed eats less compared to heavy breed and therefore have light body weight. They have great variation of colours. They are kept for eggs production. Other characteristics include: excellent laying of eggs but do not undergo brooding, they are medium in size, can weigh up to 2kg, female combs have large flops over the eye and are active. Examples include: White Leghorn, Black Leghorn, Brown Leghorn, Minorca and Ancona.

Hybrid: The hybrid chicken is produced by crossing two or more different pure breeds and sometimes crossing further after the first generation. There are hybrid crosses that produce chicken for meat, these are called broilers and those crosses that produce eggs, are known as layers. Under good management, broilers grows well and increase in weight very fast while layers produce more eggs than their ancestor parents do. Examples of hybrid chicken include Shavers, Thornber, Haco and Sterling.

Activity 5.4

1. Visit any nearby poultry farm and observe the types and breeds of poultry which are kept;
2. Ask the poultry farm owner, the reason for keeping such types and breeds of poultry chicken you have observed.
3. Ask farm owner the challenges faced in keeping the observed type and breed of poultry.
4. With reasons discuss the chicken breed which is preferred by many farmers in your area.
5. Present your work in class for discussion.

Breeds of pig

Pigs or swine is among the classes of livestock kept in Tanzania. Pigs are mainly kept for meat production. Some of the reasons why livestock keepers are interested in pig production include the followings: pigs eat a variety of feeds including kitchen wastes, they grow very fast, they can produce many offspring at a time (are highly prolific), they have short productive cycle and they produce nutritious meat. Domesticated pigs have been scientifically named as *Sus scrofa domesticus*. It was originated from the wild pigs called *Sus scrofa* from Northern Europe and *Sus vitattus* from Malaysia. Common breeds kept in Tanzania include: Landrace, Saddleback, Large White and Hampshire, which are further described in the following sub-sections:

Landrace pigs: These originate from Denmark. Their characteristic features include: white in colour, long and slim body, short legs, floppy ears, relatively high feed conversion capacity, fast growth rates and are highly prolific. Figure 5.11 shows the landrace pig.

Figure 5.11: Landrace pig

Large White (York shire) pigs: They originate from England. Their characteristic features include: having white colour, long large body size, erect ears, curved onward ribs, and having relatively high feed conversion capacity and growth rate. They are good mothers as they produce a lot of milk. Figure 5.12 shows Large White pig.

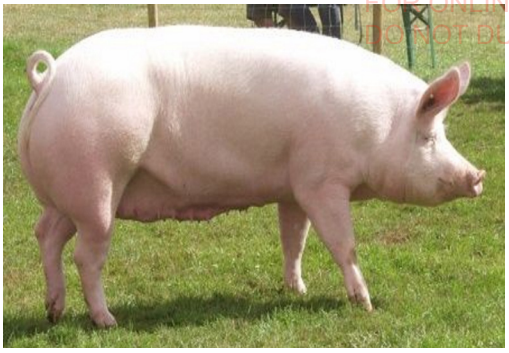


Figure 5.12: Large White pig

Saddleback pigs: These originate from England. Their characteristic features include: having black colour with white belt around the shoulder, medium sized body with arched back, floppy ears, relatively high feed conversion capacity, fast growth rate, good foragers and sows are good mothers. Figure 5.13 shows a saddle back pig.

Figure 5.13: Saddleback pig

Activity: 5.5

1. Visit a nearby pig farm and then observe the characteristic features of the breeds being raised, and compare features of these breeds with features of breed you have learned in class; then
2. Present your findings in class for discussion.

Breeds of goat

Goats are preferred by most people, because they can survive even in semi-arid areas. Also, goats can eat a variety of feeds including grasses, shrubs, and kitchen wastes and therefore have low running cost. There are four types of goat breeds; goats kept for meat are commonly called chevon goats; goats kept for milk are commonly called dairy goats. and those breeds of goat kept for both meat and milk are called dual purpose goats. Very few are kept for their hair. These are called mohair goats. Thus, the four categories of breeds of goat are as described in the following sub-sections:

Meat goat breeds

Meat goats are those which are mainly kept for meat. The meat of goat is called chevon. Meat goat breeds include Small East African breed and West African Dwarf breed. The Small East African breed is commonly found in East Africa. Generally, these are small in size weighing up to 30 kg at maturity, and vary in colours. They are hardy with slow growth rate. Although they are kept for meat production, they sometimes can produce milk. Figure 5.14 shows the East African meat goats.

Figure 5.14: East African meat goats

Dairy goat breeds

Dairy goats, are those which are kept mainly for milk production. They include Anglo-Nubian, Toggenburg, Jumnapari, Alpine, Saanen, Surti and Norwegian goats. Some of these are further described hereunder:

Anglo-Nubian goats: These originate from Sudan. It is a cross breed of British Jamnapari and Nubian goats. Their colour varies. They have large body size with tall, large floppy ears, convex nose; sometimes front legs are shorter than hind legs and they are polled. They have an average body weight of 95 kg at maturity. Figure 5.15 shows Anglo-Nubian goat.

Figure 5.15: Anglo-Nubian goat

Toggenburg goats: These originate from Switzerland. They are brown in colour, however, some few have cream strips on their legs. They are relatively short with medium body size and erect ears. Some of them are polled while others are not. They have an average body weight of 60 kg at maturity. Figure 5.16 shows Toggenburg goat.

Figure 5.16: Toggenburg goat

Alpine goats: These originate from French and Britain. They are black in colour with white patches. They are relatively short with medium body size and erect ears. Some of them are polled while others are not. They have an average body weight of 60 kg at maturity. Figure 5.17 shows Alpine goat.

Figure 5.17: Alpine goat

Saanen goats: These originate from Switzerland. Their colour is white cream or light grey. They have medium sized body with dished head and erect ears. They have an average body weight of 50 kg at maturity. Figure 5.18 shows Saanen goat.

Figure 5.18: Saanen goat

Norwegian goats: These originate from Norway. They are white in colour and have short legs. They have an average body weight of 40 kg at maturity. Also, they are highly prolific. Figure 5.19 shows a Norwegian goat.

Figure 5.19: Norwegian goat

Hair goat breeds

These are breeds of goat, which are kept for hair production. The breed is also known as Mohair goat. They include Angora and Kashmir goats. The two breeds originated from Asia. They are characterised by bearing long hair, a characteristic which makes them special for hair production. The Angora breed goats are white in colour, and can be raised in both cold and hot climates but do not do well in cold wet conditions. Figure 5.20 shows a mohair goat.

Figure 5.20: Hair goat

Dual purpose goat breeds

These are types of goats that are kept for both meat and milk production. They include Komorai and Damascus. Komorai breed originated from the Asia, while Damascus originated from the Middle East specifically Syria and Lebanon. The two varieties are good for both meat and milk production.-

Activity: 5.6

1. Visit a nearby goat farm and describe the characteristics of the breeds you have seen and compare them with the characteristics of the breeds you have read from this chapter; then

2. Present your findings in class for discussion.

Rabbit

Rabbit (Figure 5.21) is another class of livestock, which is increasingly becoming common in most areas of Tanzania. To get the insight of this class of livestock please attempt Activity 5.7.

Figure 5.21: Rabbits in a cage

Activity 5.7

1. Visit any nearby household/ agricultural institution that rabbits are raised. Then, inquire about:
   (a) Various types of the domesticated rabbits;
   (b) A place where the rabbit keeper gets the rabbits;
   (c) Opportunities and challenges related to this class of livestock; and
   (d) The initial capital, running costs of the project, availability of markets, buying and selling prices of the livestock.
2. Write a report on the field study you made above, then present in class for discussion.
3. Use this information to establish a rabbit project at your home.

Exercise

Answer the following questions:

1. Describe at least four characteristics of each of the following cattle breeds:
   (a) Friesian cattle.
   (b) Guernsey cattle.
   (c) East African Short horned Zebu.
2. Why do you think most of the people prefer keeping hybrid chicken than indigenous one?
3. Why do people keep livestock?
4. Mention four breeds of pigs and state their main distinguishing features.

Chapter Six

Livestock farming systems

Introduction

Human beings keep animals in order to obtain various products such as meat, eggs, milk, skin or hides, wool and manure. In this chapter, you will learn about the concept of livestock farming system and major livestock farming systems. The competencies developed from this chapter will enable you to decide and use appropriate system in keeping various livestock.

The concept of livestock farming systems

Keeping livestock involves managerial practices such as feeding, breeding, control of parasites and diseases and performing of other necessary husbandry practices. Depending on whether livestock are kept for home consumption or for bussiness or for both, their management requires a specific farming system. A livestock farming system which is a sub category of farming system, refers to the way livestock and crops are managed in a particular farm.

Major classes of livestock farming systems

There are three major livestock farming systems namely; intensive, semi intensive and extensive. The meaning, strengths and weakness of each system are elaborated in the following section.

Intensive livestock farming system

An intensive system of livestock keeping is a systems where the animals are confined and fed inside the enclosed area or shelter all the time. With this system, feeding and drinking facilities are provided inside the shelter.

Strengths

(a) Requires relatively small area;
(b) It focuses on high value products;
(c) Control and treatment of diseases are easy;
(d) There is high productivity per unit area; and
(e) Monitoring and control of livestock are easy.

Weaknesses

(a) The system needs high initial investment capital;
(b) Some livestock like pigs may cause chaos to people especially in populated areas;
(c) Much feed is used when using this system; and
(d) It is labour intensive.

Semi-intensive livestock farming system

This is the system of keeping livestock by allowing them for some time to stay and fed with feeds and water in an enclosed area and move outside to search for natural vegetation and other supplements for a limited time.

The area required for semi-intensive is relatively large to allow enough space for animal movement.

Strengths

(a) Limited spread of diseases;
(b) Relative cheap investment cost;
(c) Feeding cost may be reduced; and
(d) Monitoring of livestock is easy.

Weaknesses

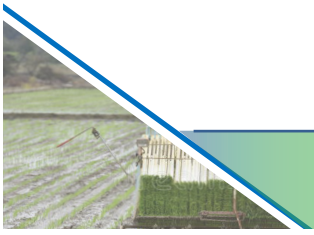
(a) Space limitation especially in urban areas;
(b) If not well fenced, animals may easily be attacked by predators and thieves; and
(c) Feeds are expensive.

Extensive livestock farming system

This is the system of keeping livestock by allowing them to move freely to search for feed and water. At certain time, normally in the evening, the animals are returned back in the shelter or enclosed area. The system needs enough space which is used for raising livestock far from the populated area.

Strengths

(a) Low investment cost;
(b) Less labour intensive;
(c) Low production per unit of land; and
(d) Low feeding cost.



Weaknesses

(a) Uncontrolled movement of animals which may expose them to predators;
(b) Difficult to monitor and attend individual animal;
(c) Requires large production area; and
(d) Difficult in detecting and controlling outbreak of diseases in the flock.

Overcoming the challenges of livestock farming system

(a) Plan in advance in terms of capital and other requirements.
(b) Avoid disturbing people around you, livestock such as pigs should be located far away from residential area.
(c) Construct a strong fence to control movement of your animals especially when semi-intensive system is used.

Factors to consider when selecting a suitable livestock farming system

The suitable system to use in a particular type of livestock depends on the following factors:

(a) Capital

Depending on breeds you want to keep, keeping livestock using intensive systems requires high investment and involves high running costs. Hence more capital is needed. If you have enough capital, you may decide to choose intensive system, but if you have less capital, you may decide to use semi- intensive system or extensive system.

(b) The type of livestock a farmer intends to raise

Each type of livestock has its own characteristics and needs which should be adhered to when keeping it. Thus, livestock keeping takes different forms to meet individual specific requirements of each type of livestock. For example, pigs are normally destructive when kept freely, thus, they are normally kept under intensive system. Birds like pigeons are kept under extensive system.

(c) A type of breed

It is also important to select a farming system based on the breed you want to keep. Normally, exotic breeds are not tolerant to diseases and severity of local environmental conditions hence they are kept using an intensive system while, indigenous breeds can be kept under extensive system.

(d) Number of livestock

Normally, if you are keeping a larger number of livestock, it may be expensive to use intensive system. But if you are keeping a small number of livestock then, intensive system may be more appropriate system to use.

(e) Space available

Space may help you to judge the livestock farming system to use. If you have limited space, use intensive system. But if you have a large space then, semi-intensive or extensive systems may be more suitable.

(f) Environmental factors

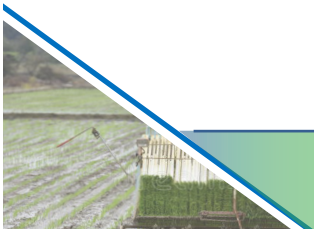
When choosing a suitable system, consider whether the place is secure, that is there are no predators and thieves.

Activity

1. Visit your school or any nearby livestock farms. Then:
   (a) Identify the type of livestock kept by the owners;
   (b) Describe the livestock farming system used by the owners;
   (c) Discuss advantages and disadvantages of the livestock keeping system being used; and
   (d) What do you think are the reasons for livestock keepers you have visited, to use those types of farming system.
2. Share your observation in class for discussion.

Exercise

1. State important things to be considered when choosing a system of keeping livestock.
2. Compare and contrast on the systems of keeping livestock.
3. With reasons, discuss systems of keeping livestock which are jpreferred by livestock keepers in Tanzania.



Chapter Seven

Introduction to mechanisation in agriculture

Introduction

Some farm operations are complex and labour intensive, requiring specialized equipment and machinery. In this chapter, you will learn the concepts of farm mechanisation, its importance and limiting factors. The competencies developed from this chapter will enable you to make appropriate decisions and choices in mechanising agriculture.

The concept of farm mechanisation

Mechanisation is the use of machinery to replace human power in farm operations. It is the art of using machineries to speed up production, accomplish task and reduce fatigue and human labour. It also involves the application of engineering principles and techniques in designing, laying out and construction of fields, irrigation schemes and farm structures among others. Farm mechanisation plays a major role in enhancing the production and productivity of different crops due to timeliness of operations, better quality of operations and precision in the application of the inputs.

The importance of farm mechanisation in agriculture

The following are important aspects of mechanisation in agriculture.

(a) Expansion of the production area

The use of machines like tractors and bulldozers enables the farmers to cultivate larger areas of land more easily and within a short period.

(b) Transportation

Machinery such as tractors, lorries and motor cycles are used in transporting agricultural inputs and products from one place to another.

(c) Timeliness of farm operations

Farm operations can be done in time because machines can do certain operations in a relatively shorter time and thereby saving time, which a farmer can use for other purposes.

(d) Increase efficiency

The use of machinery ensures efficient use of resources. For example, planting by using planter minimizes the waste of seeds.

(e) Less dependence on animal power

The use of machinery reduces dependence on animal power, which is relatively slow. Moreover, there is always fear for animal death due to overburdened or from diseases.

(f) Relief to the farmer

The use of machinery relieves the farmer from hard and dirty works, referred to as toiling works and can increase production in the agricultural sector.

Factors limiting mechanisation in agriculture

Several factors limit the effectiveness of mechanisation in agricultural production as follows:

(i) **Economic factors:** In most cases, incomes of smallholder farmers are relatively low. Therefore, farmers have very low ability of investing in mechanisation.

(ii) **Technical and educational factors:** These are factors associated with knowledge, skills and technical know-how of operating and maintaining farm machinery. Most small holder farmers have low level of knowledge thus, making it difficult for them to adopt mechanisation.

(iii) **Topographical factors:** Land features such as mountains, hills, valleys and steep slopes can limit mechanisation.

(iv) **Small farm size:** Many peasants have small pieces of land which can not be mechanised.

In view of the aforementioned important aspects and limitations, farm mechanisation increases agricultural productivity leading to an increase of crop yields and hence income. Therefore, farm mechanisation is very useful for the development of agricultural sector. In the modern world, due to its importance, many countries are making more efforts in investing in their home made machinery industry or importing them. Tanzania for example, provides loans at relatively low interest rate in order to motivate farmers to invest in mechanised large-scale agricultural production.

Mechanised farm activities

In most developing countries, farms are characterised by small-scale operations with low yields and productivity levels. Most of the works are done by family members, who engage in long, difficult and sometimes hazardous work to cut costs and compensate for the farm's low productivity. Activities such as ploughing, harrowing, planting, application of agro-chemicals, harvesting and milking are done by human beings using mere hands. As a result, many farmers do not earn enough, for decent living.

Since mechanisation is the use of machines in various operations in the farm, the following are some of the farm activities which can be mechanised especially if the farm under operation is relatively large.

(a) Ploughing

Ploughing is the primary tillage operations, which are intended to loosen soil for better plant root penetration, facilitate water infiltration, kill weeds and incoperate soil organic matters. This operation is done by a tractor using either disc plough, mouldboard plough or disc harrows depending on the nature of the soil and the stage at which the operation is done. This is the primary activity undertaken by a farmer before growing crops.

(b) Harrowing

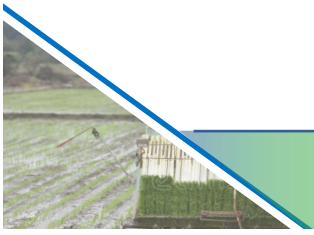
This is the secondary tillage operation intended to provide a fine tilth through crushing of the soil. Fine tilth soil is essential for easy seed germination.

(c) Planting

This is a process of placing seeds or seedlings into the soil. It is done by a tractor mounted planter, calibrated to a specific crop spacing requirement. For example, if a farmer is sowing maize, the planter will be adjusted or calibrated according to the spacing requirement of maize. The same will be applied following the standard spacing of crop under operation. For a large-scale farm, mechanised planting is more economical.

(d) Application of agricultural chemicals

This is a farm operation which involves spraying chemicals such as herbicides and pesticides to control harmful organisms that affect crops. This operation is done by using sprayers mounted on a tractor.



(e) Harvesting

This is a process of picking matured crops or their useful parts from the field either by uprooting or cutting. It is one of the activities that can be mechanised because, harvesting is a tedious work and time consuming. Various types of machines are used for harvesting various crop produce. These include lifters and combine harvesters. Harvesting crops such as corn, wheat, barley is done by combine harvesters while harvesting of other crops such as cassava, sweet potatoes and round potatoes is done by roots and tuber lifters.

(f) Milking dairy animals

This is the act of extracting milk from the udders or mammary glands of an animal such as a cow and goat. Mechanised milking can be applied in cases where a farmer has many milking animals. This farm activity is done by using automatic milking machines.

Exercise

1. What does the term mechanisation mean?
2. Outline five mechanised activities commonly practiced in the area where you are living.
3. Distinguish between ploughing and harrowing.
4. What are the advantages and disadvantages of mechanisation in agriculture?

Chapter Eight

Farm tools and equipment

Introduction

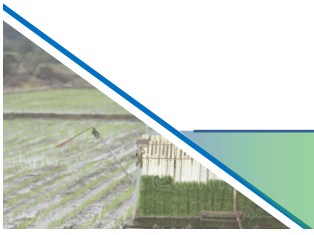
The use of tools and equipment in farming activities, play a vital role in simplifying the work. In this chapter, you will learn the concept of farm tools and equipment, and their use in crop and livestock production. You will also learn how these tools and equipment can properly be maintained for efficient and prolonged use. The competencies developed from this chapter will enable you to use appropriate farm tools and equipment in crop and livestock production for home use and income generation.

The concept of farm tools and equipment

A tool is a simple device with very few immovable parts, rigidly connected together. The functioning of the tool is facilitated by the movement of human hands during operation. Equipment is a device with few connected moving parts used in farming operations. The moving parts are assisted by human hands operating it. An implement is a complex gear consisting of several moving parts connected together and are working on their own depending on each other. In most cases, an implement is connected to a machine, for example, a disc plough connected to a tractor. In other cases an implement can be directly operated by human being, a good example is a combine harvester. Tools and equipment can be grouped into two categories based on the nature of farm enterprise they are used. These categories are crop production basic tools and livestock production basic tools and equipment.

Basic farm tools and equipment used in crop production

Basic farm tools and equipment are important in crop production operations. Basic farm tools are simple devices which are used on the farm and are operated by hands, for example, an axe, a machete, a mattock/pick axe, a slasher, a hand hoe and a forked hoe. Others are a meter rule, a tape measure, a knapsack sprayer, a spade, a rake and others.



Proper use of crop production tools and equipment

In order to use tools and equipment properly, choose and use correct tools and equipment according to the farm operation to be carried out. Description of basic farm tools and equipment are provided in the following section:

Machete/Panga: This is a tool with a short handle and a long blade sharpened on one side or sometimes on both sides. It is used for cutting woods, small bushes, shrubs, small trees, pasture grass and leaves for feeding animals. It is also used in harvesting crops such as sugarcane or maize when stoking method is used; chopping wood when making handles and other wooden tools such as hoe handles and yoke harness components. Generally, a machete is a multipurpose tool. Figure 8.1 shows a machete.

