AGRICULTURE

STUDENT TEXTBOOK

GRADE 12

ISBN 978-99990-0-077-2

2023

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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF EDUCATION

HAWASSA UNIVERSITY

First Published August 2023 by the Federal Democratic Republic of Ethiopia, Ministry of Education, under the General Education Quality Improvement Program for Equity (GEQIP-E) supported by the World Bank, UK's Department for International Development/DFID-now merged with the Foreign, Common wealth and Development Office/FCDO, Finland Ministry for Foreign Affairs, the Royal Norwegian Embassy, United Nations Children's Fund/UNICEF), the Global Partnership for Education (GPE), and Danish Ministry of Foreign Affairs, through a Multi Donor Trust Fund.

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The Ministry of Education wishes to thank the many individuals, groups and other bodies involved – directly or indirectly – in publishing this Textbook. Special thanks are due to Hawassa University for their huge contribution in the development of this textbook in collaboration with Addis Ababa University, Bahir Dar University and Jimma University.

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Printed by:

GRAVITY GROUP IND LLC

13th Industrial Area,

Sharjah, UNITED ARAB EMIRATES

Under Ministry of Education Contract no. MOE/GEQIP-E/LICB/G-01/23

ISBN:978-99990-0-077-2

Contents

Unit 1 Vegetable Crops Production and Management

Contents

- 1.1.Importance, problems and prospects of vegetable crop production in Ethiopia
- 1.2.Environmental factors influencing vegetable production
- 1.3 Classifications of vegetable crops
- 1.4.Types of vegetable crop production System
- 1.5.Principles of vegetable crops management

Learning Outcomes

At the end of this unit, you will be able to:

- Elaborate the importance, problems and prospect of vegetable crops production
- classify of vegetable crops
- list environmental factors that influence vegetable crops production
- describe types of vegetable crops production system
- state the principles of vegetable crops management

1.1. Importance, problems and prospect of vegetable crops production in Ethiopia

Brainstorming 1.1

Discuss the following questions in pairs in the classroom

- What are vegetables? What vegetable crops are produced in your locality?
- List some characteristics of vegetables.
- Explain the major benefits of vegetable crops.

Vegetables

Vegetables are plants whose fruit, seeds, roots, tubers, bulbs, stems, leaves, or flower parts are used as food.Vegetables are diverse in their growth cycles. Some are annuals. Others are biennials. Still others are perennials.

Key term

Herbaceous are plants that that have no persistent woody stems above the ground.

Vegetables constitute different types of plants including viny, shrubby, or tree in their growth habits. Vegetables are usually harvested fresh - when their moisture contents are high. This distinguishes them from field grain crops which are often harvested at mature stage. Vegetables are seasonal, perishable, and bulky in relation to their volume. They require intensive management. They are vulnerable to damage and cannot be stored for a long time.

1.1.1 Importance

The most important vegetable crops in Ethiopia include: pepper, Ethiopian mustard/kale, onion, tomato, potato, chili, carrot, garlic and cabbage. Others such as green beans, asparagus, broccoli, celery and cucumbers are also important. The major vegetables produced for domestic consumption are cabbages, tomatoes and garlic. Green beans and peas are mainly produced for export purposes.

In Ethiopia, vegetable crop production includes various important economic activities. Many smallholder farmers and large-scale commercial producers are engaged in vegetable production.

Key term

Smallholder farmers: are farmers that own an average landholding size of 0.9 hectare

They smallholders mainly produce vegetable crops for own consumption. Commercial private farms produce solely for the market.

It was estimated in 2018 that over 6.7 million households make their livelihood from vegetable production in the country. In addition, the country earns hundreds of millions of dollars every year from export of vegetables. Vegetables are mainly exported to the Middle East, to Europe and to the neighbouring countries like Djibouti and Somalia. Vegetables like tomato and chilli are among the major vegetables exported. This contributes to the national economy.

Smallholder farmers choose to grow vegetables due to the relatively shorter growth cycle of the crops. Compared to cereals, vegetables have a relatively higher value. Vegetable production has a higher potential to increase employment and household income. It is generally a profitable activity.

Productivity of vegetables is often higher than that of cereal crops. Compared to cereal crops, vegetables are often intensively managed. Vegetables usually require special care after harvest. Vegetables are highly perishable and need to be stored and transported carefully in order to preserve their fresh quality.

Public awareness about nutritional and health benefits of vegetables has been increasing recently. Public health advocacy on the role of vegetables in human nutrition and health has significantly raised public awareness about the place of vegetables in health.

An increased consumption of vegetables reduces hidden hunger (i.e., micronutrient deficiency) in children. Micronutrient deficiency is associated with the deficiency of essential vitamins and minerals. Vegetables such as spinach, tomato, etc. are often good sources of iron, zinc, and iodine.

Vegetables are rich sources of vitamin A, vitamin C (ascorbic acid), thiamine, niacin, folic acid and beta carotene. Beta carotene is responsible for the normal functioning of the visual process and the structure of the eye. Prolonged deficiency of Beta carotene leads to blindness. Leguminous and leafy vegetables are rich sources of proteins.

Another reason for an increasing demand for vegetables is the increasing prices of animal products like meat, milk and eggs. Vegetables are also raw materials for local processing industries. Local processing industries produce products like tomato paste and different juice types. Increased demand for vegetables has encouraged investment in the sector both by national and international commercial producers.

1.1.2 Potentials and opportunities

Vegetable production has enormous potential to contribute to the national economy and the livelihood of the farmers in the country. Ethiopia has

- favourable climate for production of various vegetable crops,
- abundant labour,
- vast land and water resources
- suitable regions for production of various types of vegetables

Ethiopia has diverse climate zones as indicated by altitudes ranging from 126 metres below sea level to 4620 metres above sea level. The altitude gives the country a wide range of climatic diversity. The climate varies from humid tropics to Alpine climates. These are suitable climates for vegetable production.

Key terms

Agro ecology: relationships organisms have among themselves and with the surrounding physical environment in agriculture.

Alpine Climate: Climate of high mountain regions/highlands.

Humid tropics: Regions with relatively high temperature throughout the year and where rainfall exceeds evapotranspiration for 75% of the year.

The land currently used for vegetable production is extremely small, given the huge potential for vegetable production in Ethiopia. However, vegetable production yields per unit area, as well as the amount of land used for production of the crops, is increasing. This is because of:

- an increase in public awareness about health benefits of vegetables,
- small scale irrigation
- the government support for investors
- incentives in the form of tax exemptions and other related benefits
- local demand for vegetables
- export of vegetables

In addition, vegetable production and management is intensive. This creates a remarkable size of employment opportunity. The income per hectare obtained from vegetable crops is higher than that obtained from cereals like teff or maize is more promising.

1.1.3 Constraints

Brainstorming 1.2

Think about the following questions independently and share your thoughts with the students sitting next to you

- What are the potentials for vegetable crops production in Ethiopia?
- Mention the major problems related to vegetable crops production in Ethiopia.
- Which of the problems are observed in your locality?

Ethiopia has a high potential for vegetable production. However, compared to cereal crop production, vegetable production and consumption in the country is low The major constraints are:

- inadequate knowledge of improved methods of production and marketing,
- low consumption of vegetables
- high cost of production inputs like fertilizers, improved seeds and pesticides
- poor management of vegetables,
- small size of vegetable processing facilities,

- poor soil fertility
- pests
- drought,
- postharvest losses,
- high price of fuel for pumping water for irrigation

1.2 Environmental factors influencing vegetable production

Brainstorming 1.3

Discuss the following questions in groups of 2 or 3 students

- What environmental factors influence vegetable crops production?
- How do the factors affect vegetable crops production?

Various environmental factors influence vegetable production. These factors are climatic (temperature, light, precipitation, etc.) and soil which include the chemical, physical and nutritional status of the soil and topographic factors. Biotic factors affecting crop production include insects, diseases and weeds.

1.2.1 Temperature

Temperature is an important environmental variable that affects various processes during plant growth and development. Among the processes affected by temperature are photosynthesis, respiration, transpiration, germination and flowering. Photosynthesis, respiration and transpiration increase with increasing temperature up to a certain point. Temperature also influences the shift from vegetative growth to reproductive growth stage. The effect of temperature on transition from vegetative to reproductive growth stages depends on the specific types of vegetable crops grown.

Temperature determines the types of crops that grow successfully in a given location and their yield levels. Vegetables have their minimum, maximum and optimum temperature ranges. Crops that originate in temperate regions have lower temperature requirements. Crops originating in tropical regions require warmer temperatures.

Soil temperature directly affects seed germination, root development and absorption of nutrients and water by the roots. Warmer soil temperature generally increases the rates of these processes. The size, shape and quality of harvestable parts of vegetable crops are also affected by soil temperature. Tropical and sub-tropical vegetables may be damaged at temperatures below 10 0C. This is called chilling injury.

Some vegetable crops require exposure to low temperature before moving from vegetative to reproductive growth stages. This process is known as vernalization. The Biennials and some of the cool season vegetables (e.g., onion, carrot, etc.) initiate flower formation after extended exposure to low temperature.

1.2.2 Water

Fresh vegetables contain a high level of water – often between 80% and 90% of their weight is made up of water. Also, for production of each kilogram of vegetable dry matter, about 322 litres of water is required. The following points demonstrate the roles of water in crop production:

- germination and growth of crops start only when water is available
- organic and inorganic compounds absorbed by plants are dissolved in water
- water is required in the process of photosynthesis
- water is important in cell division, enlargement and turgidity
- too little or too much water is harmful for plant growth
- water shortage during critical growth stages directly affects yields
- insufficient water supply during early plant growth stages results in the stunted growth of plants, and significantly reduces yield.

In addition, temporary shortage of water during critical growth stages (e.g., flowering, seed setting or germination) is damaging. For example, excess moisture from rainfall or irrigation can damage vegetable seedlings. It can also wash away plant nutrients from the soils. Excess moisture can erode soils and cause flooding. Floods can damage harvested vegetable crops and causes crop diseases and loss of yield.

1.2.3 Light

Key term

Succulent: a plant such as a cactus in which the leaves and stem are thick and can store a lot of water

Light is the key element in photosynthesis. Plants grown in full light develop vigorously with high chlorophyll amount and high photosynthetic activity. Plants grown in reduced light have lower chlorophyll amounts and are often succulent. Flowering and seed production by the length of the night is an example. The length of the light period (also called day length) and its quality varies according to the season of the year, altitude and latitude.

Some plants change their growth in response to day length. Long-day plants flower when the night is short (usually less than 12 hours). Short day plants flower when the night is long (usually more than 12 hours). Plants that are not affected by day length are called day-neutral plant. These plants can flower under any light period.

Table1.1. day length of some vegetable crops.

Short day	Day neutral	Long day
Sweet potato	Cucumber	Spinach
	Tomato	Onion
	Pepper	Cabbage
	Eggplant	Carrot
	Artichoke	Potato

1.2.4 Humidity

Humidity refers to the amount of water vapour in the atmosphere. High levels of atmospheric humidity is often associated with incidence of crop diseases and pests.

Humidity affects plant growth and development through its effect on plant transpiration from leaves. In humid atmosphere, the stomata open and allow diffusion of carbon dioxide, oxygen and water vapour. This allows active photosynthesis and nutrient absorption. Very high humidity could cause increased germination of certain fungal species. This damages the plants. Excessive humidity could also close stomata which would mean overheating of plants as it limits evaporative cooling. Low humidity is also harmful for the plant. It may result in increased transpiration and this may attract some pest types. Green plants convert water absorbed through root and carbon dioxide absorbed through the leaf into carbohydrates in the presence of sunlight through photosynthesis and produce oxygen (See Figure 1.1.).

Table 1.2. Vegetables that require high or low Humidity

Vegetables that require High Humidity	Vegetables that require Low humidity
Cabbage	Peppers
Carrots	Sweet potatoes
Lettuce	Watermelon
Onion	Cucumber
Spinach	Squash
broccoli	Tomato
	pumpkin
	potatoes

Source: Jeannie Nichols (2014) and Jim Myers (2011)

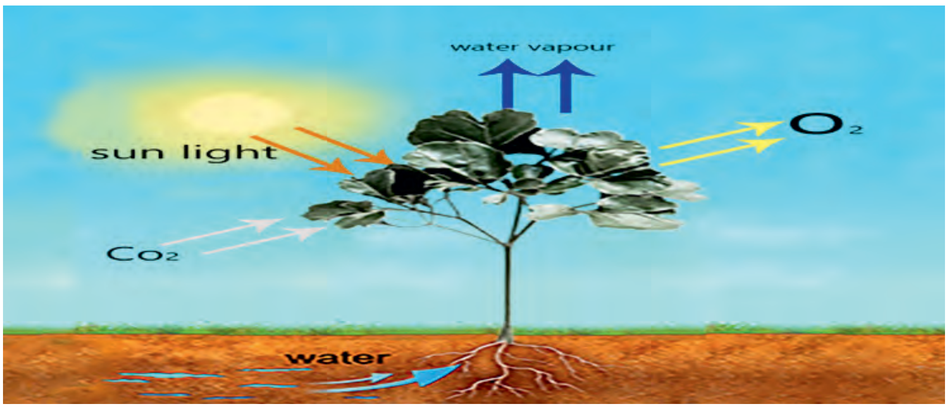


Figure 1.1.The process of photosynthesis in plants

1.2.5 Altitude

Temperature and rainfall of an area are determined by the altitude of the area in relative to sea level. With 100m increase in altitude, there is 0.6 0C decrease in temperature. This affects vegetable production. Vegetables vary in their temperature and water requirements. In Ethiopia, the highlands have high rainfall and low temperature. This is often suitable for vegetable production. The lowlands have lower rainfall, but higher temperature and are less suitable for vegetable production.

1.2.6 Soil

Soil type, soil fertility and soil structure contribute to the growth and yield levels of crops. The type of soil determines whether or not it stores sufficient water for plants to grow. It also determines if soil compaction or water lodging may be a problem.

Slow emergence and seedling growth in compacted soils increases a time a vegetable plant is vulnerable to disease, insects and weeds. The soil provides nutrients, water and physical support for roots of plants.

Soil texture refers to the particle size the soil contains. The relevant particles are: sand, silt and clay. Sand has the biggest size of the three. Silt is of medium size. Clay is the smallest size particle. Sandy soils have predominantly high level of pore space. This allows the availability of air and free drainage. It does not however, store much water for plants. Clay-dominated soils drain very slowly and can cause excess water accumulation. This, in turn, causes shortage of air for roots and soil organisms.

. **Key terms**

Compaction: is process in which soil is pressed down, (e.g., by heavy loads) and becomes very firm with little space between its particles.

Pore space: refers to the space between soil particles. It is used for air circulation and water storage. Roots grow into the soil through the pore space.

1.2.7 Biotic factors

Biotic factors refer to organisms like bacteria, fungi, nematodes, viruses, weeds and animals. The presence of these harmful organisms in the environment limits crop productivity. Vegetable crop selection should consider the adaptability of the crop to a given environment and resistance to common diseases and pests.

1.3 Classification of vegetable crops

Brainstorming 1.4

Answer the following question independently and share your answers with your classmates

- What types of vegetable crop do you know?
- List the criteria for classifying vegetable crops.

Vegetables can be classified into different groups. .

Root vegetables: These are vegetables whose roots are consumed as food. These include: carrot, garlic, radish, cassava, sweet potato and beet..

Leafy Vegetables: These are vegetables grown for their leaves or stems. Cabbage, Swiss chard, celery, lettuce and asparagus are some examples of this vegetable type.

Flower Vegetables: The flowers of 'flower vegetables' are consumed. Cauliflower and broccoli are examples of flower vegetables.

Vegetables can also be classified based on temperatures that produce optimum yields. The ability of the vegetable to flower, to set fruit and to produce seeds in different climatic region is important to consider. Vegetables can also be classified into warm season and cool season vegetable crops. Warm season vegetable crops are tropical and sub-tropical region vegetable crops while cool season vegetable crops are vegetable crops of the temperate region.

Figure 1.2 Major vegetable crops in Ethiopia

Warm season (tropical and sub-tropical) vegetables

Warm season vegetables are adapted to temperatures ranging from 18 to 29oC. These vegetables grow well only in warm areas. They cannot tolerate frosts. They are sometimes called tender plants. Cucumber, eggplant, pepper, snap bean, sweet potato, tomato and water melon are warm season vegetables.

Cool season (temperate) vegetables

These grow well in relatively cooler regions. Examples of such vegetables include broccoli, celery, cabbage, garlic, kale, onion, pea, radish and spinach. These crops require cool season to flower and to produce seeds. Cool season vegetables are referred to as 'hardy plants', as they can tolerate frost without injury.

The sizes of cool season (temperate) vegetables are often small. They are shallow rooted. They respond more readily to nitrogen fertilizer than do warm season crops. Table 1.2 classify some vegetables based on temperature requirement

Table 1.2.Classification of vegetables based on temperature requirement

Cool season crops	
Hardy	Asparagus, broccoli, Brussels sprouts, cabbage, collards, garlic, Kale, Leek, onion, parsley, pea radish, rhubarb, spinach, turnip
Semi-hardy	Beet root, Carrot, Cauliflower, celery, globe artichoke, lettuce, potato
Warm season crops	
Tender	Southern pea, snap bean, sweet corn, tomato
Very Tender	Cucumber, eggplant, lima bean, muskmelon, okra, pepper, Pumpkin, squash, sweet potato, watermelon

Vegetables can also be classified on the basis of their life cycle (phenology) or time they need to complete their life cycle.

Annuals: these are vegetable crops that complete their life cycle in a single year. Most vegetables are annuals, including spinach, lettuce and beans. Most vegetable crops are annuals.

Biennials: vegetable crops that require two growing seasons to complete their life cycle are called biennials. Examples include carrot, cabbage and beet. In the first growing season, biennials produce their vegetative parts, and during the second season, they grow their reproductive parts. Many biennials are sensitive to temperature, particularly for flowering.

Perennials: Perennial vegetables grow for more than two growing seasons. These vegetables can stay in production as long as ten years. Such crops include asparagus and artichoke.

Activity 1.1.

Form a group of 3 to 5 students:

- visit a nearby vegetable crops market and list the vegetable crops available.
- classify the vegetable crops into categories based on the edible parts and growth cycles

*prepare a summary report and submit it to your teacher.

1.4 Types of vegetable production systems

Vegetable production has evolved from primitive gathering of wild vegetables to more advanced and specialized types of vegetable production systems. There are several types of vegetable production systems.

1.4.1 Gathering of wild vegetables

This involves collection of edible parts from wild vegetable crops. Such crops include shola, wild mango tree, leaves of moringa(shiferaw) tree, sama (*Urticapilulifera*), water berry or 'Dokma', 'Agam' (*Carissa edulis)*, 'Kega' (wild Ethiopian rose) and others. Several weeds are also consumed as vegetables including Amaranthus.

1.4.2 Vegetables grown mixed with cereal crops

Ethiopian mustard grows mixed with maize crop. Taro and kale can grow mixed with coffee plants. Vegetables are most of the times is grown in places that cannot be used for growing cereals. The amount of vegetables grown in cereal fields is small.

1.4.3 Home gardening

Home gardening is the practice of allocating land close to the homestead for vegetable production. This system supplies much of the vegetable demand of the household. Home gardening can also be a source of income for the household. Various vegetables including fruit, seed, leafy and root vegetables are grown together. Such home gardens are very common in the Ethiopian smallholder farming systems. Household organic wastes can be used to fertilize the plots close to the house.

1.4.4 Commercial vegetable production

Commercial vegetable production is mainly market-oriented production that is dependent on market demand. This is common around urban centres. It supplies vegetables for the urban population. Such systems are usually intensively managed with generous use of agricultural inputs. Fertilizers, pesticides, irrigation and machinery are examples of such inputs. Commercial vegetable production centres are often located close to urban areas. This makes transporting vegetable crops to the market easy.

Activity 1.2.

Group work

- What vegetables(or products) do you and your family consume in a week? Compare your results with your classmates
- Are all these vegetables grown locally?

*Prepare a summary report and present it to the class.

1.5 Principles of vegetable crops management

Brainstorming 1.5

Discuss the following questions with your classmate

- What are the factors that determine the success of vegetable crops production in your communities?
- Which of the factors can we change and which ones can we not?

1.5.1 Site selection and management for vegetable crops

Selection and management of site for vegetable production involves taking into account the history of the site and soil properties. This includes land use history, soil pollution issues, availability and quality of water resources, etc. Site selection should also consider possible effects of adjacent crop production.

During site selection, the topography of the area should be taken into account. Gentle slopes are suitable for vegetable production. Steepness of the slope accelerates soil erosion. Conservation practices like terraces can also be implemented before using the area for vegetable production.

1.5.2 Sustainability management

Ensuring the sustainability of a farm can be assisted by recording reliable information. The following should be accurately recorded:

- the level of yield,
- crop varieties grown,
- quantity and type of fertilizer applied,
- quantity and type of pesticides applied,
- irrigation applied and other inputs used,

- soil analysis results,
- agricultural techniques used
- information about market, sales, market demand, prices, etc.

1.5.3 Planting material

When selecting the planting material to be used, factors that should be carefully considered include:

- adaptation to local conditions,
- resistance to pests and diseases,
- whether it meets the consumer demand in terms of product quality

The selected crop variety should be planted at suitable time of the season. The quality of tubers, bulbs and tubers is usually checked before use.

1.5.4 Integrated crop management

Crop rotation could be practiced in annual vegetable production to improve disease and pest control. Diverse crop rotations are effective in reducing pest/disease development. Over dependence on chemicals for crop pest and disease control should be avoided as much as possible. Planning of crop should consider previous crop protection practices used. Whether crop rotation is working or not could be checked by regularly recording information on:

- Whether yield is stable or increasing
- Whether pesticide use is decreasing or stable
- Stable or increasing organic matter levels
- Whether soil nutrient levels are stable

Chopping and incorporating of crop residues or organic fertilizer, like compost, could be used to improve the fertility status of the soil. This also improves nutrient and water storage capacities of the soil. During integrated crop management, a balanced nutrient supply for the crop is needed. A balanced supply produces quality vegetable crop with minimal nutrient losses.

In planning fertilizer application, it is necessary to consider nutrients coming from organic matter decay. Organic fertilizers and soil analysis show soil nutrient content and soil properties. The use of fertilizer should be limited to the intended crop area.

1.5.5 Water

It is important to use water in vegetable production economically. Soil moisture conservation practices should also be implemented to increase availability of water in dry areas. Irrigation with groundwater should be started only after assessment of the groundwater resources. If irrigation is used, the amount and timing should be in accordance with the crop requirement. The quality of irrigation water is very important and should be monitored closely. Besides, fertilizers should be stored in dry and clean location. This avoids water contamination in the vegetable production area.

Profitability of Vegetable crop production

Marketing is one of the most important factors that determine the success of any crop production including vegetable. Marketing starts with the decisions made by producers including choosing the crop types and their varieties to be produced and deciding how the produces are delivered to the consumers with acceptable profits. Marketing does not begin after the crops have been produced, rather before their production. Different marketing alternatives need to be considered before the production of vegetable crops.

Vegetable crops can be grown as sole crop or mixed cropping system .Whatever the cropping system is used, the economics of their production should take care of. In this regard, seeds, fertilizers, pesticides and labor to perform different field operations including cultivation, management, harvesting, postharvest handling, marketing and etc. should be taken in to account during the production of a particular commodity. Pricing of a particular commodity should therefore balance the establishment of the market share of the produce and earning of an acceptable return. In this regard, the present chapter will make the students familiar with various steps involved in the calculation of cost of production and marketing of various vegetable crops so as to make the vegetable production successful.

A vegetable crop profit analysis (Indicative only)

Assume a farmer having 1 hectare of land and produced tomato crop. He harvested about 45 quintal or 4500kg in one cropping season.

- In most of the towns, a kilogram of tomato is sold at 25 birr on average.
- This sums up a gross income of 112,500 Birr in one cropping season.
- Estimated one season farm expenses (i.e., the cost of seeds, fertilizer, chemical, transportation, labor and other expenses) = 51,300 Birr
- Net profit per month: 112,500 - 51,300 Birr = <u>**61,200 birr per one cropping season.**</u>

Unit Summary

In this unit, you have learned that:

- vegetables are edible portions of plants excluding fruits and seeds., consumed as part of the main course of a meal, often eaten fresh or cooked
- vegetable crops can be classified based on edible parts, temperature requirement or growth cycles
- vegetables are rich sources of essential vitamins, minerals and plant proteins
- Ethiopia has diverse climates vast land and water resources and a large work force. These make possible the production of various types of vegetable crop.
- the high potential for vegetable crop production in the country should be exploited to enhance the national economy as well as improve food and nutritional security
- temperature, light, water, humidity, soil and altitude are important environmental factors affecting vegetable production
- Vegetable production systems vary from simple gathering of wild vegetables to a more sophisticated commercial production.

Review Exercise

Part I. Match items under column A (examples of vegetable crops) with items under column B (types of vegetables) and write the letter of your choice on the space provided

	A	B
_________1.	Carrot and Cassava	A. Flower vegetables
_________2.	Celery and asparagus	B. Immature fruit vegetables
_________3.	Cauliflower and broccoli	C. Leafy vegetables
_________4.	Cucumber and eggplant	D. Mature fruit vegetables
_________5.	Pumpkin and tomato	E. Root vegetables

Part II. Choose the best answer from the given alternatives.

1. One of the following makes vegetables different from cereal grains
   A. Vegetables are mainly consumed fresh
   B. Vegetables have moisture contents up to 90% when consumed
   C. Often, the vegetative parts of vegetables are consumed as food
   D. All are correct answers
2. Vegetables are usually rich sources of
   A. Vitamins
   B. Minerals
   C. Carbohydrates
   D. A and B
3. Vegetable production by smallholder farmers in Ethiopia is important because they:
   A. are high value crops and increase household income
   B. create employment opportunities
   C. contribute to the national economy
   D. all are correct
4. The edible part of which of the following vegetables is their flower?
   A. Broccoli
   B. Cabbage
   C. Carrot
   D. Pepper

5. One of the following vegetables is a good source of proteins. Which one is it?
   A. Sweet potato
   B. Carrot
   C. Green beans
   D. A and B
6. Which one of the following is a warm season vegetable crop?
   A. Carrot
   B. Celery
   C. Tomato
   D. Cauliflower
7. One of the following environmental factors affects vegetable crop production. Which one is it?
   A. Temperature and Water
   B. Soil
   C. Topography
   D. All

Part III. Give short answers to the following questions.

1. What are the different types of vegetable crops production systems? Which of the systems is commonly practiced in Ethiopia?
2. List the major principles that should be followed during vegetable production and management?
3. How does altitude of an area affect vegetable crops production?
4. Does integrated crop management affect vegetable production? How?
5. What are the major constraints to vegetable production in Ethiopia? Can you suggest possible solutions to the problems?

Unit 2 Fruit Crops Production and Management

Contents	Learning Outcomes
2.1.Definition of some common terms	At the end of this unit, you will be able to: ▪ define common terms in fruit crops ▪ list the importance, problems and prospect of fruit crops production in Ethiopia ▪ classify fruit crops ▪ explain the principles and techniques of fruit propagation ▪ describe the importance of planning to establish fruit crops nursery site and the management of orchards ▪ produce and manage some fruit crops in their school and/or home garden
2.2. Importance, problems and prospect of fruit crops production in Ethiopia	
2.3 Classification of fruit crops	
2.4.Principles and techniques of fruit propagation	
2.5. Establishing a nursery	
2.6.Management of Orchards	
2.7.Factors influencing the quality of fruit crops during harvest and post-harvest	
2.8. Floriculture and Landscaping	

2.1 Key terms in fruit production

Fruit crop: is a perennial, edible plant cultivated for its true botanical fruit or products derived there from.

Fruit set: refers to the persistence and development of an ovary after flowering.

Orchard: a farm land allocated for growing fruit crops

Asexual propagation: is a vegetative reproduction or propagation where fertilization is not involved in the production of the crop.

Chilling injury: injury from prolonged exposure to low, non-freezing temperatures. Chilling injury affects tropical fruits. The injury results in discoloration, pitting, and flesh breakdown in susceptible species.

Chilling requirement: The time of exposure to cool, nonfreezing temperatures during winter. This allows normal bud break and development to take place the following spring.

2.2. Importance, problems and potential of fruit crops production in Ethiopia

Brainstorming 2.1

Do the activities below individually.

- What are fruit crops?
- List some of the importance of fruit crops production in your area.
- Mention some problems of producing fruit crops in your surroundings.

* Share your answers with the whole class.

2.2.1. Importance of Fruit crop production in Ethiopia

Fruits are inexpensive source of energy. They contain nutrients, minerals and vitamins. Their nutritional value is highest when consumed fresh. Fruit crops can be produced for both domestic consumption and selling. This improves the household food security and income. The purpose of large-scale production of fruit crops goes beyond the local consumption. Fruit crops can be exported abroad. When exported, they are a good source of foreign currency for a country.

Fruit production is an important component of agriculture. Fruit production has a vital role to play in the farmers' livelihood. The activity can contribute to the food and nutritional security of the producing communities. Fruit production is automatically profitable and good for the environment.

Fruit production enhances natural resource conservation and maintenance. The activity is also vital in diversifying the national economy. Fruit crops production is the basis for establishing agro processing industries. Agro processing industries markedly reduce unemployment. There is an increasing public awareness about the nutritional and health benefits of fruits in Ethiopia today. This has resulted in an increase in the market demand. Major fruit crops produced in the country include pineapples, passion fruits, bananas, avocados and, mangoes. Similarly, citrus fruits, mandarin, papaya, guava and grapes are among the major fruit crops in the country.

2.2.2. Problems of Fruit crops production in Ethiopia

Fruit production is relatively new to Ethiopian agricultural system. The introduction of a commercial fruit production were introduced in the late 1960s and the early 1970s (Godfrey-Sam-Aggery and Bereke Tsehai, 1987). Most indigenous fruits are wild. Most fruits produced in the household gardens and on commercial farms are recent introductions into the country. Their management is also new to producers, merchants and consumers.

Fruit production and utilization have many technical, economic and social problems that must be identified and tackled to make the industry viable and sustainable. This needs the effort of producers, processors, merchants and researchers. Very few small-scale commercial farms produce fruits primarily for local consumption.

Some farmers produce fruits for local markets, particularly in the areas most suitable for fruit production. About four decades ago, fruits used to be sold only at hospital gates even in Addis Ababa. Over the last few years, however, some changes have been observed in the production, marketing and consumption of fruits in Ethiopia. This has given rise to an encouraging increase in the number of fruit shops in big cities.

Fruit production is very low in the Ethiopian highlands. In such places, there is an acute shortage of fruits. Children in places like this collect and consume indigenous fruits such as 'Agam', 'Kega', 'Shola' and 'Koshim'.

Success in modern fruit production depends on knowledge, skill and technical competences of the producers. Technical knowledge in proper production, management and storage is lacking among most small scale producers. This limits productivity of the fruit sector.

2.2.3. Prospects of fruit crop production in Ethiopia

In recent years, the nutritional benefits of fruits have been recognized. This has fairly increased the demand for fruit consumption. Ethiopia has diverse agro-ecologies, ample water resources and cheap labor. These can enhance fruit production in the country. Also, Ethiopia is located close to the Middle East and European markets. The government has introduced and implemented attractive policies to enhance the contribution of the fruit production sector to the overall economy. Given all these, the sector has a huge potential to improving the livelihood of fruit-producing communities. If fully exploited with proper production and management systems, the sector has a promising potential to markedly support the national economy.

2.3 Classification of fruit crops

Fruits are classified into groups based on certain criteria. They can be classified on the basis of structure, temperature requirement, and plant characteristic, ripening response or response to ethylene.

2.3.1 Classification based on structure

All fruits may be classified into three major groups on the basis of the number of ovaries and flowers involved in their formation. Simple fruit, aggregate fruit, and multiple fruit are the classifications.

Simple Fruits

Simple fruits develop from a single mature ovary in a single flower. Examples: apple, grape and citrus fruits. Simple fruits can further be classified into the following:

1. **Fleshy Fruits:** pericarp fleshy at maturity. Example: grapes, bananas
2. **Dry Fruits:** pericarp dry at maturity. Example: coconut, peanut

3. **Dehiscent fruits:** These are examples of fruits that dehisce or split open when fully mature. Example: silique
4. **Indehiscent fruits:** Indehiscent fruits do not split open; they do not release seeds at maturity. Example: Pome, sunflowers

Aggregate Fruits

Aggregate fruits consist of a number of mature ovaries formed in a single flower and arranged over the surface of a single receptacle. The individual ovaries are called fruitlets. Example: strawberry

Multiple Fruits

Multiple fruits consist of the mature ovaries of several flowers fairly united into a mass. Example: Pineapple

Figure 2.1.Classification of fruits based on their structure (a) simple (apple, middle), (b) aggregate (strawberry, left) or (c) multiple (pineapple, right)

2.3.2 Classification based on temperature requirement

Tropical fruits: Tropical fruits are fruits which grow in a year-round summer-like growing season without freezing temperatures. Examples: Banana, pineapple, papaya, mango and guava

Sub-tropical fruits: These fruit types cannot tolerate severe winter temperatures; they need some winter chilling. Example: citrus, figs, and olives.

Temperate fruits: require a cold winter season as well as a summer growing season. They can survive **temperatures considerably below a**

freezing point. Examples are apples, cherries and peaches.

Figure 2.2: Common fruit crops grown in Ethiopia

2.3.3 Classification based on ripening/ response to ethylene

Fruits can be divided into two groups: Climacteric fruits and non-climacteric fruits. The classification is based on the regulatory mechanisms underlying their ripening process.

Climacteric fruit: These fruits are characterized by a ripening-associated increase in respiration and in ethylene production. The ethylene is the major trigger and coordinator of the ripening process. E.g. tomato, apple, pear, and melon.

Non-climacteric fruits: are characterized by the lack of ethylene-associated respiratory peak and the signaling pathways that drive the ripening process e.g. grape, orange and pineapple.

2.3.4 Classification based on plant characteristics

Tree fruit: These are fruits produced on trees like peach, plum, mango, citrus, avocado, guava, mango, coffee, apple, etc.

Small fruit: are fruits produced on shrubs like blackberry, raspberry, blueberries, etc.

Activity 2.2.

Group work

- Visit a local fruit shop/market and list the types of fruit available in the shop/market.
- Classify the fruits using one of the fruit classification systems.
- list what fruits are eaten in your household
- Individually, ask your parents about fruit consumption in their diets and estimate the amount consumed in the household in one week.
- discuss the relationship between fruit production and its consumption in the surveyed area.

*Report the summary of the group's finding and present/share it to the whole class.

2.4. Principles and techniques of fruit propagation

Brainstorming 2.3

Discuss in pairs.

- What techniques do growers in your area use to propagate fruit crops?
- Discuss the role of indigenous knowledge farmer's use in propagating fruits. in your local area
- What are the advantages and disadvantages of the techniques?

Crop plants can be propagated by either sexual methods or asexual (vegetative) methods. Both methods have their own advantages and disadvantages. Some crops can be propagated in both methods but others are propagated through only sexual or asexual method.

2.4.1 Sexual plant propagation

Sexual plant propagation is developing plant from seed. The method is also called seed propagation. The seed is made up of three parts: the outer seed coat, the endosperm and the embryo. The outer seed coat protects the seed. The endosperm is a food reserve while the embryo is the young plant itself.

Figure 2.3. Different fruit seeds

When a mature seed is exposed to a favorable environment, it germinates and begins its active growth. Pre-sowing treatments are methods applied to overcome seed dormancy.

Key term
Seed dormancy: A period during which seed is not growing.

This ensures rapid, uniform and timely seed germination that facilitates seedling production. Pre-sowing treatments are applied to seeds immediately before sowing. Most methods require from a few minutes to 24 hours. However, some pre-sowing methods require a few to several days.

Appropriate pre-sowing treatment methods depend on the dormancy characteristics of the seed being treated. The most common pre-sowing treatment methods to break seed dormancy are: soaking in hot/cold water, fire or heating methods, soaking in chemical or alternate wetting and drying.

Advantages of Sexual Plant Propagation

- It is the easiest and least expensive method of plant propagation
- Seedling trees are hardier and have longer life span
- Allows propagation of plants which are difficult to propagate by vegetative method e.g. papaya, phalsa, coconut, etc.

- The rootstocks for budding and grafting are obtained by means of sexual propagation
- Sexually propagated plants can be more resistant to pests and disease
- Poly-embryonic varieties (giving rise to more than one seedling from one seed) can be propagated by seed.

Disadvantages of Sexual Plant Propagation

- Seedlings take more time to bear fruits (late bearing)
- Quality of existing plants cannot be improved by sexual propagation
- Plants propagated sexually are large. This raises the cost of fertilization, pruning and spraying chemical.
- There is no guarantee about **genetic purity** of plant
- Identification of sex in seedling is not possible

The main requirement for sexual plant propagation is fresh, viable and quality seeds, seedbed, containers and nursery soil mixture. Containers are poly-bags and pots. Nursery soil mixtures are forest soil, sand, farm yard manure, usually in the ratio of 2:1:1, respectively.

Key terms

Viable seed: seed that is capable of germinating under suitable conditions.

Seedbed: an area of land tilled to produce a fine, firm and level soil surface, into which seeds will be sown.

Cross pollination: pollination of a flower with pollen from another plant of the same species.

Genetic purity: the degree of contamination of seeds caused by undesired genetic varieties or crop species.

2.4.2 Asexual Plant Propagation

Vegetative parts or fragments of plants such as leaves, stems, and roots are used for plant multiplication (propagation). These plant parts may be taken from a single mother plant or other from multiple plants. Asexually propagated trees are exact copies of their mother plants and bear the same type of fruit. The asexual methods most often are cuttings, air layering, and grafting, budding and micro propagation. The material used for asexual propagation is obtained from a plant in the adult phase. The plants created through asexual propagation and bear fruit upon receiving the external signal that induces flower development and will not have a juvenile phase unlike a plant from seed.

While saving seeds is a great practice, certain plants and trees are better propagated via cuttings. This is particularly the case with many fruit trees that cannot produce the same quality of fruit as their parent plant. People can get young sapling fruit trees from a nursery. Getting saplings from a nursery can be very costly; propagating from cuttings is inexpensive and easy.

People often expect that the apple trees they plant are going to supply a tasty fruit such as what they get from the apple trees in their backyard. In this case, cuttings, but not seeds - provide them with a replication of the apples they get from the parent tree. This implies the need for asexual propagation of the apples by cuttings.

Cuttings

Plants can be propagated by using cuttings in which apportion of a stem, root, or leaf is cut from the parent plant, placed under certain favorable environmental conditions and induced to form roots and shoots. This produces a new, independent plant which is identical to the parent plant. The stem cutting can be divided into three groups, according to the nature of the wood used: hardwood, semi-hardwood, and softwood cutting. The stem cutting is one of the most important plant propagation types in fruit propagation.

Figure 2.3.Cuttings used in the propagation of some fruit crops

The basic cutting technique is the same. The cuttings should be removed with a very sharp, clean knife from a branch of the tree. They should be at least 15cm long but not longer than 30cm. Leaves should be removed from the bottom half of the cutting. Any fruit or buds should also be taken off. The cut end of the cutting should then be dipped in a rooting hormone and put in a moist rooting medium.

Air layering

Key Term

Adventitious root is specialized root that develop from a non-root tissue part of the plant, such as stem, branch or leaves, rather than the

Air layering is an asexual plant propagation method. In air layering a portion of plant is forced to produce adventitious roots without detaching it from the parent plant. It is usually used in plant species that are particularly difficult to root. For example plants such as camellia, azalea, rhododendron, holly, etc. Air layering the intact stems allow a continuous supply of water, nutrients and plant hormones to the place of root development. Once the adventitious roots are developed, the plant is detached from the parent plant and starts to grow as an independent plant. This method is similar to propagation by cutting except that it is only detached from the parent plant after developing its own root system. When the roots are well formed, the air-layered branches are cut from the tree and either planted direct in the field or first planted in a container of soil and later set in the field.

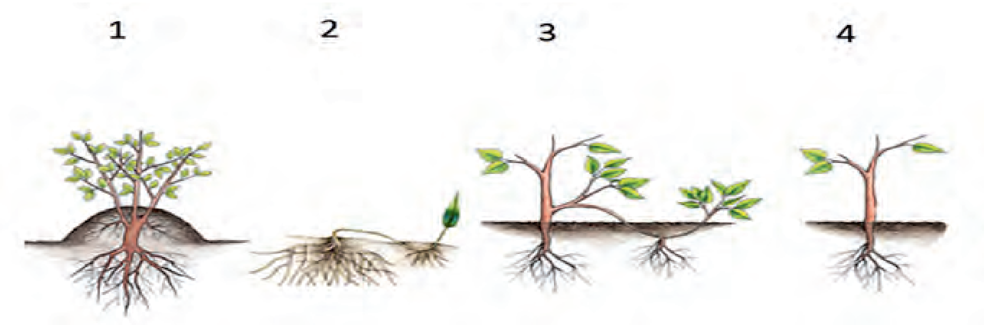


Figure 2.4. Air layering is performed in steps: 1) well developed stool (parent plant) is selected, 2) one shoot is bent to the soil while the others might be harvested, 3) the bending shoot starts to root while the harvested one re- grows and 4) the bending shoot becomes an independent plant

Grafting

Grafting is the joining of parts of plants together in such a way that they unite and continue to grow as a single plant. The part of the plant that becomes the upper portion or top of the new plant (canopy) is called the scion. The part which becomes the lower portion that includes the root system is called the stock or root stock. All methods of joining plants are called grafting.

Several grafting methods are used but, cleft or wedge grafting is the most common field level practice. Cleft or wedge grafting has a good chance of success. The stock and the scion must be compatible, or they will not unite. Grafting should involve only closely related species or plant families. For example, avocado is primarily propagated commercially by grafting upon seedling rootstocks.

Grafting requires experience and practice. The requirements below should be fulfilled to improve the performance of grafting method.

- Cambial regions of scions and stock must be in intimate contact for successful grafting
- Suitable variety should be selected both for stock and scion in terms of being healthy, strong and free from pests
- Cut surfaces should be held tightly for proper healing and flow of water and nutrients
- After grafting, all cut surfaces must be protected from drying out. This can be done by covering the graft area with wax or tape or some moist material
- Proper care must be given to the graft until the stock and scion unite
- Shoots from the stock must be removed to stop their competition for resources like nutrients and water with the scion
- Shoots from the scion can grow so vigorously that they break the scion off unless tied
- The grafting knife should always be kept razor sharp during grafting operations

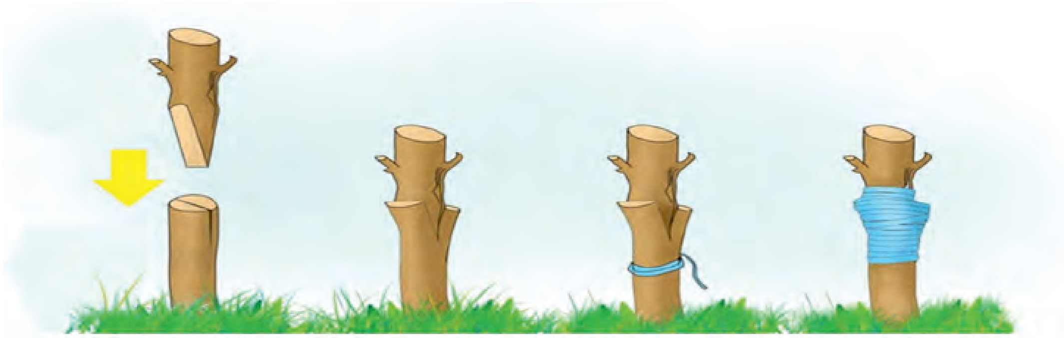


Figure 2.5: Wedge or V grafting

Key Terms

Cambial region: A layer of actively dividing cells situated between the xylem and phloem.

Root Stock: The basic root or stem onto which a scion is united to produce grafted fruit trees.

Scion: the upper part of one plant joined to the root stock in grafted **fruits or trees.**

Bud: a young shoot on a plant, which may later become a leaf or a flower.

2.5 Establishing a nursery

A nursery is a managed site, where plants are cared for during their early growth stages. The purpose of a nursery is to provide young plants with suitable conditions for germination and subsequent growth. The nursery plants stay in the nursery until they are ready and strong enough for planting in the main field. Young seedlings of tropical fruits need special care during early growth stages. For example, they need protection from severe heat from the sun. Heavy rain, drought, pests and diseases damage seedlings. The selection of a proper site is as important as the planting system. Planting distance is also a matter to be carefully considered. Successful fruit production involves proper selection of plants and their varieties.

