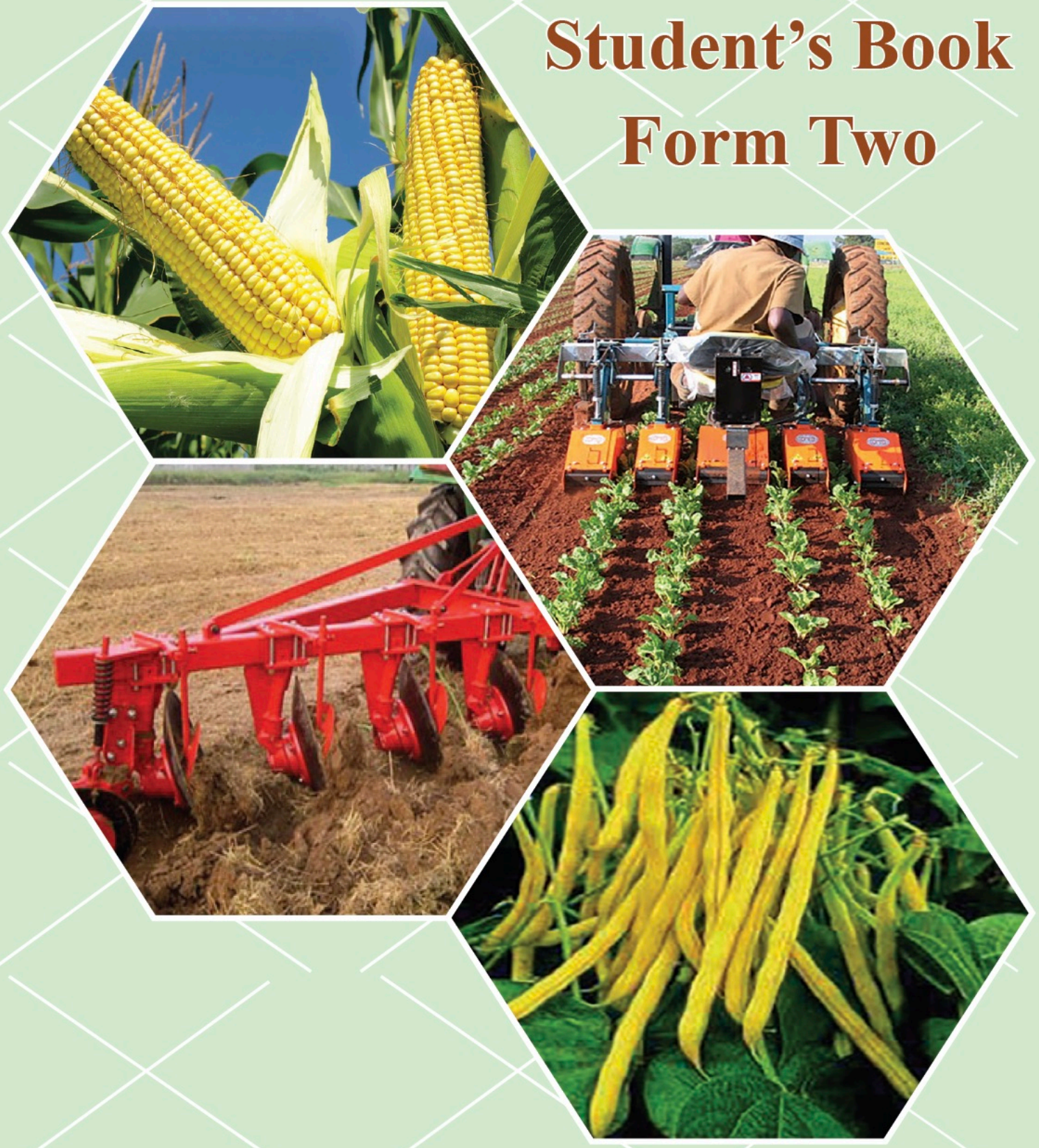
Agriculture

for Secondary Schools



Student's Book
Form Two

Tanzania Institute of Education

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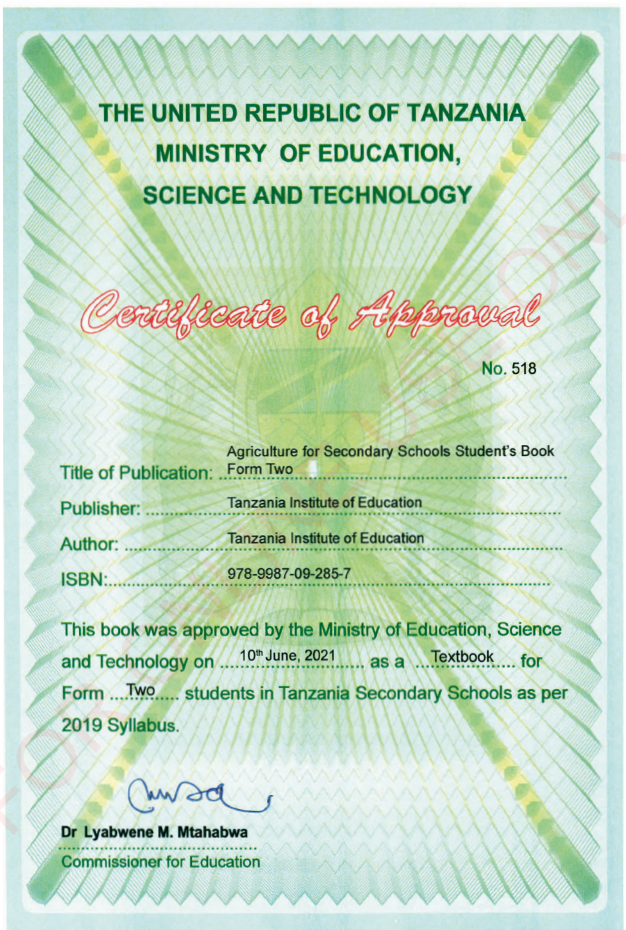

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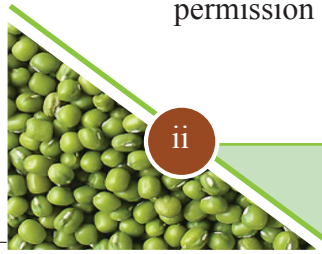

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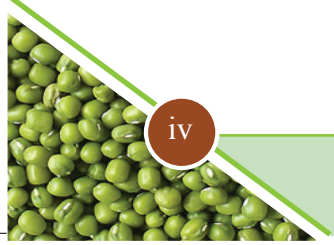

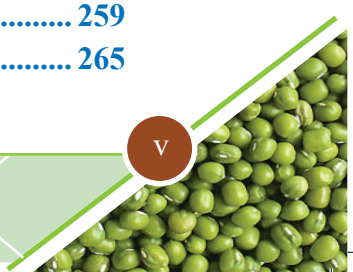

Abbreviations and Acronyms

AgriSETA	Agricultural Sector Education Training Authority
BATC	Borigaram Agriculture Technical College
CABI	Centre for Agriculture and Bio-science International
DCS-DAFF	Directorate Communication Services, Department of Agriculture, Forestry and Fisheries
FAO	Food and Agricultural Organisation of the United Nations
GTZ	German Agency for Technical Cooperation
IAEA	International Atomic Energy Agency
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
JICA	Japan International Cooperation Agency
KALRO	Kenya Agricultural and Livestock Research Organisation
MATI	Ministry of Agriculture Training Institutes
MLF	Ministry of Livestock and Fisheries
MoAFSC	Ministry of Agriculture, Food Security and Cooperatives
MUM	Muslim University of Morogoro
NCERT	National Council of Educational Research and Training.
NECTA	National Examinations Council of Tanzania
PMO	Prime Minister's Office
PSEMG	Pennsylvania State Extension Master Gardeners
SARE	Sustainable Agriculture Research and Education
SHEP PLUS	Smallholder Horticulture Empowerment and Promotion Project for Local and Up-Scaling
SNV	Netherlands Development Organization
SQA	School Quality Assurance
SUA	Sokoine University of Agriculture
TARI	Tanzania Agricultural Research Institutes
TGIPMP	Tanzania - German Integrated Pest Management Project
TIE	Tanzania Institute of Education
TZS	Tanzanian Shilling
UDSM	University of Dar es Salaam
UNESCO	United Nations Educational, Scientific and Cultural Organisation
URT	United Republic of Tanzania
WyK	Wizara ya Kilimo
WyKC	Wizara ya Kilimo na Chakula
WyKMU	Wizara ya Kilimo, Mifugo na Uvuvi

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Preface

This book, *Agriculture for Secondary Schools,* is written specifically for Form Two students in the United Republic of Tanzania. The book is prepared according to the 2019 Agriculture Syllabus for Secondary Schools, Form I-IV issued by the Ministry of Education, Science and Technology. The book is divided into 17 chapters; namely factors of production, farm management, decision-making in farm management, risks and uncertainties, and records in farming business. Others include planning for crop production, land preparation for crop production, planting of crops, maintenance of soil fertility for crop production, maintenance of soil water for crop production, pests and their control in crop production, weeds and their control in crop production, diseases and their control in crop production, special agronomic practices, harvesting and post-harvest practices, production of cereal crops as well as production of pulse crops. In addition to the contents, each chapter comprises of illustrations, activities and exercises. Learners are encouraged to do all activities and attempt all the given questions. This will enhance their understanding and development of the intended competencies for this level.

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Chapter One

Factors of production

Introduction

Resources play a vital role in any production. In this chapter, you will learn the concept of factors of production. You will also learn the major factors of production; land, labour, capital and entrepreneurship. Furthermore, you will learn the concept of scarcity in relation to prices and choice of needs and wants. The competencies developed from this chapter will enable you to make the right decisions about those resources when planning and carrying out production of a given output.

The concept of factors of production

When a producer wants to produce any output in form of good or service, he/she has to use important resources or inputs. These resources are collectively termed as the factors of production. A factor of production is an economic term that describes the resources that are directly used in the production of goods or services in order to make an economic profit. A resource is considered as a factor of production if it is productive. Thus, factors of production are very important because they contribute directly towards the quantity and quality of the output. Quantity and quality of the output is determined by the productivity of factors of production. Productivity of factors of production is the degree to which production resources are being used efficiently to produce goods and services. Moreover, factors of production are rewarded for their contribution to the production of output. Land, labour, capital and entrepreneurship are the basic factors or resources required for production of any good or service.

Land

Land as a factor of production refers to soil, minerals, water, and all other natural resources found on it. These resources include all natural living and non-living resources which are used by a farmer in production. Land resources are natural; they are not man-made. The reward of land for its contribution to the production

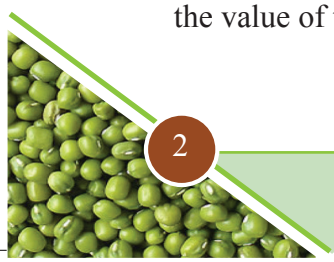
process is rent. In Tanzania, land is a government property, hence, farmers can acquire land through leasing from government where they pay a specified amount of money as rent for a given period of time. However, for native farmers at the local level, different sets of traditional or customary land laws pertain.

Land is important in that it provides raw materials for industries, for example, minerals. It also provides surface or space for setting up sites for farm structures, processing plants and manufacturing industries. Furthermore, in agricultural production, land is the main factor of production as most of crops are produced on land. Moreover, almost all sources of farm power, for example; electric, diesel, coal and oil are extracted from land.

In order for the land to provide benefits to producers, the producer has to discover its potential and thereafter find out how to use it in the production of good(s) or service(s). Some resources found in land such as soil are renewable while others such as minerals and forests are non-renewable. Furthermore, land and all its resources are generally limited in nature. Thus, for sustainable production, land and all its resources need constant maintenance of their value.

Methods of increasing land value

In agriculture, the value of land is its worthiness for agricultural production or farming enterprise. The value of land for farming enterprise depends largely on its productivity. Land productivity refers to the ability of land to sustain crop and livestock production. Generally, the higher the ability of land to sustain high crop and livestock production, the higher the value the land has. Land productivity is influenced by soil fertility and climatic condition, particularly temperature as well as amount and distribution of rainfall in that particular area. For example, a farmer can grow maize in a certain piece of land and harvest a certain amount as output, and grow sorghum in the same piece of land and harvest three times that of maize. Their differences in production is influenced by differences in adaptation to fertility and climatic conditions. The value of land for farming enterprise also depends on physical location and size of land. A land located in the area with high potential for farming business has high value compared to the same land located in low potential area. Since the supply of land is limited, in order to maximise production in a given land, farmers need to constantly increase the value of their land.



The value of land can be increased through the following methods:

(a) Irrigation of an arid land
(b) Application of manures or fertilisers to infertile soils
(c) Drainage of swamps
(d) Construction of terraces or contour strips on the lands with steep slopes
(e) Planting trees in lands where there is strong winds
(f) Land reclamation

Activity 1.1

Pay a visit to school and a nearby school's farm that is considered to be of low value and do the following:

(a) Suggest sustainable methods to increase its value.
(b) Outline the lessons you have learnt from this activity.
(c) Write a report and present it in class.

Labour

Labour refers to all human efforts; physical or mental, skilled or unskilled, used in the production process. Labour as a factor of production involves human beings. Labour is a work that is undertaken for some monetary reward. The reward for the use of labour is wage or salary. Therefore, labour, as a factor of production, does not include any work done for leisure or which does not carry any monetary reward. For example, a person looking after livestock or attending his/her garden for leisure, would not be considered to have done any labour in the sense of economics. If a person looks after the livestock or a gardener looks after a garden in payment of money for, his/her service is regarded as labour. Sometimes labour is known as human capital. Labour in combination with other factors of production is utilised to produce output in the form of goods and/or services. Labour is the most difficult factor among factors of production to deal with because it involves human beings.

In farming enterprises, there are two types of labour; skilled and unskilled labour. Skilled labour includes experts like farm managers, extension workers, horticulturists, agronomists, livestock scientists and other similar workers. Skilled labour is required for specialised tasks, although it is usually limited and relatively expensive to employ, compared to unskilled labour. Unskilled labour involves a

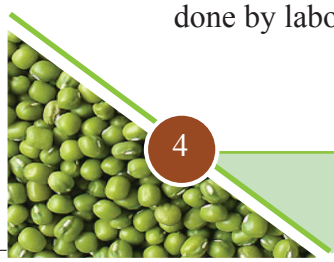
workforce performing general services such as farm attendants, gardeners and messengers. It is important to note that in Tanzania, people under the age of 18 years are considered as children. According to labour rules and regulations, they are not allowed to be employed as permanent or casual labourers. However, they are required to perform normal family chores which are safe and appropriate to their age.

Labour in production process can either be permanent or casual. Permanent labour is employed throughout the year regardless of the activities performed in production process. Permanent labour has to be paid regardless of whether it produces or not. Therefore, to maintain this labour, there is a need to make sure that the enterprise is generating revenue throughout the year. Casual labour is employed on temporary basis, usually at labour peak periods. For example, during planting, weeding or harvesting where farming activities are not fully mechanised. Sometimes family labour is used in family-owned farming enterprises to generate family income.

The capacity of labour as a factor of production is considered on the basis of output of an individual and not on the number of people employed. It considers how much work is performed rather than mere number of labour force in the production unit. This is referred to as labour productivity. Labour productivity depends on skills, training and motivation. Generally, the higher the quality of labour, the more the productive the labour force. Therefore, the capacity of labour to produce can be improved through training labour force, giving incentives, assigning labourers specific tasks and simplifying some works by using machines and technological means.

The importance of labour in production process

Labour as a factor of production enables utilisation of other factors of production, particularly land and capital goods. For example, land needs to be cultivated, seeds or vegetative planting materials need to be planted, and a tractor needs to be operated in order to perform several activities in the farm. Likewise, livestock, in livestock farming enterprises, need to be attended. They need to be fed, provided with water and their houses need to be cleaned. Moreover, their yields need to be harvested, processed and marketed by various means. These activities have to be done by labour. Thus, labour is essential for production.



Capital

Capital refers to all man-made assets or goods that help land and labour to produce, for example, machinery, buildings and roads. Permanent improvements on land (for instance, fences, terraces and irrigation structures) are also included in capital. Money is not capital unless it is intended to be used to acquire real capital assets. Capital is classified into three categories which are fixed capital, operating or working capital and liquid capital. Fixed capital includes producer goods that are not completely used in the production process. These goods are, however, subject to depreciation and in time to be replaced due to wear and tear as well as age. Examples of fixed capital include buildings, machinery, irrigation structures, perennial crops and livestock that produce various products. Operating or working capital includes raw materials for production, normally completely used in the production process. They include materials such as fuel, livestock feeds, veterinary drugs, pesticides, and fertilisers. Liquid capital is money that is meant for acquisition of any form of real capital assets or goods that can be used in the production process.

In farming business, capital investment is very important. Capital investment refers to money spent on capital assets such as equipment, stock or improvement which adds to the productivity of the farm. Capital for investing in production can be acquired in various ways including setting aside part of income as self-savings over a period of time, borrowing from credit facilities in the form of cash or inputs, and acquiring grants or donations from sponsors or well-wishers including relatives and friends. The reward of liquid capital for its contribution to the production process is known as interest.

The importance of capital in production process

Capital is an important factor of production because it assists other factors of production such as land, labour and entrepreneurship in the production process. For example, a gardener without any garden tools, seeds and manures or fertilisers cannot produce crops from his/her garden. Therefore, the importance of capital in the production process entails the following:

(a) It allows an entrepreneur to secure land by paying rental charges.
(b) It enables a farmer to hire or employ labour to increase output.
(c) The use of capital saves labour time and increases its output greatly. For example, an activity that will take ten man-days for about one month to accomplish can be done by a tractor in one day.

(d) It enables an entrepreneur to improve land productivity through improved land management.

Generally, when other factors of production are kept constant, the increase in capital can result into higher quantity and quality of output. Hence, for any enterprise to grow, gradual and continuous flow of capital is frequently required.

Activity 1.2

In your nearby school or homestead, study the labour power employed and capital assets/goods used in crop and livestock farming enterprises then

(a) identify the types of labour employed in each kind of farming enterprise.
(b) outline the strengths of each type of labour employed.
(c) list the constraints of each type of labour.
(d) show how those constraints can be solved.
(e) identify capital assets/goods which are being used in each enterprise.
(f) discuss why the capital assets/goods are productive.
(g) show if there are capital constraints experienced by those enterprises and how they can be alleviated.
(h) outline the lessons learned from this activity.
(i) prepare a report and present it in class.

Entrepreneurship

Entrepreneurship is mainly based on decision making and bearing risks in production process so as to attain the desired goals. It is sometimes regarded as management or organisation of production process. Land, labour and capital are of little importance in farming unless they are organised and managed well for production. The person who is responsible for this is known as entrepreneur. In farming, an entrepreneur is actually the farmer or farm manager. The entrepreneur normally risks his/her capital in establishing a business whose profitability cannot really be determined at that time. Therefore, the reward of entrepreneurship for its contribution to the production process is profit. However, loss may sometimes occur unpredictably.

The functions of entrepreneurship in production process

The following are the basic functions of entrepreneurship in production process:

(a) Searching for skills and knowledge relevant to the farming enterprise

The skills and knowledge required for carrying out farming enterprises can be obtained from agricultural extension services, agricultural research stations, television and radio programmes, books, newspapers and magazines, social media broadcasts and electronic-based farming resources. The skills and knowledge would be necessary on the technical aspects of raising crops and livestock, market price trends, demand and supply trends, pests and disease control, new crop varieties, and new livestock breeds. These skills and knowledge are important for planning and carrying out farming enterprises profitably. In general, an entrepreneur has to constantly develop readiness for learning.

(b) Making production plans

This involves plans and decisions for an output to produce large quantities of each factor of production needed. Essentially, these plans involve determining what to produce, how much to produce, how to produce as well as how to sustain resources and market.

(c) Implementing farming enterprise management decisions

This involves translation of decisions made on the farm into action. For example, if the plan calls for producing a specified amount of broiler meat, the entrepreneur or farm manager ensures that all the necessities for land, labour and capital resources for broiler meat production are secured. That is, to hire or buy land, labour and capital from their owners by paying rent, wages and interest. Then, they are managed in such a way that they will attain the desired goals. This also involves comparing the standard of one's enterprises with the set standards.

(d) Keeping records

Clear and concise up-to-date records are necessary for smooth production in farming enterprises. These will help the entrepreneur to control his/her cash flow and production processes. It will also help the entrepreneur to know how his/her enterprise is performing. Record keeping will also enable entrepreneurs to show others how his/her enterprise is performing. This will further enable the entrepreneur to plan for future.

(e) Innovating or developing new processes to produce valuable goods or services

This involves ability of an entrepreneur to search for current community or

market needs, compare his/her enterprise with neighbouring ones and come up with innovations. Such innovations will enable the entrepreneur's goods or services to satisfy the community or market needs and probably excel his/her neighbouring enterprises.

(f) Bearing all risks that may occur in production

Such risks include pest and disease outbreaks, competition from new products, loss or damage of goods, and fire outbreaks.

Note: Being an entrepreneur is not just a matter of owning a business but it involves performing all these functions.

Activity 1.3

Perform the following tasks.

1. Think of the reasons for initiating and owning any type of farm enterprise.
2. Consider the goods and/or services you would produce or sell in your farm enterprise.
3. Mention other farm enterprises similar to yours that you know.
4. Establish the mechanisms you would use to distinguish your enterprise from other similar enterprises.
5. Establish the means you would use to let potential buyers know about your enterprise.
6. Outline the means that can make your enterprise successful.
7. Identify all possible challenges which might face your enterprise and how to overcome each of them.

The concept of scarcity in relation to price and choice

People have unlimited economic needs and wants. The economic needs and wants are desires that can be satisfied with commodities in form of goods or services. The commodities are produced by using resources or factors of production. The resources or factors of production are usually in a limited supply, hence it creates scarcity. Scarcity means there is no enough of it and it is difficult to obtain it. In general, scarcity of resources or factors of production leads to an increase in demand. This results in an increase in the price of commodities. Scarcity is important as

it influences supply and demand of commodities. It affects competition in any price-based market. It also raises or lowers the price.

Due to limited resources and resultant scarcity, people cannot have everything they want, therefore they have to make choices. Making choice is to decide which resources should be utilised to best satisfy the people's needs and wants. Thus, for an entrepreneur, it is important to learn to make good economic choices or decisions, depending on the preferences of both consumers and producers. These choices will depend on value and profit. For example, if a hectare of sweet potato gives a revenue of 3 000 000 TZS, and a hectare of sorghum gives a revenue of 2 200 000 TZS, then the farmer will choose to grow sweet potatoes and not sorghum. This is because sweet potatoes have more value than sorghum.

Note: Choice only exists where there is an alternative. Also, choice does not exist when the item is plentiful or when there is no other alternative.

Activity 1.4

Perform the following tasks in groups.

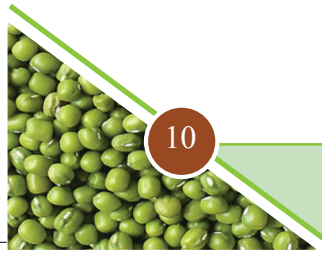
1. Think of scarcity scenarios of land, labour, capital and entrepreneurship resources of production.
2. List the scenarios and for each scenario show the choice(s) that can wisely be made as an alternative solution.
3. Prepare a report and present it in class.
4. Outline the lessons learned from this activity.
5. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What is the term used to denote the factor of production that includes any form of human effort used in production?
2. Name the term that best describes the fundamental economic problem, that is, resources are limited, but economic needs and wants are unlimited.

3. What factor of production is a tractor?
4. What is the term used to indicate the degree to which resources are being used efficiently to produce goods and services?
5. What is the term used to represent a gift of nature that makes production possible?
6. What is the term used to indicate an individual that brings together other economic resources necessary for production?
7. Name the term used to represent the reward of entrepreneurship for its contribution to the production process.
8. Name four factors of production in farming activities.
9. State at least six functions of the entrepreneur in a farming enterprise.
10. Identify at least two conditions under which economic choice exists.
11. State at least five ways in which a farmer can increase land value in the farming enterprise.
12. Show the relationship between scarcity and prices of goods and services.
13. (a) How can entrepreneurs improve labour productivity in their farming enterprises?
    (b) Identify labour peak periods in farming enterprises.
14. (a) What is capital?
    (b) Name three types of capital in farming enterprise and explain the importance of each.
    (c) Identify at least three sources of capital for an entrepreneur who intends to start a farming enterprise.



Chapter Two

Farm management

Introduction

In chapter one, you learnt about factors of production. In this chapter, you will learn about the meaning of farm management and agricultural farm, scope of farm management, principles of farm management and basic functions of farm management. The competencies developed from this chapter will enable you to apply good managerial skills in carrying out farming enterprises hence maximise profits.

The concepts of farm management and agricultural farm

Farm management is a collective term for various management strategies and methods that are employed to keep an agricultural farm productive and profitable. An agricultural farm is a portion of land on which a particular farmer or entrepreneur carries out agricultural activities for the purpose of getting profit. In farm management, the agricultural farm is considered as a production unit with various enterprises. It is also considered in terms of its function as a source of income and profit to a farmer as an entrepreneur. The agricultural activities on the farm may include growing of crops and raising livestock or both. In terms of farm management, each activity, be it growing of crops or raising livestock, is referred to as an enterprise. Therefore, a farm often consists of more than one enterprises; however, there may be one main enterprise.

Each enterprise on a farm is based on an input-output relationship. Inputs are items required for the production process. These include land, labour, entrepreneurship and capital goods such as implements, seeds, pesticides and fertilisers. Output are goods that are produced such as harvested crops and livestock products that are produced. Paddy, maize, beans, cassava, potatoes, timber and vegetables from crops and milk, meat, honey and eggs from livestock are all farm products. In many cases, the enterprises of a single farm are interlinked. This means that some of the outputs of one enterprise are used as input for the other. For example, maize and rice bran as well as oil seed cakes from cereal and oil seed crops, respectively,

may be used as feeds for livestock. Likewise, manure from livestock can be used in crop production.

Farm management involves combining the factors of production and distributing them wisely to maximise and have continuous profit out of minimum cost. Therefore, farm management is the effective and efficient organisation of the input-output relationship with the aim of maximising profits from farming. It is also worth to note that even though strategies and methods of farm management are often associated with large commercial farms, many of them can be applied on small family-owned farms and result in similar success.

The scope of farm management

Farm management is very broad as it covers almost everything in agricultural economics. The main concern of farm management is the farm as a unit. It treats every farm as a separate unit because of differences in the availability of resources, challenges and potentialities. It deals with allocation of resources at the level of an individual farm or enterprise as an independent administered business unit, however, its objective is to maximise returns from the farm as a whole. It is interested in the profitability along with practicability and sustainability. Under this context, farm management gives solutions to questions such as what crops and/or livestock enterprises to raise? What amount of resources to be applied? and how farm activities are to be performed?

The basic principles of farm management

The basic principles of farm management represent the fundamental rules on which farm management practices are built. They provide a foundation for effective farm practices. These principles are general in coverage and applicable to diverse sizes and composition of farm enterprises. They are primarily related to the purpose of an enterprise. This involves provision of goods and services which are needed by customers as well as employing the most economical and convenient enterprising methods. There are four basic principles of farm management; planning and control, organisation, coordination, and motivation.

(a) Planning and control

Planning and control provides the administrative aspect of the management. Planning and control involves four essential steps. First, setting of goals and

objectives of a farm. Second, laying down responsibilities for specific sections of a farm. Third, determining or setting appropriate performance standards which is done through systematic analysis and assessment of the relevant facts. Fourth, ensuring effectiveness, that is, making sure that what was intended is achieved. This is achieved by continuously comparing the achievements with the set goals and objectives. Therefore, to make the routine planning and control effective; work specialisation, simplification and standardisation are of great importance.

(b) Organisation

This involves dividing of a given farm enterprise into relevant sections and assigning responsibilities and inter-relations between them. A farm business with several enterprises requires sub-division into appropriate sections. The sections are of specialised and related functions. As the farm grows larger, the individual supervisor may become overloaded. This can cause the need to delegate part of the responsibilities to lower level supervisors.

In a farm, arrangements must be made to ensure effective organisation. There must be clear lines of responsibility linking the farm manager with various decision making or execution centres. Moreover, each supervisor must be responsible for a limited number of assistants in inter-related activities. Farm sections such as production and marketing must be integrated so as to avoid weakening the clear lines of responsibility and command. Delegation of responsibility does not exclude the superior supervisor from being accountable for any shortcoming. There is no good farmer or farm manager who will relax after delegating authority. Therefore, occasional checks are carried out to pick up laziness or deviation from instructions.

(c) Coordination

There must be specific responsibility for careful continuous coordination with the laid down procedures. While linking up various aspects of the enterprise, a farmer or farm manager must promote personal and social satisfaction of all workers within the farm. Group satisfaction must be sought over and above individual satisfaction. Since each individual has varying external influences, it might be very difficult to attain this group satisfaction while completely satisfying each individual. As such, coordination is the process of integrating objectives and activities of separate units so as to reach a common goal. It involves organising people or groups so that they properly work together.

Regular contact and exchange of ideas ensure harmonious relationship among respective individuals. There must be a unified command and nobody sees himself/herself inferior before the supervisor. A set of instructions should initially be developed through consultation with various levels of operators. It is very important to allow farm workers to understand why instructions are given. A clear understanding of the impact of each person's action or failure to act will gear him/her up towards his/her responsibility. These instructions must follow clear lines of command, responsibility and structural setting in the farm.

(d) Motivation

This involves increasing morale and commitment of farm workers through various means. For example, the farm manager or an entrepreneur must give workers opportunity to contribute more than mere performance of their allocated routine duties. There must be security of the job and confidence that one is not simply being exploited. Generally, the morale is kept high in farm workers by:

(i) Keeping all informed about the activities
(ii) Keeping all informed about the successes and drawbacks
(iii) Consulting them before new rules are put forward
(iv) Fostering the sense of responsibility
(v) Allowing them to develop their own capabilities within the overall goals of the farm
(vi) Giving them reward

There must be fairness in dealing with workers. Discipline must be maintained and observed by assistants. When there is a sense of responsibility, there will be no need to force people to action. The personality of the farmer or farm manager to a great extent determines the level of morale and discipline in the farm. Furthermore, the continuous participatory review of rules helps to keep farm workers in harmony and updated. This motivates them to work properly.

Basic functions of farm management

Basically, management is a decision-making process which coordinates the factors of production to produce a desired output. The basic functions of management include planning, organising, directing, controlling and staffing. These functions are explained herein.

(a) Planning

This is the establishment of farm goals and strategies for achievement. The plans made may be concerned with short-term, medium-term or long-term goals of the farm. Good planning involves setting up a goal as well as formulating workable strategy for its attainment.

(b) Organising

This is an operational function which depends greatly on the coordinated efforts of an entire farm. It involves making arrangements of activities in all enterprises of the farm in order to ensure proper management of human and non-human resources.

(c) Directing

This involves guiding, instructing, counseling and leading people to achieve the desired goals through motivation. It seeks to obtain a high level of production from labour through motivation and proper guidance by maintaining a high level of cooperation.

(d) Controlling

This deals with the supervision of the achievement of goals. It also compares actual results with those expected in the plans and the actual performances in past periods. The results are directly estimated and related to the plans and performance standards established by other managerial functions.