Figure 8.1: A machete/Panga

An axe: This is a tool with wooden or metal handle and a metal wedge shape head. It is used for cutting trees and tree stumps, splitting logs and chopping fire wood. Figure 8.2 shows an axe.

Figure 8.2: An axe

Mattock and pick axe: These are tools, which have a wooden handle with a hard curved metal. A mattock is used for uprooting tree stumps before ploughing the land and cutting tree roots during land preparation. A pick axe is used for cutting tree roots. Figure 8.3 shows a mattock and pick axe.

(i) Mattock (ii) Pick axe

Figure 8.3: A mattock and pick axe

A hand hoe: This is a broad bladed cultivating tool with a long wooden handle. It is used for cultivating land and making ridges or mounds for growing crops, preparing holes and furrows for planting, weeding and digging holes for different purposes including preparing manure pits and pit silos for silage making. Figure 8.4 shows a hand hoe.

Figure 8.4: Hand hoe

Forked hoe: This is made up of strong prongs similar to those of a fork. Forked is used for digging in hard, stony, and wet clay soils. It is good for removing rhizomatous weeds for example, couch grass and nut grass. Sometimes, a forked hoe is used to remove the rhizomes in pruning banana plants. Figure 8.5 shows a forked hoe.

Figure 8.5: Forked hoe

Spade: This is a tool with a slightly curved blade and a pointed tip. It is used for lifting, and inverting soils or manure. It is also used for mixing sand, water and cement in masonry works. Figure 8.6 shows a spade.

Figure 8.6: Spade

Rake: This tool has short spikes and a long handle. It is used for levelling soils during seedbed preparation, breaking soil clods in order to obtain a fine tilth for sowing tiny seeds, removing debries and other rubbish from the seedbed and for covering seeds after broadcasting. It is also used for collecting mowed grass. Figure 8.7 shows a rake.

Figure 8.7: Rake

Manure fork: This looks like a spade but it has spines spaced at regular intervals. It is commonly used for loosening, turning and collecting manure on the farm. Figure 8.8 shows a manure fork.

Figure 8.8: Manure fork

Hand trowel: This is a boat like blade with a short handle. It is used for loosening soils in the nursery beds and in closely spaced crops in the garden. It is also used in preparing shallow holes for transplanting seedlings and lifting out seedlings from the nursery beds during transplanting. The tool is commonly used by farmers in gardening works. Figure 8.9 shows a hand trowel.

Figure 8.9: Hand trowel

Garden fork: This looks like a manure fork except it is small in size. It has a short hand with short sturdy tines. It is used for loosening, lifting and turning over the soil in closely spaced crops such as in nurseries, onion fields and carrot fields. Figure 8.10 shows a garden fork.

Figure 8.10: Garden fork

Shovel: This resembles a spade but it has a tray like blade with non-pointed edge. It is used for lifting loose soils, manure and seeds. Figure 8.11 shows a shovel.

Figure 8.11: Shovel

Sickle: This is a curved iron blade with a small hard toothed edge and a short wooden handle. It is used for harvesting cereal crops, cutting grasses for different uses including feeding animals and thatching (roofing). Figure 8.12 shows a sickle.

Figure 8.12: Sickle

Slasher: This is a tool with a long metal blade curved at the end where both sides of the blade are sharpened. It is used for cutting or slashing grasses. Figure 8.13 shows a slasher.

Figure 8.13: Slasher

Trimming shear: This looks like a pair of scissors with wooden, metal or plastic handles. A shear is commonly used for trimming hedges and shrubs in the farm. Figure 8.14 shows a pair of shears.

Figure 8.14: A pair of shears

Secateurs: These look like shears but have a short cutting blade and one of the jaws is blunt. It is used to prune crops such as coffee, tea and cutting flowers. Figure 8.15 shows a pair of secateurs.

Figure 8.15: A pair of secateurs

Pruning saw: This is a slightly curved blade with serrated sharp edge on the curved side. It is commonly used for pruning perennial crops such as coffee, citrus trees, and for pollarding trees. Figure 8.16 shows pruning saws.

Figure 8. 16: Pruning saws

Pruning hook: This resembles a machete except, it is curved at the tip to look like a hook, which has a sharp edge. It is used for cutting branches of tall trees and pruning crops such as tea. Figure 8.17 shows a pruning hook.

Figure 8. 17: Pruning hook

Activity 8.1

Visit a school store/workshop and observe the similarities and differences between the following tools:

(a) Garden fork and Manure fork;
(b) Spade and Shovel; and
(c) Mattocks and Pick axe.

Exercise 8.1

1. Identify various basic farm tools used by farmers in clearing and preparing land for producing crop plants.
2. Give three examples of each of the following: (a) Implements, (b) Tools, and (c) Equipment.
3. List at least two tools that are used by farmers for the following operations:
   (a) Farm ploughing
   (b) Weeding and (c) Harvesting.
4. Outline any four factors to consider before buying any farm tool.
5. Explain the use of each of the following hand tools:
   (a) Manure fork (b) Hand trowel
   (c) Secateurs.

Hose pipe: This is a pipe used for conveying water from a source to the area of use. Figure 8.18 shows a hose pipe.

Figure 8.18: Hose pipe

Sprinklers: These are made of small pipes connected together on one end to form one short pipe, which is connected to the source of water. It is used for overhead irrigation. Figure 8.19 shows a sprinkler.

Figure 8.19: Sprinkler

Watering can: This is a container with an elongated mouth piece, which is perforated at the end. It is used for applying water to the seedbeds in the form of droplets. Also, it is used for watering seedlings in boxes, potted plants and nursery beds. Figure 8.20 shows a watering can.

Figure 8.20: Watering can

Wheelbarrow: This is a farm equipment that consists of a container, rubber tyres, handles and a stand, designed for transporting small loads such as soil, sand, manure, fertiliser and farm produce in short distances within the farm. Figure 8.21 shows a wheelbarrow.

Figure 8. 21: Wheelbarrow

Spring balance: This is a farm equipment with reading scales and a hook for hanging materials to be weighed. It is used for weighing farm inputs and produce. Good examples include fertilisers, seeds and vegetables. Figure 8.22 shows a spring balance.

Figure 8. 22: Spring balance

Knapsack sprayers: This is the equipment used for applying agrochemicals on crop plants, soils and crop produce. It consists of a tank, a strainer, boom nozzles, and an on-off hand level. This equipment is carried on the back during operations. Knapsack sprayers are of various sizes ranging from 10-20 litres. Other types of knapsack sprayers include pneumatic sprayers, hydraulic sprayers and motor operated sprayers. Figure 8.23 shows the knapsack sprayer.

Figure 8. 23: Knapsack sprayer

A Hand duster: This is made up of a metal container with a pump inside and a lid which is fitted with a protruding small pipe and a nozzle. It is used to apply powderly chemicals to crop plants and animals. This action is called dusting. Figure 8.24 shows a hand duster.

Figure 8. 24: A hand duster

Soil auger: A soil auger consists of a long handle and a drum with side cutters and claws for cutting in the soil as it drills into the ground. It is mainly used for collecting soil samples for soil analysis. Figure 8.25 shows a soil auger.

Figure 8. 25: A soil auger

Activity 8.2

1. If tomato seedlings in the school nursery are ready for transplanting:
   (a) Identify the appropriate tool you will use to carry out this operation; and
   (b) Demonstrate how you will carry out the operation.
2. If crop plants in your school or home farm or garden show symptoms of insects attack:
   (a) Suggest an appropriate measures to control insects attack; and
   (b) Identify appropriate farm tools/ equipment you will use in this operation.

Exercise 8.2

1. Name the tool you will use to sample the soil for various purposes.
2. What is the use of the following tools during crop production?
   (a) Watering can;
   (b) Wheel barrow; and
   (c) Knapsack sprayer
3. Outline the use of the following tools as used in crop production:
   (a) Sprayer;
   (b) Soil auger; (c) Tape measure; and (d) Wheel barrow.
4. Mention three types of sprayers which are mostly used by farmers in crop protection.

Storage and maintenance of basic farm hand tools

The life span of field tools and equipment mainly depends on the manner in which they are handled and maintained. If tools are regularly checked and maintained, they are likely to last longer. Maintenance involves caring and repairing of farm tools and equipment in order to be in a good working condition.

The following are some important basic rules of maintenance and storage of farm tools:

(a) A tool should be used correctly and according to the type of work for which it was intended.

(b) A tool should be stored in the shade when not in use to avoid rapid rusting.

(c) A tool should be returned to shade or store after use. Do not leave the tool outdoors.

(d) Cutting tools such as machete, hoes and shears, should be regularly sharpened before and after use.

(e) Metal parts of tools should be regularly cleaned and coated with oil to prevent rust in case they are not in use for a long time.

(f) Make sure that worn out parts are replaced.

(g) For the tools with moving parts like secateurs and a wheelbarrow, grease the moving parts to reduce friction.

(h) For farm tools with nozzles, for example, knapsack sprayers and sprinklers, unblock the clogged nozzles by cleaning with water immediately after use.

(i) Fix loose handles properly for tools with handles such as a mattock and hoe.

(j) Tighten loose nuts and bolts for bolted tools and equipment such as wheel barrows.

Basic farm tools and equipment used in livestock production

The routine management practises in livestock production can be easily performed by using appropriate tools and equipment. These tools and equipment are described in the following categories:

Livestock identification tools

Livestock record is one of the important management practices. For proper recording system, identification of animals is crucial. Animal identification can be performed by using the following tools: branding iron, tattooing pliers, ear tagging and notching pliers.

Branding iron: This is a tool with a long handle whose tip is fixed with an iron plate attached to a metal shape of either a number or a letter. It is used

for putting a mark on an animal. The tip of branding iron is heated to red hot and lightly pressed on the animal's skin for one to two seconds to make a mark. Figure 8.26 shows a branding iron.

Figure 8.26: Branding iron

Tattooing plier: This looks like pliers but its jaws have tattooing needles arranged in the form of a number or a letter used to put a mark on a particular animal. The jaws of the tattooing pliers are immersed in a special tattooing ink and then punched onto the ear's skin of the intended animal. The mark will be visible on the ears. The method is called ear tattooing. Figure 8.27 shows a tattooing plier.

Figure 8. 27: Tattooing plier

Ear notcher or notching plier: This looks like a plier but it is designed in such a way that it forms a v-shaped in both jaws. In one jaw, it has a protruding "v" with sharp edges while in another jaw it has a sunken "v" with sharp edges. When the notcher is punched on the edges of the animal's ear it cuts part of the ear in a "v" shape. Each v-shaped cut indicates a specific number of the animal in the farm. The method is called ear notching. Figure 8.28 shows an ear notcher.

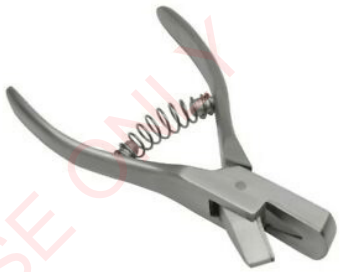


Figure 8. 28: Ear notcher

Ear tagging plier: This is a tool, which aids in fixing a label showing a number or a letter onto the ears of the animal. The label is called an ear tag and the method of identification is called ear tagging. Figure 8.29 shows an ear tagging plier.

Figure 8.29: Ear tagging pliers

Livestock castration tools

In livestock management, not all male animals are required for breeding. Thus, unsuitable male animals are made infertile to prevent unwanted breeding in the herd. This process is known as castration. Castration can be done by using two main methods namely: *closed or bloodless* and *open or surgical method*. The tools used for castration are described hereunder.

Burdizzo: Burdizzo looks like pliers with a heavy jaw. It is used in closed castration method whereby the spermatic cord and blood vessels between the testicles and the rest of the body are crushed by the jaws of a burdizzo. As a result, the animal becomes infertile. Figure 8.30 shows a burdizzo.

Figure 8. 30: Burdizzo

Rubbering elastrator: This is a tool used to stretch a strong rubber ring which is fixed around the scrotum of a bull calf above the testicles in order to prevent the circulation of blood between testicles and the rest of the body. The rubber ring squeezes the spermatic cord and blood vessels, as a result, the flow of blood between the body and testicles stops, then gradually the testicles decrease in size and finally shed off (drops). Rubber ring elastrator is used in the closed castration and can be used for docking of lamb. Figure 8.31 shows an elastrator with rubber rings.

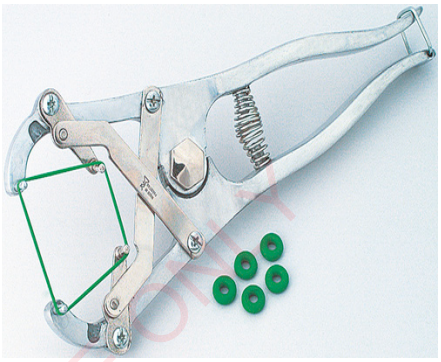


Figure 8. 31: Elastrator with rubber rings

Sharp Scalpel: This is a surgical knife used in open castration method. By using a sharp scalpel, a scrotum is cut open and testicles are squeezed out, cut and removed from the scrotum. Other tools that can be used for open method of castration include a razor blade and surgical blade. Figure 8.32 shows a sharp scalpel.

Figure 8. 32: Sharp scalpel

Livestock disbudding tools

The term disbudding refers to the action of removing horn buds from young animals. Some animals especially Zebu cattle possess long horns. To avoid the overgrowing of horns, the horns are removed at their early stage of growth. The early stage of horns growth is called a bud. Disbudding can be achieved by using the following tools:

Disbudding iron: This consists of a long cylinder metal with a handle and a sunken tip. The tip is heated to red hot then immediately pressed on the base of bud of a young animal for few seconds. The cylinder tip burns around the base of the horn bud hence removing it. Figure 8.33 shows disbudding iron.

Figure 8. 33: Disbudding irons

Disbudding scoop: This is a cylindrical in shape with sharp edges, which when fitted to the base of the horn bud and twisted, it cuts the tissue around the bud and scoop from the base. This operation should be performed with care to avoid damaging other parts of the animal body. Figure 8.34 shows a disbudding scoop.

Figure 8. 34: Disbudding scoop

Hot iron: This is used to apply heat to the horn bud in order to prevent its growth through destruction of cells around the growing bud of a horn. Figure 8.35 shows an electric iron used for disbudding.

Figure 8. 35: An electric disbudding iron

Livestock dehorning tools

Animals with long horns can harm each other, attendants or other people in the farm. Also, long horned animals occupy more spaces than short horned ones, that is why it is advised to cut off the overgrown horns. The cutting of the overgrown horns from the animal is called dehorning. Dehorning can be achieved using the following tools:

***Dehorning saw*:** This is a thin toothed steel blade with a fine teeth-like hacksaw on one end used to cut off the grown horns. Dehorning by using a dehorning saw causes pains and sometimes serious bleeding. Therefore care must be taken. Figure 8.36 shows a dehorning saw.

Figure 8. 36: Dehorning saw

Dehorning wire: This is a special wire made of stainless steel. It is used for cutting grown horn with a minimum bleeding to the animal. Figure 8.37 shows a dehorning wire.

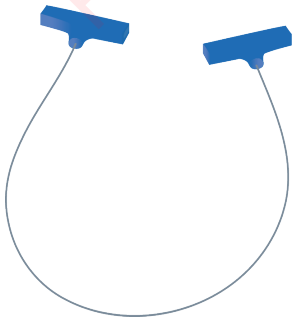
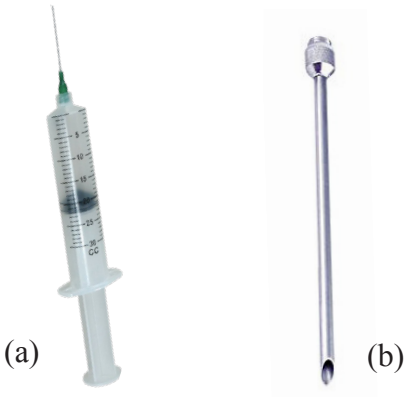


Figure 8. 37: Dehorning wire

Livestock diseases and parasites control tools

Diseases and parasites control is one of the important management activities in livestock production. Animals get sick or attacked by internal or external parasites causing death or low production of an intended product. Diseases and parasites can be controlled by using the following tools:

Syringe and hypodermic needle: A syringe consists of a barrel and a piston which are used to suck medicine into the barrel and inject it to the body of an animal through hypodermic needle fitted to the other side of the barrel. A syringe is used for administering injections, taking blood samples, vaccination and for preventing of mastitis by introducing antibiotics intra-mammary. Figure 8.38 shows a syringe and hypodermic needle.



(a) A syringe and needle, (b) Needle

Figure 8.38: Syringe & hypodermic needles

Clinical thermometer: This is a tool used to measure the body temperature of human beings and animals. When animals fall sick, they can show different symptoms. One of the symptoms is the rising of body temperature. Before taking any measure against sick animals, check the body temperature of the animal by using a clinical thermometer. Figure 8.39 shows analogue and digital clinical thermometers.

(a) Analogue thermometer

(b) Digital thermometer

Figure 8. 39: Thermometers

Strip cup: This is a cup with black plate at the top. It is used for testing mastitis in lactating cows. Mastitis is a condition in which the animal's udder tissue becomes abnormally swollen. The disease condition is caused by bacterial infections. To test for mastitis, a strip cup is used whereby some few drops of milk from each teat is milked independently and dropped on the black plate and checked for any clots or blood stains. Mastitis is a disease that can also affect human beings. Figure 8.40 shows a strip cup.

Figure 8. 40: Strip cup

Trocar and canula: A trocar is a tool, which has a sharp and pointed end, while a canula is a barrel in which a trocar is inserted during operation. These tools are used in combination, for the treatment of bloat in ruminants. This is done by inserting a trocar into a canula and piercing into the rumen; the trocar is then removed so that gas can be released through the canula. Figure 8.41 shows a trocar and canula.

Figure 8.41: Trocar and canula

Hoof trimmer: This tool resembles a burdizzo but it has sharp jaws, which are used for trimming overgrown hooves of animals like sheep, goats and cattle. Figure 8.42 shows a hoof trimmer.

Figure 8.42: Hoof trimmer

Hard brooms: Animals especially cattle, pigs and chicken can be kept indoor or outdoor. Both systems of keeping livestock need to maintain cleanliness, but more attention is needed for indoor animals. In order to keep the animals' house clean, you need to clean concrete floor frequently using simple hard brooms. Figures 8.43(a) and (b) show simple hard brooms used during cleaning the animal house.

Figure 8.43(a): Industrial made broom

Figure 8. 43(b): Local made broom

Drenching gun: This is a tool used to administer liquid drugs to animals to control internal parasites which are common to most animals. These parasites can cause slow growth of the animals and low production. Drenching is the process of administering an ant-helmatic chemical solution to an animal. Figure 8.44 shows a drenching gun.

Figure 8.44: Drenching gun

Bolus: This is a tool that is used for providing an animal with a solid drug orally when deworming it. Figure 8.45 shows a bolus.

Figure 8.45: A bolus

Stir-up pump: Stir-up pump is simply a bucket pump used for spraying animals in order to control external parasites particulary ticks, mice, tse-tse fly and flies. Figure 8.46 shows a stir-up pump.

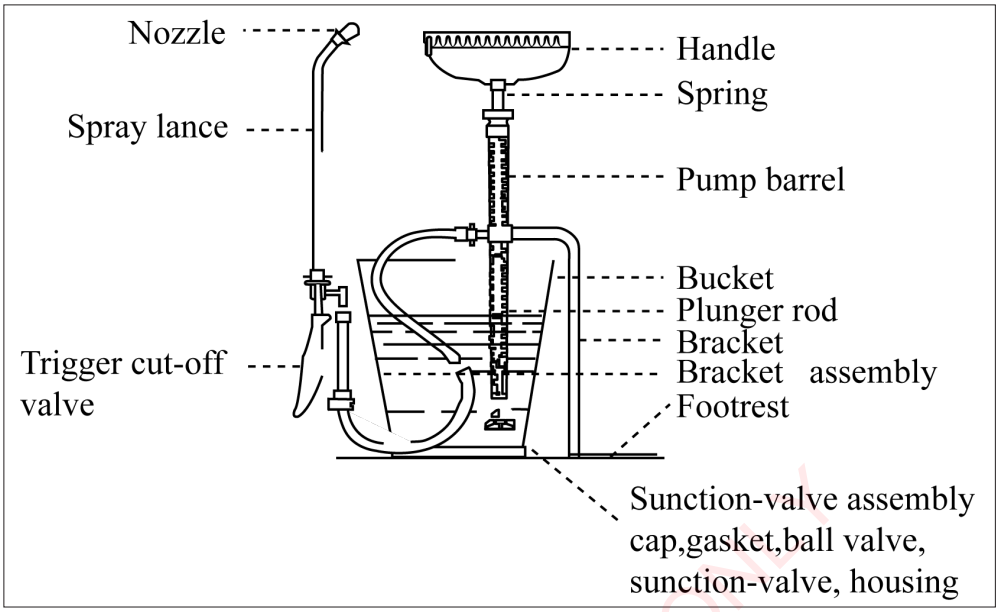


Figure 8.46: Stir-up pump

Livestock restraining tools

Some animals are very harsh and dangerous such that handling them becomes difficult. Farmers must have tools or ways of restraining them. Sometimes, a farmer may need to restrain a milking animal to avoid kicking off during the milking process. This can be done using tools such as a halter, a bull nose ring and a rope, which are further elaborated in the following section:

Halter: This is a strap or a rope tied around the neck and head of an animal for restraining and securing the animal. It allows a perfect control of an animal without hurting it. Figure 8.47 shows a halter used to restrain a bull.