Site selection for nursery

Proper site for nursery establishment should fulfill the following criteria:

1. The topography of the area should be gently slope
2. There should be a continuous and sufficient supply of water

3. The site should not be exposed to strong winds or protected with well-established windbreak
4. It should be well drained and have fertile soil
5. The area should be separated from production field but must be located near main field
6. There should be an adequate, dependable labor supply.
7. The area to be selected should be free from flooding
8. It should not be close to shade of trees or buildings

Seedlings

Seedlings could be raised in nursery beds or in polythene bags. Raising seedlings in polythene bags often gives better seedlings. This is because the tap root system is often not disturbed. It also saves labor for weeding and watering. Many problems in fruit production can be avoided by taking good care at the nursery stage of fruit development.

Nursery management includes activities like getting the right planting material from the parent plant. Getting the right planting material is followed by planting the seed. Young seedlings emerge not very long after planting the seed.

At the seedling stage, many fruit trees might show twisted or poorly developed roots or stems. Such seedlings should be discarded. They have very little chance of becoming good plants or root stocks. Only seedlings with straight stems and roots should be transplanted to the nursery pots or bags.

Figure 2.6. Mango seedlings in polythene bags in a nursery

Activity 2.2.

Group work

In a small group, visit a nearby nursery and find out

- the types of fruit seedlings grown there.
- the management methods at the site

**Report your findings to the other groups in the class.

2.6. Management of Orchards

Orchard is land allocated exclusively for fruit production. Establishment of an orchard requires planning. It takes a long time to establish good orchard. One of the most important considerations is the availability of resources. Site selection is the most important decisions that determine the success of a planting of fruit trees or orchard. Production site affects various aspects of the yield, its quality and marketability. Good fruit production sites provide maximum fruit trees per hectare.

Land preparation, preparing holes and planting of the fruits are important practices in orchard establishment and management. Seedlings have to be carefully planted into the prepared holes. This requires care not to break or bend the tap roots. The fertility status of the land is needed to be considered in the use of fertilizers on the site.

Planting and planting distance

Planting distance (spacing) is mainly determined by the type of fruit crop to be grown. Fruits can grow to big trees like mango or relatively small plants like banana and papaya. In addition to crop species, varieties could also determine fruit growth pattern and the spacing during planting. For example, the canopy of some fruit varieties could be narrow or wide. For fruit trees of wide canopies, a wide spacing is needed. Sexually propagated plants are usually larger than vegetative propagated ones and that affects spacing.

Soil quality and amount of rainfall in non-irrigated areas can also determine tree growth and size. Simply by looking at the soil quality and rainfall patterns, one can fairly determine the spacing of a given fruit crop.

In a good soil with irrigation, a planting hole slightly larger than the container that holds the root-ball can be used. This is normally a 30 by 30 cm or a 50 by 50 cm hole made using shovels or augers. The whole should be 80-100 cm deep. When a hole is dug, the topsoil should be kept on one side and the subsoil on a separate side since they normally differ in quality. The topsoil is a better quality. Before planting, mix the topsoil with organic matter such as mature moist manure or decomposed coffee husk. It is important to fill the hole to the 40–50 cm mark of the 80–100 cm depth, then topsoil is added to about 30 cm from the soil surface and compacted by stepping on the materials in the hole. Table2.1 shows the spacing used for some common fruit crops and the corresponding plant population per hectare.

Figure 2.7. Apple trees planted at regular spacing

Table2.1.The spacing of some fruit crops and plant population per hectare.

Fruit crop	Permanent spacing (m)	Trees per hectare
Avocado	9 x 12	93
Guava	6.2 x 7.6	212
Mango	10 x 10	100
Papaya	2.4 x 3.1	1344
Pasion fruit	3.3 x 4.0	1324

Source: (SNV Vegetable, Root, and Tuber Crops Production and Management Mannual, 2019).

2.6.2. Irrigation

Irrigation is the practice of applying controlled amount of water to land to help grow crops, landscape plants and lawns. Irrigation has been a key aspect of agriculture for over 5,000 years and has been developed by many cultures around the world. Irrigation helps to grow crops, maintain landscapes, and vegetate disturbed soils in dry areas and during times of below average rainfall.

It is important to consider the quality of irrigation water in terms of salt content the amount of irrigation water and the irrigation time. The fruit producer needs to avoid excessive irrigation as well as irrigation below crop requirements. Both can reduce yields. Irrigation is usually practiced either in the morning or late in the afternoon to reduce loss of water through evaporation.

If rainfall is not sufficient, supplementary irrigation is usually used.

Irrigation Methods

Irrigation methods used can be either surface irrigation or pressurized (power driven) systems. The surface irrigation systems can be divided into basin, flooding or furrow irrigation.

a. **Surface or gravity irrigation:** water is applied directly to the surface. E.g. flood irrigation, furrow irrigation.

Advantages

- it is easy to maintain
- it requires Low cost
- do not need any modern technology
- It works effectively in a low filtration rate.
- Technical skill is not required.

Disadvantages

- Level lands require high accuracy
- Not applicable on soil with a high filtration rate.
- Plants are always covered with water even when they do not need it.

- Sometimes limited space gets more water than required.
- No drainage outlet.

Figure 2.8. Furrow irrigation of fruit crops

a. Pressurized irrigation methods: In pressurized irrigation systems water is pressurized and precisely applied to the plants under pressure through a system of pipes. Pressurized irrigation systems, as opposed to the surface irrigation systems, are more effective in application of irrigation water to the crops. The pressurized irrigation type can be done through the use of either a sprinkler or through drip irrigation.

b. Sprinkler irrigation system: irrigation water is sprayed to the air and allowed to fall to the ground as rain/ mist.

Advantages and disadvantages of sprinkle irrigation method

Advantages

- Suitable for soil with high infiltration rate
- Fertigation is possible
- Practiced in not-levelled field surface

Disadvantage

- Costly to install and to maintain
- Wind drift of water droplets
- Require continuous power supply
- Adequate quantity of water.

Drip Irrigation System: Water is applied through network of pipelines and allowed to fall drop by drop at crop root zone.

Advantages

- Save water
- Facilitates easy infiltration
- Maintain moisture at root zone
- Fertigation is possible

Disadvantages

- High maintenance cost
- Not economical for closely spaced crops

2.7 Factors Influencing the Quality of Fruits during Harvest and Post-harvest

In harvesting fruit crops, the stage of the harvest, time of the harvest and the harvesting methods should be carefully considered to ensure the overall quality of the product.

Stage and time of Harvest

Maturity at harvest stage is one of the main factors that determine the compositional quality and storage life of fruit, vegetables and flowers. It is thus important to make sure that the fruit crop is at the right stage of harvest before harvesting the fruit crop.

Nearly all fruits reach peak eating quality when they are fully ripened on the tree. However, they are usually picked or harvested when they are nearly ripe.

Postharvest handling of fruit crops

Postharvest considerations for fruits are:

- **pre-cooling:** if the fruit is going to be stored for a relatively long time, it has to be pre-cooled to storage temperature immediately after harvest
- **Sorting and grading:** sorting according to size and quality level should be done.
- **packaging and packaging materials:** packaging of for market fruits is vital and the packaging materials should reduce moisture loss from the fruits
- **storage:** before storage, fruits should be cleaned for soil, dirt or insect waste
- **temperature and relative humidity during storage and transportation:** for most fruits, temperatures around freezing point (depending on fruit type) should be used. The relative humidity

should be >90% to minimize water loss from fruits

- **transportation**: fruits should be carefully handled to reduce mechanical injury during transportation. Mechanical injuries enhance disease development.

Project 2.1. Using the principles and techniques learned in this chapter establish a nursery for fruit crop, or buy fruit seedlings from fruit nursery, plant, propagate (if necessary) the fruit and manage its growth. Report its progress to your teacher.

2.8. Floriculture and Landscaping

Brainstorming 2.3.

In small group,

Discuss the concept and importance of floriculture

Floriculture

Floriculture is a branch of horticulture that deals with the cultivation of flowering plants, decorative foliage plants, cacti, orchids, succulents, bonsai, ferns, plants grown in containers as well as landscape gardening. In many of the recent literature, Floriculture is referred as Ornamental Horticulture.

Ornamental plants are:

√ either plants as such or their plant parts are: -

- decorative,
- showy, attractive, and
- used for both aesthetic and functional purposes.

They can be: flowering or non-flowering with decorative nature.

Floriculture in Ethiopia

- Ornamental Horticulture started in Ethiopia recently
- Now-a-days it is increasing and is one of the top export commodity of the country

Opportunities for expansion of Floriculture in Ethiopia

- Suitable climate to produce various flower crops
- Ample resources such as land, cheap labor, abundant water etc.
- Proximity to Middle East and European markets
- Increasing domestic market for flowers
- Government policy and investment incentives

Importance of Floriculture in Ethiopia

- Earns foreign currency
- Product diversification
- Job opportunity for the people
- Encourages supportive industries
- Promote investment

Important flower crops grown and exported from Ethiopia

Roses ***Poinsettia*** ***Geranium/Pelargonium***

Chrysanthemum ***Lilies*** ***Carnation*** ***Gypsophila Statice***

Hypericum ***Freesia***

Unit Summary

In this unit, you have learned that:

- fruits are important group of food crops that are nutritionally beneficial. They also, engage smallholder farmers and have potential to reduce unemployment and increase household income.
- fruit production has the potential to contribute to food security and national economy.
- ethiopia has a huge potential for fruit production. There are diverse climate, wide water resources and human labor.
- a lack of knowledge about improved management methods has severely limited fruit production for long. There is a trend of improving fruit production in terms of the volume of production and land allocation.
- fruits are classified into various categories based on the plant structure, temperature requirement, nature of ripening and plant characteristics.
- fruit crops can be propagated by sexual as well as vegetative methods, each with its own advantages and disadvantages.
- nursery and orchard establishment and management are important components of fruit production. Both require careful planning and implementation

Review Exercise

Part I: Define the following terms used in this chapter

Asexual propagation	Fruit	Non-climacteric fruit	Tree fruits
Chilling injury	Fruit crops	Orchards	
Chilling requirement	Fruit set	Simple fruits	
Climacteric fruits	Multiple fruits	Small fruits	

Part II. Choose the best answer from the given alternatives.

1. One of the following conditions increases the potential of fruit crops production in Ethiopia. Which one is it?
   A. Diverse climate
   B. Wide range of water resources
   C. Availability of labor
   D. All
2. In fruit crops, the edible part of the plant is often the_________.
   A. Root C. Steam
   B. Seed D. Fruit
3. From nutritional value perspectives, fruits are important sources of_________.
   A. Vitamins C. Energy
   B. Minerals D. All
4. Which one of the following is a non-climacteric fruit?
   A. Orange C. Tomato
   B. Apple D. Pear
5. Fruit crops like papaya are only propagated by________.
   A. Seeds C. Asexual propagation
   B. Sexual propagation D. A and B
6. One of the following is not a tree fruit crop. Which one is it?
   A. ango D. Blueberry
   B. Avocado E. C and D
   C. Guava
7. One of the following is asexual propagation method. Which one is it?
   A. Propagation by seed C. Propagation by grafting
   B. Propagation by cutting D. B and C

8. Which of the following is important in site selection for nursery establishment?
   A. The topography should be flat (no steep slope)
   B. There should be reliable water source
   C. The soil should be well drained
   D. All are correct
9. One of the following is not among the importance of fruit crops
   A. Improve household income
   B. Source of energy
   C. Improve household food and nutritional security
   D. provide nutrient and energy
   E. None
10. Which of the following is among the problems associated with fruit crop production and management?
   A. High Initial Orchard Investment
   B. Long Juvenile Period of Fruit Plants
   C. Lack of Storage and Transportation Facilities
   D. Perishable Nature of Fruits
   E. Low Purchasing Power of the People.
   F. Lack of High Quality Fruit Plants
   G. All

Part II. Give short answers to the following questions.

1. What important factors should fruit producers consider when establishing nurseries and orchards?
2. What is grafting? What procedures should we follow during grafting?
3. What plant characteristics should we consider when selecting a fruit planting material for scion? For root stock?
4. What important factors do we need to consider during harvesting and post-harvest handling of fruit crops?

Unit 3 Root and Tuber Crops Production and Management

Contents

- 3.1. Definition of terms
- 3.2. Classification of root and tuber crops
- 3.3.Importance of root and tuber crops
- 3.4.Prospects of root and tuber crops production in Ethiopia
- 3.5. Problems of root and tuber crops production in Ethiopia
- 3.6.Root and tuber crops managements and protection
- 3.7.Harvesting and post-harvest handling of root and tuber crops

Learning Outcomes

At the end of this unit, you will be able to:

- define common terms used in the unit
- classify root and tuber crops
- explain the importance of root and tubers crops
- elaborate factors considered during harvesting and post-harvest handling of root and tuber crops production
- analyze different management and protection methods used in the production of root and tuber crops
- assess the constraints in the production of root and tuber crops production in Ethiopia and suggest solutions to increase productivity
- describe the production and management practices of root and tuber crops
- describe some of the root and tuber crops in their school and/or home garden.

3.1. Definition of common terms

Brainstorming 3.1

In a small group

a. Describe what do you know about roots and tuber crops?

b. Are there root and tuber crops in your area and mention some of them?

Root

Root is a compact, often enlarged storage organ with hairy stems that develops from root tissue.

Tuber

Tuber is an enlarged storage organ that develops from elongated stem tissue, or rhizome. So a tuber is a root crop, but a plant can be a root and not a tuber.

Root crop

Root crop is a crop grown for its enlarged and edible roots. E.g. beet roots, carrot, parsnip, cassava.

Figure3.1. Root crops

Tuber crops

Tuber crops are crops with swollen underground stems and roots. Potatoes, sweet potatoes and yams, are edible tuber crops.

Rhizomes and roots are both found underground, rhizomes are stems that grow horizontally. Rhizomes send out stems and roots from their nodes. Many plants have rhizomes as their main stem, including ginger, calatheas, poplar trees, and bamboo.

Figure3.2. Tuber crops

Roots and Tubers

Roots and tubers are plants with edible modified roots. The modified roots consist of the tuberous and fleshy roots. A tuberous root is a thickened secondary root as seen in Sweet potato (Ipomoea batatas) and cassava (Manihot esculenta). A fleshy root is usually an enlarged primary root, as in carrot (Daucus carota), and sugar beet (Beta vulgaris). Roots and tubers yield starchy roots, tubers, rhizomes, corms and stems. Roots and tuber crops are important cultivated staple energy sources, second to cereals, generally in tropical regions in the world. They include potatoes, cassava, sweet potatoes, yams, enset, and some aroids. These belonging to different botanical families but are grouped together as all types produce underground food.

Root and tuber crops produce large quantities of energy, in comparison with cereals. They play an increasingly important roles in global food and energy security. The major root and tuber crops (potato, sweet potato, cassava, and yam) occupy approximately 53.93 million hectares worldwide and produce 736.747 million tons annually. Among the root and tuber crops, enset (Ensete verticosum), cassava (Manihot esculenta), sweet potato (Ipomoea batatas), potato (Solanum tuberosum) and yam (Dioscorea spp.) are the most important staple food crops in Africa which cover around 23 million hectares with annual production of more than 240 million tons. The production and productivity of these crops exceed that of cereal crops which is on average 169 million tons on 108 million ha of land

Activity 3.1.

Work in a small groups

a. Discuss root and tuber crops and list some examples.

b. Explain the difference between roots and tuber crops.

3.2. Classification of root and tuber crops

FAO classifies roots and tuber crops based on their use in to seven primary crops. The major indigenous root and tuber crops find in Ethiopia include: enset, anchote, Ethiopian potato, and yams. The exotic species include taro, tania, cassava, potato, and sweet potato.

Potatoes (*Solanum tuberosum*)

Potato is a seasonal crop grown in temperate zones all over the world including Ethiopia, but primarily in the northern hemisphere. It is currently the fourth most important food crop in the world after maize, wheat, and rice, with a production of 368 million tones. It provides significant amounts of carbohydrates, potassium, and vitamin C in the diet, ascorbic acid present in potatoes protect foliates from oxidative breakdown.

Figure3.3. Potatoes (Solanum tuberous)

Sweet Potatoes (*Ipomoea batatas*)

Sweet potato is a seasonal crop grown in tropical and subtropical regions. The origin of sweet potato is Central America, but at present it is widely grown in many tropical and subtropical countries in different ecological regions. Sweet potato can be grown all around the year under suitable climatic conditions; thus it is considered as an "insurance crop" and is typical food security crop. In addition, sweet potatoes are rich in dietary fiber, minerals and vitamins.

Figure3.4. Sweet potato

Cassava (*Manihot esculenta*)

Cassava is semi-permanent crop grown in tropical and subtropical regions. It is one of the world's most important food crops, with annual global production at approximately 276 million metric tons (MT) in 2013. It is most widely produced in Nigeria (accounting for ~19% of the total), Thailand (~11%), Indonesia (~9%), Brazil (~8%) and Democratic Republic of Congo (~6%). Cassava can be converted into a large number of products ranging from traditional and novel food products, livestock feeds to ethanol, starch and numerous other products.

Figure3.5. Cassava Cocoyam (*Colocasia esculenta*).

Cocoyam (*Colocasia esculenta*)

Cocoyam (Colocasia esculenta) is a starchy root vegetables that is commonly used in South American, African, and Caribbean cuisine. It has a rough, hairy outer skin, with a crisp, white or pink flesh. Once prepared, yautia (Cocoyam)'s earthy flavor can be likened to that of a nut, versus the mild flavor of a potato or yam. Yautia is nutrient-dense, low in fat, and contains fiber. Yautiaalso provides vitamin C, riboflavin, thiamine, and iron.

Figure 3.6. Cocoyam (Colocasia esculenta).

Taro ***(Colocasia esculenta)***

Taro, (Colocasia esculenta), also called eddo or dasheen, is an herbaceous plant of the arum family (Araceae) and its edible root like corm. Taro is probably native to southeastern Asia whence it spread to Pacific islands and became a staple crop. It is cultivated for its large, starchy, spherical corms (underground stems), commonly known as "taro root," which are consumed as a cooked vegetable, made into puddings and breads, and also made into the Polynesian poi, a thin, pasty, highly digestible mass of fresh or fermented taro starch. The large leaves of the taro are commonly stewed.

Figure 3.7. Taro (Colocasia esculenta).

Yams (Dioscorea sp.)

The principal edible yams are widely grown throughout the tropics. Starchy staple foodstuff, normally eaten as a vegetable, boiled, baked or fried. In West Africa they are consumed mainly as "fufu", stiff glutinous dough.

Activity 3.2.

Group work

c. List types of roots and tuber crops found in your local area and classify whether these crops are roots or tubers.

d. Discuss the type of root and tuber crops which is the most important in your life.

*share your result with whole your classmates

3.3. Importance of root and tuber crops production

Brainstorming 3.2

in group or individually,

Discuss the importance of roots and tuber crops production

Roots and tuber crops play significant roles for food and nutritional security of farmers and other parts of communities. They play major role to fill food gaps that might exist until harvest of major crops. Root crops in general, and sweet potato in particular, are drought resistant and serve as security food crops in drought-prone areas of the country. Root and tuber crops enabled farmers to get additional income which helped them to improve their livelihoods. Root and tuber crops generate income for farmers of Ethiopia. They generate income by selling the surplus from their production and earn income from it. They are also used for animal feed and raw materials for various industrial applications.

Activity 3.3.

Work in small group

Assume that you are from area that is well known for the production of different root crop and tuber crops. Based on it:-
List the type of crops that is widely produced and discuss their importance on

a. food security,
b. income generation,
c. nutritional values,
d. animal feed, etc. with their increasing order

3.4. Prospect of root and tuber crops production in Ethiopia

Despite the existences of numerous challenges of agricultural activities, Ethiopia has marvellous opportunity like a commercial farming investment on root and tuber crops. For instances the huge number of the labour force, water resource and proximity to the Middle East and other African countries to sheep products within a short period of time. The country has also a great variety of climate and soil type that can grow diverse horticultural crops for home consumption and foreign markets. Ethiopia is known as the water tower of east Africa. About 0.7% of the country is covered with natural water bodies or lakes and rivers which in turn enhances root and tuber crops production by using the irrigation mechanisms.

3.5. Problems of root and tuber crops production in Ethiopia

Even though roots and tuber crops, the production status in Ethiopia remains far below its potential. Several constraints are responsible for this among which poor access to improved seed and pesticide, unforeseen climatic conditions, weed, diseases and pest problems are the major ones.

Poor access for important inputs

The production of root and tuber crops in Ethiopia is constrained, mainly due to lack of important inputs such as

- lack of wide adaptive and improved varieties,
- shortage of quality planting material,
- Lacks of pesticides,
- weak extension systems
- delays in distributing the important inputs
- Weak Technology transfer system to successfully promote the improved varieties to farmers

Using local seed had result in lower yields because the local varieties are susceptible to late blight and of course low yield potential. For example low yield of cassava due to shortage of improved cultivars are also reported by different researches.

Disease and pest problems

Diseases and insect pest problem are another major constraint in production of root and tuber sector. Major insect pests of root crop in Ethiopia include aphids, tuber moths, leaf miners, green mite, beetle, butterfly, hornworm and weevil. Pests such as weevil and butterfly on sweet potato, tuber moth on potato and green mite and red spider mite on cassava greatly hampered the productivity of these crops. Major diseases of root and tuber crops in Ethiopia include late blight, virus and bacterial wilt. Late blight constitutes the most serious threat to increased potato production.

Policy related problem

Activity 3.5.

In small group

a. discuss how policy related problem affect root and tuber crops production in Ethiopia

b. discuss to which crops do governments and non-government organizations give priority

Ethiopia has pursued a range of policies and investments to boost agricultural production and productivity. This the major staple foods such as cereals, to increase the availability of improved seed, chemical fertilizers, and extension services for small-scale, resource-poor farmers. In addition, crop protection strategies in root crops are also regarded as secondary to cereal. For instance, the pesticide coverage for root crops was even lower than pulses.

Socio-economic problems

Compared to other food crops, production of root and tuber crops is capital-intensive, so that it requires the purchase of large quantities of bulky seed and the application of high cost inputs such as pesticides. These are lack of money to purchase, weak and limited access to markets, lack of storage, and processing facilities, lack of information services, logistics for distribution of agricultural products, problem on transportation access and post-harvest handling.

Technical Constraints

The technical constraints such as bulkiness of the crop, low multiplication rates, phytosanitary restrictions and dry matter content/yields of the crops are major technical constraints of root and tuber crops.

3.6. Root and tuber crops managements and Protection

Brainstorming 3.6

In small group

Discuss some indigenous knowledge those farmers use during managing roots and tuber crops in your area

Roots and tuber crops have to be managed effectively to ensure the sustainability in production:

Land preparation:

Land should be prepared in line with the requirement of each root and tuber crops

Figure3.8: Land preparation

Irrigation procedures has to be followed carefully:

The suitability of the irrigation water in terms of total dissolved salts, heavy metal, and microbial load and pH value for vegetable crop production should be evaluated.

Evaluate the moisture level of the soil by finger feeling method or in the laboratory Estimate the amount of irrigation water to be applied. Note: the amount of irrigation water depends on the growth stages of the crop, the environmental conditions and the soil type

Follow different Procedures of cultivation and fertilizer application Remove weeds by cultivation or other available options (chemical)

Note: Always manage the weeds before flowering and seed setting

- Mound the soil around the stems using hoe
- Do not expose the tubers to direct sunlight while cultivation
- Observe the plants for the occurrence of nutrient deficiency symptoms

- Determine the type and quantity of fertilizers to be applied based on the recommendation of the crop
- Apply the selected and recommended rate of fertilizer using appropriate method

Protection of post-harvest

The main causes of loss are associated with mechanical damage, physiological condition (maturity, respiration, water loss, sprouting), diseases and pests. To ensure effective storage of root and tuber crops, these major causative factors need to be properly understood and, where appropriate, be properly controlled, taking into account the socio-economic factors which prevail in the areas of production and marketing

Protecting Mechanical Damage

Root and tuber crops need to be handled gently to minimize bruising and breaking of the skin because of its relatively soft texture compared, for example, to cereal grains. Therefore, the following methods have to be considered to avoid mechanical damage:

Properly handle at harvest and during transport to and within a store

Proper packaging and handling

Packaging is to protect the produce from damage during handling, transport and storage and to provide containers of uniform size that are conveniently stacked and handled, easily accounted for in quantity and, where appropriate, in weight.

Temperature

Temperature is the single most important factor affecting the rate of respiration; it also influences the rate of sprout growth, the development of rotting micro-organisms and insect infestation.

Preventing pests

Critically observe the occurrence of insect pest and diseases on the planted crops throughout the growing season.

- Choose the appropriate pest management options and implement it properly
- Use the Integrated pest management methods

Cultural control methods (such as crop rotation; weed control and sanitation; use of resistant or tolerant varieties; host eradication; mulching; etc. Mechanical & physical control methods (use of trap; handpicking; tillage and mulching; seed and or seedling treatment

Biological control

This involves the use of living organisms to control pests such as insects, mites, weeds and plant diseases using other organisms that affect roots and tuber crops.

3.7. Harvesting and post-harvest handling of root and tuber crops

Since harvested root and tuber crops are living organisms, some physical, chemical and physiological processes are continuing in the storage unless they are properly handled. Such processes lead to postharvest losses. To reduce these losses, the causative factors need to be properly understood and managed taking into account the socio-economic factors that prevail in the areas of production and marketing. Because of their higher moisture content, greater susceptibility to physical damages and higher metabolic activities, harvested roots and tubers are more perishable than grain crops. While losses of grains are primarily due to external factors such as insects, rodents and molds, the losses of roots and tubers are caused primarily by physiological disorders including loss of moisture and microbial spoilages.

Activity 3.6.

Group work

- discuss factors considered during harvesting and post-harvest handling of root and tuber crops production
- mention the indigenous knowledge that farmers have in harvesting and post-harvest handling of roots and tuber crops in your area

*Present your result to your classmate and submit your the report to your teacher

Unit Summary

In this unit, you have learned that:

- Definition of terms such as root and tuber crops
- Classification of root and tuber crops based on their use like potato, sweet potato, beet roots, carrot, cassava, etc.
- Importance of root and tuber crops like they provide vitamins, carbohydrates and other nutrients, fill food gaps that might exist until harvest of major crops, provide additional income for farmers which helped them to improve their livelihoods and used for animal feed and various industrial applications.
- Problems of root and tuber crops Production in Ethiopia
- Prospects of root and tuber crops production in Ethiopia
- Root and tuber crops managements and protection
- Harvesting and post-harvest handling of root and tuber crops

Review Exercise

Part I. Write true if the statement is correct and false if it is incorrect

1. Tuber is a compact, often enlarged storage organ with hairy stems that develops from root tissue.
2. Root crop is a crop grown for its enlarged and edible seeds.
3. Beet roots and cassava are tuber crops.

Part II. Choose the correct answer

1. Which one of the following is the major problem of root and tuber crops production?
   A. Poor access for important inputs
   B. Policy related problem
   C. Socio-economic problems
   D. disease and pets)
   E. all
2. One of the following is the disease and pest that affect root and tuber crops?
   A. Aphids
   B. tuber moths
   C. leaf miners and green mite
   D. beetle, butterfly, hornworm and weevil
   E. all
3. Why different protection mechanisms are required for roots and tuber crops
   A. losses that occur during storage
   B. to prevent diseases and pests
   C. to prevent from spoilage
   D. all

Part III. Give short answers

4. Name different types of roots and tuber crops
5. Write similarities and difference between roots and tuber crops
6. Explain the importance of root and tuber crops production in Ethiopia
7. Describe the problems associated with root and tuber crops production in Ethiopia

8. What are different managements and protection methods of root and tuber
9. What factors considered during harvesting and post-harvest handling of root and tuber crops production

Part IV. Practical Questions

Go to the field individually or in a group to visit the farm land where root and tuber crops are produced and consider the following tasks or questions:

Ask the farmers and observe what types of root and tuber crops they are producing.

1. How are these crops different?
2. What importance do these crops have? What benefits do the producers get from the crops
3. What constraints do the farmers face in the production process and market of these crops? What methods did they use to ameliorate the problems and solutions do they suggest?
4. What modern and endogenous methods do the farmers use to manage and protect the crops? How effective are the methods? If possible try to practice the techniques they use to manage and protect the crops to develop such skills.
5. What do you suggest to increase the productivity of such crops and improve the livelihoods of the producers

Unit 4

Coffee, Tea And Spices Production and Management

Contents

Learning Outcomes

At the end of this unit, you will be able to:

- describe history, origin and economic importance of coffee, tea and spices
- write ecological requirements of coffee, tea and spices requirements
- practices coffee, tea and spices propagation techniques, harvesting, and processing
- differentiate the ecological and soil requirements for coffee, tea and spices and production
- explain the various cultural operations needed to establish coffee, tea and spices plantations
- explain the processes involved in the production and management of coffee and tea from seed to cup
- participate wholeheartedly in production and management of coffee, tea and spices
- develop important skills required in the processes of producing coffee, tea and spices

4.1. History, Origin, Production Status and Economic Importance of coffee, tea and spices

History and Origin of Coffee, Tea and Spices

COFFEE

Brainstorming 4.1.

Individually,

A. describe the history and origin of coffee production status in your community

B. Why do people drink coffee in your opinion?

The name coffee is derived from Kaffa. Its history dates back to 850 CE, and possibly earlier with a number of reports and legends surrounding its first use. The story goes that Kaldi discovered coffee after he noticed that after eating the berries from a certain tree, his goats became so energetic that they did not want to sleep at night. Kaldi reported his findings to the abbot of the local monastery. Of more than 100 species in the genus Coffea, the three species used in the production of the beverage coffee are *Coffee Arabica* L. (Arabica coffee), Coffea canephora P. (Robusta coffee) and *Coffea Liberica* P. (Liberian or Liberica coffee). All commercial coffee species originate from Africa and belong to the genus Coffea. The high quality Coffea Arabica species originates from the rainforests in the southwestern highlands of Ethiopia.

Activity 4.1.

Group work

Discuss the history and origin of coffee production

*present your result to your classmates

TEA

The history of tea spreads across multiple cultures over the span of thousands of year. According to legend, While a Chinese renowned herbalist, Shen Nung, was sitting under a tree and watching his servant boil drinking water, some leaves from the nearby tree blew into the boiling water. Tea was originated in southwest China as a medicinal drink most likely in the Yunnan region during the Shang dynasty . Tea first came to be known to western civilization through the Portuguese priests and merchants in the early 16th century. Tea was introduced to Ethiopia and started operation at small scale in the early 1920s during the time of Empress Zewditu, the first female head of an internationally recognized country in African continent in the 19th and 20th centuries.

Brainstorming 4.2.

In small group,

a) discuss the history and origin of tea
b) explain how it is spreaded over the world

*Share your idea with your classmates

Camellia Sinensis is a species of evergreen shrubs or small trees in the flowering plant family. It is evergreen shrub whose leaves and leaf buds are used to produce tea. Common names include “tea plant”, “tea shrub”, or “tea tree.”

Figure4.1. Tea plant special Camellia Sinensis

SPICES

Brainstorming 4.3.

In small group,

a) describe what the spices are
b) discuss the history and origin of spices

*share your results with your classmates

Spices are the aromatic parts of tropical plants traditionally used to flavor food, or the dried seeds or fruit of temperate plants used in the same way. A spice is a seed, fruit, root, bark, or other plant substance primarily used for flavoring or coloring food.

Spices origin has been known to date back to ancient times in Egypt as recorded in the bible as valuable trade items. The use of spices moves from Egypt through the Middle East and spread to the Mediterranean and Europe. For so many years, the Arab middlemen control the spice trade. Spices trade later spread to India, China and Indonesia and in the 17th century to America. Spices could be of indigenous or exotic origin. Indigenous species are those that actually originated in a particular region while exotic are those are imported from other region. Some spices are of temperate plants while from are from the tropical region.

Production status and economic importance of Coffee, tea and spices

Production status and economic importance of coffee

Brainstorming 4.4.

in small group

a) discuss the production status of coffee in your area

b)explain the economic importance of coffee

Coffee is among the most important agricultural commodities on the world market and is cultivated on approximately 10.3 million hectares and represents the sole economic income for more than 25 million families (FAO, 2021). According to FAO (2021), the crop is produced and exported by more than 60 nations. It is produced in about 80 tropical countries, with an estimated 125 million people depending on it for their livelihoods in Latin America, Africa, and Asia. Coffee-producing areas are located in latitudes between 22º N and 26º S. Overall, the annual production of coffee is estimated at nine million tons of green beans.

It is considered as one of the top cash crops in developing countries. It is also the second most valuable commodity next to fuel (Girma, 2011). Coffee accounts for the lion's share of Ethiopian export earnings and plays an important role in the economy and livelihoods for rural population. It also accounts for 25 - 30% of Ethiopia's total export earnings and 5% of GDP. Coffee generates income for producers and traders.

Activity 4.2.

In a small group, if coffee, tea or spices is grown in your village,

a. ask farmers and describe the status of coffee production and its economic importance.

If coffee, tea or spices is not grown in your village,

b. browse the internet and write about the status of coffee production in Ethiopia.

*Share your results with whole your classmates

Production status and economic importance of Tea

Tea is one of the most important non-alcoholic beverage drinks worldwide. The total world tea production was estimated to about 2.68 billion Kg of made tea. In 2005 it raised to about 3.1 billion kg of made tea. In Britain, per individual tea consumption is 1.9kg/yr. (Wikipedia, 2016) but in Ethiopia it is 70gm/year. Ethiopia has three private estates producing tea is around 7,000 tone. The economic importance of tea is that it is the source of foreign currency for countries that produce it abundantly. Tea makes a significant contribution to food security, as the income from tea covers food import bills.

Production status and Economic importance of spice

Brainstorming 4.5.

Group task

a. discuss the production status of spices

b. describe the economic importance of spices production in your area and share your idea with your classmates

The total global spice production was amounted to 12.8 million tons in the year 2018. The top five spices producer countries in the world are India, China, Turkey, Bangladesh and Indonesia, in that order. Ethiopia is one of the East African countries that produce and export various spices with production reaching 244,000 tons per year. In Ethiopia, more than 50 spice crops are grown and a total potential for growing low-land spices is estimated to be 200,000 hectares. The country mainly produces; chilies, turmeric, ginger, cumin, fenugreek, coriander, black and pepper, cardamom. Spice production in Ethiopia was expanded between 1995 and 2011 from 107,000 to 153,000 tons with annual growth rate of 9.5%. The total spice production in Ethiopia increased from 234,000 tons in 2013 to 356,000 tons in 2018, while the area under spice cultivation increased from 150,000 ha to 207,000 hectare.

The economic importance of spices is that it can offer additional opportunities for employment within the family and income earned can be used as a 'safety net' in times of need and/ or used to pay for medical expenses that the family may require. Spices contribute significantly to the national economy. Many spices, herbs and essential oils are produced in the tropics providing developing countries export opportunities. There is also a good potential for small-scale processing on-farm that can provide value-adding activities and higher income from the sale of processed spices.

4.2. Ecological and soil requirements for Coffee, Tea and Spices production

COFFEE

Brainstorming 4.6

In a small group,

a) list the ecological and soil requirements for coffee, tea and the spices production.

b) discuss the effect of each ecological condition on coffee, tea and the spices production

The productivity and longevity of coffee plantation depends upon the environmental conditions and management. Ideal conditions permit good crops to be harvested annually without exhaustion and die-back, and without pests and diseases.

Table1: Ecological conditions for coffee, tea and spices

	Optimal rainfall	*Optimal temperature for growth*	*Soil requirement*
Coffee	C. Arabica:1524-2286 mm and C. Robusta grows at 1016-2540 mm and Coffea Liberica P	*C. Arabica 18-24°C,* *C. Canephoraat 24-26°C*	Volcanic red earth or sandy loams with good structure and texture. A fertile, well-aerated, free-draining, and slightly acidic soil with a pH range of 5.5 – 6.5.
Tea	Moderate-to-high rainfall. Irrigation is used when rainfall less than1200mm	21°C to 29°C is ideal for the production of tea	Good tea soils are those of volcanic origin. The best soil type for tea production is pH is 4.5 – 5.5.

	Optimal rainfall	*Optimal temperature for growth*	*Soil requirement*
Spice	***Ginger:*** heavy and well distributed rains. ***Turmeric:*** 1000 to 2000 mm ***Korerima:***>1500mm/ annum**,** ***Pepper:,*** annual rainfall 1250 to 2000mm	**Ginger** requires 28 –350C. **Turmeric:**20 -300 C **Korerima:** 12-280C**.** **Pepper:**10 0C -40 0C.	**Ginger:** deep, well drained, humus soil **Turmeric:** drained, friable, rich sandy or clay loam soils. **Korerima:** well drained humus rich forest soils with ideal pH are 5.0 to 6.5l. **Pepper:** requires clay loam, red loam, sandy loam and lateritic soils with a pH of 4.5-6.0.

Activity 4.3.

In a small group,

Discuss the type of coffee, tea and spices that can be grown in different parts of Ethiopia

Research the ecological requirements (soil, rainfall, temperature, etc. and based on your result, suggest the type of coffee grown in your local area.

*Report your findings to the other groups in the class.

4.3. Propagation, nursery establishment and management of coffeeand tea seedling

COFFEE

Brainstorming 4.7

***In* a small group,**

a) explain methods of coffee propagation
b) list the indigenous knowledge farmers use for the establishment and management of nursery for coffee, tea and spices seedling in your locality

Coffee propagation can be done in many ways. The two most common ones are propagation by seed (sexual) and vegetative propagation (asexual).

Propagation by seed starts with careful selection of seed trees. Propagation by seed uses ripe cherries. The first criterion for selection is the year of planting of the mother tree.

Steps in Propagation of coffee by seed

I. Seed tree selection

The first step in selection is at least 1 year before starting the actual propagation. After the harvest, select trees that look healthy and vigorous. Mark the tree, write down the position of the tree, and locate trees marked the first time and check if they are performing well. Select the final number of trees that you intend to use and remove the markers off the others that were discarded.

II. Harvesting and processing

When harvesting the cherries for propagation, only pick the big, healthy red cherries. The final step of processing is the removal of pea berries, broken and insect invested parchment as well as parchment with more than 2 beans (Figure4.2).

Figure 4.2: Pea berries

Vegetative (Asexual) propagation of Coffee

Vegetative propagation can be done in two ways: grafting and cutting. The purpose of grafting is to combine several traits of different trees into one.

Cutting

Since obtaining a coffee bean crop from a plant grown from seed may take four or five years, propagation of a coffee by cutting is more efficient means of propagating the plant.

Instructions to follow

To take a cutting from an existing coffee plant:

- Choose a healthy, straight branch to avoid vine-like growth caused by crooked branches.
- Take a measure of branches from 3/6 to 5/16 in diameter containing two or more leaves
- Measure 4 to 5 inches from the tip and make a diagonal cut with sharp knife
- Wrap the end in a damp paper towel while transporting
- Prepare a small pot for the cutting by filling it with a potting medium such as a mix of half perlite and half peat
- use clean potting mix to give the coffee plant a good and help keep it from disease
- prepare the cutting for planting
- monitor the coffee cutting, keeping it evenly moist but not soaking wet
- report the coffee plant into a larger pot with any evidence of new growth, keeping the plant well watered

Cutting of coffee for propagation involves:

- Single node cutting
- Half trimmed leaves (pair leaves)

Grafting

It is an art of connecting two pieces of living plant tissue together. Grafting takes place at soldier or butter fly stage of a seedling.

Micro-Propagation (Biotechnology)

- Another possible way of propagating coffee is through Micro-propagation
- This technique is the application of tissue culture techniques

Activity 4.4.

Group task

c. describe commonly used methods of coffee propagation

d. explain propagation of coffee by seed

e. try propagating a coffee plant either in your school or your local farm

Nursery Establishment

A nursery plot consists of a raised piece of land. The plot should ideally be 1.2m wide and 20cm deep. Add (50%) fertile topsoil, 50% mixed with sand, and clean soil to remove any old roots, sticks and stones. Add also 2% of lime (20g of lime to 1l water) and stir it well and leave it for 24hours. Sow the parchment at a depth of 1cm. Finally, provide a shade to control light intensity, temperature and humidity.

N.B: Lime will increase the pH level of the water, stimulating germination.

Preparation of soil and planting bags

Bags should be sufficiently large, with a diameter of a minimum of 17cm and a depth of 25cm or more. Fill the bags with fertile top soil (80%) and 20% organic manure. Add 10kg of Phosphate fertilizer (16.5% P 2 O5) per m3 of soil-manure mixture to stimulate root development

Transplanting

Transplanting refers to gently moving seedlings from a nursery to chosen site. The planting holes should be around 10cm deep.

Nursing the seedling

Key terms:
Nursery is places where seedlings are raised for planting purpose
Nursing the seedlings refers to taking care of the plants from the time they are seed to when they are a seedling - for about 1 year.

Propagation, nursery establishment and management of Tea

Tea plants can be raised from seed, cuttings and tissue culture (micro propagation). Tea can be propagated sexually (by seed) or asexually (by vegetative means). Asexual propagation is commonly known as propagation by '**cuttings**.'

Propagation of Tea by seed

Seed propagation can be performed by sowing the seeds directly in the plantation or by first growing them in seed bags in a nursery. Seed bags in a nursery will be transplanted to the plantation at a later stage.

Vegetative (asexual) propagation

Vegetative propagation, also known as "clonal propagation", consists of taking a cutting (i.e. a stem or leaf) from a "mother bush" and growing a tea bush 'clone'.

Propagation of Tea by stem cutting

This involves single node cuttings with one leaf and well-developed auxiliary bud. Propagating tea by stem cutting involves

1. Cutting from young shoots (only the three upper internodes are rejected).
2. putting the root in plastic bags, under well-shaded nursery at a height of 2m

3. using water bed or polyethylene bag thoroughly but slowly to avoid runoff and soil wash
4. placing the cutting in the soil, leaving 12mm of stem above the soil

Advantages: Vegetative propagation allows "cloning" of mother bushes with the desirable characteristics. Vegetative propagation is a fast, easy and cheap method of propagation.

Disadvantages: Cuttings used for vegetative propagation develop fibrous root systems which are less strong than taproot systems that develop during seed propagation.

Activity 4.5.

In a small group

a. describe commonly used methods of tea propagation
b. explain propagation of tea by seed
c. discuss the difference between sexual and asexual propagation of tea

Nursery Establishment and Tea Management

Achieving an optimum tea yield requires using a suitable land for tea cultivation. Tea cultivation needs a strong foundation, unlike short term crops. The cultivation is based on the regular maintenance of the plant from the nursery stage onwards.

Brainstorming 4.8

***In* a small group,**

Discuss the importance of nursery establishment and management of tea

Selecting land for nurseries

It is essential to select land with water facilities. A nursery should be a place where:

- water flows well,
- there is no wind,
- there is even landscape or there is a slight slope,
- there is mist if water does not exist
- there are transport facilities

During the site selection, criteria such as climatic condition, edaphic factors (soil), biological factors, crops grown there previously, availability of labor, market availability for the production, etc. should be considered.

Selection of a suitable site for tea plant

Several criteria are considered in tea cultivation site selection.

Slope

The slope of the land for tea plant has to be below 55 percent. However, a 70 per cent slope is preferred due to high vulnerability of soil erosion in Mid Country.

Soil depth

Soil depth should be over 100 cm to support good root system. The land surface should not have more than 10% gravel and boulders.

Soil profile

The profile of soil for tea plant or soil layer should not be impregnated with more than 10% gravel.

Land preparation

Land preparation involves clearance, adoption of soil conservation and soil rehabilitation prior to planting tea.

Activity 4.6.

In small group

1. discuss methods of nursery establishment and management of tea
2. explain the methods of nursery site selection and its benefits

4.4. Field establishment and management practices of Coffee, Tea and Spices

Field establishment and management practices for Coffee

Brainstorming 4.9.

In small group

Discuss how coffee producing farmers establish and manage their coffee farm in your area. Share your results to student next to you

The area to be planted with coffee must be prepared at least one year before the small coffee trees are planted. The five procedures to be followed are: land preparation, planting windbreaks, mark out the rows, establish shade trees and prepare for irrigation.

Figure4.3: Shade trees for coffee

Planting procedure

Prepare the holes one month before planting. Mark the planting holes, dig holes of 600 x 600 x 600 mm (Figure4.4), Pile topsoil to one side of the whole, subsoil to other side of hole, Mix in 2 kg of dry farmyard manure (FYM) + 3 heaped soupspoons (about 85 g) Triple Superphosphate (TSP). Feel the hole with topsoil; use both the subsoil and topsoil to complete filling the hole. Re-mark the center of the hole with a stick.