(e) Staffing

This is a management function devoted to acquiring, training, compensating and appraising employees. It involves analysis of farm tasks or jobs, recruitment and hiring of labour with the necessary skills for appropriate tasks or jobs. It also involves providing or facilitating ongoing training so as to update skills.

Activity

1. Using your experience, identify at least three small to medium-scale farms that are typical of the farms you know in your area.
2. Describe each farm in terms of the following:
   (a) Size of the main enterprise in terms of hectares or number of livestock.

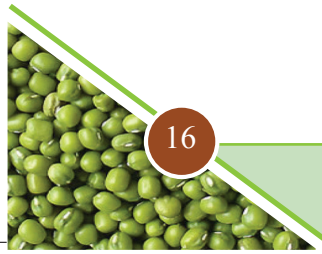
(b) Size of other enterprises of each farm, if any.
(c) Inter-relationship of the enterprises in each farm.
(d) Purpose of farming enterprise in each farm (whether food, cash or both).
(e) Major inputs used and outputs.
(f) Practices of the general management functions.

3. Share your results in class.
4. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What do you understand by an agricultural farm and farm management?
2. Describe the scope of farm management.
3. What are the objectives of farm management?
4. Planning and control, organisation, coordination, and motivation are the basic principles of farm management. Describe the major features underlying each principle.
5. (a) List four basic functions of farm management.
   (b) By using relevant example(s), explain each function listed in 5 (a).



Chapter Three

Decision-making in farm management

Introduction

Farmers have to make decisions about running their farms. In this chapter, you will learn about the meaning of decision-making, basic steps in decision-making, types of farm management decisions and selection of appropriate farm enterprise. The competencies developed from this chapter will enable you to carry out farming profitably.

Meaning of decision making

Decision-making in farming business is one of the most important activities that a farmer or farm manager has to do. Decision-making is a mental process of selecting a course of action from a set of alternatives. It is important that a farmer should follow a gradual and sequential process in making decisions. A wrong decision at a particular stage in production process can lead to total failure of the farm business. Thus, to a large extent, the success of any farming business will depend on the right decision the farmer or farm manager makes.

Basic steps in the decision-making process

There are seven essential steps that must be followed when making decision in farm management. These are as follows:

(a) Identifying the problem

A problem is identified as soon as the farmer notes some deviations from normal conditions or past experience. Once the farmer notices any strange happenings or unusual occurrence, then the problem is already identified.

(b) Defining the problem

Definition of problem involves locating the root cause of the problem identified. This requires establishing what is responsible for the problem identified.

(c) Suggesting solutions

After establishing the cause of the problem, you can now suggest some possible solutions to it. You need to have enough information about the problem. Some information is within farmer's experience, so the farmer can seek them through the process of self-assessment. Other information are beyond farmer's experience, so the farmer can find them from extension workers, experienced farmers, or other people; also using books, online sources and other sources.

(d) Analysing the suggested solutions

Analysis of the suggested solutions involves getting the implications of each possible solution. This involves getting the cost of each solution, the resources required; both human and materials, and workability of the solutions.

(e) Selecting the best solution

The farmer can choose the best alternative solution based on cost, resources available and workability of the solution.

(f) Implementing decision

The next step after choosing the best alternative solution is to put the chosen solution into action.

(g) Evaluating the implemented decision

This step involves comparing the result or performance of your farming enterprise before the implementation of the decision and after its implementation.

Types of farm management decisions

There are basic decisions which a farmer has to make in running his/her farm profitably. These decisions are based on the following questions:

(a) What to produce?
(b) How to produce?
(c) How much to produce?
(d) How to sustain resources and markets?

Decisions on what to produce

Farming involves a combination of factors of production to produce agricultural products. In deciding what to produce, a farmer has either to choose specialisation

or diversification. By choosing specialisation, the farmer will produce only one type of product. This allows the farmer to lower the costs per unit of output. It also allows the farmer to become more efficient in producing what he/she decides to produce. On contrary, by choosing diversification, the farmer will produce several different products at the same time. This helps the farmer to reduce risks and uncertainties. It also allows the farmer to use different parts of his/her farm according to its nature. Furthermore, it allows the farmer to exploit complementary and supplementary relations of different products.

When several products are produced on a farm at the same time, the products take on different product-product relationships which are joint, complementary, supplementary or competitive. Products are said to be jointly produced if they are naturally related in such a way that if a given quantity of product is produced, the quantity of the other is fixed in nature (refer to Figure 3.1 (a)). A good example of joint products can be oil seeds and seed cakes or beef and hides. Complementary relationship exists if an increase in the production of one product causes an increase in the production of the other (refer to Figure 3.1 (b)). Two products are said to have supplementary relationship if the production of one can be increased without increasing or decreasing the production of the other (refer to Figure 3.1 (c)). Similarly, the products are said to be competitive if the production or output of one of them can be increased only by decreasing the production or output of the other (refer to Figure 3.1 (d)). Therefore, depending on the farmer's objectives and limited nature of production resources, the farmer has to consider the relationship among products in deciding what to produce.

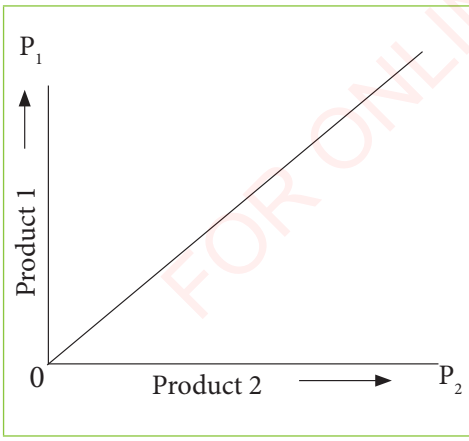


Figure 3.1(a): Joint products

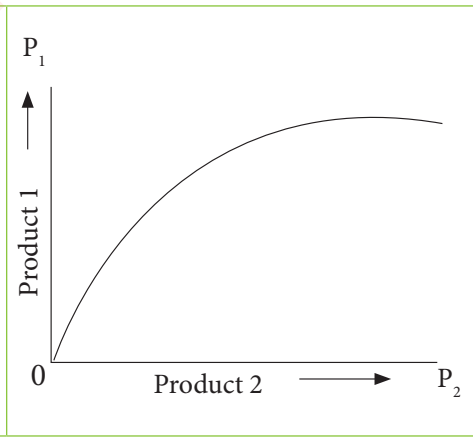


Figure 3.1(b): Complementary products

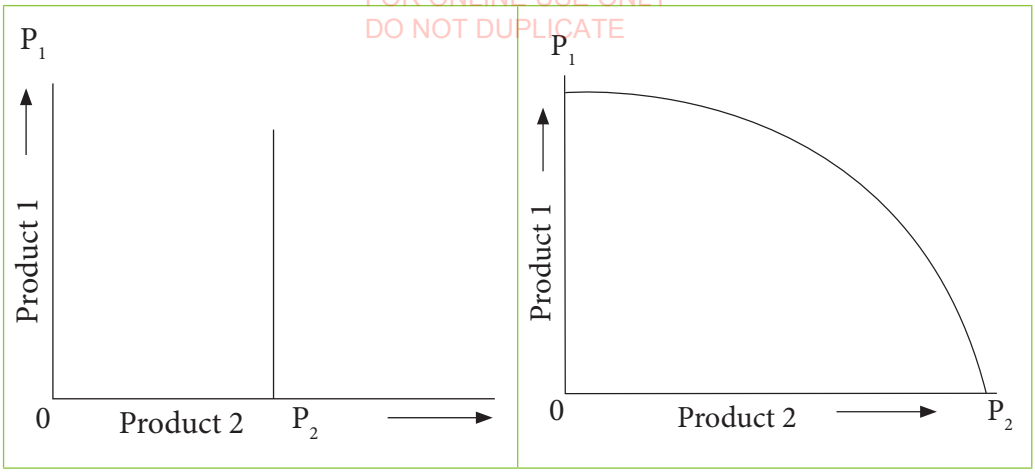


Figure 3.1(c): Supplementary products

Figure 3.1(d): Competitive products

Decisions on how to produce

There are several possible ways of producing agricultural products. When a farmer wants to decide how to produce, he/she has to determine the combination of production resources which are to be used. For example, the farmer has to decide how much land, labour and capital to use in producing the product(s) decided. Since production resources are limited in quantity, the farmer has to be careful in choosing the combination to use. It is worth noting that the same output of a given product can be obtained by changing the combination of the quantities of resources or inputs that are used. Therefore, the farmer has to choose a combination of the quantities of resources that will keep production costs as low as possible while maximising profits.

Decision on how to produce involves finding out several information about inputs and production. For inputs, farmers need to have basic information such as who are the reliable suppliers, where can they obtain credit, what a fair interest rate for credit is, what inputs are available or which ones are the most appropriate inputs, and what prices will ensure profits, that is, how will prices affect profit. For production, farmers need to have basic information which include available resources and their condition, skills needed for each enterprise, inputs and labour required for each enterprise as well as technologies appropriate for their resources.

Decisions on how much to produce

There is a number of possible levels of output for each agricultural product. For each product a farmer plans to produce, he/she has to decide the right quantity to be produced according to demand, resources available and technology used. Entrepreneurial farmers do not produce more than what they expect to sell for profit. They also tend to increase output when they expect good prices. The quantity of production which is most profitable in production process depends on the quantities of inputs and method of production used. For example, a farm which is large enough to employ mechanical implements profitably may find it profitable to produce more output than a farm which uses hand-labour.

Decisions on how to sustain resources and markets

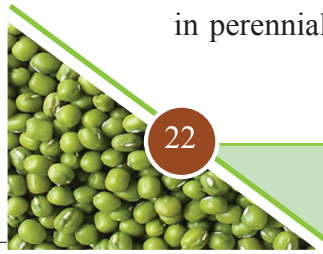
Basically, all decisions farmers have to make should aim at maximising profits while sustaining the farm's resources. The farm's resources are susceptible to many factors that may cause them to decrease in value or reduce their productive capacity. Reducing the susceptibility of a farmer's land, labour and capital resources will help to ensure that they are productive for many years. Farming for high profits without taking steps to sustain resources will eventually lead to lower profits in future. Therefore, good farm management decisions should be made. Decisions should focus on utilising farm's resources in a way that the farm will be profitable in both short and long terms. The farm management decisions on land, labour, capital and market sustainability are elaborated herein.

Farm management decisions on land sustainability: Land is the first resource base on which a farm is established and run. In farming, farmers take from and influence land. Farmers need to be very aware of the inter-relationship between farms and their land resource base. Land gets exhausted or degraded and destroyed by one of the following forces: acts of nature such as droughts, floods and erosion caused by moving water and wind; planned acts of humans such as over-grazing and harmful production practices. Some actions that can be taken by farmers to enable the land remain productive are: introduction of soil conservation measures, improved land reclamation and integration of livestock with crop production. Although each of these actions take place at a cost, they have long-term benefits as they will contribute to the sustained profitability of the farm.

Farm management decisions on labour sustainability: Decisions about labour in farm represent choices in technologies. They represent productivity, technology choices and how the farmer earns income. These decisions depend on farmers interest, needs and objectives. For example, farmers need to decide if it is better for their families to sell their labour in town or to use it on the family farm. Depending on availability of labour, farmers may opt for labour saving technologies, changing farm enterprises and combinations as well as increasing productivity. In opting for labour saving technologies, better tools that have been tried out successfully elsewhere can be adopted. This may include replacing hand-labour with more sophisticated power by using draught animals, tractors or motorised implements. It is worth to note that each of these approaches has an additional cost to the farm. Therefore, farmers should decide to use labour saving technologies only when sufficient returns can be generated to cover extra costs.

Changing farm enterprises and combinations can be an effective way of increasing farm profitability and copying with labour productivity problems. Some possible changes include intercropping, introducing a new crop, rearing more than one type of livestock and introducing a new class or type of livestock. However, market-based farmers should consider adding or changing crops or kinds of livestock carefully. In opting for increasing labour productivity, various ways can be employed. These include introducing new technology, producing more per hectare, choosing the right enterprises, improving farm layout, using improved tools and working methods and practising good labour relations. Good relation means treating labourers justly, paying fair wages and providing good supervision for hired labour. However, farmers have to be aware that increased productivity based on intensified crops or livestock production techniques together with mechanisation often results in increased labour constraints.

Farm management decisions on capital sustainability: Farmers have to be aware that capital is always limited and it should be used where is mostly profitable. They need to make both short-term and long-term decisions about physical and financial capital. In deciding for long-term capital investment on different enterprises, the farmer has to be aware that once capital has been invested in durable assets, its flexibility is lost. The capital invested, for example, in perennial crops, livestock, buildings or machinery and equipment cannot be



readily changed into another form of capital which might earn a higher rate of return. Therefore, farmers have to carefully protect the capital invested in these enterprises by taking good care of them.

Taking good care of perennial crops like orchards, planted forests, cashew trees and coffee trees is very important to protect the money that has been spent in growing them. This is because the capital cost involved is equal to the cost of growing them up to the stage of full production. Therefore, if the crops die before they have produced anything then the capital is lost. Similarly, animals being kept for meat, milk, eggs or other products should be kept healthy so as to produce efficiently. This is due to the fact that the capital cost involved in production is equal to the cost of keeping that livestock up to the stage it reaches full production. If the animals die before producing then the capital is lost. Therefore, farmers need to protect the capital invested. In cases where farmers cannot afford to raise livestock, they can also hire, particularly draught animals, if possible and practical. In this way, farmers can get high returns from their livestock.

Likewise, careful repair and maintenance of farm buildings will make the buildings last longer and this will reduce depreciation costs. Therefore, the cost of farm buildings can be kept low if the farmers utilise their buildings to the maximum. Where possible and practical, a farmer can hire a building. Buildings that are hired should also be put to maximum productive use. An empty building is a waste of money. Also, there is no use in filling with stored produce where it will be losing value. Therefore, if produce can be sold at a good price, it should be done so. Equally important, investment in machinery and equipment can be very profitable if the farmer could manage finance for increased profitability. Otherwise, they can be costly in terms of buying, repairing and maintenance. Farmers can opt to hire machinery and equipment especially the heavy power-driven ones. This saves the cost of buying them. Hiring is often cheaper than buying. Cooperative use of machinery or sharing is another option.

Farms also require several decisions about physical and financial capital that affect the farm for a relatively short time, for example, a single season. These decisions are like: which seed to buy, when to plant and which market to use. It also includes choices about what to do with limited liquid capital or cash. For example, should the farmer repair a weakening fence this season or use the cash

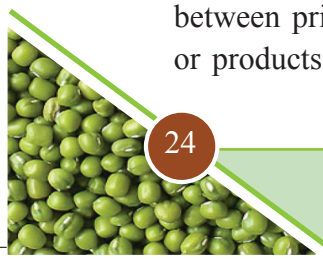
to buy all the seeds needed? Not buying all the required seeds will limit income. Likewise, not repairing the fence may allow animals into the fields and destroy the crops. Farmers will need to think carefully about the short-term decisions to be made. They need to foresee what long-term effect the short-term decisions will have. This is because there are short-term decisions which have great impact on the long-term sustainability of the farm.

Farm management decisions on inputs sustainability: Farmers have to decide on inputs sustainability. Generally, they need to know which inputs to use and where to get them. They need to determine whether the additional cost of using inputs will generate sufficient additional income to cover those costs. Inputs can be obtained from various sources, for example, the farmer's own farm, another farm, private suppliers, local general dealers, farmer cooperatives and distributors. In each case, the farmer must consider the price, quality, and availability offered by various sources of inputs. Decisions on choice of inputs, input supplier, operations and maintenance are further elaborated as follows:

(a) Decisions on choice of inputs

When deciding on inputs, there are basic things a farmer should consider. These include technical effectiveness, quality and dependability, price judgement, availability when needed, quantities or sizes offered for sale, and many others. Inputs like seed, fertiliser or other items must be technically effective. Here farmers need to find out if the seeds produce as expected, fertilisers perform as intended, livestock medicines are effective, farm implements do the work they are supposed to do, and if input or equipment is appropriate to the farm system. Sustained quality is another important feature for inputs. Farmers need to find out several information about quality and dependability so as to decide accordingly. For example, farmers may need to find out whether the equipment is built to last, the equipment has a guarantee, the seed is within its expiry date, the pesticides contain any illegal chemicals, the feeds have been properly mixed, and the supplier is reliable and honest.

With reference to price judgement, a farmer should not buy inputs just because its price is low. The inputs must also be effective and of good quality. In all events, farmers must take into account the price, especially the relationship between prices and inputs and the prices the farmer can get for farm produce or products. It is also worth considering the availability of inputs because the



need for most agricultural inputs is highly seasonal. For example, seeds must be available shortly before planting and can rarely be sold at any other time of the year. Fertilisers must be applied at specific times and few farmers have facilities for storing them satisfactorily. The same applies to pesticides, although small amounts of them can be held for future use. Where a farmer has no favourable facilities for storing the extra amount until the following year or season when it may be needed again, it is advisable to opt for the size which can be used up.

(b) Decisions on choice of inputs supplier

Farmers need to know who are reliable and trustworthy suppliers of inputs; be it equipment, machinery, spare parts and maintenance supplies. Farmers also need to know what each supplier offers in terms of prices, quality and availability of inputs in order to decide accordingly.

(c) Decisions on operations and maintenance

One of the key factors in profitability is maintaining capital. The best equipment is maintained in order to retain its productive power. Good farm management includes care for all of the physical capital on the farm. Since maintenance costs money, all farm management decisions must be measured against the income they generate.

Farm management decisions on market sustainability: Decisions on market are very important for farmers. They can also be among the most difficult to make because market generally represents the unknown. Farmers cannot be certain of the supply of farm products, the demand for certain products and the market prices. Farmers can make decisions which are informed by knowledge of how markets have performed in the past. They can make decisions based on the best available information regarding the market, product and marketing chain issues. Therefore, important things that farmers can learn about the market for the products they want to sell include searching answers for questions such as how are the crop or livestock products marketed at present? What are the main markets and where to sell products? What is the demand for the products? Who buys the products? When to buy and in what quantities? What is the best day for arrival in the market? Who are the most important intermediaries or buyers and who have the best reputation?

Some important decisions on the market are elaborated in the later sub-sections. These include decisions about prices and pricing, market promotion, marketing costs and margins, sales, product type and form, product competition, product market potential, product quality standards and packaging, product preparation and packing, product handling, transport, and delivery of products.

(a) Decisions on prices and pricing

For a farmer to make decisions about prices and pricing of his/her produce or products, he/she needs to gather several information including prices that are paid for products, the extent of variation between the prices received by farmers for similar produce in the same area, and the reasons for the decision made. A farmer also needs to know whether there is competition between buyers and if they provide credit to farmers and on what conditions. If buyers expect credit from farmers in the form of delayed payment; questions about what credit the buyer requires and how this affects price need to be addressed. Moreover, the farmer needs to know the current price levels, price policies or plans, conditions of sale and payment terms found in the market. For example, if the farmer is a price maker, he/she should consider the price strategy to be followed in order to secure good or even extra high prices. Other examples of important information a farmer has to gather are: market prices obtained on an average (maximum and minimum), effect of different quality standards and seasonal conditions on price. Others include information on how the location of the market affects prices, how time of day affects prices and how much the price normally fluctuates during the year.

(b) Decision on market promotion, costs, margins and sales

For market promotion, farmers need to gather information on whether the market is aware of the product, whether the market knows the volume available and how to purchase the product, whether the product needs promotion and how producers can give advance notice of changes in their ability to provide the goods. Considering the marketing costs and margins, farmers need to know the overall costs of marketing and the marketing margins. About sales, farmers need to gather information on factors that are likely to affect sales, for example, weather, special festivals, day of arrival in the market as well as potentials and techniques for developing sales. To decide on product type and form, the farmer needs to know products other farmers are interested in producing and market forms; whether fresh or processed.

(c) Decisions on product competition and market potential

On product competition, farmers need to know how competitive the market is, who are the main suppliers to that market, and whether the marketing plan is to be adjusted to reflect changes in competition. About product market potential, farmers need to know the market needs to be satisfied, how large is the market, how much can the market absorb, which market is he/she willing and able to satisfy, and what percentage of produce should farmers be interested in producing.

(d) Decisions on the product quality standards, preparation, packaging and packing

Farmers need to know the grades and quality standards of the produce, type of packaging required, and the cost of packaging. Also they need to know who can/ should prepare and pack the product according to the market requirements as well as the cost of preparation and packing. Farmers also need to know who can/ should handle the product.

(e) Decision on transport and delivery of product

About transport, farmers need to know the best way to transport goods to the market, who provides transportation, the unit price of transport to different markets, how long the journey takes, how frequently the transport leaves the area, how efficient the transport links, and whether the transport of produce is pooled or sent individually. About delivery, farmers need to know how should the product be delivered, what method of transportation the consumer requires, what methods of transportation the producer or trader has, whether small farmers meet the markets' delivery requirements, whether the crop/livestock produce can be stored, and if so, where and by whom. Farmers also need to know how much of the product should be stored, what storage arrangements are required, whether storage and stocking are required to meet the buyers' delivery schedule, whether associations and cooperatives are a necessary link in reaching the market, whether goods are delivered directly to the buyer by producers, and what size units the buyer requires.

Activity 3.1

Prepare and give a presentation in class on the following tasks.

1. By considering the three small to medium-scale farms you have identified in the activity of the previous chapter, perform the following tasks:
   (a) Assess the suitability of the main and other enterprises in those farms by considering land, labour and capital resources available in the area as well as the market of the products.
   (b) Think of the reasons that can necessitate changes in the decisions about the enterprises for the betterment of the enterprise.
2. For farmers to make rational decisions for sustainable profits and use of their production resources, they need to find out several information.
   (a) Identify the basic kinds of information a farmer in your area will need.
   (b) For each kind of information, identify the source(s) and the ways farmers can secure those information in the area.
   (c) Identify the challenges facing farmers, in your area, in finding out those information and how those challenges can be solved.

Selection of appropriate farm enterprise

There are various crops and livestock that can be produced in farming business; however, their productivity and profits are dependent of several factors. For example, different crops grow better in different types of soil. Likewise, different types of livestock perform better in different ecological conditions. It is therefore very important to select farm enterprise by considering the key factors which influence its success. These include goals of farming enterprise, available resources, range of crops and/or livestock enterprises which can be undertaken, compatibility of crops or livestock with the available resources, markets and marketing as well as potential risks and returns on investment.

(a) Goals of farming enterprise

Anyone engaging in something has his/her own goals. Selection of enterprises is critical in determining whether or not your goals will be met through farming. This is because the individual goal to be fulfilled through engaging in farming

will serve as internal reinforcement to work hard in your farming business. Your farming goals need to be specific, measurable and have a time frame associated with them so as to be evaluated within the time.

(b) Available resources

The availability of resources should influence your choice of farming enterprises because resource requirements among enterprises vary. The major resources needed include land, labour, capital and entrepreneurship or management. A list of resources available in a given area should be prepared. This list will be compared later to the resources required by each enterprise in the farm. The list of resources is determined by considering various characteristics or qualities of each resource.

(i) Land characteristics to be considered include its quality, location and ownership. Land quality with respect to soil types, nutrient level, drainage and climate should be considered. Land location with respect to accessibility to market and input services should be considered. Likewise, land ownership with respect to rental charges versus buying costs should be considered.

(ii) Labour characteristics to be considered include availability and quality.

(iii) Capital characteristics to be considered include types of capital available, namely, fixed, operating and liquid. Fixed capital with respect to equipment, machinery, buildings and other structures as well as their maintenance and repair should be considered. Operating and liquid capital with respect to inputs and money to secure them should also be considered. Generally, the amount of start-up capital varies with types of enterprises. It can be low or high. It is important to determine where your capital belongs; if not enough, how will it be secured?

(iv) Entrepreneurship characteristics to be considered include personal knowledge and skills in managing the activities in farming enterprises as well as information access.

(c) The range of crops and livestock enterprises which can be undertaken

This involves development of a list of possible farming enterprises, be it crop or livestock. For example, it includes description of crops and livestock enterprises that are most predominant in the area, other successful crop and/or livestock enterprises in other areas with similar soil and climatic conditions, crops and/

or livestock which have been raised on your land in the past, and crop and/or livestock types with which you feel more personally compatible; be it cultivated trees, field crops, fruit crops, vegetables, ornamentals, vegetative planting materials, cattle, goats, sheep, rabbits, fish, poultry and many others.

(d) Compatibility of crops or livestock with the available resources

This involves carefully comparing the resource needs for each crop or livestock enterprise to the resources available with an assistance from local agricultural extension worker or other relevant agricultural experts. It can also be useful to access information from other sources such as library, agricultural social media and magazines.

(e) Markets and marketing

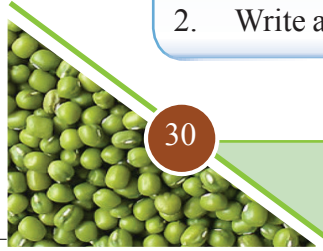
This involves careful consideration of the market potential and accessibility. A thorough business plan should be developed before you produce the intended product. A business plan should include information on who will buy your product. Furthermore, a marketing strategy which will enable the farmer to reach the targeted buyers should be developed.

(f) Potential risks and returns of investment

Potential risks are considered by finding out types of risks that might be there for crop and/or livestock enterprises considered, their costs and measures that can be employed to encounter or minimise them. Similarly, potential returns in relation to profits have to be considered. This is because profit usually serves as the main motivation in carrying out any enterprise although it may not always be a major factor in choosing an enterprise. It is worthy noting that enterprises with the greatest potential returns are also the ones with the greatest risk or the greatest capital investment requirement. Therefore, careful studying of the costs and returns for the enterprises of interest is highly important. Also, considering the budgets with various expected yields and prices can help to determine the likelihood of a profit.

Activity 3.2

1. In groups, use key points to determine the farming enterprise that suits your school. Prepare your response and give a presentation in class.
2. Write a summary of what you have learnt from this chapter in your portfolio.



Exercise

Answer the following questions.

1. Explain the meaning of decision-making.
2. Identify seven essential steps in decision-making process.
3. Enumerate at least five major decisions that farmers have to make on their farms.
4. Identify the basic four steps a farmer has to follow in selecting an appropriate enterprise(s) for his/her farm.
5. Why is it important for farmers to carry out crops and livestock enterprises by adhering to the agro-ecological conditions of their farms?
6. For a farmer to decide how to produce, he/she needs to have several information about inputs and production. In each case, list at least five information a farmer should have at hand.
7. Why is it important for a farmer to decide about how much of each product to produce in his/her enterprises?
8. Why is it important for a farmer to consider sustainability of both profits and production resources when planning and running his/her farm enterprises?
9. Identify the basic decisions farmers have to make in utilising the following resources sustainably:
   (a) Land
   (b) Labour
   (c) Perennial crop trees
   (d) Producing livestock
   (e) Buildings
   (f) Machinery and equipment
   (g) Short-term production inputs
10. What are the important things farmers have to consider when deciding about market of their products, particularly on:
    (a) Prices and pricing
    (b) Market promotion
    (c) Marketing costs and margins
    (d) Sales
    (e) Product type and form
    (f) Product competition
    (g) Product market potential
    (h) Product quality standards and packaging
    (i) Product preparation and packing
    (j) Product handling
    (k) Transport of the products
    (l) Delivery of products

Chapter Four

Risks and uncertainties

Introduction

In farming, there are some unforeseen challenges which are beyond farmer's control. These are described as risks and uncertainties. In this chapter, you will learn about the meaning of risk and uncertainty, factors that cause risks and uncertainties in farming business, types of risks and uncertainties in farming business, and methods of overcoming their effects. The competencies developed from this chapter will enable you to understand risks and uncertainties and have management skills on how to anticipate problems and overcome their effects, thus, ensure sustainable farming business.

Meaning of risk and uncertainty

Farmers decide to raise crops or livestock. They decide what to produce, how much to produce, how to produce, as well as how to sustain resources and markets. These decisions may appear simple, but for each decision, there are many possible consequences. This is because many of the factors that affect such decisions cannot accurately be predicted. Therefore, at the time the decision is made, the outcome is uncertain, that is, it is not certainly known. When a chance or probability of an outcome is known in advance, the situation is called risk. When the chance of an outcome is not known in advance, the situation is called uncertainty.

In other words, risk is a situation whereby there is sufficient knowledge or information for planning what to be done but the outcome of implementing the plan is not certainly known. The outcome may be good or bad. If it is bad, the farmer incurs loss. If it is good, the farmer gains profit. However, this chapter will only consider risky situations which lead to loss. Risk is the unknown situation that has measurable likelihoods of happening due to implementation of production plans on the farm. For example, yields of crops and livestock depend on environmental conditions such as weather, pests or parasites and disease outbreaks which may be beyond the control of the farmers.

Likewise, uncertainty is a situation where there is imperfect knowledge on the outcomes of implementing production plans on the farm. Uncertainty involves unknowns with no measurable likelihoods of outcome. Any situation where one cannot predict what can happen is normally regarded as uncertain situation. For instance, a farmer cannot assign the likelihood to how many times he/she or her/his worker(s) will fall sick within a year. Farmers normally calculate their labour requirements on the ground that their workers will be healthy throughout the year and that each labour will supply at least eight working hours per day. Similarly, no one can precisely predict his/her own death. A farmer may project his/her activities for the whole year or season but may not accomplish them due to various reasons including death.

Note: The farmer can insure his/her crops, livestock, buildings, machinery and other assets against risks. But, he/she cannot insure such assets against uncertainties. Insurance companies usually do not agree to offer insurance against uncertainties.

Risks in farming business

In farming business, risks are caused by several factors. The common factors that cause risks in farming business include weather hazards, fire outbreaks, pest and disease outbreaks on crops and livestock, theft, health of the farmer and other people on the farm. These factors are further explained as follows:

(a) Weather hazards

The yields of crops and livestock depend on environmental conditions. When hazards such as excessive rains and floods, storms, drought or frost happen, crops and/or livestock may be badly affected. For example, these hazards may cause delayed cropping calendars which lead to reduced crop and pasture yields. Also storms and floods may damage buildings, machinery and other farm assets.

(b) Fire outbreaks

Fire outbreaks on crops in the farm or store, livestock and farm buildings may occur. Fire outbreak may cause serious loss on the farm when it occurs.

(c) Pest and disease outbreaks on crops and livestock

Crops and/or livestock may be infested by pests/parasites and/or diseases. This causes yields to be poor.

(d) The health of the farmer and other people on the farm

The health of the farmer and other people involved directly or indirectly in the farming business is not predictable. Anyone may fall sick at any time thus interfering the smooth running of the farm.

(e) Theft

Thieves may steal the farmer's crops/produce, livestock, machinery and other assets. This can cause great loss to the farming business.

Types of risks that affect farming business

Risks that affect farming business can be categorised as production, marketing, financial, human and institutional. These are elaborated as follows:

(a) Production risks

This type of risks originate from uncertainty of factors that affect the quantity and quality of farm produce. Weather, disease, pests, and other factors affect both the quantity and quality of commodities produced from crops and livestock enterprises.

(b) Marketing risks

This type of risks exists because of the variability of product prices and the uncertainty of future market prices. The nature of price risk varies significantly from commodity to commodity.

(c) Financial risks

This type of risks occurs when money is borrowed to finance the farm business and creates an obligation to repay debt. The aspects of financial risks include rising interest rates, prospect of loans being called by lenders and restricted credit availability.