Figure 8.47: A halter used to restrain a bull

***Bull nose ring*:** This is a ring which is fixed to the nose of the bull animals. Sometimes, a long stick is attached to the ring called lead stick to prevent dangerous bulls from coming closer to the handler. Figure 8.48 shows Bull nose ring.

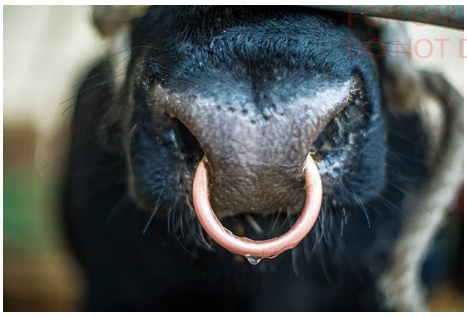


Figure 8.48: A ring on nose of a bull

Rope: This is one of the restraining tools made of sisal fibres or manila. It is used for restraining and tethering animals such as goats, sheep and cows. It is also used for pulling heavy objects. Figure 8.49 shows a sisal rope.

Figure 8.49: A sisal rope

Milking tools and containers

These tools include a milking bucket, milk churns and a strainer which are elaborated hereunder:

Milking bucket: In a milking industry, there is a special milking bucket made of stainless steel used to collect milk during milking. Figure 8.50 shows a milking bucket.

Figure 8. 50: Milking bucket

Milk churns: Milk churns are special milking containers made of stanless steel. They are used for storage and carrying milk during transportation. Figure 8.51 shows the milk churns.

Figure 8. 51: Milk churns

Milk strainer: This is a tool used for straining any foreign material from the milk after milking. Figure 8.52 shows a milk strainer.

Figure 8. 52: Milk strainer

Storage and maintenance of livestock hand tools and equipment

All livestock tools and equipment discussed above need proper storage and maintenance. If tools are poorly handled, apart from damage, they might be contaminated with pathogens such as bacteria; hence, they may act as disease transmitting agents.

The following need to be done, for the maintenance and storage of livestock tools and equipment.

(i) Tools such as syringes and hypodermic needles should be cleaned properly before and after use.

(ii) Each tool should be cleaned, disinfected and stored in an appropriate cabinet after use.

(iii) The rotating parts of tools and equipment like burdizzo, elastrator and hoof trimmers should be greased to prevent friction.

(iv) Disposable tools and materials, for example, plastics, syringes, hypodermic needles and used drug containers should be properly disposed off.

(v) The milking bucket and milk churns should be well cleaned after use and stored in their proper places.

Activity: 8.3

1. By using examples, outline the procedures for maintenance and repairing of farm tools after use.
2. A farmer wants to identify his/her cattle in the farm. Based on the knowledge you have gained from this topic, choose one of the following identification methods and describe it to the farmer:
   (a) Ear notching (b) Ear tattooing
   (c) Branding and (d) Ear tagging.
3. In the animal farm, identify an appropriate tool used to administer drugs to a given animal to control internal parasites.
4. Visit a Ward Veterinary Office and ask the officer to demonstrate how castration and dehorning operations are performed using the tools you have learned in class.
   (i) Take notes of the description given by the expert;
   (ii) Mention the tool used in each operation;
   (iii) Discuss the advantage and disadvantage of the tools used; then
   (iv) Present your report in class for discussion.

Exercise 8.3

1. Explain why it is important to consider maintenance and storage of hand farm tools?
2. Explain any five rules which guarantee long life of farm tools.
3. (a) Explain why identification is one of the important management practises in livestock keeping.
   (b) Name the identification tools commonly used in livestock management.
4. (a) Explain the term castration and its types as used in livestock production.
   (b) Why do we castrate animals?
   (c) Name the tools used in castration.
5. (a) Explain the terms disbudding and dehorning as used in animal production.
   (b) Name the tools used in
   (i) disbudding and
   (ii) dehorning practises.
6. Late in the evening, you realise that one of your cattle is showing symptoms of bloat condition. Explain what you will do to save the life of your animal.
7. What is the purpose of smearing a grease or using oils on the metal surface of a tool before storage?
8. Mr. Ngozimali went to his neighbour to hire a bull for serving his cow. Unfortunately, the bull was so stubborn. Explain livestock tools you will advice Mr. Ngozimali to use in handling the bull.

Chapter Nine

Farm workshop

Introduction

A farm workshop plays a vital role in the maintenance of farm tools. In this chapter, you will learn the meaning of a farm workshop, the functions of a workshop, workshop tools and safety precautions in handling workshop tools. The competencies developed from this chapter, will enable you to maintain and use efficiently a farm workshop, farm tools and machinery in agricultural production.

The meaning of farm workshop

When a farmer wants to sharpen a machete, he/she needs to have a metal file or a sharpener stone which is kept in a special room. When a carpenter needs to repair a broken window glass; some tools such as glass cutter, hammer, screw driver and a square may be needed. These working tools are normally kept in a special room. Also, livestock keepers who are in need of poultry feeders and drinkers will require forging or soldering equipment which are also kept in that special room or shed. Therefore, a farm workshop is a special room or shed where maintenance and repair of farm tools and equipment are carried out, also it is where machines for repair and maintenance are kept.

The farm machinery, equipment and tools should be kept and stored in good condition. A workshop can be a simple shed or a room depending on the farmers' financial ability but it should contain all the necessary and basic tools. Moreover, a workshop should be orderly and systematically arranged, with ample room for working with machines and allow a good system of storing and protecting tools and equipment. All tools should be kept where they can be readily available when needed. With increased mechanisation, it is necessary for the farmer to be skilled in the use, repair and maintenance of mechanical equipment and all farm structures.

Functions of a farm workshop

Whether big or small, all farms have some forms of workshop. It may be located in the existing building or built a separate place to serve the purpose. Its size will depend on the acreage and type of farm. Typical works carried out in a

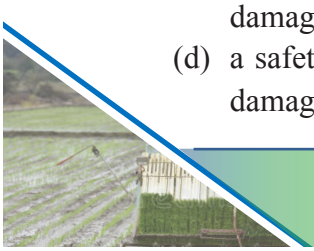
farm workshop include: servicing, repairing, estate maintenance and fabrication of new farm equipment. Depending on the capital level, a large-scale farmer may decide to build a complete workshop and install all facilities including work-bench, wrenches, spanners, tractors, ploughs, harrows and other similar machines. A small-scale farmer may start by using a tool storage cupboard that can be locked for security and a work-bench with a simple homemade vice for holding tools while they are being sharpened or fitted with new handles. From this simple beginning, a more complete facility may gradually be developed as farm operations increase.

Since repaired tools and supplies signify a considerable investment, most farmers will require to store them in a safe place. Many small-scale farmers will not require a separate store for this purpose, but if hand tools and small implements are stored together, the number of items may force the farmer to build a storeroom by enclosing part of the workshop with solid walls. The equipment needed in the workshop will depend on the type and extent of work to be done. Generally, this means those tools required to perform day-to-day maintenance of machines and to carry out general repair works and small construction jobs will require a special building or room. Furthermore, any workshop, regardless of size, will need some simple tools such as bastard files for sharpening field tools. Other tools such as wrenches and spanners are needed for removing worn-out parts and fixing new ones. Also, a workshop may include welding tools and space for a welder to perform welding operations. This may be located away from the wood working area and preferably near the main door where it can conveniently be used inside or outside the building.

Thus, a farm workshop should include spaces for woodworks, metal works and space for storage of tools and equipment. The size and design of a workshop, however, should correspond with the size of the farm and the works to be done.

Generally, the farm workshop provides:

(a) a focal point at the farmstead for the repair and maintenance of machines, implements and farm structures;
(b) a place where tools can be stored in an orderly manner, a store for supplies of spare parts, and a shelter where work can be carried out during harsh weather;
(c) day-to-day facilities needed in the farm operations such as replacement of damaged tools and equipment; and
(d) a safety place of storing equipment, implements and other tools to avoid damage and theft.



Storage of tools, equipment and implements

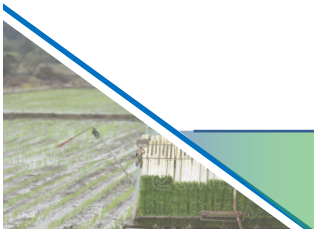
In many small-scale farms in Tanzania, nearly all cultivation and transport operations are done manually. The few small-sized hand tools and equipment used in such farming can normally be stored in any multipurpose store at the farmstead. The store needs only to be secured for protection of the equipment from damage and theft. It should also be kept dry so as to avoid deterioration of the metal and wooden parts. The tools will last longer if they are cleaned and the working surfaces are greased prior to longtime storage. The tools may be hung on rails or hooks on the wall or from the ceiling for order, convenience and protection from dampness penetrating the earth floor in the store.

Similarly, implements such as ploughs, harrows and cultivators are damaged slowly by rust when left outdoors. These should be properly cleaned prior to storage. Metal surfaces particularly threaded parts used for adjustments, should be greased to prevent damaging caused by rust. A fenced compound can provide adequate protection against theft during storage. Although implements containing wooden parts are more susceptible to decay, those parts can usually be replaced at low cost. Tractors and other complex machines will work better if they have been stored under cover and given a complete off-season check-up. An adequate storage structure for these machines is likely to be economically feasible.

Storage of fuel and chemicals

Different farm operations utilise various chemicals such as fuels and agricultural chemicals. These materials are considered as hazardous materials because they pause risks of injuries or even death, hence they have special storage requirements. Fuels such as petrol, kerosene and diesel are highly flammable. These materials should be stored in a place where naked flame is less likely to occur. Agricultural chemicals such as insecticides, acaricides, herbicides and fungicides are highly poisonous. If by accident they come in direct contact with humans or animals or feeds, they can cause injuries or even death. Thus, poisonous materials have to be kept separate from other materials in the workshop. Also, a warning sign to alert people should be placed where hazardous materials are stored.

Other chemicals used in the farms have their special storage requirements, which should be observed. For example, inorganic fertilisers and cements have a tendence of absorbing moisture from the atmosphere that is they are hygroscopic. These materials have to be stored in a cool and dry place.



Basic farm workshop tools and equipment

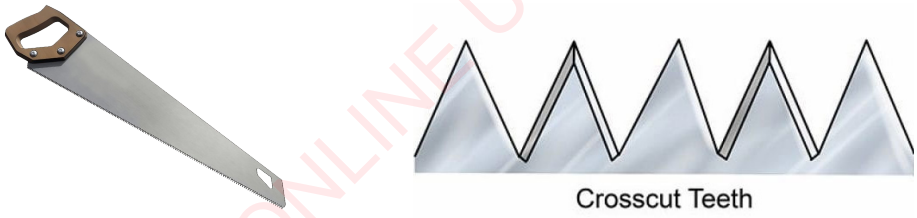
Basic farm workshop tools and equipment are devices that facilitate repairing, maintaining, making and constructing farm tools, equipment, machinery and structures. Based on their uses, they can be categorised in four main groups. There are tools and equipment used in woodworks, metalworks, plumbing works and masonry works. Some of these basic workshop tools and equipment are discussed in the following sub-sections.

Woodwork tools and equipment

Some chairs, tables, doors, and windows are made of wood. Wood is also used to make farm structures. Woodwork tools and equipment are used in making, repairing and maintaining wooden parts of farm tools, equipment and structures.

Hand saws: These are tools used to chop wood into different shapes and sizes. Hand saws are powered solely by human energy and do not require batteries or electrical power. There are many different types of saws, and each has different characteristics and uses as discussed hereunder.

(i) *Cross cut saw:* This is a common saw for cutting wood across the grain. The nature of its teeth entails the crosscutting. The teeth are upright and close to each other as opposed to other saws such as rip saw. Figure 9.1 shows a crosscut saw.

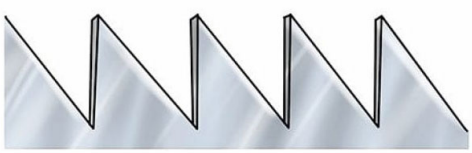


(a) Crosscut saw (b) Teeth - upright oriented

Figure 9.1: Cross cut saw

(ii) *Rip saw:* Rip saw is used to cut wood along the grain (ripping). It has large teeth which are set at an angle. Figure 9.2 shows a rip saw.

(a) Rip saw

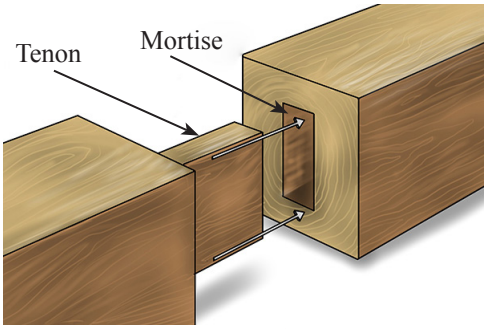


(b) Teeth orientation – slant forward

Figure 9.2: Rip saw

(iii) Tenon saw or backsaw: Tenon or backsaw is a hand saw, which has a stiffening rip at one side and a cutting edge at the other side. The rip enables more precise and better control of wood during working on tenon. The saw is normally used for precise work, such as cutting dovetail or tenon in woodworks. This saw can be used on hard and soft woods. Figure 9.3 shows a tenon saw or backsaw and an example of a worked piece of wood with tenon and mortise features made by the tool.

(a) Tenon saw



(b) Work piece wood with tenon and mortise

Figure 9.3: Tenon saw and pieces of wood

(iv) Dovetail saw: Dovetail saw is a small backsaw with thin blade, fine teeth and straight handle used for accurate work. Dovetail saws are very similar to tenon saws, except that they tend to have a thinner blade with more teeth per inch. A dovetail saw sometimes has a straight handle. This type of handle is usually found on saws used for precision works, such as tenon and coping saws.

Dovetail saw is used for sawing jointing parts of the timber for example dovetail joints and tenon as shown in Figure 9.4.

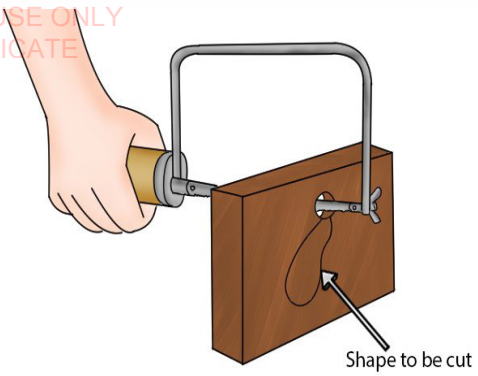
(a) Dovetail saw

(b) Pieces of wood worked by dovetail saw

Figure 9.4: Dovetail saw and pieces of wood

(v) Coping saw: This has a thin and flexible blade, in most cases, due to its flexibility of blades, it is used for making curves on woods. A coping saw uses a very thin metal blade stretched on a metal frame to make turning cuts on woods, plastics, or metal depending on the blade selected. Figure 9.5 shows a coping saw with a piece working wood.

(a) Coping saw



(b) Working with a coping saw

Figure 9.5: Coping saw and a piece of wood

A coping saw can also be used to cut shapes in the middle of a piece of material. This is done by removing the blade from the frame, drilling a hole in the material, threading the blade through and reattaching it to the frame.

(vi) Compass or key hole saw: This is a small saw with a long, narrow and pointed blade used for cutting small holes. It is also used to cut other difficult shapes on wood such as curves and round. A compass saw is designed for cutting curves or working in a confined space where a larger saw could not fit.

Figure 9.6 shows a compass or key hole saw and the worked piece.

(a) Compass or key hole saw

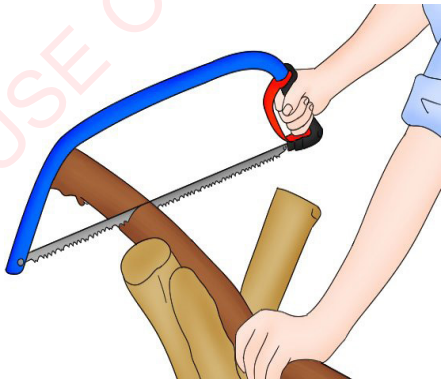
(b) A piece of wood with round structure

Figure 9.6: Compass saw and a worked piece of wood

(vii) Bow saw: A bow saw has a bow-shaped frame and a long straight blade with coarse and wide teeth. It is a special saw for cutting logs and branches. The frame of a bow saw can be made by wood or metal. The hollow metal frame makes the bow saw reasonably lighter compared to wooden frame. Figure 9.7 shows a wooden and a metal bow saw, and how they are used in wood works.

(a) Wooden frame bow saw

(b) Metal frame bow saw



(c) Working with a bow saw

Figure 9.7: Bow saw

Activity: 9.1

Visit a school workshop or a nearby carpentry workshop and then:

1. Observe different types of saws in terms of: (a) Teeth orientation; and (b) Size of teeth;

2. Identify types of the observed saws; then
3. Present your findings in class for discussion

Hand planes: These are tools for shaving and smoothing rough surfaces of wood to give plain surface. They are made of metal or wood. Common types of plane include Jack plane, Smoothing plane and Try plane. All planes have to be adjusted to suit the desired shavings.

(i) Jack plane: A jack plane is a general–purpose woodworking tool for dressing timber to the correct size in the preparation of edge jointing. It is usually the first plane used on rough surfaces. This type of plane is longer than other types of planes. It is the most commonly used plane. It can be used for both rough and smooth plaining. The plane frame can be made of wood or cast-iron as shown in Figure 9.8(a) and (b).

Figure 9.8(a): Metal jack plane

Figure 9.8(b): Wooden Jack plane

(ii) Smoothing plane: Smoothing plane is a tool used to further smoothen wood surfaces after the application of a Jack or Try plane on such surfaces. Figure 9.9 shows smoothing metal and wooden planes.

(a) Metal Smoothing plane

(b) Wooden Smoothing plane

Figure9.9: Smoothing planes

(iii) Try plane: This type of plane is also called a jointer plane. It is used to level long surfaces and edges to give a perfectly true and flat surface or edge. A finally set plane with a sharp blade will slice through the wood leaving a smooth and straight surface. It can be made of metal or wood as shown in Figure 9.10.

(a) Metal try plane

(b) Wooden try plane

Figure 9.10: Try planes

(iv) Spoke shave: This is a type of plane used to shape and smoothen round edges of the wood in making such things as wheel cart, wheel spokes, chair legs, paddles, bows, and arrows. Unlike other planes, spoke shaves are operated by holding it with two hands. It can be made from flat-bottom, concave, or convex soles, depending on the type of structure to be designed as shown in Figure 9.11(b).

(a) Spoke shave

(b) Working with a spoke shave

Figure 9.11: A spoke shave

Activity: 9.2

Visit a school workshop or any nearby carpentry workshop and then:

(a) Observe and identify different types of planes;
(b) Explain the uses of each plane you have observed;
(c) Work in a group to discuss the care and maintenance requirements for planes; then
(d) Present your works in class for general discussion.

Hammers: Hammers are hand tools used for striking objects and pulling nails. They are designed for different purposes and therefore are of different shapes and sizes. The commonly used hammers in woodworks are claw hammers and joiner mallets. A claw hammer is mainly used for hammering the nails into the wood and pulling the nails from the wood. On the other hand, a joiner mallet is usually used in carpentry to fix wooden pieces together. It is also used to drive chisels especially those with non-metal handles. Being wooden in nature, a mallet does not cause deformation on the striking end of chisels or surfaces of the working wooden pieces, as most metal hammers would do. Figure 9.12 shows a claw hammer and a joiner mallet.