Figure 4.4. Planting procedure

Field management of young coffee trees

To achieve high yields of quality coffee, good field management practices are essential. Poorly managed coffee will take longer to produce a good crop and will suffer from dieback. Keep the ground free of weeds and cut short ground covers in the frosty period. This will protect the plant from frost.

Control weeds and mulch plants

Figure 4.5: Control of weeds and mulch plants

Weeds compete for both nutrients and water. It is thus essential to keep the area under the canopy of trees. Make the area also weed-free. Mulching will reduce the amount of weeding required. Dead or dry weeds can be used as mulch. Fresh weeds may re-grow, especially in wet weather if they are not dried properly before being added as mulch.

Water plants

Do not allow the plant root ball to dry out after planting. Irrigate (or hand water where irrigation is not installed), two to three times per week for the first few weeks. If planted at the recommended time (June to August), there is a good chance of rain. This keeps the soil moisture maintained.

Field establishment and management practices for Tea

Tea plant management is the most important aspect of tea plantation. These involve:

Brainstorming 4.10.

In small group

a) discuss the field establishment and management practices of tea in your area

b) Describe procedures followed to establishment and manage tea

1. **Mulching: Mulching helps**
   - control soil erosion;
   - increase soil moisture;
   - inhibit weed growth;
2. **Weed management**

Manual methods like cheeling, sickling and mulching are extensively used. Cheeling removes the above ground weed growth.

3. **Pruning**
   - is cutting off branches for more fruitful growth
   - can keep tea plant to a height of 1.5 m

Plant Quality

The following factors have a great impact on the quality of the made tea. These are:

i. age of the bush,
ii. standard of plucking,
iii. plucking round, and
iv. a space of time from the previous pruning

Figure4.6. Quality Tea plant

Proper tea plant management enhances production. A well-managed young tea plant is an investment for future. The following are a few important aspects of proper growing of young teas:

I. Density of Population

Compact frames allow a planter to plant a total of 15,000 to 16,000 plants per hectare

II. Spacing:

The minimum spacing required between plants is 60 cm. The maximum spacing required between rows is 100 cm.

Activity 4.7.

Form yourself in to groups and take a coffee and tea farm field visits around your area or in your school. Based on it:

Ask a coffee or tea producing farmers about their indigenous knowledge in establishing field and managing their coffee and tea farm,

*prepare a report and present it to your classmates

4.5. Harvesting and processing of coffee, tea and Spices

Harvesting and processing of coffee

Brainstorming 4.11.

Discuss methods of harvesting and processing of coffee in your local area

TThe color of unripe coffee is green. The color turns bright or dark-red when the cherries ripen. . Cherries ripen faster under lower altitudes and higher temperatures. Coffee can be hand-harvested by people to ensure that only the ripe cherries are picked. Hand-picking is hard and laborious task. Whether by machines or humans, coffee is always harvested by one of the following two methods:

- **Strip picking** – The cherries are stripped off of the branch, either by hand or by machine
- **Selective picking** – The red cherries are picked and the green ones are left to ripen.

Processing the Cherries

Once the coffee has been picked, processing must begin as quickly as possible to prevent fruit spoilage. Depending on location and local resources, coffee is processed in one of two ways:

The Dry processing Method

This is the age-old method of processing coffee and still used in many countries where water resources are limited. The freshly picked cherries are simply spread out on huge surfaces to dry in the sun.

Figure4.7. Dry processing of coffee

The Wet processing Method

This method involves removing the pulp from the coffee cherry after harvesting. First, the freshly harvested cherries are passed through a pulping machine to separate the skin and pulp from the bean. Then the beans are separated by weight as they pass through water channels. The lighter beans float to the top, while the heavier ripe beans sink to the bottom. Depending on a combination of factors such as the condition of the beans, the climate and the altitude, they will remain in these tanks for anywhere between12 - 48 hours. This removes the slick layer of mucilage (called the parenchyma) that is still attached to the parchment.

Figure4.9. wet processing of coffee

Drying the Beans

If the beans have been processed by the wet method, the pulped and fermented beans must now be dried to approximately 11% moisture to properly prepare them for storage. The dried beans are known as parchment coffee, and are warehoused in jute or sisal bags until they are readied for export.

Milling the Beans

Before being exported, parchment coffee is processed in the following manner:

Hulling: machinery removes the parchment layer (endocarp) from wet processed coffee. Hulling dry processed coffee refers to removing the entire dried husk - the mesocarp, monocarp and endocarp of the dried cherries.

Polishing is an optional process where any silver skin that remains on the beans after hulling is removed by machine.

Grading and Sorting is done by size and weight. Beans are also reviewed for color flaws or other imperfections.

Exporting the Beans

The milled beans, now referred to as green coffee, are loaded onto ships in either jute or sisal bags loaded in shipping containers, or bulk-shipped inside plastic-lined containers.

Roasting the Coffee

Roasting transforms green coffee into the aromatic brown beans that we purchase in stores or cafés. Roasting is generally performed in the importing countries because freshly roasted beans must reach the consumer as quickly as possible.

Grinding Coffee

The objective of a proper grind is to get the most flavors in a cup of coffee. How coarse or fine the coffee ground is, depends on the brewing method.

Activity 4.8.

Form yourself in to groups and take a coffee farm visit to your local area

a. Ask the coffee producing farmers about the methods of harvesting and processing coffee. Write down their replies.

b. discuss which of the methods of harvesting and processing coffee do you recommend

*Share your result to your classmates

Harvesting and processing of tea

Brainstorming 4.12

In pairs,

Describe different methods of Tea harvesting and processing in your area

Plucking or Picking

Plucking or harvesting tea is picking fresh tea leaves and fresh young shoots from the tea tree.

1. Plucking/ Harvesting can be carried out manually or mechanically

Plucking tea manually or by hand is a traditional way of picking tea leaves. Plucking occurs when the tea bush flushes or pushes out new leaf shoots. For a fine black or green tea, the pluckers take the first two leaves and one new bud.

Figure4.10. Manual tea plucking

Plucking should be done in the morning because

- the quality (flavor) of tea is highest in the morning
- there is enough time to pluck and process tea the same day
- there is less soluble sugar and more catechism in the morning

Mechanical Harvesting

Mechanical harvesting is the removal of tender, growing shoots from the surface of the bush using machine.

Figure 4.11. Mechanical Harvesting

Tea Processing

Tea processing is the method where tea plant is transformed to the dried leaves for brewing. Processing of tea involves plucking, withering, crushing, drying, rolling and shaping of tea leaves. Shaping makes the leaves ready for brewing.

Withering

Withering is the process of placing freshly plucked tea leaves on a long trough to blow air through the leaves. Withering reduces the moisture content of the leaf (from 80% - 68/70%) and makes the leaves easier to cut. Withering is used to eliminate excess water from the leaves and allows slight oxidation. Cold or warm air is blown through the leaf for 12 to 18 hours.

Figure 4.12. Tea Withering

Rolling

Rolling or shaping the leaves by hand or with machine makes compound to be formed between enzymes and the polyphones. Tearing the leaves and twisting them into thick rolls is important before putting them in the machine. The main purpose of rolling tea leaves is to damage the cell walls. Tea leaves are twisted and pressed in order to extract the juices that are held inside. The goal is to distribute the moisture evenly on the outside of the leaves.

Figure 4.13. rolling of Tea

Fermentation

Fermentation is an oxidation and tanning process of the cell fluids released during rolling. To ferment, the leaves are spread out on tables in layers of 10 cm. In modern factories, spraying water from rotating ventilators humidifies the room in which fermentation takes place. During the fermentation - which takes 2 - 3 hours - the leaves change their color. The color gradually becomes a copper-red.

Figure4.14. Fermentation of tea

Drying

Drying is the method of processing tea to stop the oxidation process and reduce the moisture content to 2-3%. Drying takes place for only 20min at a temperature of 100 – 150oc. Dried tea is black in color and mainly has a perfect aroma. Drying involves a heater with forced ventilation

Figure4.15: drying of tea

Activity 4.9.

Do the activities below in small groups.

a. Ask the owners about their methods of harvesting and processing tea. Write down their replies.

b. Which of the methods of harvesting and processing tea do you recommend? Why?

* Prepare a report and present it to your classmates

Processing of Spice

Brainstorming 4.13.

in a small group,

a. discuss the ways of processing of spices in your area

b. explain the importance of processing of the spices

The processing of spices usually involves most of the following stages:

I) Washing II) Grading and cleaning III) Drying IV) Grinding V) Packaging VI)Washing of Spices

Washing most commonly takes place when fresh spices are delivered to the processing unit. Washing the spices takes place through dipping the nutmegs in water to remove unsound nuts or “floaters”, and cardamom which may receive a sodium bicarbonate dip to preserve its green color.

Figure4.16. Washing process of spices

Drying

Various types of dryers are used for processing herbs and spices, ranging from simple sun drying to gas or kerosene-fired dryers. The type of dryer that is used and the way in which it is operated may have a significant influence on the quality of the finished product in the following ways:

Contamination by dust and dirt

There is obviously a high risk of contamination occurring if the raw materials are laid out in the sun. Solar and powered dryers protect against contamination and are thus strongly recommended.

Drying time and temperature

The quicker the drying time the better the final microbial quality of the product. Drying rates may be increased in two ways: by increasing the air flow and by increasing the air temperature. Spices must be dried to a moisture content that is low enough to prevent the growth of micro-organisms such as moulds and bacteria.

Figure4.17. Drying of spices

Storage

After drying, the material should be packed quickly into clean heavy-gauge plastic sacks to avoid any moisture pick-up. It is a good idea to retain samples in airtight bottles for future reference.

Figure 4.18. Storage of spices

Grinding

Grinding is normally done using either a hammer mill or a disc mill. Ground spice should be passed through a fine sieve to give a product with a uniform particle size. Finely ground spices absorb water much more quickly than whole spices and it is important that the ground material is quickly packed into airtight containers.

Figure 4.19. Grinding of spices and herbs

Packaging

The type of packaging needed for spices depends on the product, the intended market and the types of climate that the food will be exposed to. Spice that is marketed in a cool dry area may only need simple packaging such as paper. Most spices are packed in plastic film as either large bulk bags or small retail packs.

Figure 4.20. Packaging of spices

4.5. Cultivation practices of individual spices

Brainstorming 4.14.

In a small group,

a) discuss the cultivation practices of individual spices in your area
b) describe commonly use methods of spices processing

Ginger

Ginger is a commercially produced horticultural crop in SNNPR, Ethiopia. The producing areas in SNNPRS are said to be ginger belts in Ethiopia where much of the country's ginger production and marketing activities are located. Ginger is used as a spice. It is used for the preparation of ginger oil and oleoresin, soft drinks, alcoholic beverages. Green ginger is used in the culinary preparations. Preserved ginger is used for the manufacture of processed food.

Land preparation

The land should be well prepared to a fine soil and loose. Fine tilt helps development and expansion of the rhizomes

Planting

Ginger is always propagated by portion of seed rhizomes. Rhizomes are cut into small pieces (setts) of 2.5 to 5.0 cm. They may weigh about 15 – 20 grams having one or two buds.

Planting time/Season

March -April and Seed rate: 1500 – 1800 kg per ha. Spacing: 15 x 30 cm 20x 30 cm

Figure 4.22. Ginger

Spacing: varies with the cropping system 15 x 30 cm / 20x 30 cm

Manures and fertilizers since the crops are heavy feeder, the adequate manuring is essential in Ethiopia. There is no fertilizer recommendation.

Mulching: In ginger cultivation, mulching the field is an important operation. Mulching has several advantages such as source of organic manure, prevents washing of soil and conserves soil moisture.

Irrigation:

Irrigate at 4-10 day interval. During mid-September to 3rd week of December irrigate at fortnightly interval.

Turmeric

Curcuma longa is an erect herbaceous perennial 60-100 cm rhizome with fingers. Rhizome is brown on outside and dull orange colored inside. Leaves are broadly lanceolate with long leaf stalk.


Figure 4.23. Turmeric

Preparation of land

Plough land 4-6 deep to get fine tilth up to 20 -25 cm depth. Field is laid out into beds or ridges and furrows. Beds of 1 m width and convenient length with a spacing of 40 to 50 cm between beds where natural drainage does not exist, ridges and furrows are prepared at 45 to 60 cm spacing.

Seed rate: mother rhizomes 2000 – 2500 kg per ha. Primary fingers 1500 to 2000 kg per ha

Spacing: Red loamy soils – 30 x 15cm and Black heavy soils – 46 x 23 cm

Mulching: Mulch with dry leaves thickly on which a layer of cow dung is spread. Second mulching is done after weeding and application of fertilizers, after 50 -60 days of sowing

Korerima (*Aframomum corrorima)*

Aframomum korrorima is a species in the ginger family, Zingiberaceae. The spice, known as Korerima, Ethiopian cardamom, or false cardamom, is obtained from the plant's seeds (usually dried), and is extensively used in Ethiopian and Eritrean cuisine.

Land preparation and planting

Prepare a hole with the size of 45-60cm and a depth of about 60-75cm at spacing of 3m × 3 m. After a week refill the hole with top soil and farmyard manure. The time for planting in south west Ethiopia is on June to August. Korerima can be intercropped with some perennial crops like coffee, black pepper and others.

Weed management: weeds grow comfortably between plants till the crop cover the area. Frequent weeding is necessary.

Cardamom (*Elitaria cardamomum*)

It is known as the **Queen of Spices** and also **Green Gold.** Cardamom is an herbaceous perennial plant.

Nursery site and planting: Seedlings are normally raised in primary and secondary nurseries.

Dig the land to a depth of 30-45 cm. The beds of 1 m width and of convenient length raised to a height of about 30 cm are prepared.

Seed rate: 10 g per m^2 of nursery bed area.

Manuring at the rate of 90 g N, 60 g of P, and 120 g of K per bed of 5 x 1 m size in 3 equal split doses at an interval of 45 days is recommended to produce healthier seedlings.

Planting:

The best season of planting seedlings or suckers is May- June after the receipt of monsoon showers. The seedlings or suckers are planted in the pits up to collar region for better growth. Cloudy days with light drizzle are ideal for panting.

Figure4.24. Cardamom

Black pepper (*Piper nigrum)*

Pepper is the most important of all spices and popularly known as the '**king of spices**'. Black pepper is a dried mature fruit of perennial ever green climbing woody vine.

Selection of site: Well drained leveled land and hill slopes are suitable for growing pepper

Figure 4.25. Black pepper (Piper nigrum)

Planting

Can be planted directly to permanent field or raised in the nursery for further rooting

For rising of rooted cuttings, the following points should be considered

- polythene bags
- Rooting media (forest soil (3): Sand (1)

After filling the polythene bags, each cutting is planted at an angel of 45^0, 3-4 nodes deep.

Field planting

- Select appropriate size
- clear the land
- Make holes/pit about 45x45cm deep usually 15-30cm away from the support
- Fill in the holes with mixture of top soil +farm yard manure
- Transplant the rooted cuttings during the onset of the rainy season

Spacing: usually 3m X 3m or 3m X 2m (on sloppy areas).

Unit Summary

In this unit you have learnt about:

- history, origin, production status and economic importance of coffee, tea and spice herbs production Ecological requirements of spices;
- coffee production and processing, tea production and processing and spices production and processing;
- economic importance of coffee, tea and tea
- ecological and soil requirements for coffee production;
- propagation, nursery establishment and management of coffee seedling;
- field establishment, management practices and harvesting and processing of coffee and coffee and cultivation practices of some spices.

Review Exercise

Chose Best Answer

1. Which of the following is related to the history of coffee?
   a. North eastern Ethiopia
   b. South Sudan
   c. Southwestern highlands
   d. all
2. One of the following is herbs. Which one is it?
   A. Ginger
   B. Pepper
   C. Basil
   D. Cardamom
   E. All
3. What is the importance of spices?
   a. Generate foreign exchange rate
   b. Create employment opportunity
   c. Source of income
   d. all
4. Tea processing involves?
   a. Withering
   b. Rolling
   c. Drying
   d. Fermentation
   e. all
5. Which one of the following crop is considered as Queen of Spices?
   a. Ginger
   b. Turmeric
   c. Cardamom
   d. None
6. Which one of the following crop is considered as the king of spices?
   a. Rosemary
   b. papaya
   c. Pepper
   d. ginger
7. Which one of the following crop is propagated by portion of **seed rhizomes**?
   a. Ginger
   b. Turmeric
   c. Cardamom
   d. none
8. Tea crop requires -------kind of soil?
   a. infertile and basic soil
   b. acidic and lodged soil
   c. well drained, acidic and fertile soil
   d. all
9. The type of propagation that involves taking a part of one parent

plant and causing it to regenerate itself into a new plant is call ed--------------------------?

a. sexually propagation
b. asexual propagation
c. propagation by seed
d. b & c
e. all

10. Propagation of tea by stem cutting involves---------------------------?
    a. cut from young shoots (only the three upper internodes are rejected)
    b. rooting in plastic bags, under well shaded nursery at height of 2m
    c. using water bed or polyethylene bag thoroughly but slowly to avoid runoff and soil was
    d. cutting should be inserted into the soil leaving 12mm of stem above the soil
    e. All

Write short answer

11. Briefly discus the economic importance of coffee, tea and spices production
12. Write the optimum ecological requirements of coffee tea and spices production
13. Describe the effect of temperature on coffee production
14. Describe different types of coffee harvesting methods
15. Mention different types of coffee---

Practical Questions

Form a group of five to seven members. Select a chair person to lead the group. Name a group reporter to organize and present your findings at the end of your visit.

Arrange a visit to farms related to either coffee, tea and spices production if available in your area. Before the visit, ask your teacher to contact responsible individuals (i.e., owner of the site/farm, agricultural development agent, head of the farmer association, etc.) at the selected site for permission. After you get permission to visit, conduct observations and interview the experts/farmer there on the following points:

1. What is the production status and economic importance that coffee, tea and spices contribute to the local area?
2. How effective and conducive are the ecology and soil types to

requirements for coffee, tea and spices production?

3. What propagation type (modern and traditional) do the farmers use to produce coffee and tea? How productive are the methods? What steps do they use to propagate coffee and tea?
4. Explain the methods they use to process coffee cherries.
5. How do they establish field for coffee, tea and spices?
6. How do they manage the processes involved in coffee, tea and spices production from seed to cup (planting, harvesting, processing methods, milling, roasting (for coffee), grinding and packaging)?

7. Report also on the constraints and opportunities tea and spices producers are facing and getting?

Ask about the measures taken by the local government, development agents (extension workers), and non-government organizations to increase the technical efficiencies, of coffee, tea and spices producers, sellers and exporter?

Unit 5 Introduction to Plant Biotechnology

Section	Learning Outcomes
5.1. Introduction to tissue culture	At the end of this unit, you will be able to: ▪ explain what tissue culture means. ▪ point out types of crops produced by tissue culture ▪ describe the benefits of tissue culture in crop production ▪ appreciate the techniques of growing plant cells, tissues, and organs in growing plants ▪ apply the techniques of growing plant cells, tissues, and organs
5.2. Types of crops produced by tissue	
5.3. Benefits of tissue culture	
5.4 Introduction to genetic engineering	
5.5. Application of genetic engineering in crop production	

5.1. Introduction to tissue culture

Plant tissue culture is the technique of growing plant cells, tissues, and organs on an artificial nutrient medium under aseptic condition. It is in vitro cultivation of plants, seeds and various parts of the plants (organs, embryos, tissues, single cells, and protoplasts). Plant tissue culture is also called micro propagation. With micro propagation, plant clones can be produced using a minute part or explants of the mother plant. Single cells, plant cells without cell walls (protoplasts), pieces of leaves, stems or roots can often be used to generate a new plant on culture media giving them the required nutrients and plant hormones.

Brainstorming 5.1

In a small group,

Explain plant tissue culture and share your result with the student next to you

The basis of plant cell and tissue culture is totipotency. Tissue culture requires sufficient space and an exclusive laboratory requirement such as vacuum pump, autoclave, culture tubes, flasks and different glassware.

The controlled conditions such as nutrients, pH medium, adequate temperature, proper gaseous and auxins, cytokinins and liquid environment provide the culture an environment conducive for growth and multiplication. Auxins stimulate root development, while cytokines are needed to stimulate shoot development.

The controlled conditions such as nutrients, pH medium, adequate temperature, proper gaseous and auxins, cytokinins and liquid environment provide the culture an environment conducive for growth and multiplication. Auxins stimulate root development, while cytokines are needed to stimulate shoot development.

Key Terms

Culture in this context is the term generally used for artificial growth of plant/crop.

Totipotency is the capacity of cell to develop into an organism by regeneration.

Aseptic condition is the absence of germs, such as bacteria, viruses, and other microorganisms that can cause disease.

Figure 5.1. Plant Tissue culture

5.2. Types of crops produced by tissue culture

Brainstorming 5.2

In a small group,

Mention crops produced by tissue culture

Tissue culturing of medicinal plants is widely used to produce active compounds for herbal and pharmaceutical industries. Conservation of genetic material of many threatened medicinal plants also involves tissue culturing techniques. In vitro micro propagation techniques are used for plants such as:

- Medicinal plants: Medicinal plants are grown for decorative purpose in the garden. Aloe species, Eucalyptus globulus, Acmellacaulirhiza, Acacia species, Citrus species, Clematis species, Coffee Arabica, etc. are good examples.
- Ornamental plants and crops to be mentioned as examples of threatened medicinal plants are coriander, myrrh, cardamom, chat, caraway, rosa, iris, hyacinth, freesia, and begonia.
- Agricultural plants such as asparagus, cucumber, grapevine, banana, alfalfa, citrus, sugarcane, groundnut, etc.

Asparagus

Asparagus, a member of the family Liliaceae, is a perennial of which the spears or growing stems are eaten. It is propagated from seed, but the differences in yield between the plants are considerable. This species is dioeciously with unisexual flowers, which means that generative propagation gives roughly equal number of male and female plants.

Male plants are high yielders and preferred commercially over female plants. Tissue culture techniques could efficiently promote vegetative propagation of male plants and pave the way for efficient plant breeding.

Figure 5.2. Asparagus

***Solanum tuberosum* L.:** Potato – (Solanum tuberous L.) is an annual solanaceous plant. Tissue culture is employed as a technique for rapid multiplication of potato plants free from diseases. The disease free potato tubers are washed both with detergent and distilled water to remove impurities and allow sprouting.

Figure 5.3. Multiplication and Regeneration of Potato

Activity 5.1.

Group task

a. mention crops that can be produced by tissue culture in your local areas.

b. try out multiplying and regenerating crops using the tissue culture methods in your home or school garden.

5.3. Benefits of tissue culture

Brainstorming ***5.3***

In a small group

Describes the benefits of tissue culture.

Plant tissue culture is one of the most rapidly growing areas of plant biotechnology. Plant tissue culture has a high potential to develop improved crops and ornamental plants. It has several advantages. These include:

I. rapid multiplication of genetically uniform plants (clones) that possess desirable traits.
II. the production of multiples of plants in the absence of seeds or necessary pollinators to produce seeds.
III. the regeneration of whole plants from plant cells that have been genetically modified.
IV. the production of plants in sterile containers that allow them to be moved with greatly reduced chances of transmitting diseases, pests and pathogens.
V. the production of plants from seeds that otherwise have very low chances of germinating and growing, e.g. orchids and nepenthes.
VI. obtaining plant that is free of viral and other infections. This 'cleaned stock' can be quickly multiplied and used in horticulture and agriculture.

5.4. Introduction to genetic engineering

A genetic modification, sometimes called genetic engineering, refers to the methods used to change the pattern in genetic material or information in a plant, animal or human being in order to produce some desirable trait. The genetic material found inside cells in molecules called DNA, is the "blueprint" for any living thing. Genetic engineering is the name of a group of techniques used for direct genetic modification of organisms or populations of organisms using the recombination of DNA.

The conventional breeding:

- is limited to exchanging genetic material between the same or very closely related species.

- has little or no guarantee of any particular gene combination from the millions of crosses generated
- may result in transferring undesirable genes along with the desirable ones.
- takes a long time to achieve desired results.

Genetic engineering or modification:

- allows the direct transfer of one or just a few genes, between either closely or distantly related organisms.
- results in crop or animal improvement in a shorter time compared to conventional breeding.
- Allows plants or animals to be modified by removing or switching off particular genes.

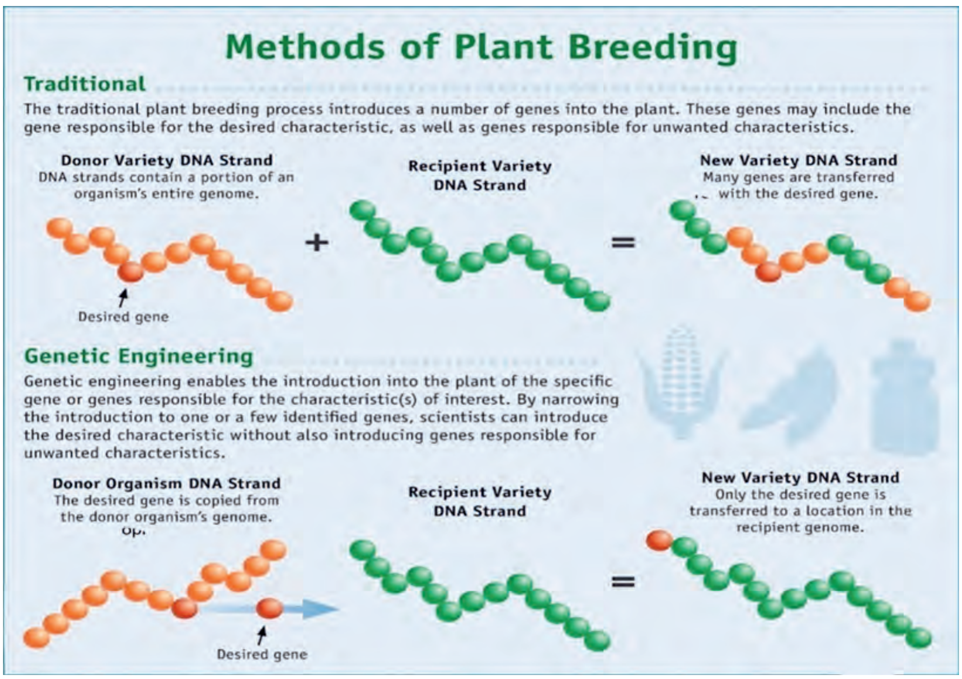


Figure 5.4.Traditional breeding and modern genetic engineering.

Activity 5.4.

In a small group

a. explain genetic engineering

b. compare conventional breeding techniques against the modified breeding ones.

*Share your results with your classmates

5.5. Application of genetic engineering in crop production

Some benefits of genetic engineering in agriculture are increased crop yields, reduced costs for food or drug production, reduced need for pesticides, enhanced nutrient composition and food quality. Achieving species resistant to pests and disease and species that are of greater food security is another benefit of genetic engineering in agriculture. Achievement of species that have medical benefits to the world's growing population is yet another benefit of genetic engineering in agriculture.

Recombinant DNA and transformation techniques allow plant breeders to use genes from essentially any source as tools for crop improvement. For example, scientists used genes from daffodils, pea, a bacterium and a virus to enable rice grains to accumulate and create the so-called "Golden Rice," Beta-carotene is converted into vitamin A when consumed by animals. Transgenic plant methods enable these four well- characterized genes to be inserted into a transgenic plant, producing a highly specific change in only the trait of interest

Transgenic breeding enables the transfer of genes across taxonomic boundaries unlike conventional breeding. In conventional breeding it is possible to transfer genes from closely related species only.

The following points are some application of genetic engineering to plant breeding.

- Herbicide resistant
- Insect resistant
- Resistance against viral infection
- Resistance against bacterial and fungal pathogens
- Improvement of the nutritional qualities in crop plants
- Improvement of crop plants against abiotic stresses

Activity 5.5.

Group work

Discuss the advantages and disadvantages of the application of genetic engineering to crop production.

- Present the outcomes of your discussions to the class.

Unit Summary

In this unit, you have learned that:

- Plant tissue culture is the technique of growing plant cells, tissues and organs on an artificial nutrient medium under aseptic condition. It is also called micro propagation in which clones can be produced using a minute part or explants of the mother plant such as pieces of leaves, stems or roots.
- different types of plants that can be produced by tissue cultures such as ornamental, commercial, agricultural and horticultural plants.
- benefits of tissue culture such as rapid multiplication of genetically uniform plants, production of multiples of plants in the absence of seeds, production of plants in sterile containers that allow them to be moved with greatly reduced chances of transmitting diseases, pests and pathogens.
- genetic modification or genetic engineering deals with the methods that make it possible to change the pattern in genetic material in a crop plants, in order to produce some desirable trait.
- the conventional breeding is limited to exchange between the same or vessry closely related species whereas genetic engineering allows the direct transfer of genes between closely or distantly related organisms.
- Obtaining herbicide resistant species, insect resistant species and, infection resistant species, etc., are the benefits associated with genetic engineering. Improvement of the nutritional qualities in crop plants is another example of the benefit of application of genetic engineering to plant breeding.

Review Exercise

Part I. Say True or False to each of the following questions.

1. The conventional breeding is limited to exchanges between the same or very closely related species.
2. Achieving species that are of greater food security is one of benefit of genetic engineering in agriculture.

Part II. Choose the letter corresponding to the appropriate answer.

1. Which of the following is correct about explants?
   A. minute part of mother plant
   B. pieces of leaves, stems or roots
   C. plant cell wall
   D. a and b
3. The applications of genetic modification can be used for :
   A. human
   B. Plants
   C. Animals
   D. All of the above
4. Which one of the willowing is not true about genetic engineering?
   A. Allows direct transfer of one or more genes between either closely or distantly related organisms
   B. Improvement can be achieved in a shorter period of time compared to conventional breeding
   C. Allows plants or animals to be modified by removing or switching off particular genes
   D. None of the above
5. The techniques of reproductive manipulation of gametes and embryos are:
   A. Cloning
   B. In vitro fertilization
   C. Embryo transfer
   D. All
6. Benefits of genetic engineering in crop production are:
   A. Increase crop yield
   B. reduced need for pesticides
   C. enhanced nutrient composition
   D. All

Part III Give short answers

1) What is tissue culture?
2) What commercial plants are produced by tissue culture?
3) List the components of plant tissue culture.
4) Describe the benefits of tissue culture?

Unit 6 Beef Cattle Production and Management

Contents	Learning Outcomes
6.1. Beef cattle breeds and methods of selection 6.2. Beef cattle feeds and feeding methods 6.3. Beef cattle housing 6.4. Major disease of beef cattle and control methods 6.5. Meat production and processing	At the end of this unit, you will be able to: ▪ identify different beef cattle breeds and make proper selection ▪ categorize beef cattle breeds and explain selection procedures. ▪ describe beef cattle housing ▪ explain beef cattle feed resources and their feeding methods ▪ judge the cattle housing used by beef cattle breeders based on the criteria required ▪ list major diseases and parasites of beef cattle and methods to control them ▪ describe the methods involved in the processing and handling of meat ▪ show interest in breeding beef cattle ▪ promote the production and management of beef cattle in their localities.

6.1. Beef cattle breeds and methods of selection

Beef cattle breed

There is as such no specialized beef cattle breed in the tropical countries. However, some cattle breeds such as Boran, Africander, Brahman, Gir, Nelore, Guzerate, Red Sindhi, Indo-Brazilian and Ankole-Watusi are used as beef cattle. These cattle breeds have good beef characteristics in relation to weaning weight, slaughter weight, carcass percentage, dressing percentage and meat quality. Currently, these cattle types are used for crossbreeding with local animals to enhance their beef production and productivity. The breeds kept for meat production by farmers or fattening farm owners vary from place to place. The following table shows the cattle breeds used for meat production.

Key terms

Beef is meat from bovines, especially domestic cattle (cows, bulls, heifers, or steers).

Fattening or finishing is the laying of fat or muscle.

Beef cattle are those breeds of cattle that have been primarily used to produce meat.

Dual/multi-purpose breed are breeds selected for both beef, dairy production, work, etc.

Breed Name	Boran
Other name	
Breed purpose	Mainly meat
Special notes	Strong, very hardy, excellent meat quality, grow relatively faster
Breed size	Small to medium
Bull’s weight	250-395 kg (the improved Kenya Boran cattle may range from 500 to 850 kg)
Cow’s weight	225 – 355 kg
Climate Tolerance	Native Climates
Coat Color	Black, fawn, red, white
Horned	Yes
Milk Yield	Poor
Place of Origin	Southern Ethiopia

Figure 6.1. Boran Cattle.

Breed name	Brahman
Other name	None
Breed purpose	Meat, milk , drought
Special notes	Very strong and hardy, known for their extreme tolerance to heat and are widespread in tropical regions. They are also resistant to insects due to their thick skin.
Breed size	Medium to large
Bull's weight	800 – 1000 kg
Cow's weight	500 – 700 kg
Climate Tolerance	All climates
Coat Color	Mainly gray and red, other colors also available
Horned	Yes
Milk yield	Good
Place of origin	India

Figure 6.2. Brahman Beef Cattle.

Breed name	Afrikander
Other name	Africander
Breed purpose	Mainly meat
Special notes	Well-muscled, good resistance to tick-borne diseases, economical to raise, good temperament, good fertility, cows are very maternal.
Breed size	Medium to large
Bull’s weight	820 -1090 kg
Cow’s weight	450 – 600 kg
Climate Tolerance	Native climates
Coat Color	Usually deep red colored
Horned	Yes
Milk Yield	Poor
Place of Origin	South Africa

Figure 6.3. Afrikander Cattle.

Activity 6.1.

Conduct a Survey

In a small group, conduct a survey of individuals who own cattle in your community and find out the breeds that are commonly used for fattening. If there is no such farms around to visit alternatively you can watch videos of fattening activities.

*Report your finding to the whole class.

The temperate cattle breeds refer to cattle found in the temperate zones especially in the USA and in Europe. The breeds are often deliberately selected for various purposes. They can easily be differentiated from other breeds due to their particular features such as body color, length, shape of a horn, have no hump and other similar traits. Temperate cattle breeds include Hereford, Angus, Shorthorn, South Devon, to mention just a few. Temperate cattle breeds are well known for their beef.

Breed name	**Hereford**
Other name	None
Breed purpose	Meat
Special notes	Very hardy, active, well adapted to almost all climates
Breed size	Medium to large
Bull's weight	Around 1200 kg
Cow's weight	Around 800 kg
Climate Tolerance	All climates
Coat color	Dark red to red-yellow
Horned	Yes, or polled
Milk yield	Poor
Place of Origin	England

Figure 6.4. Hereford beef cattle.

Breed name	Angus
Other name	Aberdeen Angus
Breed purpose	Meat
Special notes	Very hardy and strong, well-adapted to cold climates
Breed size	Medium to large
Bull's weight	Around 850 kg
Cow's weight	Around 550 kg
Climate Tolerance	All climates
Coat color	Black or red
Horned	Polled
Milk yield	Poor
Place of Origin	Scotland

Figure 6.5. Black Angus beef cattle.

Breed name	Charolais
Other name	None
Breed purpose	Mainly meat , also draught
Special notes	Extremely hardy, strong, easy calving, excellent maternal qualities, good quality meat
Breed size	Large
Bull's weight	Around 1100 kg
Cow's weight	Around 900 kg
Climate Tolerance	Native climates
Coat color	Mainly white
Horned	Yes or polled
Milk yield	Poor
Place of Origin	France

Figure 6.6. Charolais beef cattle.

Activity 6.2.

Listing exotic beef cattle breeds

Besides the local cattle breed, there are breeds selected and bred for meat production.

Individually, list the exotic beef cattle breeds of the world. What physical differences do you observe in the local and exotic beef cattle breeds? Propose whch exotic cattle they would suggest for crossbreeding with local breeds and what characterstics do you expect this to produce?

Share your answer with the other students in the class.

Beef Cattle Traits

There are various traits for consideration in the selection of beef cattle. The traits need to be carefully considered during the selection in order to achieve improved beef cattle. Below is a list of some essential traits to consider:

- **Weaning weight** is a weight that is taken when a contemporary group (same-sex, age-range, and management) of calves' averages about 205 days of age. It is used to evaluate differences in the growth potential of calves and the milking ability of dams.
- **Dressing percentage/yiel**d is the ratio of dressed carcass weight to the weight of the live animal expressed as a percentage.
- **Birth weight** is the first weight of calf, taken just after born.
- **Pre-weaning weight** is a weight that is taken before an animal is weaned.
- **Post weaning weight** is a weight that is taken after an animal is weaned.
- **Yearling weigh**t is a measure of combined pre-weaning and post-weaning growth, taken between 320 - 410 days of age.
- **Carcass weight** is the weight of the carcass of an animal at the packing plant after the internal organs have been removed.
- **Carcass grade** is the definition of beef quality, cutability and undesirable carcass.

- **Carcass fat thickness** is measured between the 10th and 11th ribs at the "three quarter" position as in beef.
- **Carcass loin-eye-area** is the number of square inches of muscle in a cross section of the longissimus dorsi muscle.
- **Carcass tenderness** is a quality of meat gauging how easily it is chewed or cut. Tenderness is a desirable quality, as tender meat is softer, easier to chew, and generally more palatable than harder meat.
- **Carcass rib-eye-area** is the surface area of the longissimus dorsi (eye) muscle between the 12th and 13th rib of a beef or lamb carcass.
- **Marbling** is defined as the flecks of fat within the muscle (i.e., intramuscular fat) and is associated with the flavor and juiciness of meat.
- **Meat quality** is normally defined by the compositional quality (lean to fat ratio) and the palatability factors such as visual appearance, smell, firmness, juiciness, tenderness, and flavor.

Carcass Traits

Carcass traits describe the characteristics of beef. Broadly, carcass traits are divided into carcass quality (composition) and carcass quantity traits. Carcass quality traits include marbling score, fat thickness, kidney, pelvic, heart fat percentages, ribeye, and yield grade. Carcass quantity traits comprise pre-slaughter live weight, hot carcass weight, and dressing percentage.

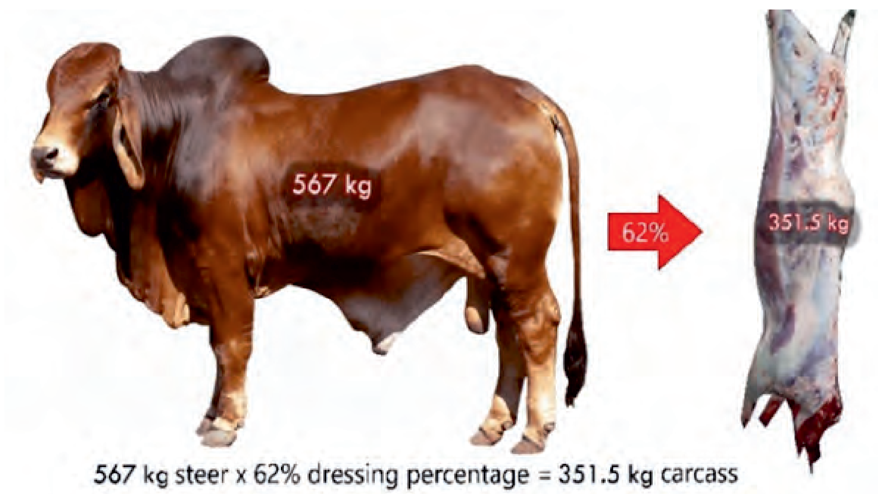


Figure 6.7. Steer vs carcass.

Activity 6.3.

Individually, visit fattening farm, small meat processing plants or butchers shop and survey the manager about the traits of beef cattle/carcasses consider.

Share the information you gather with the whole class.

Beef Cattle Selection methods

Selection is one of the genetic improvement options in the beef cattle production system. Beef animals with good performances are selected to be the parents of the next generation. In a condition where there is a high variation among the individuals of the population, selection can bring about large genetic improvements in the beef herds. There is a possibility to narrow the difference amongst the individuals of the beef cattle population. Beef cattle can be selected based on the pre-set objectives. Producers need to achieve their interest by selecting animals of good performances. Good performance refers to high meat yield. Quality meat, fast growth rate, high feed intake, disease and heat tolerance, foraging ability, etc. can be mentioned as some examples beef cattle criteria.

Key term

Feedlot is a type of animal feeding operation which is used in intensive animal farming, notably beef cattle, but also swine, sheep, chickens, prior to slaughter.

Activity 6.4.

Showing differences and characteristics of breeds

In a small group, study figures 6.1 - 6.6 and their descriptions. Also, think about the beef cattle breeds you know closely from experience. How different are the tropical breeds from the exotic ones? Write also their similarities. Share your answers with the whole class.

6.2. Beef Cattle Feeds and Feeding Methods

6.2.1. Beef Cattle Feeds

There are various feed resources used for beef cattle. These feed resources are commonly grouped into three forms as shown below.

Dry feeds: This type of feed resources includes hays, grains, oilseed meals, straw, stover, corn cobs, corn husks, soybean hulls, soybean mill feeds, cottonseed hulls, peanut hulls, oat hulls, rice hulls

Green feeds: This feed resource includes pasture and green chop. (Feeds are roughages daily chopped in the feed and brought to livestock for feeding).

High moisture feeds: Feed resources like high-moisture grain, haylage, wet byproduct feeds, roots and tubers, fresh milk, silage, cactus, Enset, etc.

The availability of feed resources highly related with agroecology, season, location, the level of fattening farm, and land availability. Farmers or livestock owners use the resources based on their estimated nutritional values, their experience and the animals' physiological status. Natural pasture, crop residue from maize stover and teff straw, stalker and improved cultivated forage crops, and maize grain are the main feed resources for cattle fattening in Ethiopia. Commercial cattle fatteners prefer noug seed cake, cotton seed cake and faba or lentil bean bran as protein sources. Commercial cattle fatteners choose wheat bran, ground sorghum and maize as energy sources. In the commercial feedlot, operators use confined feeding system. In the feedlot operation, beef cattle should be offered roughage first. Following roughage, the beef cattle are offered concentrate feeds. This happens twice a day depending on their requirements.

6.2.2. Beef Cattle Feeding Methods

Beef cattle require nutrients to support manintainance , reprodicution, lactation, and growth. From these components, requirements for energy, protein, minerals, and vitamins are calculated for animals. The level at which each nutrient is required by an animal depends on whether the animal is being fed for:

- maintenance

- maintenance + production
- maintenance + production + reproduction

Most nutrients can be fed in excess, but if any nutrient is not present in an adequate amount, the performance of the animal will be limited.

Factors determining the level of nutrient requirement

The nutritional needs of beef cattle vary by breed, age, weight, level of production, and activity. physiological status, stress from environmental such as health conditions and weather, can also affect nutritional requirements. By understanding the different factors that affect requirements, producers can make adjustments to changes such as cold weather, moving to a hilly pastures, or the last third of pregnancy period.

- Age and Weight: The aged or the larger the animal, the greater its maintenance requirement, mainly energy, and protein.
- Breed: Extremely heavy-muscled breeds will have greater maintenance requirements than light-muscled breeds.
- Level of production: Heavy milking breeds have an increased nutritional requirement. Nutrient requirements for lactation are based on the amount of milk at peak lactation and the composition of the milk. Animals that produce more milk, and milk with more fat and protein, will have higher nutrient requirements.
- Activity: Increased activity or rough land will increase maintenance energy needs as will extremely cold, hot, wet, or muddy conditions.
- Environment conditions: high environmental temperatures and weather conditions can impact feed intake. As temperatures increase above the animal's thermal neutral zone, the point at which heat stress begins, dry matter intake decreases.
- Physiological status: Pregnancy and lactation increase basal metabolism, so maintenance requirements are altered accordingly. Adjustments to requirements for reproduction are based on expected birth weight and stage of gestation.

Activity 6.5.

Surveying the feed resources available in the community and their components

In pairs,

a. ask farmers/livestock owners in your area about the feed resources available to them.

b. find out from the farmers/livestock owners also information on the major components of the feed used for their cattle.

c. get information on how the farmers/livestock owners in the community use the resources.

If this is not possible to visit a local farm , search the internet for information to answer the questions.

6.3. Beef Cattle Housing

Housing gives protection to the animals from various environmental stresses such as solar radiation, rain shower, cool, strong wind, predators, and so on. An appropriate housing system enhances the performances of the animals. The housing system depends on the location of the farm. For example, the housing system suitable to tropical environment is different from that needed in temperate regions.