(d) Institutional risks

Institutional risks occur because of unpredictable changes in the provision of services. This type of risk results from uncertainties surrounding government and other stakeholders' actions. Tax laws, regulations for chemical use, rules for animal waste disposal, and the level of price or income support payments are examples of government decisions that can have a major impact on the farming business.

(e) Human risks

Human risks refer to the risks to the farm business caused by human illness and personal relationships of the farm family or labour that can affect the farm business. Accidents, illness, death, and divorce are examples of personal crises that can threaten the farming business.

Uncertainties in farming business

There are several uncertainties in farming business which are caused by several factors. These include technological, political, price, production and consumer uncertainties which are caused by changes in technology, government policy, demand as well as price fluctuations and availability of agricultural inputs.

(a) Technological uncertainties

These include the uncertainties related to changes in technology. When a change in technology occurs, it may affect production on the farm. For example, the introduction of a new type of agricultural machine may necessitate a change in the techniques of production on the farm.

(b) Political uncertainties

These include the uncertainties related to changes in government policy. Government policy has a strong influence on farming. For instance, the government may influence the agricultural sector through pricing policy that favours some crops at the expense of others. Other policies that may influence farming business are those which have influence on land tenure, marketing and the import/export business.

(c) Price uncertainties

These include the uncertainties related to price fluctuations. Farmers usually plan production on the basis of market prices. However, prices can change over time for some reasons such as change in demand, supply, quality of products and cost of production. These changes cause uncertainty in farming business.

(d) Production uncertainties

These include the uncertainties related to uncertain supply and availability of agricultural inputs. Sometimes farmers may fail to get the agricultural inputs in time due to shortage in supply and availability. This leads to low production, therefore, higher demand and higher prices for agricultural products. In other

cases, the inputs may be available somewhere else but transport may be a problem. In most cases, farming takes place in the rural areas, unfortunately, some roads in such areas are impassable during some periods of the year. This may affect transportation of produce to markets.

(e) Consumer uncertainties

These include the uncertainties related to changes in demand of a given commodity. Demand and supply determine the price of agricultural products. When a change of demand of some agricultural products occurs, it affects the price of such products and even other related products as well.

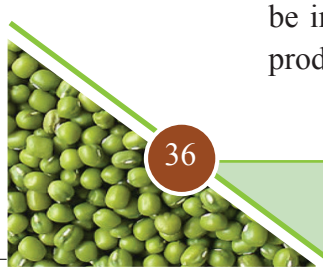
Methods of overcoming the effects of risks and uncertainties in farming

Good management of risks and uncertainties involves anticipating potential problems and planning to reduce their harmful effects. Reacting to unfavourable events after they occur is not a good risk management practice. In order to succeed, farmers must have the skills of managing risks and uncertainties. In so doing, farmers often make a trade-off between maximising profits and minimising risks and uncertainties. The following are some of the methods that can be used by farmers to reduce the effects of risks and uncertainties:

(a) Diversification

Diversification is a situation whereby a farmer carries out more than one enterprise on the farm at the same time. For example, the farmer can plant different crops in different parts of the farm in the same season or year. Diversification can also be done by raising different types of livestock on the farm. Mixed farming and mixed cropping or intercropping are also examples of diversification. Diversification can also be done by growing same crops at different times. It can help to cope with uncertain rainfall whereby earlier planted crops may suffer, but later planted crops may do well because the rains come at a better time for the crops. Diversification is done with the expectation that all enterprises will not fail together. If one enterprise does not do well, the farmer has another option to rely on. In this way, the farmers' income is not totally dependent on a single enterprise. Essentially, diversification is in line with the saying, "Don't put all your eggs in one basket".

Note: It is important that enterprises selected for diversification should neither be influenced in the same manner by the same factors nor should their products' prices rise and fall together.



(b) Insurance

Insurance may be defined as the substitution of a certain small cost for the possibility of a large but uncertain loss. Insurance companies take the risk of ensuring crops, livestock and farm buildings and machinery against loss. Farmers pay a certain amount of money, which is premium, as insurance cover to the insurance companies. The cover guarantees them compensation in the event of loss. It covers losses due to crop failure, death of livestock, theft, fire and accidents involving farm machinery. In this way, farmers guard themselves against hazards which may occur on the farm and which cannot be predicted with accuracy.

(c) Maintaining flexibility in production

Making production flexible is to make it easy to change or modify the farm enterprises when the need arises. This can be achieved by designing flexible physical assets like buildings. Physical structures which can be used for different purposes are less subjected to uncertainty due to their flexibility. Such structures can easily be used for another enterprise with minimum modification. For example, a poultry house can be designed such that in case of poor market for poultry products, it can easily be converted for goat or pig rearing. Change in production is usually done when consumer preference changes in favour of other different products but also to minimise risks and uncertainties.

Making production flexible also entails maintaining liquidity. Maintenance of liquidity refers to a situation whereby the farmer keeps liquid capital or money that can quickly be used to implement changes in production plans when there are some indicators of risk and uncertainty. For example, the liquid money can be used by a poultry farmer keeping layers to buy broiler-chicks, feeds and some building materials in order to make some necessary alteration to the poultry houses and also to minimise risks.

(d) Production on contract basis

In this method, farmers may enter into an agreement with customers or buyers to supply a certain quantity of goods with a certain standard at a specified price during a specified period. On one side, uncertainty, with regard to market conditions, is reduced on the part of the farmers. That is, if prices fall, farmers gain and this is a major advantage. On the other side, it has disadvantage in that, if market prices rise, the farmers would not benefit. The farmer may receive lower incomes in the long run where the contract prices are lower than the average market price.

(e) Selecting more reliable enterprises

The degree of fluctuation of commodity prices varies from one product to another. For example, it would be wise for a farmer to invest in an enterprise which is not prone to high price or yield fluctuations. This would enable a farmer to have more steady income over time. More reliable enterprises often give lower, but more predictable incomes. Thus, under conditions of uncertainty, it is better investing in more reliable enterprises.

(f) Wise use of information and services for improved production technologies

There are various information about farming. If used wisely by a farmer, the effects of risks and uncertainties may be reduced or avoided. For example, information on weather forecasting on the onset of rains enables the farmer to prepare land and plant at the right time. This increases the likelihood of good growing conditions for crops hence good yields. Likewise, from research and extension services, farmers may be enabled to select high yielding and disease resistant crop varieties, adopt new techniques of production, and select improved and more adaptive breeds of livestock in the market. These improved technologies enable farmers to have steady high yields and income from their enterprises. However, the added cost of doing these improvements has to be compared against what could happen if they are not employed.

(g) Use of low cost practices and technologies

Profits are also affected by the prices of inputs. The inputs used in agricultural production are related to technology. Using costly inputs could increase the risk of income shortfall. Sometimes more stable yields from using costly inputs may not lead to a more stable income. Farmers may use low cost practices such as composting to reduce the amount and cost of purchased fertiliser. Determining whether or not technology reduces risk depends on the type of risks that the farmer is trying to address.

(h) Maintaining reserves

Reserve is a quantity of something stored for future or for possible emergencies. It can be kept by farmers in a form of money, physical inputs, final products or food. Keeping reserves of inputs and products could protect farmers against the risk of price changes. Product reserves also provide some security against the risk of crop failure.

(i) Spreading crop and livestock sales

Spreading sales means making several sales of a product during a year for the purpose of reducing price uncertainty. Farmers with marketing flexibility can spread cash sales and obtain a price similar to the seasonal average price. This method of selling enables a farmer to avoid selling all products at the lowest price in the market.

(j) Partial processing

Partial processing of farm products especially perishables can be used to reduce price uncertainty. Examples of perishable products include vegetables, fruits and meats. Dried foods can be sold in relatively higher prices at times when a particular food item is out of season or in short supply. This method can be used in combination with maintaining reserves and spreading sales.

Activity

1. Examine the production plans and implementation records of the enterprises in your school and home farm or any other enterprise you can access. Also contact resource persons for those farms then perform the following tasks:
   (a) Identify the common risks and uncertainties experienced in the past five production cycles.
   (b) Explain how those risks and uncertainties were overcomed.
   (c) Discuss why the methods used to overcome those risks and uncertainties were satisfactory.
   (d) Outline alternative methods that could be satisfactory in overcoming the respective risks and uncertainties.
2. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

1. Differentiate between risk and uncertainty.
2. Describe some common sources of risks and uncertainties in farming business.
3. Identify five major types of risks that affect farming business.
4. In what ways farmers can deal with the effects of risks and uncertainties in farming?

Chapter Five

Records in farming business

Introduction

In farming business, normally there are two types of records kept; namely physical records and financial records. In this chapter, you will learn about physical records in which you will learn the concept of record keeping and basic physical records in farming business. The competencies developed from this chapter will enable you to easily identify and appropriately deal with anything happening on the farm and within the business. In turn, this will enable you to analyse the performance of your farm business and plan for improvements.

The concept of record-keeping

Record-keeping is a process by which information is systematically collected, organised and stored. Farm records are the means of storing data and information about activities on the farm so that it can be recalled and used at some other time. Records of farm activities are collected and kept on daily basis. All daily activities including performance of crops and livestock, symptoms of diseases observed, farm operations, and other events must be recorded promptly and accurately in the farm record book. Farm records may also include off-farm information about things like market prices, input prices, and market demands. All farm records which are non-financial are collectively termed as physical farm records. These records show the quantity of inputs used and/or the output obtained in each enterprise on the farm. They also show events which happened on the farm.

There are various reasons why a farmer should keep physical farm records. The well-kept physical records enable the farmer to:

(a) Evaluate the performance of any farm or farm enterprise within a given period of time: Farm records will enable the farmer to know the contribution of each enterprise to the overall progress of the farm.

(b) Manage farm easily: With the help of records, a farmer can keep a close check on whether the work on the farm is going on according to his/her plans. For instance, a farmer can check on whether he/she is using too much animal

feeds or too much seed; or whether crop and livestock yields are increasing or decreasing. It is important to detect where and when farm activities are going wrong so that they can be corrected before losses occur.

(c) Make plans to modify farming activities: This is so because a farmer needs records to estimate what yields are expected from crops and livestock and what costs and receipts the farmer is likely to get.

(d) Know how much is produced in terms of amount of yields of a particular crop or livestock.

(e) Know whether there is a progressive gain or loss in terms of amount of yields and inputs used in production.

(f) Obtain loans from banks and other financial institutions. Most of financial institutions including banks, normally give loans only if a farmer can produce adequate physical records with the corresponding financial records as well as the overall farm plan. This is necessary and beneficial to both the bank and the farmer. This is because records demonstrate the farmer's ability to manage his/her enterprise.

In keeping records, there are important things to consider. These include the following:

(i) Farm records require self-discipline and commitment to fill the record books regularly and accurately.

(ii) Records kept should be simple and not to take much of the farmer's time, though it has to serve the intended purpose.

(iii) For the yield records to give a true picture of enterprise productivity, they have to record quantities sold, quantities used for the family, and the ones given to friends on non-cash terms.

(iv) Monthly or yearly events for each kind of physical record for both crop and livestock have to be summarised and compared so as to find out if there are positive or negative changes. This has to be followed by finding reasons for changes and planning for improvement.

Basic physical records in farming business

The type of physical records that are kept on each particular farm depends on the type of farm enterprises being undertaken on that farm. Whatever enterprise, physical farm records can be divided into two groups; records of general nature and single unit records. Records of general nature are those records kept regardless of

the specific enterprises carried out. These include farm map, farm diary and labour records. Single unit records are on specific enterprises or on single units of a specific enterprise. This category includes crop and/or livestock production records.

A farm map

This is a layout of the whole farm showing different fields with their sizes and uses, buildings and other structures present on the farm as well as how to reach each of them. A farm map enables the farmer to keep information related to location and size of farm enterprises as well as natural and built features on the farm. A farm map can also help to identify soil types and other physical features such as slopes, valleys, rivers and swamps that can be helpful in making management decisions like grazing plans and crop rotations. A farm map can also be helpful when selecting manure storage areas. Moreover, a farm map can play an important role in emergency planning. Figure 5.1 shows an example of a map of a certain farm.

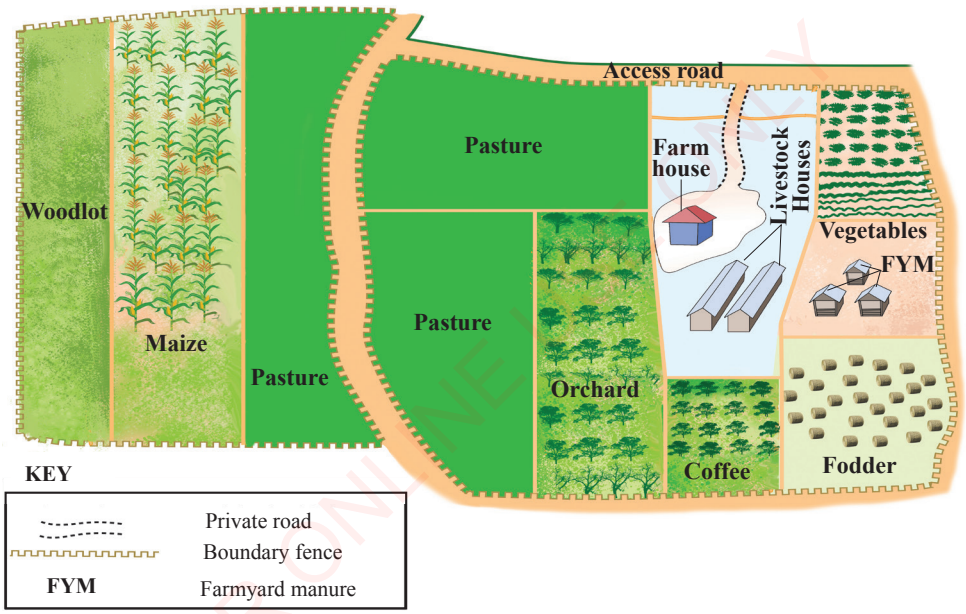


Figure 5.1: A typical map of a farm

Activity 5.1

1. Visit your school farm's office and observe all the physical features shown on your school farm's map. Identify the features you have observed.
2. If your school farm's office has no farm map, take a survey on your school's farm then make a sketch map of your school farm.

A farm diary

This is a record or document that contains all important events or observations that happen on the farm on daily basis. Large farms, which keep a complete set of accounting books, use a diary for non-financial records only. These records include work performed by labourers, fertiliser applications on specified crops and fields, dates of sowing and harvesting, servicing of machineries, yields, feed given to animals, and the like. Table 5.1 shows an example of a farm diary.

Table 5.1: Sample template of a farm diary in a month

A farm diary		
Date	**Enterprise**	**Event**
01/08/2020	Dairy cattle	Outbreak of East Coast Fever, 1 calf died
08/08/2020	Dairy cattle	All cattle and calf pens disinfected
10/08/2020	Garden	All amaranths from vegetable plot harvested and sold
15/08/2020	In all enterprises	Farm fence checked and repaired
.		
.		
.		
30/08/2020		

A farm diary is very important as it serves as a reference document to obtain past information on the farm. Therefore, it is very important for the farmer to keep records of all events that happen on the farm daily. This is because it is normal for humans to forget things easily. It is worth to note that it is not a farm dairy if it is not used daily. Thus, for a farm diary to serve its intended purpose, it has to be used on daily basis.

Activity 5.2

1. Visit your school farm's office, make a close observation of the farm diary. Identify things you have observed.
2. Outline the lessons you have learnt from the observations.

Labour records

It is important to keep accurate records of all labour used in every farm enterprise, whether family labour, hired casual or hired permanent labour. The common labour record is labour utilisation record which shows how labour is utilised on the farm in a given time. This helps the farmer to determine labour allocation and requirement for the purpose of hiring, for example, when labour is at peak demand. Labour records also enable the farmer to determine when to reduce labour. Moreover, it helps the farmer to determine whether the labour is productive or not. Table 5.2 shows an example of labour utilisation record template.

Table 5.2: Labour utilisation record template

Labour utilisation record					
Date	Man-days			Total per day	Remarks
	Crop production	Livestock production	Horticultural production		
Total man-days involved					

For permanent labour, a farmer should keep record of individual workers, showing details such as name of the worker, date when hired, marital status, next of kin, contact address, qualifications, salary, leave days entitlement, health status and special attributes or habits.

Crop production records

These records present operational details for each of the crop field or enterprise. They may be presented under different classes depending on the type of crop enterprise concerned and the choice of farmer. More often, the details include the following:

(a) Field identification and size
(b) Details of seedbed preparation, for example, dates of ploughing
(c) Planted crop and variety
(d) Planting dates
(e) Spacing used and seed rate used
(f) Type and quantity of manure or fertilisers applied
(g) Weed control methods applied and dates
(h) Pests and diseases control methods and dates
(i) Other farm operation details, for example, thinning and pruning
(j) Harvesting dates
(k) Yield per unit, that is, per hectare, and total yield, including quantity consumed at home, quantity given to friends and quantity damaged, if any. This gives a true picture of yield rather than considering the quantity sold only.
(l) Post-harvest handling operations involved
(m) Processing and/or value addition operations, if any
(n) Marketing of the produce including quantity sold, dates, place and buyer
(o) Labour used including the number of workers involved and their wages

Livestock production records

Livestock production records are many and varied. Unlike crop production records which are generally similar, each livestock enterprise has its specific types of records. Nonetheless, the general types of livestock records include those on breeding and reproduction, feeding, laying, kidding, calving, health, deaths, yields, produce handling, processing and/or value addition of produce, if any, as well as marketing. Details of these records, however, differ from one livestock enterprise to another due to the varied nature of different livestock especially in breeding, yielding and feeding.

Activity 5.3

1. There is a wide range of livestock which can be kept including dairy and beef cattle, woollen and meat sheep, dairy and meat goats, layers, broilers, ducks, turkeys, ornamental poultry, rabbits, fish, bees, porkers, cutters, baconers, and larders. In your groups:
   (a) Identify all the basic details or information to be kept for each type of livestock mentioned above.
   (b) Design a convenient and suitable template for recording each of the detail or information identified in (a) above.
   (c) Discuss why it is important for a livestock farmer to have each of the identified records.
   (d) Share your work in class.
2. Pay a visit to your school farm's office to learn about various physical records for crops and livestock produced in your school farm.
   (a) Explain how and why the records are sufficient.
   (b) Explain if there is a need to make amendment in those records.
3. Using appropriate record templates or forms, keep the physical records for crop and livestock enterprises in the school farm or at home for a period of one month. Discuss the records you have kept, focusing on how to improve production.
4. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Attempt the following questions.

1. Differentiate record keeping from farm records.
2. What types of information should be kept for an individual permanent labour?
3. What is the importance of the following records on a farm:
   (a) Farm map
   (b) Farm diary
   (c) Labour utilisation record
4. List the types of information that a crop farmer should record.
5. What are the major kinds of information that a livestock farmer should record?

Chapter Six

Planning for crop production

Introduction

Planning for production is the foremost principle in crop farming and is more crucial than any other decision in crop farming business. In this chapter, you will learn about factors to consider in physical and financial planning for crop production and working out an implementation plan for crop production. The competencies developed from this chapter will guide you on how to stay on track in reducing capital risks and maximising profits from every unit of production factors.

Factors to consider in physical and financial planning for crop production

There are important factors to consider in planning for crop production. These include:

(a) Individual's goals for crop production and their practicability
(b) The available resources
(c) Possible crop enterprises which can be undertaken
(d) Compatibility of possible crop enterprises with the available resources
(e) Growing considerations
(f) Compatibility among crop enterprises if more than one enterprises have to be undertaken

Individual goals and their practicability

The individual's crop production goals have to be determined. These goals need to be specific, measurable, achievable, realistic and have a time frame associated with them. Therefore, when writing down your goals, also write down the time frame and ways you can measure their achievement. This will help in evaluating the success of your crop business and in developing an implementation plan. It is important for each person involved in the farm to record his/her goals individually before the goals of the crop farming business as a whole are formulated. Individual goals to be fulfilled through engaging in crop farming will serve as internal reinforcement to work hard in your crop farming business.

The following is a list of questions that can be used to help developing your list of goals:

(i) What is your primary reason for crop farming? Is it to maximise income, to have a rural lifestyle, or other reasons?

(ii) What other activities are you involved in, and what are the priorities of those activities in relation to the crop farming business?

(iii) Do you want to devote full-time or part-time crop farming?

(iv) How much do you want to invest in terms of time and capital demands in your crop farming business?

(v) Do you want to eventually transfer the ownership of the crop farming business to a partner or family member?

(vi) Is income from the crop sale of the farm an important part of your retirement plan?

(vii) What is the desired period between initial investment and cash returns?

(viii) Do you want to learn new skills through self-study or formal training?

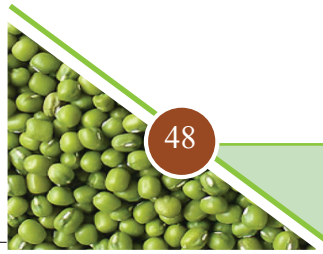
The answers for these questions and many others may help you to be more focused in determining realistic goals.

The available resources

The availability of resources will ultimately limit your choice of crop enterprises simply because the resource requirements among crop enterprises vary. A list of resources include land, labour, and capital. However, in determining the available resources, there are other factors to consider such as climate, access to information, management skills, and markets.

A list of resources available in a given area should be prepared. This list will be compared later to the resources required by each crop enterprise you are considering. The list of resources is determined by considering various factors associated with land, climate, irrigation water, farm structures, machinery and equipment, financial factors, management factors, labour and marketing factors.

Land factors: In considering these factors, you need to determine how much land you have; the physical profile and topography of the land, soil texture, drainage capability and nutrient levels, types of weeds that grow on the soil, and other crops that can be grown on the land.



Climatic factors: In considering these factors, you need to determine the rainfall distribution, average rainfall in your area particularly rainy season, when high and low temperatures occur in your area, average daily temperature as well as direction and strength of winds.

Irrigation water factors: In considering these factors, you need to determine where your water come from and its cost, water quality, and water rights. You need also to consider if you are within an irrigation scheme; when the water for irrigation will be available to you and its amount, and the type of irrigation to adopt based on cost and efficiency factors.

Farm structure factors: In considering these factors, you need to determine the type of buildings you have and their conditions. You need also to consider if you have structurally sound fences, if you need additional buildings or fences, and the cost of their construction.

Machinery and equipment factors: In considering these factors, you need to determine the type of farm power and machinery you have, farm implements you have, your transportation equipment (e.g., truck, pick-up, trailer or bike) including its capacity and efficiency. You have also to consider whether to lease or rent some equipment, and determine the possibilities of contracting with custom operators in your area.

Financial factors: In considering these factors, you need to determine the amount of start-up and operating capital you are willing and able to invest. If you are able or willing to borrow capital, what is your cash flow situation or what is your ability to pay recurrent expenses and purchases for production. You need also to consider if high rate of return on your investment is important and if you are willing to consider risky enterprises.

Management factors: These factors are mainly personal skills and information access. In management skills, the following are to be determined: your skills in record keeping, personnel management, budgeting, adequate familiarity with tax and other relevant laws. Moreover, it involves determining your mechanical skills, your knowledge on arable crop farming, greenhouse farming, hydroponics, and the like. Management factors also include whether you would prefer handling

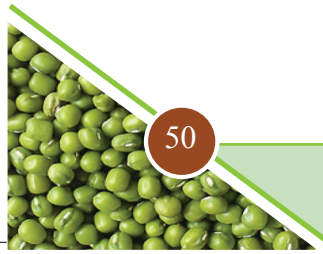
a diversified farm of several crops or you would prefer one or two major crop enterprises.

In considering information access, you need to determine if you are familiar with any agricultural information delivery systems, if you are able to access the resources of these systems, if sufficient information is available for the enterprises in which you are interested, and if you are willing to learn new skills if they are deemed necessary.

Labour factors: In considering these factors, you need to determine your labour needs on a monthly basis; if you are planning to use mostly family or mostly hired labour, if you have checked out the regulations of the country labour law, and if you have considered the labour cost foregone by using your own labour.

Marketing factors: In these factors, you need to determine if you have a preferred marketing channels (be it broker, retailer, cooperative, contract with processor, or direct such as roadside stand, farmer's market or U-pick). You should also determine your closeness to various potential markets. Further, you may need to consider contacting potential markets for their advice on crop selection, time period you are willing to spend marketing your products, and possession of cooling facilities for perishable products. Moreover, you should determine if you are familiar with marketing regulations for the crop enterprises you want to carry out.

Market accessibility and potential are the most commonly overlooked factors in the enterprise selection process, however, they can be your most limiting constraint. This is simply because being able to grow crop does not mean you can transport it to the market and sell it. Likewise, just because you can sell products does not mean that it will be profitable. Furthermore, there may be a possibility that you will be able to sell the products at a profit making price but you will only be able to sell a limited amount of the product, that is, less than the total amount that you are able to produce. Therefore, there is a need to carefully consider your market potential and accessibility. If you wish to produce a crop product(s) that has never been tried before in your area, plan to take several years to get established.



Possible crop enterprises

After identifying your goals and resources, develop a list of possible crop enterprises. The following questions can help to develop a list of possible crop enterprises:

(i) Which crop enterprises are predominant in your area?

(ii) Are there any successful crop enterprises in other areas with similar soil and climatic conditions that interested you? Here you need to refer to crop enterprises that are potential in your area but not been established.

(iii) What is the type of crop(s) that was raised on your land in the past?

(iv) Which are the crop enterprise types with which you feel more personally compatible? (For example, field crops, orchard crops, vegetables, ornamentals, growing transplants, and raising seeds).

Compatibility of possible crop enterprises with the available resources

This involves determining which crops are compatible with the available resources by evaluating the potentiality for each of the crops on your list. This task can be done by systematically comparing the resource needs for each crop enterprise to the resources available. Determining the resource requirements for each crop enterprise will probably require a good deal of homework. A good place to start is by consulting your local agricultural extension worker. Another alternative could be talking to other growers in your area or elsewhere about their experience with the crop enterprises. You may also gather information through other sources including library, agricultural social media and magazines.

Growing considerations

Growing considerations are made through finding out the information given for each crop enterprise and checking for compatibility to your resources as you go along. The information is under the following themes:

General crop situation: Find out what is known about variety adaptability in your area, the effects of spacing on yield and quality, your personal experience with the crop, the research base for the crop under consideration, where else the crop is grown, and whether the hectareage under production in your area is increasing or decreasing and why.

Climatic requirements: Find out the crop's adaptability to the climate during the intended growth period, the crop's tolerance for rainfall and temperatures, and

how the climatic conditions during the planned cropping period will affect the growing and production processes of the crop.

Rotation considerations: Find out how the crop fits into rotation with other crops planned, how much time is from planting to total harvest period, what will be the effect of weed management practices used on the crop under consideration on following crops in the rotation, and whether the crop is susceptible to the same soil-borne diseases as rotation crops.

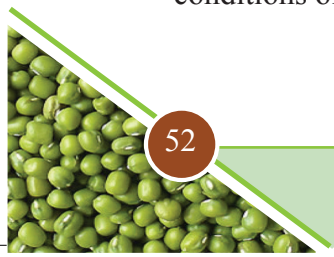
Equipment requirements: Find out whether there is a need for special materials or equipment such as cultivation or harvesting equipment, or storage facilities. You also need to find out what will be their cost and availability.

Irrigation: Find out how much water is needed, how often you need to irrigate, what type of irrigation methods are recommended for the crops and whether the quality of water influences production.

Management of pests and diseases: Find out the important pest and disease problems for the crop, whether there are particular control measures available and affordable for use in particular place, whether there are available varieties which are resistant or tolerant to important pests and diseases of the crop, and if so, find out if they have good yield and quality characteristics in relation to the intended purpose.

Labour requirements: Find out how many hectares of the crop you can handle with the amount of labour that you can afford. You will also need to consider whether it would be more economical to buy or rent labour-saving systems, for example, mechanical planter versus hand planting, or selective herbicide versus hand weeding. You will also need to find out whether seasonal labour is available.

Operation and investment capital: Find out how much money is needed to be invested in growing the crop, and where will that capital be obtained (whether from self savings, family, loan or grant). You also need to find out the terms and conditions of loans (its duration, interest, equity requirement and collateral).



Harvesting: Find out how many harvests are required to obtain an economic yield, how the harvest interval is affected by weather (temperatures, rainfall and/or humidity). You will also need to find out how long it will take with your available labour to harvest your crop each time, how the crop is processed and packaged for market and what will be the costs of processing and packaging materials.

Marketing: Find out whether you are thoroughly familiar with the market quality standards for the crop, and whether you have studied the market history and market trends of the crop. This means that crop selection should not be based only on recent high market prices. You will also need to determine whether you have explored various types of market outlets. It is worth noting that it is highly important to produce what you can sell instead of trying to sell what you have produced.

Profitability: Find out the total production costs, kinds of yields you expect, expected gross and net income as well as variation in net income you expect. You need also to compare returns of a particular crop with other crops. You may also compare its expected returns with those of other enterprises like livestock.

Risks and uncertainties: Find out the risks and uncertainties that might be there for the crop, the cost of the risks and uncertainties, and how the predicted results of risks and uncertainties can be minimised.

Compatibility among crop enterprises

Before making any final decisions, you must consider the relationships among crop enterprises if you wish to carry out more than one crop enterprise. For example, you may have enough labour to carry out one crop enterprise as long as you don't also select another labour intensive crop enterprise. It is clear that the timing of the resources requirement can be as critical as the amount of the resources required. A monthly chart of resource needs for each crop enterprise may be helpful. After you have developed a final list, go back and review your goals. Make sure that the long-term and short-term goals meet your plan.

It is worth remarking that there are lists of crops recommended for optimal production in each region and district of Tanzania Mainland. The lists are in the *"Mwongozo wa uzalishaji mazao kulingana na kanda za kilimo za kiikolojia*

(2017)" prepared by the ministry responsible for agriculture. Despite inclusion of the list of crops, you still need advice from agricultural extension workers in various stages of production. Each crop under consideration should carefully be evaluated in consultation with appropriate advisors.

Note: Do not be discouraged by how demanding planning process is. You better spend much time on paper to ensure effective planning for crop production than working in the field while you are not well prepared. Therefore, the effort put into searching information should directly be related to the amount of capital at risk and the potential rewards.

Working out an implementation plan for crop production

Having considered all the important factors for planning crop production in the previous section, you will now be in a position to develop your implementation plan by doing the following:

(i) Identifying and summarising your personal goals.

(ii) Choosing the suitable crop and variety to be planted.

(iii) Determining your yield targets.

(iv) Matching the yields of the chosen crop to the market.

(v) Identifying all required production resources including land, labour, capital resources and inputs for the chosen crop enterprise with their estimates.

(vi) Choosing the suitable field for the chosen crop enterprise.

(vii) Determining when and how to perform all the activities involved in the production of the selected crop(s).

(viii) Drawing the budget for producing the selected crop enterprise(s).

(ix) Examining the total costs versus total projected revenues so as to determine the profitability of the selected crop enterprise(s).

(x) Financing the production of the selected crop enterprise(s).

(xi) Getting all the identified resources in place.

(xii) Letting all the determined activities done.

An implementation plan can simply be developed by completing the information required in Tables 6.1 for your personal goals, 6.2 for crop production goals and targets, and 6.3 for annual crop calendar with budget.