(a) Claw hammer

(b) Joiner mallet

Figure 9.12: Woodwork hammers

Boring tools

Boring tools are used for making holes. A hole can either be drilled or bored. A drilled hole is usually smaller than a bored hole. Hand tools, which are used to make holes in woodwork include hand drill, brace and wood chisels. These are described hereunder:

(i) *Brace and hand drill:* In order for a brace or hand drill to be used, an auger bit or a drill bit must be attached. Figure 9.13 shows a brace and a hand drill.

(a) Brace with auger bit

(b) Drill with drill bit

(c) Auger bit

Figure 9.13: Brace and hand drill

(ii) Wood Chisels: These are used for chopping wood into desired shape or hole. There are two types of chisels: a firmer chisel which is used for general purposes, and a mortise chisel, which is used for making mortise holes in a piece of wood. Figure 9.14 shows wood chisels.

(a) Firmer chisel

(b) Mortise chisel

Figure 9.14: Wood chisels

Marking tools

(i) Carpenter's square: This is used to determine squares of various structures. Figure 9.15 shows a carpenter's square.

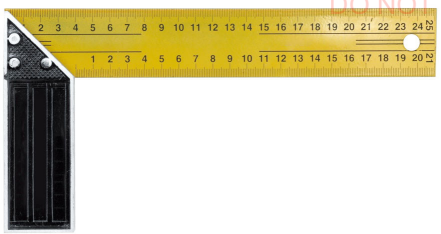


Figure 9.15: Carpenter's square

(ii) Marking gauge: This is used to scribe a line parallel to a reference edge or a surface in woodworks. Figure 9.16 shows a marking gauge.

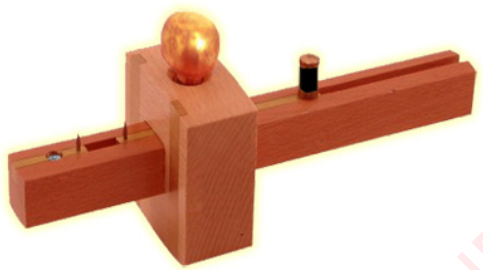


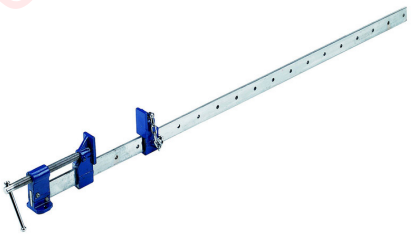
Figure 9.16: Marking gauge

Gripping tools

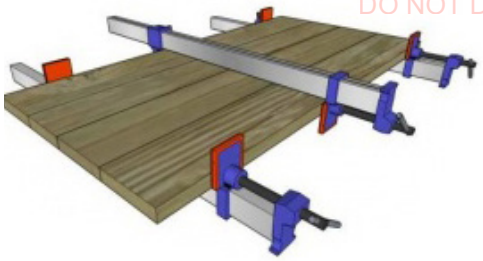
(i) G-clamp: This is used for fastening together pieces of timber by holding work pieces in the workshop when drilling or cutting. It is also used for holding together working pieces when performing other tasks such as sawing and cutting timber. Figure 9.17 shows the G-clamp.

Figure 9.17: G-clamp

(ii) Sash clamp: This is a tool with a long bar, and two jaws used for fastening together parts of wood when joining for example doors and windows. It is also used to hold together work pieces when performing other tasks such as sawing and cutting timber as indicated in Figure 5.18.



(a) Sash clamp



(b) Working with Sash clamp

Figure 9.18: Sash clamps and work piece of wood

(iii) Bench vice: This is a holding device attached to a working bench. It has two jaws to hold work pieces firmly in a place when working in a farm workshop. Figure 9.19 shows a bench vice.

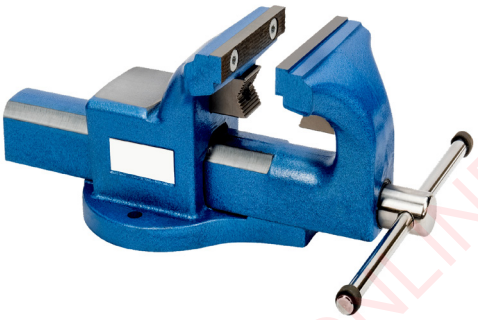


Figure 9.19: Bench vice

Metal work tools and equipment

Metal work in a farm workshop involves operations such as cutting, joining, sharpening, and grinding pieces of metals. Such operations are facilitated by using various tools. For example, there are different tools for joining metals temporarily or permanently. Temporary joining of metal plates can be accomplished by the use of tools like nuts and bolts. Permanent joining is done using processes such as riveting, gluing, brazing, welding and soldering. Forging is a process of shaping a metal by heating it in fire and then hammering. In this section, we shall discuss tools and equipment used in soldering and forging processes.

Basic soldering tools and materials

Soldering is the process of joining metal parts by a means of fusible alloy called solder. The molten solder is applied between metal parts to be joined. When it cools, it gets hardened forming a joint. The tools and materials include soldering iron, solder wire, wire brush and flux which are elaborated in Table 9.1.

Table 9.1: *Soldering tools and materials*

Name of Tool/material	Description
(i) Soldering iron  (a) Electric soldering iron  (b) Gas/Charcoal fired soldering iron	This is a tool, which is heated and used to melt solder wire that fuses in between metal parts to form a joint. There are various types of soldering iron in accordance to the source of heat namely, electric-soldering iron, gas-fired soldering iron, charcoal-fired soldering iron and open flame soldering irons.
(ii) Solder wire 	It is the alloy, which is melted to form a joint in metals.
(iii) Wire brush 	It is used to clean metal parts before and after soldering in order to remove any coated dirty.
(iv) Flux 	It is used to prevent oxides to be formed on metals when heated up during soldering. However a flux is a corrosive chemical substance, it must be washed from the work piece after soldering.

Forging tools and equipment

Forging is a process by which heated metal is hammered into a required shape. This process is achieved by using the tools and equipment shown in Table 9.2.

Table 9.2: Forging tools and equipment

Name of Tool/equipment	Description
(i) Hand fan forge 	It is a tool used to provide additional air by blowing on chalcoal or coal to provide more and more heat when heating the metal.
(ii) Anvil 	It is a heavy metal used to support the work piece while it is hammered.
(iii) Sledge hammer 	It is used for striking heated metal during forging. It can be used directly or by using a striking forming tool.
(iv) Tongs 	It is used for holding heated metal when striking it into desirable shape.

Other metal working tools and equipment: These include hack saw, metal files, tin snip, pliers, spanners and cold chisel which are described hereunder.

(i) *Hack saw:* This is used for cutting metals through the process called hacksawing. Some hacksaws have an adjustable frame and others have a fixed one. Figure 9.22 shows a hack saw.

Figure 9.22: Hack saw

(ii) Metal file: This is used for smoothing metals or reducing the size of metals. Figure 9.23 shows the metal file.

Figure 9.23: Metal file

(iii) Tin snip: This looks like pliers but it has sharp cutting edges.It is used to cut sheets of metals such as iron sheet. Figure 9.24. shows a tin snip.

Figure 9.24: Tin snip

(iv) Pliers: This is used for cutting thin wires, holding them, gripping work pieces and tightening of nuts when a strong grip is required, for example, during tightening of nuts onto the bolt. Figure 9.25 shows some pliers.

Figure 9.25: Pliers

(v) Spanners: These are of varying types, they include: Open ended spanner, which is used for gripping sides of nuts when loosening or tightening. Ring spanner, which is used for gripping the top of nuts when loosening or tightening and a socket spanner, which is used for tightening and loosening nuts in the sunken parts. Adjustable spanner is used to loosen or tighten nuts or bolts of different sizes. Figure 9.26 shows some of the spanners commonly used in farm workshop.

(a) Open ended spanner | (b) Ring spanner | (c) Socket Spanner | (d) Adjustable Spanner

Figure 9.26: Spanners

(vi) Cold chisel: This is used to cut thick metal sheets and to make shape in metal sheets. Figure 9.27 shows a cold chisel.

Figure 9.27: Cold chisel

Plumbing tools and equipment

Plumbing is a system of pipes and other fittings that carry fluids from one place to another for various uses. As a process, plumbing involves cutting, threading, and pipe fitting operations. A plumber is a person who is specialised in fitting and maintaining plumbing systems. Plumbing is accomplished by using various tools and equipment. Below are some of the basic plumbing tools and equipment that are commonly used on the farm.

Pipe cutter: It is used to cut pipes into the required length as shown in Figure 9.28.

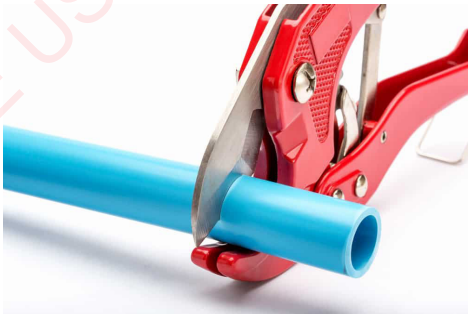


Figure 9.28: Pipe cutter

Pipe stock (Stock and die): This is used to make threads on the pipes where a die of required size is inserted. Figure 9.29 shows a pipe stock.

Figure 9.29: Pipe stock with its structural parts

***Pipe wrench*:** This is used for gripping and tightening pipe fittings while connecting pipe line in the field. Figure 9.30 shows a pipe wrench.

Figure 9.30: Pipe wrench

Pipe vice: Is a tool for fastening firmly the work piece while working in the workshop; this may include cutting or threading. For effective working, a pipe vice is normally bolted in the working bench. Figure 9.31 shows a pipe vice.

Figure 9.31: Pipe vice

Masonry tools and equipment

Masonry is the art of building structures from individual units like blocks, bricks and stones. These units are often laid in and bound together by a mortar as a binding material. Some commonly used tools and equipment in masonry works include a plumb bob, spirit level, brick layer's trowels, metal/wood floats and brick hammer.

Plumb bob: This is a small heavy pointed metal used in general constructions to establish and maintain vertical perfectness of vertical structures such as walls and other uprights. Figure 9.32 shows a plumb bob.

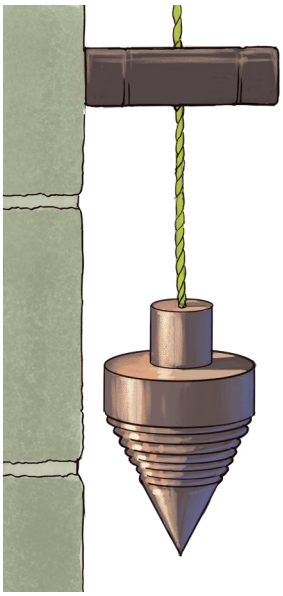


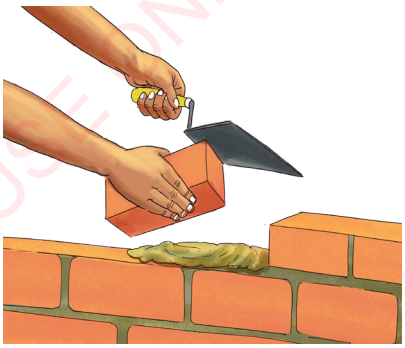
Figure 9.32: Plumb bob suspended on a wall

***Spirit level*:** This is used to check the straightness of surfaces in construction. Figure 9.33 shows a spirit level.

Figure 9.33: Spirit level

***Brick layer's trowel*:** This is used for placing mortar on its position during construction. Figure 9.34 shows a brick layer's trowel and its uses in construction.

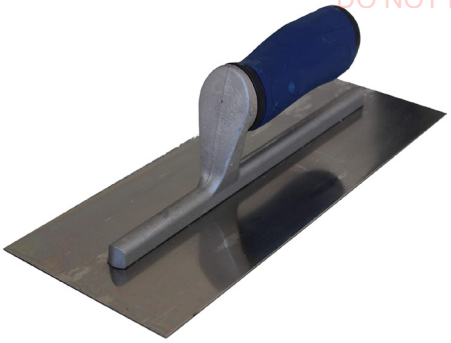
(a) Brick layer's trowel



(b) Constructing using a brick layer's trowel

Figure 9.34: Brick layer's trowel and its uses in construction

***Wood or metal float*:** This is used for holding mortar before placing it on its position and smoothing the wall and floor surfaces. Figure 9.35 shows metal and wood floats.



(a) Metal float

(b) Wood float

Figure 9.35: Metal and wood floats

***Brick hammer*:** This is a tool used for reducing the size of bricks accordingly and adjusting bricks or blocks into their place in the wall. Figure 9.36 shows brick hammers.

(a) Brick hammer with wooden handle

(b) Brick hammer with metal handle

Figure 9.36: Brick hammers

Other workshop tools and equipment

Tape measure: This is a tool marked with numbers. It is used when measuring linear distances for various purpose. Figure 9.37 shows a tape measure.

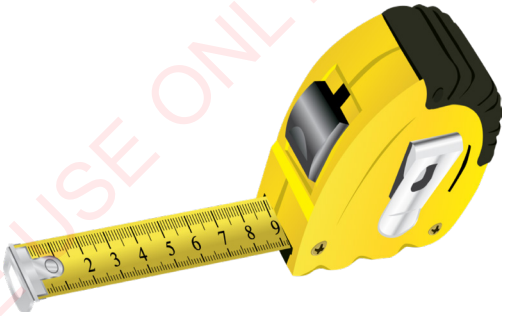


Figure 9. 37: Tape measure

Metre rule: This is a tool used to measure distances between two points. For example, a metre ruler is used in measuring the recommended spacing and when marking small plots in the farm. Figure 9.38 shows a metre rule.

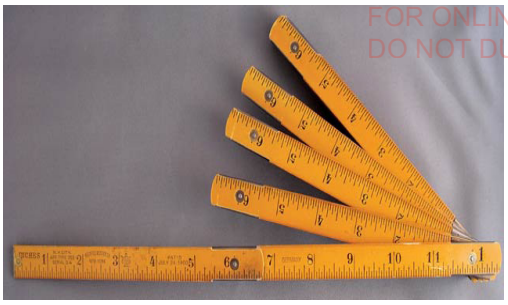


Figure 9.38: Metre rule

Try Square: This is a tool used for checking if two objects are at right angles. For example, checking if two walls on construction intersect at right angles. Figure 9.39 shows a try square.

Figure 9.39: Try square

Rasp file: This is a tool used for smoothing hard rough woods. Figure 9.40 shows a rasp file.

Figure 9.40: Rasp file

Screw drivers: These are tools used in screwing in or out the screws when working with such activities in woodwork. The screw drivers can be either a star-shaped (star screw driver) or flat-shaped (flat screw driver) at their respective tips. The star screw driver is used to screw in or out the star headed screws in wood or metal surfaces. The flat screw driver is used to screw in or out flat headed screws in wood or metal surfaces. Figure 9.41 shows the star and flat screw drivers.

(a) Star screw driver

(b) Flat screw driver

Figure 9.41: Screw drivers

General safety precautions in handling basic farm tools

Improper use, storage and handling of farm tools and equipment may cause accident to users or other people and damage to the building as well as tools and equipment.

Activity: 9.3

1. Have you ever witnessed any accidents caused by neglecting safety precaution in using and handling a farm tool or equipment? If so,
   (a) Briefly explain how it happened;
   (b) What was the effect of the accident?
   (c) Basing on your own knowledge, how could the accident be prevented?

Consider the following scenario: A farmer was using a spanner instead of a hammer to strike a metal bar in order to straighten it. The spanner broke off and one piece hit him on his forehead. The farmer was seriously injured. Based on the above scenario, and your knowledge on workshop tools and their uses, what contributed to the occurrence of this accident?

It is important to observe rules and safety precautions in and around the workshop in order to prevent accident and protect workshop building tools and equipment. This section deals with how to keep a house, protect oneself against injury, and protect the property against fire hazards.

(a) House keeping

(i) Working place should be kept free from any obstruction.

(ii) The floor should be kept clean by wiping spilled greases, oils and disposing all junks and rubbish properly.

(iii) Benches, equipment and tools, should be cleaned and stored properly in their appropriate places.

(b) Personal protection against injuries

(i) Wear goggles and use shield when grinding or welding to protect your eyes from intense light and any resulting particles.

(ii) Extra care should be taken when using electric power saws and other sharp equipment that might cause injuries.

(iii) Wear safety boots in order to avoid injuries that might be caused by sharp equipment, which can be found on the floor.

(iv) Wear overall garment to protect your skin and clothes and hand gloves to protect your hands.

(v) Machine with belts and gears should be fitted with guards to avoid accidents

(vi) Each tool should be used properly according to the intended work.

(c) Protection against fire hazards

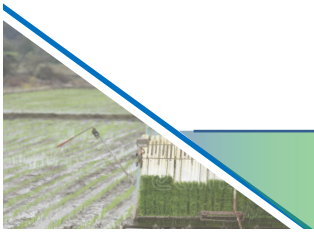
(i) All flammable liquids should be stored in approved containers and properly covered.

(ii) In places where welders, forges and other machine are installed, it is advisable to partition them by using metal sheets, asbestos or cement boards.

(iii) Fire extinguishers should be kept in the workshop and at the place where they will be easily accessible.

Exercise

1. Define the term farm workshop.
2. Describe the uses of each of the following workshop tools:
   (a) Pipe stock;
   (b) Pipe wrench; and
   (c) Wood float.
3. Differentiate between cold chisel and wood chisel.



Chapter Ten

Farm machinery

Introduction

Machines are used to simplify farming activities. In this chapter, you will learn the meaning of farm machinery and machines commonly used in the farm. You will also learn some important practices for general care and maintenance of farm machines, and factors to consider in the selection of farm machinery. The competencies developed, will enable you to select and utilise farm machinery in simplifying farm operations.

The meaning of farm machinery

Farm machinery refers to machines and implements, which are used in the production, harvesting, and storage of farm products. It includes a variety of devices from simple to complex and modern implements. It also includes trailers that are used to transport agricultural produce or other agricultural materials from the production area to the market or storage place.

Most of the farm machines and implements are helpful in modifying the soil in order to make it suitable for plant growth. This involves soil manipulation operations such as ploughing and harrowing the soil, which are collectively termed as tillage. Ploughs, harrows, and cultivators are examples of tillage implements; while tractors, planters, combine harvesters and mowers are examples of farm machines. Milking machines are used to simplify milking operations in most medium and large dairy farms.

Machines and implements commonly used in the farms

Several machines and implements are used to perform various activities in the farm. They include primary and secondary tillage implements, milking machines, trailers and carts, and maize shellers. Others are harvesters, mowers, manure and fertiliser spreaders, planters and seeders. These are briefly described hereunder:

(a) Primary tillage implements

These implements are basically used to break up the soil and bury weeds in soil before sowing or planting. They include mouldboard plough, disc plough, chisel plough and sub-soiler as shown in Figure 10.1. These implements are normally mounted on a tractor as shown in Figure 10.1 (ii).

(i) Disc plough

(ii) Disc plough mounted on a tractor

(iii) Mouldboard plough

(iv) Chisel plough

(v) Sub-soiler

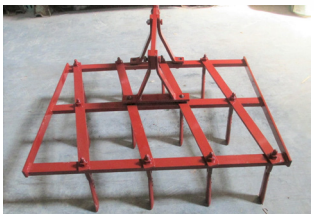
Figure 10.1: Primary tillage implements

(b) Secondary tillage implements

These are implements used to create fine soil tilth for planting. They are used to till land in a shallower and less aggressive manner as compared to primary tillage implements. Examples of secondary tillage implements include harrows, cultivators and ridgers which can either be driven by draught animals or mounted on tractors. Figure 10.2 shows some secondary tillage implements.

(i) Disc harrows

(ii) Spring tined cultivator



(iii) Spiked tooth harrow

Figure 10.2: Some secondary tillage implements

(c) Planters and seeders (seed drill)

These are specialised machines and implements used in sowing or planting. They include seed drills, precision planters and trans-planters. Seed drills are used in sowing seeds which are small sized such as paddy, millets and pastures. Precision planters are used in sowing seeds in specified spaces between and within rows in the field. Trans-planters are used in transplanting seedlings. Planters and seeders can be operated manually or motorised. Figure 10.3 shows a six-row precision planter, seed drill and paddy trans-planter.

(i) A six-row precision planter

(ii) A seed drill

(iii) Paddy trans-planter

Figure 10.3: Planters and a seed drill

(d) Manure spreaders

These are used to apply manure or fertilisers in a field. Some of the spreaders are mounted on tractors while others are motor powered. Figure 10.4 (i) shows a section of spinning disc manure spreader while 10.4 (ii) shows a manure spreader in operation.

(i) A section of spinning disc manure spreader

(ii) A manure spreader in operation

Figure 10.4: Manure spreader

(e) Mowers

These are machines and implements, which are used in mowing unwanted or wild plants and tough weeds in a farm. They are also used in harvesting fodder and forage crops. Figure 10.5 shows a tractor mounted with a mower in a field.