In tropical areas, cattle houses are constructed in the way they can reduce heat stress. Appropriate housing, in addition to protecting the animals from stress and potential diseases, makes management practices such as feeding, watering, clearing, and breeding easier. There are many factors to consider prior to establishing beef cattle farms. See below.

a. **Location**: this refers to the place where the farm is to be located in relation to soil structure, drainage, road access and proximity to other farmhouses, etc.

b. **Ventilation**: the farm must be located in high areas that can secure sufficient ventilation. Sufficient ventilation allows air circulation within the house. This keeps the heat stress and relative humidity to the minimum

c. **The direction of the house**: Animal house should be in the east-west direction to protect them from morning and afternoon sun and rain.

d. **Roof:** A gable roof is highly preferred for its protection from the sun and the rain. A well-designed roof is quite important in reducing heat and cold stresses.

Figure 6.8. House design for fattening oxen producer.
(Source: ILRI/Tesfaye, 2016; Ethio Agri-CEFT fattening PLC.)

In Ethiopia, open overhead shelter with enclosures is the predominant type of animal housing system across all the commercial cattle fattening system as presented in Figure 6.8. Among the medium and small scale fattening farms, however, a housing system with open enclosure is available.

Activity 6.6.

Assessing the housing system of beef cattle farmers or fattening farm owners

Work in buzz-group and ask farmers or fattening farm owners the following questions:

a. What type of cattle housing system do they have?

b. What type of materials do they used for construction?

c. Compare the housing system you identified with what others identified, Are they the same? If not, explain their differences. What is the advantage of one over the other?

6.4. Major Disease of Beef Cattle and Methods of Their Control

There are various diseases that commonly affect beef cattle. These are infectious and non-infectious diseases. Infectious diseases are divided into three: viral, bacterial and protozoal. The division is based on the causes of the diseases. Examples of viral diseases are rinderpest, Foot and Mouth Disease (FMD), rabies, bovine viral diarrhea, etc. Some examples of bacterial diseases are contagious bovine pleuropneumonia (CBPP), tuberculosis, anthrax, blackleg, etc. Protozoa diseases include trypanosomiasis, coccidia, cryptosporidium, etc.

In additions to the diseases, ruminants particularly, the beef cattle, are victims to various internal and external parasites that live within or on the surface of the animal body.

6.4.1. Viral Disease

Rinderpest (RP)

Rinderpest is an acute, highly contagious, fatal viral disease of cattle. Manifested by inflammation, haemorrhage, erosions of the digestive tract, wasting and often bloody diarrhea. Some swine species are also susceptible. Man is not susceptible to RP virus.

Symptoms:

- High fever
- Nasal discharge and excessive salivation
- Punched out erosions in the mouth
- Loss of appetite and depression
- bdominal pain (grunting, arched back)
- Constipation followed by bloody diarrhea and straining
- Dehydration and rough hair coat
- Marked debility
- Abortion
- The classical “milk fever position” in cattle

Mode of transmission:

- Direct contact with infected animals or their excretions and secretions and fomites. The virus appears in the blood and in secretions before the onset of clinical signs and this may cause infection in abattoirs and stockyards.

Treatment:

- No known treatment

Prevention:

- Vaccination
- destruction of infected and contact animals
- disposal of carcasses and infective materials
- sanitation and disinfection.

Foot and Mouth Disease (FMD)

FMD is an acute viral and extremely contagious disease of cloven-footed animals such as cattle, sheep, and goats. It is manifested by vesicles and erosions in the muzzle, nares, mouth, feet, teats, udder, and pillar of the rumen.

Symptoms:

- Fever
- Dullness
- Lack of appetite
- Drastic reduction in milk production
- Uneasiness and muscle tremors
- Smacking and quivering of lips
- Extensive salivation and drooling
- Shaking of feet and lameness
- The vesicles and later erosions are commonly found on the muzzle, tongue, oral cavity, teat and on the skin between and above the hoofs of the feet.
- In more chronic cases in cattle the hoof become loose and the animal may walk with characteristic “clicking” sound.

Mode of transmission:

- Direct and indirect contact with infected animals and their secretions including saliva, blood, urine, feces, milk and semen, aerosol droplet dispersion, infected animal by-products, swill containing scraps of meat or other animal tissue.

Treatment:

- There is no specific treatment for FMD. The conventional method of treating infected animals mainly involves the use of antibiotics.

Prevention:

- Vaccination

Rabies

This is an acute infectious viral disease of the central nervious system in animals.

Symptoms:

- Restlessness
- Aggressive, may attack other animals
- Sexual excitement
- Bellowing
- Paralysis and death
- Sagging and swaying of the hind quarters
- Drooling and salivation
- The tail is held to one side
- Tenesmus or paralysis of the anus
- Paralysis
- The animal falls to the ground

Mode of transmission:

- It is usually transmitted through the saliva by a bite from a rabid animal, commonly the dog or jackal. Man is infected the same way.

Treatment:

- No known treatment

Prevention:

- Vaccination
- Identify and control the source of virus introduction.
- Restrict the movement of animals.

Bovine viral diarrhea (BVD)

BVD is a disease of cattle caused by the Bovine Viral Diarrhea Virus This is an infectious viral disease of cattle manifested by active erosive stomatitis, gastroenteritis and diarrhea.

Symptoms:

- Fever
- Congestion and erosions in the mucous membranes of the oral cavity
- Depression and anorexia
- Cough, polypnea and salivation

- Dehydration and debilitation
- Foul-smelling diarrhoea
- Cessation of rumination
- Reduced milk production
- Abortion in pregnant cows
- Laminitis
- Congenital anomalies of the brain (cerebellar ataxia) and arthritis in young calves

Mode of transmission:

- Direct contact with clinically sick or carrier animals, indirect contact with feedstuffs or fomites contaminated with urine, nasal and oral secretions or faeces and contact with aborted fetuses. Transmission through aerosol droplet dispersion or by insect vectors may also be a possibility. The virus may persist in recovered and chronically ill cattle which are considered a potential source of infection.

Treatment:

- No known treatment.

Prevention:

- Vaccinate with BVD vaccine two weeks prior to moving.

6.4.2. Bacterial Disease

Contagious bovine pleuropneumonia (CBPP)

This is an acute, subacute or chronic highly infectious disease of cattle caused by Mycoplasma mycoides var, mycoides.

Symptoms:

- Fever
- Lack of appetite and loss of weight
- Coughing on exercise
- Shallow rapid respiration, grunting and gurgling
- Extended neck, lowered head and open mouth
- Arched back and outward rotated elbow
- Arthritis in young animals

Mode of transmission:

- Aerosol and droplet infection from the infected animals. The recovered animal called "lungers" act as carriers and shedders, especially under stress.

Treatment:

- Treatment is recommended only in endemic areas becouse the organisms may not be eliminated and carriers may developed. There are drugs to treat CBPP such as Tylosin and danofloxan.

Prevention:

- Vaccination.

Bovine Tuberculosis (TB)

Tuberculosis is a chronic disease of many animal species and poultry caused by bacteria of the genus Mycobacterium. It is characterized by the development of tubercles in the organs of most species. Bovine tuberculosis is caused by Mycobacterium bovis. It is a significant zoonotic disease.

Symptoms:

- Low grade fever
- Chronic intermittent hacking cough and associated pneumonia
- Difficult breathing
- Weakness and loss of appetite
- Emaciation
- Swelling superficial body lymph nodes

Mode of transmission:

- An infected animal is the main source of transmission. The organisms are excreted in the exhaled air and in all secretions and excretions.
- Inhalation is the chief mode of entry and for calves, infected milk is an important source of infection.

Treatment:

- Bovine TB is usually treated with antibiotics.

Prevention:

- There is no proven effective prevention mechanism.

Anthrax

Anthrax is a peracute disease of ruminants manifested with septicemia, sudden death, and tarry blood from the body openings of the cadaver. It is caused by Bacillus anthracis.

Symptoms:

- staggering,
- trembling,
- Edematous swelling of the throat and neck

- swallowing and breathing difficulty,
- convulsions, and death

Mode of transmission:

- Man may contract anthrax by inhalation, ingestion and through a wound in the skin. Biting flies have been shown to be transmitters.

Treatment:

- Antibiotics

Prevention:

- It is prevented through vaccination.
- Condemnation of the carcass and its parts by burning or burial. If disposed by burial, the carcass should be buried at least 1.8 meters below ground. The site should be surrounded by a foot-thick layer of quicklime.

Black leg

Black leg is an acute infectious disease of cattle and sheep manifested by severe inflammation of the muscle with high mortality. It is caused by *Clostridium chauvoei*.

Symptoms:

- High fever (41°C)
- Lameness
- depression
- Loss of appetite
- Discoloured, dry or cracked skin
- Stiff gait and reluctance to move
- Crepitating swellings often on the hips and shoulder
- Rapid breathing

Mode of transmission:

- The organisms of blackleg are found in the soil. During grazing, organisms may enter the digestive tract of a susceptible animal. Clostridium chauvoei is also found in the digestive tract of healthy animals.

Treatment:

- Treatment is ineffective.

Prevention:

- Vaccination of all calves at an early age.

- Carcasses of animals affected with black leg should be condemned. It is prohibited to slaughter and dress an animal diagnosed with this disease at antemortem examination.

6.4.3. Diseases caused by protozoa

Trypanosomiasis

Symptoms:

- Fever
- Weakness
- Lethargy and anemia
- Reduction in fertility and milk production

Mode of transmission:

- Bovine trypanosomosis transmitted by tsetse flies is a major constraint to cattle health and productivity in all sub-Saharan countries.

Treatment:

- If detected early, Trypanosomosis can be treated with trypanocidal drugs for therapeutic and prophylactic purposes. Therapeutic drugs for cattle such as diminazene aceturate, homidium chloride and homidium bromide.

Prevention:

- - Killing parasites or vectors with Trypanocides or insecticides.

Coccidia

Symptoms:

- Loss of appetite,
- Diarrhoea (from green to slimy bloody)
- Dehydration,
- Straining,
- abdominal pain,

Mode of transmission:

- Coccidiosis is transmitted from animal to animal by the fecal–oral route. Infected fecal material can contaminate feed, water or soil; therefore, cattle can contract the disease by eating and drinking from contaminated sources, or by licking themselves or other animals.

Treatment:

- Antibiotics

Prevention:

- Clean water tanks regularly, with more regular cleaning when new animals are introduced.
- Clean feces from feed bunks before each feeding.
- Clean and disinfect holding areas between groups of cattle. ...
- Do not overcrowd animals.
- Reduce manure buildup

Cryptosporidium

Cryptosporidium parvum, commonly referred to as Crypto, is a protozoan (a one-celled organism) that causes diarrhea in calves (as well as other mammals).

Symptoms:

- Watery diarrhea
- Feces can contain mucus , blood, or undigested milk.
- Stomach cramps or pain
- Dehydration
- Nausea
- Vomiting
- Fever
- Weight loss

Mode of transmission:

- Cryptosporidium oocysts are transmitted between hosts via the fecal-oral route, either directly via contact with feces from infected hosts, or indirectly through environmental contamination or ingestion of contaminated food or water.

Treatment:

- Antiprotozoal drugs

Prevention:

- Cleaning calf housing and feeding equipment with soap or detergent as well as ensuring bedding is changed frequently can prevent the spread between calves.

6.4.4. Parasites

Parasites suck the animal's blood and compete for blood nutrients. The diseases cause a great economic loss to the farm animal by reducing the animal's weight, feed intake and carcass quality.

Internal and External parasites

Internal parasites: Internal parasites include nematodes (round worms), tapeworm, liver fluckes, etc. Cattle are infected with parasites while feeding on grazing lands. The eggs and larvae of the parasites are found in the pasture.

External parasites: horn flies, face flies, stable flies, grubs, ticks, lice, and mites are examples of external parasites.

6.4.5. Strategies of disease control in beef cattle

In Ethiopia, the best way to successfully control animal disease is to work out a risk-based strategy and concentrate surveillance on identifying areas of infection, endemic maintenance and areas at high risk of acquiring infection. Effective strategies of controlling the major beef cattle diseases may include, the availability of adequate information, proper diagnosis of diseases, vaccines of appropriate quality and a functional veterinary services. Vaccines and anthelminthic drugs are used in the treatment of animal diseases. Animal house cleaning, proper drainage, rotational grazing, etc. are effective measures to control the diseases.

Activity 6.7.

Work in pairs and answer the following questions in writing. Your teacher will tell you what to do with your answers.

a. Which are the diseases that affect beef cattle in your locality?
b. Categorize the beef cattle diseases as infectious and non-infectious diseases.
c. Describe the beef cattle disease type that is more prevalent in the area.
d. Why is the type identified more prevalent in the area than the other disease type?
e. Explain the indigenous knowledge and practices the local community use to present or combat the diseases.

6.5. Meat production and processing

6.5.1. Meat production

In Ethiopia, a significant proportion of beef comes from old oxen kept for draft purposes, culled cows, and surplus young bulls. In most farms, beef production is not a primary objective. Meat production per head of livestock is low by the standards of other significant livestock-producing African countries. The estimated average live weight of cattle is 250 kg with 14% offtake rates and carcass weight is 110 kg with 44% dressing percentage due to many-sided challenges related to production, husbandry, and marketing (AGPLMD, 2013). Ethiopian meat production over time is rising moderately with some fluctuation. The total meat production increased from 578,240 tons in 2004 to 749,430 tons in 2010. However, a considerable decrease in production was witnessed in 2017. In 2017, about 597,765 tons of meat were produced.

Despite the huge size of the livestock population in the country, there is still a shortage of production of meat in the country. Ethiopia contributes only about 0.2 percent of the world's total meat production. This is due to low off-take rates, the inability to fulfill international standards, and the presence of legal and illegal live animal export in the country. The country produces about 1 million tons of beef per year valued at USD 5.1 billion (ASL, 2018). The annual contribution of ruminants to meat production in Ethiopia is estimated to be over 3.2 million tonnes representing over 72 % of the total meat production, from which beef accounted for over 70 % of the total red meat production. The volume of meat and meat products exported from Ethiopia is given in Figure 6.9 which covers between the year 2013/14 to the 2nd quarter of 2017/18 (4428.5 metric tons).

Ethiopia's average per capita meat consumption is approximately 8 kg, which is low, compared to averages in developing countries (25 kg) and developed countries (77 kg). This is because of low per capita incomes. Non-commercial oriented animal husbandry practices in the country are another cause of low meat consumption in the country. A similar other cause for low domestic consumption of meat is the increase in the price of meat.

In terms of beef production, the level of productivity in Ethiopia (110 kg/head) is about 25-30 % lower than in East Africa (143 kg/head). The continental average is 156 kg/head) while the world average is 212 kg/head. The annual national mutton and goat meat productions are 77 and 62 thousand metric tons, respectively. This is largely because of the high average off-take rates which is estimated to be about 30% from sheep and 36% from goats. Sheep and goat constitute 21%- 16.8% of the total ruminant livestock meat output

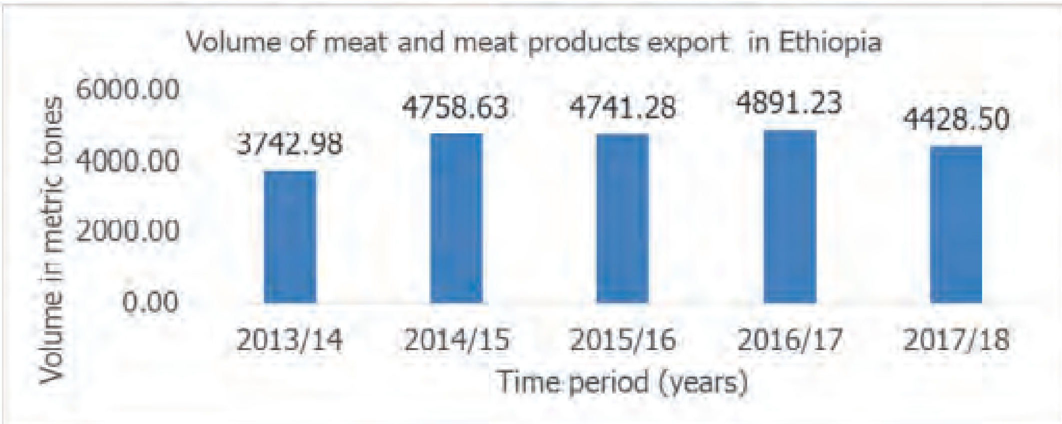


Figure 6.9. The volume of meat and meat products export between the years 2013/14 – 2017/18. Source: NBE (2018).

Brainstorming 6.1

In your view, what is the importance of meat processing? Discus what you know about meat products with students sitting next to you.

6.5.2. Meat processing

Meat Processing starts with slaughtering animals and processing carcasses (cutting, inspecting, packaging, and processing it into other products) for sale as fresh meat (to consumers and to the food processing industry).

Slaughtering Beef Cattle

After stunning, animals are usually suspended by a hind limb and moved down a conveyor line for slaughter procedures. They are typically bled by the insertion of a knife into the thoracic cavity and severance of the carotid artery and jugular vein. This method allows for maximal blood removal from the body. At this point in the process, the slaughtering procedures begin to differ by species.

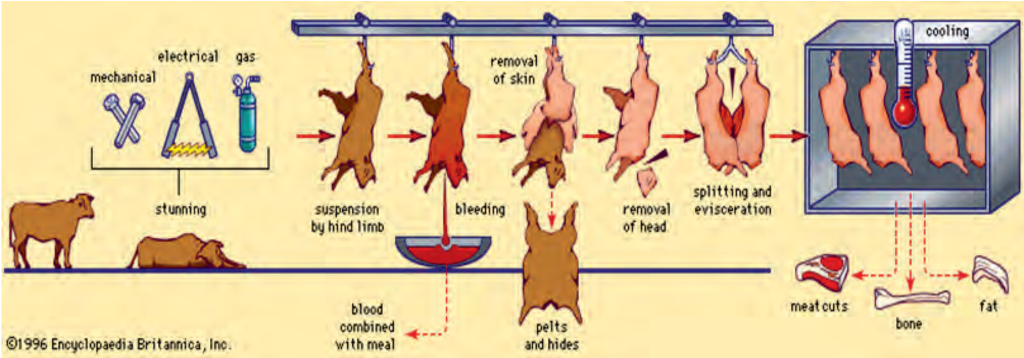


Figure 6.10. Basic animal sloughtering procedure.

Activity 6.8.

Abattoir Visit

Visit an abattoir or meat processing plant found nearby to your school or your resident and see how animals are slaughtered as well as meat is processed. Report the summary to the whole class.

Meat processing technology comprises the steps and procedures in the manufacture of processed meat products. Meat processing involves a wide range of physical and chemical treatment methods, normally combining a variety of methods. Meat Processing also takes the meat in its raw form and turns it into another product that is marketable, safe for consumption, and attractive to consumers.

Physical/technical processes are:	Chemical or biochemical processes are:
- cutting, chopping, comminuting - mixing, tumbling - Stuffing/filling of semi-fabricated meat mixes into casings, synthetic films, cans, etc. - heat treatment.	- salting and curing - utilization of spices and additives - smoking - freezing and refrigeration, and - drying

Salting: The water holding capacity of meat can be increased with the addition of salt up to a concentration of about 5% to lean meat. Sodium chloride (NaCl) has only a very low capacity to destroy microorganisms. Its preserving power is attributed to its capability to bind water and deprive the meat of moisture.

Curing: Curing is the treatment of muscle meat with salt (NaCl) and sodium nitrite (NaNO2). To achieve the desired red or pink color, meat or meat mixes are salted with salt (NaCl). Curing often results in ared or pink color.

Smoking: Smoke is produced from thermal destraction of raw wood components. The principle of smoking is that the smoke infiltrates the outside layers of the product to develop flavor, color, and a certain preservation effect.

A B

Figure 6.10. Smoking (A) and drying (B) of meat at household level.

Meat Drying:In physical terms, drying is the lowering of the water activity in meat and meat products. Microorganisms need certain amounts of free water for growth, and their growth is halted without a minimum level of moisture. Drying may be done to dehydrate fresh meat for extension of storage. Drying may also be one of the various processing steps during the manufacture of specific meat products. The manufacture of fermented meat products, such as dry sausages, or “quanta”, is an example, where drying is one of the processing components amongst several others.

Activity 6.9.

Individually,

a. ask your parents about how they preserve meat, and for how long.

b. ask them also about the advantages and disadvantages of their preservation methods

c. join two other students and discuss the data the three of you collected.

Meat Canning: In pasteurized "cooked" meat products, the survival of heat resistant microorganisms is accepted. In sterilization of meat products, the destruction of all contaminating bacteria including their spores is recommended to ensure public safety.

Meat canning process involves two essential operations:

- The product must be heated at a sufficiently high temperature and for long enough to make it fully or commercially sterile,
- It must be sealed in a hermetic container which will prevent recontamination of the product.

Heat processes for canned products are designed to inactivate large numbers of spores of the organism Clostridium botulinum. Clostridium botulinum is an anaerobic, rod-shaped spore-forming bacteria. These organisms are responsible for foodborne botulism that causes illness as a result of ingestion of toxic-containing foods. Symptoms include muscle weakness, double vision, difficulty breathing, and paralysis.The form of food poisoning produced by Clostridium botulinum is called Botulism.

Unit Summary

In this unit, you have learned that:

- beef is meat from bovines, especially domestic cattle (cows, bulls, heifers, or steers).
- some of the potential beef cattle breeds in tropical environment like Boran, Africander, Brahman, Gir, Nelore, Guzerate, Red Sindhi, Indo-Brazilian and Ankole-Watusi. i.e. these cattle breeds have good beef characteristics.
- list of some essential traits beef cattle traits to consider in the selection: Birth weight, Pre weaning weight, Yearling weight, Carcass weight, dressing percentage etc.
- quality meat, fast growth rate, high feed intake, disease and heat tolerance, foraging ability, etc. can be mentioned as some examples beef cattle criteria.
- dry feeds, green feeds, and high moisture feeds can be mentioned as examples of high moisture feeds.
- the level of nutritional requirement of beef cattle determines by breed, age and sex, level of production, environmental stress, etc.
- the availability of feed resources is highly related to the agroecology, location, season, the level of fattening enterprise, land availability, etc.
- appropriate housing, in addition to protecting the animals from stress and potential diseases, makes management practices such as feeding, watering, clearing, and breeding easier.
- there are various diseases (infectious and non-infectious) that commonly affect beef cattle. In additions to the infectious diseases, beef cattle are victims to various internal and external parasites that live within or on the surface of the animal body.
- meat processing involves a wide range of physical and chemical treatment methods, normally combining a variety of methods.

Review Exercise

Part I. write True or False for each of the following questions.

1. Good performance for beef cattle refers only to high meat yield.
2. Smoking treatment of meat products develops flavor, color, and a certain preservation effect.

Part II. Choose the correct answer from the given alternatives to the following questions.

1. Which one of the following is not the consequences of parasitic infection in beef animals?
   A. Reduction feed intake
   B. High carcass quality
   C. Reduce animal weight
   D. None of the above
2. Meat processing involves one of the following techniques:
   A. Chemical treatments
   B. Physical treatments
   C. Combination of both
   D. All of the above
3. One of the following is not important to be considered prior establishing of beef cattle farms?
   A. Location
   B. Direction of the house
   C. Ventilation
   D. Roof
   E. None of the above
4. Effective strategies of controlling the major beef cattle diseases doesn't include:
   A. Proper diagnosis of diseases quality
   B. Functional veterinary services
   C. Vaccines of appropriate
   D. None of the above
5. Of the following indicates the importance of beef cattle housing?
   A. Protect animals from stress
   B. Easier breeding
   C. Easy management
   D. All of the above
6. Which Of the follwing is source of beef in Ethiopia:
   A. Young oxen
   B. Surplus young bulls
   C. Mature cows used for milk
   D. All of the above
7. One of the following is not among the decisive criteria in beef cattle selection. Which one is it?
   A. Weaning weights,
   B. Carcass percentage
   C. meat quality
   D. Rich milk yield
   E. None of the above

8. One is not among the lists of beef breed cattle. Identify it
   A. Heroford
   B. Angus
   C. Holstein Friesian
   D. Charolais
9. Beef cattle feeding is not influenced by
   A. Type of Breed
   B. Color of cattle
   C. Stress from the environments
   D. Age and sex the cattle

Part III. Write a short notes on the following topics

1. Describe carcass traits?
2. Draw a table like the one below and complete it with examples of major infectious beef cattle disease and suggest ways of controlling or treating each disease.

Viral	Bacterial	Protozoal
____________	____________	____________

Unit 7 Sheep and Goat Production and Management

Contents

- 7.1. Sheep and goat breeds and selection
- 7.2. Sheep and goat feeds and feeding
- 7.3. Sheep and goat housing
- 7.4. Major diseases of sheep and goat and methods of controlling the diseases
- 7.5. Sheep and goat meat and milk production and processing

Learning Outcomes

At the end of this unit, you will be able to:

- classify different sheep and goat breeds and make selections for preferred traits
- clarify sheep and goat feed resources and their feeding methods
- identify different types of housing for sheep and goats
- list the major sheep and goat diseases and parasites and the controlling methods
- explain the major products and product processing of sheep and goat

7.1. Sheep and goat breeds and methods of selection

Indigenous sheep and goat genetic resources have developed specific adaptations to survive and produce under adverse local environmental conditions. Climatic stresses, poor quality feed, seasonal feed, and water shortage, endemic disease, and parasite challenge are examples of adverse local environmental conditions.

Indigenous sheep breeds

The sheep found in Ethiopia are classified into different breeds and types. The habitats of sheep range from tropical to temperate environments. Attempts to identify and characterize Ethiopia's sheep breeds or types have been made since 1975. Solomon (2007) summarizes the distribution of Ethiopian sheep breeds in Figure 7.1 below.

Figure 7.1. Geographic distribution of some of the major Ethiopian sheep breeds (ESGPIP, 2008).

Key terms

Does: mature female goats are referred to as does.

Buck: intact males are called bucks. When male lamb reaches 1 year old, they become known as bucks unless they are castrated.

Ewe are mature adult female sheep.

Ram is a male sheep aged over 12 months.

Lamb: sheep under the age of 12 months.

There are 14 - 15 common sheep breeds distributed across the country. Afar, Arsi-Bale, Blackhead Somali, Horro, Menz, Washera (Dangla) and Menz are some examples of the sheep breed identified in the country.

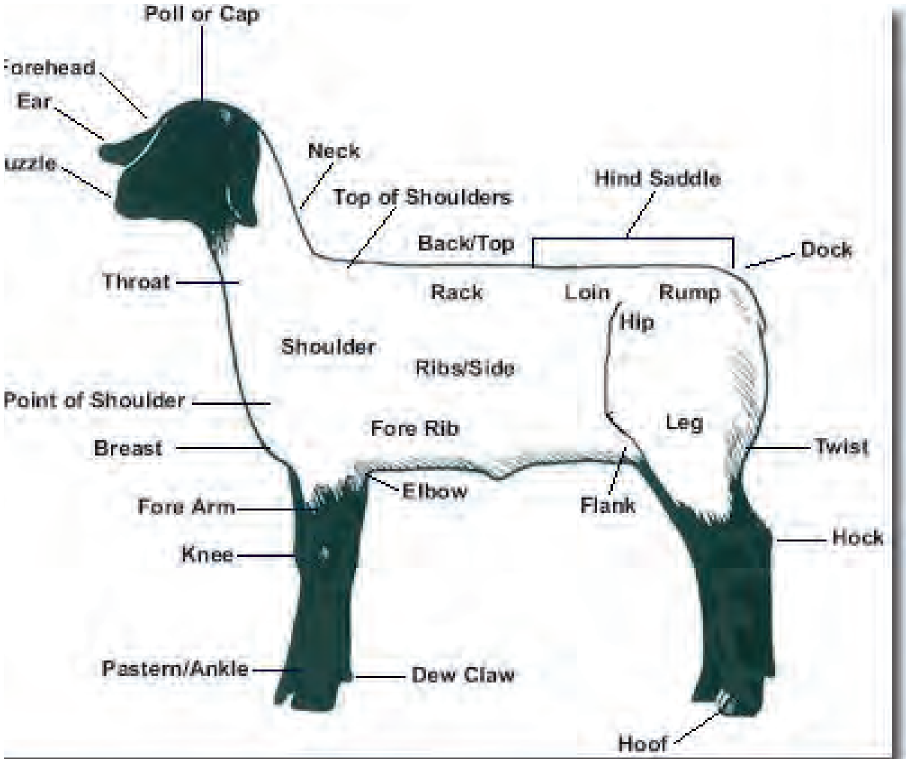


Figure 7.2. Sheep showing anatomical parts.

Brainstorming 7.1

In pairs, list down breeds of sheep and goats common in your area. In your view, what are the differences you can observe between the breeds already known? Share the summary of your discussion with other students sitting next to you.

Menz Sheep breed

The natural habitat of Menz sheep is North Shoa and parts of Wollo zone of the Amhara region. Menz sheep are the most prominent coarse wool-bearing sheep in Ethiopia. The body is compact and mostly covered with coarse hair, with a wooly undercoat.

Shearing is done twice a year and the yield is 1 - 1.6 kg. The wool is used for "Burnos" and coarse blanket weaving. The coat color is black or dark brown, perhaps with white spots on the head, neck, and legs. Other colors such as light brown, roan and white also exist. Rams mostly have twisted horns while ewes are usually hornless.

The tail is short and fat. It has a broad base, ending halfway to the hocks with a slight twist at the end. The mean height at the shoulders is 64 cm and 58 cm for one year of age, respectively. The weight of Menz sheep is about 2.3 kg, 11 kg and 26 -30 kg at birth, weaning (90 days) and one-year of age, respectively. Ewe mature weight is estimated to be about 35 kg. Twin births arc common and the incidence sometimes reaches 60%.

Afar (or Adali) sheep breed

This is a small-sized breed with mature weight ranging from 30 - 35 kg. The natural habitat of the breed is the Middle Awash Valley in eastern Ethiopia. This extends as far as Dire Dawa in the east and the town of Bati in the north. The Afar sheep are hardy. They can tolerate periods of drought well. The Afar sheep have small ears. They usually have a dewclaw and thick layers of fat on the brisket (see Figure 7.3 for the body parts). The fat tail has a wide base and reaches below the hocks. The hair is short and coarse. Their predominant color is solid blond with other colors ranging from shaded white to light brown. Afar sheep weigh about 2.5 kg, 13 kg and 25.8 kg at birth, weaning (90 days), and one year of age, respectively.

The mature weight of ewe is about 31.6 kg. Twin births are not common.

A B

Figure 7.3. Menz sheep breed (A) and Afar sheep breed (B).

7.1.2. Indigenous Goat Breeds

The Ethiopian goat breeds are classified into four family based on the origin, body size (small, medium, or large), ear shape (long, short or lop) and function (meat, milk or skin).

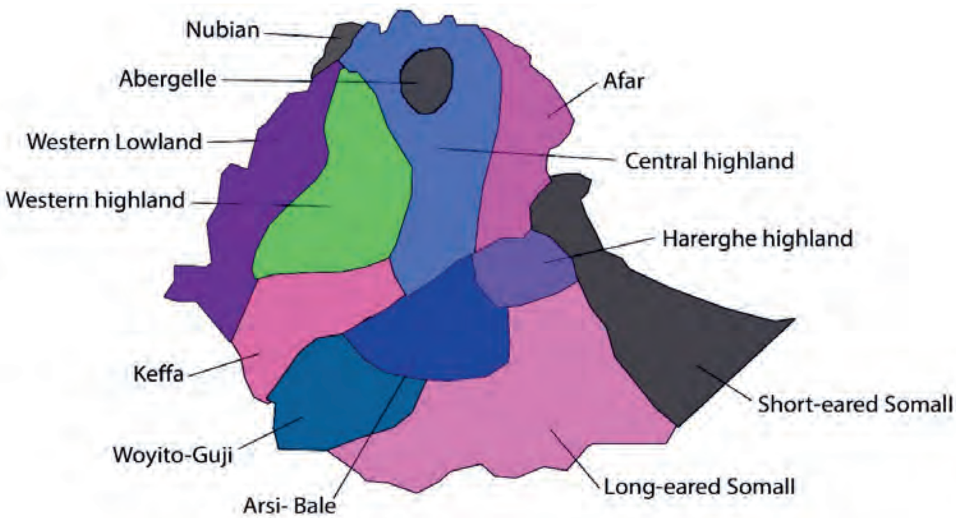


Figure 7.4. Geographic distribution of goat breeds in Ethiopia (adapted from ESGPIP, 2008).

Based on the classification criteria given above, the following important goat breeds and their characteristics are presented.

Afar Goats Breed

The Afar goat is also referred to as the Adal and Danakil goat. Its natural habitat is the Afar Region, but it can also be found in northern and western Hararghe areas of the Oromia Region. Its distribution extends to the Afar area of Eritrea and northern Djibouti. Afar goats are well adapted to arid environment where they are watered every three or four days. The breed is known for being leggy. Both males and females are horned. Most males have beards while wattles could appear in both males and females. Mean height at the shoulders is 64.5 cm and 60 cm for adult male goat (buckes) and female goat (does), respectively. Afar goats are milked for domestic use or sale. The goats are maintained for meat, milk, and skin production and for social affairs as they are commonly given away as dowry.

Figure 7.5. Afar female goat breed.

Arsi-Bale Goats Breed

The Arsi-Bale goats are widely distributed covering the whole of Arsi, Bale and western Hararghe zones of the Oromia Region, and high-altitude areas of Sidama regional state. They are mostly kept in small flocks in mixed farming areas. The Arsi-Bale goat has a straight facial profile. Males have curved and backward-pointed horns. Females mostly have shorter horns. Some males have ruffs while most have beards. Arsi-Bale goats have fairly long ears, and some of them have pendulous ears. Mean height at the shoulders is 73.2 cm and 66.1 cm for adult male and female goats, respectively. The body weight ranges from 30 - 42 kg with height of 66 - 75 cm. Female Arsi-Bale goats

Figure 7.6. Arsi-Bale male goat breed.

are noted for their twin and multiple kidding. Arsi-Bale goats are reared for meat, milk, and skin.

7.1.3. Exotic Sheep and Goat Breeds

There are various sheep and goat breeds that are globally known for their meat, milk, and wool production. Some of these breeds have been imported to Ethiopia to improve meat and fiber production of the indigenous breeds, particularly the Menz sheep. This includes Merino, Corriedale, Rommeny, Hampshire, and Bleu du Maine. Awassi and Corriedale sheep breeds are recognized for their meat production.

Similarly, exotic goat breeds, namely, the Anglo-Nubian, Brown Alpine, Nera Verzasca, Saanen and Toggenburg are well- known worldwide.

Activity 7.1.

In pairs, visit a local sheep/goat market:

a. identify the breeds of sheep and goats available in the market
b. get information on the breed types of both animals in the market
c. find out if the sheep and the goat in the market come from the same area
d. get information on the breed of sheep/goat preferred for meat by the market community
e. find out the basis of the market community's meat preference.

*Report your finding to the whole class.

Exotic Sheep Breeds

Awassi Sheep Breed

Awassi sheep are widely distributed in the Middle East with a range covering Israel, southwest Iran, and southern Iraq, Syria and northeast Arabia. These are fat-tailed sheep known mainly for their meat and coarse wool along with dairy potential. The average traditionally maintained mature weight is between 40 and 50 kg. Rams have large horns and ewes are polled. The average ewe has single lactations over 300 liters per 210-day of lactation. The breed is calm around people, easy to work with and easily milked.

The breed is well-suited to a grazing production system as well as a confinement operation. The Awassi has a brown face and legs with fleece varying in color from brown to white. Individuals can also be found with black, white, grey, or spotted faces. The fleece is mostly carpet type with a varying degree of hair.

Dorper Sheep Breed

The Dorper is a meat breed developed in South Africa. It is a crossbred between the Dorset Horn and Blackhead Persian breeds. Dorper sheep are also widely distributed in some African countries such as Botswana, Zimbabwe, Zambia, and Kenya. Dorper sheep can also be found in North America and other countries around the world. The body of Dorper sheep, except the belly and the face, is covered with a mixture of hair and some coarse wool. Dorpers have a

black head and neck with a white body. Dorper sheep are relatively big and ewes under a favorable environment weigh about 60 kg. Dorper sheep are fast-growing. They are known for their good meat production. The breed is well adapted to dry environments and is well-suited to a wide range of production systems.

A B

Figure 7.7. Awassi sheep breed (A) and Dorper sheep breed (B).

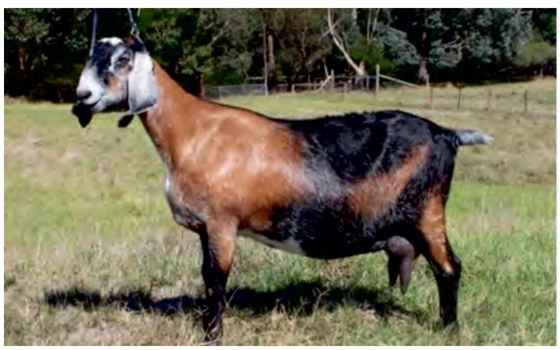
Exotic Goat Breeds

Boer Goat Breed

The Boer goat was developed in South Africa through crossing Africander, South African Common, indigenous Baitus, European, Angora, and Indian blood. Boer goats are medium to large, 75-80 cm in height at the shoulders. Male and female Boer goats weigh up to 130 and 80 kg, respectively. The coat color is white with red or brown on the head and neck. The hair is short and shiny. Boer goats have horns and large drooping ears.

Anglo-Nubian Goat Breed

The Anglo-Nubian is a dual-purpose breed known for both meat and milk production. The breed was developed through the crossing of Jamnapari (Indian) and Zaraiby (Egypt) breeds with Nubian and Damascus ancestry. The breed is well-adapted to tropical environments and was introduced to Ethiopia through FARM-Africa to upgrade Hararghe Highland goats for milk production. They have been used in grading-up programs in many tropical countries to increase the milk and meat production of local breeds. Anglo-Nubians are large, with does weighing at least 64 kg. The average height of the breed, measured at the withers, is 81 cm for does and 94 cm for bucks.



A B

Figure 7.8. Boer goat breed (A) and Anglo-Nubian goat (B).

Breed selection methods

Different breeds have different environmental adaptability. Animals which are adapted to cool areas may not be suitable to hot areas. Animals which have evolved within a certain area are usually better adapted to that area than other breeds. Therefore, it is wise to make use of such animals in improvement programs. In such programs, productivity improvement should come through selection and better management. Introduction of other animals (breeds) may be considered if their own - or that of their crosses with local breeds - adaptability to the area is proven and if their performance shows clear superiority to local animals under similar management conditions.

Selection among breeds must be based on performance data collected from groups raised in the same environment. Comparisons need to be made in the actual environment in which the animals will be raised. Comparisons must be thorough to give realistic estimates of not only lifetime production but also their reproductive, mortality and morbidity rates.

7.2. Sheep and Goat Feeds and Feeding

You have learned in Unit 5 that there are two main classes of feedstuff: roughages and concentrates. Similarly, sheep and goats differ in their feeding habits. Selection and intake of forage depends not only on the available plant resources but it also depends on the feeding behavior of animals. Knowledge of feeding habits that have nutritional implications is important in improving sheep and goat nutrition. A comparison of the feeding habits of sheep and goats is presented in Table 7.1 and Figure 7.9.

A B

Figure 7.9. The feeding habits of sheep (A) and goats (B).

Goats prefer to consume a wide variety of feedstuffs. Goats are more selective and browse more, especially under extensive conditions, than sheep. The potential for goats to select their feed is reduced under intensive management.

Feed Resources for Sheep and Goats

Natural grazing land is the predominant feed source for sheep and goats in Ethiopia. Very little land is planted specifically for pastures or forage crops. This is especially true for the pastoral and agro-pastoral areas. Grazing areas are usually communally owned. Crop residues and agro-industrial by-products represent a large proportion of feed resources in the mixed crop-livestock system. Reliance on crop residues for animal feed is ever-increasing as more land is cropped to feed the fast-growing human population. A list of feed resources available for sheep and goats in Ethiopia in different systems is presented in Table 7.1.

Table 7.1. Availability of feed resources in different production systems.

Coffee-Enset production system	Coffee- crop production system	Crop production system	Pastoral–agro-pastoral system
Natural grazing	Natural grazing	Natural grazing	Natural grazing
Hay	Hay	Hay	Standing hay
Enset by-products	Cereal crop residues	Cereal crop residues	Browsing
Sugar cane tops/ leaves	Oilseed cakes	Pulse crop residues	
Root crop leaves	Enset by products	Oilseed cakes	
Local brewery by products	Sugar cane tops/ leaves	Sugar cane tops/ leaves	
	Root crop leaves	Local brewery by-products	
	Local brewery by products	*Molasses	
	*Molasses	*Milling by-products	
	*Milling by products		

*Molasses and milling by-products are available only near factories.

As you have learned in Grade 11, the nutrient requirement of sheep and goats depends on their physiological state and function. Maintenance and production are also needs to be considered in the decision to be made related to sheep and goats feeding. Nutrient requirements of sheep and goats are similar although specific nutrient requirements for sheep and goats in Ethiopia are not developed. Requirements for different animal functions derived from information on animals in the tropics are presented below.

The overall nutrient requirements of a particular sheep or goat are the sum of its maintenance requirement and other physiological functions (e.g., pregnancy, growth, lactation etc.). Maintenance requirements are presented in Tables 7.2 and 7.3.

Table 7.2. Daily maintenance and pregnancy requirement estimates for energy (ME) and digestible crude protein (DCP) for sheep and goats.

Live weight (kg)	*ME (MJ/kg/dry matter)		DCP(g/day)	
	Confined	Extensive	Maintenance	Pregnancy
10	2.32	3.25	15	30
20	3.91	5.47	26	50
30	5.30	7.42	35	67
40	6.58	9.21	43	83
50	7.78	10.89	51	99
60	8.92	12.49	59	113

Source: Devendra (1982); NRC (1981);

*ME (MJ/kg/dry matter) is the amount of useable metabolizable energy (ME) in a given weight of feed

Requirements for lactation depend on the level of milk production and its composition. Requirements for lactation are presented in Table 7.3. The nutrient requirement for pregnancy rises substantially during the last two months of gestation. It is particularly high if the dam is carrying twins or triplets. There is a need to increase nutrient content of the diet during this period to prevent low birth weights and/or serious loss of body condition by the dam.

Table 7.3. Daily nutrient requirements per kg of milk production.

Fat content of milk (%)	ME(MJ)	DCP (g)	Ca (g)	P(g)
3.5	4.5	47	0.8	0.7
4.5	5.2	59	0.9	0.7
5.5	5.7	73	1.1	0.7

NRC (1981).

Strategies for ensuring appropriate nutrition of sheep and goats include:

- Matching sheep and goat production systems to available feed resources.
- Introducing more efficient use of agricultural and industrial by-products as sources of feed; and
- Encouraging increased intake.

Activity 7.2.

Assessing the feed resources available

In pairs,

a. ask farmers/sheep and goats owners in your area about the feed resources available to them.

b. find out from the farmers or owners also information on the major components of the feed used for their sheep and goats.

c. get information on how the sheep and goats farmers in the community use the resources?

If such feed resources are not found around alternatively see videos or photographs by your school or teacher.

7.3. Sheep and goat housing

Housing design and materials can be kept simple. Housing should be light, well ventilated, well drained, protective and easily cleaned. Having an appropriate design for sheep and goat housing is a crucial priority to beginning construction. The design of all housing can include floor plan, walls, roofing, Feeding (hay racks), watering troughs and other additional facilities like, sorting pens, lambing/kidding unit, hospital area, dips/spray races, and foot baths.

7.3.1. Types of housing

Ground level housing

Ground level housing is common in most parts of the tropics, particularly in semi-arid and sub-tropical regions where rainfall is not excessive. Lean-to type: shed is attached to existing buildings with height of 2-3 m and sloping to 1-1.5 m. Single buildings are used for larger flock sizes. In more modern houses, double cone roofing is used to increase ventilation.

Stilted housing

The floor should rise 1.5 m above ground level to facilitate easy cleaning and collection of dung and urine. Such type of housing provides good ventilation. This is commonly seen in high rainfall areas in Asia. The spaces between the slatted floors should be about 2 cm.

Corals

This type of housing practice is greatly used in Central America for large flock of small ruminants (500-2000) that are reared under extensive conditions. The roof should be sloped to drain runoff to the rear of the structure, and should be situated where drainage is not a problem. This is usually designed for goats (aproximately 1.5 - 1.8 meters tall at the front and measuring 1 to 1.2 meters tall at the rearside).