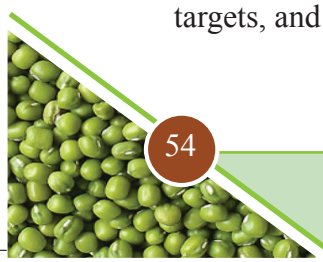


Table 6.1: Sample template of personal goals

My goals
1. How much money do I want to make every season/year? ……...
2. Which business should I start or continue to do so as to get this money? (a) …… (b) …… (c) …… (d) ……
3. What do I want to use it for? (a) …… (b) …… (c) ……

Table 6.2: Sample template of crop production goals and targets

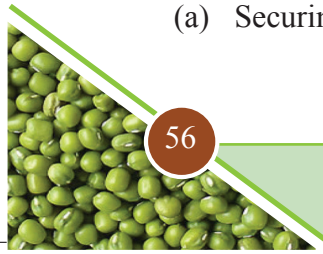
My crop production goals and targets	
Year	
Season	
Plot No.	
Location of farm	
Revenue target for the season	
Crop(s) to be planted	
Variety	
Most likely prices at time of harvest	
Harvest volume to meet target	
Size of land to be planted (hectares)	

Table 6.3: Sample template of annual cropping calendar with budget

Annual cropping calendar with budget - Plot No. ...													
Crop to be planted:													
Land size (hectares):													
Year i.e. all seasons in a year:													
Farm activities to be performed	When and how much money *(Figures/costs to be filled in the months in which the activity is done)*												Total cost
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
Total cost													

It is important to note that farm activities to be performed depend on the type of crop(s) to be grown. Generally, the activities may involve the following:

(a) Securing production resources including land, labour and capital



(b) Land preparation
(c) Planting
(d) Irrigation/drainage (if required)
(e) Operations for water conservation (if required)
(f) Manure/fertiliser application (if required)
(g) Operations for soil fertility conservation (if required)
(h) Operations for control and management of weeds
(i) Operations for control and management of crop pests (if required)
(j) Operations for control and management of crop diseases (if required)
(k) Operations for special agronomic practices (if required)
(l) Harvesting operations
(m) Operations for post-harvest handling of produce (if required)
(n) Operations involved in processing and value addition of a given crop produce (if required)
(o) Storage of produce/products (if required)
(p) Operations involved in marketing of the produce/product(s)
(q) Record keeping

Furthermore, the cost for carrying out the planned crop production activities may be financed by using various means already learnt and considered, provided that they are reasonable.

Activity

1. (a) In groups, carefully go through the factors to consider in physical and financial planning for crop production.
   (b) Discuss the importance of considering each factor.
   (c) For each factor, discuss the consequences of not adhering to it in planning for crop production.
   (d) Outline the lessons you have learnt from these tasks.
   (e) Make summaries of your responses and share them in class.

2. Perform the following tasks. For each task, state why you did that way.
   (a) Choose at least two suitable crops that could be raised in your school.
   (b) Set goals for producing the crops and yield targets.
   (c) Choose the suitable variety for each of the crop chosen.

(d) Identify all required resources to raise each of the chosen crop; including land, labour, capital and inputs.
(e) Choose the suitable pieces of land in your school area to grow each of the chosen crop.
(f) Identify all necessary activities to perform in raising each of the chosen crop.
(g) Determine when and how each of the identified activity will be done.
(h) Develop a cropping calendar for the identified activities for each of the chosen crop with budget estimates.
(i) Examine the total costs of producing each of the chosen crop versus the set goals and targets.
(j) Determine how raising of each of the chosen crop will be financed.
(k) Identify the kinds of records that are important for each of the chosen crop.
(l) Set schedule and templates for record-keeping for each of the chosen crop.

3. Record all your tasks' proceedings in portfolio. Assess and evaluate your tasks periodically.
4. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What is the importance of setting your personal goals before production goals in planning for crop farming business?
2. Planning is said to be the "beginning with the end in mind". Discuss this statement with reference to planning for crop production.
3. (a) Why is it insisted to produce what you can sell instead of trying to sell what you have produced?
   (b) How can it be achieved?

Chapter Seven

Land preparation for crop production

Introduction

Land preparation is an important principle in crop production that follows after planning. In this chapter, you will learn about the concept of land preparation, time for preparing land for various crops and methods of land preparation. The competencies developed from this chapter will enable you to prepare land timely and properly so as to enhance germination, growth and maximise yields from your crop farming enterprises.

The concept of land preparation

Land preparation involves all the activities that make land suitable for planting. A piece of land that is prepared for planting is referred to as a seedbed. In a seedbed, planting materials are planted and/or transplanted and grow to maturity and then harvested from the same place. For land to be ready for planting, certain necessary physical conditions of the soil must be achieved in order to facilitate germination or growth of planting materials and their development. These conditions include suitable size of soil clods, soil depth, looseness of the soil, and the absence of weeds.

Time for preparing land is very important in crop production. Land should be prepared well before the onset of rains in order to give weeds and other vegetations enough time to dry up and decompose into organic matter. Also it needs enough time to allow carbon dioxide and other gases to diffuse out of the soil while being replaced with oxygen, which is important for seed germination and for growth of beneficial soil organisms. Early land preparation gives enough time for other subsequent operations to be done; giving way to early planting.

Proper time for land preparation differs with the type of crop but a virgin land needs longer time than unvirgin land. For perennial crops, it is advisable to prepare the land about three months before the time of planting. This is because sufficient time is required for land clearing, ploughing and harrowing. Enough

time is also required for preparation of planting holes and refilling holes with top soil mixed with manures. When organic manures are used, sufficient time is required for them to decompose before planting. This facilitates planting the crop in time during the beginning of the long rain season, where irrigation is not possible.

For annual crops, land preparation should be done close to the planting time. If cultivation is done by tractor, it may be done at the end of dry season before the next wet season. When cultivation has to be done by using human power or animal power, it should be done as early as possible at the beginning of wet season. The presence of moisture in the soil will make cultivation easier particularly in heavy soils. Heavy soils are usually too hard to cultivate during dry season.

Activity 7.1

In groups, perform the following tasks.

(a) Revisit the activity of the previous chapter then list the crops recommended and those that can be grown in your local area.

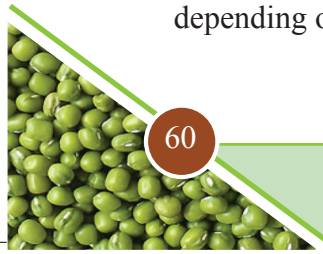
(b) Find out the proper time for preparing land for each crop.

(c) Outline the lessons you have learnt.

(d) Record all your tasks' proceedings in portfolios. Share your observations and lessons learnt in class.

Tillage

It is often necessary to subject land to some forms of tillage before the crop is planted. Tillage is changing the soil condition with a tool for the purpose of obtaining ideal conditions for seed germination, seedling establishment and growth of crops. There are tillage operations which are done before planting. These are collectively referred to as preparatory tillage. They are done to prepare the seedbed for raising crops. They involve deep opening, loosening or other manipulation of the soil to bring about a desirable tilth, depending on the nature of land and crop to be planted. The tilth is the physical condition of soil obtained through tillage or as a result of tillage. The tilth may be coarse, moderate or fine depending on the requirement of the crop to be grown.



The preparatory tillage may be primary, secondary or tertiary. Primary tillage is the foremost opening of the soil after clearing the land. Basically primary tillage is the same as ploughing. Secondary tillage is the operation that follows the primary tillage. It entails seedbed refinement practices before planting and it is mainly harrowing. Tertiary tillage operations are those operations which are carried out to suit production of specific crops or land. They are sometimes referred to as layout of seedbed. They are usually carried out after primary and secondary tillage operations. They include operations such as ridging, mounding, levelling, terracing, bed-making and rolling.

Furthermore, there are tillage operations which are done to standing crop after sowing or planting and before harvesting of the crop. These operations are called post-seeding or post-planting cultivation. In addition, there are special forms of tillage operations, for example, sub-soiling and minimum tillage.

Purposes of ordinary tillage

With exception of minimum tillage, the tillage operations highlighted in the previous section are the ones termed as ordinary tillage. They are also referred to as traditional or conventional tillage. They are carried out to fulfil one or a combination of the following purposes:

(a) Seedbed preparation

Tillage loosens the soil and results in a seedbed suitable for seed germination and development of the young seedlings. A good seedbed should be moist and should not contain large lumps of soil that may prevent close contact between the planted seed and soil particles. It should not contain large quantities of undecomposed organic matter.

(b) Control of weeds

Weeds growing on a fallow plot can often be controlled by being ploughed under. Ploughing before cropping may also serve to kill the present weeds. Tillage between rows of growing crops can be an important method of weed control.

(c) Incorporation of organic matter into the soil

Organic matter and crop residues can be incorporated into the soil through tillage. Once in the soil, they decompose rapidly thus releasing the nutrients they contain to the soil for the growing plants. The incorporation of plant residues in the soil through tillage also serves to improve soil structure.

(d) Soil and water conservation

Tillage often serves the purpose of breaking up the surface layers of the soil so that water is able to infiltrate more rapidly into the soil. This has the dual benefit of increasing the amount of water available in the soil for crops and decreasing the amount of soil erosion caused by excessive run-off. For these reasons, the land that is not cropped immediately may occasionally be ploughed or tilled as a soil and water conservation measure.

(e) Improvement of physical condition of soil

The physical condition of soil can be improved by tillage. For example, where the surface layers of the soil have formed a hardpan, it may be beneficial to break up the hardpan through tillage. This allows plant roots to penetrate more deeply and water to penetrate more easily into the lower layers of soil.

(f) Increases soil aeration

Tillage opens up the soil, thus improving soil aeration which increases the oxidation of chemical compounds in the soil. This helps plant roots and soil micro-organisms to respire and function properly.

Forms of tillage operations

There are various forms of tillage operations which are described in the following sections.

Ploughing

This is the foremost opening of compact soil with the help of different types of ploughs. It is the first soil tillage after last harvest or after the virgin land has been cleared. It is also referred to as primary tillage. It involves breaking, loosening and turning over the soil to a depth of 15 – 30 cm. The soil is left in lumps of various sizes and may require other operations in order to make a suitable seedbed. It is normally conducted when the soil is wet enough to allow ploughing and strong enough to give reasonable levels of traction. Resonable levels of traction enables machinery wheels or tyres to move without sliding. Implements which are used for ploughing include tractor mounted mouldboard plough and disc plough. Animal-drawn ploughs are used in small scale farming. Tools such as hand hoe or forked hoes are also used though it is tedious and time consuming.

Ploughing can be done immediately after the crop harvest or at the beginning of the next wet season. Figure 7.1 shows ploughing by using disc plough.

Figure 7.1: Disc ploughing

Source: *https://images.app.goo.gl/8G1fhkvt6uuZRRbu7*

The depth of ploughing is determined by the type of crop to be planted, implements available and type of soil. The depth is important to be considered because deep-rooted crops require a soil which has been ploughed deeply to facilitate easy root penetration. Shallow-rooted crops may not need deep ploughing. In heavy soils, some implements cannot cut the soil beyond a certain depth. Such implements can be sharpened or sometimes weight could be added on them in order to make them plough deeper according to the requirement.

The choice of the correct implements for ploughing is another important aspect to consider in ploughing. This is determined by the condition of the land, type of tilth and depth of cultivation required. If, for example, the land to be ploughed has a lot of stones and stumps, it would be advisable for a farmer to choose a disc plough which would not break easily when working on such land. On a land which has perennial weeds particularly those with rhizomes such as couch

grass, a hand hoe cannot be used efficiently because it cannot pull out all the rhizomes. In such a case, a forked hoe would be appropriate. Heavy soils are hard particularly when they are dry. Therefore, simple implements such as hand hoe and forked hoes tend to dig shallowly on such hard soils. Where a very fine tilth is needed, it requires the use of different types of implements. At times, special implements such as cultivators might be needed. Heavy implements are necessary when deep ploughing is needed. Light implements are required when shallow ploughing is necessary.

It is advisable to plough the field during dry season. Very wet soils are difficult to cultivate and may lead to development of hard pan. Similarly, very dry soils may be difficult to penetrate with simple implements. Therefore, it is important to schedule the ploughing operation so as to coincide with the time when the soil moisture is at its optimum working condition.

Importance of ploughing

(a) It makes subsequent operations easier.
(b) It controls weeds by burying or uprooting them.
(c) It buries cleared vegetative materials to decompose and add organic matter and nutrients into the soil.
(d) It destroys soil-borne pests by exposing them to predators and sun.
(e) It eases the penetration of the crop roots.

Harrowing

This is the seedbed refinement practice which follows primary tillage or ploughing. It is also referred to as secondary tillage. Harrowing involves breaking down large clods of soil and leaving an even soil surface. A time period of three to four weeks between ploughing and harrowing is advisable so as to allow easy water infiltration. Implements such as animal-powered and tractor- powered disc, spike-toothed or spring-tines harrows are used. In small-scale farming, tools such as hand hoe, forked hoes and garden rakes are used. Figure 7.2 shows harrowing by using notched disc harrow.

Figure 7.2: Disc harrowing

Source: *https://images.app.goo.gl/cxcpdi66b1imn3Dy9*

The number of harrowing can be one or more, depending on various considerations. These include the following:

(a) *Condition of the soil after ploughing:* Some conditions after ploughing necessitate more harrowing. For example, where there are plenty of cleared vegetative materials as in ploughed virgin land, more harrowing operations are necessary to incorporate the materials into the soil.

(b) *Size of the planting materials:* Big-sized seeds such as maize and groundnuts require a fairly course soil tilth whereas the small-sized ones such as those of finger millet require a finer one, thus more harrowings are necessary.

(c) *Slope of land:* A very fine soil tilth on hilly land could encourage soil erosion thus, to avoid this, it is advisable to reduce the number of harrowing.

(d) *The moisture content of the soil:* In dry soils, less harrowings are preferred compared to wet soil so as to conserve the available moisture.

(e) *Type of implement used during ploughing operation:* Some implements are more effective than others. For example, in a land ploughed by a disc plough, the soil clods tend to be larger and requires more harrowings compared to the one ploughed by a mouldboard plough.

The importance of harrowing

(i) It breaks large soil clods into fine particles for easy planting.
(ii) It destroys weeds which may have germinated after primary tillage.
(iii) It levels the field in order to achieve a uniform depth of planting and subsequent uniform establishment of crops in the field.
(iv) It mixes organic manure, that is, farmyard manure and compost manure in order to accelerate the release of nutrients into the soil.
(v) It incorporates organic materials such as crop residues into the soil in order to encourage decomposition.

Ridging

This is one of the various forms of tertiary tillage which involves heaping of soil to form a ridge or bund and furrow as it is shown in Figure 7.3. Ridges are important for planting tuber crops such as round potatoes, sweet potatoes, cassava, taro, yams and groundnuts. The furrows are made when planting sugar cane as they are important in conserving soil water. In large scale, farmers use tractor-mounted ridgers in making ridges while small scale farmers use hand hoe and animal mounted ridgers.

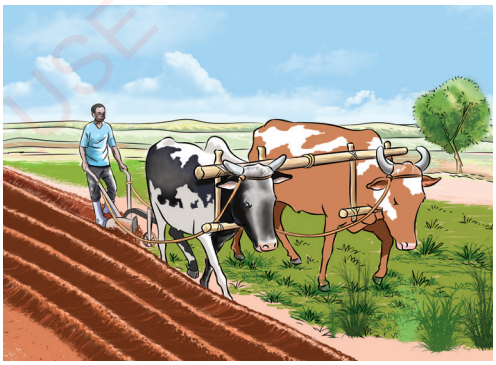


Figure 7.3: Ridging

Source: *https://images.app.goo.gl/Mig1rDhRKqWuUB7S7*

Benefits of ridging

(a) It encourages expansion of crop tubers thus, increasing the yield of the crop.
(b) It makes harvesting of tuber crops easy.
(c) It helps in the conservation of moisture within the furrows so that the moisture is retained for a long time for crop use.

(d) It serves as soil conservation measures on hilly land as it controls soil erosion.
(e) It reduces salt rising to crop roots in salt affected soils.

Mounding

This involves the collection of soil into more or less conical heaps or mounds. The mounds usually vary in height from 30 - 100 cm. Mounds are usually of approximately the same height on a particular farm. The distance from one mound to the next also varies but it is the distance that determines how many plants can be planted in the lower-lying spaces between the mounds. Figure 7.4 shows large and small mounds. Mounds are made manually by using hand hoes and spade.

(a) Large mounds

(b) Small mounds

Figure 7.4: Mounds

Source: *https://images.app.goo.gl/TgANKGJqGRyTXRBH8*

Mounding is the most common form of soil collection tillage in Tropical Africa and it is often associated with intercropping since it simultaneously permits two or more kinds of seedbed on the field. The top of the mounds is used for crops such as tubers which require a deep layer of loose soil. The low-lying furrows are used for crops that have high requirement for water such as paddy while the slopes of the mounds are used for intermediate crops.

Benefits of mounding

(a) It provides a deep, loose seedbed which is particularly suitable for the development of tuber crops.
(b) It provides a variety of seedbed types on the same field which may be advantageous to intercropping.
(c) It helps elevating the seedbed and plant roots above water table in fields with high water table.

(d) It improves aeration for roots, facilitates the growth and development of underground tuber crops and pods of groundnuts.
(e) It makes harvesting of tuber crops and pods of groundnuts easier.

Despite the benefits of mounding, it has some challenges. The major challenge of mounding is that it has not been mechanised and would probably be extremely difficult to mechanise. Moreover, mounds impede free movement of people and machinery through the field. For these reasons, mounding is mostly confined to traditional agriculture with intercropping to which it is well suited.

Levelling

It is also known as grading. Levelling is most commonly done where it is desired to use furrow or some other forms of surface irrigation. The land is levelled in such a way that the point of water supply is the highest on the field and the field slopes downwards from water source. Levelling of crop field is also encouraged where the farmer intends to hold water for flooding required for crops such as paddy or taro. Elevated areas or banks or walls are constructed around the field so that water does not flow away once held. Figure 7.5 shows levelling exercise using a tractor mounted equipment.

Figure 7.5: Levelling

Source:*https://ien.kverneland.com/Soil-Equipment/Seedbed-Cultivators/Features-Seedbed-cultivators/Zone-1-Levelling*

The importance of levelling

The following are the benefits farmers can get from levelling:

(a) It ensures uniform supply of water at the same depth in the entire seedbed.
(b) It facilitates germination and growth of the paddy crop.
(c) It controls pests like rodents which may hide in some patches in paddy fields.

Terracing

This is one of the methods of managing extremely sloping land for crop production. It creates a series of relatively flat horizontal portions alternating with vertical portions; very similar to a flight of stairs. The flat portions are used for cropping. Terracing provides erosion control measures and permits cropping on land that would have otherwise remained useless for cropping. Figure7.6 shows terraces.

Figure 7.6: Terraces

Source: *https://images.app.goo.gl/QUkpyDZ6RURXvK8g7*

Bed making

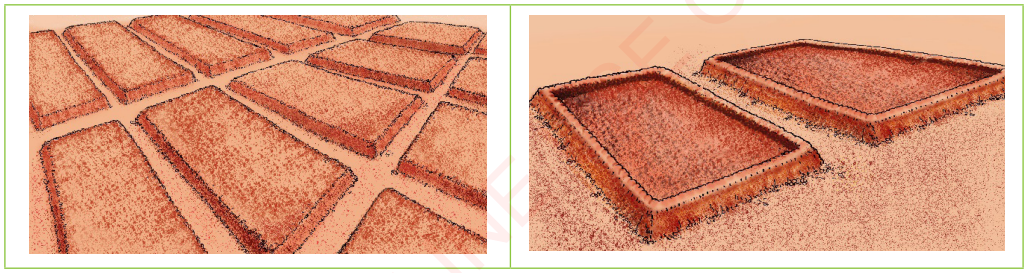
This is a form of land preparation which is more often used in horticultural and nursery practices than in field crop production. There are raised, sunken and flat beds.

(a) Raised beds

Raised beds are particularly advantageous for clayey soils; under high rainfall or any field where drainage is likely to be poor. They can also be used in other

situations. For example, where crops are irrigated through furrow method, raised beds are essential so that water can flow down the furrows between them. Raised beds are usually 10 - 30 cm high. However, the best height depends mainly on soil texture and moisture considerations. For example, raised beds are often 20 - 30 cm high on clayey soils under high rainfall where poor drainage is likely to be a problem. On coarse-textured soil under the same conditions, bed height might be 15 - 20 cm. When raised beds are used in drier conditions, a bed height of 10 cm or less may be best to avoid excessive moisture loss due to evaporation from the exposed sides. The width recommended for raised beds is 100 - 130 cm. Bed making is most commonly done with hand tools in small to medium scale farming while in large scale farming is done by machines.

Raised beds usually are not a good choice during dry season because they dry out more quickly than flat or sunken beds. Also, water tends to run off them and is lost into the path ways. These disadvantages can be partly overcomed by mulching the bed, making a lip around the bed's edge to reduce run-off, and by reducing bed height to 10 cm or less (see Figure 7.7). The bed in Figure 7.7 (a) is best suited to high-rainfall areas. The beds in Figure 7.7 (b) have a lip around all four sides which helps to prevent water from running off especially in drier conditions.



(a) Raised beds without lip around *(b) Raised beds with lip around*

Figure 7.7: Raised beds

Advantages of raised beds

(i) They provide much better drainage compared to flat or sunken beds.
(ii) They provide a double layer of topsoil because they are made by dragging in topsoil from the surrounding pathways.
(iii) Plants on raised beds are easier to reach when doing hand operations such as weeding and thinning.
(iv) In temperate regions, raised beds warm up more quickly in the spring. This tendency may benefit cold-sensitive crops and even permit earlier planting.

(b) Sunken beds

These are seedbeds which are about 100 - 130 cm wide made by removing the soil at 2 - 5 cm below the surrounding soil level. Their depth should not exceed about 5 cm. There are two ways of making sunken beds without losing topsoil. First, take off the topsoil and then replace it after removing enough subsoil to sink the bed. Second, make a sunken bed by mounding pathway soil around the bed's borders. This will work well in clayey soil, however, the border walls made of sandy soil may wash out when the bed is watered. The sunken beds conserve water much more effectively than raised beds for two reasons. First, they don't have the exposed sides of raised beds from where considerable moisture can be lost by evaporation. Second, none of the applied water is lost by run-off. Sunken beds are commonly used in dry regions, particularly on sandy soils with low water-holding capacity. Figure 7.8 shows sunken beds.

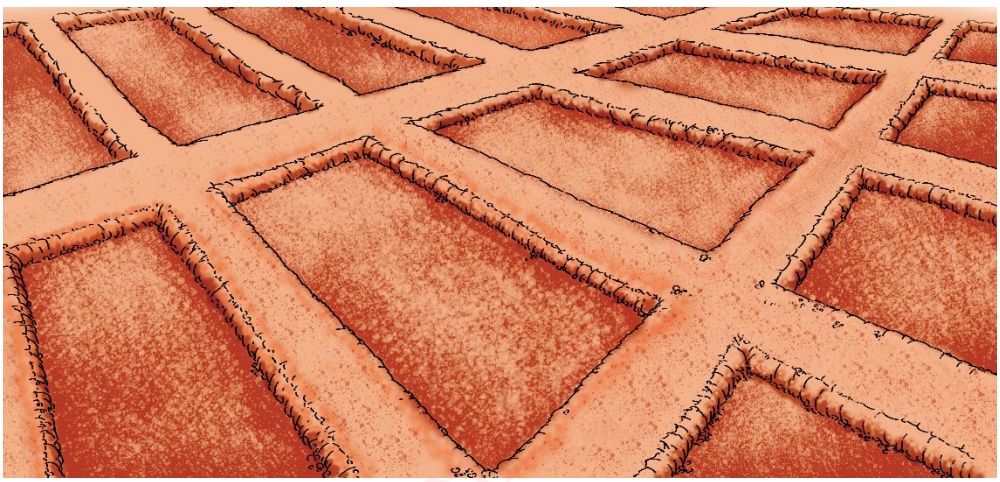


Figure 7.8: Sunken beds

The major challenge of sunken beds is that some topsoil is lost in the usual method of construction. They are made by pulling off soil from the bed area and placing it in the surrounding paths. This probably won't affect crop growth, as long as the topsoil is of normal depth at least 15 cm and enough compost or farmyard manure is added.

(c) Flat beds

These are seedbeds prepared by leveling the area to be planted. Flat beds are used where water availability is adequate and there are no drainage problems. In some

areas, crops are initially planted on a flat bed then as the season progresses, soil is thrown into the crop row to mound up the plants. This process is called "hilling up" or "earthing up". This is also done to control in-row weeds, provide support, and improve drainage. For tuber crops, hilling-up keeps the developing tubers covered with soil. Hilling-up only works with plants that have enough stem height and leaf clearance to tolerate partial burial, for example, maize. Figure 7.9 shows flat seedbeds on two soil types.

Figure 7.9: Flat beds

Rolling

This is the flattening and pressing of the seedbed which has loose or fine tilth soil as it is shown in Figure 7.10. It completes and prepares the soil for sowing crops which have very small seeds such as wheat, barley, simsim, finger millet, and grass pastures. Despite the fact that the field has been harrowed ready for sowing; many rocks, plant debris, roots and other solid objects may still remain in the field. These objects interfere with the germinating seedlings or may later damage combined harvesters when harvesting close to the ground. Therefore, to avoid poor seedling emergence and damaging of machines, it is advisable to roll the soil prior to sowing. Rolling can also be done after sowing crops too. Rollers are the implements which are used for this operation.

Figure 7.10: Rolling of soil to prepare the seedbed

Source: *https://blog.agrivi.com/post/soil-rolling-a-good-farm-decision-or-total-yield-breakdown*

Advantages of rolling

(a) It creates smooth and firm seedbed.
(b) It protects the top soil layer and very small seeds from being carried away by wind.
(c) It promotes faster and uniform germination of crops with very small seeds.
(d) It enables the soil to retain moisture for a longer period.

Inter-tillage

This is commonly practised with respect to crops that are planted in rows. It is also known as inter-row cultivation. It involves tilling the areas between the crop rows as it is shown in Figure 7.11. The objectives of inter-tillage are usually to control the weeds between the crop rows and to promote water percolation into the soil. The implements used in large scale farming are tractor mounted weeders or cultivators. In small to medium scale farming, animal mounted weeders or hand tools are used.

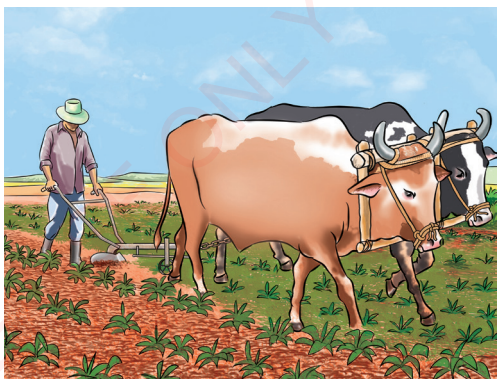


Figure 7.11: Inter-tillage

Source: *http://www.edwardsfarmmachinery.com/product/comeb-inter-row-rotavator/*

Sub-soiling

This is a special tillage which involves breaking up of the hard soil to a depth of 60 - 90 cm, without bringing it to the surface. This is done particularly after the soil has formed hard pans. The hard pans may be formed as a result of continuous use of heavy machinery on wet soils in land preparation. The implements such as sub-soilers and chisel ploughs are used in breaking up hard pans. Figure 7.12 shows sub-soiling by using sub-soilers. Sub-soiling is important in that it breaks

the hard pans thus allowing deep penetration of plant roots, and it improves soil aeration. It also improves water infiltration deep into the soil. This conserves soil moisture and reduces surface run-off.

Figure 7.12: Sub-soiling

Source: *https://images.app.goo.gl/XSS2Msgzauc1b7VW7*

Minimum tillage

There has been a realisation that frequent ordinary tillage operations tend to destroy the soil structure and increase soil degradation. This is because they expose the soil to adverse effect of rainfall and strong wind. For example, it makes the soil more susceptible to run-off and erosion. Yet, continuous use of heavy ploughs creates hard pan in the subsoil thus, resulting in poor infiltration. Moreover, the conventional tillage operations are capital intensive. Thus, to avoid these bad effects, scientists have developed the soil conservation system of minimum tillage. With minimum tillage, crop production is carried out with little tillage or soil disturbance as possible.

Minimum tillage can be achieved through some or a combination of the following practices:

(a) Restricting cultivation to the area where seeds are to be planted. This can be achieved by using herbicides to kill existing vegetation, followed by tillage to open only a narrow furrow on the ground to put the seed.

(b) Drilling of seeds directly into the stubble of the previous crop and then controlling the weeds using herbicides.

(c) Cultivating only where there is a crop plant to remove weeds followed by slashing weeds in the rest of the field.

(d) Slashing or uprooting weeds in perennial crops.
(e) Using mulch on the soil surface.
(f) Planting of cover crops.

Advantages of minimum tillage

(a) It ensures least soil compaction.
(b) It does not destroy soil structure.
(c) It reduces loss of soil organic matter.
(d) It minimises water loss through run-off and erosion especially in light soils.
(e) It promotes timely planting since little time is spent on tilling land.
(f) It prevents the exposure of humus to adverse conditions such as the sun's heat that causes volatilisation of nitrogen.
(g) It saves labour and cost which would normally be incurred in other forms of tillage operations.
(h) It prevents disturbance and damage to crop roots as well as underground structures during weeding, for example, in coffee, citrus and tuber crops.

Challenges of minimum tillage

(a) It may lead to a less porous surface with increased run-off and erosion particularly in heavy soils. This is because minimum tillage does not interfere much with the soil surface.
(b) The quickness of planting may be reduced by large amounts of residue in the field.
(c) There may be difficulties in weed control by alternative methods to weeding.
(d) There may be an accumulation of soil-borne pests and diseases.

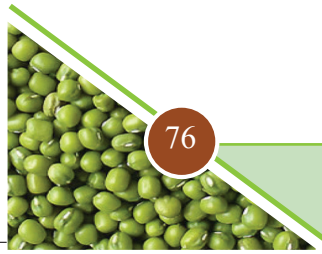
Activity 7.2

1. Revisit the list of crops recommended in your area and outline the methods and procedures of preparing land for each crop.
2. Imagine a plot of land is allocated to you in the school demonstration unit. Using available tools and equipment, carry out land preparation for each crop by following possible methods and procedures until it is ready for planting.
3. Outline the lessons you have learnt.
4. Record all your tasks' proceedings in portfolios. Assess and evaluate your tasks periodically. Share your observations and lessons learnt in class.
5. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. (a) What is a seedbed?
   (b) State four reasons for preparing a seedbed before planting.
2. (a) What is tillage?
   (b) State six purposes of tillage.
3. (a) What does it mean by primary tillage?
   (b) Why is primary tillage an important operation in crop production?
4. Why are the following operations carried out in crop production?
   (a) Rolling
   (b) Levelling
   (c) Mounding
   (d) Ridging
5. Explain why dry-season ploughing is better than wet-season ploughing?
6. (a) What is harrowing?
   (b) Give five reasons why harrowing is done before planting?
   (c) State the factors that determine the number of times a farmer would harrow his/her land?
7. What is sub-soiling? Why is it done? How is it done?
8. (a) What is minimum tillage?
   (b) Why is minimum tillage practised?
   (c) How is minimum tillage practised?
   (d) What challenges can you face in practising minimum tillage?
9. (a) Identify the basic types of beds.
   (b) For each type, identify the conditions which make it suitable and the challenges which a farmer may face in using it. How can each of the challenges identified be alleviated?