Figure 10.5: A tractor mounted mower

(f) Harvesters

These are machines, which are used in harvesting crops. Examples of harvesters are combine harvester, round potato digger and forage harvesters. Combine harvesters are multipurpose as they harvest crops from the field, de-husk or thresh grains, winnow and pack the grains in the containers for processing, storage and marketing. They are commonly used in large scale farming for harvesting cereals,

such as maize, wheat and paddy. Potato lifters are used to harvest and collect root crops particularly round potatoes and sweet potatoes. Forage harvesters are mounted to tractors and used for harvesting forage crops such as maize plants and napier or elephant grass. They are used such as mowers or cutters. Figure 10.6 shows a combine harvester.

Figure 10.6: A combine harvester

(g) Maize sheller

This is a machine used to remove maize grains from cobs and winnow them. Figure 10.7 shows a maize sheller.

Figure 10.7: Maize sheller

(h) Trailers and carts

These are transporting equipment. They are used for transporting farm produce and inputs from and to the farm. The trailers which are commonly used in Tanzania include those drawn by draught animals and tractors. Figure 10.8 shows an ox-cart and trailers.

(i) An ox-cart

(ii) A tractor-drawn trailer

Figure 10.8: An ox-cart and a tractor drawn trailer

(i) Milking machines

These are special machines used for milking dairy animals. In small scale, the portable milking machines are more suitable, while fixed milking machines are preferable in medium to large scale farms. Figure 10.9 shows a portable and a fixed milking machines.

(i) A portable milking machine

(ii) Milking with a machine

(iii) Milking parlour with fixed milking machines

Figure 10.9 Milking machines

Activity: 10.1

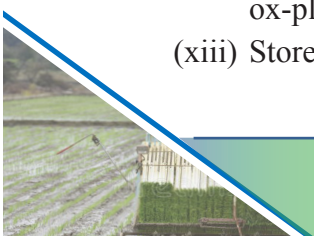
In a group, visit any nearby mechanised farm then:

(a) Observe and identify the machines and implements which are used in the farm;
(b) Note down the farm operations done by each machine; and
(c) Write your field report for presentation in class.

General care and maintenance of farm machinery

Handling and routine maintenance of farm implements and machines are important for many reasons. They prolongs a long lifespan of the machine. It minimises incidences of accidents and allows the user to operate and perform their work smoothly. These practices also increase work efficiency and effectiveness. For care and maintenance of farm machinery, observe the following practices:

(i) Clean each implement or machine after using.
(ii) Check for worn out parts and replace.
(iii) In case of cultivators, check for any breakage of tines, discs and shovels and repair or replace.
(iv) For machines with belts, make sure they are fitted with proper belts and well adjusted.
(v) In case of planters and seeders after using them, make sure that all seeds are removed from hoppers and detach all stuck seeds from seed slots then disassemble the unit.
(vi) For sprayers, empty the tanks after use and clean the sprayer thoroughly then check for nozzles and filters.
(vii) If sprayer have to be stored, remove nozzles and store them separately Keep sprayers covered during storage.
(viii) For harvesters, remove all stack materials after use.
(ix) For implements with hub bearings like ox-cart and wheelbarrow, make sure that hub bearings are lubricated by greasing them.
(x) For implement/machines with tyres, check for pressure before and after work and inflate if needed.
(xi) For ox-carts, make sure that yokes are properly padded for harnessing in order to avoid injury to the animals.
(xii) During off season, lubricate with oil all land working parts of the implements such as shares and paint other parts, for example, handles of ox-plough.
(xiii) Store all implements and machines in the shed.



Factors to consider in the selection of farm machinery

Since farm machinery are available in many different types and sizes, the appropriate and correct selection, increases efficiency in farm operations. The following are factors to consider when selecting a farm machinery:

(a) Types of soil

Heavy soils need heavy machinery such as chisel plough and sub-soiler while light soils, need light machinery such as disc plough and mouldboard ploughs.

(b) Size of the farm

Large scale farming encourage the use of large machinery such as tractors whereas in small scale farming, small machinery such as power tillers can be enough.

(c) Topography

Different topographies of the farming environment may dictate the choice of a farm machinery to be used. In mountainous areas, ox-drawn and hand operated implements may be more convenience to work with on flat lands; however, tractors and other machines may work better.

(d) Required tilth of seedbed

Some farm operations produce finer tilth than others. When a farmer is intending to plant a crop with smaller seeds like finger millet, he/she will need to choose an implement that will produce fine tilth.

(e) Required depth of cultivation

Different implements can till the land at different depths, depending on the needs of the farmer. For deeper cultivation, for example, subsoiler and chisel plough are more proper compared to disc and mouldboard ploughs.

(f) Financial ability of the farmer

A farmer can choose a tractor drawn machinery or ox-drawn machines depending on capital or financial ability. In the selection of farm machinery, the farmer should take into consideration the initial investment and maintenance costs that are associated with the machinery.

Activity 10.2

In a group, visit a school workshop or any nearby mechanised farm or a garage. Then, under the permission of the manager:

(a) Observe and inquire how care and maintenance of machines and their respective parts are done;
(b) Identify different types of lubricants used in lubricating different types of machines and parts of the machines;
(c) Write a field report and present i t in class for discussion.

Exercise

1. In your own words, explain the concept of farm machinery.
2. Identify various farm machines found in your area and state their uses.
3. Outline any five general practices applied in the maintenance of farm machinery.
4. Explain any five factors to consider before selecting farm machinery for farm operations.
5. With examples, discuss the uses and limitations of any five farm machines in farming operations.

Chapter Eleven

Farm power

Introduction

In order for the farm tools, equipment and machines to work, some mechanical forces are needed to make them produce the desired effects such as cultivating, cutting and harvesting. This mechanical force is obtained from energy. The rate of energy used in doing work is proportional to the rate of doing that particular work and it is called power. In this chapter, you will learn the meaning of farm power and discuss various sources of farm power. The competencies developed from this chapter will enable you to analyse various sources of farm power and utilise them in simplifying farm works.

The meaning of farm power

Farm power can be defined as a rate of energy expenditure in doing farm work. There are two forms of energy available for farm use. These are, animated and inanimated energy. Animated energy is the form of energy that is derived from human beings and animals such as cattle, donkeys, horses, camels and buffaloes. Inanimated energy is the energy expended through transformation of natural resources for example wind, water, biomass, solar radiation and fossil fuel.

Sources of farm power

There are various sources of farm power, namely, humans, animals, wind and water. Other sources are solar, biogas, geothermal and fossils.

Human power

Human beings can work in the farm using legs and hands. They are able to cultivate land and operate machines by using hands and legs; they can also control and guide animals to do works in the farm. They can work with merely hands, for example weeding in the farm of crop plants, trimming hedges by using shears and transplanting seedlings in the garden by the use of hand trowel. Also, in a mechanised farm, apart from using farm hand operated tools and equipment, a human being is the one who operates implements and machines in most of the farm operations. However, a human being can do these works within limits because he/she can get tired. A full grown and healthy man can generate up to

0.1 kW of power per day only. Figure 11.1 shows a farmer working on the farm using a hand hoe.

Figure 11.1: Human source of power

Limitations of using human power

(i) Heavy energy expenditure operations take a long time to be completed.
(ii) It is reliable as it depends on the health of a person.
(iii) It depends on skills that a person has.

Animal Power

Some farm animals are used to generate power for various farm operations, these animals are called draught animals. The use of draught animals is called oxenisation. Some farm operations which can be done by using draught animals include ploughing, harrowing, ridging, planting, weeding and transportation.

In Tanzania, commonly used draught animals are cattle and donkeys. Other draught animals used include horses, buffaloes and camels. Cattles used as draught animals, are referred to as oxen.

For effective oxenasation the following conditions should be met.

(i) Farmers should practise mixed farming system including cattle from which an oxen can be chosen.
(ii) The area should be free from tsetse flies and animal diseases and parasites-related problems.
(iii) The land should be reasonably flat with light soils and at least minimum or no soil obstacles such as stones, tree stumps and gullies.

(iv) Extension services should be available to advice farmers on animal training and the use of ox-drawn implements and equipment.

(v) Animals should be well trained, harnessed and managed.

Training of draught animals for oxenisation

To maximise utilisation of draugth animals in the farms, animals should be well selected and trained. In training animals, the following are essential aspects:

(i) The age should be between 2-3 years for local breeds and 1.5-2 years for exotic breeds;
(ii) Animals to be trained, should be steers (castrated male animals);
(iii) Indigenous cattle are more preferred as they are suitable to local environmental conditions;
(iv) Humped animals are recommended as the hump prevent the yoke from sliding off the back;
(v) The animal should be low tempered;
(vi) Animals should be harnessed properly with a paddled yoke to make them comfortable and work for long time;
(vii) Animals of the same size should be kept in a pair during training; and
(viii) Make sure that animals are well trained in order to provide more power output.

Figure 11.2 shows a yoke harness and a pair of harnessed oxen.

(a) Yoke harness

(b) Pairs of harnessed oxen

Figure 11.2: Animal Power

Animal power in farm operations has the following benefits:

(i) It has low initial cost;
(ii) It has low maintenance and management cost in terms of feeding, provision of clean water, disease and parasites control;
(iii) It generates high power output compared to human power;
(iv) It can be used in mountainous areas that are in fairly steep land; and
(v) It requires less skills to operate.

Limitations of animal power

Since animals are living organisms, using them as a source of farm power, we can face the following challenges:

(i) The animal should be in good health to work. Sometimes the animal may fall sick and take long to recover, hence, delaying to complete farm works in time.
(ii) Animals get tired, thus they can only work within time limits.
(iii) Animals require proper feeding but unfortunately during dry season forage becomes scarce hence reducing working efficiency.
(iv) Animals require training to perform farm operations properly.
(v) Animal power is limited only in some areas, which are free from disease vectors such as tsetse flies.
(vi) Animals require a farmer to keep aside a piece of land for pasture.

Wind power

Wind is a moving air containing kinetic energy, which can be harnessed and converted into mechanical energy using a device called wind mill. The windmill consists of a propeller made of several blades and attached to a top of a vertical shaft. When the wind blows, it makes the windmill rotates. The reciprocating movement of the windmill provides mechanical energy and hence farm power for various farm operations. Figure 11.3 shows wind mills.

Figure 11.3: Wind mills

Uses of a windmill in the farm

A windmill can facilitate the performance of the following farm operations:

(i) Water pumping: This is the most popular use of windmill in Tanzania.

(ii) Electricity generating for various purposes in the farm, such as heating and running machines.

Advantages of a windmill

A windmill has the following advantages:

(i) It is environmentaly friendly resource since it does not cause any pollution;

(ii) It has low running costs because it does not require fuel; and

(iii) Windmill power is unlimited. This means that, it is a continuous resource.

Disadvantages of a windmill

(i) It depends on weather conditions, so it is unreliable.

(ii) It is limited in areas where wind is predominant.

(iii) The initial cost of installing windmills is high.

Water power

Water provides power in two main forms. Moving water contains kinetic energy, which can be used directly for farm operations. These operations include, transportation of agricultural products such as tree logs, operations of machines which pump water to the uphill tanks for different purposes such as irrigation.

Also, water is used to generate electricity through the following procedures:
A dam is constructed along the river, and a narrow passage constructed to the downside of the dam at a steep slope along which, turbines are installed. These turbines are connected to the generator. Water from the dam is allowed to pass into the passage with high-speed forcing the turbine to rotate; eventually, the turbine rotates a generator which generates electricity. The generated electricity is then transmitted through cables to various places. This is called hydro-electric power.

Most of the electricity used in Tanzania is generated by water from different hydro-electric power stations. The power stations include: Hale in Tanga, "Nyumba ya Mungu" Dam in Kilimanjaro, Mtera Dam in Iringa, Kihansi and Kidatu both in Morogoro. Figure 11.4 illustrates how hydro electrical power is generated.

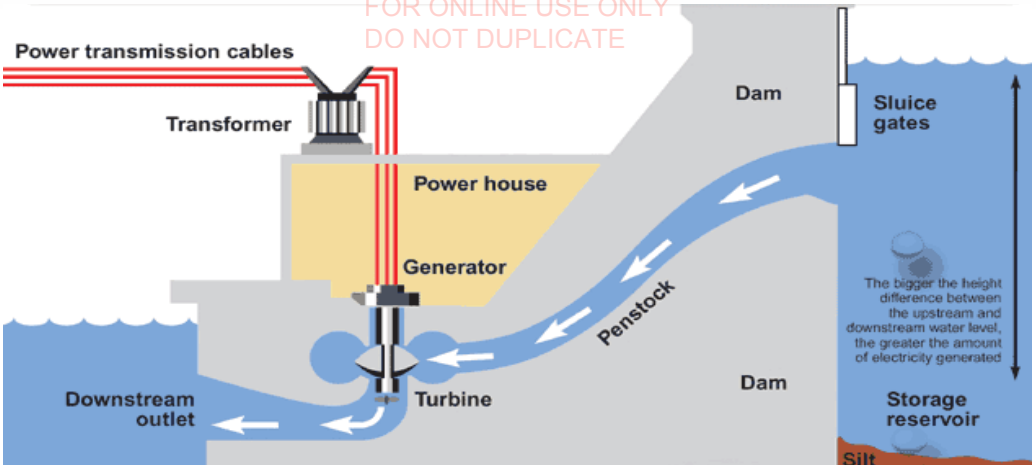


Figure 11.4: Hydro-electric power generation

Hydro-electric power is used for lighting, heating; cooking and running various machines such as water pumps, milking machines, welding and milling machines.

Hydro-electric power has the following advantages: it does not pollute the environment, it is supplied in a continuous manner and once installed it is relatively cheap to run. Similar to wind mill, hydro-electric power can be used for different farm operations, for example, drilling metals or woods, soldering, welding and running milling machines.

Hydro-electric power has the following limitations: the installation of hydro-electric power plant is costly; and the maintenance costs of power generating machine is high. Also, power generation is highly affected by fluctuation of water levels in the river or dam causing a shortages of power in certain seasons of the year especially during dry season.

Solar power

Solar energy refers to heat and light from the sun. Solar power is derived from solar energy, which reaches the earth surface in the form of electromagnetic radiations from the sun. It is used in three ways:

(i) Light energy facilitates the photosynthesis process by which plants manufacture their own food through chemical reactions.

(ii) Solar radiation can be absorbed and converted into heat energy, for example, a solar drier. Figure 11.5 shows a solar drier.

Figure 11.5: Solar drier

(iii) Solar radiations can be converted into electricity. The solar panels are used to trap sunlight and convert them into electrical energy, which can be then stored in solar batteries. This can be used in various farm operations such as pumping water as shown in Figure 11.6. Likewise, solar energy is used in drying crops by exposing the crops directly to the sun.

Figure 11.6: Solar panels

Advantages of Solar power

The power is sustainable since sunlight is supplied in a continuous manner, it is non-pollutant so it does not affect the environment and it is easily available especially in tropical countries.

Limitations of Solar power

Solar power depends on the weather conditions; thus, during cloudy days, little amount of electricity is generated. Installation costs are relatively high and require skilled personnels to install and maintain it. In most cases, it is not used directly in the farm operations rather it has to be changed to electrical energy then utilised in the form of electricity for farm operations.

Bio-gas

Organic matter such as cattle manure, plant leaves, garbage, crop straws and industrial wastes can produce gas that can be used in the farm to accomplish some farm operations such as lighting, cooking and heating. Gas can be produced in the farm under anaerobic conditions through the action of bacteria on cellulose present in the organic materials. For example, manure from cattle can be collected, thoroughly mixed with water and placed in a silo called digester. After a few days, gas bubbles appear to form gas that will be accumulated above the water in the digester silo or reservoir. The gas produced is called biogas and mainly consist of methane gas (60-70 percent), which is flammable. Digester silo consists of digester, mixing chamber, inlet valve, outlet valve, slurry channel, pipe to a farm house. Figure 11.7 shows the diagram of a biogas production unit.

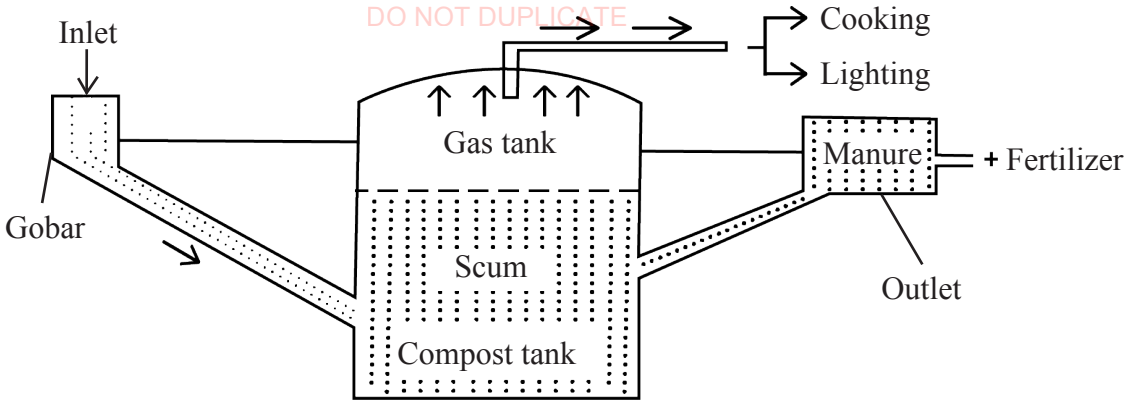


Figure 11.7: Diagram of biogas production unit (digester silo)

Advantages of Biogas

Biogas is non pollutant and provides good manure slurry, which is the remains after the gas production.

Limitations of Biogas

Biogas is limited to few farm operations and is also very laborious since it requires large amount of organic matters and frequent stirring of the content.

Geothermal power

Do you know that steam has power? Take a cooking pot, fill it with water and cover, with a lid and heat it to boil to the maximum. Observe what happens. Definitely, the lid will start to bump off the pot. This shows how steam is powerful. The same applies to the geothermal power. Geothermal power is generated by superheated water emanating from the earth's crust to the earth surface. It occurs in geysers where steam is continuously emitted under high pressure from enclosed cavities.

The steam is harnessed and used to run turbines, which rotate the dynamo to generate electricity. The generated electricity is transferred through cables and transformers to the farm and other places for use. Geothermal power is among the cheap sources of power, renewable and non-pollutant. The generated power can be used in various farm operations such as running water pumps, welding, drilling, cooking, heating and milling. Figure 11.8 shows geothermal power plant.

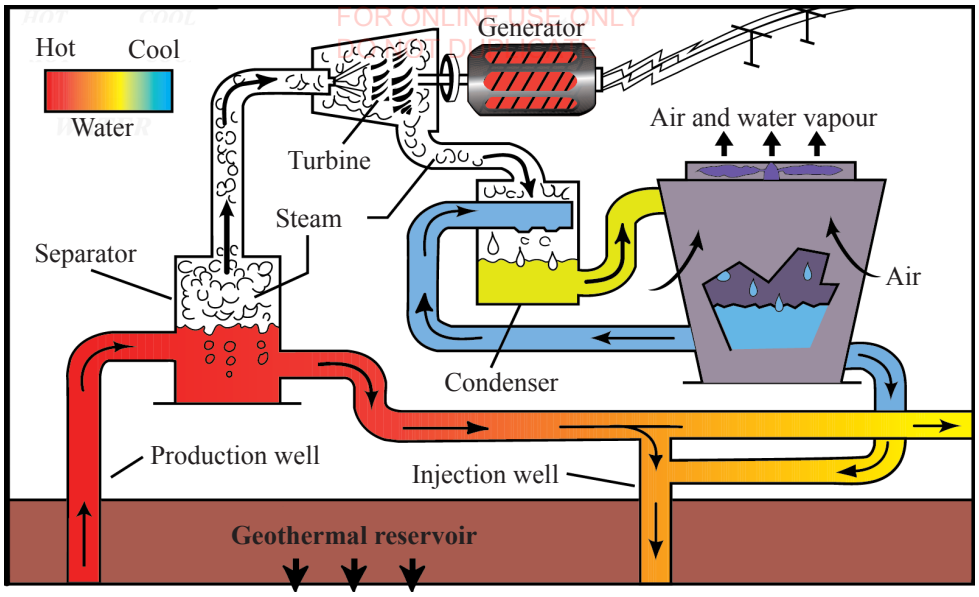


Figure 11.8: Geothermal power plant

Fossil fuels (Chemicals)

For a car to move, it requires fuel; likewise, in order for a tractor to work in the field it requires fuel. Also, for hurricane lamp to produce light, it requires fuel. All types of fuels are refined from fossil fuels. These are hydrocarbon compounds that produce power upon combustion. They include: natural gas, petroleum, coal and bio-fuel. During their combustion, the chemical energy is converted to a mechanical energy, which is used in driving motor engines of such machines as vehicles, tractors, and generators. Some of fossils fuels are described as follows:

Natural gas

Normally, natural gas is found together with petroleum deposits. It is one of the important sources of power in the farm, and which can be used to facilitate several farm operations such as heating, lighting, cooking and welding. In Tanzania, natural gas is currently found in Mtwara and Lindi regions.