This Length and depth of the structure can vary depending on the number of animals it is designed to shelter and the enviropment condition.

7.3.2. Housing Designes

Floor plan: The space requirement of the animals influences the design of the floor. The suggested requirements for different production system for sheep and goats are given in Table 7.4. Space requirements vary depending on whether animals are kept in individual or group pens. The space requirement also varies with the size of animals, i.e., bigger animals require larger space than the smaller ones.

Table 7.4. Space requirements for sheep and goat housing.

Type of housing	Space requirement (m^2/Animal)		
	Breeding female	Breeding male	Young stock
Permanent confinement (zero grazing)	1.2	2.0	0.8
Night housing and daytime grazing	0.8	1.5	0.5

Roof: The roof is important as it protects animals against the sun and rain. The under-surface of the roof should remain cool and watertight. To ensure adequate ventilation, the height of the roof and the design should be considered. A high roof encourages air movement but is more likely to be damaged by strong winds.

Walls: In warm climates, walls are partially open to allow movement of air through the house. In some cases, however, complete walling is needed to keep out predators.

Figure 7.10. Simple goat (elevated) and Sheep (one side open) housing designs.

Activity 7.3.

Field visit to area where there is Sheep or Goats keepers.

Work in pairs,

a. Sketch what kind of housing and materials used in your area.

b. Ask why housing is needed for sheep and goats?

7.4. Major Diseases and Parasites of Sheep and Goat and Methods of Their Control

Serious outbreaks of sheep and goat diseases, such as sheep and goat pox, contagious caprine pleuropneumonia CCPP), peste des petits ruminants (PPR), Foot and mouth disease (FMD), pasteurellosis and anthrax are common in Ethiopia. All cause significant production losses. Widespread epidemics are controlled through prevention measures and nationally organized campaigns in the face of outbreaks. Production losses resulting from disease outbreaks are still significant but are lower than those caused by poor nutrition and internal parasites.

Contagious Caprine Pleuropneumonia (CCPP): CCPP is a per-acute, acute, or chronic contagious disease of goats. It affects the respiratory system. Infection occurs through direct contact between goats. The disease is widely distributed in the Rift Valley and lowland parts of the country.

Maedi-visna: The occurrence of Maedi-visna in Ethiopia was reported in imported sheep in 1986 at Agarfa, Bale. It was also reported in eastern Amhara. Lambs are infected by drinking infected colostrum or milk during nursing. Adult animals become infected when they come in contact with nasal discharges of the infected animals. The disease principally attacks sheep but has also been observed in goats.

Maedi-visna: The occurrence of Maedi-visna in Ethiopia was reported in imported sheep in 1986 at Agarfa, Bale. It was also reported in eastern Amhara. Lambs are infected by drinking infected colostrum or milk during nursing. Adult animals become infected when they come in contact with nasal discharges of the infected animals. The disease principally attacks sheep but has also been observed in goats.

Rift Valley Fever (RVF): Rift Valley Fever is a viral infection of ruminants and humans. Animals become sick with RVF 1-5 days after infection. Animals are infected when bitten by infected mosquitoes. The disease only occurs every few years and usually after a very wet period when mosquitoes hatch from infected eggs lying dormant in dry mud. The occurrence of this disease interrupts export market of live sheep and goats.

Sheep and goat pox: Sheep pox occurs in both sheep and goats. It is severe in very young animals. Some young sheep and goats die before showing signs of the disease. The disease spreads by direct contact between animals and contaminated materials.

7.4.2. Parasites Common among Sheep and Goats

External parasites

The common external parasites for sheep and goats are: Ticks, lice, sheep ked, mites, Psoropticovis- the sheep scab mite, Sarcopticovis, flies.

External parasites are responsible for a great diversity of animal health problems.

Internal parasites

The major types of internal parasites of sheep and goats can be categorized into four groups according to their location in the animal.

- Abomasal worms - nematodes (round worms)
- Liver flukes - trematodes (leaf-like worms)
- Intestinal worms -cestodes (tape worms)
- Protozoa (coccidia)

Internal parasites are mainly controlled using anthelmintic drugs. Curative deworming, preventing deworming, strategic deworming and pasture management are integrated worm management program or strategies for controlling internal parasites of sheep and goats.

7.4.3. Strategies of Disease Control

Quarantine: Quarantine is the isolation of animals that are either infected or suspected of being infected with a disease or diseases.

Vaccination: Vaccines are used routinely to prevent diseases. Routine vaccination using some of the following vaccines: Parasturellosis, sheep and goat box, Anthrax, PPR is very helpful.

Control of biological vectors: Infectious diseases transmitted by biological vectors (insects, birds, rodents, etc.) can be controlled by eliminating the vectors.

Disinfestation of formites: Formites include farm equipment, surgical instruments, etc., used with animals. Formites can be disinfected to prevent the transmission of infectious agents.

Disease prevention: Preventing disease is much more effective than trying to cure sick animals.

Drenching and spraying: *T*he build-up of parasites is likely to occur where sheep and goats are kept in intensive conditions. Spraying or dipping of animals is needed to reduce external parasites during periods of high infestation.

Activity 7.4.

group work

Field visit to nearby veterinary laboratory or agricultural office with animal health department. Identify different kinds of internal and external parasites that affect sheep and goats. Ask the farmers what strategies they use to control these parasites.

7.5. Sheep and Goat Meat and Milk Production and Processing

7.5.1. Meat Production and Processing

Meat is the most important product of small ruminants in tropical countries. Small ruminant meat is often used for celebrations. Therefore, the value of a live goat/sheep is often higher than the separate parts. Goat meat has a dark color and is coarse in texture. A characteristic of the species is that fat is deposited on the viscera and the male goats cause a strong smell on the meat. Fat deposition is sparse and yellow in color. There is a limited number of studies on goat meat efficiency. Efficiency is normally expressed as the amount of product/amount of feed input x 100. For energy in goats, this is 4.7% , and for protein 9.1%. This should not be confused with feed conversion efficiency, which is expressed as the amount of feed necessary per kg product. Criteria to take into consideration for meat production are growth rate, total number of goats and efficiency of production. Looking at the quality of meat, the quantity and distribution of fat is very important. The growth rate of lambs is normally in the range of 20-200 g/day. Male lambs grow faster than Female lambs, whether or not the diet is restricted. Ewe lambs get fatter than ram lambs on a given diet and castration reduces growth rate and increases fatness.

Meat roduction and Processing begines with slaughtering of sheep and goats and processing carcasses (cutting, inspecting, packaging, and processing it into other products) for sale.

Sloughtering Sheep and Goats

The stunning methods that have been identified as relevant for sheep and goats can be grouped in two categories: mechanical and electrical. The mechanical techniques include penetrative and non-penetrative captive bolt stunning and using percussive blows to the head and firearms with free projectiles. Electrical methods include head-only and head-to-body stunning.

The slaughtering of sheep and goats for human consumption can take place in a slaughterhouse, on farm, or at home. Sheep and goats are often slaughtered at home for consumption at family gatherings, ceremonial meals, or religious celebrations. Safe food handling practices must be used during home slaughter and processing to ensure the meat is free from disease-causing organisms and contamination. Since the sheep and goat meat processing procedures are very similar, the general sanitation procedures are summarised below:

- start with a clean animal; it is also best if the animal has been held off feed overnight. A full belly makes the skinning and especially the evisceration process difficult. The animal should always have access to water that addresses animal welfare concerns.
- Clean and sanitize the work area before starting work.
- Wash and sanitize hands; put on disposable gloves if desired.
- Have sanitizer available for hands and knives for use during the procedure.
- Sanitize the knife and hands between steps, drying with a paper towel afterward.
- Do not allow the hair side of the hide to touch the meat.
- Wash and sanitize hands that have been in contact with the outside of the hide before touching the meat.

If a sheep or goat carcass will not be consumed immediately and there is a place to chill and store the carcass at less than 4°C, it will be useful to age the carcass for 3 to 7 days to increase tenderness, especially if a dry heat cooking method will be used. Meat can be wrapped and frozen at less than 0 °C for longer periods of storage. Promote food safety by always keeping hot foods hot (above 63°C) and cold foods cold (below 4 °C) and refrigerating leftovers at 4 °C or below promptly.

As you have learned in Unit 6 section 6.5. in detail about the beef meat processing, methods of meat processing in sheep and goat also include the following physical and chemical treatments such as salting, curing, fermentation, smoking, and/or the addition of chemical preservatives.

7.5.2. Milk Production and Processing

Sheep's milk production is reported in only a few countries in the tropics. Sheep and goat's milk is rarely sold. Compared to sheep milk, goat milk is commonly used. Under very favorable conditions the best sheep can produce 2.5 liters of milk per day, but 1.0 liter per day is regarded as excellent. In tropical environments, milk yields of 0.3 liter per ewe per day are more common (50 liters in a 100-day lactation). However, the efforts in genetic selection and better feeding conditions led to several superior goat and sheep breeds in some countries in terms of milk and solids productivity, proving a great potential for evolution in both species, and responding to increasing market demand and popularity, especially of cheeses from goat and sheep milk. Some sheep breeds can produce more than 1000 kg milk in one lactation and several goat breeds more than 2000 kg milk, but in physiologically comparable terms of 4% fat-corrected milk both species can be equal. The best Goat breed for milk production has been capable of producing 10 kg of milk per day of lactation.

Ewes are milked once a day. Lambs are separated from the ewes in the morning while the ewes go out to graze. In the evening, the ewes are milked before they are returned to their lambs. Compared to cow's milk, sheep's milk has high solids content and is more concentrated in fat and protein. Goat milk contains less lactose, but its fat content is also much simpler for human digestion than cow milk. This means that the fat globules in goat milk are smaller and easier for our milk fat-dissolving enzyme lipase to break into smaller pieces as they pass through our gut.

In your Grade 11 of unit 5, you have learned about cow milk processing. The fundamental processing techniques involved in the processing of fluid sheep and goat milk are also similar to that of cow milk. Receiving milk, filtering, standardizing, pasteurizing, chilling, packing, storing, and distributing fluid goat milk are the key processes and techniques used. Sheep and goat milk can successfully be made into cheese, yoghurt, butter, and ghee. Ghee is made from sheep's and goat's milk. Sheep's milk produces especially high yields of cheese per liter of milk.

Activity 7.5.

Work individually,

a. What are the products obtained from small ruminants?
b. How does goats or sheep (if consumed) milk differ from that of cow milk?

*Show your answers to your teacher.

Unit Summary

In this unit, you have learned that:

- local sheep and goat breeds have developed specific adaptations to survive and produce under adverse local environmental conditions.
- the sheep found in Ethiopia are classified into different breeds and types. The habitats of sheep range from tropical to temperate environments. There are 14 - 15 sheep breeds distributed across the country.
- Afar, Arsi-Bale, Blackhead Somali, Horro, Menz, Washera (Dangla) and Menz are some examples of the sheep breed identified in the country.
- Afar, Abergelle, Keffa, Woyto-Guji, Arsi-bale, long-eared Somali, Hararghe hihlands are some of the goat breed identified in the country.
- some of exotic breeds have been imported to Ethiopia at some time in the past to improve meat and fiber production of the indigenous breeds.
- selection and intake of forage depends not only on the available plant resources but it also depends on the feeding behavior of animals.
- natural grazing land is the predominant feed source for sheep and goats in Ethiopia.
- hosing should be light, well ventilated, well drained, and easily cleaned. Having an appropriate design for sheep and goat housing is a crucial priority to beginning construction.
- sheep and goat diseases, such as sheep and goat pox, contagious caprine pleuropneumonia CCPP), peste des petits ruminants (PPR), pasteurellosis and anthrax are common in diseases Ethiopia.
- meat is the most important product of small ruminants in tropical countries. On the other hand, sheep's milk production is reported in only a few countries in the tropics.
- compared to cow's milk, sheep's milk has high solids content and is more concentrated in fat and protein. It can successfully be made into cheese, yoghurt, butter, and ghee.

Review Exercise

Part I. Say True or False for each of the following questions.

1. Poduction losses resulting from disease outbreaks are still considered significant but are lower than those caused by poor nutrition and internal parasites.
2. Knowledge of feeding habits has value in improving sheep and goat nutrition.

Part II: Match items under Column A with those under B.

	"A"	"B"
______	1. Menz sheep breed	A. Coarse wool-bearing sheep in Ethiopia
______	2. Afar sheep breed	B. Reared in Middle Awash
______	3. Arsi-Bale goats	C. Developed in South Africa
______	4. Awassi Sheep breed	D. Twins and multiple kidding
______	5. Boer goat breed	E. Fat tailed sheep
______	6. Anglo-Nubian goat breed	F. Indian and Egyptian breed type
		G. Latin American origin

Part III. Choose the correct answer from the given alternatives for the following questions.

1. Strategies for ensuring appropriate nutrition of sheep and goats include:
   A. matching sheep and goat production systems to available feed resources.
   B. introducing more efficient use of agricultural and industrial by-products as sources of feed; and
   C. encouraging increased intake.
   D. all of the above
2. Of the following housing type is not common in tropics:
   A. Ground level housing   C. Silted housing
   B. Corals   D. All of the above
3. Breeds can be classified based on one of the following criteria
   A. Origin   C. Body size
   B. Ear shape   D. Function   E. All of the above

4. Housing design should not be
   A. Well ventilated
   B. Easy to clean
   C. well drained
   D. none of the above
5. Which one of the following should not be included as part of sheep and goat housing design:
   A. Floor plan
   B. Feed and water trough
   C. Roofing
   D. All of the above

Part IV. Write short notes on the following topics.

1. Describe the feeding habits of goats?

Unit 8 Camel Production and Management

Contents	Learning Outcomes
8.1. Camel breeds and selection	At the end of this unit, you will be able to:
8.2. Camel feeds and feeding	▪ recognize different camel breeds and selections
8.3. Camel housing	▪ describe camel feeds and feeding methods
8.4. Major disease of camel and methods of their control	▪ differentiate camel housing from other livestock housing
8.5. Camel meat and milk production and processing	▪ state the major diseases of camel and suggest their controlling methods
	▪ explain the techniques used in camel meat and milk production and processing
	▪ describe camel meat and milk production and processing
	▪ promote camel production and management in their locality (in the low land of Ethiopia)

8.1. Camel Breeds and Selections

There are two types of camels: one humped and two humped types. The two humped camels (*Camelus bacterianus*) evolved from the earliest camels. The modern *Camelus bacterianus* (i.e., one humped) camel is found in cold deserts of central deserts. The one-humped (*Camelus dromedarius*) have evolved from the two humped camel types (*Camelus bactrianus*). The evolution took place in one of the hotter and more arid areas of the central and southern Arabia. The present distribution of dromedaries is in wormer desert areas (India-Mali of West Africa).

FAO officially recognizes 5 breeds in Ethiopia (Somali/Ogaden, Ethiopian Dromedary, Afar, Anfi, and Borena); however, pastoralists of the region recognize additional breeds.

Bacterianus Camels

- They are two-humped and fatty.
- Their skull bone is shorter and wider than those of the dromedary camels.
- Long hair grows on the top of their head, the lower part of their neck and on their hump and legs.
- Adapted to cold area:
  - limited to economic importance.
- Coat color: is reddish-brown; they have short limbs. They live in the cold desert regions of central Asia.

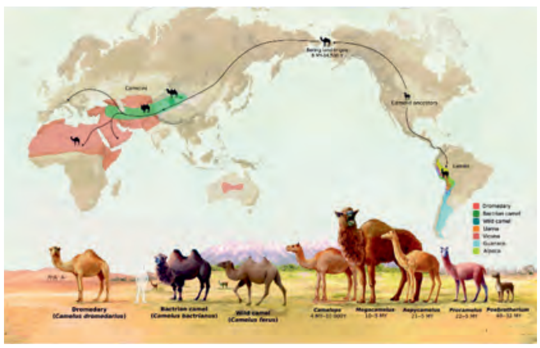


Figure 8.1. Migration map of the historical camelid family.

Dromedary Camels (Arabian camel)	**Wild Bactrian camel (*Camelus Ferus*)**
▪ One humped and larger camel than bacterian camels ▪ Possess short, fine and spacey distributed coat color. ▪ They have lean tissue, longer limbs and broad feet. ▪ Important to the hotter areas of Africa ▪ Adapted to trapdoor nostrils to protect the entrance of sandstorms into the nasal cavity. ▪ Importance is very high – especially in countries like Ethiopia.	▪ A critically endangered species of camel living in parts of northwestern China and southwestern Mongolia. ▪ They are closely related to the camel of Bactria (*Camelus bactrianus*). They are both big, double-humped, even-toed ungulates native to the Central Asian steppes. ▪ Only around 1,000 camels survive. Most live in China's Lop Nur Wild Camel National Nature Reserve. A smaller population lives in Mongolia's Strictly Protected Great Gobi Forest.

Bacterianus Camel

Breed	**Kalmayk**
Breed purpose	Have a great capacity to carry loads and to work.
Breed size	Large with well-developed skeleton, musculature and hair cover
Males weight	760 kg (Max. 1042 kg)
Females weight	650-700 kg
Tolerance	Adapted to arid and desert
Coat color	Reddish brown to blackish
Milk yield	1925 – 2012.5 liters/ lactation
Place of origin	Kazakh SSR

Figure 8.2. Kalmayk camel breed.

Breed	Alahshan
Breed purpose	A multi-purpose animal, mainly used for work, wool and meat production
Breed size	Medium
Males weight	680 kg
Females weight	454 kg
Tolerance	Mountains, semi-desert and desert
Coat color	Apricot yellow, purple, brown, white.
Milk yield	1.4 kg daily plus the milk suckled by the young
Place of origin	China, Mongolia

Figure 8.3. Alahshan camel breed.

Dromedary Camel

Breed	Afar
Breed purpose	Milk and work (pack).
Breed size	Light to medium
Males weight	400 and 600 kg
Females weight	300 and 540 kg
Tolerance	Arid and semi-arid environment
Coat color	Generally a shade of brown
Milk yield	2.01-12.0 liters per day in 2-3 milking times.
Place of origin	Somalia

Figure 8.4. Afar camel breed.

Breed	Bikaneri
Another name	
Breed purpose	Multi-purpose animal, mainly used for work, wool, meat and milk production
Breed size	Heavy built
Males weight	670 Kg
Females weight	556 Kg
Tolerance	Arid and sandy with extreme hot and cold climates.
Coat color	Varies from dark brown to light brown and from light red to dark red.
Milk yield	Average daily yield 2.7±0.05 liters.
Place of origin	India

Figure 8.5. Bikaneri camel breed.

Activity 8.1.

Do the questions below in pairs. Share your answers with other students.

a. Have you ever seen a camel? In which region or area are camels found in Ethiopia?

b. Are there camels in your area? If yes, what are their breed types?

c. What are the breeds or types of camel found in Ethiopia?

Camel Selection Methods

Selection is important to identify the best types of camel for improvement of production and productivity in camels. Camel selection is an important activity among the pastoralists. Body size/appearance, growth rate, color, work performance and libido are the most important traits to consider in the selection of breeding male camels. Male camels that have large body and that grow fast are the most preferred by most of the pastoralists in both sites.

Age at first calving and milking abilities are the most highly rated traits in selecting breeding female camels. The trait most selected for milk production and for other related characteristics are posture and size of udder, size of mammary gland and pedigree. Growth rate is also considered in selecting breeding females.

Activity 8.2.

Do these questions in a small group. Share your answers with other pairs.

a. Write the distinctive characteristics of Dromedary camels.

b. What selection criteria are used to select male and female camels for breeding?

c. Why are camel selection criteria so important for the pastoralists?

Brainstorming 5.2

What do you think are the main feeds and feeding methods of camels?

What camel feed resources are available in your community?

8.2. Camel Feeds and Feeding Methods

Camels are very versatile and opportunistic feeders. They accept a wide range of browse species that are often avoided by other animals. They also feed on some types of grass species. Examples of the plants camels choose are the camel thorn, acacia and salt bushes.

The main camel feeds are trees or bushes. They also graze grasses when trees to browse are not available. Camels optionally utilize wet season herbs, grasses and cereals. These are the least preferred feed types.

Pastoralists mostly migrate in the dry season to search for pasture, water and to prevent their animals from diseases that occur during the dry seasons in the area. During the dry season, female camels are shifted to areas of better feed availability. Male camels are often kept around settlement area for transportation of goods.

Figure 8.6. Acacia tree with thorns.

Supplementing camels' feed with both protein (groundnut cake) and energy (maize) is strongly recommended to increase camel productivity. Feeding a lactating camel 4kg of protein supplements like groundnut cake or oil seed cakes daily improves the milk yield and therefore the net income, in the dry and wet seasons.

Camels have a higher salt requirement than other livestock. Supplementation of feed in the form of mineral salt, or allowing them to graze on salty grasses and on saline soils is recommended. Many Ethiopian camel herders offer 0.5 kg table salt per head at 2 months intervals especially during the wet season.

Activity 8.3.

In pairs,

a. identify camel feeds, feeding habits and feeding methods. Report the summary of your discussion to the whole class.

b. discuss the water requirements of camels and their unique characteristics regarding water requirement.

The camel is a highly resistant to water deprivation. It can survive for a long time without water, the only effect being loss of up to 20% of its body weight. The camel can drink up to 200 liters in 20 minutes when required. The camel's water requirement is influenced by dietary and environmental factors such as dry matter, minerals and ambient temperature. Physiological conditions such as lactation also influence camel's water requirement.

8.3. Camel housing

Mostly, camel housing systems are categorized into two main classes: open and closed. The category is on the basis of the age of the camel. Their living environment, availability of construction materials, settlement of the owners, and the animals' exposure to predators are also important matters to consider in camels' housing systems. Mature camels are housed in the fence around the owners' home during the night and herded during the day on communal grazing lands. The calves are housed in an enclosure made for keeping calves separately from the rest of the herd. The enclosure is constructed with wood and fenced by available pieces of thorn wood and bush plants. In Ethiopia, almost all camel breeders keep their animals in traditional **kraal** made up of thorny bushes. This protects the animals from predators.

Figure 8.7. Examples of camel house designs.

Key term

Kraal is an enclosure for cattle or other livestock around the pastoralists' settlement or it is a village surrounded by a fence of thorn bush branches, It is roughly circular in shape.

Activity 8.4.

class work

In small group,

a. discuss the different designs of camel housing. Which do you think is most effective. Report the summary of your discussion to the other groups sitting next to you.

8.4. Major Diseases of Camel and Methods of Their Control

Health management is critical in controlling mortality and improving production and the productivity of camel. Camels have better potential to resist diseases than other livestock species. However, they still are susceptible to a wide range of diseases. Infection with pathogenic viruses or bacteria and infestation with parasites are commonly observed diseases of the camel.

High incidence of parasitic as well as many infectious diseases in camel herds are reported as serious concern. Trypanosomiasis, camel pox, contagious ecthyma, dermatomycosis, pneumonia, mange mite infestations and internal parasites are among the major health problems reported in camels in Ethiopia. Camels may also be susceptible to bovine viral diarrhea, infectious bovine rhinotracheitis, parainfluenza-3, respiratory syncytial virus and the Rift Valley fever.

Viral disease	Bacterial disease	Parasite
▪ Camel pox ▪ Foot and mouth disease	▪ Anthrax ▪ Brucellosis ▪ Corynebacteriosis ▪ Pulmonary-affection-complex ▪ Rickettsiosis	▪ Helminthiasis ▪ hydatidosis ▪ Myiasis ▪ Mange ▪ Ticks

Control is invaluable once a disease is diagnosed

- Separate sick animal (good to have an isolation area).
- Disinfecting is a cornerstone among many control measures.

Activity 8.5.

In a small group,

c. discuss the major diseases of camels and their controlling methods.

d. categorized the listed major disease as viral, bacterial and protozoal.

Report the result of your discussion to the rest of the students in the class.

8.5. Camel meat and milk production and processing

Camel is a multipurpose animal used for production (meat, milk, wool, skin), leisure (races, tourism, sport, bueaty contest), agricultural work.

8.5.1. Meat production and processing

In Ethiopia, camels are kept in the arid and semiarid lowlands of Borena, Ogaden and the Afar regions. These area cover 50% of the pastoralist areas in the country. The weight of an adult camel varies depending on age, sex, breed, nutritional status and stomach fill, from approximately 320 to 750 kg. Camels gain this weight between their age of five and seven years in pastoral production systems.

Dressing percentage, as in other herbivores, ranges from 45 to 55%. Meat quality is largely age dependent, and as in other meat animals, good meat is from young slaughter stock. Camel meat production has increased at a rate of 2.8% from 123,000 to 356,000 tones (t). The major camel meat producers are Sudan, Egypt, Saudi Arabia (KSA) and Somalia (Figure 8.8). The Sudan and Somalia export camel meat, while Saudi Arabia and Egypt are camel meat importers.

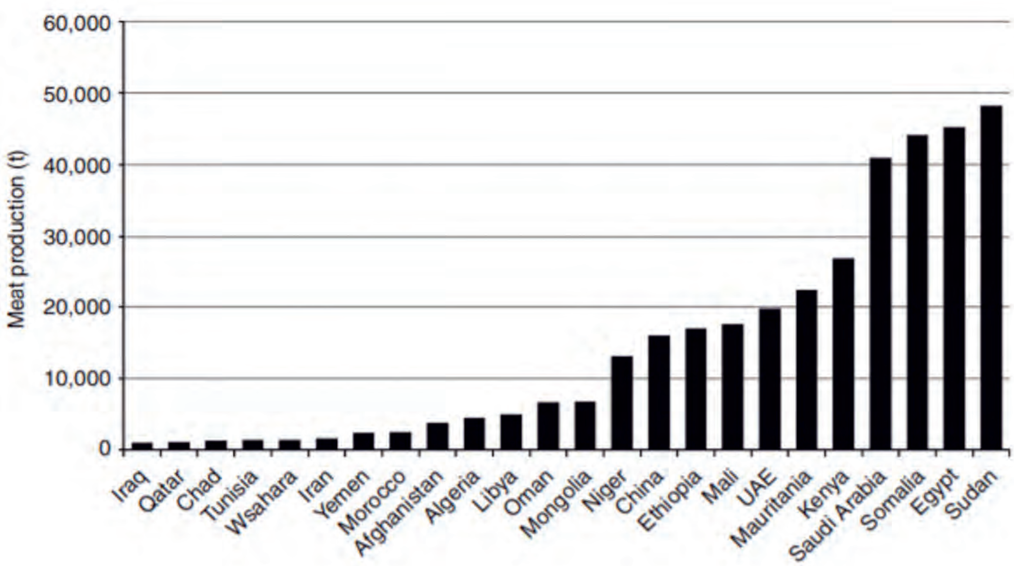


Figure 8.8. Camel meat production in the countries producing more than 1000 tones (t).

Other than in Sudan, camel meat markets and camel meat consumption are not well developed in Eastern Africa. There are encouraging export opportunities in Egypt and Libya. Camels have low reproductive rate. This is a cause for them to be not efficient meat producers. Offtake rates of 3 to 5% might already constitute a stress on the camel population.

Although many pastoralists consume camel meat when available, camels are rearly slaughtered for home consumption of meat. Only occasionally do camel herders slaughter camels at home. Funerals, weddings and religious festivals can be mentioned as examples of occasions in which slaughtering of camels at home can be observed. Camels injured in accidents can also be slaughtered. Camel meat is sold at butcher shops in towns such as Dire Dawa, Harar and Jijiga.

8.5.2. Milk production and processing

Ethiopia produces about 4.2 million cubic meters of milk annually according to 2021 reports. Out of this, 80% is cow milk. The rest comes from camels and goats. Milk is the most important camel production in arid and semi-arid environments of Eastern Africa. In this region, camel milk is a valuable food source for humans. The total dry matter content of camel milk ranges from 12 to 15%. The range of its protein content is 2.7 to 4.5%. What ranges from 2.9 to 5.2% is the fat content of camel milk, while the lactose content of the milk is 5.5%.

The milk has a high content of vitamin C. This may reach 2.9 mg/100 g. This is of special importance particularly in areas where food of plant origin is scarce. Reported daily yields of milk range from 3.5 to over 20 liters. The annual lactation yields vary from 800 to over 4000 liters. Lactation lengths show a large variation - eight months to almost two years, for example.

A B

Figure 8.9. Automatic camel milking technology (A) and bucket milking machine for camel (B).

Few companies based in the country's eastern regions of Ethiopia are currently erecting a plant that processes camel milk. Camels can produce an adequate amount of milk in drought areas where other domestic animals have very low production. The annual camel milk production in Ethiopia is estimated to be 170, 000 tons in 2021. The country ranks fourth. Somali, Kenya and Mali are the first three camel milk producers. In Ethiopia, pastoralists produce different fermented camel milk products such as "dhanaan". Dhanaan is produced by pastoralists in Somali region and "ititu" is a fermented camel product in Boran zone.

A B

Figure 8.10. White camel cheese (A) and camel powder milk (B).

Activity 8.6.

Answer the following questions individually. When you finish, compare your answers to your neighbor's.

a. Have you ever drank camel meat or milk or ate camel meat?
b. If you have, how is it different from the meat or milk of other livestock type?
c. Do you know the meat or milk production and processing potential of camels?

Unit Summary

IIn this unit, you have learned that:

- camels are domestic animals which are living in desert or hot areas of the tropics including parts of Ethiopia.
- there are two types of camels: one humped and two humped types. The two humped camels (Camelus bacterianus) evolved from the earliest camels.
- the one-humped (Camelus dromedarius) are evolved from two humped (Camelus bactrianus).
- skull bone, hair, adaptation, and coat color are the criteria or differences of among Dromedary (Arabian camel) hump, Bacterianus and Wild Bactrian (Camelus Ferus) camels.
- selection methods for camels are almost similar to other animal selection methods.
- body size/appearance, growth rate, color, work performance and libido are the most important traits to select breeding male camels.
- camels are very versatile and opportunistic feeders, they accept a wide range of browse species that are often avoided by other animals, for example camel thorn, acacia and salt bushes.
- the main camels feed resources are trees or bushes, but they also graze grasses when browsing tree are not available.
- the camel is highly resistant to water deprivation it can lose up to 20% of its body weight and drink up to 200 liters in 20 min.
- mostly camel housing system categorized in to two main classes; named as open and closed housing systems
- in Ethiopia, almost all the camel breeders kept their animals in traditional kraal made up of thorny bushes to protect the animals from some predators.
- in comparison, camels have the potential to resist many diseases than other livestock species. But still camels are susceptible to wide range of disease for which the main cause is infection with pathogenic viruses or bacteria, infestation with parasites.
- separate sick animal and disinfecting are invaluable diseases controlling mechanisms.
- camel meat production increased at a rate of 2.8 from 123,000 to 356,000 tones.
- camel meat markets and camel meat consumption are, with the exception of Sudan, not very well developed in Eastern Africa.
- milk is the most important camel product in arid and semi-arid environments of Eastern Africa.
- the annual camel milk production in Ethiopia is estimated to be 170,

000 tons which ranked the country fourth next to Somali, Kenya and Mali.
- in Ethiopia, pastoralists produce different fermented camel milk products such as “dhanaan” which is produced by pastoralists in Somali region and “ititu” in Borana.

Review Exercise

Part I. write True or False for each of the following questions.

1. The camel is highly resistant to water deprivation.
2. Camels have a lower salt requirement than other livestock.

Part II. Choose the correct answer from the given alternatives for the following questions.

1. Housing system in camel mainly depend on:
   A. Living environment
   B. Settlement of the owners
   A. Locally available construction materials,
   B. Exposure to predators.
   E. All of the above
2. Which one of the following is important trait to select breeding male camels:
   A. Appearance C. Growth rate,
   B. Work performance D. Libido
   E. All of the above
3. Which one of the following is used as feed resources for camel:
   A. Trees C. Herbs
   B. Bushes D. Grass
   E. All of the above
4. Of the following breed is not dromedary camel, which one is it?
   A. Afar C. Bikaneri
   B. Somali D. Kalmayk E None of the above.

Part III. Write short notes on the following topics.

1. What are the importance of camel in dissert areas of the tropics?
2. What are the major types of diseases or parasites of camel and ways of controlling them?
3. Mention some products produced from camel milk?

Unit 9 Poultry Production and Management

Contents

Learning Outcomes

At the end of this unit, you will be able to:

- analyse the characteristics of both indigenous and exotic poultry breeds in Ethiopia
- recognize poultry breeds, classification and selection methods
- clarify poultry feed resources and feeding methods
- estimate the feed requirements for different types of poultry breeds
- compare common types of poultry housings
- describe egg incubation and hatchery management
- explain poultry brooding and rearing methods
- describe layers and broiler management
- mention poultry diseases and suggest their controlling methods
- initiate their classmates to engage in poultry production and management

9.1. Poultry breeds, classification and methods of selection

There are three main categories of chicken breeds: pure commercial breeds, hybrid breeds (i.e., cross- and local) and local or land races. There are also four types according to utility or economic values: Egg type (e.g. Leghorn), Meat type (e.g. synthetic), Dual purpose (e.g. Rhode Island Red), and Ornamentals (e.g. Bantam).

Brainstorming 9.1.

In small groups, discuss the types of chickens kept in your area and breeds that you already know.

9.1.1. Indigenous poultry breeds of Ethiopia

There are ten common local chicken breeds or ecotypes: Chefe, Gebsima, Horro, Jarso, Kei, Naked neck, Netch, Tepi, Tikur and Tilili. The indigenous chickens are non-descriptive breeds. They are closely related to the jungle fowl. They vary in color, comb type, body conformation, and weigh. They may or may not possess shank feathers. Broodiness (maternal instinct) is pronounced. Indigenous chickens have an inherent scavenging and nesting habit. They are more resistant to diseases, less prone to predator attacks and can survive under harsh nutritional and environmental conditions. Slow growth, late maturity and low production performance characterized Indigenous local chicken breeds.

Figure 9.1. Horro breed (A), Chefe breed (B) and Tepi breed (C).

9.1.2. Commercial or exotic breeds

Commercial or exotic breeds are those chicken brought from other countries for the purpose of improving the local chicken production such as egg, meat or both.

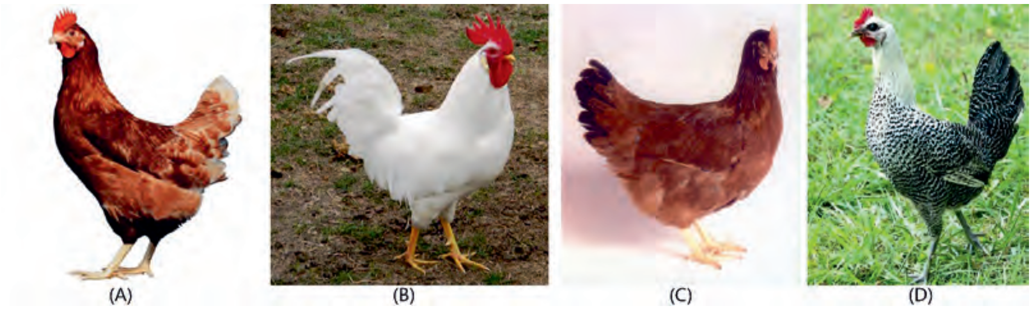


Figure 9.2. Bovans Brown (A), White leghorn (B), Babcock (C), and Fayoumi (D).

Layers

These breeds are used primarily for egg production. Most of the time, the eggs of the parent stock are imported. Then the generations are used for their egg production while the parent stock is used for hatchery purposes. In the past, several layer breeds used to be imported to Ethiopia, but today only layer breeds are imported for egg production. Layer breeds Bovans Brown and White Leghorn.

Bovans Brown

It is the bird of choice for today's egg farmers who expect high egg numbers. Giving the breed essential ingredients, can make the farm a profitable business. The breed performs well for egg producer with traditional production facilities. Bovans Brown is a very docile breed. This makes the breed the perfect bird for an alternative production.

White Leghorn

These are known for laying lots of white eggs. They need little feed, due to their small size. White Leghorns are therefore very efficient layers. At the end of the laying period, the breed gives little meat.

Broilers

Modern commercial broilers are specially bred in large scale for efficient meat production. They grow much faster than egg laying hens. Broilers often reach a harvest weight of 4 - 5 pounds, dressed, in only five weeks. Those that grow more slowly in free-range, they reach slaughter weight at 12 - 16 weeks of age. Babcock is the chicken breed that is currently imported and used for a fattening purpose.

Dual purpose:

Dual purpose breeds of chicken are the chicken used both for egg and meat production. Fayoumi breed are known for their best adaptability to the harsh, hot and arid environment of Egypt.

Activity 9.1.

In small groups,

a. list local poultry breeds common in your area.

b. identify the breeds that owners prefer to keep.

c. which breeds are more common, those kept for utility or the breeds kept for economic values?

Your teacher will tell you what to do with your finding.

Poultry breed Selection methods

Selecting the best breed involves evaluating color and conformation, demand for vaccination and susceptibility to disease. Consumption of feed, hardiness and adaptability, productivity, and efficiency are equally essential characteristics to be considered in poultry breed selection. Layers, for example, are selected and/or culled on the basis of their performance and appearance. See below:

a) Individual performance

- Precocity
- Intensity of laying
- Persistency of laying

b) Individual appearance

- Physical body make up (vigor, head and comb)
- Physical body change (pubic bone, abdomen and vent)
- Physiological change (pigmentation and mounting

Activity 9.2.

Individual Work: Answer the questions below individually. Compare your answers with your neighbors' answers. Discuss your answers with neighbors. Report any differences in the criteria of breed selection methods.

a) Do your parents keep chicken? If they do, for what purposes? How do they select the specific chicken breed they keep?

b) If there are smallholder poultry farms in your community, visit them and take notes on some important aspects of the farms and the animals. Study the important points you learned in this unit and choose important aspects to focus on during your visit.

9.2. Poultry feeds and feeding methods

Poultry feed resources

Crops grown and their by-products can be used as potential sources of feed for smallholder poultry farmers. The potential supplementary feed resources used by smallholder poultry farmers are maize and cereal debris. Smallholder farmers also use major green feeds available (like e.g., cabbages, grass, vegetable, weeds, enset by-product, and alfalfa). Non-conventional feed resources including worms and insects are also available. Figure 9.3 shows examples of poultry feed resources.

Figure 9.3. Examples of poultry feed resources.

Poultry feeding and nutrient requirements

The average feed consumption of chicken is usually 40gm/head/day up to their age of 8 weeks. Recommended calorie-protein ratio is 135:1. In the day old chicken, flat feeders cut out from chick boxes, egg trays and flats can be used. As they grow up, the feeders should be changed to deeper and longer containers. Shallow drinkers must be used during this period.

For Layers the requirement is:

ME/ kg/kcal	Cp	C.fat	Lys	Met	M+c	C	P
2750	16.5	8	0.7	0.28	0.6	3.5	0.8

The recommended calorie-protein ratio (C: P ratio) of layers ration is 170 -180:1. The average feed consumption of layers is 115 – 125 gm/ head/day. Normal feed conversion ratio (FCR) is 1.8. In case of Broilers, the objective is rapid growth rate. This makes it important to provide sufficient feeding spaces and good quality feed. Always adjust Cal/protein ratio according to standard. Lower calorie content reduces growth.

The recommended Cal/protein ratio is:

- Starters chicken (0 - 3 weeks) = 135:1
- Finishers chicken (>3 weeks) = 155:1

Activity 9.3.

In pair

a. identify poultry feed resources, and

b. poultry feeding methods and explain to the class.

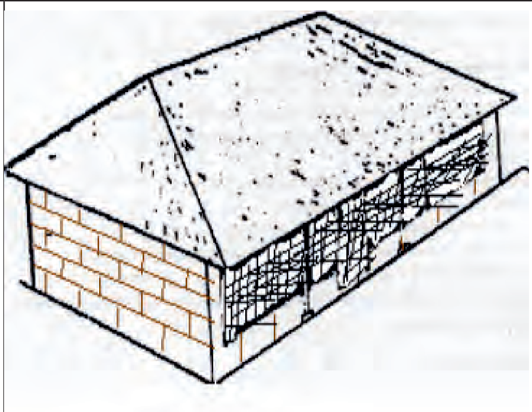
9.3. Poultry housing

Why do we keep chickens in house? Below are some reasons:

- to protect chickens against rain, wind, other animals and predators.
- to reduce outbreaks of disease.
- to provide chickens with nests, comfortable dark places to lay, brood and hatch their eggs.
- to increase egg and meat production.
- to increase income.

A properly constructed poultry house has certain essential features. Poultry house should have watertight roof and proper ventilation. The inner surfaces should be easy to clean. It also shouldn’t let in rats and wild bird, etc.

The common types of poultry houses are Open Houses, Open Front Houses, Curtain Houses, Closed Houses, Deep Pit House, and High Rise Houses.

Open Houses ▪ Have two open sides. ▪ Roof often has large overhang (1.0 meter or more) to protect birds from rain & sun. ▪ Wire mesh often used for the sides. ▪ Additional removable/ ventilation fans are recommended in large houses. ▪ Suitable for tropical areas.	 Figure 9.4. Poultry house with two open sides.
Open Front Houses ▪ Comparable to open house, main difference is they have only one side open. ▪ Suitable for areas where temperatures range from 15-30 °C. ▪ Open houses and open front houses should not be wider than 9 meter. ▪ The climate inside & outside the houses is almost the same.	 Figure 9.5. Open front poultry house design.

High Rised Houses

- Built above ground level or above a fish pond, as a system of integrating.
- Always have the cage system or full slatted floors.
- Suitable for tropical climates.

Figure 9.6. High Rised Poultry House.

9.4. Egg incubation and hatchery management

Incubation can be achieved either by natural means using broody hen or by artificial means.

Artificial incubation

The development of a fertile hen egg into a young chick requires:

- a temperature of 37.5 - 39 oC for three weeks
- a supply of fresh air allowing the embryo to breathe
- enough humidity to prevent the egg content from drying out
- space for movement (turning) of the egg to prevent the embryo from sticking to one side of the egg.

Figure 9.7. Natural (A) vs. artificial incubation (B) and their hatching techniques.

An incubator must therefore have a:

- source of heat
- thermostat to maintain the temperature at 37.5-39 oC
- tray which holds the egg steady but allows the movement of air around the eggs.

- supply of water to humidify of (to moisten) the air in the incubator.
- ventilator to provide fresh air and to remove stale air.

Cleaning and disinfection of incubator: HHatchery sanitation aids in breaking the disease cycle. This should be done after hatch and before using it for the next cycle.

Collection and storage of hatching eggs: Hatching eggs should be collected as at least four times a day.

The following are important factors to achieve a good production:

- temperature, humidity, ventilation, and hygiene.

Activity 9.4.

In a group,

a) Visit poultry housing systems available in your locality. Observe their incubation and hatchery methods.

b) Find out about the effects of their egg incubation and hatchery methods on production.

c) Interview the farm owners for information on the status of the farm.

d) Write your inclinations and opinion about feeling about poultry production and management. Do you want to engage in poultry production and management in the future? Why?

Your teacher will tell you what to do with the findings of your fieldwork.

Note: If there is no such farm in your area please use the internet or library and find out what is the common poultry housing system in Ethiopia. Explore their egg incubation and hatchery techniques.

9.5. Poultry brooding and rearing

Brooding refers to the period when young chicks require a lot of care. The period ranges from one-day of age to about four weeks in the tropics. During this period supplementary heat is provided for the chicks comfort. It is the most critical period in the life of the birds and there can be more deaths during this short period than throughout the rest of the birds' lives.

There are two methods of brooding chicks:

1. Natural brooding by the chicken
2. Artificial brooding

Artificial heat sources are (brooders can be made of):

- Electric brooder (infra-red heat bulbs)
- Kerosene brooders
- Hot air, hot water or radiant heat.

A B

Figure 9.8. Natural (A) and artificial (B) brooding and rearing.

9.6. Layers and broilers management

Layers

In well-developed poultry industry, hens start laying eggs when they are about 20 weeks of age. The production of the whole flock then rises rapidly to a peak after 8 weeks. At that point most of the hens lay eggs almost every day. Each day there are as almost as many eggs to be gathered as there are laying hens. The ratio of number of birds to the number of eggs gathered on one day is called 'laying percentage'.

A B

Figure 9.9. Layers housing (A) vs broilers housing (B).

Laying house equipment

Laying nest

- Laying nest is a place where hens lay their eggs.
- There are two types of laying nests: individual nest and communal nest. The individual nest should be 30 cm wide, 35 cm long and 40 cm high. Allow one nest for every 4 - 5 layers.
- Communal nest which can be used by 10 - 15 birds at the same time is not generally suitable for tropical condition.
- The hens need sufficient spaces to get rid of their body heat very well.