Chapter Eight

Planting of crops

Introduction

Planting is an important operation in crop production that principally follows after land preparation. In this chapter, you will learn about the concept of planting, types of planting materials, and criteria for selecting planting materials. You will also learn preparation of planting materials, placement of seed or planting material in the field as well as time and methods of planting various crops. The competencies developed from this chapter will enable you to plant crops properly and timely so as to enhance growth and maximise yields from your crop farming enterprises.

The concept of planting

Planting of crops is an operation which follows land preparation. Before planting is done, the seedbed must be prepared to the appropriate tilth depending on the kind of planting material to be used. Planting involves placement of a planting material in the soil or other planting media so as to initiate growth or establishment of a crop. Planting is sometimes referred to as propagation. The term sowing is used when seeds are used as planting material. Planting crops by using seeds is also termed as generative or sexual propagation while establishing crop by using vegetative materials is called asexual or vegetative propagation. Examples of crops which are established by sowing seeds include maize, groundnuts, sorghum, millets, wheat, cowpeas and water melon. Crops such as yams, sugar cane, ginger, sisal, cocoyam/taro, sweet potatoes and cassava are normally established by planting vegetative parts. Therefore, the farmer often has to opt for using seeds or vegetative planting materials, depending on the crop he/she has chosen to raise.

Seeds as planting materials

Seeds are produced by flowering plants after pollination and fertilisation. Seeds contain part of the plant that germinates into seedlings and later grow into new plants. Figure 8.1 shows seeds of some crops grown in Tanzania.

Figure 8.1: Seeds of some crops

Advantages of using seeds in planting crops

The following are the advantages of using seeds as planting materials.

(a) Seeds are easy to treat against soil-borne pests and diseases.

(b) Seeds are not bulky and therefore easy to store and transport.

(c) They save on planting time as seeds can easily be handled during planting. Moreover, it is easy to plant seeds by using machines like planters and seeddrills thus making the operation faster.

(d) It is possible to apply fertilisers together with seeds during planting.

Challenges of using seeds in planting of crops

The following are the challenges of using seeds as planting materials.

(a) Some seeds have long dormancy and may need special treatment in order to germinate.

(b) Plants raised from seeds of crops that are open pollinated may show some variations from the mother plant due to cross pollination. Therefore, this may introduce undesirable characteristics.

(c) On planting, seed materials can easily be destroyed or eaten by birds, rodents and other pests before germination. Likewise, soil-borne pests may damage seeds if left for sometimes in the soil before sufficient moisture is made available, e.g., through rain to facilitate germination.

(d) Some seeds may lose viability if stored for long time.

Vegetative materials for planting

Vegetative planting materials are plant parts which have the ability to produce roots, then grow and develop into new plants. Once the vegetative planting materials have developed roots, they give rise to new plants. Plant parts used for planting include cuttings, tubers, suckers, crowns, slips, splits, bulbs and bulbils. These materials are described herein.

Cuttings

These are portions of plant parts which are cut and then planted. They may be from stems, roots, or leaves. Stem cuttings are more common than root and leaf cuttings. Stem cuttings can be obtained from branch tip or parts below the tip of a shoot. Basal leaves are removed from cutting obtained below the tip of a shoot. For crops with hard wood or semi-hard wood stems, all the leaves are removed. A good stem cutting must have a bud or an eye which develops into a shoot. Figure 8.2 shows an eye on cassava cutting and a bud on sugar cane sett. It is worth noting that cuttings must produce leaves as soon as possible so that they can start making their own food.

Figure 8.2: A bud or an eye on cuttings

In some crops, cuttings are big enough to be planted directly to the main seedbed while others are first raised in a nursery. For example, cuttings of napier or elephant grass, cassava, sugar cane and sweet potato are planted directly to the main seedbed and cuttings of tea and most vines are first raised in a nursery.

Generally, the establishment of new plants from vines requires the cuttings for planting to have at least two nodes so as to allow roots to develop from the nodes. Figures 8.3 (a), (b) and (c) show stem cuttings of sugar cane, cassava and tea plants, respectively while Figures 8.4 (a), (b) and (c) show cuttings and seedlings of sweet potato, grape and yam, respectively.

(a) Cassava cuttings (b) Sugar cane cuttings (c) Tea cuttings

Figure 8.3: Cuttings from cassava, sugar cane and tea stems

(a) Sweet potato vines (b) Grape vines (c) Yam vines

Figure 8.4: Sweet potato, grape, and yam vine cuttings

Tubers

Tubers are underground food storage organs which are generally thick and short and some are long. They are used as vegetative planting materials because they sprout and produce roots for growth. There are mainly two types of tubers. These are stem and root tubers. Stem tubers have some auxiliary buds which are sometimes referred to as eyes. These eyes sprout to produce stems which grow into plants. Stem tubers are swollen stems with scale leaves. An example of stem tubers is round potatoes (refer to Figure 8.5 (a)). Root tubers develop from the thickening of the adventitious roots. Root tubers are not commonly used to raise

crops because they produce weak stems. A good example of a root tuber crop is sweet potato (refer to Figure 8.5 (b)).

(a) Round potato (b) Sweet potato

Figure 8.5: Tubers

Rhizomes

These are swollen modified stems that run horizontally under the ground. Rhizomes for planting are produced by cutting into pieces of about 3 - 6 cm long from living rhizomes. Each piece should possess at least two to three living buds which will produce shoots. The sections of rhizomes are planted horizontally in the same way they were growing in the parent plant. Such crops include ginger and turmeric as shown in Figure 8.6.

(a) Ginger (b) Turmeric

Figure 8.6: Rhizomes

Suckers, crowns and slips

Suckers are small plants that grow from the base of the main stem. Suckers are also termed as side shoots. They have adventitious roots which grow quickly when planted to form a new plant. Suckers are used as planting materials for bananas, sisals, pineapples, underground and aerial yams as well as aroids such as taros or cocoyams. When planted, suckers give uneven growth leading to maturity at different times. Suckers of good quality should be planted when they are young. Figure 8.7 shows banana, taro and sisal suckers while pineapple suckers are shown in Figure 8.8

(a) Taro suckers (b) Banana suckers (c) Sisal suckers

Figure 8.7: Banana, taro and sisal suckers

Crown and slips are the materials used in planting pineapples. Crowns are born on top of fruits. They are broken off and prepared for planting. Crowns are more preferred to suckers because they give uniform growth and they grow relatively faster and take short time to reach maturity. Slips are born at the base of the pineapple fruits. They are cut and prepared for planting. Slips grow fast from planting to maturity, however, they do not provide uniform growth in the field. Crowns and slips may be planted in the nursery first before transplanting to the main seedbed. Figure 8.8 (a) shows pineapple crown and slips and Figure 8.8 (b) shows pineapple suckers.

(a) Pineapple crown and slips (b) Pineapple suckers

Figure 8.8: Pineapple crown, slips and suckers

Splits

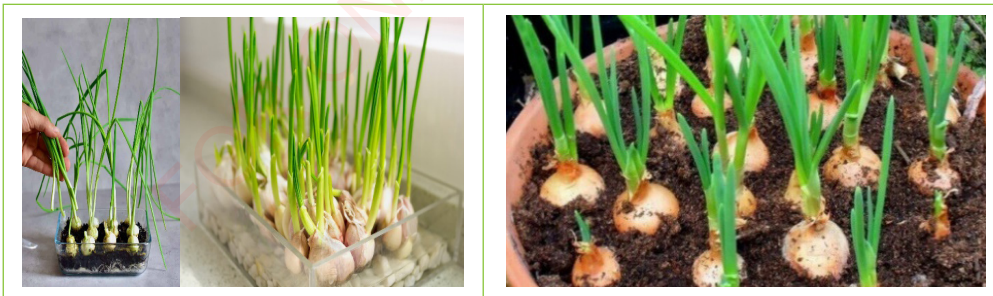
Splits are plantlets divided from the mother plant with complete leaves and rooting system. Splits are mostly used as planting materials for pyrethrum and pasture grasses. Pyrethrum splits are first raised in nursery and thereafter transplanted to the main seedbed (see Figure 8.9).

Figure 8.9: Pyrethrum splits raised into seedlings

Due to advancement in technology, rapid multiplication of pyrethrum splits has been enabled through micro-propagation tissue culture technique. This technique produces a large number of splits of high quality by using just a few mother plants. Pasture grass splits, for example, star grass can be planted directly to the main seedbed. It is advisable to plant the splits on the same day of uprooting and splitting.

Bulbs

Bulbs are flattened stems with nodes bearing fleshy scale leaves surrounded by some dry leaves. The food is stored in the fleshy scale leaves. Examples of these crops are onions and garlic. Raising onions and garlic from bulbs is usually practised in urban areas where small gardens or containers are used. In this case, leaves may frequently be harvested for consumption. Figures 8.10 (a) and (b) show garlic and onions raised from bulbs in containers, respectively. Otherwise, onions are commonly raised from seeds while garlic is raised from cloves.



(a) Garlic (b) Onions

Figure 8.10: Garlic and onion bulbs planted in containers

Bulbils

Bulbils are modified floral buds with stored food. Depending on the type of plant, bulbils may resemble small nodule-like buds in clusters or individual. They either come from the bottom of the plant moving up or aerial ones at the top of the plant. Examples of these crops are aerial yams and sisal. Figure 8.11 (a) shows the bulbils on aerial yams and Figure 8.11 (b) on sisal.

(a) Aerial yam bulbils

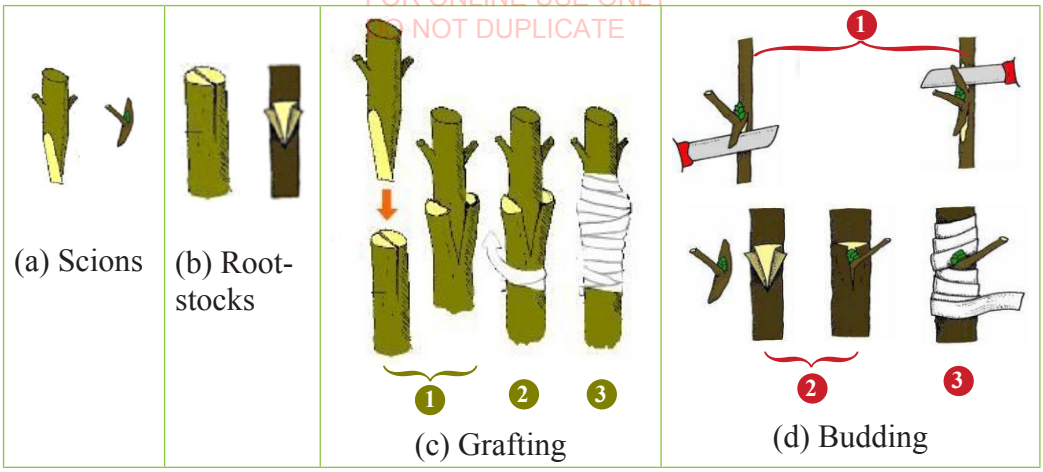
(b) Sisal bulbils

Figure 8.11: Bulbils of aerial yams and sisal

When bulbils mature, they fall off to the ground. They are then collected and raised in the nurseries before they are transplanted to the main field. Bulbils make good planting materials and they are better than suckers of the respective crops. When used, there is uniformity in crop growth in the field.

Grafts

These include shoots and buds taken from one woody plant so as to be joined to another woody plant which is compatible in order to grow together. The shoots and buds used are collectively termed as scions (refer to Figure 8.12 (a)) while the part which provides base with rooting system is termed as rootstock (refer to Figure 8.12 (b)). The technique used in joining scions with the rootstocks is termed as grafting (refer to Figure 8.12 (c)). The technique is termed budding when only one bud is used (refer to Figure 8.12 (d)). There are various methods of grafting and budding that you can get from your teacher and other agriculture experts.



(c) Grafting	(d) Budding
1 Joining scion and rootstock	1 Removing the bud from the scion plant
2 Enclosing the union	2 Inserting bud into the rootstock
3 Enclosed union for healing	3 Enclosing wound for healing

Figure 8.12: The use of grafts in raising crops

Corms and side shoots

Corms are short and swollen underground stems protected by dry scale leaves. Sometimes they are termed as bulbo-tubers since they have the characteristics which resemble to those of tubers. A corm has one or more buds located on the underside of the leaf with adventitious roots at the base. Examples of crops which can be planted by using corms and side shoots include taro/cocoyam and other aroids (refer to Figure 8.13).

Figure 8.13: Taro or cocoyam plants, corms and shoots developed from a corm

The corm shrivels when the food reserves are used up as the bud grows into aerial shoots. The dark top section of the aroid corm is chopped into small pieces. These pieces should be left for a day to allow surfaces to dry before replanting. Alternatively, side shoots from the mother corm are separated from the main plant when they are at least 15 cm in height for replanting.

Advantages of vegetative planting materials

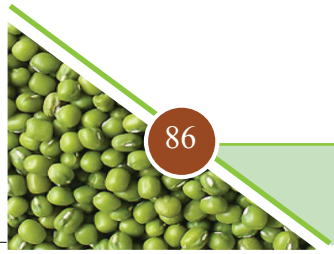
The following are the advantages of using vegetative materials as planting materials.

(a) It facilitates the growing of crops which do not produce seeds or do not produce viable seeds. Such crops include sugar cane, bananas and napier or elephant grass.
(b) Crops raised using vegetative planting materials mature early compared to the same crop raised using seeds.
(c) Crops from vegetative planting materials have better controlled plant growth and higher yields in terms of quantity and quality.
(d) Vegetatively planted crop plants show uniformity in qualities such as disease resistance, seed size, colour, keeping or storing quality and chemical composition.
(e) It makes possible to combine more than one type of genetic characteristics into a single plant. For example, in grafting, the rootstock and the scion can have different characteristics.
(f) It is used to select and maintain genetic characteristics of plants.

Challenges of vegetative planting materials

The following are the challenges of using vegetative materials in planting of crops.

(a) The materials can be in bulky and heavy to transport and store.
(b) The materials cannot be stored for long time without loosing their vegetative qualities.
(c) Preparation and handling of the materials require strict hygiene as diseases can easily be transmitted through the tools and equipment used.
(d) Genetic weaknesses and characteristics of particular plants are commonly carried over. For example, stem cuttings suffering from certain diseases will spread them faster.



Criteria for selecting planting materials

When selecting materials for planting, the following criteria are to be considered.

(a) Suitability of the materials to the ecological conditions

The planting materials should be well adapted to the environmental conditions in the area. For example, soil conditions, temperatures and the amount of rainfall. There are many crop varieties developed to suit conditions prevailing in different areas. Therefore, each variety will grow well and produce high yields if grown in areas where the targeted conditions will be met.

(b) Purity of the materials

Planting materials should be pure and not mixed with other contaminants. The contaminants might be foreign materials like chaff, dirt, and seeds from weeds or other varieties of the crop. The percentage purity of planting materials will affect the seed rates used. Seed rate is the quantity of seeds to be used in a given area, normally expressed as grams or kilograms per hectare. Lower seed rates are used for pure materials while higher seed rates are used for impure planting materials.

(c) Germination percentage

This is a measure of the germination potential of seeds in percentage. For example, a germination percentage of 90 means that for every 100 seeds planted, 90 of them are expected to germinate. The germination percentage can be determined in the laboratory by growing a given number of seeds under suitable germination conditions. The number of seeds germinating out of the total number of seeds sown will give the germination percentage. Germination percentage is given by the formula:

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Germination percentage helps to determine the seed rates of crops. Generally, seed rates higher than the recommended ones are used for seeds with lower germination percentage.

Besides the conditions necessary for germination and subsequent emergence, there are a number of other factors which may influence germination. These include:

(i) Physical damage to the seeds because broken seeds with damaged embryos will have low germination percent. Moreover, broken seeds have higher chances of developing moulds. These defects, in turn, affect seed viability.

(ii) Too shallow or deep planting may hinder germination. Too shallow planting may hinder germination due to desiccation and too deep planting may hinder germination as seeds may exhaust their food reserves before emerging.

(iii) Presence of seed-borne and soil-inhabiting organisms which destroy the seeds before emerging.

(iv) Use of immature seeds may lower germination ability.

(v) Rough tilth of soil hinders germination due to obstruction.

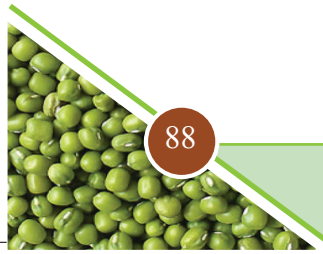
(d) Disease resistance

Healthy, strong and disease resistant planting materials are preferred. Disease resistance is highly important particularly for viral diseases which have no cure.

(e) Certified planting materials

These are materials which have been tested and proven to be potential for a given area. They are free from pests and physiological disorders. Certified planting materials give high yields if they are properly cared. Unless advised by agricultural experts, re-use of these materials for repeated planting should be avoided. This may lead to reduced yields. It is always advisable to obtain new planting materials which are certified every time planting is done.

Note: If you have to prepare the planting materials on your own, you should have to consider selecting materials from: healthy plants still in the field and which have similar characteristics in growth and production; plants with no signs of diseases and which are resistant to pests and diseases; fast-growing plants; the most productive plants which are fairly large and of similar size as well as colour and free from defects. However, no matter how good the crop may be while growing in the field, do not select seeds for planting in the next season from a crop raised by planting hybrid planting materials. For seed, should be well air or sun dried depending on the crop, and should not have been damaged in any way by pests or other means. For vegetative materials, they should be at a stage of regenerating to new growth.



Activity 8.1

1. With the assistance of your teacher, carry out a germination test of various crop seeds found in your local area. Record all the procedures and findings.
2. Share your methodology and experimental findings in class.

Preparation of planting materials

After the planting materials are selected, they have to be prepared in different ways before they are planted. Depending on the kind of planting material, several ways are used to prepare the planting materials. These include breaking seed dormancy, seed dressing against pests, legume seed inoculation, and chitting or sprouting.

Breaking seed dormancy

Seed dormancy has to be broken before the seed is planted. Therefore, depending on the crop, some of the following methods can be used to break seed dormancy.

(a) Treatment of seeds with immature embryos

One type of primary dormancy is characterised by immature embryos. Although the seeds are shed by the plant, the embryo must continue to develop before germination occurs. Problems of immature embryos will be overcomed if the seeds receive appropriate treatment after ripening. For this treatment, often elevated temperatures are required for a certain period of time. For example, certain palm seeds require to be treated at 38°C to 40°C for three months.

(b) Stratification

Seeds of many plants require moist chilling conditions for a certain period of time to render them capable of germination. This process is called stratification. Chilling is usually 0°C to 10°C for 7 to 180 days. For example, apple seeds require up to 60 days in moist medium at 3°C to 5°C to overcome dormancy.

(c) Counteracting growth inhibitors

This involves destroying the inhibitors by dipping seeds in specified chemicals, for example, sulphuric or hydrochloric acid.

(d) Scarification

Scarification is the process of weakening the hard seed covers or coats so as to facilitate germination and subsequent emergence. Seeds of some crops have a very hard covering that may prevent them from germination unless treated. Hard seed coat can prevent absorption of water and gaseous exchange or may physically prevent the embryo from growing and emerging. It is, therefore, necessary to make these covering weaker or permeable to water and gases through the process of scarification. Depending on the nature of the crop, scarification may be done in the following ways:

(i) Physical or mechanical scarification

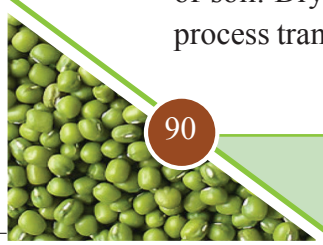
This is a method which aims at scratching the seed coat to make it permeable to water. It is done by rubbing small sized seeds against hard surface such as sand paper, or slightly pounding them in a mortar or hand mill. For large sized seeds and in small amounts, scarification can be done by cutting with a file or knife or cracking them with a hammer. For large amounts of seeds, special equipment or mechanical scarifier is essential. Scarification should be carefully done so as not to cause injury to the internal part of the seed. Examples of seeds that need scarification are herbaceous legume pasture seeds, mango seeds, castor oil seeds, parchment coffee, cotton seeds, and some forest tree seeds.

(ii) Hot water scarification

This involves the use of hot water. It softens the seed coat, making it permeable to water and thus enabling it to germinate. Seeds are soaked in hot water about 100 ^{0}C for 3 - 5 minutes after which the water is allowed to drain off. The seeds are then soaked gradually in cooling water for 12 - 24 hours. The process allows some seeds to swell as an indication of breaking dormancy. The unswollen ones indicate failure to break dormancy. Thus, they will be subjected to further treatment. Examples of seeds which can be treated in this way include those of *Leucaena*, *Calliandra* and *Acacia* species.

(iii) Dry heat scarification

This involves burning the seeds slightly. Light burning also serves the same purpose as hot water scarification. There are two ways of carrying this out. It can be done by spreading seeds on a flat ground then covering them with a thin layer of soil. Dry vegetative materials or trash are then burnt on top of the soil. This process transmits the heat to the seeds underneath, causing them to crack. In turn,



it makes the seed coat soft and permeable to water. Alternatively, the hard seeds are spread on a flat ground then trash is heaped on them and burnt. Hot ashes from the burnt trash will heat the seeds below thus cracking their coats. After seeds have been burnt, they are retrieved and planted. Fire modifies the seed coats by burning away some hair coverings or melting away the resin covering the seed coat. Examples of seeds treated in this way include acacia and wattle tree seeds. Overheating should be avoided because it may destroy the seeds.

(iv) Chemical scarification

Seeds are dipped in some chemicals such as concentrated sulphuric acid for 2 minutes and then removed. This is done on dry seeds which are placed in glass, earthenware or wooden containers. Use of plastic or metal containers should be avoided as they react with the acid. The chemical wears off the seed coat making it permeable to water. Care should be taken not to leave the seeds in the chemicals for too long as this will kill the embryo. Examples of seeds treated using this method include cotton seeds. This process removes the lint or fibres on cotton seeds and the process is called delinting.

(v) Soaking in water

Seeds are soaked in water for a period of 12 - 24 hours until they swell. Seeds may be soaked up to 48 hours. However, for longer soaking, the water should be changed. If possible, seeds are soaked in running water. Soaking softens the testa and allows water and oxygen intake by the embryo. Thus, the seeds treated germinate very fast. Seeds are then removed and planted immediately. This method is commonly used when raising paddy and coffee in nurseries.

Seed dressing

This is the coating of seeds with a recommended fungicide or an insecticide or a combination of the two chemicals. This is particularly common with cereals, sugar cane and legumes. The chemicals protect the seeds and seedlings from soil-borne diseases and pests. Most of the certified seeds which are normally sold by approved seed sellers have been dressed with these chemicals. Farmers can also dress seeds on their own with an advice of recommended chemicals from agricultural extension workers. Furthermore, hot water treatment of cuttings is an effective way of controlling mosaic diseases and brown streak diseases in cassava and smut disease as well as ratoon stunting disease in sugar cane.

Legume seed inoculation

In areas where soils are deficient in nitrogen, legume seeds should be coated with an inoculant. An inoculant is a preparation which contains the right strain of rhizobia bacteria depending on the type of the legume. This encourages nodulation in legume roots during growing, hence nitrogen fixation. Examples of such legumes include common beans, cow peas, pigeon peas, green gram, soya bean, groundnut and bambara-groundnut.

When handling inoculated seeds, care should be taken to prevent them from coming into contact with chemicals. This means that inoculated seeds should not be dressed with chemicals because the chemicals will kill the bacteria. They should also be planted when the soil is moist enough to avoid dehydration which kills the bacteria.

Sprouting

This is a method of preparing vegetative materials especially tubers for planting. It involves putting the materials in a suitable environment so as to initiate root and shoot development. Sprouting is mainly done to make sure that growth commences immediately when the materials are planted. This makes maximum use of the rains for higher yield. It also ensures faster and uniform establishment of the crop.

The targeted planting materials are placed in a light and cool place but shielded from direct sunlight. The planting materials are arranged in layers of 2 or 3 tubers deep in a partially darkened room. The tubers should be arranged with the rose-end facing upward and the heel-end downward. Diffused light is then allowed to pass through. This light encourages the production of short, green and healthy sprouts as shown in Figure 8.14. Tubers with short, green and healthy sprouts are the ones which will be planted. These tubers result into good establishment and development of the crop. Sprouting in potatoes is referred to as chitting.

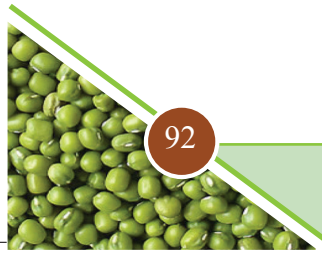


Figure 8.14: Chitting of round potato tubers

If sprouting is done in complete darkness, the sprouts that will develop may be long, pale and thin. Moreover, they may break easily during planting. During sprouting, pests such as aphids and potato tuber moths should be controlled by dusting or spraying using suitable and recommended pesticides. Sometimes, chemicals may be used to break the dormancy in tubers. Farmers have to find the recommended ones under the advice of agricultural experts.

Activity 8.2

1. Recall the list of recommended crops and others which can be grown in your area.
2. For each crop:
   (a) Identify the recommended planting material(s) including varieties.
   (b) Find out the suitable methods and techniques for preparing each of the planting materials identified.
   (c) Record all your findings in portfolio. Assess and evaluate them periodically.
   (d) Share your findings in class.

Placement of seed or planting material in the field

Placement of seed or planting material in the soil affects germination and ultimately crop stand and yields. There are several aspects to consider in placing the seed or planting material in the soil. These include spacing between and within stands, plant population and seed rate, number of seeds per stand, depth to which seeds are placed, and position of the seed with respect to the tillage operations.

Spacing between and within stands

This is the distance between successive rows and individual plants within each row, that is, distance of crop plants between and within the rows. It is commonly expressed in centimetres by centimetres or metres by metres. The spacing between and within plants or stands is largely determined by the extent of the root and shoot system of the crop plant under consideration. Spacing determines the root and shoot space available to each plant. Generally, planting crops in accurate spacing enables farmers to obtain optimum number of plants per unit area which is referred to optimum plant population. Optimum plant population, in turn, will make maximum use of the environmental factors and finally optimum yields.

As a rule of thumb, the larger the plant the greater the area required for it to perform well. Too wide spacing leads to a reduced plant population which means lower yields. Too close spacing could lead to overcrowding of plants. This may lead to competition for nutrients and other resources. Therefore, proper spacing produces yields of high quality that are acceptable in the market. When planting with machines, the spacing between and within the plants is usually adjusted to mechanical planters which can manage it.

Factors that determine spacing of crops

Spacing of crops is determined by several factors. These include the following:

(a) *Type of machinery to be used:* If machines are to be used in performing various operations in the field, the space between the rows should allow sufficient free passage depending on the kind of machinery.

(b) *Fertility status of the soil:* A fertile soil can support high plant population, therefore, closer spacing is possible.

(c) *Size of the plant:* Tall crop varieties require wider spacing while short varieties require closer spacing.

(d) *Growth habit or patterns of the crop:* Tillering and spreading crop varieties require wider spacing than erect and those which do not spread much.

(e) *Moisture availability in the soil:* Areas with optimal rainfall are capable of supporting a large number of plants hence closer spacing than areas of low rainfall.

(f) *The purpose for which the crop is intended:* For example, maize intended for silage is grown at a closer spacing than that intended for grain production. Likewise, potatoes grown for seed are more closely spaced than those grown for food which require large-sized tubers.

(g) *Whether the crop is pure stand or intercropped:* To allow intercropping, wider spacing is practised.

(h) *Number of seeds/plants per hole:* It is often recommended to have a limited number of seeds/plants per hole. If more seeds are planted per hole, wider spacing is necessary.

(i) *Proneness of field to soil erosion:* In areas where soil erosion is common, closer spacing is encouraged to minimise soil erosion. This is because closer spacing provides sufficient foliage cover of the soil.

Note: Appropriate spacing for various crop varieties has been developed in agricultural research institutions and by authorised plant breeders. Therefore, it is important for farmers to consult local agricultural extension workers or other reliable agronomists to get advice on spacing and other agricultural production practices. Moreover, spacings for most crops are summarised by the ministry responsible for agriculture in the *"Mwongozo wa uzalishaji wa mazao kulingana na kanda za kilimo za kiikolojia (2017)"*.

Plant population and seed rate

Plant population is the number of plants per unit area. It is determined by the number of stands per hectare together with the number of plants per stand. Sometimes it is termed as plant density. Optimum plant population enables plants to get enough resources they need for growth and development. Such resources include soil nutrients, moisture, light and air. This leads to high crop yields if other crop production factors are kept constant. Over-population and under-population of plants often result in reduced yields. Over-population of crops results in competition for resources whereas in under-population, the environmental resources are underutilised.

Plant population is determined by dividing the planting area by the spacing of the crop. Plant population is given by the formula:

$$\text{Plant population} = \frac{\text{Area of the land}}{\text{Spacing of a crop}}$$

The area of one hectare of land is 10 000 square metres. If the crop spacing is in centimetres, the area of the land should be converted to square centimetres. For

example, if the determinate variety of cow pea is spaced at 75 cm x 20 cm, then the plant population per hectare would be:

Note that 1 m^2 = 10 000 cm^2

$$\text{Plant population} = \frac{\text{Area of the land}}{\text{Spacing of a crop}}$$

$$= \frac{10\,000\ cm^2 \times 10\,000\ cm^2}{75\ cm \times 20\ cm}$$

$$= \frac{100\,000\,000\ cm^2}{1\,500\ cm^2}$$

$$= 66\,666 \text{ plants/ha}$$

Plant population enables a farmer to estimate seed rate of the crop under consideration. Seed rate is the amount of planting materials required for sowing/planting per unit area. Seed rate is usually measured per hectare. When planning for planting, it is always necessary to give an allowance for seeds which may fail to germinate and the young plants which may be destroyed by pests. Therefore, more seeds can be sown per hole during planting.

Factors that determine seed rate

(a) *Purity of seeds:* The presence of foreign matters in the planting materials leads to a demand for higher seed rates so as to compensate for the foreign matters.

(b) *Germination percentage of the seeds:* Seeds with lower germination percentage are required in larger amounts. Less seeds are used when their germination percentage is higher.

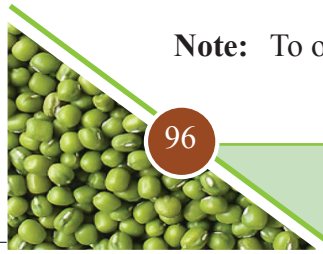
(c) *The growing habit of the crop:* Crops which have spreading habits should have lower seed rates.

(d) *Planting method:* Seeds planted through broadcast method have higher seed rates compared to drilled or row planted seeds.

(e) *Number of seeds per hole:* When two or more seeds are planted per hole, higher seed rate is required than when only one seed is planted per hole.

(f) *The purpose for which the crop is intended:* This may influence spacing of crop and hence seed rate. For example, maize grown for green manure may be more closely spaced hence higher seed rate than maize grown for grains.