Petroleum

When crude petroleum is refined, we get products such as, kerosene, petrol, and diesel. With the exception of kerosene which is mainly used as fuel for cooking and lighting, the rest are used to run motor engines. These are used to run machines which perform functions like ploughing, pumping water, spraying chemicals, mowing, lighting, transportation and processing of farm products.

Advantages of using petroleum in engine include high power output and availability.

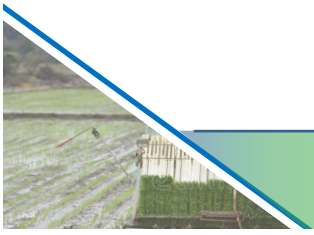
However, there are some challenges associated with the use of petroleum, which include pollutants, non-renewable and expensive. Also, it is flammable hence, it requires specialised means of storage.

Activity 11.1

1. With the aid of an atlas, work in pairs to identify geographical areas where the following sources of farm power are found in Tanzania:
   (a) Natural gas;
   (b) Hydro-electric power; and
   (d) Wind power.
2. Share your findings in class for discussion.

Exercise

1. Explain the meaning of farm power as used in agriculture
2. Discuss the importance of farm power in agriculture
3. (a) Outline five sources of farm power
   (b) State advantages and disadvantages of each source of farm power outlined in (3a).



Chapter Twelve

The concept of soil

Introduction

Soil is one of the important earth materials on which different human activities including crop production and livestock keeping are done. In this chapter, you will learn the meaning of soil from agricultural point of view, the constituents of soil and their proportions, soil formation process and development of soil horizons. The competencies developed will enable you to choose the appropriate soil for efficient crop production.

The meaning of soil

Soil is a very important earth material that influences the life of all living organisms. Generally, soil is defined as the uppermost part of the earth's crust, that consists of rock minerals mixed with organic matter and pores that are occupied by air and water. In agriculture, soil can be defined as a material upon which plants grow. This material provides support and nutrient elements to plants. It also, nourishes animals and microbes. In summary, soil is a medium for plant growth.

Constituents of the soil

Soil is a porous material composed of mineral matters, organic matters, water, living organisms and air. Mineral materials and organic matters together form what is known as solid part of the soil body. They cover about 50 percent of the soil body by volume, where mineral matters cover about 45 percent while organic matters cover 05 percent. The part of the soil body which is covered by water and air is known as pore space and it covers about 50 percent of the soil body by volume, that is, water 25 percent and air 25 percent. Figure 12.1 shows the distribution of soil components by volume.

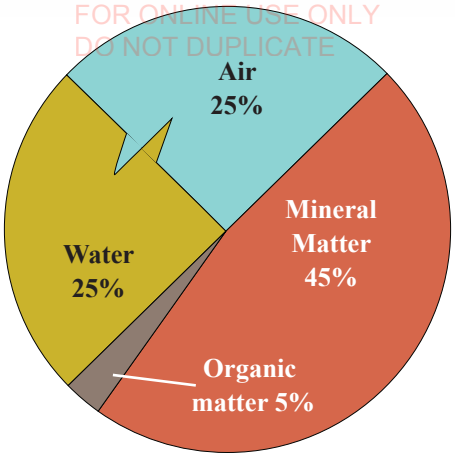


Figure 12.1*:* Distribution of soil components by volume

(a) ***Mineral matter***

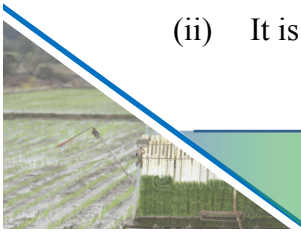
Soil mineral matter consists of particles which are mainly small pieces or rocks and different kinds of minerals. Mineral soil particles are derived from rocks which have been broken down into smaller and smaller pieces over millions of years. The major mineral soil particles are sand, silt and clay. Those mineral particles which have persisted with no changes or little changes in composition from original rocks are known as primary minerals while those which have undergone compositional changes are known as secondary minerals. As a soil component, mineral matter has an influence on both chemical and physical properties of the soil. Soil drainage, moisture retention capacity, ease of root penetration, plasticity, aeration and retention of plant nutrients are important soil characteristics influenced by soil mineral matter.

(b) ***Organic matter***

The organic matter present in the soil is formed from the remains of plants and animals and it is in two main forms. These forms are plant and animal remains which have not yet been completely broken down and those which have already been broken down completely. The plant and animal remains which have already been broken down completely are termed as humus. Humus consists of very small particles which are usually black or brown in colour. Humus has a great influence on the physical and chemical properties of the soil. It is important because of the following reasons:

(i) It is a source of mineral salts which are used by plants.

(ii) It is a good binding agent for soil particles.



(iii) It makes the soil more porous, thus improving soil aeration, infiltration and drainage.

(iv) It serves as source of food for soil organisms.

(v) It holds plenty of moisture; thus increasing the soil's capability to withstand drought.

(c) ***Living organisms***

The soil contains members of living organisms from both plant and animal kingdoms. These organisms include those which are large and can be seen with naked eyes (macro-organisms); and the very small ones (micro-organisms) which can only be seen under microscope. Soil living organisms have a very important influence on the physical and chemical properties of the soil. Living organisms play an important role in breaking down the remains of plants and animals. For example, earthworms, insects, bacteria and fungi feed on plant remains. In so doing, the remains are broken down and nutrient elements which were present in the plant tissues are released. The nutrient elements which are released in this way can then be absorbed by plant root. Humus is also formed by the action of soil organisms.

(d) ***Soil air***

Soil air occupies spaces between soil particles not occupied by water. The space between soil particles is called pore spaces. Soil air is a continuation of the atmospheric air, that is in a constant state of motion from soil pores into atmosphere and from the atmosphere into the soil pore spaces. In particular, oxygen and carbon dioxide need to be exchanged between the soil and the atmosphere for root respiration to occur. Soil air is also important for respiration of soil organisms.

(e) ***Soil water***

Water in the soil is held within the pore spaces. Soil water comes from rain or irrigation. The water in soil contains salts which are dissolved in it. The mixture of water and mineral salts is termed as soil solution. Water in soil plays an important role as a solvent for mineral nutrients. It is also important in transporting the dissolved mineral nutrients to the plant roots for absorption. Soil water is also essential for living organisms in soil.

Note: For most agricultural crops, conditions are best when the soil pore spaces are filled about equally with water and air.

Activity 12.1

Visit different places in the school compound and collect different samples of soils from a depth of about 20 cm. By using the provided materials and apparatus, perform the activities in parts A, B and C. Then, answer the questions that follow.

Requirement: beam balance, 100 ml beaker, 250 ml beaker, desiccator evaporating dish, measuring scale, stirring road, water, samples of soil, Pyrex beaker, oven or other heat sources, muslin cloth, lime water, conical flask and a cork

Part A

(i) Fill a 100 ml beaker with an air-dry soil sample and pour it into a 250 ml beaker.

(ii) Measure 100 ml water and add it into a 250 ml beaker containing 100 ml soil sample.

(iii) What do you observe?

(iv) What is the reading of the mixture? Does it give you 200 ml as expected?

(v) Explain your observation.

Part B

(i) Measure the weight of an evaporating dish when empty.

(ii) Half fill the dish with soil sample then find out the weight of the soil sample.

(iii) Heat the dish with its contents in an oven at about 105° C or with a bunsen burner until it is completely dry. The soil should be occasionally stirred to help in evaporation of moisture.

(iv) Cool the soil sample then reweigh several times until a constant weight is obtained.

(v) Compare the weights of the soil sample before and after drying it.

(vi) Do the two soil samples have the same weight? Explain.

Part C

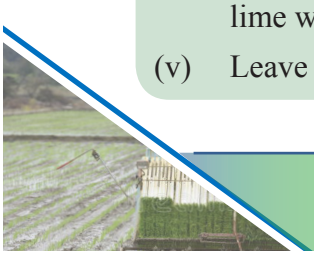
(i) Take another sample of soil, subdivide it into two parts and label them as samples A and B.

(ii) Sample A should be burnt in a Pyrex beaker. Leave sample B fresh.

(iii) Take sample A and put it in a muslin cloth then hang it in a flask containing lime water.

(iv) Take sample B and put it in a muslin cloth then hang it in a flask containing lime water.

(v) Leave the two samples for two hours then observe changes in colour.



Questions

1. What did you observe from each part of the activity 12.1?
2. With reasons, provide conclusions from the findings of each part of this activity.

Soil development process and horizons

Soil develops from breakdown of rocks and minerals which are collectively termed as parent materials. The breakdown of the parent materials to form soil is a natural and continuous process that takes place over extremely long period. The continuous breakdown of parent materials under natural conditions is also termed as weathering. The action of weathering on parent materials is aided by various physical, chemical and biological processes. Basically, soil development involves breakdown of parent rocks and mixing of the broken materials. As the mixing of materials goes on, horizontal layers of soil develop. Weathering and later development of horizontal layers within soil in a given place is influenced by the interaction of numerous factors. The most important factors include climate, living organisms, topography, parent materials and time. The development of soil from weathering and formation of different layers within the formed soil evolve at varying speeds depending on the strength of these factors. Soil formation, development of soil horizons and factors of soil formation are thus described in the following sections.

Soil formation

Soils are formed from breakdown of parent rocks under natural conditions over a long period. This breakdown of parent rocks to form soil is termed as weathering. Weathering involves various natural processes that act on the parental rock. These are physical, chemical and biological weathering processes (refer Figure 12.2).

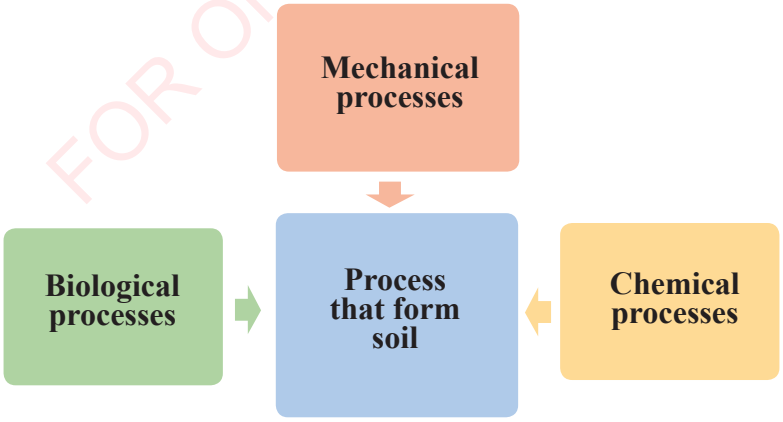


Figure 12.2: Soil formation processes

(a) ***Mechanical (Physical) processes:*** These involve the processes which bring physical breakdown of parent rocks. Wind, running water, falling rain, glaciers, freezing and thawing are typical abrasive forces which cause physical breakdown of parent rocks.

(b) ***Chemical processes:*** These involve several chemical reactions that occur continuously in soils. As some of the mineral components of rock are dissolved by water or acids, small particles break off. Over time, rock materials are converted to many tiny particles.

(c) ***Biological processes:*** These involve physical and chemical processes brought about by living organisms in breaking down the parent rocks. The growth of plant roots and lichens, for example, causes physical weathering by widening the rock joints during their growth. Grazing and burrowing animals too can cause both physical and chemical breakdown of parent rocks. Micro-organisms play an important role in chemical breakdown of parent rocks by creating organic acids which contribute to chemical weathering.

Development of soil horizons

When a vertical section is dug through soil, there are different layers of soil that can be observed. The vertical section dug through soil from top to the underlying bed rock is termed as soil profile while the different layers of soil profile are called soil horizons. The layers are called horizons because they are spread from side-to-side or horizontally. Typical soil profiles which normally found in a virgin land and undisturbed soils have four major horizons. These are surface horizon of organic materials and three horizons of mineral materials. Each horizon is different from the others. The thickness of each horizon varies with location and conditions. Figure 12.3 shows a typical soil profile while Figure 12.4 shows the cross-sections of soils revealing horizons. Note that all horizons are not always present in soils profile especially in a disturbed condition. The horizons "A", "B" and "C" are most typical profiles in fields while "O", "A", "B", and "C" are more often found in forests.

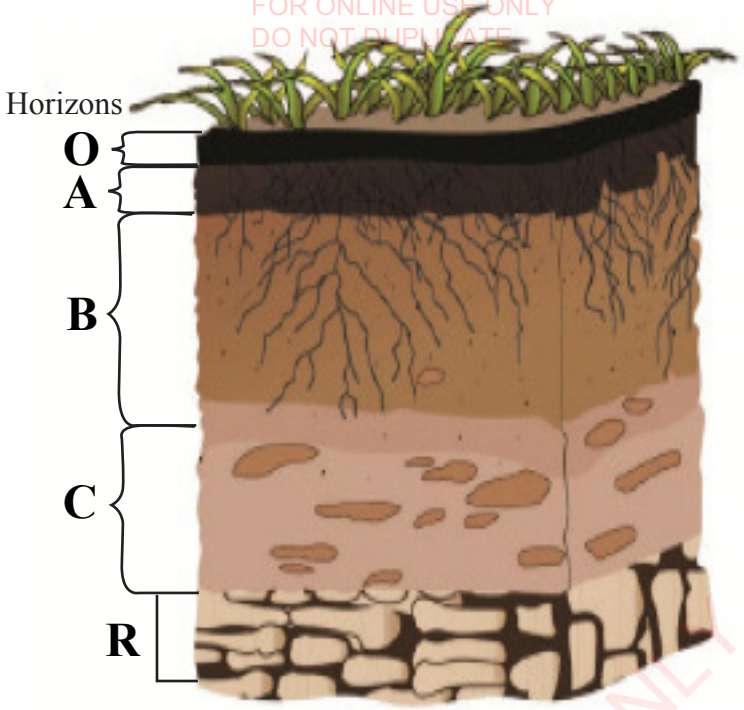


Figure 12.3: Typical soil profile

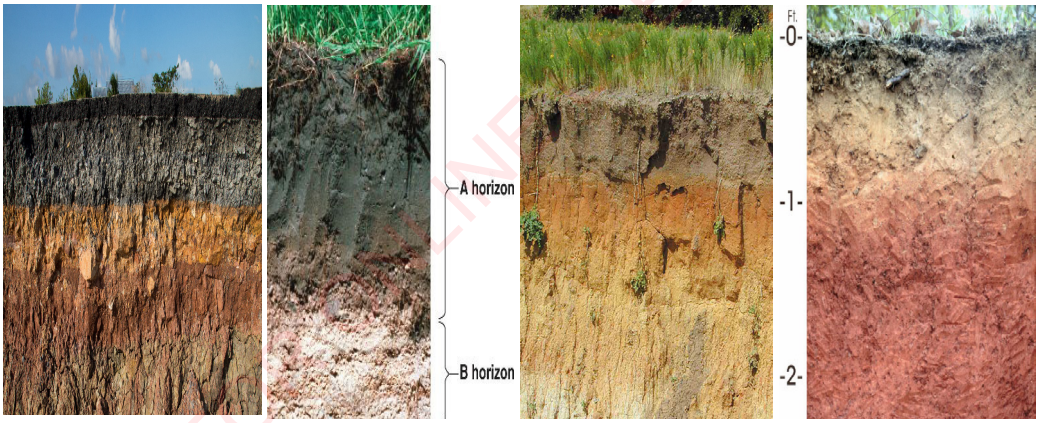


Figure 12.4: Cross-sections of soils revealing horizons

"O" horizon: This is a top layer of soil. It is a thick layer of organic materials such as grasses, twigs, dead leaves and animals. The "O" horizon is usually dark brown in colour due to presence of humus and it is high in nutrients that plants need to grow. "O" horizon is generally identified by the following criteria:

(a) It contains identifiable organic remains such as dead leaves and grass which are accumulated at the surface level of the soil.

(b) It is dark brown colour.

(c) It feels squishy.

"A" horizon: This is the first mineral horizon which lies just below the "O" horizon. It is also called the top-soil. Its thickness ranges from 6 - 30 cm. The soil in this horizon is rich in nutrients and allows for air and water to drain through providing conducive environment for living organisms. This is because, as plant and animal remains decompose on the "O" horizon, they eventually mix into this horizon. This is the only mineral horizon where plants grow well. Organisms such as ants, earthworms and rodents like moles and rabbits, live in this horizon as well. Depending on the climate of the place, this horizon may be characterised by leaching or eluviation due to removal of iron and humus. "A" horizon is generally identified by the following criteria:

(a) It contains mineral soil material which is well mixed with decomposed organic matter.

(b) Soils in "A" are sandier or coarser than "B" horizon.

(c) It is darker in colour than underlying horizons, that is, "B" and "C".

"B" horizon: This is the second mineral horizon located just below the "A" horizon and which is also called sub-soil. Tree roots grow down to this horizon. This horizon has clay, mineral deposits and has less organic materials than the horizons above it. It is lighter in colour than the horizons above it due to the natural colour of the mineral grains. The "B" horizon may or may not be present in some soil profiles. Depending on the climate of the place, this horizon may be characterised by accumulation or illuviation within the soil. "B" horizon is generally identified by the following criteria:

(a) It is lighter in colour than over or underlying horizon.

(b) Soils in "B" are clay-like and they are finer than "A" horizon.

"C" horizon: This is the third mineral horizon and it is called parent material. This horizon is slightly affected by soil forming processes. It contains mostly broken up rocks. It does not have many nutrients. Plant roots cannot grow in this horizon because it is too dense. This horizon is also called parent material because other horizons above originate from it. "C" horizon is generally identified by the following criteria:

(a) It contains very little soil which lacks structure, that is, the rock-like pattern is still obvious.

(b) It has rocks which are slightly affected by soil-forming processes and in most case with the colour of the parent material.

Note *"R"* is a layer of hard bedrock found at the bottom of all soil profiles. It is an un-weathered parent material. Criterion for identifying the bedrock in the field is that you cannot dig it with a shovel or an excavator.

Basic processes in development of soil horizons

Development of soil horizons involves four major processes that occur in soil. These are additions, losses, translocations and transformations as shown in Figure 12.5 and described hereunder:

(a) ***Additions:*** These include actions that add materials to the soil profile. For example, addition of water through rain, dust settling through wind, minerals and soil particle settling through moving water as well as organic matter remains through death of soil's living organisms.

(b) ***Losses:*** These are removal of components from the soil profile. For example, erosion by wind or moving water taking away soils from upper horizons. Decomposition can transform organic materials to carbon dioxide which then moves to the atmosphere and causes loss of soil particles. Actions such as evaporation, nutrient uptake, leaching of nutrients and elements cause losses of materials in soil profiles.

(c) ***Translocations:*** Translocation involves moving components within the soil horizons without leaving the profile. Translocations mainly involve actions such as pulling down of water and dissolved materials by gravity, movement of organic matter in many directions due to soil organisms, and clay movement from "A" to "B" horizon. However, movement is not always down as evaporation can cause minerals dissolved in water to move upwards, for example, salts on the surface of some desert or drier soils.

(d) ***Transformations:*** Under transformation, one component changes to another. For example, plant leaves decompose to humus, hard rocks break into smaller pieces, minerals in rocks weather to clay, and iron in minerals reacts with oxygen then turns to rust giving soil a reddish colour.