Figure 9.10. Laying nest for small-scale poultry production.

Perches

- An object on which a bird alights, typically a branch or horizontal bar.
- Provide 15 - 20 cm of perching space placed at 25 cm apart per bird depending on the size of the birds.
- Perches are installed at about 1 meter above the floor

Feeders

- Feeders are equipment or structures made to feed chicken or birds.
- Make sure that there are enough feeders (>12 cm depth) in the house. Provide 5 - 10 cm feeding space per bird of rectangular feeder and less than this in case of round feeder.
- Place a stick (spinner) above the feeder to avoid birds from sitting on the feeder.

Drinkers

- Drinkers are equipments or structures prepared for drinking purpose of hens.
- Provide 3 cm drinker space per bird.
- Provide clean cool water, it should be always available.

Lighting

- Lighting increases feed intake, promote growth, stimulate laying, deter hens from their eggs, reduce stress and energy.
- Provide a laying flock natural or artificial light of 16 hours per a day (min. of 12 hrs, and maxim. of 16 hrs).
- A 40 watt bulb is recommended to be placed at 3 meter apart
- A 60 watt bulb can be placed at about 5 meter apart.

Age of moving to laying house

- Pullets can be moved to permanent laying house starting from 18 weeks of age.
- Change of ration to layer diet can be done just before the first egg is laid

Broilers

The main guiding principle of broiler rearing is the “all-in, all-out” principle. This means only birds of the same age are kept on the same site. The birds can be reared to slaughter weight in eight weeks, and two weeks are needed between each batch. Special care is needed for the litter, since caked litter can lead to the formation of breast blisters and the down grading of the carcasses

Figures 9.11. Broiler birds.

A small chicken business scenario

Assume Mr Tadesse has 50-layer chickens and produces eggs every day. She/he collected about 43 eggs a day.

In the nearby market, the price of a single egg is 8.5 ETB on average. This sums up a gross income of 365.5 ETB per day. The production cost (i.e., the cost of feed, medication, transport, labor, and other expenses) of one egg is estimated to be 4.70 ETB.

Net profit per week is 1143.8 ETB (or 4575.2 ETB per month).

*Discuss in a small group (3 to 5 students) on how possible it is to reduce the production cost of an egg and share your outcomes with the students sitting next to you.

9.7. Major Diseases of Poultry and Methods of Their Control

In poultry, it is very important to keep infection by contacts with sources of infections to a minimum. Germs can be spread via animals and people. Infection is also possible through contact with infected objects such as crates or cars. All kinds of diseases can be transferred by birds, vermin, insects and other parasites. Remember that feed and dirty drinking water can also carry germs.

There are three main causes of poultry disease: Infectious (viral, bacterial), Parasites, and deficiencies of a certain kind of nutrient. Other issues include feather pecking and cannibalism.

Newcastle diseases, infectious bursal diseases, avian coccidiosis, helminth infestation, ecto-parasite infestation, and Salmonella and Campylobacter infections are the most common chicken diseases.

Poultry disease controlling methods:

- The best prevention of diseases is good hygiene and disinfect.
- To use the 'All- in- all-out' system.
- Vaccinate against some diseases or use anti-coccidial agents.
- In case of serious problems, consider slaughtering the whole stock and start anew. To do this, thoroughly clean and disinfection the place.

Activity 9.5.

In small group,

a. list out the major diseases of poultry that you observed or experienced in your area

b. explain their possible indigenous controlling mechanisms.

Unit Summary

In this unit, you have learned that:

- pure commercial breeds, hybrid (crossbred) and local breeds are the main categories of chickens by breed.
- based on utility or economic values, chicken are classified in to Egg type, Meat type, and Dual purpose.
- color and confirmation, demand for vaccination and susceptibility to disease, consumption of feed, hardiness and adaptability, productivity, and efficiency are the common criteria to select breed or individual poultry for breeding.
- in rural poultry, scavenging in and around the homesteads and household leftover, wastes, anything edible found in the immediate environment are the feed resource. Small amount of grain supplements are provided by the household.
- in case of the (mixed farming) smallholder farmers, Crops grown and their by-products can be used as a potential source of feed for poultry.
- poultry housing is to protect against rain and wind, predators, provide comfort, increase income and efficiency of work.
- incubation can be achieved either by natural means or by artificial means.
- infection (viral, bacterial), Parasites, deficiencies of a certain nutrient, and other abnormalities and major disease causing in poultry.
- poultry disease controlling mechanisms:
    - good hygiene and disinfection.
    - best is to use the “All- in- all-out” system particularly in poultry.
    - vaccinate against some diseases according to the vaccination calendar.
    - quarantine, if suspected
    - provide a clean environment for the animals.

Review Exercise

Part I. Choose the correct answer from the given alternatives to the following questions.

1. One of the following is not the characteristics of local chickens. Which one is it?
   A. They vary in color
   B. They have pronounced brooding ability.
   C. They have an inherent scavenging habit
   D. They are prone to predator attacks.
2. Based on utility or economic values, chickens can be classified as________
   A. Egg type C. Dual purpose
   B. B. Meat type D. All of the above.
3. Which one of the following traits is not considered in breed selection?
   A. Conformation C. feed consumption
   B. B. Adaptation D. None of the above
4. The development of a fertile hen egg into a young chicken requires:
   A. A temperature of 37.5 to 39 ^{0}C.
   B. A supply of fresh air
   C. Some space for movement or turning around
   D. Humidity to prevent the egg content from drying
   E. All of the above.
5. Artificial brooder can be;
   A. Kerosene brooder C. Radiant heat
   B. Electric brooder D. All of the above

Unit 10 Fishery Production and Management

(b)

Contents

10.1. Basic terms in aquaculture and farmed fish species in Ethiopia
10.2. Basic anatomy of bony fishers
10.3. Fish feeds and feeding practices
10.4. Fish culture techniques
10.5. Fish rearing
10.6. Fishing methods
10.7. Handling fish and fish products
10.8. Diseases in aquaculture
10.9. Indigenous knowledge in fish processing

Learning Outcomes

At the end of this unit, you will be able to:

- recognize farmed fish species in Ethiopia.
- explain basic anatomy of bony fishers.
- describe fish feeds and feeding practices.
- examine the fish culture techniques.
- explain fish rearing methods.
- identify fishing methods.
- express the handling of fish and fish products
- list the major disease of fish and control methods.
- elaborate the application of indigenous knowledge in fish processing.
- give values for indigenous knowledge in fishery management.
- practice handling fish and fish products effectively.

10.1. Basic terms in aquaculture and farmed fish species in Ethiopia

Aquaculture is the farming of aquatic organisms. Ethiopian fish fauna are the bony fish. Fresh water contains the majority of teleost (i.e. the group contains most of the bony fishes) fish type. Ethiopian fish fauna consists of 153 indigenous and 10 exotic species. The diversity and abundance of Ethiopian fish fauna is not complete and further works are still underway. The Ethiopian indigenous freshwater fauna is a mixture of three different forms.

- Nilo-sudanic forms,
- East African high land forms and
- Endemic forms.

These are the dominant forms in terms of diversity and are represented by a large number of species found in the Omo-Gibe, Baro-Akobo, Tekeze and Abay drainage basins. They are predominately found in the Nile basin (Baro-Akobo, Tekeze and Abay). However, some elements of these forms also occur in the Southern Rift Valley Lakes (Lakes Abaya and Chamo), and the Shebelle-Ghenale basins. The Grand Ethiopian Renaissance Dam (GERD) is also expected to have potential for fish farming. The Nilotic fishes are almost entirely absent from the Awash and northern rift valley lakes.

The East African highland forms are those related to fishes of eastern and southern Africa and include genera such as Labeo, Barbus, Clarias, Garra, Oreochromis, and Varicorhinus. These are found in the northern Rift Valley lakes (e.g. Lakes Hawassa, Ziwai, Langano), the highland lakes (e.g. Tana and Hayq), and associated river systems, and the Awash drainage basin.

The endemic forms are very few comprising about 38 species and 2 subspecies. Examples include a few genera such as Danakilia, Nemacheilus, and Gara (Lakes Abaya and Chamo), Barbus (Lakes Tana and Chamo), etc. Exotic fish that were introduced to Ethiopian water bodies include fish such as carp in Koka and Fincha dams. The economically important families of Ethiopian fish include the following.

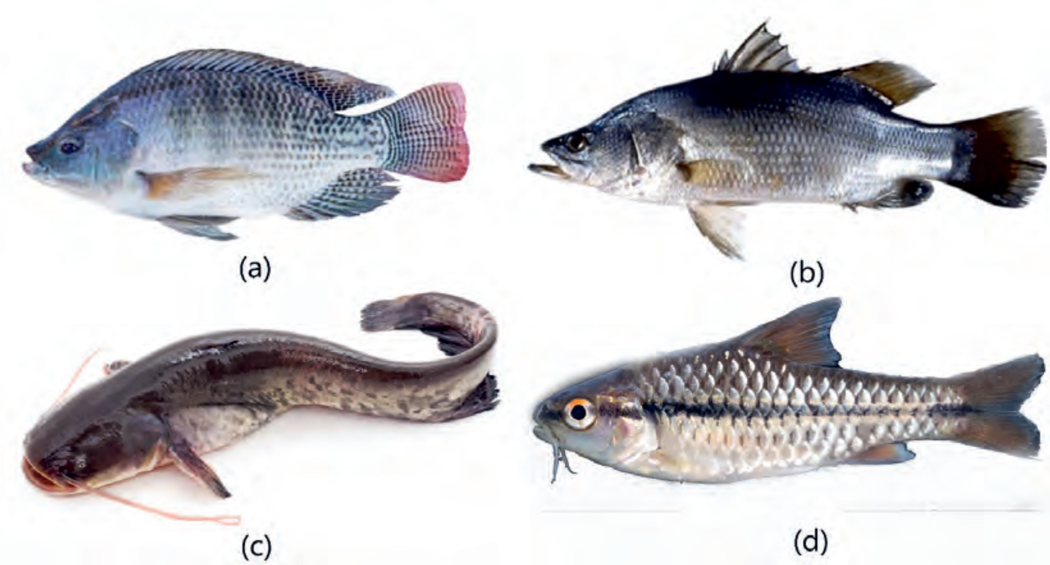


Figure 10.1. Oreochromisniloticus (Nile tilapia) (a), Latesniloticus (Nile perch)(b), Clariasgariepinus (commonly called Catfish, “Ambaza”) (c), and Barbus sp (Commonly named as Nech-asa) (d).

1. Family Cichlidae (Cichlids)

This family includes three species of tilapias in Ethiopia.

These are

- Oreochromisniloticus (O. niloticus),
- Tilapia zilli and
- Tilapia galilaea

O. niloticus is found in most Ethiopian freshwaters and commonly known as “Qoroso”, St. Peter fish, Chogofe, etc. O. niloticus is the predominant fish in most the Ethiopian fisheries.

2. Family Centropomidae (Centropomids)

Most members of this family are marine and only genus Lates is a freshwater form both in Ethiopia and in other parts of Africa. L. niloticus (commonly called the Nile perch) is the major species of the genus found in Ethiopian Lakes such as Chamo, Abaya, Gambella lakes and Baro River. L. niloticus is carnivorous on other fish and is not good to introduce them into water bodies other than their natural habitats.

3. Family Claridae (Clarids)

The common example is Clariasgariepinus (commonly Catfish, "Ambaza") found in Lake Tana, Lake Abaya and the Awash River. C. gariepinus can be easily recognized by their elongated body and long hair like barbells around their mouth.

4. Family Cyprinidae (Cyprinids)

This family includes genera such as Barbus (commonly in Nechasa), Labeo and Carp. Barbus is more common in rivers than in lakes and is much common in Lake Tana. Three carp species (Common carp, grass carp and silver carp) are the introduced species belonging to this family.

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Activity 10.1.

Field Visit

In pairs, visit a local fish market and

a. identify the species available in the market
b. if possible see if the same species can be found in rivers or lakes close to your school
c. identify the differences in color and physical appearances.
d. ask the farm owners about the local communities fish-eating culture

If there is no fish market in your vicinity use the library or internet to research.

* Report your finding to the whole class.

10.2. Basic Anatomy of Bony Fishes

Bony fishers have a bony skeleton. They are generally flattened. They have five pairs of gills protected by an operculum, and a mouth at or near the tip of the snout. The dermis (skin) is covered with overlapping scales. Bony fish have a swim bladder which helps them maintain a constant depth in the water column.

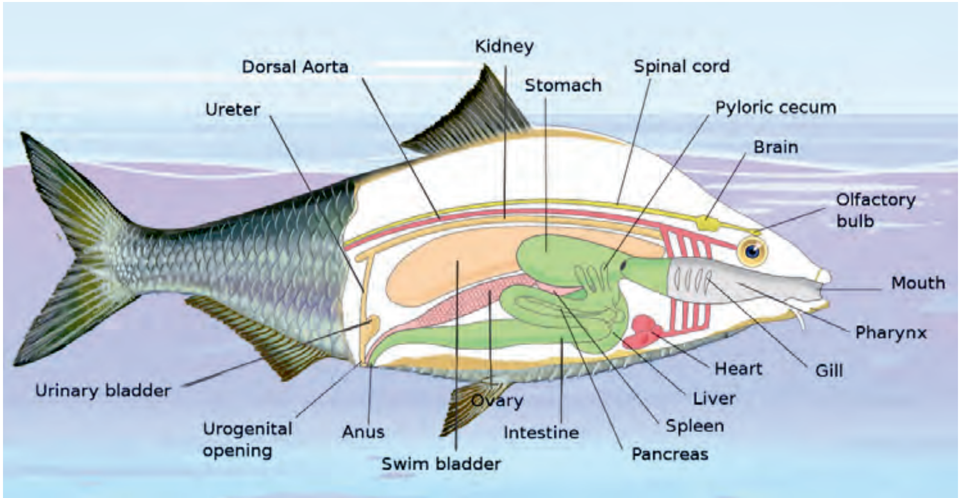


Figure 10.2. Internal anatomy of a bony fish.

The main external features of the fish, are composed of either bony or soft spines called rays which, with the exception of the caudal (tail) fins, have no direct connection with the spine. They are supported by the muscles which compose the main part of the trunk (Figure 10.3).

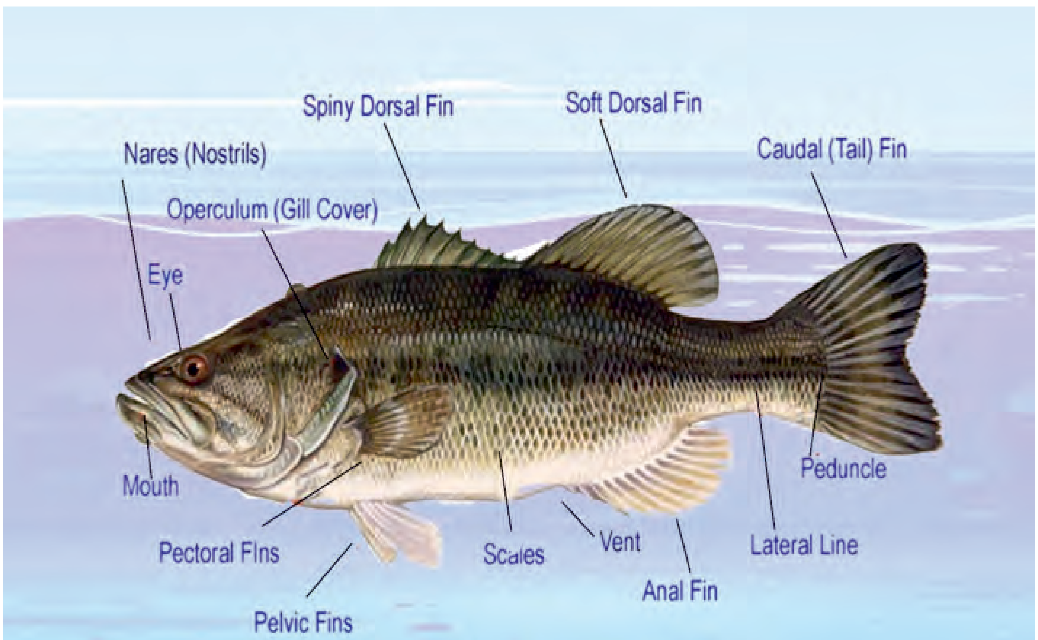


Figure 10.3. External body parts of bony fishes.

Activity 10.2.

Group Work

Visit fish market or other possible sources in your area.

a. See if there are some of the species mentioned in this unit on the farm.

b. Ask the owners or fisherwomen or fisherman to tell you about the basic anatomy of the fish

Your teacher will tell you what to do with the answers.

Note that if there is no river/lake and fish market/farm available in the area, practice with pictures provided by your teacher.

10.3. Fish feeds and feeding practices

The survival, growth and reproduction of fish depends on fish-feeding activities. Fish have a considerable capacity to resist starvation.

Feeding: food preparation, feeding mechanism of fish

Food capture: most food eaten by fish is obtained through three basic feeding styles. i.e. Ram feeding, Suction feeding, and Manipulating or Biting feeding method.

Feeding habits of fish

The food and feeding behaviour, varies characteristically in different species of fish. There are four categories of fish food. These includes basic food, secondary food, incidental food, and obligatory food.

Fishes occupy almost all trophic categories. i.e., from herbivores to piscivores. Trophic categories in fishes are:

- **Detrivorous fish:** are fishes that feed on the dead and partially decomposed plants by the action of bacteria and fungi. They are mostly benthos, fish that live on the bottom of seas or lakes. e.g, Tilapia, Barbus.
- **Scavengers:** are fishes that feed on the decaying animal flesh: e.g. Eel, clarias

- **Plankton feeders:** fish which feed upon the planktons, both on phyto and zooplankton are included in this category
- **Herbivorous fishes:** fishes that feed on the plant materials (vegetation) comprising flowers, fruits, seeds, leaves and pieces of stem of vascular plants, etc. They even scrap algae from the rocks and stones with their broad lipped mouth under the snout. Their stomach is delicate and less acidic. They have large intestine and small stomach. Non predator have narrow gap in size, Tilapia and Barbus sp. are among the fish species that possess this kind feeding habits.

Figure 10.4. Women feeding fish.

Activity 10.3.

In pairs, list down fish feed resources and feeding methods.
Report your findings to the whole class.

GERD as potential for Fish farming

GERD (Grand Ethiopian Renaissance Dam) is filled to the level of 600 meters which can serve as a potential for fish production and the reservoir volume is 74 billion cubic meters. The reservoirs under construction such as Gilgel-gibe III, GERD and others expected to significantly increase the total inland water when they are completed.

Task 1: For example lake of Hawassa is about 1.3 billion meter cubes of water and has a potential of 600 tones per year to harvest fish. GERD could be six times more productive than lake Hawassa.

In a small group, take one example of lake that you know most and compare the estimated potential for fish production of GERD.

Task 2: Researching the capacity of the GERD and type of water, region where it is located and suggest also what type of fish might be suitable. Share your estimation potential for fish production with the other groups of students in your class.

Figure 10.5. Grand Ethiopian Renaissance Dam.

10.4. Fish culture techniques

Types of aquaculture can be classified on the basis of fish culture, enclosure density or integration.

10.4.1. On the basis of culture

1. Monoculture: Raising only one species of fish in available water body. For example, raising of one of the following types: tilapia, rainbow trout, catfish, etc.
2. Polyculture: Culturing two or more than two species of fish in the same water body. For example, rearing of bighead carp and grass carp.
3. Mono-sex culture: Raising either male or female of single fish species. It is practiced for maintaining breeding male and female fish.

Advantages	Disadvantages
▪ Cultivation practices such as feeding, disease diagnosis and treatment is easier. For example, feeding is easier in raising single species due to uniform feeding habit ▪ Typical characteristics of fish can be studied more accurately	▪ Productivity of pond is not fully utilized ▪ Market supply cannot be fulfilled and is riskier.

4. Poly-sex culture
   - Either male or female of two or more species is reared in the same pond.

Advantages	Disadvantages
▪ Productivity of pond is fully uti-lized ▪ Yield per unit area is higher ▪ Less risky	▪ Cultivation practices is difficult ▪ Costly and labor inten-sive. ▪ Selective harvesting is difficult ▪ Costly and labor inten-sive

10.4.2. On the basis of enclosure

Classification of fish culture based on the basis of enclosure can be further divided into Pond fish culture, Cage fish culture, and Pen/enclosure fish culture (Figure 10.5).

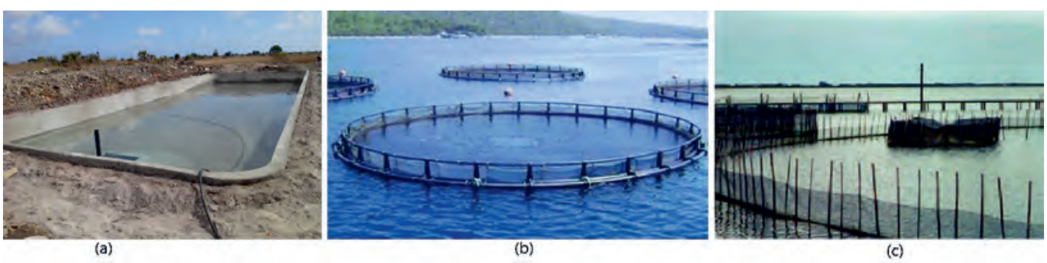


Figure 10.6. Pond fish culture (a), Cage fish culture (b), and Pen/enclosure fish culture (c).

10.4.3. On the basis of density

- Intensive fish farming system
- Semi intensive fish farming system
- Extensive fish farming system

10.4.4. On the basis of integration

- Pig and fish farming
- Duck and fish farming
- Horticulture crop and fish farming
- Rice paddy and fish farming

Activity 10.4.

Work in a group,

a. discuss the common fish culture techniques in Ethiopia

b. reason for choosing these particular fish culture

c. types of fish farming the students know so far

Report the summary of your discussion to the whole class.

10.5. Fish rearing management

There are three main events in the fish rearing or farming timeline: hatching, rearing, and harvesting. Hatching includes caring for breeding colonies, inducing spawning, egg extraction or nursery isolation, etc. Once hatched, fry are then collected and moved to grow out ponds. Unlike other fish, fresh water fish like tilapia tend to be hardier against poor water quality.

Best practice shows that the dissolved oxygen level should be around 4 mg/l. Low oxygen levels in water often lead to mass fish death. In terms of pH, tilapia can tolerate a wide range but a pH over 6.5 is good for algae growth which is useful as feed for the fish. Temperatures around 25 ºC are most favored by the fish. Tilapia can be stocked at densities up to 60 kg/m cubed (depending on water and management conditions). However, high stocking densities may have a negative impact on growth performance and health status. Low stocking densities, however, can often lead to aggression between the fish. Rearing, or grow-out, is the part of fish farming that picks up after the hatchery has raised them to fingerling size. Harvesting or processing involves selecting of tilapia and moving them to a finishing pond.

Activity 10.5.

Work in pairs. Discuss fish rearing methods and share the summary of the discussion with the rest of the students.

10.6. Fishing methods

Figure 10.7. Local fishing techniques.

A number of different fishing methods are employed to capture fish. The method used is dependent upon the species being harvested, available technology and local conditions such as bottom type and water depth.

Fishing gears is a device used to capture fish. There are two major types of fishing gears, i.e. passive fishing gear and active fishing gear.

Passive fishing gear is a device that is not moved by man or machine to capture fish. The machine is set at a given position in the water and left for some times until the fish come to the gear to be caught. It is placed stationary in one place. Examples include long line, gill net, traps and pots, etc.

On the other hand, active fishing gears are towed or pulled in water column using fishing crafts to catch the fish. These include trawl nets, seine nets, dredge nets, lift nets, etc. The major types of fishing methods used for fish include netting, lining, trolling, trawling and seining. Trawling, dredging, jigging and pots are often used for capturing shellfish (such as squids and crabs).

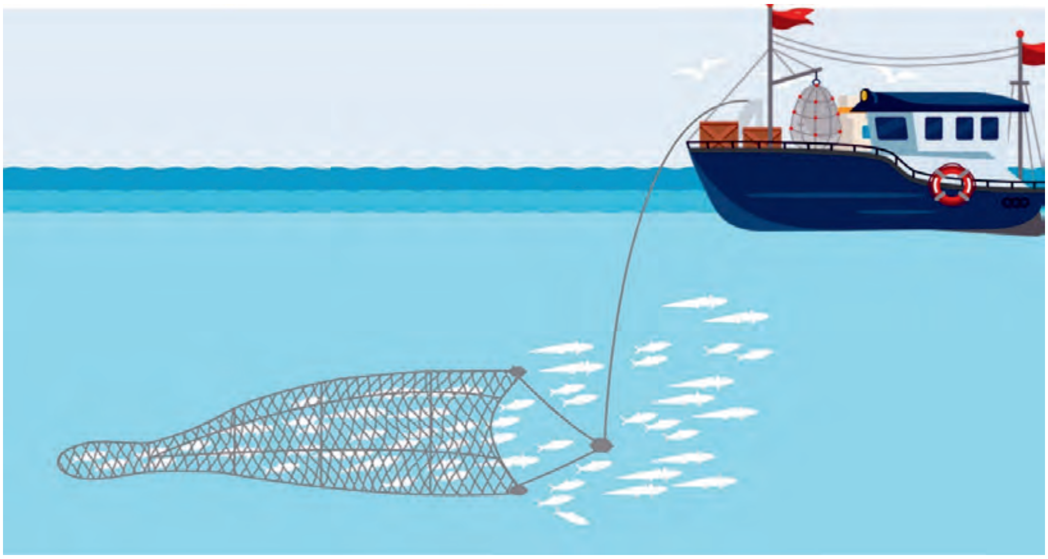


Figure 10.8. Bottom trawl fishing method.

Activity 10.6.

In a small group, discuss the differences that you can think of between the traditional and the modern fishing techniques. Make a list of major fishing methods and share your answers with the whole class.

10.7. Handling of fish and fish products

Fish is a highly perishable food/product requiring proper handling, processing and distribution

- Minimizing losses helps to improve productivity.
- Fish should be slaughtered in fishery abattoir equipped with the required facilities
- Fish should be eviscerated immediately after slaughter and preserved until consumption.

Figure 10.9. Local Fish market.

Brainstorming 10.1.

Tell your classmates the types of fish products that you know. What do you know about fish processing methods?

Fish Processing Methods

Fish processing refers to the processes associated with fish and fish products from the time fish are caught or harvested, from capture fisheries and/or aquaculture, to the time of the delivery of the final product to the end user. Fish and fish products deteriorate quickly. The easy deterioration in fish quality is because of the post-mortem (after death) biological changes that take place in the body of dead fish. The central concern of fish processing is to prevent fish from deteriorating Therefore, fish and fish products need appropriate processing procedures in order to prevent deterioration. Changes in fish quality often come in the form of unpleasant odor and microbial spoilage.

Stages of fish processing

Fish processing stages can be classified as preliminary and main stages depending on the extent of application of techniques and skills. Stages of fish processing are:

Preliminary Processing

This stage is also referred to as pre-processing stage. Preliminary processing of fish usually consists of grading, removal of slime, beheading, scaling, washing, cutting of fins, gutting and evisceration, slicing of whole fish into steaks and skinning. The process can also includes filleting, grinding of skinned fillets, meat-bone separation, or various combinations of these.

Main Processing Stage

Fish Preservation is the creation of unfavorable condition for the growth or survival of spoilage organisms. Ancient methods of preserving fish included drying, salting, pickling and smoking. All of these techniques are used today but the more modern techniques of freezing and canning have taken on a large importance.

This stage is mainly concerned with fish preservation processes. Microorganisms particularly the spoilage bacteria require appropriate temperature, sufficient water and oxygen, and low acidic environment to reproduce and multiply. Thus, the various techniques used in fish preservation are based on the principles of interrupting these conditions as summarized in Table 10.1.

Table 10.1. Techniques used in fish and fish products preservation.

Parameter to be controlled	Method used
Temperature	Chilling, Refrigeration, Freezing
Water activity	Smoking, Freeze-drying, Oxygen Vacuum pumping
Chemical control of microbes (pH)	Addition of acids
Physical control of microbes	Microwave heating, Ionizing

Types of fish products

Figure 10.10. Types of fish product.

Some fish products are cooked fish, frozen fish, dried fish, smoked fish, salted fish, canned fish, fermented fish, etc. See the details of each below.

Cooked fish: Products are most usually for immediate consumption and require no sophisticated packaging. The shelf-life can be extended for a few days by using refrigerated storage and the product should be covered to prevent contamination.

Frozen fish: Products have relatively long-term preservation, but the technique is relatively expensive in terms of equipment and operating costs. Thus, it is not recommended for the majority of small-scale fisheries.

Cured fish: Dried fish, smoked fish and salted fish products have reduced water content and this prevents the development of spoilage bacteria.

Canned fish: Products have much longer shelf life.

Fermented fish: Products are formed by encouraging the development of bacteria that increase the acidity of the fish so that pH of the fish products is lowered. Low pH discourages the growth of spoilage microorganisms.

Fermented fish: Products are formed by encouraging the development of bacteria that increase the acidity of the fish so that pH of the fish products is lowered. Low pH discourages the growth of spoilage microorganisms.

Activity 10.7.

In small groups, discuss fish and fish product handling methods. Report the summary of your discussion with other groups.

10.8. Diseases in Aquaculture

Microorganisms such as viruses, bacteria, water molds (fungi), and parasites cause diseases of freshwater fish in warm-water aquaculture. Some of these agents are obligate pathogens (require a host for survival in nature), but many do not require a host and can be found living in aquaculture waters. These microorganisms facultative agents are opportunistic and cause problems when the host's resistance is compromised.

The most common pathogens that affect aquaculture include:

Viral diseases: The most serious viral disease is channel catfish virus disease (CCVD). This is most commonly found in juvenile channel catfish during their first summer of life. Channel catfish virus is a herpesvirus that attacks swim-up fry to 10 cm fingerlings when water temperatures are 25 °C or above. Mortality due to CCVD can be acute and reach up to 90 percent, especially in densely populated tanks or ponds.

Bacterial diseases: Bacteria cause more infectious disease problems than any other group of pathogens in warm-water aquaculture. The motile aeromonad septicemia (MAS) is a common disease of fish, including salmonids, and other aquatic animals that inhabit freshwater, but MAS can also occur in brackish water. The motile aeromonads are a heterogeneous group of ubiquitous, mesophilic, gram-negative bacteria that are also a normal component of the microbial flora of fish (Lim and Webster, 2001).

Activity 10.8.

In small groups,

Study the major diseases of fish in the small scale fish farms in your locality and their possible control methods. If fish farms are not available in your locality, go to the school library and search the Internet for information on major diseases of fish in small scale fish farms.

Share your answers with the whole class.

10.9. Local knowledge in fish processing

Ethiopian consumers prefer for whole fresh fish. As a result, the bulk of the fish harvest from the lakes is sold fresh. However, frozen filets are increasingly being marketed in lakeside towns as well as in the capital city, Addis Ababa.

Smoking and drying is carried out only on some remote fishing locations. " Quanta ", which is a dried fish product, is largely available around Arba-Minch. The product is obtained by filleting the fish, cutting them into large strips and hanging them up on strings to dry for two to three days. The dry product can be packed in sacks for storage on the floor. Once packed, it can be stored for up to a month without substantial quality deterioration.

Drying is increasingly becoming a method frequently used to preserve excess catches. Dried fish is becoming more available in large consumption centres such as Addis Ababa and at the expatriate market.

Traders face major storage problems due to the shortage of basic cold chains or cooling systems. This results in significant losses. " Quanta " is generally prepared in poor hygienic conditions, insufficiently dried and stored on bare ground. This often significantly decreases the quality.

A B

Figure 10.11. Fish fillets hung for immediate sundry in Wagan wetland fishers' camp of Gambela region, Ethiopia (A) and fish smoking/frying (B).

Unit Summary

In this unit, you have learned that:

- fish are generally defined as aquatic vertebrate animal. They usually possess gills in the adult stage and having limbs, when present, in the forms of fins.
- they are broadly categorized as bony fish and cartilaginous fish, though they can be grouped in many forms as well.
- bony fish are flattened, have five pairs of gills protected by an operculum, and have a swim bladder and a mouth at or near the tip of the snout.
- the energy and nutrients generated by the feeding activities of a fish affect the survival and reproduction performance of fish.
- monoculture, polyculture, mono sex or poly sex cultures are the common fish culture types.
- on the basis of density, fish farming can be classified into three.
- fish rearing is a part of fish farming in which owners raise the hatched fish to the harvest size.
- fishing methods used to capture fish are dependent upon the species being harvested, available technology and local conditions such as bottom type and water depth.
- the overall aim of fish and fish products handling is to:
  - minimize the losses and improve productivity. Slaughter fish in fishery abattoirs with required facilities and preserve it.
  - fish products are cooked fish, frozen fish, dried fish, smoked fish, salted fish, canned fish, fermented fish, etc.
  - the main infectious disease agents are viruses, bacteria, water molds (fungi), and parasites.
  - smoking and drying (in the form of Quanta) are the common local fish processing methods carried out in some remote fishing locations.

Review Exercise

Part I. Choose the correct answer from the given alternatives.

1. Which one of the following is not among the major fishing method used for fish?
   A. Netting method C. Trolling method
   B. Dredging method D. None of the above
2. Which of the following is true about aquaclture management?:
   A. Temperatures around 25 ºC are most favored by the fish.
   B. High oxygen level in water often lead to mass fish death.
   C. High stocking densities may have a negative impact on growth performance.
   D. All are true
3. Diseases of fresh water fish can be caused by:
   A. Virus C. Bacteria
   B. Water molds and fungus D. All of the above E. Only C

Part II. Answer the following questions.

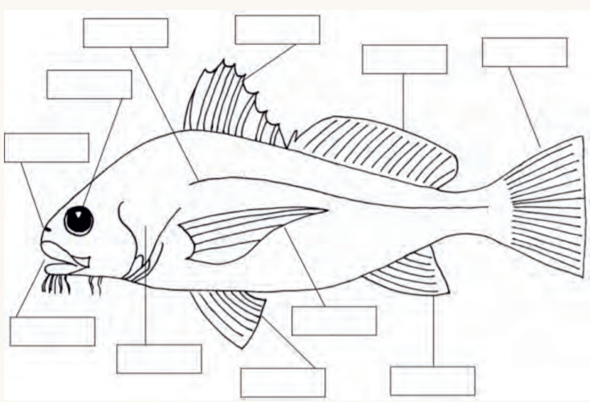
4. List down at least three common fish products?

   (a).__________________________

   (b).__________________________

   (c). __________________________

5. Look at the artwork below and explain the difference between bones and cartilage. Use the blank fish diagram given below to talk about each of the anatomical parts. Alternatively, you could draw your own version.



Unit 11 Apiculture

Contents

Learning Outcomes

At the end of this unit, you will be able to:

- explain the situation of honey bee management in Ethiopia
- recognize bee biology and behavior
- list types and members of honey bee colony and describe their roles in a colony
- identify honey bee management and queen rearing techniques
- describe hive products and processing methods
- mention major diseases, pests, predators of honey bees and their control methods
- give values for indigenous knowledge used in apiculture and committed to improve the application
- compare indigenous knowledge against scientific knowledge in apiculture
- give values for indigenous knowledge used in apiculture and committed to improve the application
- Prepare modern hives

11.1. Introduction to honey bee management

Ethiopia has a comparative advantage for apiculture. There are over 7000 melliferous plant species in Ethiopia. All these that produce significant amounts of nectar and pollen which makes them appearing to bees. Due to bimodal rains, honey can be harvested at least twice a year. Five wild bee species have been identified. It is estimated that more than 2 million bee colonies exist in the forests and crevices in Ethiopia. According to Mohammed and Hassen (2021), Ethiopia has the potential to produce up to 500,000 tons of honey and 50,000 tons of beeswax per annum.

Apiculture is an integral part of agriculture in Ethiopia. It contributes markedly to household income and national economy. Honey is produced in almost all parts of Ethiopia. Honey bees provide pollination services that are crucial for sexual reproduction in many plants. This helps in improving the quality and quantity of many agricultural crops. From the significant 53 crops cultivated in Ethiopia, 33 (62.2%) of them are dependent on biological pollinators. Besides, honey bees play a vital economic role, and their contribution to pollination service in agricultural crops is at around 0.815 billion dollars in Ethiopia, which is 6.24% of the agricultural GDP (Getachew, 2018). Nevertheless, this contribution is unnoticed by Ethiopian farmers. Pollination by honey bees plays an essential role in human nutrition and food security, income in households, and ecosystem services.

Activity 11.1.

Do these questions in a small group. Share your answers with the other pairs.

a. How many times do beekeepers harvest honey per year?
b. What is the role of honey bee in agricultural economy?

11.2. Bee biology and behavior

Honey bee biology

Honey bees are one of the few insects that have a social structure. Honey bees have a caste or role. A hive consists of a single reproductive queen, numerous drones, and about 60,000 worker bees. The reproductive queen lays all the eggs in the honeybee colony. Drones are male honeybees.

Worker bees are non-reproductive female bees.

Honey bees undergo complete metamorphosis and develop through four life stages: egg, larva, pupa, and adult. Several thousand worker bees cooperate in nest building, food collection, and brood rearing. Each honey bee in the worker caste has an age-related task to perform. The task begins inside the hive (house bee) and eventually moves to foraging outside the hive. The immature forms of the bee are called brood, they are fed and cared for by the worker bee caste.

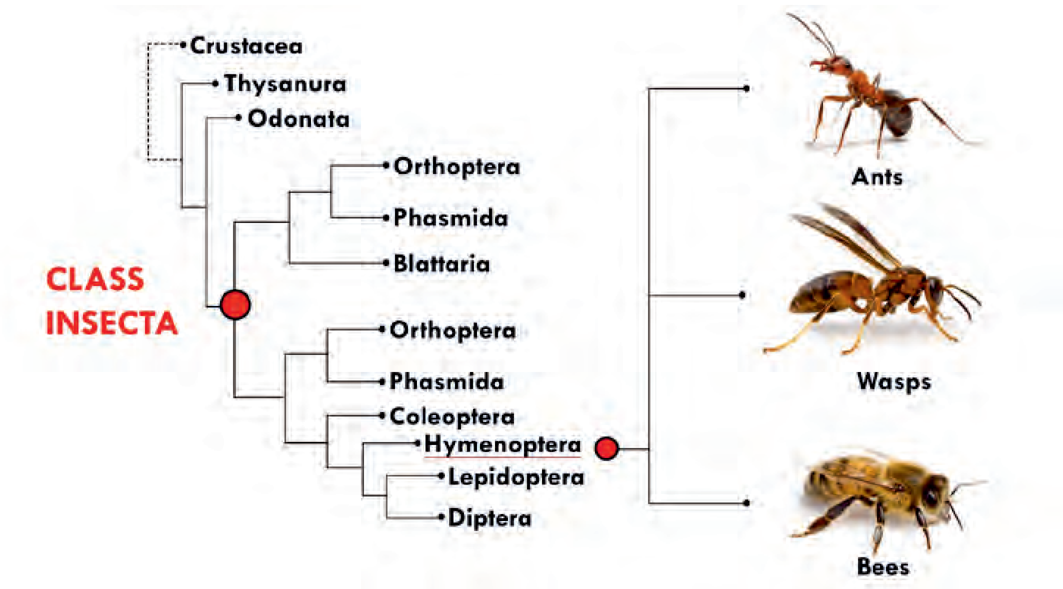


Figure 11.1. Classes of insects

Honey bees have the following physical characteristics. They:

1. have two pairs of thin, veined wings with the forewings much larger than the hindwings.
2. have chewing-lapping mouth parts with a long tongue or proboscis to suck nectar out of flowers and mandibles (jaws) to manipulate wax or other materials.
3. undergo complete metamorphosis during development.
4. have three major body regions: the head, thorax, and abdomen.
5. have a constriction or “thin waist” separating the thorax and abdomen.

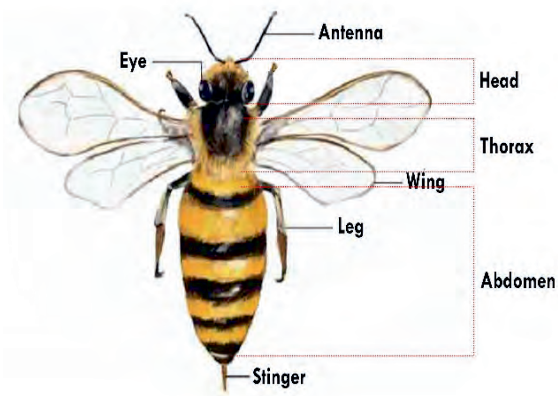


Figure 11.2. Body parts of honey bee

Honey bee Behavior

A bee colony is sometimes described as a super-organism. The colony is made up of many thousands of bees. The honey bee colony makes decisions almost unanimously. Each bee will take turns to do different specific tasks in the hive. The tasks, typically change every few days as they age. The change follows a general pattern of development, but it allows them to adjust their behaviors as circumstances dictate.

Activity 11.2.

Class work

Discuss in groups the bee biology and behavior. Share your points with the class through your group leader.

Where do bees live?

In nature, bees live in hollow trees or small caves. The beekeeper keeps bees in boxes called 'hives' Hives are made up of interchangeable parts. The inside part can be examined by the beekeeper, and the various parts can be moved from one hive to another.

Figure 11.3. The natural habitats of honey bee.

11.3. Types of honey bee colony

There are millions of honeybee colonies in different agro-ecological regions of the Ethiopia. Five types of honeybees can be identified in different ecological systems. These are: *Apis mellifer aadansanii* which exists in south and western part of the country. *Apis mellifera jemenitica* is found in the low land areas of eastern Ethiopia. *Apis mellifera monticola* can be found in Southeast Mountain of Bale-Dinsho. *Apis mellifera litorea* exists in southwest low land, while *Apis mellifera abyssinica* is available in highland area of central, west and southern parts of the country.

Members of the bee colony

As you have learned in Grade 11, there are three kinds of bees in a colony: the worker, queen, and drone. A good colony of bees has from 50,000 to 60,000 workers, 1,000 or more drones, and one queen.

Worker bees

- do all of the foraging for the hive and are, therefore, the agents of pollination.
- are the smallest bees in the colony - most of the colony is made up of workers.
- do not lay eggs. They carry out all the other duties in the colony, including comb building, brood care, and colony protection.
- secrete wax from specialized glands on the underside of their abdomens to build honeycomb.
- convert nectar into honey and store it in the hive as food for the members of the colony.
- keep the hive clean.

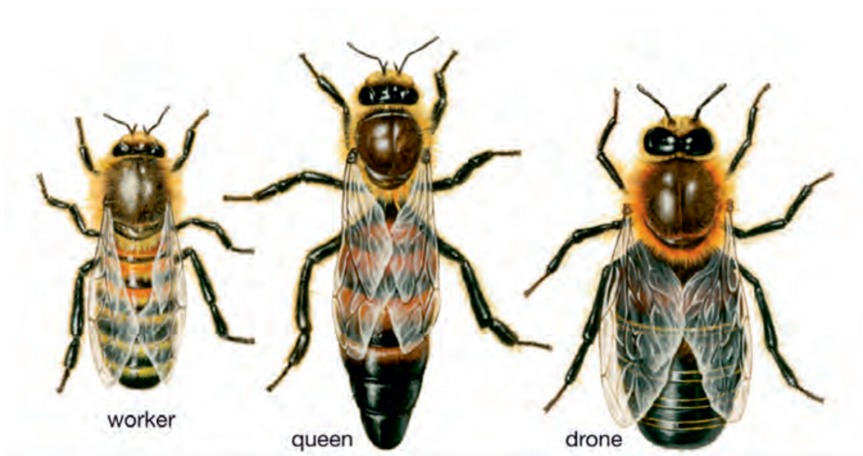


Figure 11.4. Workers, drones, and queen bee.

Queen bee

A queen bee has well developed ovaries and lays all the eggs in the colony. She lacks many of the specialized glands and pollen baskets of the worker and her jaws are too small for manipulating wax. Her sting is not barbed but smooth and curved.

Drone bee

Drones are male bees. They have large eyes that meet in the front of their heads. Their eyes and large heavy bodies make them appear different from the workers and the queen. Their jaws are smaller, and they have no sting.

Figure 11.5. Workers nursing the larvae in the comb (A) and queen surrounded by workers (B).

Activity 11.3.

Individual work

a. List the types of honey bee found in Ethiopia

b. Eplain their characteristics of each caste of honey bee.

Together with your neighbour, discuss your answers.