Note: To obtain proper seed rate, the extension worker needs to be consulted.



Number of seeds per stand

The number of seeds sown per stand depends on the expected percentage germination of the seed and the number of plants desired per stand. The expected percentage germination is determined by prior germination tests. If the germination percentage of a particular seed is low, the number of seeds sown per stand is comparably increased. Sometimes the number of seeds sown on each stand is kept purposely high so that the number of plants emerging on each stand is higher than the desired number. When the seedlings are well established the extra plants are removed, leaving just the desired number per stand. This procedure of removing excess emerged seedlings is referred to as thinning. Intentional over-seeding and later thinning is beneficial in that it provides the opportunity to select out weak seedlings and retain the vigorous ones.

It is also advisable to ensure that every stand has the correct number of seedlings by filling the free gaps. After sowing and seed germination in the field, there could be some planting holes where seeds have failed to germinate thus creating gaps within plant rows. Likewise, after transplanting, some transplanted seedlings may fail to re-establish. The empty spaces left within the rows need to be filled. Filling of the gaps should be carried out at the right time in order to promote uniformity of crop growth in the field. It should be done within the first week of germination or transplanting. If done late, the later seedlings will be shaded by the early grown crop plants resulting in stunted growth.

Depth of planting

This is the distance from the soil surface to where the seed or planting material is placed. With some exceptions, a good rule of thumb is to plant seeds at a depth equal to 2 - 3 times their width or diameter. Therefore, the smaller the seed, the shallower the depth of planting. When seeds are planted at the correct depth, it ensures quick and uniform germination of the seeds. This leads to a uniform plant stand. However, if deviations have to be made, it is better to plant seeds in shallow depth. It is also advisable to follow seed package instructions for sowing depth or advice from agricultural extension workers.

Factors affecting depth of planting

The depth of planting is influenced by various factors. These include:

(a) *Seed size:* Larger seeds can be planted deeper than smaller ones. This is because larger seeds have more food reserve than the smaller ones. Therefore, they are able to shoot up and emerge through the soil to the surface before exhausting the reserves.

(b) *Soil type:* All other factors being constant, seeds will easily emerge from greater depths in lighter soils (for example, sandy soils) than in heavier soils (for example, clayey soils). Sowing depth can therefore be adjusted according to soil texture.

(c) *Soil moisture content:* In dry soils, deeper planting is required. This allows the seeds to come in contact with the little moisture available underneath. In wet soils, shallow planting is recommended in order to prevent rotting of the seeds.

(d) *Type of seedling emergence during germination:* Seeds with epigeal type of germination, e.g., beans, require planting at shallower depth than those characterised with hypogeal germination, e.g., maize seeds. This is because seeds with epigeal germination have to push their cotyledons to the surface and therefore have limited ability to emerge from great depths.

(e) *Ecological conditions of the area:* Shallow planting is more suitable in high altitude areas than in low altitude areas. This is because when seeds are planted deeper in high altitude areas, they inhabit cooler areas of the soil which slow the rate of germination.

Position of seeds in respect to land preparation

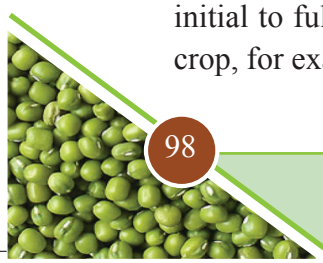
The position of the seed with respect to the tillage operations entails whether the seed is sown on the ridge or mound, on the furrow, on the slopes of the ridge, or on the flat. This depends on the nature of the crop and climatic factors. For example, under waterlogged conditions, the seeds of crops which are not water loving are normally planted on top of the mound or ridge so that they are not near or within water table. Oppositely, in very dry land areas, planting the crop in the furrow may ensure greater moisture availability.

Time of planting crops

Time of planting is essential for maximum and quality produce if other factors are constant. It is influenced by a number of factors which include rainfall, temperature, occurrence of pests, marketing of the crop and cropping system. These factors are elaborated as follows:

(a) Rainfall

Rainfall or the availability of moisture in the soil is one of the main factors which determine when a crop should be planted. As a general rule, seasonal crops should be planted at a time when there will be enough subsequent rainfall from initial to full establishment. For this reason, the planting of long-season annual crop, for example, yams, must be done at the beginning of the rainy season. This



will enable the crop to obtain sufficient moisture for its growth and development during the entire rainy season. For short-season annuals such as common beans, cow peas, sweet potatoes and maize, planting may be delayed till later in the rainy season, as long as the crop can complete its growth and development before the onset of the dry season.

Furthermore, planting has to be timed so as to let the maturity period of crops correspond with rainless periods. This is done so particularly when dry pulses or cereals are required during harvesting. For example, the sowing of cow peas, common beans, maize or millets is often timed so that the crop matures during dry period. In this case, planting should normally be done in moist soil to allow rapid seed germination. For this reason, planting is normally done within a few days after rain. However, in some areas where rainfall is scarce, dry planting is also recommended. For perennial crops, planting in the field early in the rainy season is also advisable so that the crop can become established before the dry season sets in.

(b) Temperature

In the temperate regions, this aspect is crucial, but in the tropics it is only at high altitudes where planting should be done when the soil is warm enough to permit rapid germination. In other parts of the tropics, especially in the drier regions, excessively high temperatures may seriously affect seedling emergence.

(c) Occurrence of diseases and pests

The occurrence of diseases and pests may influence the time of planting. It is advised to adjust the time of planting so that the crop is in the field during the time when diseases and pests are least prevalent. Common beans production in some parts of Tanzania, for example, has been strongly influenced by this factor. Common beans sown in the early part of the rainy season are highly affected by numerous diseases and insect pests but if sowing is delayed until the latter half of the rainy season, the incidence of diseases and insect pests can be less severe and high yield can be obtained.

(d) Marketing

Marketing consideration may also influence the time of planting. Planting is timed so that harvesting occurs when the crop can obtain a good market price. This is particularly important for vegetables and other crops which cannot be stored for long.

(e) Cropping system

The place of a crop in a rotation or in an intercropping system may determine the time of the cropping cycle it is planted. For example, where intercropping is practised, crops like cassava may usually be planted in latter part of the rainy season after the earlier intercrops such as okra and melon have been harvested. The cassava could have been planted earlier, but it is made to wait until the earlier intercrops are harvested.

Timely planting

Timely planting in crop production is very important and it is facilitated by timely land preparation. Timeliness in planting time mainly depends on how the factors you have learnt influence maturity period of a crop. Generally, proper time for planting crop is the one that enables it to get enough moisture and escape environmental stress, diseases and pests infestation. Timely planting enables crops to thrive, reproduce and their maturity to coincide with conducive environment for harvesting and post-harvest handling practices and finally fetch good market price or be in good condition for storage or processing.

When crops are planted timely, the following results can be obtained:

(a) There is maximum use of rainfall and suitable soil temperature, leading to vigorous growth.
(b) Crops benefit from nitrogen flush which is available at the beginning of the rain.
(c) Crops escape from serious pests attack.
(d) Crops establish earlier than weeds hence smothering them.
(e) Crops are harvested and marketed when prices are high particularly for the horticultural crops.

Methods of planting crops

Planting of field crops is generally carried out by several methods. These include broadcasting, row planting, drilling, transplanting, over-sowing and under-sowing.

Broadcasting

This is a deliberate random scattering of seeds on the field or prepared seedbed. It is commonly adapted for light and small seeds. For good results, the seedbed should be weed-free, firm and have a fine tilth. Crops commonly planted by this

method include paddy, wheat, sesame, some vegetables and pastures. This method is relatively easier, quicker and cheaper in terms of labour and time involved. It also gives a good ground cover. However, it uses more seeds than row planting. Moreover, the seeds are spread unevenly leading to crowding of plants in some places in the field. In addition, post-planting practices such as weeding, spraying, manure or fertiliser application as well as harvesting cannot be mechanised. Also there is high chance of competition for nutrients, water, light and air, hence low quality and quantity of produce.

Row planting

This involves planting seeds or vegetative materials with a definite or known distance between one row to the other and from one plant to the other. The planting materials are placed in holes, drills or furrows. This method is practised when planting many types of annual and perennial crops. When row planting is done mechanically and machines are set to plant seeds in well-defined distances between and within rows as well as depth and number of seeds per hole, it is referred to as precision planting. With precision planting, a precise plant population is achieved.

Advantages of row planting

(a) It is easy to establish the correct plant population.
(b) It ensures maximum productivity and high yield.
(c) Low seed rate is used compared to broadcasting method.
(d) Machines can easily be used between the rows.
(e) It is easy to carry out some after-planting operations such as weeding, manure or fertiliser application, spraying and harvesting.

Challenges of row planting

(a) It does not provide sufficient foliage cover, hence the soil may easily be eroded by moving water and wind.
(b) It requires some skills in measuring the distances between and within the rows, if done manually.
(c) It is relatively expensive in terms of labour and time, if it has to be done manually. Owning or hiring a row planter for doing it mechanically may also be expensive.

Drilling method

In this method, seeds are placed in shallow furrows created manually or mechanically and then buried. The spacing between plants may not be regulated.

Many field crops are planted using this method including paddy, wheat, sesame/ simsim, some vegetables and pasture grasses. When drilling is done mechanically, the seed drill sows the seeds at equal distances between rows and proper depth, ensuring that the seeds get covered with soil and are saved from being eaten by birds. Drilling method can save time and less seeds are wasted compared to broadcasting method. Moreover, it is easy to carry out some operations manually or by machines after planting. These operations include weeding, manure or fertiliser application, spraying and harvesting. However, the method may be expensive for small farmers to afford owning or hiring machinery for drilling. Also, there is a need for a skilled operator who can maintain the machine and carry out the operation.

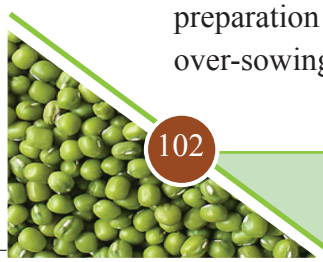
Transplanting

Some crops are first raised in the nursery and later transplanted into the main seedbed where they mature and complete their growth cycle. For example, seeds of tobacco, tomato, pepper, and many vegetable and fruit crops are first raised in the nursery before being transferred to the field. Paddy and sorghum are also transplanted in some instances. Transplanting has the advantage of reducing wastage of seeds and offer farmers the chance to transplant only healthy and vigorous seedlings for best results. However, it is time and labour consuming.

Over-sowing

This is the introduction of new and always better pasture species such as legumes in an existing grass pasture. Before over-sowing, the existing cover needs to be reduced in height and population. This can be achieved through hoof cultivation by grazing livestock that walk during grazing. This, in turn, enables the over-sown seeds to drop directly into the ground. The livestock should also be allowed to walk on the field after sowing so as to tread the seeds into the soil. Thereafter, the grazing livestock should be removed when the seeds start to germinate. Alternatively, the existing cover can be burnt at the end of the dry season or cleared by mechanical mower before over-sowing.

Over-sowing is advantageous as it promotes mixed stand of pasture establishment for better livestock feed. Moreover, the use of nitrogenous fertilisers is minimised due to the presence of legume pastures. It also saves the cost of extensive land preparation since only a minimal preparation is required before sowing. With over-sowing, however, there is wastage of seeds of the over-sown crop as some



seeds will land on the spaces where the earlier established crop is growing. Some of the seeds may be smothered off or fail to germinate due to competition. Furthermore, over-sowing is mostly limited to establishment of pasture crops.

Under-sowing

This is the sowing of a crop preferably leguminous pasture in a field which is already planted with a crop such as maize, sorghum, or bulrush millet. In this method, the first crop is planted and then allowed to establish where necessary operations such as weeding and fertiliser application are normally done. After the last weeding, the second crop's seeds are then sown and no further weeding is done. The already planted crop provides shade to the tender under-sown crop as it germinates and establishes before being exposed to harsh environmental conditions. The first crop is harvested early to expose the young second crop seedlings to sunlight. The benefits of under-sowing include facilitating more intensive land utilisation. Moreover, it encourages an early establishment of pastures or any second crop involved due to conducive environment created by the first crop. However, competition between the two crops for moisture and nutrients may occur. Also, damage to the under-sown crop during harvesting of the first crop may occur.

Activity 8.3

Perform the following tasks.

1. By using library search and consulting resource persons, work out on the list of recommended crops and others which can be grown in your area to find out the following for each of the crops:
   (a) Correct spacing
   (b) Recommended plant population
   (c) Seed rate or amount of planting materials required per hectare
   (d) The factors influencing planting time
   (e) An accurate time for planting
   (f) Proper method(s) for planting
2. Record all your findings in your portfolio and share them in class.
3. With reference to the factors in 1(a) - (f) above, demonstrate how you can plant materials of crop(s) of your choice in your school and home.

4. With assistance from your teacher, establish and maintain crop museum in selected area at your school. The museum should contain all the recommended crops and others which can be grown in your area. Refer to *"Mwongozo wa uzalishaji wa mazao kulingana na kanda za kilimo za kiikolojia (2017)"* set by the ministry responsible for agriculture.
5. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What is meant by "timely planting"? Why timely planting of crops is highly emphasised?
2. Identify five factors to be considered in determining time for planting a particular crop.
3. List down four advantages and challenges of using seeds in planting crops.
4. State four strengths and shortfalls of using vegetative materials for planting crops.
5. You have visited your aunt who is eager to carry out field crop production in her locality but she doesn't know how to select the best planting materials. What will you advise her to adhere to in selecting the materials? Summarise the advice you will give her by considering at least five major criteria.
6. What do you understand by the term "spacing in planting crops"? Why is it important?
7. Why is the number of plants per stand an important consideration during planting of crops? How this number is maintained?
8. With examples, explain why the position of seeds or planting materials in respect to land preparation is an important factor to consider during planting crops?
9. (a) What depth is generally considered optimum in planting crops?
   (b) Describe five factors influencing depth in planting of crops.
   (c) It is advisable that if deviations have to be made in planting depth, it is better to plant seeds too shallow than too deep. What is the major reason(s) for this advice?
10. (a) List six methods commonly used in planting of crops.
    (b) For each method, identify the most suited crops.
    (c) Outline the strengths and weaknesses of using each method.

Chapter Nine

Maintenance of soil fertility for crop production

Introduction

The supply of plant nutrients and maintenance of its level in the soil is an essential principle in crop production. In this chapter, you will learn about the meaning of soil fertility, roles of plant nutrients in plant growth and production and its deficiency symptoms. You will also learn about the causes of loss of soil fertility, methods of maintaining soil fertility and finally you will carry out soil fertility conservation practices. The competencies developed from this chapter will enable you to supply and conserve soil nutrients so as to ensure good growth of crop plants and high yields.

The meaning of soil fertility

Soil is among the most important land resource components in crop production. Apart from providing anchorage to the plants, air and water; it also provides nutrients for proper growth and production of crops. The supply of plant nutrients must be adequate for crop plants to grow well and produce high yields. The soil which is able to supply plants with adequate nutrients is said to be fertile. Therefore, soil fertility is the ability of the soil to provide crop plants with the required nutrients in proper proportions for optimal production. A decrease in amount or deficiency of nutrients needed by crop plants affects growth leading to low yields.

Plant nutrients

The most important characteristics of a fertile soil is the ability to supply nutrients needed to be taken by plants. Sixteen nutrients are essential for normal growth of plants. These nutrients have to be supplied to plants in sufficient quantities and in good proportions. Some of these nutrients originate from air, others from water but most of them originate from the soil.

Some nutrients are required by plants in large quantities while others are required in very small quantities. Those which are required in large quantities are termed as macro-nutrients while those which are required in small quantities are called micro-nutrients or trace-nutrients. Plant nutrients are also called elements. Figure 9.1 shows the classification of plant nutrients.

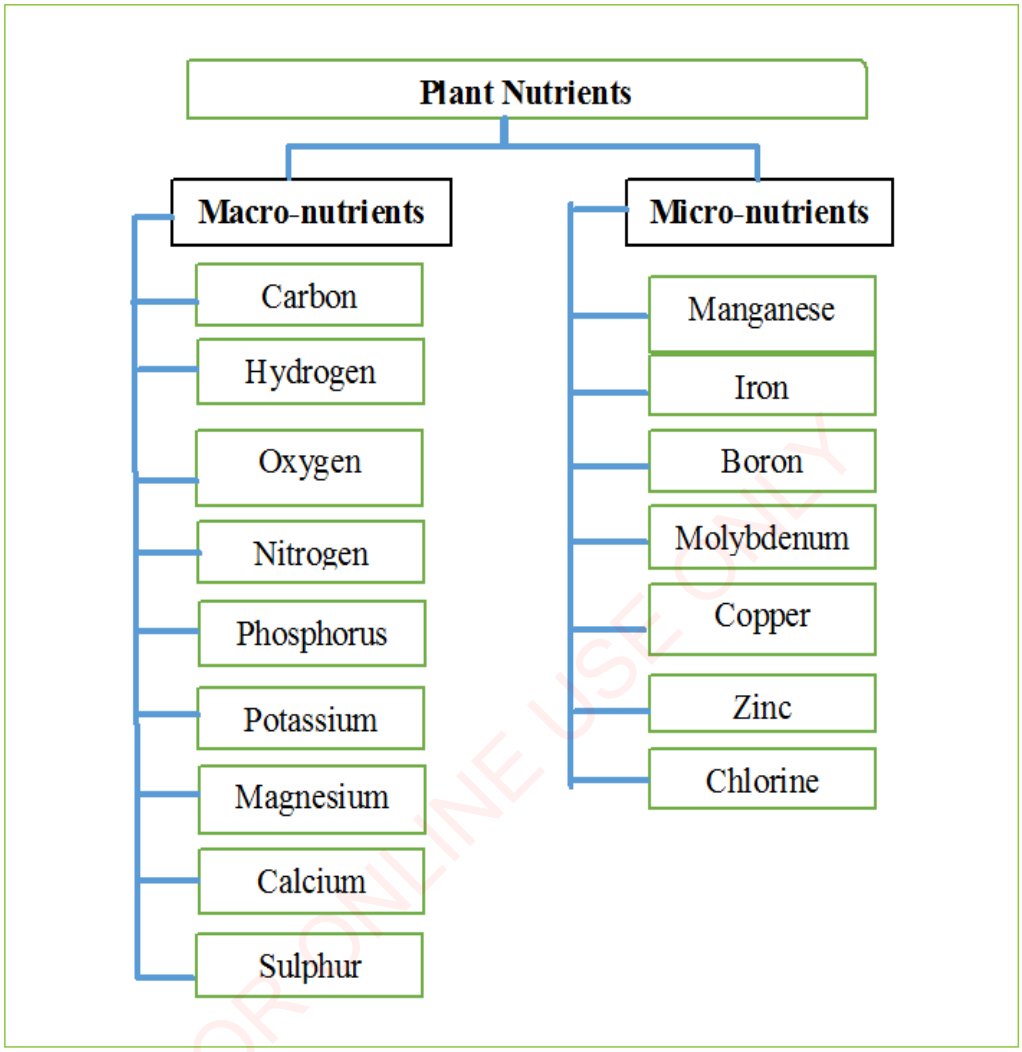


Figure 9.1: Classification of plant nutrients

Macro-nutrients include carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, magnesium, calcium and sulphur. The macro-nutrients are further classified into basic, primary and secondary nutrients. Carbon, oxygen and

hydrogen are basic macro-nutrients. Nitrogen, phosphorus and potassium are primary macro-nutrients while magnesium, calcium and sulphur are secondary macro-nutrients. With exception of carbon and oxygen which are obtained by plants from air, the rest are obtained from soil.

Micro-nutrients consist of manganese, iron, boron, molybdenum, copper, zinc, and chlorine. All these nutrients are obtained by crop plants from the soil. Some of the nutrients which are obtained from the soil such as nitrogen, manganese, boron, copper and zinc can also be absorbed by crop plants through leaves. Thus, these nutrients can be applied in solution to crop plants as foliar fertiliser.

Functions of nutrients in plants

The functions of each plant nutrient as well as its deficiency symptoms are covered herein. It is important to note that excessive supply of some nutrients in the soil may have some harmful effects.

Carbon, hydrogen and oxygen: Carbon is a constituent in all tissues of living organisms. Plants take in carbon in the form of carbon dioxide from the atmosphere through stomata. In the presence of sunlight and water, the green parts (chlorophyll) of the plant convert carbon dioxide into carbohydrates through the process called photosynthesis. To ensure continuous supply of carbon, there is a natural continuous circulation of carbon through plant tissues, animal tissues and atmosphere. This circulation is known as carbon cycle. Hydrogen and oxygen are both taken in by plants in the form of water. Water is necessary for the life of plants. In addition, it functions as a solvent for various substances and it is involved in many other physiological functions of the plant. Without water in the soil, plants wilt and die. Oxygen is also needed for respiration.

Nitrogen: Naturally, nitrogen occurs as a gas (N_2) in the atmosphere. However, nitrogen can only be absorbed by plants in ionic form, either in form of nitrate ions (NO_3^-) or ammonium ions (NH_4^+). From the atmosphere, nitrogen gets into the soil through the process of nitrogen fixation by micro-organisms and lighting. Like carbon, there is a continuous circulation of nitrogen through plants, animal tissues, and atmosphere. Thus, the continuous circulation of nitrogen through plants and animal tissues as well as atmosphere is called nitrogen cycle.

Nitrogen is necessary for the formation of chlorophyll and proteins. It is essential for plant cell division and vital for plant growth. Nitrogen is also necessary for vegetative growth hence it improves leaf quality in leafy crops such as tea and cabbages. Deficiency symptoms of nitrogen are associated with yellowing of the leaves which is termed as chlorosis (refer to Figure 9.2). Chlorosis tends to appear first on older leaves, while the younger leaves remaining green. Deficiency symptoms of nitrogen are also associated with stunted growth, premature shedding of leaves, premature ripening and light seeds. Excessive supply of nitrogen to crop plants is characterised by excessive vegetative growth, delayed maturity as well as low yield and quality of grains and fruits.

Figure 9.2: Chlorosis due to nitrogen deficiency

Phosphorus: Phosphorus exists in the soil either in inorganic or organic form. It is absorbed in form of phosphate ions. Phosphorus encourages fast growth of roots, improves the quality of plant, hastens maturity of crops, influences cell division and stimulates nodule formation in legumes. Deficiency symptoms of phosphorus include slow growth of plant and discolouration of leaves to grey or purple colour (refer to Figure 9.3). The deficiency of phosphorus is also characterised with delayed maturity and lowered yield of grains, fruits and seeds.

Figure 9.3: Discolouration due to phosphorus deficiency

Potassium: It is abundantly found in clay soils since it is a constituent element of clay particles. It is absorbed by plants in form of potassium ion (K^+). Potassium is readily leached in sandy soils. Potassium increases plant vigour and disease resistance, increases the size of grains and seeds and reduces ill-effects due to excess nitrogen. Potassium also prevents too rapid maturation due to excess phosphorus.

The deficiency of potassium is characterised with short joints and poor growth of plants, lodging of plants before maturity and development of a burnt appearance

on the leave margins. In cereals, a burnt appearance starts at the tip of the leaf and continues from the edge usually leaving the midrib green (refer to Figure 9.4). Moreover, when potassium is deficient, leaves at the lower end of the plant become mottled, spotted or streaked.

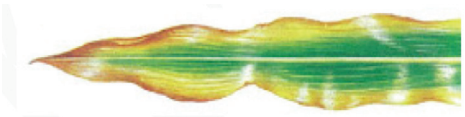


Figure 9.4: Leaf scorch due to potassium deficiency

Magnesium: Magnesium is needed by plants in relatively smaller quantities than nitrogen and potassium. It is absorbed as magnesium ion (Mg^{2+}). Magnesium is readily leached in soils that receive a high amount of rainfall. However, most soils have large reserves of magnesium, enough to meet crop requirements. Where deficiencies occur due to mineral depletion, magnesium lime or farmyard manure that contains magnesium, may be added.

Magnesium in plants forms part of chlorophyll. Magnesium promotes the growth of the soil bacteria and enhances the nitrogen fixing power of the legumes. It also activates the production and transportation of carbohydrates and proteins in the growing plant. The deficiency of magnesium is characterised with loss in green colour which starts from the bottom leaves and gradually moves upwards. The leaves also become streaked. The veins remain green and curve upwards along the margins (refer to Figure 9.5). Moreover, stalks become weak and the plant develops long branched roots.

Figure 9.5: Magnesium deficiency symptom

Calcium: Soil calcium is derived from rocks through the process of weathering and it is absorbed as calcium ions (Ca^{2+}). Calcium improves the vigour and stiffness of straw and it neutralises the poisonous secretions of the plants. It also helps in grain and seed formation. Furthermore, calcium reduces soil acidity hence promotes bacterial activities in the soil. When there is a deficiency of calcium, terminal buds of shoots and apical tips of roots will fail to develop and

therefore growth of the plant stops. This deficiency symptom is termed as drying back of plant tips. Also there are light green bands along the margins of leaves. Moreover, plants shed or drop buds and flowers prematurely. Figure 9.6 shows the deficiency symptoms of calcium.

Figure 9.6: Calcium deficiency symptoms

Sulphur: It exists in the soil in form of organic sulphates or inorganic form. Plants absorb sulphur in form of sulphate ions (SO_4^{2-}). Sulphur is an essential part of proteins. Sulphur also helps to develop enzymes, vitamins, oil contents and seeds. When there is deficiency of sulphur, plant growth is retarded, plants become thin stemmed, rigid, brittle and stunted. Also there is poor nodulation in legumes. Younger leaves become yellowish green or chlorotic (refer to Figure 9.7)

Figure 9.7: Sulfur deficiency symptoms

Manganese: It is necessary for the formation of chlorophyll. It is associated with copper and zinc metabolism. It acts as catalyst in many metabolic reactions such as respiration and synthesis of chlorophyll. When there is deficiency, veins of young leaves remain green while areas between veins become chlorotic (refer to Figure 9.8). The loss of colour is often followed by the development of dead tissue spots (necrosis) and dead spots may drop off giving the leaf a perforated appearance.

Figure 9.8: Manganese deficiency symptoms

Iron: It is essential for the formation of chlorophyll. It is a constituent of various enzymes, thus, it takes part in various metabolism processes, for example, respiration, reduction of nitrates, sulphates, and photosynthesis in plants. When there is deficiency, young leaves of plants first become chlorotic in area between veins. If deficiency continues, the leaves turn completely white (refer to Figure 9.9). Sometimes, leaves may curve in an upward direction, in the same way it happens in cabbage.

Figure 9.9: Iron deficiency symptoms

Boron: It is required for the formation of flowers, fruits and roots. Boron is also necessary for the translocation of substances within plant. It regulates the potassium/calcium ratio in plants and it is essential for protein synthesis. When there is deficiency, the younger leaves become pale green in colour especially at the bases. Growing points of plants become deformed and stop growing and later on, they die (refer to Figure 9.10). Also, there is change in colour at the tips of the growing shoots. The terminal bud becomes light green with traces of reddish-brown. It may cause the shoot tip to die and flowering may fail to occur. An excess of boron causes death of older leaves while the growing points remain normal. It is also important to note that boron requirement in plants is extremely small and a slight increase over the required amount will result in severe toxicity.

Figure 9.10: Boron deficiency symptoms

Molybdenum: It is required by rhizobia bacteria for nitrogen fixation in legumes. It is also required for nitrate reduction in plants. When there is deficiency, areas of leaves between veins can become chlorotic (refer to Figure 9.11). Leguminous plants normally turn yellow and become stunted. Molybdenum is required by plants in a very small amount. Any excess may be toxic both to plants and animals which graze in the fields with excess molybdenum.

Figure 9.11: Molybdenum deficiency symptoms

Copper: It is an activator or catalyst for various chemical reactions within the plant. It promotes formation of vitamin A. It also regulates the functions of nitrogen and it is important in the utilisation of iron by plants. Generally, when there is deficiency, leaves turn yellow and plants become stunted. However, the deficiency symptoms of copper vary from one type of plant to another. For example, citrus fruits show die back of new shoots and the stem is marked with a reddish brown gummy secretions. Cereals show chlorotic leaf tips and failure to set seeds. Figure 9.12 shows the deficiency symptoms of copper.

Figure 9.12: Copper deficiency symptoms

Zinc: It acts as an activator or catalyst in many chemical reactions in plants. It helps in the formation of growth hormones. It is involved in the reproduction processes of certain plants. It plays a role in protein synthesis. In addition, it aids the utilisation of nitrogen and phosphorus in plants. When there is a deficiency, symptoms appear first on the younger leaves as interveinal chlorosis followed by reduction in the rate of growth of shoots. This leads to rosetting, that is, short and bunchy growth habit due to shortened internodes with no comparable reduction in leaf size. In sorghum and maize, a band of bleached tissue occurs on each side of the midrib while leaf margins remain green (refer to Figure 9.13). This is called white band. Therefore, white band can be defined as a condition resulting from zinc deficiency where sides of the midrib of cereal crops are bleached while leaf margins remain green. Also there is delayed maturity of plants uniformly in the field.

Figure 9.13: Zinc deficiency symptom

Chlorine: Plants take up chlorine as the chloride (Cl^-) ions. Chlorine is key in stomatal regulation. It helps plants to adjust to changing water availability especially during stressful dry periods. Chlorine is also important in chemical breakdown of water in presence of sunlight during photosynthesis. It also activates several enzyme reactions in plants. Furthermore, chlorine supports the transport of nutrients such as calcium, magnesium and potassium within a plant. Chlorine deficiency shows up as discoloured yellow spot on leaves which first appears in young leaves (refer to figure 9.14). Excess of chlorine is detrimental for crops such as potatoes and tobacco. In both of these crops, leaves become thick. Also the burning and keeping quality of tobacco is lowered.

Figure 9.14: Chlorine deficiency symptoms

Activity 9.1

1. (a) With assistance of your teacher and other resource persons, find out the deficiency symptoms of each plant nutrient in each of the crops recommended to your area as well as other crops which can be grown in your area.

   (b) Record all the findings in your portfolio.

2. Pay visits to various farms so as to observe and get familiar with the symptoms of plant nutrient deficiencies in your area. Prepare a visit report and share it in class. Alternatively, collect plants or plant parts exhibiting deficiency symptoms of nutrients you have learnt. Display them in an appropriate place and observe them so as to gain familiarity with the symptoms. If possible, take pictures and store them electronically or by physical means using the available facilities or materials. Record your observations in your portfolio.

Exercise 9.1

Answer the following questions.

1. What do you understand by the term "soil fertility"?
2. Outline five characteristics of a fertile soil.
3. List sixteen nutrient elements that are essential for normal plant growth.
4. Differentiate between "macro-nutrients" and "micro-nutrients".
5. Give five reasons why it is important to have a good supply of available phosphorus and potassium in the soil?
6. State the deficiency symptoms in plants for the following nutrient elements:
   (a) Nitrogen
   (b) Calcium
   (c) Potassium
   (d) Iron
7. What are the effects of excessive supply of the following nutrient elements to plants:
   (a) Nitrogen
   (b) Chlorine
   (c) Boron

8. What do you understand by the following terms, as far as the deficiency symptoms of nutrient elements in crop plants are concerned:
   (a) Chlorosis
   (b) Die back
   (c) Leaf scorch
   (d) White band
   (e) Rosetting

Causes of loss of soil fertility

The soil loses fertility in several ways. The most common causes of loss of soil fertility include soil erosion, burning of vegetation cover, water logging, leaching, flooding, and crop removal through continuous cropping and grazing. Others include weeding and weeds removal, mono-cropping, change in soil pH led by some agronomic practices, accumulation of salts, volatilisation and being used up by soil micro-organisms. These causes of loss in fertility are explained herein.