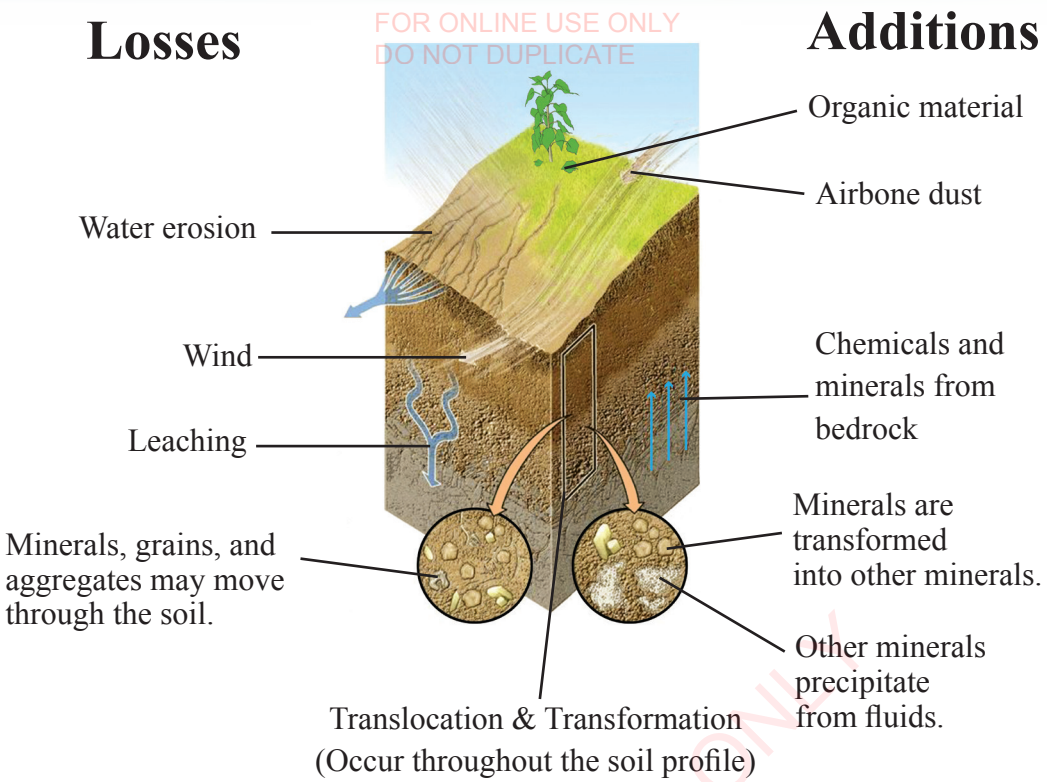


Figure 12.5: Soil horizon development actions

Factors influencing soil development process

Soils differ from one place to another. The type and nature of soil, which is formed and developed in any place, is influenced by five major factors; climate, living organisms, topography, parent material and time. Each of these factors interacts with others during soil development process.

Climate: It includes all aspects such as temperature, rainfall, snowfall, wind and amount of sunlight. Temperature and moisture influence the speed of chemical reactions that control how fast rocks weather and dead organisms decompose. As temperature increases weathering increases. Rain or water added also increases weathering. Soils develop faster in warm and moist climates and slower in cold and arid ones or even hot and dry climates.

Living organisms: Soil organisms such as plant roots, burrowing animals, and micro-organisms speed up the breakdown of large soil particles into smaller ones. Roots and lichens are a powerful soil-forming force. As they grow, they cause cracking of rocks. In so doing, they physically break rocks to allow water to enter and further weather the soil. Plant roots also produce carbon dioxide that mixes

with water and forms an acid that wears away rocks. Soil organisms produce organic acids that break down minerals and other organic materials. Bacteria, fungi, and worms help to break down organic matter as well.

Topography: Topography or slope position of a land can greatly influence soil development. This is due to its influence on drainage and water movement. In steep slopes, soils show less development as they are likely to be eroded and are unstable. Deeper soils with more horizons form at the bottom of a hill than at the top because gravity and water move soil particles down the slope. Stable and or flat lands show more development of soil with deeper and more horizons. These are areas where particles from up slope accumulate.

Parent material: Many of the soil properties are inherited from the material from which they are formed. Parent materials can be divided into three basic groups: parent bedrock, transported materials and organic materials. Soils developed in place from the underlying parent bedrock inherit properties from the rock and the manner in which the rock weathers both physically and chemically. Soils can be developed from deposits resulted from river stream/channel or flood plain associated with the channel. The soil sediments developed in this manner are coarser when near the channel where the water is moving fast. Furthermore, the areas adjacent to the coast contain multiple environments for soil sediment deposition. Soils deposited in a marine environment are of variable texture depending on energy involved in depositing the soil particles. When low energy is involved, it gives fine textured soils and high energy results into coarse textured soils.

Time: Time determines how long the factors of soil formation have been at work in weathering the parent materials. Older soils, for example, differ from younger soils because they have longer time to develop. More development means more horizons and less development means fewer horizons to that particular soils' profiles.

Importance of learning soil development process

By studying soil development process you learn about the soil, its characteristics, and how to use it properly. Soil profile, for example, allows you to examine various properties which influence life of plants and other organisms in soil. Moreover, soil profile is an important tool in nutrient management for crop production. By examining particular soil profile, you can gain deep understanding on fertility of the soil. This is due to the fact that as the basic four processes of soil horizons

development interacts, the profile of soil changes. The changes may positively or negatively affect the suitability of the soil for agricultural production.

Activity 12.2a

1. In a group, visit a school farm and dig a pit about 2m vertically from the top downwards. Note and record physical changes of the soil as you dig down.
2. Based on the physical characteristic-features you have observed, identify different layers (horizons) of the soil.
3. Among the studied horizons, which one, has been influenced by weathering?
4. Name the horizon in which organic matters are largely undecomposed.
5. Present your findings in class for discussion.

Activity 12.2b

1. In a group, collect empty transparent plastic bottles and different soil samples representing horizons (refer instruction one in Activity 12.2a)
2. Place the samples of soil into the bottle in the order as it was observed from the field.
3. Compare the arrangement of soil samples in the bottle with that which you saw from the field.
4. Present your findings in class for discussion.

Exercise

1. Explain the meaning of soil and its origin.
2. Identify soil constituents and their proportions.
3. Explain the sources and forms of each soil constituent.
4. Describe soil development and horizons.

Chapter Thirteen

Physical properties of soil

Introduction

The physical properties of soil play important roles in improving land productivity. In this chapter, you will learn soil physical properties, which include soil texture, structure and porosity. You will also learn how these physical properties relate to each other and to crop production. The competencies developed will enable you to choose appropriate soils and associated management practices for efficient agricultural production.

The concept of soil physical properties

Various physical forces interact in the development of soils. The resulting effect causes characteristic properties to soils which can be described in physical terms. Physical properties of soil have a great influence on root penetration, drainage, air movement, retention of moisture, availability of plant nutrients, as well as chemical and biological characteristics of the soils. Examples of physical properties of soil are texture, structure and porosity. These are described in the following sub-section.

Soil texture

Soil consists of mineral particles of different sizes in diameters. Mineral particles of soil are sand, silt and clay.

(a) Sand

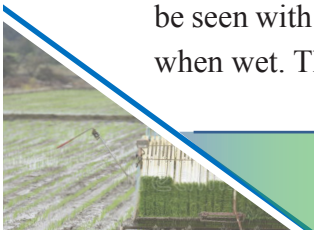
This is the largest particle of the soil and is visible by naked eyes. Sand particles are gritty, hold little water and they are not slick or sticky when wet. The sand particle is between 2 and 0.05 millimetres in diameter.

(b) Silt

This is medium-sized soil particle. Silt particles feel like flour or talcum powder when dry. They have greasy and somewhat sticky felt when wet. The silt particle is between 0.05 and 0.002 millimetres in diameter.

(c) Clay

These are the smallest particles of soil. Most individual clay particles can only be seen with a powerful microscope. Clay particles feel hard when dry and sticky when wet. The clay particle is less than 0.002 millimetres in diameter.



The relative proportion of sand, silt and clay particles in the soil is referred to as soil texture. Soil texture also refers to as the feeling of coarseness or fineness of soil determined by the relative proportions of sand, silt and clay particles. The particles are also termed as soil separates. The presence of particles with different sizes in soil can be determined by sedimentation test. This enables soil particles with different sizes to settle in different depths (refer to Figure 13.1).

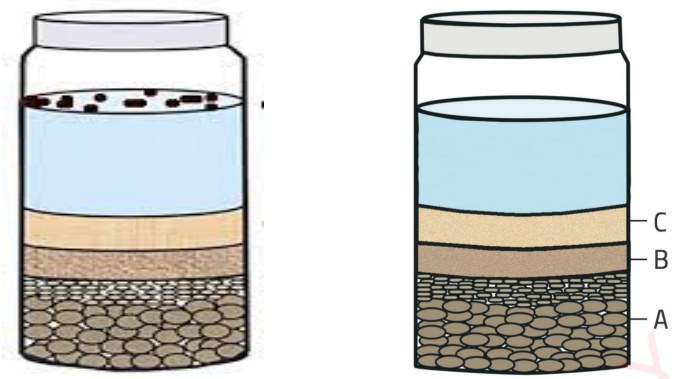


Figure 13.1: Jars with soil sediments

Activity 13.1

In a group, perform the following tasks:

1. Prepare apparatus and materials for carrying out soil particle sedimentation test (including an auger or a shovel, 2 mm sieve, two bottles, water, ruler or measuring tape, pen/pencil, marker pen and a workbook).
2. Walk around the school compound to collect a sample of dry soil.
3. Divide the soil sample into two portions and sieve one portion through a 2 mm screen.
4. In one bottle, fill approximately ⅓ full of un-sieved soil and the same volume of sieved soil in another bottle.
5. Add water to each bottle until it is ¾ full. Cap the bottles and shake them vigorously for 10 minutes to mix everything thoroughly. Ensure that no soil is clinging to the bottom of the bottle.
6. One to two minutes after you stop shaking the bottles, set them on the desk and let them settle for two five minutes. Measure the height of sediments settled at the bottom (A). Wait for two hours and then take the second measurement (B). Leave the bottles undisturbed for 24 hours or when the water is clear to take the third measurement (C), (D) and (E). Mark the level of the layers of the soil and record your group's data in the workbook as in the following chart.

Type of layer	Thickness of sediments (mm)	
	Bottle with un-sieved soil	Bottle with sieved soil
Layer A		
Layer B		
Layer C		
Layer D		
Layer E		

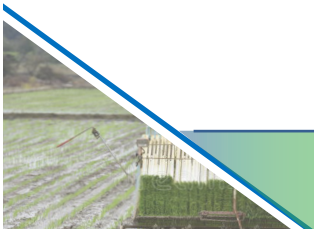
1. Describe your observations and lessons learnt from this activity then present them in class for discussion.

Determination of soil texture

Soil texture can be determined using laboratory analysis or simple methods which can be easily carried out in field such as texture by feeling method. Normally, laboratory analyses of soil texture are costly and take time, while feeling soil texture by hand is cheap, quick, and accurate. Soils are divided into three broad texture groups: coarse-textured soils, medium-textured soils, and fine-textured soils. The term coarse-textured is often used for soils that are dominated by sand. Fine-textured soils refer to soils that are dominated by clay, and medium-textured soils are a more balanced mixture of sand, silt, and clay particles. The medium-textured soils are also termed as loam soils.

Determination of soil texture by feel method

This method is used to determine the textural class of soil in the field by simple field tests and feeling the constituents of the soil. The soil sample must be in the state between moist to weak wet. Gravel and other constituents greater than 2 mm in diameter must be removed.



Procedure for determining soil texture by feel method

Step 1: Take a handful of soil. If the soil is dry, moisten it just enough to determine if it will form a ball when squeezed in the palm of the hand (refer to Figure 13.2). If the moist soil will not form a ball, it is sand.

Figure 13.2: Forming soil ball

Step 2: Bounce the ball. If the moist soil remains in a ball when the hand is opened, bounce the ball in the hand. If the ball breaks when it hits the hand, it is a loamy sand. If the ball does not break, move on to step 3.

Step 3: Determine if the moist soil will form a ribbon when a soil ball is extruded between the thumb and forefinger (refer to Figure 13.3). Also determine how long a diameter ribbon will form when rolled between palms or on a flat table.

When starting with dry clays, make sure you allow time for the clays to become moist, and make sure "gritty" particles are not aggregated.

Figure 13.3: Forming ribbon from soil ball

The principle behind forming ribbons is related to the cohesion that exists among clay particles. Clays are sticky when moist, and so the ribbon length is proportional to the clay content.

If the ribbon length is:

(a) less than 2.5 cm, the general category of soil texture is loam.

(b) between 2.5 cm and 5 cm, the general category of soil texture is clay loam.

(c) greater than 5 cm, the general category of soil texture is clay.

After determining the general category by clay content, move to step 4.

Step 4: After completing the ribbon test, determine the modifier if it is necessary. Add water to a pinch of soil in the palm of your hand until you have a muddy puddle. Rub the mud puddle

against your palm (refer to Figure 13.4). Feel as the sample is worked in the hand.

Figure 13. 4: Feeling the texture of soil in the palm

If grittiness:

(a) dominates, then the modifier, "sandy" will be added to the general category determined in step 3, example, sandy loam, sandy clay loam, or sandy clay.

(b) does not dominate, but smoothness does, then a form of silt will be added, example, silt loam, silty clay loam, or silty clay. Silt is not sticky, but is smooth like flour, foundation make-up, or talcum powder.

Activity: 13.2

Under guidance of your teacher, perform the following tasks.

1. Collect soil samples of different types.
2. Use procedures in step 1 - 4 (pages 131 and 132) to determine textures of the soil samples by feel method.
3. What conclusions can you draw from this activity?
4. Present your findings in class for discussion.

Soil textural types and their properties

Based on textural properties, the following are the types of soils.

(a) ***Sandy soils:*** Sandy soils consist of small particles of weathered rock. Sandy soil is one of the poorest types of soil for growing plants because it has very low nutrients and poor water holding capacity, thus making it hard for plant roots to absorb water. This type of soil is very good for the drainage system. Sandy soil is usually formed by the breakdown or fragmentation of rocks like granite, limestone and quartz. The following are the properties of sandy soil in different situations.

When dry: Loose, single grained, gritty, no or very weak clods.

When moist: Gritty, forms no crumbled ball, does not ribbon.

When wet: Lacks stickness, but may show faint clay staining. Individual grains can be both seen and felt under all moisture conditions.

(b) ***Silty soils:*** Silty is another type of soil which holds water better than sand. If you were to hold a handful of dry silt in your hand, you would feel almost like flour. If you were to add water to the silt in your hand, it would hold the water and become stickier and smoother than is the case with sand. Silty soils have smaller particles compared to sandy soils and are made up of rocks and other mineral particles, that are smaller than sand and larger than clay. The smooth and fine qualities of the soil hold water better than sand. Silty soil is mainly found near the river, lake and other water bodies; also, silty soil is easily transported by moving currents. Silty soil is more fertile compared to the other three types of soils. Therefore, it is used in agricultural practises to improve soil fertility. The following are the properties of Silty soil:

When dry: Clods moderately, difficult to break and rupture suddenly to a floury powder that clings to fingers; shows fingerprint.

When moist: Has smooth, sticky, velvety, or buttery feel; forms firm ball; may ribbon slightly before breaking; shows good fingerprint.

When wet: Smooth with some stickness from clay like; stains fingers.

(c) ***Clayey soil*:** Clayey soil has the larger proportion of clay particles and have the smallest particle size compared to other types of soils. The particles in this soil are tightly held together to each other with very little or no airspaces. This soil has very good water storage qualities and makes it hard for moisture and air to penetrate into it. It is very sticky when wet, but smooth when dry. Clay soil is the most dense and heavy type of soil, that does not drain well or provide space

for plant roots to flourish. Its properties may be summarised as follows:

When dry: Clod often cannot be easily broken even with extreme pressure.

When moist: Forms firm, easily moulded ball; squeezes out to a very thin ribbon of 5 cm or longer.

When wet: Stains fingers, clouds water; usually very sticky with stickness masking both smoothness and grittiness; and wets slowly.

(d) ***Loamy soil*:** Loamy soil is a combination of sand, silt and clay such that the beneficial property from each soil texture is included. For instance, it has the ability to retain moisture and nutrients; hence, it is more suitable for farming. This soil is also referred to as an agricultural soil as it includes an equilibrium of all the three types of soil materials namely sand, clay, and silt, it also has humus. In addition, it has higher calcium and pH levels because of its inorganic origins. Textural-wise, it is the most difficult soil to place since it possesses all the characteristics of sand, silt, and clay but none of them predominates. The textural properties of loam soil can be summarised as follows:

When dry: Clods slightly difficult to break; somewhat gritty.

When moist: Forms firm ball; ribbons poorly; may show poor fingerprint.

When wet: Gritty; smooth, and sticky all at the same time. Stains fingers.

Importance of soil texture in agricultural production

Soil texture is fundamental to soil properties and their impact on plant growth and overall farm productivity (refer to Table 13.1). Texture influences soil behaviour in many ways. It is an important factor in water retention and availability, soil structure, aeration, drainage, soil workability and capability of supporting agricultural traffic without degrading soils, soil biodiversity as well as the supply and retention of nutrients. It is for this reason that determining soil texture is of great importance in agricultural production.

Table 13.1: Soil properties associated with soil texture

S/N	Property/Behaviour	Extent associated with soil particles		
		Sand	Silt	Clay
1.	Water holding capacity	Low	Medium	High
2.	Aeration	Good	Medium	Poor
3.	Drainage/infiltration	High	Medium	Very slow

S/N	Property/Behaviour	Extent associated with soil particles		
		Sand	Silt	Clay
4	Decomposition rate of soil organic matter	Rapid	Medium	Slow
5.	Compactibility	Low	Medium	High
6.	Susceptibility to wind erosion	Moderate	High	Low
7.	Susceptibility to water erosion	Low	High	Low
8.	Easiness to swell and shrink	Very low	Low	Moderate to very high
9.	Suitability for tillage after rain	Good	Medium	Poor
10.	Ability to retain plant nutrients	Poor	Medium	High
11.	Soil organic matter level	Low	Medium	High
12.	Resistance to pH change	Low	Medium	High
13.	Sealing of ponds, dams, landfills	Poor	Poor	Good
14.	Easiness to leach pollutant	High	Medium	Low

Note: Soil texture remains fairly constant and is not altered by management practices.

Soil structure

Soil particles do not exist independently as single grains. Instead, they are bound together in clusters called aggregates or peds. The binding of the soil particles is done by moist clay, organic matter and/or organic compounds. The arrangement of the individual soil particles in aggregates or peds within the soil refers to as soil structure. The shape and arrangement of soil aggregates within a soil determines soil structural type. There are major four soil structural types. These are sphere-like, plate-like, block-like and prism-like (refer to Figures 13.6 (a) to (d)). The sphere-like, plate-like, block-like and prism-like types are also termed as spheroidal, platy, blocky and prismatic structures, respectively. Spheroidal structure is commonly found in O-horizon, platy in A-horizon while blocky and prismatic structures exist in B-horizon.

(a) Sphere-like/Spheroidal type

(b) Plate-like/Platy type

(c) Block-like/Blocky type

(d) Prism-like/Prismatic type

Figure 13.6: Soil structural types

Note: Soils which do not exist in these structural types are referred to as structureless soils. The structureless forms are common to soils that are mainly formed by sand or clay particles. The former are single grains while the later exists in massive form.

Determination of soil structure type

To determine soil structure type preferably of the top soil, follow these steps:

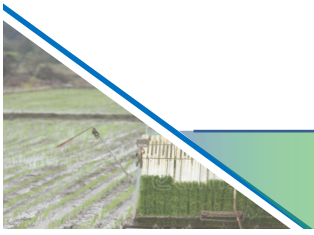
(i) Dig a hole about 20 - 30 cm deep.
(ii) Take a slice off the side and carefully lift it out so that it stays intact.
(iii) Lay the slice on its side to examine it.

Alternatively, drop test can be used. This involves taking off slices of soil sample at a depth of 20 - 30 cm, dropping them at about a metre high, grading the clods according to size, and thereafter identifying the structure type of a given soil.

Activity 13.3

Under guidance of your teacher, perform the following tasks.

1. Dig a hole about 20 - 30 cm deep.
2. Take slices off the side and carefully lift it out so that it stays intact.
3. At about one metre high, drop the soil slice onto the wooden square in the plastic basin. Any other thing with hard surface in the plastic basin or polythene sheet can be used.
4. Repeat number (iii) three times, every time for new slice.
5. If there are large clods which did not break out, collect and drop them individually.
6. Transfer the soil onto the trays and grade so that the coarsest clods are at one end and the finest aggregates are at the other end (refer to Figure 13.7).