11.4. Management of Honeybees

There are four types of beekeeping practices in Ethiopia, namely, traditional forest, traditional backyard, transitional and improved or modern beekeeping.

Traditional forest Beekeeping: Several million of bee colonies are managed with the same old traditional beekeeping methods in almost all parts of the country. Traditional beekeeping is of two types: forest beekeeping and backyard beekeeping. The most universal type of traditional hives, known to have been in use is simple cylindrical type.

Figure 11.6. Traditional forest bee keeping practices (A) and traditional log hive (B).

Transitional system of beekeeping: This is a type of beekeeping intermediate between traditional and modern beekeeping methods. Generally, this uses a top - bar hive, which is a single story long box with sidewalls sloping inward toward the bottom and covered with bars of fixed width.

Figure 11.7. Top bar hive.

Modern system of beekeeping: Modern movable- frame hive consists of precisely made rectangular box hives (hive bodies) placed one above the other in a tier. The number of boxes is varied seasonally according to the population size of bees.

Figure 11.8. Improved frame hives.

Practical movable- frame hive was invented in 1851 by Lorenzo Lorraine Lang troth in U.S.A. Later on, different countries developed their own movable frame hives (for instance Zander, Dadant) and Lang troth was the prototype of movable frame hives used today. In many countries, Lang troth hive boxes have proved to be convenient for handling and management.

Activity 11.4.

Do these questions in a small group. Share your answers with other groups.

a. Identify the types of bee hives in your area.

b. What materials are used to make bee hives in your area?

11.5. Colony management and Queen Rearing

Colony inspection

Beekeepers inspect their honeybee colonies at different times. Many frequently inspect their apiary and honeybee colonies externally. Through external inspection of apiaries and honeybee, beekeepers safeguard honeybee colonies from different natural hazards. They also observe their flight movement.

Feeding management

Honeybees store honey for their own consumption during periods when there are fewer flowers to feed from.. Beekeepers harvest this honey, and as result, honeybees may face starvation due to lack of feed. To overcome the problem, supplementary feed is required for the honeybees. The most common locally available feed types used for colony supplements (in order of use) are sugar syrup, Shiro (peas and bean flour), barley flour, maize flour, honey, and fafa (supplementary food for infants).

Figure 11.9. Common feeding practices in honey bee.

Hive supers, foundation sheet and queen excluders

Movable frame beehives allow common bee management practices. Examples of management practices are migratory beekeeping, supers adding or reducing, regular inspection, and quality honey harvest. Other examples include swarm control, feeding during dearth periods, stimulating early colony growth, and pest and disease control. Similarly, the following measurements should be taken into consideration.

- Put additional hive supers by inspecting the internal condition of the colonies
- Reduce the super during the dearth period.
- Replace very old brood combs from their colonies every year.
- Remove the queen excluder immediately after honey is harvested.

Queen rearing

In its natural state, a honey bee colony may experience several scenarios that trigger the production of a new queen. Beekeepers can utilize a number of different queen rearing techniques to produce healthy new queens for their hives.

Key term
Pheromone is a chemical substance produced and released into the environment by queens.

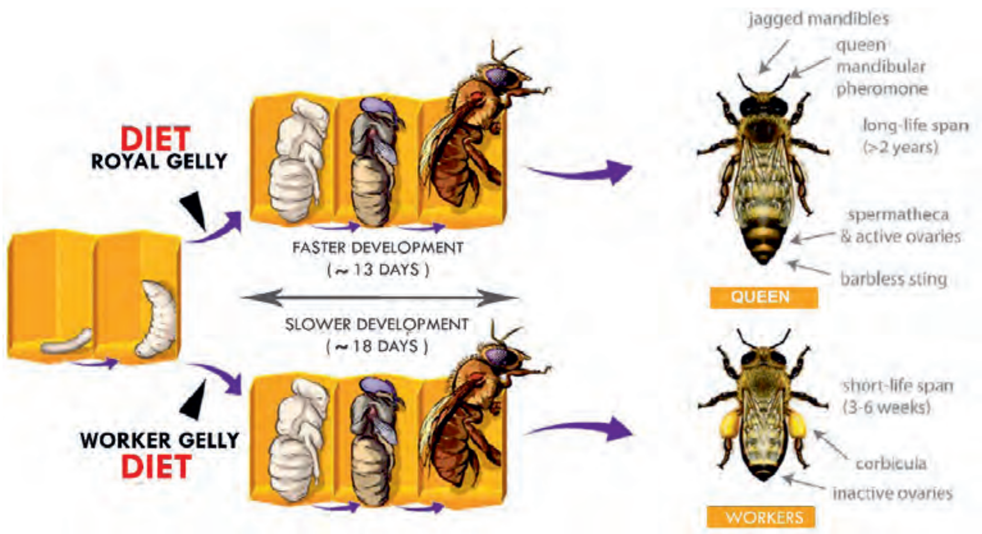


Figure 11.10. Honey bee queen vs. workers.

Why do colonies raise new queens?

A strong and actively laying queen is one of the essential components of a successful honey bee colony. She provides a constant source of new workers. Through her pheromones, she helps to direct the activities that keep the colony healthy and productive. There are several scenarios, however, that will prompt a colony to naturally produce a new queen.

- Aging or ill Queens
- Swarming
- Missing Queen

Figure 11.11. Queen rearing practices.

Activity 11.5.

Ask beekeepers these questions in pairs.

a. What honey bee colony management move on to next line.

b. what queen rearing techniques. Share your answers with other pairs.

11.6. Hive products and processing

Honey

Honey, the natural product of honeybee is an excellent energy source. It contains simple sugars that are ready for assimilation immediately on reaching the intestine.

Local beverage (Tej production)

In Ethiopia, much honey has traditionally been fermented to make "Tej". Over three-fourths (85%) of the total honey estimated to be brought to market is used for "Tej" production. Only 15% of the total honey produced is consumed at home.

Beeswax production

In Ethiopia, beeswax collection is not significant and the beeswax produced by bees is wasted. Lack of awareness about what to do with it is the cause for this. Nevertheless, the annual beeswax production of the country is estimated to be 3,658 tones.

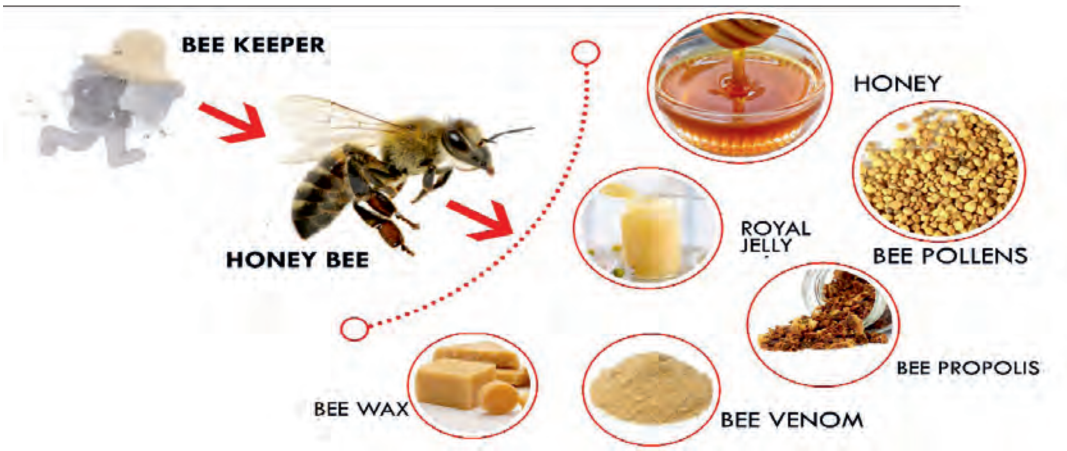


Figure 11.12. Honey bee products.

Activity 11.6.

Work in pair.

Iidentify hive products and processing methods. Discuss in pairs and share your points with the whole class.

11.7. Bee diseases, pests and predators

Some honey bee diseases kill bees and affect the production and processing of honey. These diseases include chalk brood, nosematosis, and amoeba. Moreover, the production of honey is influenced by honeybee pests. Such pests include small hive beetle (aethinatumida), bee lice, ants (dorylusfulvus), wax moth (gelleramellonella), mice, spiders, snakes etc.

Different types of pest and predator control methods are employed in different bee keeping areas. For example, honeybee keepers use mechanical barriers. For example, they put thorny woods around the tree or fix smooth iron sheet on the trunks of a tree where hives are hanged. Hanging hives on ficus trees which have very smooth bark is another method controlling mechanism. Smooth barks are not suitable for honey badgers to climb the tree.

A B

Figure 11.13. Predatory birds (A) and Asnts (Dorylusfulvus) (B).

Activity 11.7.

Answer these questions in small groups. Share your answers with other groups.

a. What honeybee diseases are common in your area?
b. What local knowledge do beekeepers in the area use to control the diseases?
c. Are there predators that affect honey bee in the community?
d. Do you like to engage yourself in honeybee keeping in the future? Why or why not?

11.8. Indigenous knowledge in apiculture

Local farmers have acquired knowledge from past generations. They have been involved in agriculture using limited resources under harsh and insecure conditions. The following are some of the traditional knowledge practiced by beekeepers in different part of Ethiopia:

Traditional honeybee feeding practices: Where there is little honeybee forage, beekeepers provide supplementary feeds like flour of roasted grain of barely as well as that of maize, bean and pea in order to strengthen the colony for the next season.

Traditional swarm control: A lack of space is the main causes of swarming. Traditionally, beekeepers make use of indicators to control swarming. For example, they try to identify the sound of the queen during the night. If there is a piping sound by queen then the colony is close to swarming.

Traditional swarm catching and baiting hives management: The use of baiting hives to catch swarm is part of the traditional beekeeping practices in many places in Ethiopia. Baiting hives are prepared and smoked very well using barks of Ekebergiacapensi (sombo). The farmers may sometimes use honeycomb, body soap, and spray perfume in the inner part of baiting hives to attract scout bees.

Traditional use of honey as medicine: The type of medicine prepared from honey, its utilization (see in Table 11.1) and harvest time may vary from place to place. Some beekeepers believe that honey harvested in October is useful for medical purpose in the treatment of many human diseases.

Table 11.1. Type of medicine prepared from honey and its use by beekeepers.

Type of medicine prepared from honey	Type of utilization
Honey	Relieves Cough
Honey + barely + flax (telba)	Relieves back pain
Honey + coffee	Relieves stomach pain
Honey + barley + " Aja "	Repairs broken bones
Honey + egg + butter + coffee	Relieves Cough
Honey + " Chat " (boiling)	Cures gonorrhea
Honey + garlic + " bishops weed, and black cumin	Heals eye disease

Adapted from Workneh Abebe (2011).

Traditional bee hives and equipment: Almost all of the tools and equipment used in the traditional beekeeping system are made from local materials like wood, clay and pennisetum (grass type).

Figure 11.14.Traditional hive mostly used by farmers made from different locally available materials.

Traditional honey harvesting and processing methods: Beekeepers often collect bee products without wearing bee suits during the night. However, smokes of barks of selected trees are often used. Beekeepers believe that smoke generated from the stem of Olea europaea could induces brood rearing. Observations of pollen on the leg of bees helps the beekeepers to conclude that bees are brood rearing. If the legs of bees are free then they are honey making and there is a possibility to obtain mature honey. Beekeepers also insert a thin stick or metal into the hive which they immediately withdraw and examine. If milky color comes out with the stick then they concluded that the colony is on brood rearing. If what comes out with the stick is sweet when tasted and yellow in color, beekeepers can start honey harvesting.

Unit Summary

In this unit, you have learned that:

- there are over 7000 plant species in Ethiopia serving as forage suitable for honey production.
- the country has the potential of producing up to 500,000 tons of honey and 50,000 tons of beeswax per annum.
- significant number of crops cultivated in Ethiopia are dependent on biological pollinators.
- honey bees are one of the few insects that have a social structure, a caste, which consists of a single reproductive queen, numerous workers, and a small number of drones.
- in Ethiopia, there are five types of honey bees. They include Apis mellifera adansanii, Apis mellifera jemenitica, Apis mellifera monticola, Apis mellifera litorea, and Apis mellifera abyssinica.
- four different types of beekeeping practices exist in Ethiopia: traditional forest, traditional backyard, transitional and improved or modern beekeeping.
- colony inspection, feeding , hive supers, foundation sheet, and queen excluders , queen rearing, etc. are the areas where focus and proper management is required by the beekeepers
- aging or ill queens, swarming, missing queen are the common triggers of a colony to naturally produce a new queen.
- raising new queen artificially could be done to replace aging queens and to avoid swarming due to large colony.
- honey, bee pollens, royal jelly, propolis, bee venom, beeswax, etc. are the common honey products, and
- chalk Brood Diseases, nosematosis and amoeba are the major honey bee disease. There are also plants that are poisonous to honey bee, honey bee pests and predatory birds.
- local farmers have acquired knowledge from generations about honey season identification, traditional honey extraction, siting protection, swarm catching, using honey as medicine, etc.

Review Exercise

Part I. Write True or False for each of the following questions.

1. In Ethiopia four types of honeybees are found in different ecological settings.
2. Traditional forest beekeeping is one of the types of honey beekeeping practices in Ethiopia.

Part II. Choose the letter corresponding to the appropriate answer.

1. Which one of the following is honey bee product?
   A. Propolis C. Beeswax
   B. Bee venom D. None of the above
2. Which of these is not a characteristic of a worker bee?
   A. Doing all of the foraging for the hive C. Are the smallest bees in the colony
   B. Laying eggs D. Secreting wax from specialized glands
   C. Converting nectar into honey
3. Which one of the following is the type of beekeeping practices in Ethiopia?
   A. Modern beekeeping C. Traditional forest
   B. Traditional backyard D. All of the above
4. One of the following scenarios prompts a colony to naturally produce a new queen. Which one is it?
   A. Aging or ill queens C. Swarming
   B. Missing Queen D. All of the above

Part III. Write short notes on the following topics

5. What is Beekeeping and its contribution to the farmers?
6. What is the role of queen bee in the colony?

Unit 12 Nursery and Plantation Technology

<table>
<tr><th>Section</th><th>Learning Competencies</th></tr>
<tr><td>12.1.Nursery establishment and management</td><td rowspan="4">At the end of this unit, students will be able to:
▪ define nursery establishment and management.
▪ explain nursery site selection, preparation and layout.
▪ discuss methods of producing plants from seeds</td></tr>
<tr><td>12.2 Design and layout of the nursery</td></tr>
<tr><td>12.3. Producing plants from seeds</td></tr>
<tr><td>12.4.Plantationestablishment and management</td></tr>
</table>

12.1. Nursery establishment and management

Brainstorming 12.1

In a small group,

a) describe what nursery is and methods of its establishment and management.
b) mention the steps followed in nursery establishment and management

The objective of the best nursery practices is to produce high quality seedlings of the desired species. This can be done through employing the most cost-effective, environment friendly and socially acceptable technologies. Nursery establishment involves:

12.1.1. Site Inspection

Information most commonly included in site inspection is:

- Climate - temperature, rainfall (amount and distribution), relative humidity, and wind.
- Soil - depth of soil and its capacity to retain moisture, texture, parent material, pH, degree of compaction and drainage.
- Topography - important for its modifying effects on both climate and soil.
- Vegetation - composition and ecological characteristics of natural and introduced vegetation
- Other biotic factors - fire, domestic livestock and wild animals, insects and disease
- Availability of supplementary water sources: ponds, lakes, etc..
- Distance from nursery.
- The availability of labour.
- The distance of the forest plantation to the market and consumer centers.

12.1.2. Selection of the planting site

A good nursery should:

- be open, level and well-drained
- have light or loose-textured soil to facilitate nursery operations
- have a good source of water without possibility of being flooded
- be accessible to transportation and
- be far from existing potential sources of insect pests and diseases .

12.1.3 Species selection

The aim is to choose species which will fit the site, remain healthy through anticipated rotation, produce acceptable growth and yield, and meet the objectives of the plantation (fuel wood production, protection, etc.).

5. Preparation of the planting site

Create conditions that will enable the soil to catch and absorb rainfall. Create conditions to minimize danger from fire and pests
After that, clear the site. Layout the beds and build the nursery structure. Finally, prepare the germination beds.

Figure 12.1. Nursery establishment and management.

Activity 12.1.

Group work

Form a group that contain 4 to 6 member and visit different nursery management sites and write a report to your teacher

***Share your result with your whole classmates**

12.2. Design and layout of the nursery

Good design and preparation increases the efficiency and productivity of a nursery operation. Nursery design depends on the site. The size, orientation, and location of the nursery beds are important considerations. While establishing a nursery, keep the following things in mind.

a) **Identify a suitable location:** The shape of the nursery should be square or rectangular. An irregular shape increases the boundary lines and this maximizes the amount of fencing. The ideal shape is square since this reduces the distance between seedbeds /pot beds and the area where seedlings are planted.

b) **The orientation of Site:** Division is done by establishing road network. Roads are prepared for ease of management and transportation. Usually, roads are established at the end of the bed or between every 6 – 10 beds. The width of the road should be 3 – 5 meters.

c) **Division of Nursery:** Division is done by establishing road network. Roads are prepared for the purpose of transportation. Usually, roads are established at the end of the bed or between every 6 – 10 beds. The width of the road should be 3 – 5 meters.

d) **Preparation of Beds:** *Seedbeds are typically around 1m wide and 5-10m long. They require a shade cover (e.g. palm leaves, bamboo, wire mesh) for protecting from harsh sun.

Beds are of two types: raised and sunken beds

Figure12.2. Bed Preparation of nursery

The orientation of nursery bed should be towards the sun for photosynthesis. Length can be increased or decreased; width cannot be increased because it creates a problem in weeding and hoeing. Establishment of water supply system after preparation of the bed is needed.

12.3. Producing plants from seeds

Activity 12.1.

In small group

Discuss methods of producing plants from seeds in a nursery.

Producing plants from seed requires a number of steps. See below:

1. Container

Seed-starting containers should be clean, measure at least 2-3 inches deep and have drainage holes. They can be plastic pots, cell packs, peat pots, plastic flats, yogurt cups, or eggshells.

2. **Soil**

Start with quality soil. Sow seeds in sterile, seed-starting mix or potting soil available in nurseries and garden centers. Don't use garden soil; it's too heavy. Garden soil contains weeds seeds. It may also contain disease organisms. Wet the soil with warm water before filling seed-starting containers.

3. **Planting**

Plant seeds at the proper depth. The general rule of thumb is to cover seeds with soil equal to three times their thickness – but be sure to read the seed packet planting instructions carefully. Some seeds, including certain lettuces and snapdragons, need light to germinate. They should rest on the soil surface but still be in good contact with moist soil. Gentle tamping after sowing will help. After planting the seeds, use a spray bottle to wet the soil again.

4. **Water**

Use Water wisely. Always use room-temperature water. Let chlorinated water sit overnight so chlorine can dissipate or use distilled water. Avoid using softened water. It's important to keep soil consistently moist, but avoid overwatering. Overwatering promotes diseases that can kill seedlings. Try not to splash water on leaves.

5. Maintain Moisture

Maintain consistent moisture. Prior to germination, cover your container to help trap moisture inside. Use a plastic bag, but it should be supported so it doesn't lay flat on the soil. Remove covers as soon as seeds sprout. Once seedlings are growing, reduce watering so soil partially dries, but don't let them wilt.

6. **Temperature**

Keep soil warm. Seeds need warm soil to germinate. They germinate slower, or not at all, in soils that are too cool. Most seeds will germinate at around 78°F. After germination, air temperature should be slightly below 70°F. Seedlings can withstand air temperature as low as 50°F as long as soil temperature remains 65-70°F..

7. **Fertilize**

Start feeding your seedlings after they develop their second set of true leaves Apply a half-strength liquid fertilizer weekly. Apply it gently so seedlings are not dislodged from the soil. After four weeks, apply full-strength liquid fertilizer every other week until transplanting.

8. **Light**

Key term
Etiolation is a process in flowering plants grown in partial or a complete absence of light

Give seedlings enough light. Not enough light leads to leggy, tall seedlings that will struggle once transplanted outdoors. Seedlings often require protection from full sun. Shade reduces watering requirements and stress to seedlings. Partial shade is better than complete shade; the latter can raise humidity which can increase the proliferation of plant diseases. Also, too much shade causes etiolation, which means a plant's main stems grow spindly and weak. Thus, allow more sunlight to get through. . Ideally, seedlings need 14-16 hours of direct light per day for healthiest growth

9. **Air**

Circulate the air. Circulating air helps prevents disease and encourages the development of strong stems.

10. **Harden off seedlings before transplanting outdoors.**

Key Term
Acclimation is physiological, anatomical, or morphological adjustment within crops/plants/organisms that improve performance or survival in response to environmental change

Acclimatizing seeds to their new, harsher surroundings before moving them outdoors is recommended. This procedure is called “hardening off”.

12.4. Plantation establishment and management

Brainstorming 12.3

In a small group,

c) explain plantation establishment
d) mention plantation management practices you know in your area.

The success of fuel wood and small timber plantations is largely dependent upon careful establishment and management in the early stages of growth. This is of special importance in fuel wood plantations utilizing nitrogen-fixing tree species. Thus the major portion of labor and material inputs to community forestry plantings should be during the initial 12-18 months. During this time crucial establishment management operations must be carried out. Plantations may be established from seedlings, stem cuttings, or direct seeding. Each of these types of plantings must be done during periods of adequate rainfall, and must be protected from weeds and nests.

Weed control is the most important maintenance operation.

Fertilization is a practice used to increase production on millions of hectares of forest land every year.

In order to sustain production on a single site, the negative effects of harvesting must be minimized. This can be done by attending to:

- Fertility management. Care must be taken to retain many of the nutrients taken up by trees on the site. Nutrient losses might be minimized by allowing harvested trees to dry on the site before removal to allow leaves to dry, fall off and remain on the site. Nitrogen-fixing plants can be used to improve and maintain soil productivity
- Erosion control. Soil erosion losses must be minimized by minimizing the risk of exposing soils to the erosive forces of rainfall and runoff.

Unit Summary

In this unit, you have learned that:

- best nursery practices to produce high quality seedlings of the desired species. Employing the most cost-effective, environment friendly and socially acceptable technologies are recommended.
- different nursery establishment mechanisms such as site reconnaissance, selection of the planting site, selection of plant species and preparation of the planting site.
- design and layout of the nursery - i.e., identifying suitable locations, the orientation of the site, division of nursery and preparation of beds.
- different mechanisms of producing plants from seeds – i.e., choosing appropriate container, starting with quality soil, planting the seedling at the proper depth, etc.

Review Exercise

Part I: Choose the correct answer

1. Which of the following is involved in nursery establishment?
   A. Site selection
   B. Species selection
   C. Planting site preparation
   D. Planting the seeds
   E. All are correct
2. Which of the following is not true about good design and nursery layout?
   A. Increasing the efficiency
   B. productivity of a nursery operation
   C. increasing productivity of fuel wood
   D. None
   E. all
3. While establishing a nursery, keep the following things in mind.
   A. Orientation of site
   B. Identify a suitable location
   C. Preparation of Beds
   D. Division of Nursery
   E. all
4. The practice used to increase production on millions of hectares of forest land every year is called
   A. Application of seed
   B. selection of site
   C. fertilization
   D. all

Part II. Give short answer to the following questions.

1. Explain the importance of nursery establishment and management
2. riefly list and describe plantation establishment and management principles-

Part II Practical activities and field visits

1. Select a site in your school compound where students individually or in a group prepare a bed, and grow seedlings. Apply the necessary management and report what you learnt.
2. Go to the field individually or in a group where nursery establishment and management are practiced. Consider the following tasks
   a. Visit the nursery establishment and management methods in the sites and write a report.
   b. Ask pertinent offices about how they design the layout of the nursery.
   c. What methods do they use in plantation establishment and management?

Unit 13 Basics of Agro-Forestry Systems and Practices

Contents	Learning Outcomes
13.1. Definition of agro-forestry, agro forestry systems, practices and technologies 13.2. Significance of agro forestry 13.3. Classification of agro forestry systems 13.4. Agro forestry species, their establishment and management methods	At the end of this unit, you will be able to: ▪ define what agro-forestry and related terms. ▪ discuss the significance of agro forestry in the agricultural systems ▪ analyze the types of agro-forestry systems ▪ discuss about agro-forestry species, establishment and management methods ▪ appreciate the establishment and management of agroforestry in their local area

13.1. Definition of agro-forestry, agro forestry systems, practices and technologies,

Agro-forestry

Agro forestry is a collective name for land use systems and technologies where wood perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management as agricultural crops and animals in same form of spatial arrangement or temporary sequence. It is an integrated approach which benefits from combining trees and shrubs with crops and livestock as its component. Agro forestry requires both the agricultural and forestry technologies to create more diverse, productive, and sustainable land-use systems important to secure food and nutrition availability at local to national scale.

Brainstorming 13.1

In a small group,

a) describe agro forestry, agro forestry systems, practices and technologies
b) mention the agroforestry practices and technologies find in your area

Figure 13.1. Agro forestry systems

Agro forestry systems are also suited for the rejuvenation of marginal land in both temperate and tropical zones. Among the agroforestry systems used worldwide are improved fallows; Taungya; home gardens; alley cropping; growing multipurpose trees and shrubs in farmlands; boundary planting; farm woodlots; orchards and tree gardens; tree plantations; shelterbelts; windbreaks; conservation hedges; fodder banks; live fences; silvopastoral systems; and apiculture with trees.

Activity 13.1.

individually,

a. describe agro forestry system

b. mention different types of agro forestry systems practiced in your area.

*Share your results with students next to you

Practices and technologies of Agro forestry

Brainstorming 13.2

Form yourself into 3 to 5 groups and share the idea with the student next to you

a) mention types of practices and technologies of Agro forestry

b) describe the types of agroforestry in your environment

Home gardens/multistory

Home garden is an integrated system of multipurpose trees and shrubs with annual and perennial agricultural crops and livestock within the compounds of individual houses, managed by family labor. In the tropics in general, and in Ethiopia particular, home gardens often involve crop production with rearing of livestock and the growing of trees on small plots of land. Perennial crops such as banana, inset, papaya, yam, coffee and timber and fruit trees are useful home gardens, in the regions.

Figure 13.2. *Home gardens practices*

Alley cropping or hedgerow intercropping

Brainstorming 13.3

In a small group,

a) describe alley crop and hedgerow intercropping
b) list types of alley cropping/hedgerow that is practiced in your area
c) mention its importance to your classmates

Alley cropping or hedgerow intercropping is an agroforestry practice in which perennial, usually leguminous trees or shrubs are grown simultaneously with an arable crop. The trees, managed as hedgerows, are grown in wide rows and the crop is planted in the interspace or 'alley' between the tree rows. Alley cropping is, thus, a form of hedgerow intercropping, and combines the regenerative properties of bush fallow system with food-crop production.

Hedgerow intercropping (HI), the practice of farming annual crops in the spaces or 'alleys' between rows of multipurpose trees

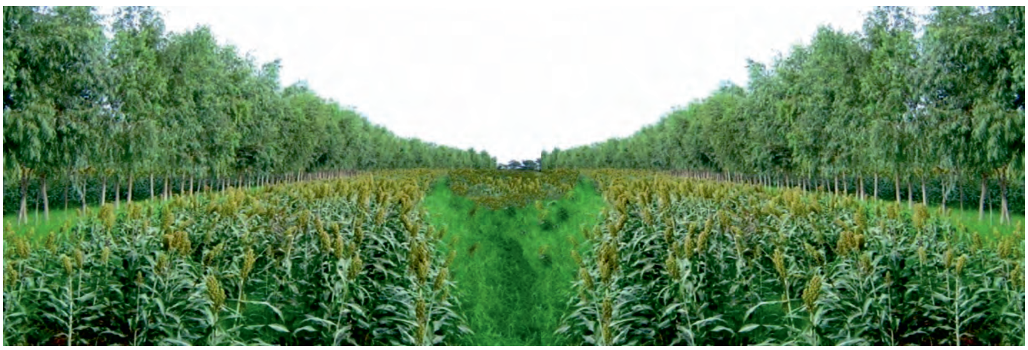


Figure 13.3. Alley cropping

Boundary planting

Brainstorming 13.4

In a small group,

a) describe boundary planting
b) mention the importance of boundary planting in your area

*Share your results with the class

Boundary planting is often referred to as living fences or barrier planting because it involves planting trees along all types of boundaries. These can be the edges of property, agricultural fields, pastures, roads or any other place where fences might be located. Typically they are used to make the boundaries of delimitate property, agricultural field, pastures, roads, etc.

Figure13.4: Boundary plating

Wind breakers and shelter belts

Wind breakers and shelter belts are the first chains in the system of agroforestry plantations. These are essentially protective and ecological value in general. Their major purpose is primarily to control wind erosion. When wind speed is reduced, evaporation and transpiration are lessened. Soil loss from wind erosion is reduced by windbreaks, and wind-transported soil particles from other areas are intercepted and added to the soil under the windbreaks.

Figure 13.5. Wind breakers and shelter belts

Tree fodder and silvopastoral systems

Silvopastoral systems are those that combine tree growing with the production of livestock. These systems typically include pasture systems containing trees that are widely spaced or planted in clusters throughout the pasture. Although the system may be used primarily to provide shelter for animals it can also be used as fodder to enhance livestock feed. Some are very effective at providing more favorable conditions for livestock with increased survival and body weight of the animals when using an effective silvo-pastoral system.

Figure 13.6. Tree fodder and silvopastoral systems

Fodder (browse) is an agricultural term for animal feed, and fodder trees and shrubs are those plants (shoots or sprouts, especially tender twigs and stems of woody plants with their leaves, flowers, fruits or pods) that are raised, used and managed to feed livestock. Examples of tree fodder like **WychElm**, Aspen, Salix caprea, gray Alder, etc.

Figure13.7: Tree fodder.

Activity 13.2.

Group work

a. describe tree fodder and silvopastoral systems
b. List some important tree fodder and silvopastoral systems practiced in your area

13.2. Significance of agro forestry

Brainstorming 13.5

Individually,

a) Mention the significance of agroforestry in your area
b) Compare the type of trees that are the most economical important in your area

Agro forestry systems are multifunctional systems that can provide a wide range of economic, socio-cultural and environmental benefits. Agro forestry can be particularly important for smallholder farmers because it generates diverse products and services on a limited land area. .

Economic benefits

Most agro forestry systems aim to increase or maintain the production and productivity of farming systems; reduce agricultural inputs and thus production costs; and diversify production by the use of trees or other woody perennials to produce, for example, food, fodder, lumber, building materials and wood fuel. Agro forestry can help reduce rural poverty by increasing on-farm production and household income and by providing employment opportunities.

Social benefits

An increase in production, productivity and product diversity through agro forestry can help improve the health and nutrition of the rural poor. The on-farm production of fuel, fodder and other tree products, otherwise collected from off-farm sources, can reduce the time and effort needed to obtain them (often lessening the burden on women) or save money if the products would otherwise be purchased. The perpetuation of traditional agro forestry practices can help maintain social bonds established through mutual-help arrangements (e.g. in the case of shifting cultivation).

Environmental benefits

Agro forestry systems can provide a range of environmental services. For example, they can improve soil fertility, protect crops and livestock from wind, restore degraded lands, improve water conservation, limit pests and prevent soil erosion. If properly designed and managed, agro forestry systems can contribute to biodiversity conservation and climate-change adaptation and mitigation.

13.3. Classification of agro forestry systems

The commonly used criteria for classifying agro-forestry systems and practices are:

- Structure of the system (nature and arrangement of components),

- Function of the system (role and output and outcome of components),
- Agro-ecological zones where the system exists or is adoptable, and
- Socioeconomic scales and management levels of the system Based on these criteria.

Based on these criteria, **there are three major classification of agro-forestry:**

1. Agrisilvicultural systems

Agrisilvicultural systems are combination of crops and trees such as alley cropping or home gardens.

Figure 13.8. Agrisilvicultural systems

2. Silvo pastoreal Systems (Tree-Livestock/Animal)

This system involves raising livestock on improved pasture grown in association with trees. Some commonly used systems are alley farming and live fencing.

Figure 13.9. Silvo pastoral Systems

3. Agro-Silvo pastoral system (Tree-Crop-Livestock)

This system involves the three ways mixture based on combination of crops, trees and animals. This system requires skillful management and can be sustainable even in harsh environment and fragile soils.

Activity 13.3.

individually,

Discuss the methods of agro forestry system classification

*Share your idea with your classmates

13.4. Agro forestry species, their establishment and management methods

13.4.1. Agro forestry specie: the multipurpose trees

ultipurpose trees (MPTs)

Brainstorming 13.5

In a small group,

Describe multipurpose trees in your and mention some of them found in your area.

The term agro forestry species" usually refers to woody species, and they have come to be known as "multipurpose trees" (MPTs).

In the agro-forestry context, multipurpose trees are understood as "trees and shrubs which are deliberately kept and managed for more than one preferred use, product, and/or service. The retention or cultivation of these trees is usually economically but also sometimes ecologically motivated, in multiple-output land-use system." Examples of MPTs include, Leucaena spp, Acacia spp, Casuarina spp, and Calliandra calothyrsus L.

Fodder trees

Tree and shrub species used regularly as feed sources for animals. A large number of tropical trees and shrubs are traditionally known and used for their fodder. For example, Acacia mangium L., Acacia nilotica L., Acacia tortilis L. and Albizia lebek L.

Fuel wood trees

Fuel wood trees refer to plants suitable for deliberate cultivation to provide fuel wood for cooking, heating, and sometimes lighting. These include trees that have uses other than providing fuel wood, are easily established and require little care; adapt well to different ecological conditions, etc. For example Acacia mearnsii is used for fuel wood and charcoal.

Figure 13.10. Acacia mearnsii

Fruit trees

These are common components in most home gardens and other mixed agro forestry systems; they are also integrated with arable crops either in intercropping mixtures or along boundaries of agricultural fields. These fruit trees are well adapted to local conditions and are extremely important to the diet, and sometimes even the economy, of the people of the region, but they are seldom known outside their common places of cultivation.

13.4.2. Management methods of Agro forestry

The tree management practices should be carried out by farmers to ensure a desirable product, properly manage the tree canopy and roots in order to facilitate maximum resource utilization, management of organic residues for nutrient cycling method of harvesting tree as well non-timber tree products and ensure protection from biotic and abiotic stresses.

Brainstorming 13.4

In small group,

1. describe management methods of agroforestry practices in area
2. mention the importance of management of Agro forestry in your area
3. mention indigenous knowledge that farmers use to manage agro forestry In your local area

Aboveground Management Practices

The aboveground management practices include pruning, thinning, pollarding, lopping and coppicing.

Pruning

Pruning is the practice of managing perennial tree species by cutting away dead or overgrown branches as per the requirement of crop and tree growth to

- Restore the functional balance between above - and below-ground plant organs by reducing root respiration
- Reduce the competition between tree and crops for growth factors such as light, water and nutrients.

Thinning

Selective process of removing or killing some trees to allow the remaining trees to maintain a steady growth rate to

- To obtain firewood and wood for construction purpose in earlier years of plantation:
- To selectively remove poorly formed trees and species of lower value.
- To provide suitable light conditions to the crop and to eliminate the excess root competition between the trees and crops.

Pollarding

Pollarding is a process in which crown of the trees are cut at least 2 m above the ground level i.e. beyond the reach of cattle, in order to get flush of new shoots reprouting.

Figure 13.11. Aboveground Management Practices, (A) Tree before pollarding (B) Tree after pollarding (C) Resprouting.

The objectives of pollarding are:

- Early harvest of wood, fodder or other biomass.
- Production of wood or fodder at heights that is out of the reach of livestock, hence there is no need for protection from browsing.
- Reduction of shading of nearby crops.
- Regeneration of the tree crown to promote growth

Lopping

Lopping is the cutting of tree branches e.g. (mainly of leafy branches or twigs) from a tree.

Figure 13.12. Lopping of trees

- The objectives of lopping are given below :
- To meets seasonal needs for food, fodder, fuel wood and other subsistence requirements.
- To encourage new flush of growth.
- To maintain the hygiene of the trees

Coppicing

This practice involves cutting the tree down to the stump and allowing it to re-grow to maximize biomass production.

Belowground Management

The management of belowground interactions is most important where trees and crops are grown in close proximity and where soil resources (water, nutrients) are limiting, as in seasonally dry climates and semi-arid tropics.

Root Pruning

Tree root pruning is a potential tool for managing belowground competition when trees and crops are grown together in agro forestry systems. Root pruning, usually by way of trenching, has been used as a mean to separate root systems of trees and crops, thereby reducing belowground competition significantly.

Unit Summary

In this unit, you have learned that:

- definition of agro-forestry, agro forestry systems, practices and technologies such as hedge grow alley cropping or hedgerow intercropping, home gardens, etc.
- significance of agro forestry including social, economic and environmental benefits, etc.
- classification of agro forestry systems
- agro forestry species, their establishment and management methods
- management practices of agro forestry

Review Exercise

Part I: Choose the correct answer

1. The combined tree growing with the production of livestock is called…..
   A. fodder tree
   B. alley cropping
   C. silvopastoral systems
   D. agro forestry
   E. none
2. One of the following is the environmental benefit of agroforestry. Which one?
   A. protect crops and livestock from wind
   B. restore degraded land
   C. improve water conservation
   D. limit pests and prevent soil erosion
   E. all
3. Agroforestry is classified based on--------
   A. Structure of the system
   B. Function of the system
   C. Agro-ecological zones
   D. Socioeconomic scales and management levels
   E. all
4. Agrisilvicultural systems are combination of-----------
   A. crops and trees
   B. livestock and trees
   C. crops and livestock
   D. none
5. Which one of the following multipurpose tree
   A. Fodder tree
   B. Fuel wood trees
   C. Fruit trees
   D. all
5. What is the importance of agro forestry system in your locality?
   A. Increase soil quality
   B. enhances diversity
   C. increase crop production and productivity
   D. environmental stewardship
   E. all

6. The three ways of mixture based on combination of crops, trees and animals is called----?
   A. Silvo pastoral Systems
   B. Agro-Silvo pastoral system
   C. Agrisilvicultural systems
   D. none

Part II: Give short answer to the following question.

1) Define agroforestry and agroforestry system
2) What does it mean when we say agroforestry is integrated approach?
3) What is the importance of tree fodder and silvopastoral systems?
4) Describe the importance of multipurpose trees and shrubs on farmland
5) Describe the benefits of agroforestry
6) Mention and describe the different types of management practices of agro forestry?

Unit 14 Soil and Water Conservation

Contents	Learning Outcomes
14.1. Soil properties	At the end of this unit, you will be able to: ▪ describe soil properties. ▪ elaborate the types of soil erosion ▪ illustrate the major causes of soil erosion ▪ analyze the negative impacts of soil erosion on the environment ▪ describe the types of soil and water conservation practices ▪ justify the need of soil and water conservation ▪ mention types of indigenous knowledge's applicable in Soil and water conservation
14.2. Soil erosion	
14.3. Major causes of soil erosion	
14.4 Negative impacts of soil erosion	
14.5. Types of soil and water conservation practices	
14.6. Need of soil and water conservation	
14.7.Indigenous Knowledge in Soil and water conservation	

14.1. Soil properties

Soil is a mixture that contains minerals, organic matter, and living organisms. It consists of inorganic particles and organic matter. The combinations of these determine the soil's properties such as its texture, structure, porosity, chemistry and color. Soil provides the structural support to plants used in agriculture and is also their source of water and nutrients. Soil has both physical and chemical properties

The physical properties of soil include all the aspects that we can see and touch such as texture, color, depth, structure, porosity (the space between the particles), stone content.

Texture

Soil texture refers to the proportion of the particles of soil such as sand, silt, and clay. These soil separates have the following size ranges: Sand = <2 to 0.05 mm, Silt = 0.05 to 0.002 mm and Clay = <0.002 mm. Sand and silt are the "inactive" part of the soil matrix, because they do not contribute to a soil's ability to retain soil water or nutrients.

Structure

Structure refers to the aggregation of primary soil particles (sand, silt and clay) in to compound particles.

Consistency

Is the resistance of soil to deformation and is determined by adhesive and cohesive properties of the soil in various moisture.

Bulk density

Bulk density of the soil is mass of the soil per unit volume of soil

The chemical properties of soil include cat ion exchange capacity and soil reaction (pH)

Activity 14.1.

In small groups,

a. define what soil is and describe its properties
b. explain the differences between physical and chemical properties of soil

14.2. Soil erosion

Soil erosion is a gradual process that occurs when the impact of water or wind detaches and removes soil particles, causing the soil to deteriorate. Soil erosion is the natural process in which the topsoil of a field is carried away by physical sources such as wind and water. Soil erosion is the steady, degenerative process of the loss of topsoil. It is caused by heavy rainfall, flooding, high winds, and even mass movements.

Figure 14.2. Soil erosion caused deforestation

Activity 14.2.

Individual, answer the following question

Define soil erosion and list its major causes

14.3. Major causes of soil erosion

Brainstorming 14.1

In a small group,

a) amention causes of soil erosion
b) explain how these exacerbate soil erosion in your area

Modifications in land use are one of the most impactful ways of accelerating soil erosion. These changes then have a cascade effect as the loss of fertile topsoil cover sends millions of tons of sediments into lakes and reservoirs. The followings are the major causes of soil erosion:-

Deforestations and Urbanization

Key term:
Urbanization is the expansion of urban area and conversion of natural physical landscape to town.

The cutting down of trees and removal of vegetation exposes soil to erosion more easily. Soil experiences direct impact from rain water or from the wind. The losses of trees, which anchor the soil with their roots cause widespread erosion. With time, as topsoil (the most nutrient-rich part of the soil) is lost, putting agriculture under threat.

Figure 14.3. Deforestations and Urbanization

Overgrazing and Agricultural Tillage

Overgrazing is grazing by livestock or wildlife to the point where the grass cover is depleted, leaving bare, unprotected patches of soil and as a result, water and wind cause soil erosion. Overgrazing is caused by intensive cattle rising. As plants don't have the recovery period they need, they end up being crushed and compacted by cattle. In this process, topsoil sediments are transported elsewhere. As for the remaining soil, it can lose its infiltration capacity. Tillage is the mechanical manipulation of soil with tools and all has all along been contributing negatively to soil quality. Since tillage fractures the soil, it disrupts soil structure, accelerate surface runoff and soil erosion.

Figure 14.4. Overgrazing and Agricultural Tillage

Excessive use of Agrochemicals

The use of chemicals under the form of pesticides and fertilizers ends up causing an imbalance of microorganisms in the soil moisture, stimulating the growth of harmful bacteria. As the soil gets degraded, the risk of erosion increases and the sediments sweep into rivers and nearby regions

Construction and Recreational Activities

Setting up buildings and roads also has their share of responsibility when it comes to soil erosion as they don't allow for the normal circulation of water.

Heavy Rain falls and Resulting Floods

Heavy rainstorms can splash as much as 90 tons of soil per acre. Most of the splashed soil particles do not leave the field; they clog surface pores and which in turn reduces water infiltration, increases water runoff and increase soil erosion.

Figure 14.5. Heavy Rain falls and Resulting Floods

14.4 Negative impacts of soil erosion

The loss of soil from land surfaces by erosion is widespread and reduces the productivity of all natural ecosystems as well as agricultural, forest, and pasture ecosystems. Soil erosion is a world-wide challenges for sustainability of agriculture especially in tropical regions. Loss of soil trough erosion decrease rooting depth, soil fertility, organic matter in the soil and plant-available water reserves. It is a dynamic process which may lead to a decline of soil productivity, and result in lower agricultural yield and income. It results loss in arable land, deteriorate the water quality in downstream pollution of rivers, death of fish, silting up of reservoirs.

Figure 14.6. Negative impacts of soil erosion

Activity 14.3.

Group task

1. discuss the negative impacts of soil erosion
2. explain the impacts of soil erosion you experienced in your area

Share your results with your whole class

14.5. Types of soil and water conservation practices

Key phrase

Soil and water conservation are activities of maintaining or enhancing the productive capacity of soil, water and vegetation in areas prone to degradation.

A variety of soil and water conservation measures are well known. These are Biological Soil and water Conservation, Physical (mechanical or technical practices), and agronomic (sometimes called best management practices), etc.