(a) Soil erosion

Soil erosion is the carrying away of the top soil by moving water or wind and being deposited in another place which was not intended. Since top soil is the most fertile, it means that when erosion occurs, the remaining soil becomes less fertile.

(b) Burning of vegetation cover

When the vegetation cover is burned on the surface of the soil, organic matter is destroyed. Since the protective layer of vegetation is lost, the ground is exposed to agents of soil erosion, that is, moving water and wind thus making the land prone to erosion. In addition, organic carbon, nitrogen, phosphorus and sulphur which are present in the vegetation, also get destroyed. Only a few minerals such as potassium remain in the ash. Moreover, such minerals can easily be taken away by moving water and wind then erosion occurs hence loss of fertility.

(c) Water logging

This occurs when all the air spaces in the soil become filled up with water. In water logged soil, almost all the air is removed from the soil. This leads to failure of plant roots to get oxygen which is important for respiration. Thus, plant growth is impaired and plants may die if water logging continues.

(d) Flooding

This occurs when the soil becomes filled up with excessive amounts of water. If there is a slope, flood moves from high areas to low areas with a high speed. In that way, nutrients are carried away together with water.

(e) Leaching

This is the loss of water-soluble plant nutrients from the soil due to rain and irrigation. The nutrients are dissolved and are then carried downwards in the soil profile, away from the plant root zone. Leaching is common during heavy rains. When this happens, the plant roots cannot absorb the nutrients.

(f) Crop removal through continuous cropping and grazing

When crops are harvested, nutrients which were absorbed by plants from soil are taken away. Similarly, grazing animals eat large amounts of grasses and legumes which contain large amounts of plant nutrients. Therefore, continuous cropping and harvesting cause a continuous loss of nutrients from the soil. The same applies to continuous grazing.

(g) Weeding and weeds removal

Weeds are plants that grow in a place where they are not wanted. Uprooting weeds and taking them away from the field lead to loss of nutrients they had absorbed from the soil. It is, therefore, advisable, if possible, to allow weeds which have been uprooted to decompose to humus on the field rather than throwing them away. However, troublesome weeds should be removed.

(h) Mono-cropping

This is the practice of growing one type of crop on a piece of land annually. It is also called monoculture when the same crop is grown on the same field repeatedly. The crop grown uses only those nutrients it needs while other nutrients remain unused. This results in exhaustion of some nutrients leading to their deficiency in the following seasons/years. In addition, the crops grown exploit nutrients from a certain zone where roots can reach thus the soil in that zone becomes infertile, as far as that particular crop is concerned. This result into low yields.

(i) Change in soil pH led by some agronomic practices

Change in soil pH may be brought by continuous use of fertilisers. For instance, the application of acidic fertilisers in an area over a long period of time may

lower soil pH. Similarly, the application of basic fertilisers for extended periods would raise the soil pH. Changes in soil pH influence the activity of soil micro-organisms as well as the availability of soil nutrients.

(j) Accumulation of salts

Soil water usually contains dissolved mineral salts which come from the parent rock. Other salts may come from the decomposition of organic matter. Under normal circumstances, salts are washed away by rain water thus keeping their concentration low in the soil. However, in arid and semi-arid areas, rainfall is irregular and insufficient to remove salts from the soil. This, together with high evaporation rates and poor natural drainage, results in salt accumulation on or below the soil surface. Soils with a lot of salts are said to be saline and the state of having too much salts in the soil is termed as soil salinity. Too much salt in soil causes water deficiency in plants as water moves out of roots under the osmotic pressure of the salt solution. In addition, the accumulation of salt in the soil may lead to change in soil pH. Therefore, salt accumulation in the soil leads to loss of soil fertility.

(k) Volatilisation

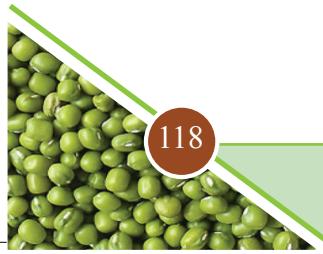
Some mineral nutrients are lost through volatilisation. This is especially the case with nitrogenous compounds which are volatised when applied in hot weather.

(l) Being used up by soil micro-organisms

Some living micro-organisms in soil take up different mineral nutrients for their nourishment.

Activity 9.2

Perform the following tasks.
(a) Find out the major causes of loss of soil fertility in your area.
(b) Record all the findings in your portfolio.
(c) Present your findings in class.



Exercise 9.2

Answer the following questions.

1. (a) Why accumulation of salt is common to soils found in arid and semi-arid areas?
   (b) How does too much salts in the soil cause loss of fertility?
2. (a) What agronomic practices may lead to change in soil pH?
   (b) How does change in soil pH reduce soil fertility?
3. "Mono-cropping is considered as one of the causes of loss of soil fertility". What justification can you give on this statement?
4. Briefly, explain how soil erosion can cause loss of soil fertility.
5. Waterlogging, flooding and leaching are among the causes of loss of soil fertility.
   (a) What does each of them mean?
   (b) Show how each of them causes loss of soil fertility.
6. Describe briefly how continuous removal of crops causes loss of soil fertility.
7. "It is not advisable to burn vegetation cover". In view of soil fertility, discuss this statement briefly.
8. Under what circumstances do weeds and weeding cause loss of soil fertility?

Methods of maintaining soil fertility

There are three broad methods of maintaining soil fertility. These are:

(a) Use of good agronomic or cultural practices
(b) Use of materials containing organic matter to the soil
(c) Use of materials containing plant nutrients in a concentrated form to the soil

Use of good agronomic practices

Basically, the use of good agronomic practices maintains a reasonable level of organic matter in the soil. Good agronomic practices act in one way or the other against the cause(s) of loss of soil fertility. There are various agronomic practices which can be adopted to meet these purposes. These practices include crop rotation, mulching, cover cropping and intercropping, contour farming, strip cropping, use of grass strips, afforestation, re-afforestation and use of windbreaks, agro-forestry, rotational grazing, avoiding excessive cultivation as well as use of proper spacing and proper grazing.

Crop rotation: This is a practice of growing a different type of crop on the same piece of land in each year or growing season, using a set pattern. Crop rotation is beneficial in that by inclusion of legume in rotation as well as rotating heavy feeder with light feeder crop plants on the field, the level of nutrients in the soil is maintained at a reasonable level. Also, by rotating shallow-rooted crops with deep-rooted crops, nutrients at different depths in the soil are fully utilised. This is because shallow-rooted plants absorb nutrients from the upper layers of the soil while deep-rooted crops absorb nutrients from the lower layers of the soil profile. In addition, inclusion of legumes and fallow periods in rotations helps in increasing and maintaining soil fertility.

Activity 9.3

1. (a) Find out several possibilities for rotating the crops recommended for your area.
   (b) List all the possible rotation cycles.
2. (a) Identify the challenges you can face in each possible rotation cycle.
   (b) Explain how each challenge would be solved.
   (c) Share your findings in class.
3. Summarise your findings in your portfolio.
4. Of the possible rotations you have listed in 1(b), choose one and practice it in your school farm in groups and under the guidance of your teacher. Record all the work proceedings in your portfolio. Assess and make reflections on your work done at mid and end of every season in the rotations.

Mulching: It is the practice of covering the soil with a layer of grass, straw or plant remains (refer to Figure 9.15 (a)). Opaque polythene sheets can also be used (see Figure 9.15 (b)). Where the grass straw is used, it is advisable to make sure that the material is free from seeds so as to prevent weed invasion. Mulching is mainly used in vegetable gardens and plantations such as orchard trees and pineapples. Mulching helps to conserve moisture in soil by preventing or reducing evaporation of moisture from the soil. Also it helps to reduce loss of soil by erosion, to control weeds particularly the ones with broad leaves and regulate soil temperatures. Moreover, when mulch decomposes, it adds organic matter to the soil. It is worth to note that polythene sheets can decompose but they cannot yield or add organic matter to the soil.

(a) Grass mulch

(b) Polythene sheet mulch

Figure 9.15: Mulch in the field

In spite of the benefits, mulching has some challenges. If the soil is deficient in nitrogen and mulch is low in nitrogen, much of the soil nitrogen is used by soil micro-organisms which break down the mulch. This means that the soil organisms may compete with plants for nitrogen. Consequently, plants fail to get sufficient nitrogen from the soil. Mulch may also be attacked by termites or catch fire that may lead to destruction of the crop. Furthermore, extra land may be needed to produce mulch if it is required in large quantities. Likewise, heavy work is involved in carrying and spreading mulch. Moreover, if the mulch has seeds, they may germinate hence lead to problems of weeds. Mulch may also carry or harbour pests.

Activity 9.4

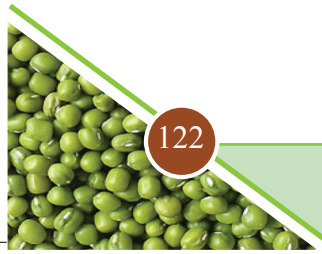
1. Explain how mulching can be practised for conserving soil fertility in your area.
2. (a) Identify the challenges you can face in conserving soil fertility by mulching in your area.
   (b) Outline how you would solve each of the identified challenge.
   (c) Share your responses in class.
3. Summarise your findings in your portfolio.
4. Practise mulching in your school garden.

Cover cropping and inter-cropping: Cover cropping involves the establishment of a crop that spreads out over the empty spaces between rows of plants specifically to cover the soil surface of a particular space. Crops that are suitably used as

cover crops include sweet potatoes, spreading varieties of beans, cow peas and spreading leguminous pastures. A good cover crop should not compete with the crop plants for nutrients, water and rooting space or light in case of climbers. Also it should be drought resistant and able to grow well even on poor soils. Moreover, it should not be an alternative host of insect pests and/or other disease causing organisms. Cover crops protect the soil from evaporation and therefore improve the infiltration of water into the soil. Since most of cover crops are legumes, they help to improve the nitrogen content of the soil. This is because the bacteria rhizobia living in the root nodules fixes nitrogen from the atmosphere. Furthermore, when remains of cover crop decompose they add organic matter in the soil.

Inter-cropping involves planting two crops in the same field so as to provide adequate ground cover. Crops with little cover should be inter-planted with legumes or other crops which give good ground cover. In using cover cropping and intercropping, crops can also be planted on ridges along the contours. Ridges trap rain water and hold it in furrows so that it can infiltrate into the soil. This water is also used by crop plants. Figure 9.16 shows sections of maize field intercropped with a leguminous cover crop.

Figure 9.16: Maize intercropped with leguminous cover crop



Activity 9.5

1. Explain how cover cropping can be practised for conserving soil fertility in your area.
2. (a) Identify the challenges you can encounter in conserving soil fertility by cover cropping in your area.
   (b) Outline the means at which each challenge can be solved.
3. Share your responses in class.
4. Summarise your findings in your portfolio.
5. Practise cover cropping in your school farm under the guidance of your teacher.

Contour farming: In contour farming, all operations are done along the contour. Tillage and planting are done across the hill to create ridges on the land which holds up water and prevents erosion by reducing water run-off. The decreased run-off in contour farming permits better retention of the nutrients leading to increased yields. Contour farming reduces erosion on gentle slopes and it includes contour ridging and contour planting where crops are grown on the ridges. Crops which cover the soil can be alternated with row crops like maize which are less effective soil covers. Figure 9.17 shows an example of contour farming.

Figure 9.17: An example of contour farming

Strip cropping and use of grass strips: Strip cropping is a method of farming which involves cultivating a field partitioned into long, narrow strips which are alternated in a crop rotation system. It is used when a slope is too steep or when

there is no alternative method of preventing soil erosion. Crops which give little cover such as maize are grown in alternate strips with those having good ground cover such as sweet potatoes. Strips of grass can also be included. Different strips control the movement of soil particles hence help in controlling soil erosion thus maintaining soil fertility.

Grass strips are uncultivated strips measuring at least 1 - 2 metres wide along the contour between the cultivated strips. These strips are normally of grass however, legumes may be used. Figure 9.18 shows the use of grass strips in farming across the contour.

Figure 9.18: An example of grass strips

The distance between one strip and another depends on the degree of slope of the land. Grass strips minimise erosion by reducing the speed of flowing water thus maintaining soil fertility. Also they filter out soil as a result, they gradually form terraces after several years of existence. Grass strips can also be used as livestock fodder. However, the major challenge of grass strips is that they limit machine use and may increase pest infestation and disease spreading as they may harbour certain pests.

Afforestation, re-afforestation and use of windbreaks: Afforestation is the planting of trees in an area where trees had never existed and re-afforestation is planting of trees where trees or forests have been cleared. The planting of trees plays a big role in soil fertility conservation by controlling soil erosion. Moreover, trees which act as wind breaks, apart from controlling soil wind erosion, they protect crop plants from potential wind damage, improve the soil

micro-environment for increased plant yield, manage rainfall water dispersion, and improve irrigation efficiency. Figure 9.19 shows the trees which serve as wind breaks. Windbreaks refer to a single or several rows of trees or shrubs in linear configurations perpendicular to the predominant wind direction.

Figure 9.19: Wind-breaks

Agro-forestry: Agro-forestry is a collective term used to cover a variety of land use that combines tree growing, pasture and crop production practices on the same piece of land. This is done for the purpose of increasing or improving the output of the soil. In agro-forestry, the planting of trees and shrubs is purposely done in association with other farm enterprises. In addition to enabling the farmer to grow trees for various uses, keep livestock and produce agricultural crops. This system of land use has an important role to play in soil and water conservation.

Use of rough tillage and minimum tillage: During tillage, the soil surface should be kept as rough as possible to absorb rain water. This is because excessive tillage tends to break down soil structure and destroy organic matter. Therefore, good tillage operations is the one that greatly conserve the soil. Minimum tillage can be achieved by direct drilling into undisturbed soil. The soil can be loosened only where the seed is sown. The control of weeds is done by other means than cultivation, for example, by slashing or using herbicides. Moreover, cover crops can be planted during dry or off season thereafter they are uprooted. This provides a mulch to soil thus maintaining soil fertility. Figure 9.20 shows examples of minimum tillage.

Figure 9.20: Examples of minimum tillage

Use of proper spacing: Correct spacing of crops also serves as soil fertility conservation measure. This maintains a closer vegetative cover over the soil hence reduces soil erosion.

Use of proper grazing: Where livestock is kept, particularly in drier areas where nomadic herding is practised, special care must be taken to prevent overgrazing. Overgrazing also leads to excessive removal of nutrients from the soil. This is because overgrazing can destroy grass and allow erosion to take place. Therefore, controlled or rotational grazing can be used to allow pastures to recover after each period of grazing. For rotational grazing, fencing in paddocks is required to ensure proper grazing control.

Activity 9.6

1. Explain how contour farming, strip cropping, grass strips, wind breaks, minimum tillage and agro-forestry can be practised for conserving soil fertility in your area. Summarise your responses and share them in class.
2. (a) Identify other agronomic practices of maintaining soil fertility used in your area.
   (b) Explain how each of the agronomic practices can be practised.
   (c) Identify the strengths and challenges of each practice.
   (d) Explain how each of the challenges can be solved. And, if those challenges can be solved differently, explain the reason why you think so.
   (e) Share your responses in class.
3. Of the practices worked out in task 1 above, choose those practices that seem to be possible and practical in your school and practice them under the guidance of your teacher.
4. Highlight the lessons that you have learnt about conserving soil fertility by using agronomic or cultural methods and record the lessons in your portfolio.

Exercise 9.3

Answer the following questions.

1. What do you understand by the term "mulching"? How does it maintain soil fertility?
2. (a) What does it mean by "crop rotation"?
   (b) How does crop rotation maintain soil fertility?
3. Cover cropping and inter-cropping are both considered as agronomic methods of maintaining soil fertility. Compare and contrast between the two.
4. What do you understand by the term "contour farming"? How should it be practised to maintain soil fertility?
5. In conserving soil fertility by agronomic practices, great emphasis is put on maintaining a reasonable level of organic matter in the soil. What is the importance of organic matter in conserving soil fertility?

Use of materials containing organic matter to the soil

These materials are collectively termed as organic manures or natural manures or organic fertilisers. They improve the level of organic matter when added to the soil. They also add plant nutrients to the soil thus improving fertility of the soil. Generally, organic matter is important in the soil in several ways including the following:

(a) It supplies nutrients such as nitrogen, phosphorus and potassium which are required by growing plants. Mineral elements present in the organic matter are released when soil organisms act on them in the process called mineralisation. As a result, the elements which are released into the soil can then be taken in by plants through roots.
(b) It makes the soil spongy and therefore increases the water holding capacity of the soil.
(c) Since organic matter makes the soil spongy, it also improves the aeration of the soil.
(d) It binds soil particles thus improving soil structure.
(e) Fresh organic matter supplies food to micro-organisms living in the soil. This enhances mineralisation.

There are several types of organic manures. The most common ones include farmyard manure, compost and green manure. These organic manures are briefly described herein.

Farmyard manure: It is a decomposed mixture of faeces and urine of farm animals together with beddings or litter and leftovers from feeds such as roughages or fodder fed to animals. It is recommended that fresh layer of bedding materials should be put on top of bedding at regular intervals. When the layer of manure mixed with the beddings becomes too thick on the floor, it is advised to be removed. The manure is then heaped under a simple roof. This helps to keep it from getting excessively wet due to rainfall or from being exposed to direct sunlight. An exposure of the farmyard manure to excessive wetness causes nutrient loss by leaching or washing out, if it is caused by rainfall. Likewise, an exposure to direct sunlight causes nutrient loss through volatilisation of nitrates. These nitrates are converted into ammonia gas.

The heap of manure should be kept compact and moist but not wet. If it gets too dry, more faeces and urine are added together with some water. This allows decomposition and mineralisation of the materials in the mixture thus permitting the manure to become well decomposed and therefore suitable for application on the field.

Farmyard manure is ready for use in fields when stored for about three to six months depending on the weather and its source. Three to four weeks before sowing or planting the crops, partially decomposed farmyard manure can be applied to the soil. This allows the manure to decompose more and provide the soil with nutrients. If there is a long delay between putting the manure on the soil and planting the crops, the nutrients could be washed out of the soil by excessive rain. If the manure is already decomposed enough, it can be applied immediately before the crops are planted or sown. Farmyard manure can be used in a wide range of crops, but it works better with vegetable and fruit crops.

Note: Fresh farmyard manure from the stalls should not be applied because the bacteria which breaks it down to release nutrients will fix the available soil nutrients and make them unavailable for plants.

Quality of farmyard manure: The quality of farmyard manure varies and it is essentially determined by a number of factors. These include type of animals, type of food eaten by the animal, type of beddings used, method of storage, and age of the manure.

(a) Type of animal enterprises used to produce farmyard manure

Different types of animal enterprises provide varying qualities of farmyard manure, depending on the animal's mode of nutrition and nutrient requirements. For example, faeces from fattening animals have higher level of nutrients than those from dairy animals. This may be caused by the fact that dairy animals use most of the feed nutrients for production of milk. Similarly, non-ruminants such as poultry and pigs give faeces which have a higher level of nutrients as they absorb less nutrients from their feeds. Table 9.1 shows the order of nutrient richness of farmyard manure from different types of animals.

Table 9.1: Order of nutrient richness of farmyard manure

Manure from:	Richness of nutrients
Poultry	
Sheep	
Pig	
Horse	
Cattle	

(b) Type of food eaten

Animals that are fed on nutritious feed produce faeces and urine which are rich in nutrients. In other words, feedstuffs that are highly nutritious result in manure with a higher level of nutrients.

(c) Type of beddings used

Generally, beddings with a high urine absorption capacity produce a farmyard manure with high quantities of nutrients.

(d) Method of storage

The farmyard manure which is stored in a place with a leak-free roof and a concrete floor has more nutrients. This is due to minimum leaching and vaporisation caused by rain and heat, respectively.

(e) Age of the manure

A well decomposed manure is rich in nutrients and it is easy to handle and mix with the soil.

Compost: Different from farmyard manure, compost is prepared from composted or heaped organic materials or wastes, not from animal stall. Generally, any plant material can be used. Leaves, weeds, lawn cuttings, small prunings and garden wastes are commonly used materials. Kitchen refuse and leftovers may also be included, provided that they can decompose. Materials that should be avoided include synthetics and plants with diseases, pests and weed seeds.

Regardless of the method of composting, basic materials needed include:

(a) Farm residues after harvesting such as leaves, straws, dry stalks, legume plants and vegetable peels.
(b) Animal wastes particularly fresh animal manure like that of cattle, chicken, pig, duck or rabbits.
(c) Kitchen waste materials particularly ash.

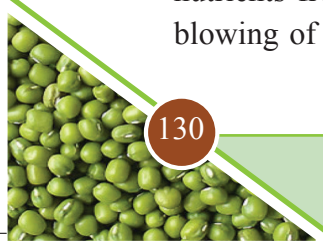
Compost can be prepared using several methods, depending on rainfall, soil types and availability of composting materials.

You can easily make compost by heaping or piling method. By this method, you have to follow these steps:

(i) Make a pile of dry farm residue about 1 metre x 1metre and 30 - 40 cm high.
(ii) Cover the pile with fresh animal waste to about ⅓ to ½ the height of 10 - 20 cm high.
(iii) Add ash for neutralising acidic condition.
(iv) Repeat numbers (i) and (ii) until the pile is1 to 1.4 metres high. If the surface of the pile gets dry, supply water to keep it moist.
(v) Spread soil (up to 2.5 cm thick) evenly on top of the pile to speed up the process of compost making.

After about 2 weeks, the compost pile will be hot inside (60 - 70°C). Mix the compost well and if it is dry, water the pile to dampen it. Make sure that the compost is exposed to fresh air by turning the material over from the top to the bottom after every two weeks. The smell of compost is strong at this time. When the compost is ready for use, its colour will turn to dark brown or black and temperature inside the compost will be about the same as outside temperature. The texture of compost will be soft and easy to spread. The smell of compost will be better and the volume or height of the pile will decrease.

The site for making compost should be well-drained as waterlogging leaches nutrients from manure. The place should also be situated in a way that direct blowing of wind from the compost to the homestead is avoided. This prevents



bad odour from being blown to the homestead. Moreover, the site should be centrally placed to the area of the farm where compost manure is to be used. In addition, the site must be easily accessible to make it easy for transportation of materials needed for preparing the compost. Also, it is advised to make compost under shed in order to keep away from rain.

It is important to note that the method of making compost explained here seems to be the basic one and simple. There are several other methods which can be used to make compost including pit composting, closed bins, open bins, tumblers, and vermicomposting. However, adaptations can be made to suit the resources you have or the characteristics of your area. Moreover, you can find out more from your teacher and agricultural experts in your local area.

Compost is applied before planting seeds or seedlings. A well decomposed compost is spread on field then the soil is ploughed. Approximately 1 - 2 tons of compost which is about 1 - 2 piles of the compost is sufficient for 10 hectares of land. However, if you are not using chemical fertiliser, 3 - 4 tons of well decomposed compost is needed. It is important to note that the application of undecomposed compost can result in damage to crops.

Compost needs to be properly cared for. It should never be left uncovered in the rain or in the sun. The rain washes out the nutrients and the sun can cause vaporisation, making it to lose its fertility. Therefore, to reduce this loss, the compost should be covered. Some useful covers are banana leaves, intertwined palm leaves or a sheet of polythene paper. If the compost is left too long after it has decomposed, it may also become a breeding place for unwanted insects such as termites and rhinoceros beetles.

Green manure: Green manure is made up by growing a crop on a piece of land and then incorporated into the soil at flowering stage while it is still green and tender. Alternatively, green manure is created by leaving uprooted or cut crop parts to wither on a field so that they serve as mulch and thereafter manure. The plants used for green manure are often cover crops grown primarily for this purpose. Sometimes they are termed as green mulch. Crops which grow rapidly even on poor soils and produce an abundant quantity of green leaves and tops can be used as green manure crops. In addition, green manuring crops should have

high nitrogen content and preferably be leguminous. They should be short for easy ploughing into the soil. Crops such as cow peas, pumpkins or water melons have proved useful green manure.

Activity 9.7

1. (a) Prepare any of the following organic manure: farmyard, compost or green manure at your school farm.
   (b) Record all the procedures and observations.
2. Outline the lessons you have learnt in this activity.

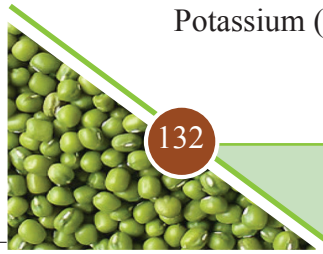
Exercise 9.4

Answer the following questions.

1. Describe the characteristics of a good green manuring crop.
2. What are the factors to consider when selecting a site for composting?
3. Describe factors that determine the quality of farmyard manure.
4. What are the functions of the following in the preparation of compost manure:
   (a) Top soil
   (b) Wood ash
   (c) Layer of farmyard manure
5. Why are leguminous plants preferred for green manuring?
6. Using any method of your choice, describe the procedures followed in making compost manure.
7. What would happen if farmyard manure and compost manure are:
   (a) Exposed to direct sunlight?
   (b) Exposed to rainfall?
   (c) Kept wet?
   (d) Kept for too long?

Use of materials containing plant nutrients in a concentrated form to the soil

Any natural or manufactured material that contains at least 5% of one or more of the three primary nutrient elements which are Nitrogen, Phosphorus and Potassium (N P K) can be called fertiliser. Industrial manufactured fertilisers are



called mineral or inorganic fertilisers. Fertiliser may contain one or more of the essential nutrient elements. Those fertilisers that contain only one of the major nutrient elements are termed as single, simple or straight fertilisers. And those fertilisers that contain two or more of the major nutrient elements are classified as mixed or compound fertilisers. Nitrogen, phosphorous and potassium are the main fertiliser nutrient elements. Therefore, these three elements provide the basis for the major groups of fertilisers.

Straight fertilisers: These are the fertilisers that supply nitrogen, phosphorus or potassium in concentrated form. Therefore, the major straight fertilisers are nitrogenous, phosphatic and potash fertilisers. Generally, fertilisers have different properties. These properties guide how and when to use them as well as instructions to adhere to in using them.

General properties of nitrogenous fertilisers

(a) They are very soluble. Due to this, they can easily be washed from the root zone. Thus, their residual value is very low. This means that when such fertilisers are applied during one cropping season, very little of the fertiliser remains in the soil during the next cropping season.

(b) With an exception of few fertilisers, many of them tend to burn or scorch plant leaves when they come in contact with them. Furthermore, if they are applied directly on seedlings, they may kill them. Therefore, these fertilisers should be applied on the soil within the limit of plant leaves and not on the plant stem.

(c) Too much application of nitrogenous fertilisers should be avoided particularly on cereal crops. This is because they may cause plants to develop a lot of vegetative matters but with very few and small seeds. For this reason, it is important to follow the recommended rates of application.

General properties of phosphatic fertilisers

(a) They are not as soluble and mobile as nitrogenous fertilisers. Thus, they have to be applied close to the roots of plants.

(b) They are absorbed slowly by plant roots.

(c) They do not scorch plant leaves, roots or seeds.

(d) They have a higher residual value than nitrogenous fertilisers.

(e) They encourage development of roots and seeds.

(f) Since they have high residual value and they encourage root development, they are applied during planting crops or sowing seeds.

General properties of potash fertilisers

All potash fertilisers consist potassium in combination with chloride, sulphate, or nitrate. Almost all potash fertilisers are water soluble and they move slowly in the soil.

Compound fertilisers: Compound fertilisers supply two or three of the primary plant nutrient elements. They are produced by either physical mixing of the straight fertilisers or by chemical processes done in factories. When a compound contains all the three elements it is termed as complete fertiliser. Normally, complete fertilisers with different proportions of N: P: K are manufactured for use in different areas according to local conditions. For example, a 20:10:10 compound fertiliser shown on its bag means that the fertiliser contains these major elements in the proportions of 20% N: 10% P: 10% K.

Determination of fertiliser needs: To determine fertiliser needs for crops and soils in a given locality, the farmer must know the status of nutrients in the soil and quantity of each nutrient needed to get the highest or most profitable yield. These information can be found through

(a) finding out the fertiliser recommended for crops. These recommendations can be found in literature including *"Mwongozo wa uzalishaji wa mazao kulingana na kanda za kilimo za kiikolojia (2017)"* and by consulting local agricultural extension workers.
(b) looking at nutrient deficiency symptoms.
(c) soil analysis to determine the available nutrients and amount needed. These tests are normally done in soil laboratories by soil scientists.
(d) plant or plant tissue test in the field. These tests are also done in specialised laboratories.
(e) fertiliser field trials.

Rate of fertiliser to be applied: The amount of fertiliser to be applied per hectare on a given field is determined by the amount of nutrients needed by plant for optimum growth and productivity, amount of the available nutrients in the soil, and moisture status of the soil. It also depends on the type of crops to be grown and types of fertilisers available. Usually mineral or inorganic fertilisers are delivered in 50 kg bags while the nutrient content, that is active ingredients, is given in percentages, for example, N20 P10 K10, meaning that, each 50 kg bag contains 20% N, 10% P, and 10% K.

To determine the amount of fertiliser needed for a particular nutrient, multiply the rate of the desired nutrient by 100 and divide by the percentage of the nutrient in the fertiliser.

For example,
If the recommended rate of N is 36 kg/ha, using a fertiliser with 46% of Nitrogen, the amount of fertiliser required is:

$$\text{Amount of fertiliser required to supply 36kg N/ha} = \frac{\text{Recommended rate (kg)} \times 100\%}{\text{Percentage of Nitrogen in fertiliser}}$$

$$= \frac{36 \text{ kg x } 100\%}{46\%}$$

$$= \frac{3{,}600}{46} \text{ kg}$$

$$= 78.26 \text{ kg}$$

$$= 78 \text{ kg of fertiliser}$$

Time for applying fertilisers: The supply of nutrients to crop plants has to be done at proper time for good results. Nutrients are required at different growth stages because they perform different functions in plants. In deciding when to apply fertilisers, the following general rules shall apply.

(i) It is always recommended that the entire quantity of phosphatic fertilisers be applied in single dose immediately before sowing or planting. This is due to the fact that it is required in greater quantities during the early growth period for root formation and development. In addition, all phosphatic fertilisers become available for the growing plant.

(ii) Nitrogenous fertilisers are normally applied in several small applications throughout the growing period. This is because nitrogen is required throughout the growth period. Therefore, it is better not to apply too much nitrogen at one time. Moreover, nitrogenous fertilisers are highly soluble therefore they can't stay long in the root zone. Initially, they have to be applied 2 - 4 weeks after seeds have germinated or after transplanted seedlings have taken root. It is important to apply nitrogenous fertilisers within this timeframe in order to be absorbed easily by plants and avoid loss through leaching.

(iii) Potash fertilisers can be applied before sowing and/or 2 - 4 weeks after seeds have germinated. This is due to the fact that potassium is absorbed right up to the harvest stage but it becomes available slowly.

(iv) Compound or mixed fertilisers, particularly those with a high nitrogen content, can be applied at about the same time as nitrogenous fertilisers.