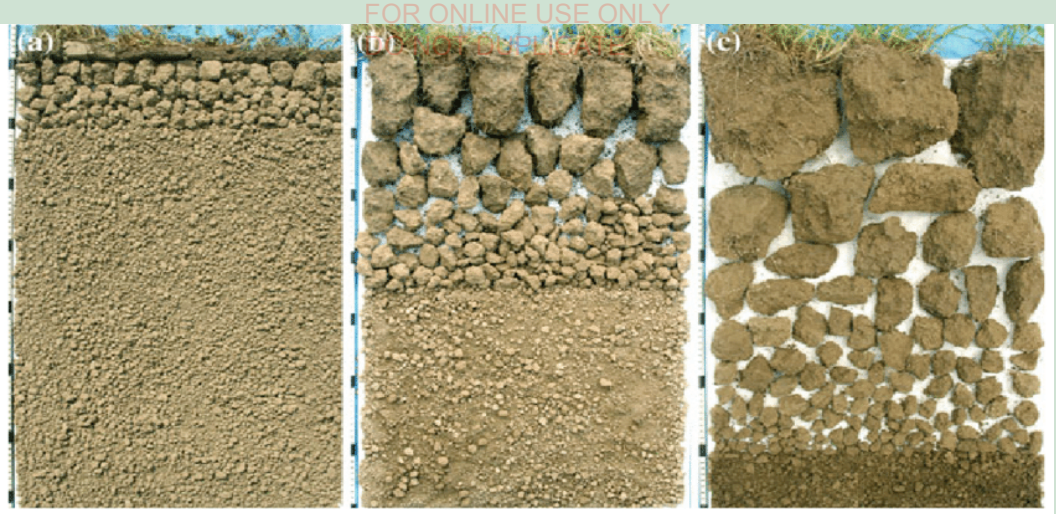


Figure 13.7: Soil aggregates sorted according to size

7. Identify the structural type(s) of the soil laid out on the trays. You may use photographs or field guide to aid identification.
8. Record your observations and present your findings in class for discussion.

Importance of soil structure in agricultural production

Soil structure in isolation is not a plant growth factor, however it influences almost all plant growth factors. Soil structure influences water movement, aeration, heat transfer, and porosity. For example, granular soils with a loamy texture are the best for farming of most crops because they hold water and nutrients well. Single-grained soils with a sandy texture don't support most crops because water drains out too fast. Platy soils, regardless of texture, cause water to pond on the soil surface hence they can't support growth of crops which are not water loving.

Influences of agronomic practices on soil structure

Agronomic practices such as ploughing, cultivation and manuring can bring about a change in soil structure. For example, heavy machinery or continuous cropping may weaken the soil structure. For good growth, development and yields of crop plants, the soil must have a good structure. Good soil structure can be enhanced by practices such as application of organic manures, tilling clayey soils at proper moisture content to avoid compaction as well as adopting crop rotation and mixed cropping.

Soil porosity

Soil porosity refers to the amount of pore spaces, or open spaces between and within soil aggregates. A pore space is the sum total of spaces not occupied by solid matter in the soil mass (refer to Figure 13.8).

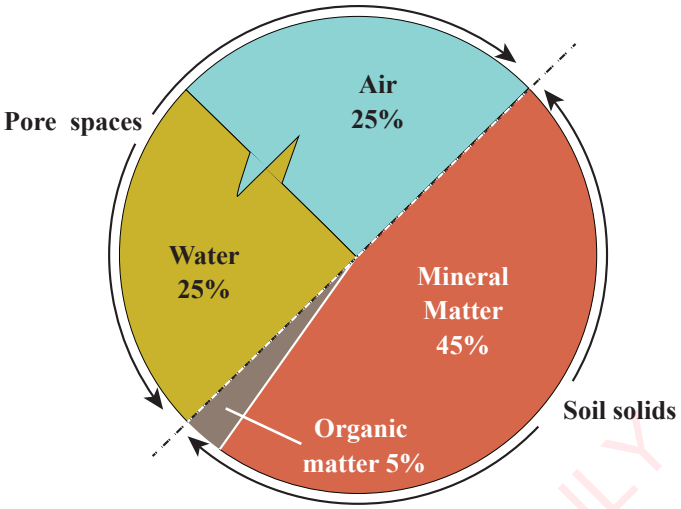
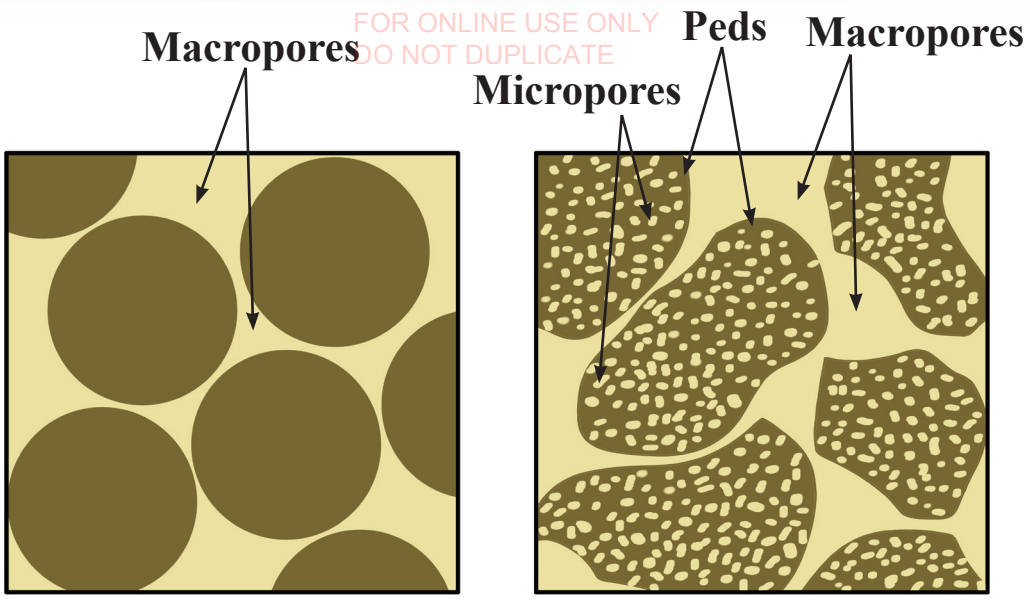


Figure 13.8: Distribution of pore-spaces and soil solids

These spaces are usually filled with water and air. Based on size, two types of pores are recognised namely, macro-pores and micro-pores. The macro-pores also known as non-capillary pores, are found between soil aggregates. They are bigger in size and allow free movement of air and water. They do not hold much water under normal conditions. The micro-pores, also known as capillary pores, are found within soil aggregates and they are quite small in size. The sum total of both pores together represents the total porosity of the soil. When expressed as percentage of the total soil volume, it is called percentage pore-space or soil porosity.

Pore spaces may be formed due to the movement of roots, worms and insects, expanding gases trapped within these spaces and/or the dissolution of the soil parent materials. Soil texture and structure can also influence porosity by determining the size, number and inter-connection of pores. Coarse-textured soils have many large (macro) pores because of the loose arrangement of larger particles with one another. Fine-textured soils are more tightly arranged and have more small (micro) pores (refer to Figures 13.9 (a) and (b)). Macro-pores in fine-textured soils exist between aggregates. Because fine-textured soils have both macro-pores and micro-pores, they generally have a greater total porosity, or sum of all pores, than coarse-textured soils.



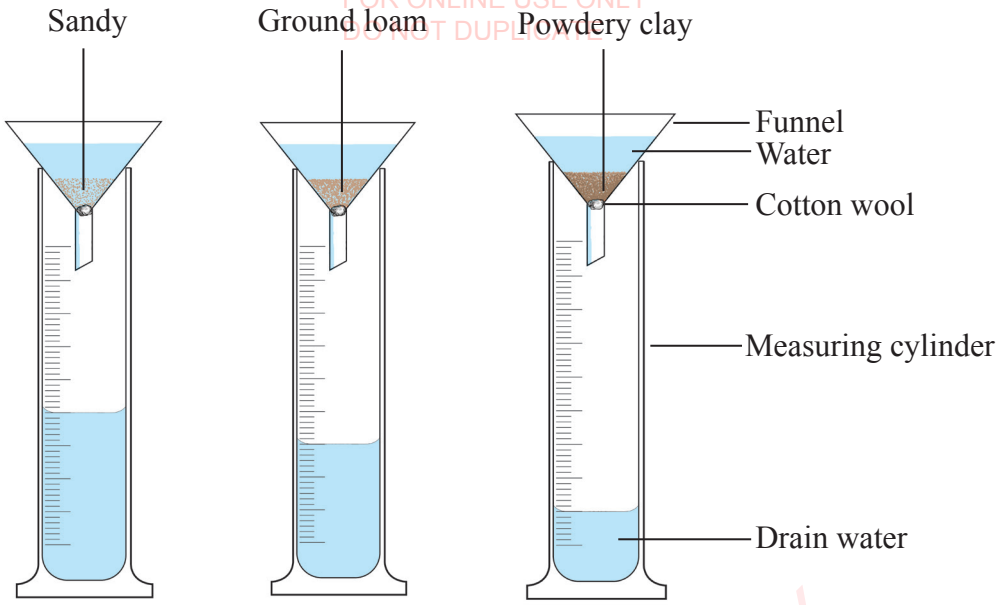
(a) Loose structured sand particles (b) Aggregated clay particles

Figure 13.9: Generalised porosity in sandy and clayey soils

Activity 13.4

Under guidance of your teacher, perform the following tasks.

1. Prepare apparatus and materials for carrying out an experiment to compare porosity and water holding capacity of the major three soil types, that is, Sandy, Clayey and Loamy. These include measuring jars, funnels, cotton wool, water, stop-clock as well as dry sand soil, dry clay soil, dry loam preferably with high proportion of organic matter.
2. Crush all the soil samples except the sandy one into fine particles after they have been dried in the sun.
3. Place equal volumes or masses of the dry sand, clay and loam soil into separate funnels plugged with cotton wool.
4. Tap the funnels carefully and persistently on the working bench until all visible air spaces are filled.
5. Stand each funnel in the open end of 100 cm^3 measuring cylinder as shown below. Then, quickly pour 50 cm^3 of water into the funnel containing each soil sample.



6. Note the time taken for the first drop of water to drip through into the measuring cylinder. In each case, allow the same amount of time after which the level in the measuring cylinder is read. If necessary, allow the apparatuses to stand overnight and then measure the volume of water which passed through in each case.
7. Find the volume of water retained in all cases by subtracting the volume of water drained from the volume poured.
8. Record your observations and present your findings in class for discussion.

Importance of soil porosity

Soil porosity is an important soil property for many reasons. Soil pores contain ground water. Another important aspect of soil porosity relates to the oxygen found within these pore spaces. A well-aerated soil is important for growing crops.

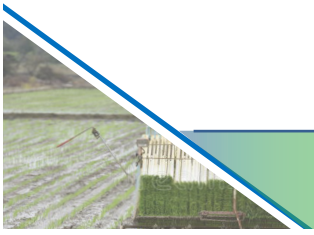
Influences of agronomic practices on soil porosity

Unlike texture, porosity is not constant and can be altered by management, water and chemical processes. Long-term cultivation tends to lower total porosity because of the decrease in soil organic matter and large peds. Soil compaction by construction equipment or our feet decrease porosity and inhibit water entry into the soil, possibly increasing surface run-off and erosion. It also impacts negatively the ability of soil to provide oxygen. Generally, increasing soil organic

matter levels, reducing the extent of soil disturbance, and minimising compaction and erosion improves structure and ultimately increases soil porosity.

Exercise

1. Explain the concept of texture, structure and porosity of the soil.
2. Show the relationship between texture, structure and porosity of soil.
3. Describe different soil types and their properties.
4. Explain how management practices affect soil physical properties.
5. Explain how the physical properties of soil affect crop production.
6. Define the term soil porosity. Why is soil porosity important in agricultural production?



Revision exercise

Choose the most correct answer from the given alternatives.

1. The genesis or evolution of soil from parent materials is called:
   (a) soil accumulation
   (b) soil formation
   (c) soil erosion
   (d) soil deposition
2. When a farmer grows two or more crops in one field at the same time in defined rows is referred to as:
   (a) intercropping
   (b) mixed cropping
   (c) inter-planting
   (d) mixed planting
3. A term referring to the process of removing overgrown horns from cattle is known as:
   (a) cutting
   (b) disbudding
   (c) dehorning
   (d) removing
4. The process of loosening the soil using a machine in order to make it conducive for planting is termed as:
   (a) cultivation
   (b) digging
   (c) ploughing
   (d) harrowing
5. Useful plants, which are selected and managed in the farms for human and animal consumption are referred to as:
   (a) vegetable crops
   (b) crops
   (c) oil crops
   (d) tuber crops

6. A special room or shed for the maintenance and repair of farm tools and equipment is called:
   (a) kitchen
   (b) store room
   (c) farm workshop
   (d) laboratory

7. Which one of the following are examples of primary tillage implements?
   (a) disc plough and chisel plough
   (b) sub soiler and disc harrow
   (c) disc harrow and spiked tooth harrow
   (d) spiked tooth harrow and spring tined cultivator

8. The poorest type of soil for growing plants because it has low nutrients and poor water holding capacity is called:
   (a) loam soil
   (b) silt soil
   (c) sand soil
   (d) clay soil

9. All of the following except one, are the criteria to consider when deciding on the best cropping system to use in a given field.
   (a) the best combination of the crop plants
   (b) nature of roots of the crop plants
   (c) growth habit of the plants
   (d) using monoculture in each successive crop rotation

10. The art and science of keeping livestock for producing a desirable animal output or services is called:
   (a) agriculture
   (b) livestock production
   (c) crop production
   (d) domestic animal

Write TRUE for the true statement and FALSE for the false statement.

1. Livestock is dealing with keeping animals.
2. Mixed cropping is the planting of crops in a piece of land in rows.
3. In an intensive system of keeping livestock, animals are allowed to move freely outside to search for food and taken back to their shed late in the evening.
4. Soil texture is a relative proportion to soil particles of different diameter.
5. A Jack plane is used to shave round objects.
6. A specific group of domestic animals which are similar in appearance, and other characteristics distinguishing it from other organisms of the same species, is called a breed.
7. Zebu, Ankole and Nganda are examples of indegenous cattle introduced in East Africa from Europe.
8. Ayrshire and Guernsey cattle breeds are comparative not adaptive to environment with high temperature.
9. Chicken, rabbits, goats, geese and ducks are some classes of poultry kept in Tanzania.
10. Some advantages of keeping pigs is that, they grow very fast and produce many offsprings at a time.

Match each statement from column A with its corresponding item from column B.

C:1

Part A	Part B
i. A branch of Agriculture which deals with the classification, conservation and management of soil for crop and animal production.	(A) Agricultural mechanisation (B) Agricultural economics (C) Soil science (D) Crop husbandry (E) Animal husbandry
ii. A branch of Agriculture which deals with the development and use of tools, implement and machines in crop and animal production.	
iii. A branch of Agriculture which deals with the study of supply and demand in relation to agricultural production.	
iv. A branch of Agriculture which deals with the aspects of animal health and production of animal products such as milk and eggs.	
v. A branch of Agriculture which deals with aspects of crop production such as planting, crop management, harvesting, processing and storage.	

C:2

Part A	Part B
i. A farm tool with a short handle and a long blade used for cutting woods, bushes and small trees.	(A) Rake (B) Planter (C) Maize sheller (D) Machete (E) A hoe
ii. A farm tool with a long wooden handle and a broad blade used for digging land and making mounds.	
iii. A farm tool with a long wooden or a metal handle used for levelling soils in seed beds.	
iv. The specialised machine used for sowing or planting crops.	
v. A machine used to separate maize from cobs and winnowing process.	

C:3

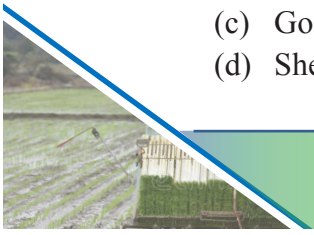
Part A	Part B
i. A tool used for trimming overgrown hooves of animals.	(A) Caustic stick
ii. A tool used to measure body temperature of an animal.	(B) Branding iron
iii. A chemical stick used to rub onto the horn buds to prevent growth of horns.	(C) Hoof trimmer
iv. A castration tool.	(D) Clinical thermometer
v. A tool with a long handle placed with the iron plate attached with either numbers, or letters for identification of animals.	(E) Burdizzo

C:4

Part A	Part B
i. A tool used to cut shapes like a curve or round on wood.	(A) Joiner mallet
ii. A tool used to drive chisels onto working woods.	(B) Tape measure
iii. A tool used for gripping and tightening pipe fittings while connecting pipe line in the field.	(C) Compass saw
iv. A tool used for checking if two objects such as walls are at right angles.	(D) Try square
v. Can be a right tool when measuring the size of a piece of land.	(E) Pipe wrench

Attempt the following questions.

1. Mention three types of each of the following tools:
(a) Planes.
(b) Saws.
2. Briefly describe the concept of soil formation as used in Agriculture.
3. Mention two types of each of the following livestock:
   (a) Cattle
   (b) Poultry
   (c) Goat
   (d) Sheep



4. Briefly explain how agriculture is applied in daily life
5. With the help of an illustration, describe the concept of crop rotation and how it can be applied in crop production.
6. Outline any three measuring tools, which are used in farm workshop.
7. (a) Define the term soil as used in agriculture.
   (b) Mention five constituents of the soil.
   (a) Explain the meaning and importance of farm mechanisation.
   (b) Identify any five farm activities that can be mechanised.
8. Improper use, storage and handling of farm tools and equipment may cause accident to the user. Describe any five precautions to be considered when handling farm tools and equipment to protect injuries.

Write an essay on:

1. The importance of agriculture to an individual and national economy.
2. Livestock farming systems. Use the following guidelines:
   (a) meaning and types of livestock farming system practiced in Tanzania;
   (b) three main features of each livestock farming system practiced in Tanzania;
   (c) challenges facing each livestock farming system; and
   (d) ways to overcome challenges facing each livestock farming system.
3. How Agriculture relates with any other five subjects you are studying at school.
4. Farm power. Use the following guide lines:
   (a) meaning of farm power;
   (b) sources and importance of each farm Power;
   (c) advantages and disadvantages of each identified farm power.
5. Livestock. Use the following guidelines:
   (a) classes and types of livestock kept in Tanzania; and
   (b) importance of livestock to the family and the nation.

Glossary

Aeration in soil — movement of oxygen into root zone.

Angiosperm — a flowering plant whose seeds are enclosed in an ovary.

Artificial Insemination — the injection of semen into the vagina or uterus by means of a syringe or a similar tool instead of a sexual intercourse.

Biogas — a mixture of methane and carbon dioxide produced by the bacterial decomposition of organic wastes and used as a fuel.

Botanical characteristics — a total of plant features needed to identify the species of a plant, which include leaf shape, leaf lobes and sinuses, apex, base, margin, venation, and texture.

Broiler — any chicken (*Gallus gallus domesticus*), which is bred and raised specifically for meat production.

Brooding. — a pattern of behaviour of certain egg-laying animals, especially birds, marked by cessation of egg laying and readiness to sit on and incubate eggs.

Cash crops — agricultural crops which are grown primarly for earning an income.

Cash economy-system — a system or a stage of economic life in which money replaces barter in the exchange of goods.

Deworming — removing worms from the digestive system particularly the stomach, intestines and the liver.

Food crops — are crops such as rice or wheat, which are grown primarly for human consumption.

Geomorphological features	relating to the form of the landscape and other natural features of the earth's surface created by physical, chemical or biological processes operating at or near the Earth's surface.
Geothermal power	the power that is generated using steam produced by heat coming from the melting centre of the earth.
Geysers	a hole in the Earth's surface from which hot water and steam are forced out.
Herbaceous	are vascular plants that have no persistent woody stems above ground, including many perennials, and nearly all annuals and biennials.
Humus	a brown or black material in soil that is formed when plants and animals decay.
Infiltration	entry of surface water into the soil.
Inter-row	the distance between rows, especially rows of a crop.
Intra- row	the distance between one plant and another in a row of crop plants.
Layer	any chicken that is bred and raised for egg production.
Milking	a process of draining off milk from the duct of the animal udder.
Paddocks	an enclosed area/field normally divided into portions used especially for pasturing or exercising animals.
Prolific	an animal, person, or plant that produces a large number of babies, young plants.
Restrain	prevent an animal or group of animal from action or motion.

Semen	fluid that is emitted from the male reproductive tract and that contains sperm cells, which are capable of fertilizing the female's eggs.
Slurry	a thoroughly homogeneous mixture of animal dung and water used as raw materials in biogas production.
Soil compactibility	easiness to be compressed e.g. by heavy machinery.
Soil horizons	layers parallel to the soil surface whose physical, chemical and biological characteristics differ from the layers above and beneath.
Specific epithet	the second element in the Latin binomial name of a species, which follows the generic name and distinguishes the species from others in the same genus.
Spermatophyte	a major division of the plant kingdom, characterised by reproduction by seed and subdivided into the gymnospermae (gymnosperms) and angiospermae (angiosperms).
Subsistence farming	a type of farming in which most of the produce (subsistence crop) is consumed by the farmer and his or her family, leaving little or nothing for sale.
Transplanting	the process of moving a fully germinated seedling and replanting it in a permanent location for the growing season.

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