14.5.1. Biological soil conservation

Biological soil conservation practices involve using different biological methods that poses protective impact on the vegetation cover. Biological soil and water conservation practices includes Conservation Tillage, Conservation Farming, Improved Water Use Efficiency, Alley cropping and grass strip

Key Words:

Tillage is the mechanical manipulation of the soil for the purpose of crop production affecting significantly the soil characteristics

Conservation Tillage

Conservation Farming is a set of practices which conserve the soil, water, and soil moisture, enhance fertilizer and seed use, and finally, saves time and money. Conservation farming has three main principles which help in biodiversity and environment protection. These principles are:

1. Minimum soil disturbance
2. Crop residue management; leaving of previous crop residue in the field or planting a cover crop
3. Crop rotation practices

The emphasis of conservation farming is on conservation tillage practices, during which the soil is tilled just enough to be possible to sow seeds.

Figure 14.7. Crops are planted without tillage in soil covered with crop residue

Afforestation and Reforestation

Afforestation or forestation is process where new forests are planted across land without tree, whereas reforestation is the important means for regeneration of the soil and water balance. It increase above-below ground biomass accumulation and enhance biodiversity, prevent soil erosion, improve ecosystem functions and services.

Figure 14.8. Reforestation and afforestation

14.5.2. Physical soil and water conservation mechanisms

Bench and hillside terraces

A bench terrace is a conservation structure where a slope is converted into a series of steps, with a horizontal cultivated area on the step and steep risers between two steps.

Figure 14.9. Bench terrace in Tigray (A) and Bench terrace in Konso (B).

Level and graded fanya-juu

A level Fanyaa-Juu ('throw uphill' in Swahili language) is an embankment along the contour, made of soil and/or stones, with a basin at its lower side. The Fanyaa-Juu reduces or stops the velocity of overland flow and consequently soil erosion.

14.5.3. Agronomic soil and water conservation mechanisms

The agronomic practices includes area enclosure, traditional ditches, contour plowing, grass strips

Alley cropping and grass strip

Alley cropping is an agro forestry system in which food crops are grown in alleys between rows of hedges.

Area enclosure and controlled grazing

Area closure is a protection system to improve land with degraded vegetation and/or soil through natural regeneration. No livestock are allowed to graze, and no human interference tolerated for 2-3 years, until a 50% natural grass cover is obtained

Grass strip

A grass strip is a ribbon-like band of grass laid out on cultivated land along the contour. Grass Strips help to reduce runoff and to filter out sediments carried by runoff.

Figure 14.11. Grass strip

Activity 14.4.

Group work

a. list soil and water conservation measures practiced in your area

b. list different indigenous knowledge farmers use in conserving their soil and water in different parts of Ethiopia

c. compare and contrast biological and physical soil and water conservation practices

14.6. Need of soil and water conservation

The soil and water conservation measures are the first line of defense that mostly acts as barrier due to the creation of obstacles against surface runoff. Soil and water conservation measures predominantly applied for the following purposes:

- to control runoff and thus prevent loss of soil by soil erosion, to reduce soil compaction;
- to maintain or to improve soil fertility;
- to conserve or drain water;
- to harvest (excess) water

- to reduce nutrient and soil losses, and hence increasing agricultural productivity
- conservation of soil, water and natural vegetation leads to higher productivity of crops and livestock and thus the improvement of livelihoods

14.7. Indigenous Knowledge in Soil and water conservation

In order to overcome soil erosion and flooding problems, local people have developed many indigenous soil and water conservation practices which are used to reduce impact of soil erosion and flooding on agricultural production systems.

Indigenous Biological Soil and Water Conservation Measures

This includes mixed cropping, intercropping, crop rotation, indigenous agro forestry, fallow, alley cropping, minimum tillage and mulching.

A B

Figure 14.12. Traditional type of agro forestry (A) and Traditional intercropping (B).

Indigenous Mechanical Soil and Water Conservation Measures

Include cultivation on ridges/rows, stone band/barrier; traditional dams/ water retention ditches, traditional cut-off drain/drainages systems and terraces.

Figure 14.13. Traditional dam or water retention ditch (left) and Konso people's Terrace (right).

Activity 14.5.

Form a group and discuss the following questions

Discuss different types of Indigenous Knowledge in Soil and water conservation in your environment

Unit Summary

In this unit, you have learned that:

- soil properties such as chemical and physical properties
- soil erosion and its effect
- major causes of soil erosion
- negative impacts of soil erosion
- types of soil and water conservation practices
- need of soil and water conservation and
- indigenous knowledge in Soil and water conservation

Review Exercise

Part I Choose the correct answer

1. Which one of the following is true about the components of soil?

A. Minerals C. living organisms E. all
B. organic matter D. a & c

2. The proportion of the particles of soil such as sand, silt, and clay is called-------

A. Soil structure C. soil texture
B. soil color D. all

3. The inactive part of the soil matrix is called-----?

A. Sand C. silt E. none
B. clay D. Sand and silt

Part II: Give short answer

1. Define soil and describe its properties?
2. List major components of soil and differentiate them?
3. List and describe different properties of soil with the example and differentiate them?
4. List and explain major causes of soil erosion problem?
5. What are negative impacts of soil erosion?
6. Define and describe soil and water conservation practices?

Part III: Practical activities and field visits

7. Go to the field individually or in a group to visit the soil and water conservation sites an and write the report based on the following questions

A. ask the farmers or Development Agents/DAs/ about soil and water conservation practices and prepare a report
B. Ask the farmers and observe what types of soil and water conservation practices they use
C. Visit the field that farmers practice soil and water conservation measures indigenously and compare it differ from the modern one
D. How effective are the methods? If possible try to practice the techniques they use to manage and protect the soil erosion to develop such skills
E. Ask farmers what benefits they get by practicing soil and water conservation on their farm

Write your conclusion and suggestion about what you observed from the field visit

Unit 15 Gender and Human Nutrition

Contents	Learning Competencies
15.1. Basic gender-related terminologies 15.2. Gender role in food production and consumption 15.3. Empowering women in food production and consumption	At the end of this unit, students will be able to: ▪ define gender related terminologies ▪ explain roles of gender in food production and consumption ▪ describe the role of empowering women in food production and consumption

15.1. Basic gender related terminologies

Sex refers to the biological differences between males and females. Sex differences are concerned with males' and females' physiology.

Gender refers to the economic, social, political, and cultural attributes and opportunities associated with being women and men. The social definitions of what it means to be a woman or a man vary among cultures and change over time. Gender is a socio-cultural expression of particular characteristics and roles that are associated with certain groups of people with reference to their sex and sexuality.

Gender Equity is the process of being fair to women and men. To ensure fairness, measures must be taken to compensate for historical and social disadvantages that prevent women and men from operating on a level playing field.

Gender Equality is the state or condition that affords women and men equal enjoyment of human rights, socially valued goods, opportunities, and resources.

Gender Integration refers to strategies applied in program assessment, design, implementation, and evaluation to take gender norms into account and to compensate for gender-based inequalities.

Gender Mainstreaming is the process of incorporating a gender equality perspective into policies, strategies, programs, project activities, and administrative functions, as well as into the institutional culture of an organization.

Women's Empowerment means improving the status of women to enhance their decision-making capacity at all levels, especially as it relates to their sexuality and reproductive health.

Gender sensitivity: Gender sensitivity means acknowledging that differences and inequalities between women and men require attention.

Gender responsive is being gender sensitive and articulating policies and initiatives which address the different needs, aspirations, capacities and contributions of women and men

15.2. Gender role in food production and consumption

Brainstorming 15.1.

In a small group,

1. *What roles do you see women and men playing in food production in your community?*
2. *Is there difference between what men and women are expected to do in terms of food production?*

A better understanding of the role of gender in the agricultural food production could greatly A better understanding of the role of gender in the agricultural food production could greatly increase productivity, reduce poverty, and improve food production and food security. Women form about a half of the agricultural workforce and are agents of change and resilience builders. Women often play a greater role in ensuring nutrition, food safety and quality. Women are also often responsible for processing and preparing food for their households. Women tend to spend a considerable part of their cash income on household food requirements.

Women play a greater role in food production. They provide the bulk of food production labour. They contribute much labor to each stage in farm task. This begins with the initial farm operations such as land clearing and seedbed preparation. It passes through sowing (planting) and weeding and goes until it reaches the final farm operations such as harvesting and transportation.

Women also play a significant role in livestock and poultry production and off-farm income-generating activities such as petty trade, and informal labor work. Research indicates that the relative number of households where females provided more field labour than males was higher among female-headed households than among the male-headed ones.

Food systems are experiencing rapid and intense transformations. There is an urgent need to feed a growing global population in a context of persisting economic, environmental and social challenges. Agricultural production and rural livelihoods are being increasingly jeopardized by the impacts of climate change and continuing depletion of natural resources. Promoting gender equality and women's empowerment is inextricably linked to the strengthening of food systems to fight hunger and malnutrition, and improve the lives and livelihoods of rural populations. Without gender equality and rural women's economic, social and political empowerment, food security, nutrition and sustainable agriculture will not be achieved.

Activity 15.1.

In a small group,

1. describe the roles of gender in food production and consumption in your area
2. briefly discuss the impact of family planning in agriculture

argue with your groups whether family planning contribute to agricultural production or not

15.3. Empowering women in food production and consumption

The idea of women empowerment in food production is the inclusion of women in decision-making and budgeting income. This includes making decisions over agriculture production, having access to and control over productive resources and having access to and control over income. The participation of men in household tasks to reduce women's labour is another important issue to be considered in women empowerment

Outside the Women Empowerment in Agricultural Index, women and men also stated that women's ability to feed children nutritious food was an example of women's empowerment. Improving women's nutrition outcomes through better access to a more diverse diet has been identified as a key strategy towards improving the lives and livelihoods of women. This could be attributed to the link between improved dietary intake and health outcomes and by extension, enhanced economic productivity.

Dietary diversity is usually measured as a snap-shot of women's consumption of different food items with a recall period of 24 hours to 15 days. Measures or indicators for the empowerment of women in food consumption were constructed in five domains of empowerment. These include:

1. Decisions about agricultural production: sole or joint decision-making over food and cash crop farming and fisheries

2. access to, and decision-making power about productive resources: autonomy in production
3. control of use of income: sole or joint control over income and expenditures
4. leadership in the community
5. time allocation based on a log of different activities

Figure 15.3. Women in food production

Activity 15.1.

Group work

a. explain importance of empowering women in food production and consumption
b. describe the roles of women's indigenous knowledge in producing food consumption of food

* share your results with whole your class.

Unit Summary

In this unit, you have learned that:

- different terminologies of gender such as sex, gender, gender equality, gender equity, gender mainstreaming, and women's empowerment, etc.
- roles of gender in food production and consumption. These roles are women's participation in agricultural production, food production and consumption.
- role of women in food production - land clearing and seedbed preparation, sowing or planting and weeding - harvesting and transportation.
- empowering women in food production and consumption
- indicators of the empowerment of women in food consumption: e.g., decisions about agricultural production, joint decision making over food and cash crop farming and fisheries; having access to and decision-making power about productive resources, autonomy in production control of use of income, sole or joint control over income and expenditures, leadership in the community, etc.

Review Exercise

Part I. Choose the correct answer.

1. The process of being fair to women and men is called----
   A. Gender Equality
   B. Gender Equity
   C. gender role
   D. all
2. Incorporating a gender perspective into policies, strategies, programs, project activities is called__________
   A. Gender Integration
   B. Gender equity
   C. Gender equality
   D. Gender Mainstreaming
3. What empowerment indicators are important for women's food consumption?
   A. Decisions about agricultural production
   B. Access to and decision-making power about productive resources
   C. Control and use of income
   D. Leadership in the community
   E. None
   F. All
4. The failure to recognize that the roles and responsibilities of men/ boys and women/girls are given to them in specific social, cultural
   A. Gender equality
   B. b) Gender blindness
   C. c) Women empowerment
   D. d) All

Part II: Give short answer

1. What is the difference between empowering woman and gender mainstreaming?
2. The condition that affords women and men equal enjoyment of human rights, socially valued goods, opportunities, and resources is called____
3. Briefly explain the differences between gender and sex.

Part III: Case study

Direction: Organize yourself into small groups and conduct a case study in your village based on the following questions and present your report to the classroom:

1. Ask the elders, women and the leaders of your Kebeles Women and

Children's Affairs and determine the kinds of tasks performed by women in agricultural production and the time spent by women in these tasks in the village.

2. Examine the relationship between women's participation in task performance and their role in intra-family decision making.
3. Examine the relationship between women's income and their role in decision making
4. Write your reflection on how the villagers feeling about gender equality and equity in food production and consumption. How sensitive are the local villagers towards gender sensitivity. Do you support their views? Why?

Unit 16 Safe Food Production and Postharvest Handling

Contents

16.1. Food safety hazards and health risks

16.2. Source of food contaminants

16.3. Food safety and nutrition linkage

16.4. Indigenous knowledge in safe food production and postharvest handling

Learning Outcomes

At the end of this unit, you will be able to:

- explain food safety hazards and human health risks
- state source of food contaminants that affect human beings
- examine food safety and nutrition linkage
- mention types of indigenous knowledge in safe food production and postharvest handling

16.1. Food Safety Hazards and Health Risks

There are four primary categories of food safety hazards to consider: biological, chemical, physical, and allergenic. Understanding the risks associated with each can reduce the potential of a foodborne illness in the food chain. Each has their own unique characteristics, but all can be avoided through a robust food safety management system.

Biological hazards: are characterized by the contamination of food by microorganisms (See Table 16.1). Microorganisms are found in the air, food, water, animals, and in the human body. These tiny organisms are not inherently unsafe – many provide benefits to our anatomy.

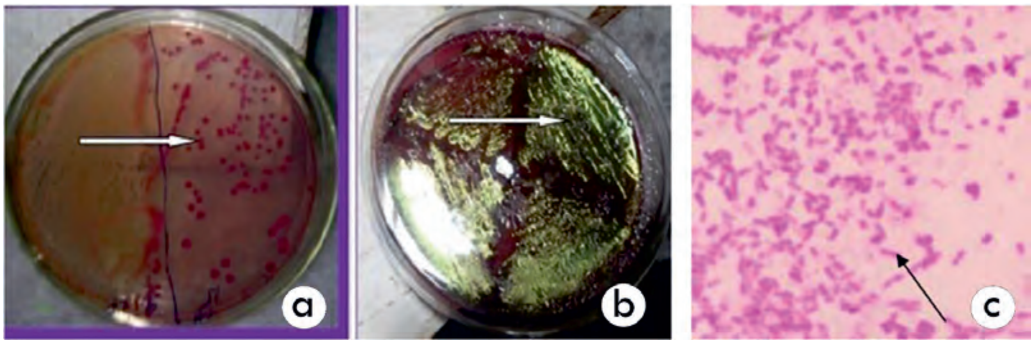


Figure 16.1. Bacteria colonies on a petri dish from raw milk samples.

Table 16.1. Examples of biological hazards and foods commonly infected.

Biological hazard	Commonly found in
Salmonella	Eggs, poultry, meat, unpasteurized milk or juice, cheese, fruits and vegetables, spices, and nuts
Norovirus	Produce, shellfish, ready-to-eat foods
Campylobacter	Raw and undercooked poultry, unpasteurized milk, contaminated water
E. coli	Undercooked ground beef, unpasteurized milk or juice, raw milk cheeses, raw fruits and vegetables, contaminated water
Listeria	Ready-to-eat deli meats and hot dogs, unpasteurized milk or juice, raw milk cheeses
Clostridium perfringens	Beef, poultry, gravies

Chemical hazards: are caused by the presence of harmful substances that can be found in food naturally, or unintentionally added during processing.

Some chemical hazards include naturally occurring chemicals, such as mycotoxins. Intentionally added chemicals, including the preservative sodium nitrate, and unintentionally added chemicals like pesticides can cause chemical hazards.

Figure 16.2. Tractor spraying pesticide, which can inadvertently find its way into the food we consume.

Table 16.2. Examples of Chemical Hazards.

Chemical Hazard	Examples
Mycotoxins	Produced by fungi and can be toxic to humans and animals. They are formed by moulds which grow on crops and foods under certain conditions.
Natural Toxins	Biochemical compounds produced by plants in response to certain conditions or stressors.
Marine Toxins	Decomposition or microscopic marine algae accumulated in fish and shellfish.
Processing-induced Chemicals	Undesirable chemicals can be formed in certain foods during processing as a result of reactions between compounds that are natural components of the food.
Pesticides/ Agricultural Products	Used to control, destroy, or repel a pest, or to mitigate the effects of a pest.

Physical Hazards: are foreign objects found in food products. They are either naturally found in the specific item, such as stems in fruit, bones in fish or not normally part of the food item, such as hair or plastic. Natural hazards are more like bones which present a puncture or choking risk.

Unnatural physical hazards are generally more dangerous to health, whereas natural physical hazards can be harmless.

Table 16.3. Physical Hazards Examples.

Physical Hazard	Examples
Natural	Stems in blueberries, microscopic airborne debris, dirt on potatoes, or minute insect fragments in figs
Unnatural	metal fragments, pieces of plastic, wood chips, and glass

Many countries have regulatory bodies to implement laws that help to minimize food safety risk and ensure safer food safety practices.

Activity 16.1.

Do the questions below in pairs. Share your answers with other students.

Explain the following food safety risks and their causes. Give examples;

a). biological hazards

b). chemical hazards

c). physical hazards

16.2. Source of food contaminants

Major contamination sources are water, air, dust, equipment, sewage, insects, rodents, and employees. Contamination of raw materials can also occur from the soil, live animals, external surface, and the internal organs of meat animals. Additional contamination of animal foods originates from diseased animals, although advances in health care have nearly eliminated this source. Contamination from chemical sources can occur through accidental mixing of chemical supplies with foods. Ingredients can contribute to additional microbial or chemical contamination.

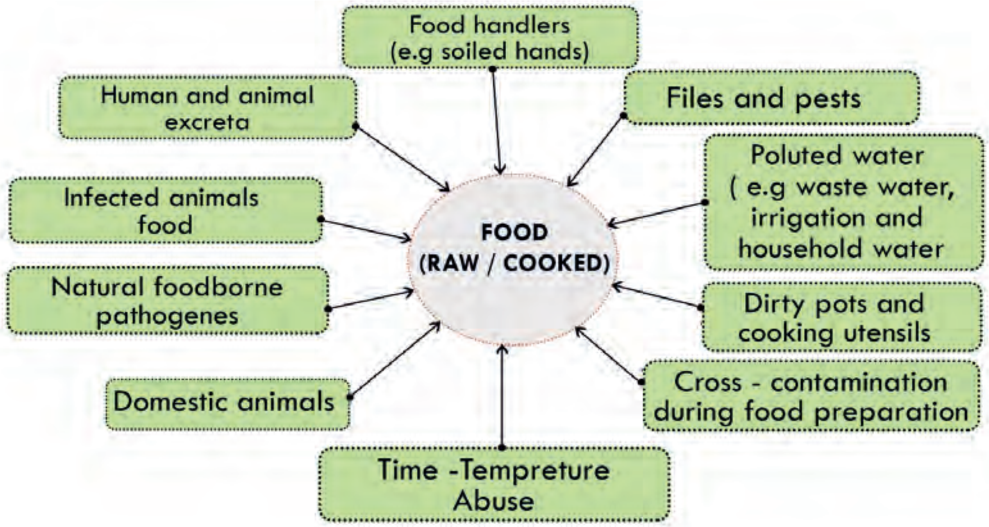


Figure 16.3. Sources of food contaminations.

Activity 16.2.

Individual work

a. list down any food contamination you might have observed or encountered.

b. what might have caused them?

c. what were their consequences?

d. how were the consequences handled? Share your points with your classmates.

16.3. Food safety and nutrition linkage

Clean and safe foods are very important. We need to prevent germs from getting into foods and water. Germs not only cause diseases, but they can also destroy valuable nutrients in the food. Food safety is about handling, storing and preparing food to prevent infection. We should make sure that our food has enough nutrients that keep us healthy and strong. Food and water, if exposed to dirt and germs, can be unsafe to health.

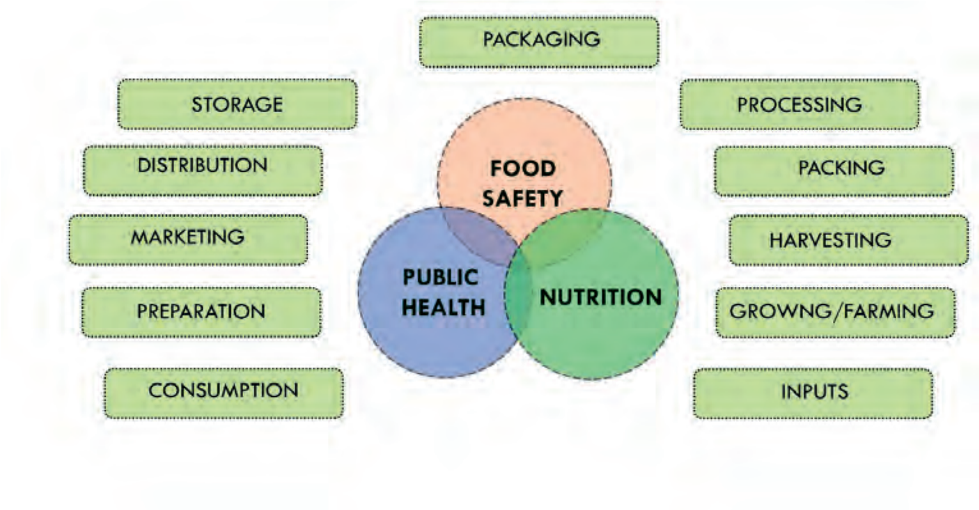


Figure 16.4. Linkage between safe food, nutrition and public health.

Unsafe food can cause infections or diseases such as diarrhea, meningitis, etc. These diseases can make people very sick; they can even be life - threatening. When people are sick, they are weak and have difficulty working or concentrating. Some infections also make it difficult for our bodies to absorb the nutrients they need to get healthy. Stale foods have lost nutrients. Eating stale food is very risk for human health.

Activity 16.3.

In pairs,

Ask a health, agriculture or any other professional/expert you know about the linkage between food safety and nutrition. Try to probe the professional/expert for in-depth information on the relationships between public health, nutrition and food security. Browse the Internet for more information that can strengthen your understanding of the link. See if the information obtained from both sources match. Share your findings with the rest of the students in the class.

16.4. Indigenous knowledge in Safe food production and postharvest handling

Post-harvest losses are one of the major challenges for food security in the developing world. Farmers' indigenous pest management knowledge is site specific and could be used as the basis for developing integrated pest management (IPM) techniques. Farmers take measures such as sufficiently drying maize before storage, using storage structures which are moisture proof and are adequately aired as mechanisms to reduce losses incurred after harvest.

There are different forms of traditional storage structures that are generally made of locally available materials. Similarly, farmers use botanicals and wood ash for the same purpose.

In case of animal origin foods (milk and meat), farmers predominantly use smoking, natural fermentation and proper casing using locally available plant materials as shown in Figure. 16.5.

(A) (B)

Figure 16.5. Ethiopian whole sour milk (ergo) (A), and fresh butter (B).

Underground Storage (Pit): Grains such as sorghum and maize are stored underground in some parts of the Ethiopia, but it is unusual for teff to be stored in such pits. Underground pit grain storage is common in dry lands of Ethiopia where there is a shortage of wood and other materials for construction of above the ground storage bins. The pit gate is covered with a combination of locally available materials such as strips of timber, stone, soil, animal dung and mud.

Above-the-Ground Traditional Storage Structure: Gombissa is an above-the-ground cylindrical shaped traditional storage bin used to store maize cob. It is type of circular granary, made by interweaving locally available materials; mostly bamboo split by local artisans. It is an outdoor container made from split or whole bamboo poles or other tree sticks. The roof is thatched by dry grass/ hay or corrugated iron sheet. It is usually raised off the ground, and placed on stones or a wooden platform.

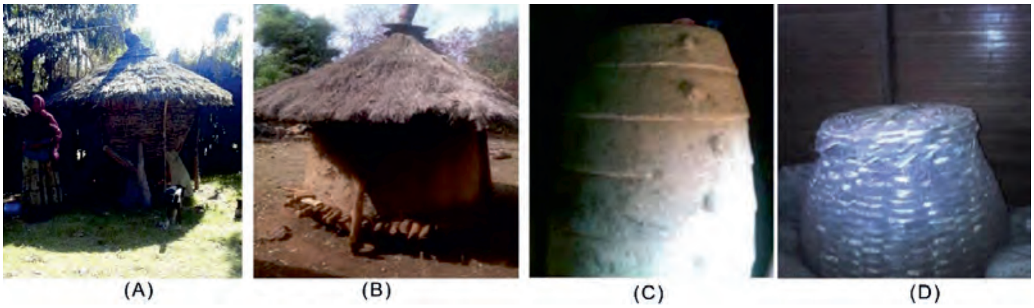


Figure 16.6. Grain storage structures: Gombissa plastered with mud (A) and un-plastered Gombissa (B) and Gumbi (C) and Kefo (Togogo or Kirchat) (D).

Use of Botanicals: These are chemicals produced by plants and that repel insects and deter feeding and oviposition on the plant. They also disrupt the behavior and physiology of insects in various ways. Botanicals include spices, medicinal weeds and other plants.

Wood Ash: Wood ash has been used for centuries as a botanical pesticide against maize storage insect pests.

Storing unshelled maize: Maize cobs that are completely covered by the husk are less infested than those whose tips are slightly exposed.
Mixing with sand and dust: Inert dusts are chemically unreactive and thus, used for protecting stored grains by physical means.

Mixing with small size grain: Many farmers in Ethiopia have reported mixing teff with maize grain for protection from insect attack in the storage. Teff admixture with maize provides effective protection of grain from insect pests in storage.

Figure 16.7. Traditional milk utensils (A= Okkole; B= Gorfa).

Activity 16.4.

individual work

1. Explain the role of indigenous knowledge in safe food production and
2. Mention types of indigenous knowledge applicable to safe food production and postharvest handling.

*Share your answers with other students.

Table 16.4. Examples of locally growing washing and smoking plants used as milk preservative.

Scientific name	Local name (Amharic)	Plant type	Parts used	Form used	Application techniques
Olea Africana	Woira	Tree	Stem	Dry and fresh	Smoking utensils
Catha edulis	Khat	Tree	Stem	Dry	Smoking utensils
Ocimum hardiensem	Kesie	Shrub	Leaf	Dry and fresh	Rinsing utensils
Thymus serrulatus	Tosign	Shrub	Leaf	Dry and fresh	Rinsing utensils
Ruta chalepensis	Tenadam	Herb	Leaf and stem	Fresh	Soaking in milk

Adapted from Zerihun *et al*. (2021).

Unit Summary

In this unit, you have learned that:

- there are four primary categories of food safety hazards: biological, chemical, physical, and allergenic.
- major contamination sources are water, air, dust, equipment, sewage, insects, rodents, and employees.
- food safety is about handling, storing and preparing food to prevent infection and help to make sure that our food keeps enough nutrients for us to have a healthy diet.
- the link between safe food, the nutritional quality of food and health of consumers. Unsafe food and water is food or water that is exposed to dirt and germs, or may even be rotten, which can cause infections to consumers.
- farmers use different traditional methods to protect their seeds from infestation with insects.
- bamboo split, wooden walls, mud, and thatched grass roofs are among the common forms of traditional storage structures
- farmers use botanicals and wood ash to protect their crops against damages, Storing unshelled maize, mixing crops with sand and dust, mixing large size grain with the small size ones, hanging grains on fire places, etc. are all traditional ways of protecting crop or animal products from different contaminants.

Review Exercise

Part I. Say True or False to the following questions.

1. Unsafe food and water means that it has been exposed to dirt and germs.
2. Farmers' traditional knowledge cannot be used as basis to develop integrated safe food production and postharvest handling.

Part II. Choose the letter corresponding to the appropriate answer

1. Which one of the following is considered as sources of contamination?
   A. Human and animals excreta
   B. Dirty pots and cooking utensils
   C. Polluted water
   D. Insects
   E. All of the above.
2. Which one of the following is not among primarily categories of food safety hazards?
   A. Physical hazards
   B. Allergy
   C. Biological hazards
   D. Chemical hazards
   E. None of the above
3. Which one of the following is true about the link between food safety and nutrition?
   A. Germs both cause diseases and destroy nutrients.
   B. Assuring and ensuring food safety during preparation is enough.
   C. Stale foods are not risky for animals
   D. Unnatural physical hazards can cause food more unsafe compared to the natural physical hazards.

Unit 17 Application of Information and Communication Technologies (ICT) in Agriculture

Contents	Learning Competencies
17.1. Roles of ICT in agriculture 17.2. Major application of ICT in agriculture 17.3. Drawbacks and solutions of ICT in agriculture	At the end of this unit, students will be able to: ▪ describe the roles of ICT in Agriculture. ▪ explain the major applications of ICT along the agriculture products value chain. ▪ discuss the drawbacks and solutions of ICT in agriculture. ▪ Value using ICT in agriculture activities. ▪ Use ICT in agricultural activities.

17.1. Roles of ICT in Agriculture

Agriculture is increasingly becoming knowledge-intensive and millions of smallholder farmers around the world are confronted by constraints such as poor access to markets and financial services, low levels of human and physical capital, poor access to education and weak information flows. Given the present market scarcity, low skills and weak capacity, agriculture across the developing world will have to overcome a number of challenges in the future.

ICT has provided a possible pathway to better access, efficiency, and affordability of agricultural information. The use of ICT can improve business and networking between farmers, buyers, and extension agents (Figure 17.2.). It also facilitate access to reliable markets. ICT has further made innovations that bring financial services, including mobile money, to smallholder farmers.

Figure 17.1. Smallholder farmers' use of mobile phones for agriculture.

Moreover, ICT facilitates electronic-agriculture and has advantages such as improving productivity and profitability, efficient management and utilization of resources, to get important and timely information about weather conditions, and improved agricultural technologies.

The information needs of farmers will only increase as farmers have to make more and more complex decisions on how to use their land, what crops/livestock products to produce, and how, and, where to buy inputs and sell their products. Their decisions, which also include choices on how to finance their business and reduce the risk they face, impact the livelihoods of their families and society.

ICT is needed to improve information flow and to connect people within the rural areas. The use of ICT has proved that the illiteracy of farming communities may no longer be an excuse to deny some form of extension system. Communication or the dissemination of information about agricultural extension and productions play a vital role in sustaining an effective agricultural extension service in the country.

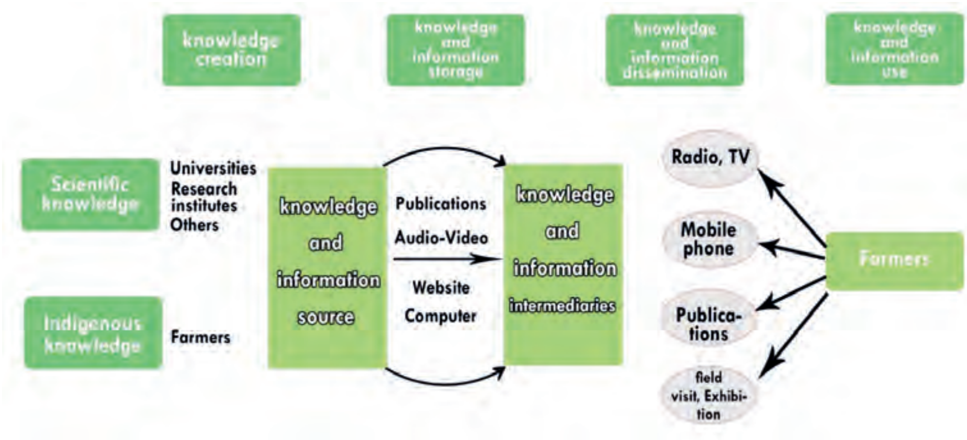


Figure 17.2. Creation, accumulation and dissemination of agricultural knowledge using various methods (Adopted from UNDP, 2012).

Effective knowledge management enables appropriate knowledge and information to reach smallholder farmers and other practitioners at the right time and in the right way. Knowledge is created through scientific research often carried out at universities, and research institutes while indigenous knowledge is available with farmers and local institutions. Knowledge that is created through scientific research is stored and disseminated to the public through written documents/publications and electronic media such as computer, website and audio-video. The wider audience can also accesses new knowledge through radios, televisions, publications, exhibitions, cell phones etc.

Activity 17.1.

Individually,

a. Explain the role of ICT that you observe locally in your area.

b. Compare the farmers with better access to market information and extension against those who do not have such a facility. Explain the benefits those who have the access have over those who don't.

17.2. Major application of ICT in agriculture

The application of ICT in agriculture is increasing in developing countries. Electronic-agriculture describes an emerging field focused on the enhancement of agricultural and rural development through improved information and communication processes. A World Bank (2009) report on ICT for development indicated that connectivity, whether through the internet or mobile phones, is increasingly bringing market information, financial services, and health services to remote areas, and is helping to change people's lives in unprecedented ways. ICT and mobile-enabled agricultural services act as instruments to deliver extension services and help to create awareness amongst farmers. In most developing countries, however, the extension system does not have a modern mechanism like ICT to acquire and deliver information to farmers. There are research efforts to check the challenges and opportunities of ICT application by engaging extension workers in rural areas (Figure 17.3).

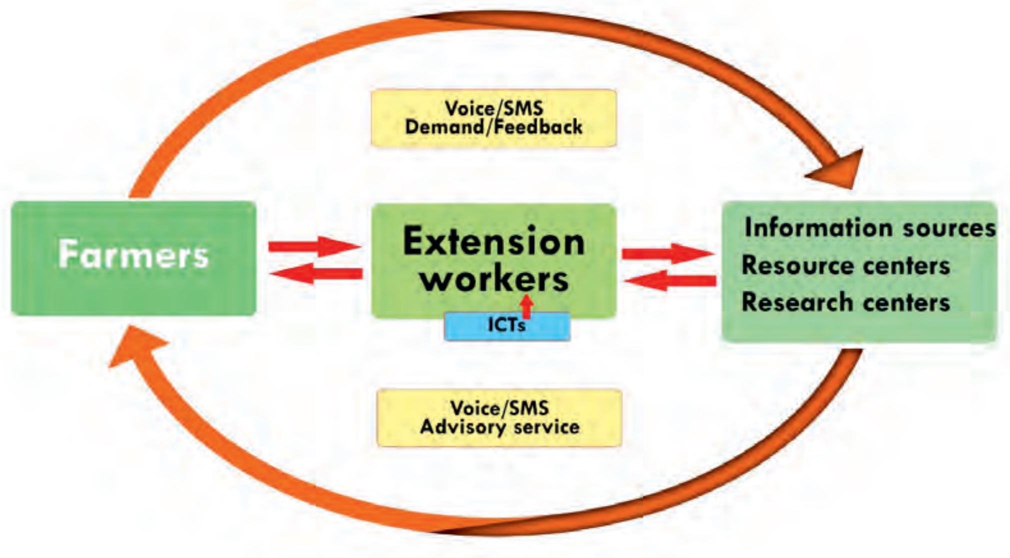


Figure 17.3. ICTs enabled agricultural advisory system or conceptual frame work (adapted from Fiseseha *et al*., 2017).

In Ethiopia, mobile telephone has quickly become the most common way of sending information and services. Particularly, in agricultural extension communication, mobile telephone provides the most affordable and swift way to access information including technologies, markets, weather forecasts, and early warning. This has happened because of the increasing expansion of mobile networks and cell phones in recent years in rural areas of Ethiopia. Mobile telecommunications in Ethiopia grew from a mere 1.2 million subscribers in 2007 to around 54.3 million subscribers in 2021. According to Ethio-telecom (2021), the total number of subscribers both in mobile pre-paid and post-paid systems have reached 56.2 million in 2021. However, mobile texting in agricultural extension is not regularly programmed and is formally linked with Ethio-Telecom service.

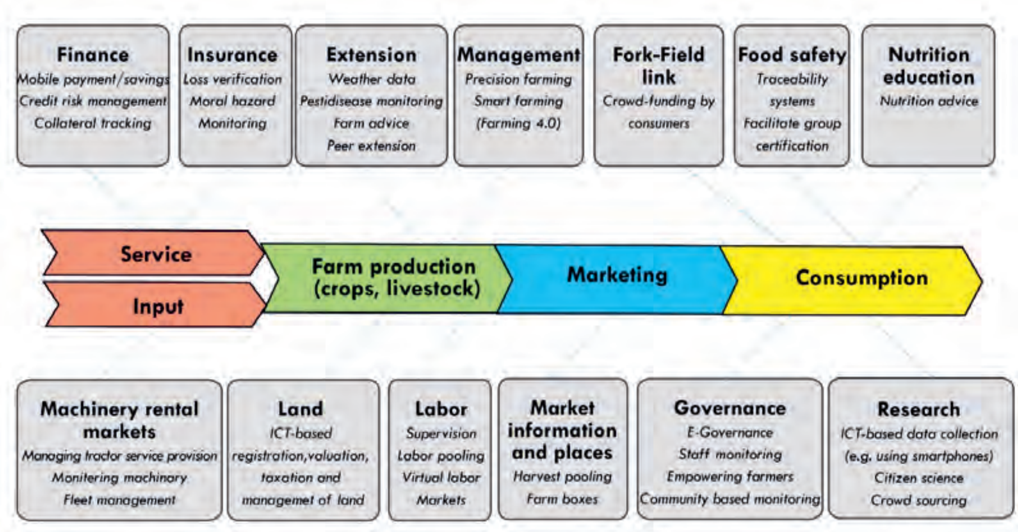


Figure 17.4. Examples of ICT applications along the agricultural value chain.

There are many applications and ICT enabled tools for data collection and dissemination purposes. Some examples of ICT applications and their descriptions in Africa are given in Table 17.1.

Table 17.1. Examples of ICT application and their description used in agriculture.

Application	Where	Description
Ethiopian Commodity Exchange (ECX)	Ethiopia	ECX was formed to overhaul the country's agriculture sector and create a dynamic, forward-looking, and efficient agricultural market system. Commodity exchanges are organized market venues where buyers and sellers of a commodity meet to trade it or its derivatives. They are designed to help mitigate counterparty risk and ensure that payments are made through reliable financial service providers. Exchanges provide a framework for market actors, financial institutions, and commodity operators to interact based on rules that provide legal protections. http://www.ecx.com.et/
iCow	Kenya	The iCow approach was developed in Kenya for small-holder dairy farmers and helps them manage their cows to have a greater profit. http://www.icow.co.ke
AgriNet Uganda Ltd	Uganda	The company works with real-time markets and links value chain players to marketing information, niche markets, market development and agribusiness development services including agricultural finance real time, customized agricultural market information on mobile phone, information boards and e-mails. http://www.agrinetug.net

Application	Where	Description
ESOKO	Africa	Smallholder farmers can sign up to Esoko to receive a package of weekly advisory services. This typically consists of current market prices, matching bids and offers, weather forecasts, news and tips. In some countries, advisories may also be sent by voice messages, and a live call centre of agricultural experts can be available to complement data alerts with voice support. http://www.esoko.com

Automation in agriculture is the main concern and an emerging subject across the world. The population is increasing tremendously and with this increase, the demand for food and employment is also increasing. The traditional methods which were used by the farmers were not sufficient to fulfill these requirements. Thus, new automated methods were introduced. These new methods satisfied the food requirements and also provided employment opportunities to billions of people. There are many technologies or tools that have brought an agriculture revolution like Artificial Intelligence (AI), Data Science, Electronic-Agriculture (E-Agriculture), remote sensing and Global Positioning System (GPS), etc.

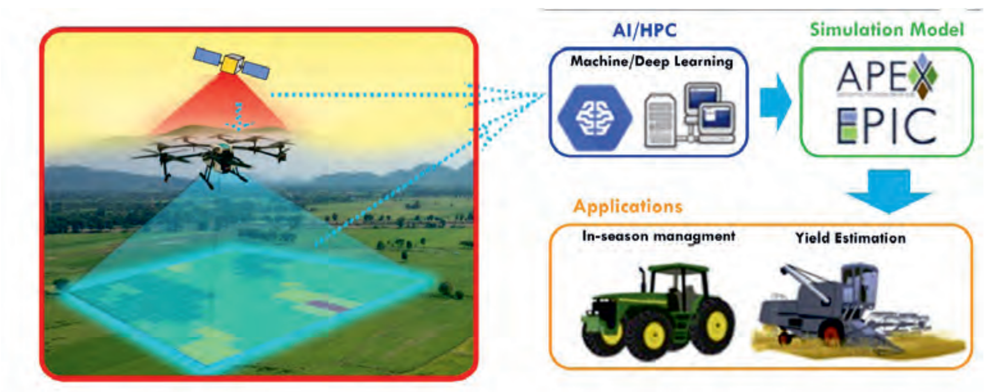


Figure 17.5. Advances in digital agriculture from the integration of remotely sensed data, advanced crop simulation models, and artificial intelligence (AI).

Activity 17.2.

Group work

a. Discuss in small groups the advantages of the application of ICTs to agriculture production.

b. Work in groups to indentify an emerging technology and suggest how it might be applied to agriculture in the future.

c. Also identify the main sources of agricultural information in Ethiopia that can be accessed through ICT tools. What information can be gained from these sources?

*Report the summary of your discussions to the class.

17.3. Challenges and Solutions of ICT in Agriculture

ICT improve agricultural economic growth, but there are challenges and opportunities regarding the application of ICT in agriculture in developing countries. With low markets availability, low skills, and weak capacity, agriculture across the developing world will face a number of challenges in the future. Challenges that prevent the maximum benefit of ICT innovations from being realized can be roughly grouped into three categories:

Technology

In some perspectives, technology is not considered an actual challenge, but a tool that evolves over time based on market forces and public policies. Technology is only a frustration when our demands exceed its ability to deliver services. With much focus on mobile technology, there are constant reminders that even in developed countries, the internet and/or cellular coverage is not present in many rural areas. In other instances, where innovations are available, the cost of these services remains a barrier. Despite the widely reported rapid growth of mobile network coverage in developing countries, concern remains that mobile network operators (MNOs) will not expand coverage into the most remote, low population areas.

Capacity

ICT may make tools and information available, but farmers must know they exist and be able to use tools. The capacity of individuals to use the ICT that are available is often overlooked, or taken for granted, leaving older people and women in some communities at a particular disadvantage. One solution suggested to address limited individual capacity is the use of intermediaries. Another solution is to include capacity development in all ICT services from the beginning.

Content

Content, in many instances, does not exist in forms usable with modern ICT. Ultimately, if ICT are to provide real decision tools, it will be necessary for an "ecosystem" of relevant information and data to exist. This sort of information is under development in some examples, but in many cases there is a lack of clarity regarding who should be responsible for the creation or mobilization, quality assurance and dissemination. Information should be developed according to needs of the end users (i.e. farmers), and provided in local languages, in simple, interactive form. Information must be up-to-date, relevant and supplied in a timely manner.

Activity 17.3.

In a-group, discuss the challenges that prevent farmers from getting the maximum benefit of ICT in agricultural in your locality. Present the summary of your discussion to the class.

Visit a nearby farm or agricultural market and ask the farmers about the types of ICT used in their agriculture. Report your finding to the class.

Unit Summary

In this unit, you have learned that:

- agriculture is increasingly becoming knowledge-intensive.
- ICT has provided a possible pathway to better access, efficiency, and affordability of agricultural information.
- effective knowledge management enables appropriate knowledge and information to reach smallholder farmers and other practitioners at the right time and in the right way.
- the use of ICT can improve business and networking between farmers, buyers, and extension agents. It also facilitate access to hidden markets.
- in Ethiopia, the application of mobile telephone has quickly become the most common way of sending information and services.
- many applications and ICT have enabled data collection and dissemination purposes like ECX, iCow, ESOKO, etc
- there are also many technologies or tools that have brought an agriculture revolution like Artificial Intelligence (AI), Data Science, Electronic-Agriculture (E-Agriculture), remote sensing and GPS etc., and
- challenges that prevent the maximum benefit of ICT innovations from being realized can be roughly grouped into three categories: technology, capacity and content

Review Exercise

Part I. Say True or False to each of the following questions.

1. In agricultural extension communication, mobile telephone provides the most affordable and swift way to access information.
2. ICTs can be used to create, accumulate and disseminate agricultural knowledge.
3. The automation in agriculture is the emerging subject across the globe.

Part II. Choose the letter corresponding to the appropriate answer.

1. Which one of these is not among the roles of ICT in agriculture?
   A. Facilitate access to information
   B. Helps in integrating information
   C. Assess information about market
   D. Making decisions using the information gained
   E. Disregarding cultural information dissemination
2. Which one of the following is not among the challenges that prevent the maximum benefit of ICT innovations in developing countries?
   A. Technology B. Capacity
   C. Content D. None of the above
3. Which one of the following is not among the ICT technologies or tools used in agriculture?
   A. Artificial intelligence B. Remote sensing and GPS
   C. Electronic agriculture D. None