Application of fertilisers to the soil at planting time is termed as basal dressing. The application of fertilisers after seeds have germinated, normally 2 - 4 weeks after germination, is termed as top dressing.

Methods of fertiliser application: The method of applying fertilisers is highly influenced by the properties of a particular fertiliser. Generally, it is important to place fertiliser where most of it will be easily absorbed by plants. Nitrogenous fertilisers can be applied on the soil surface because they are easily soluble in water and have high mobility. Phosphatic fertilisers should be placed closer to the plant roots because they move slowly from the point of placement. To reduce phosphate fixation, phosphatic fertilisers should be placed in a way that they come into minimum contact with the soil particles and are close to the plant roots. Similarly, potash fertilisers should be placed near root zone because they move slowly in the soil. Therefore, based on these remarks, the following methods are used to apply fertilisers.

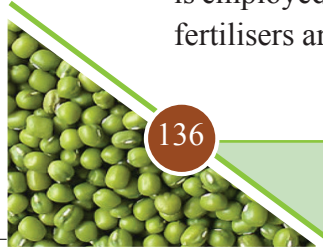
(a) Broadcasting

The fertiliser is spread over the entire soil surface to be fertilised with the aim of distributing the whole quantity of fertiliser evenly and uniformly and incorporating it in the plough layer. Broadcasting is done when crops are dense and not planted in rows or in dense rows and on grassland. It is also used when the fertiliser should be incorporated into the soil after the application to be effective as for phosphatic fertilisers. It is used when one wants to avoid evaporation losses of nitrogen in certain fertilisers. Also, it is used when easily soluble nitrogenous fertilisers are used and large quantities of fertilisers are applied. Furthermore, it is used when the crop planted produces an extensive root system.

Incorporation through tilling or ploughing-in is also recommended to increase the fertility level of the entire plough layer. In addition, whether the fertiliser is broadcasted by hand or with fertiliser spreading equipment, the spreading should be as uniform as possible.

(b) Row or band placement

This refers to the application of fertilisers into the soil close to the seed or plant. It is employed when relatively small quantities of fertilisers are to be applied. When fertilisers are placed along with, or close to the seed or plant in bands or pockets,



the roots of the young plants are assured of an adequate supply of nutrients and this promotes rapid early growth. This method of placement also reduces the fixation of phosphorus and potassium.

When seeds or plants are sown close together in a row, the fertiliser is put in continuous band on one or both sides of the row. This method of application is referred to as row placement and it is used for crops such as potatoes, maize, tobacco, cotton, and sugar cane. Where crops are cultivated by hand and planted in hills, the recommended grams of fertiliser are placed in the row or planting hole, under, or beside the seed, and covered with soil. This process is known as hill placement. Great care has to be taken such that no fertiliser is placed either too close to the seed or to the germinating plant to avoid toxicity.

(c) Top-dressing

Top-dressing is mainly used for small and large grain crops and for crops such as forage, wheat and barley. Top dressing of additional nitrogen is done when a single application of the total nitrogen needed at sowing might lead to losses through leaching and run-off. Also, it is used where crops show a special need for nitrogen at certain stages of growth.

Top dressing of potassium, which does not move in the soil to the same extent as nitrogen, might be recommended on light soils but it should be divided where part of it is applied during basal dressing and the other part of it to be used during top-dressing. Phosphate hardly moves in the soil at all. Therefore, it is usually applied before or at sowing or planting time as basal application, preferably in combination with potassium and part of nitrogen.

Spreading fertiliser between the rows or around the plants is another form of top-dressing which is termed as side dressing. Crops such as maize, cotton, sugar cane, trees and other perennial crops are normally side-dressed.

(d) Foliar application

Foliar application refers to spraying the leaves of growing plants with suitable fertiliser solutions. It is mainly used to correct micro-nutrient deficiencies. To minimise the risk of leaf scorch, the recommended concentration has to be adhered to and spraying should preferably be done on cloudy days and in the early morning or late afternoon.

(e) Direct application into the soil

With the help of some special equipment, liquid fertilisers such as anhydrous ammonia and nitrogen solutions can be applied directly into the soil. There is very little plant injury or wastage of ammonium if the material is applied about 10cm below the seed, and when the soil is moist.

(f) Application through irrigation water

Straight or mixed fertilisers which are easily soluble in water are allowed to dissolve in the irrigation stream. The nutrients are thus carried into the soil in solution. The fertilisers most commonly applied through irrigation water are nitrogenous fertilisers. This is advisable particularly where drip irrigation is practised.

Note: Where fertilisers have to be stored in the farm, the store should be water proof with concrete floor and water-tight roof so as to avoid caking of fertilisers due to moisture. Fertiliser bags should be placed on pallets, otherwise some of them may absorb moisture from the floor. Also, bags of different kinds of fertilisers should be heaped separately.

Activity 9.8

1. Find out the common straight nitrogenous, phosphatic, potash and compound fertilisers commonly found in your area.
2. Collect their sample, display them and identify their distinguishing features.
3. With assistance of teacher and/or resource persons, determine the fertiliser needs for the crops recommended in your area.
4. Calculate the amount of fertilisers needed.
5. What are the appropriate times and methods of applying fertilisers for each crop recommended for your area.
6. Demonstrate fertiliser application in the school demonstration plot under guidance of your teacher.
7. Outline the lessons you have learnt from this activity.
8. Summarise all your findings and record them in your portfolio.
9. Share your findings in class.
10. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise 9.5

Answer the following questions.

1. What do you understand by the term "inorganic fertiliser"?
2. Distinguish between straight fertiliser from compound fertiliser.
3. (a) Name the methods which can be used to gather information about the status of nutrient elements present in a particular soil as well as quantity of each element required by the crop plants.
   (b) For what purpose are these information required?
4. Why phosphatic fertilisers have to be applied in a single dose immediately before planting or sowing?
5. Explain why nitrogenous fertilisers
   (a) use split application.
   (b) are not applied during planting.
6. (a) What is the meaning of fertiliser rate?
   (b) Why is it important to determine fertiliser rate before applying fertilisers?
   (c) The amount of phosphorus recommended for a certain crop grown in a given field is 40kg/ha. Suppose the amount has to be supplied by using fertiliser "Y" with 48% P. Determine the rate of the fertiliser "Y".
7. Distinguish "basal dressing" from "top dressing".
8. State the conditions that determine the application of fertilisers by using the following methods:
   (a) Foliar application
   (b) Broadcasting
   (c) Row or band placement
   (d) Application through irrigation water

Chapter Ten

Maintenance of soil water for crop production

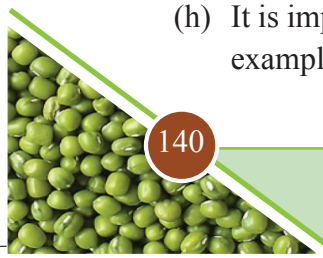
Introduction

Water is essential for growth and development of crop plants. Too much or too little water in the soil influences the crop farming enterprise positively or negatively. In this chapter, you will learn about the concept of optimum soil moisture levels for crop growth, methods of determining soil moisture levels, critical stages of crop growth in relation to moisture requirements and conservation of soil moisture. You will also learn management of deficit of soil moisture levels as well as management of excessive water levels in soil. The competencies developed from this chapter will enable you to supply and conserve soil moisture so as to ensure good growth of crop plants and optimum yields.

The concept of optimum soil moisture levels for crop growth

Water which is held in spaces between soil particles is termed as soil water or soil moisture. Normally, it contains nutrient elements dissolved in it. This water containing dissolved nutrients is called soil solution and it acts as a source of both water and nutrients to plants. Soil moisture is important in a number of ways. Some of them are:

(a) It plays an important role for seed germination and plant growth.
(b) It is a source of water absorbed by plant roots to replace the one lost from leaves by transpiration.
(c) It serves as solvent and carrier of food nutrients for plant growth.
(d) It is a great regulator of physical, chemical and biological activities in the soil and plants. As such, it plays an important part in photosynthesis and respiration as well as other metabolic processes in plants.
(e) It is required by micro-organisms inhabiting the soil for their metabolic activities.
(f) It maintains the turgidity of plant cells and, in return, gives plants shape and strength.
(g) It helps to reduce variations or changes in soil temperature and soil air.
(h) It is important in determining the quality of tilth during land preparation, for example, good tilth can be secured at right status of moisture content.



Plants lose water in the form of water vapour from their surfaces. This process is termed as transpiration. It occurs mainly at the surface of plants particularly from leaves. If this water is not replaced, plants will wilt and eventually die. Water is also lost from the soil surface especially during daytime by the process called evaporation. As water evaporates, the amount of water in the soil is reduced. As a result, plant roots find it more and more difficult to absorb water from the soil. If water is not added in the soil through irrigation or rain, plants will wilt and then die. Water must therefore be present in the soil at an optimal level to prevent plants from wilting. Loss of water from the soil and plant leaves is termed as evaporation and transpiration, respectively. The two processes of evaporation and transpiration together are referred to as evapo-transpiration.

Each crop plant grows and yields well only in areas with soils that supply an optimal amount of water. It is important to note that the ability of crop plants to withstand deficit or excess water in the soil varies from one type of crop to another. Some crop plants withstand excess water in soil while others withstand deficit in varying degrees and their water requirements also differ. Water requirements among crop plants are also dependent on other factors such as stage of growth, metabolism within the plant processes and the prevailing weather conditions. As a result, optimum soil moisture levels for crop growth also vary from one type of crop plant to another.

Activity 10.1

1. Recall the list of crops which are grown in your area.
2. Group them according to their soil water requirements, that is, crops which grow well even when there is very little moisture in the soil, crops which grow well only when there is plenty of water in the soil, and crops which grow well only when there is neither too much water nor too little water in the soil.

Determination of soil moisture levels

Determination of soil moisture level is mainly necessary for assessing the availability of water and scheduling of irrigation when needed. Soil moisture level can either be determined by direct or indirect methods. With direct methods, the measurement of moisture content in the soil is carried out. This is done by removing water from a soil sample through evaporation and calculating the mass

of water removed. With indirect methods, the measurement of water potential or stress or tension under which water is held by the soil is determined either by using instruments or appearance and feel. The latter is simple and the easiest method hence commonly used by farmers.

Determination of soil moisture by feel and appearance method

The feel and appearance of soil vary depending on its texture and soil moisture content. Due to these properties, soil moisture content could be estimated through how it feels and appears when handled. With this method of soil moisture estimation, moisture is typically sampled in increments to the root depth of the crop at around three or more sites per field. To carry out this approach, it is advisable to vary the number of sample sites and depths according to crop, field size, and soil texture.

Procedures of determining soil moisture by feel and appearance method

(i) Obtain a soil sample at a selected depth using either an auger or a shovel.

(ii) After obtaining a soil sample and handling it, squeeze the soil sample firmly several times to form an irregularly shaped ball.

(iii) Then squeeze the soil sample out of your hand between your thumb and forefinger to form a ribbon with the soil.

(iv) With careful attention to soil texture, ability of the soil to form a ribbon when squeezed, firmness and surface roughness of the ball, water glistening, loose soil particles, soil colour and staining on the fingers; one can then estimate the percentage of soil moisture.

Table 10.1 shows general soil textures with their respective classes while Table 10.2 provides a guideline on how to estimate soil moisture using the feel and appearance method for soils of different textures.

Table 10.1: General soil textures and their respective classes

General texture	Textural class
Coarse	Sand, Loamy sand
Moderately coarse	Sandy loam
Medium	Loam, Silty loam, Silt, Sandy clay, Sand clay loam, Silty clay loam
Fine	Silty clay, Silty clay loam, Clay

Table 10.2: Guideline for estimating soil moisture content by feel and appearance method for soils of different textures

Feel or appearance of soil				Available soil moisture
Coarse texture	**Moderately coarse texture**	**Medium texture**	**Fine texture**	
Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure	Dry, forms a very weak ball, aggregated soil grains break away easily from ball	Dry, soil aggregations break away easily. No moisture staining on fingers, clods crumble with applied pressure	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure	0 to 25%
Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers	Slightly moist, forms a weak ball with defined finger marks, darkened colour, no water staining on fingers, grains break away	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure	25 to 50%
Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened colour, moderate water staining on fingers, will not form a ribbon	Moist, forms a ball with defined finger marks. Very light soil/ water staining on fingers. Darkened colour, will not slick	Moist, forms a ball, very light water staining on fingers, darkened colour, pliable, forms a weak ribbon between thumb and forefinger	Moist, forms a smooth ball with defined finger marks, light soil/ water staining on fingers, ribbons between thumb and forefinger	50 to 75%
Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened colour, heavy water staining on fingers, will not form a ribbon	Wet, forms a ball with a wet outline left on hand, light to medium water staining on fingers, makes a weak ribbon between thumb and forefinger	Wet, forms a ball with well-defined finger marks, light to heavy soil/ water coating on fingers, ribbons between thumb and forefinger	Wet, forms a ball, uneven medium to heavy soil/ water coating on fingers, ribbons easily formed between thumb and forefinger	75 to 100%
Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/ water coating on fingers	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers	Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky	100% (Field capacity)

Determination of deficiency or excess soil moisture by visual indications of plants

In determining soil moisture levels by appearance, deficiency or excess can be predicted from visual indication of plants. Generally, when plants have too little water, initially they show temporary wilting during the warm part of the day, later leaves turn brown and wilting is increased. This also occurs when plants have too much water. The biggest difference between the two is that too little water will result in plant's leaves feeling dry and crispy to the touch while too much water results in soft and limp leaves. Moreover, there is falling off of leaves in an excessive soil water condition. Normally, both young and old leaves become yellowish and fall at the same extent.

It is worth noting that plant roots neither grow in dry soil nor water logged soil with an exception of paddy and other few water loving crops. Therefore, the application of excessive amounts of water in the soil inhibits root growth and activity, thus causing plants to grow slowly. Stunting and slow growth accompanied by yellowing of leaves is also a symptom of excessive soil water. Other indications of excessive soil water are rotting of roots and greening of soil which is caused by the growth of algae.

Symptoms of either deficiency or excessive water help farmers to decide either to apply water or remove water in order to ensure good productivity. With indications of excessive water, the amount of water applied to the soil should be reduced. Excess water is not good for moderately water loving crops and has to be removed. With temporary wilting, during the warm part of the day as a major soil moisture deficiency symptom for most crops, water has to be applied. However, in perennial fruit crop production, it is not practical to wait for wilting to detect moisture requirements. Instead, farmers are advised to follow the recommended irrigation routine.

Activity 10.2

1. With assistance of the teacher and the information provided on Tables 10.1 and 10.2 determine soil moisture levels in school garden by appearance and feel method.
2. Repeat task No. 1 for different days and record all observations in your portfolio.
3. Outline the lessons you have learnt from this activity.

Critical stages of crops in relation to moisture requirements

Certain periods or stages during crop growth and development are more sensitive to soil moisture stress compared to others. These stages or periods are said to be moisture sensitive periods for optimum crop production. The term critical period is commonly used to define the stage of growth when plants are most sensitive to shortage of water. If a farmer needs to realise high yields then these stages should be known for effective production. This is because inadequate water supply during moisture sensitive periods will irreversibly reduce the yield. Hence, provision of adequate water to crop plants during such periods or stages is highly necessary so as to avoid yield loss that can occur.

Generally, optimal soil moisture for plant growth varies with the stage of crop growth. In case of vegetables, when they are young, they transpire less water but they need a stress free moisture condition. This is due to weak root system which is sparsely distributed and located in the upper 15 to 20 cm layer of soil that dries quickly. They utilise and transpire more water in the later stages of growth during which moisture stress obviously reduces yield. Therefore, to realise optimum benefit from scarce irrigation water, irrigation is to be scheduled at moisture sensitive periods by withholding irrigations at other periods of lesser sensitivity. Such irrigation schedules along with improved soil moisture conservation practices increase the water-use efficiency in crop production. Table 10.3 shows critical soil moisture content in relation to growth stage of some crops.

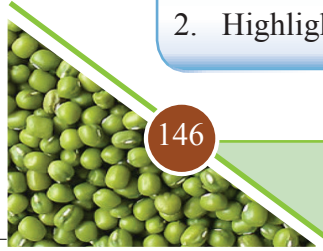
Table 10.3: Critical soil moisture content and growth stage of some crops

Crop	Available soil moisture (%)	Stage of crop growth
Potato	65	Stolon formation, tuberisation and tuber enlargement
Chillies	50	Tenth leaf to flowering, fruit development and after periodical harvests
Onion	60	Bulb formation and bulb enlargement
Tomato	60	Flowering, fruit development and at harvest
Peas	40	Flowering and pod development
Cabbage	60	Head formation and enlargement
Cauliflower	70	Curd formation and enlargement
Cucumber	50	Flowering and fruit development

Crop	Available soil moisture (%)	Stage of crop growth
Leafy vegetables	70	Entire crop duration
Citrus	50	Flowering, fruit setting and fruit growth
Banana	50	Early vegetative period, flowering and fruit formation
Mango	50	Start of fruiting to maturity
Pineapple	50	Vegetative growth
Grape	50	Vegetative growth but frequent irrigation during vegetative stage may cause rotting of fruits
Maize	60	Seedling, tasseling and silking
Sorghum	40	Seedling and booting to heading stage
Millets	40	
Sunflower	40-50	
Paddy	100	Tillering, heading and flowering
Common beans	60-70	Early vegetative growth, flowering and pod setting
Cow peas	40-50	
Pigeon peas	40-50	
Groundnuts	40-50	Pegging to pod development
Sesame/simsim	40-50	Seedling, branching and flowering to seed setting

Activity 10.3

1. Visit your nearly farms of different 10 crops.
   (a) Observe and record any signs of moisture deficiency in the plants. Repeat this exercise for 10 days.
   (b) Identify the crop plants that are more sensitive to moisture stress. Show the growth stage which is more sensitive to moisture stress.
   (c) Record all findings in your portfolio.
2. Highlight the lessons that you have learnt from this activity.



Conservation of soil moisture

This is an important means of maintaining the necessary water for agricultural production. It is mainly targeted to minimise the amount of water lost from soils through evapo-transpiration, percolation and run-off. Run-off occurs when the rainfall intensity exceeds the infiltration capacity of the soil which is a measure of the ability of the soil to absorb and transmit rain water down the soil profile. Conservation of soil moisture also helps to minimise irrigation needs of crops. There are various methods that can be used to conserve soil moisture. Most of the methods rely on providing some kind of cover for the soil or other means to minimise loses of water through evaporation, percolation and run-off. It is worth to note that most methods used for conserving and improving soil fertility learnt in Chapter nine will also yield benefits to soil moisture conservation. Some of the methods used in conservation of soil moisture include:

(a) Spreading of well decomposed compost, farmyard manure or crop residue over the soil surface

This minimises evaporation. In addition, organic matters released from compost or farmyard manure improve the capacity of soils to hold moisture.

(b) Placing mulch on the plants

Mulching reduce evaporation of moisture from the soil. Materials such as dead seed free plant residues, rice husks, wood shavings, as well as groundnut and coffee hulls can be used. It is worth noting that mulching is most suited for low to medium rainfall areas.

(c) Use of minimum or conservation tillage

This is reducing or completely eliminating tillage. It helps to maintain healthy soil organic matter levels. Conservation tillage increases the capacity of the soil to absorb and retain water. With conservation tillage, crop residue is left on the soil to reduce evapo-transpiration, protect soil surface from impacts of wind, sun and heavy rain.

(d) Use of crop rotation

Growing different types of crops every season helps to improve soil structure and thus water holding capacity. In addition, rotating deep-rooted and shallow rooted crops helps in making use of previously unused soil moisture. This is because plants draw water from different depth levels within the soil.

(e) Use of green manure

This is done by growing plant materials with the sole purpose of adding them to the soil to improve organic matter in the soil. This improves the soil water retention capacity.

(f) Practising deep tillage for some areas and soils

This can help to increase porosity and permeability of the soil so as to increase its water absorption capacity.

(g) Mixed cropping and inter-planting

Cultivating a combination of crops with different planting times and different length of growth periods in mixed cropping and inter-planting methods improves ground cover and reduces water loses through evaporation.

(h) Contour ploughing

Ploughing the soil along the contour instead of upward and downward slopes reduces the velocity of run-off. Thus, more water is retained in the soil and distributed more equally across the crop land.

(i) Fallowing

This is a practice of leaving the land to rest after one or more seasons of planting the intended crops. It is one of the most effective water conservation techniques particularly in areas of limited rainfall.

(j) Ridging

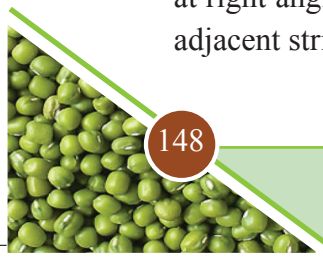
Ridges facilitate water retention in the furrows. They help to make water available for uptake by plants for a much longer period after irrigation or rain. The use of ridges also helps surface drainage during rains and prevents young plants from being washed away.

(k) Terracing

This minimises the loss of surface water which may occur when water flows down slopes after intense rainfall or excessive irrigation.

(l) Strip cropping

This involves establishing the spreading vegetation or crops in a strip which is at right angles to the flow of water or the prevailing wind. It gives protection to adjacent strip or rows of crops or fallow land.



(m) Water harvesting

Where possible, there should be mechanisms of harvesting rainwater because rainwater harvesting minimises run-off. The collected water can later be used for irrigation.

Activity 10.4

1. Identify all potential techniques that can be used in conserving soil moisture in your area. For every technique, indicate opportunities available, challenges that may be encountered and the means to deal with them.
2. Practise those techniques in conserving soil moisture in your school farm and crop museum.
3. Record all the proceedings in your portfolio.
4. Outline the lessons you have learnt from this activity.

Exercise 10.1

Answer the following questions.

1. Discuss the various cultural practices of soil water conservation.
2. State the role of mulch in soil and water conservation.
3. Explain the importance of the following in soil and water conservation:
   (a) Crop rotation
   (b) Cover crops
4. Discuss the similarities and differences between water conservation and soil conservation.

Management of deficit of soil moisture levels

In deficit of soil moisture levels, water has to be applied on soil for the purpose of supplying sufficient moisture essential for growth of crop plants. This is referred to as irrigation. There are four main types of irrigation namely surface, sub-surface, drip and overhead irrigation as describe in the following sections.

Surface irrigation

In surface irrigation method, water is applied directly to the soil surface from a channel located at the upper reach of the field. Efficient irrigation can be achieved in surface methods by an appropriate combination of the size of irrigation

stream, shape and slope of the land to be irrigated, soil infiltration rate and plant population.

Surface irrigation could be made more efficient by observing the following:

(a) Water distribution system should be properly constructed to provide adequate control of water to the fields.
(b) Land should be well prepared to allow uniform distribution of water over the fields.
(c) Fine-textured soils with low infiltration rate require smaller streams to avoid excessive losses due to run-off at the downstream end and deep percolation at the lower reaches.
(d) Coarse-textured soils with high infiltration rates require larger streams to spread over the entire strip rapidly and avoid excessive losses due to percolation at the upper ridges.

Surface irrigation methods may be grouped into two broad categories which are complete flooding of the soil surface and partial flooding or furrow method. In complete flooding, the entire land surface in the area being irrigated is covered with water. Common methods of complete flooding irrigation include free and basin flooding as shown in Figures 10.1 (a) and (b), respectively.

Figure 10.1(a): Free flooding irrigation

Figure 10.1(b): Basin irrigation

In partial flooding, the entire irrigated area is only partially flooded. It involves the use of closely spaced furrows or small ditches which contain and distribute water that moves both laterally and downward from the furrow to moisten the plant root zone. The most common method of partial flooding is furrow irrigation which is shown in Figure 10.2.

Figure 10.2: Furrow irrigation method

Suitability of surface irrigation: Flooding method of irrigation is most suitable for land having such regular surfaces where other surface irrigation methods are impractical. It is also suitable for areas where irrigation water is abundant and inexpensive. It is suitable for crops such as paddy which require standing water in most stages of their growing season.

Generally, surface irrigation is popularly used due to its adaptability, flexibility, and economy.

(a) Adaptability

Surface irrigation can be used on nearly all types of soils and crops. The system can be designed to accommodate a wide range of stream sizes and still maintain high water application efficiency.

(b) Flexibility

Surface irrigation systems permit ample latitude to meet emergencies. The capacity of surface system is efficient to permit an entire farm to be irrigated in a short period of time.

(c) Economy

Surface irrigation is usually less expensive to operate compared to other irrigation methods because of low power requirements. Water is usually applied directly to the farmland by gravity flow from irrigation project canals and laterals. Where water is pumped from wells, rivers, storage reservoirs or other sources of supply; only enough power to raise water slightly above the land surface to be irrigated is needed.

Despite its popularity, surface irrigation faces some challenges. These include:

(i) Level lands require high accuracy that sometimes is not easy to achieve.
(ii) Some methods for surface irrigation, such as free flooding, are not suitable for large fields.
(iii) It is not applicable on soils with high filtration rate.
(iv) There is wastage of water especially in complete flooding as plants are always covered with water even when they do not need it.
(v) There is high cost of mobilising sufficient quantities of water.

Sub-surface irrigation

In sub-surface irrigation, water is applied below the ground surface by maintaining an artificial water table at a predetermined depth, depending upon the soil texture and rooting depth of the plant. Water reaches the plant roots through capillary action. Figure 10.3 shows an example of sub-surface method of irrigation. Sub-surface irrigation is suitable to soils having reasonably uniform texture and permeable enough for water to move rapidly both horizontally and vertically within and for some distance below the crop's root zone. In terms of crops, it is suited for irrigating vegetables, small grains, pasture grass, most forage crops and flowers.

Figure 10.3: Sections showing sub-surface method of irrigation

Advantages of sub-surface irrigation

(i) It is effective on soils having low water holding capacity and high intake rates where other methods are impracticable due to labour, equipment and water costs.
(ii) It reduces dispersion of weed seeds, thus reducing weed control costs.
(iii) Evaporation loss of water from land surface is minimal.
(iv) Special tillage and frequent land preparation for conveying surface water is eliminated, thus less damage to soil structure.
(v) The amount of water for irrigation can be controlled and even distribution is possible.

(vi) Normal farm operations can be carried out without interference or major alteration of the layout.

Disadvantages of sub-surface irrigation

(i) It has a tendency to cause salt accumulation in the root zone.
(ii) It requires a more complex combination of physical conditions not readily found in nature.
(iii) There are extra costs associated with the need for thorough drainage and leaching practices to assure adequate salinity control.
(iv) It is expensive and should be used only for high-value crops.

Drip irrigation

Drip irrigation sometimes called trickle irrigation involves laying a system of perforated plastic pipes on the ground. The pipes are fitted with outlets called emitters or drippers which allow water to pass out and water is applied close to plants so that only part of the soil in which the roots grow is wetted (refer to Figure 10.4). Normally, the system drips water into the soil at very low rates ranging from 2 to 20 litres/hour.

Figure 10.4: Sections of drip irrigated farms

Unlike other systems of irrigation which involve wetting the whole soil profile, with drip irrigation, water applications are more frequent, usually every 1-3 days. This provides a very favourable high moisture level in the soil in which plants can flourish. Drip irrigation is suitable for row crops, for example, vegetables, fruits and vine crops where one or more emitters can be provided for each plant. In addition, drip irrigation is suitable for most soils. On clay soils, water must be applied slowly to avoid surface water pooling and run-off. On sandy soils, higher

emitter discharge rates will be needed to ensure adequate lateral wetting of the soil.

Advantages of drip irrigation

(i) It minimises losses through deep percolation, run-off and soil water evaporation.
(ii) There is a considerable saving in water because it can be applied precisely to the root zone.
(iii) It permits the application of fertiliser through the system.
(iv) It has a greater advantage over sub-surface irrigation systems because it is easily laid down and can be removed at any time after the crop has been harvested.

Despite these advantages, only high value crops are generally considered in using drip irrigation. This is due to high capital costs of installing drip system.

Overhead irrigation

This is a method of applying irrigation water which is similar to natural rainfall. It is also called sprinkler irrigation. In this method, the irrigation water is applied to crop from above the ground surface in the form of spray. Sprinkler irrigation systems consist of a pump to develop the desired operating pressure. They contain main lines, laterals and risers to convey water. Sprinkler head or nozzles discharge water in the form of spray. For sprinkler irrigation, water must be clean and free from sand, debris and large amounts of dissolved salts. Stable supply of water must always be available. Figure 10.5 shows an example of sprinkler irrigation.

Figure 10.5: Sprinkler irrigation

Sprinkler irrigation is both technically and economically very suitable for terrain that is too uneven for surface irrigation, as well as for sandy soils. It is also used for nearly all crops except paddy and jute. However, it is not suitable for heavy clay soils where the infiltration rate is very low.

The advantages of overhead irrigation

(i) Water application can be more uniform and carried out with greater precision with sprinkler system than with surface irrigation, except during times of high wind.
(ii) Water use efficiency is also greater with sprinkler irrigation.
(iii) Elimination of field ditches required for surface irrigation increases the area available for crop production. Also water losses due to seepage and percolation is reduced.
(iv) It does not interfere with the movement of farm machinery, if properly installed.
(v) Soluble fertilisers and fungicides can be applied together with the irrigation water, however, they should be applied with great care to avoid overdose.
(vi) It is used to protect crops against high temperatures that reduce the quality and quantity of the produce.

In spite of the advantages, the sprinkler system is challenging in that the capital investment for equipment is relatively high. Also water loss due to evaporation and interruption of water by the foliage is greater with sprinklers than with surface irrigation method. Moreover, it is not well suited to very windy areas.

Choice of an irrigation method

To choose an irrigation method, the farmer must know advantages and challenges of various methods. Farmers must know which method suits best the local conditions. In many cases, there is no single best solution. The factors elaborated in this section, however, give general guidance and indicate several important criteria in the selection of a suitable irrigation method. The choice of the method to be used depends on factors such as type of soil, topography of the land, local weather patterns of the area, type of crop to be irrigated, water availability and quality, costs and benefits, required labour inputs and level of technology as well as capital required. These factors are elaborated herein.

(a) Type of soil

The type of soil affects the irrigation method to be used as well as the irrigation frequency and rates. Sandy soils typically require frequent applications of water at a high rate to keep moisture in the root zone. Lighter clay soils can hold moisture longer than sandy soils but may require frequent applications at a lower rate to prevent run-off.

(b) Topography of the land

Hilly or sloping land can be a challenge. Sprinkler or drip irrigation are preferred over surface irrigation to steeper or unevenly sloping lands as they require little or no land levelling.

(c) Local weather patterns of the area

Under very windy conditions, for instance, drip or surface irrigation is more suitable than overhead irrigation. This is because strong wind can disturb the spraying of water from sprinklers. Similarly, in arid areas with low humidity, sprinkler irrigation is not suitable since water losses due to evaporation can be extremely high. Instead, drip irrigation works well in both of these situations.

(d) Type of crops to be irrigated

Surface irrigation can be used for all types of crops. Sprinkler and drip irrigation are mostly used for high value cash crops such as vegetables and fruits because of their initial high capital investment. They are rarely used for lower value staple crops. Also drip irrigation is not suitable for close growing habit crops.

(e) Water availability and quality

Water application efficiency is generally higher with sprinkler and drip irrigation than surface irrigation. Sprinkler and drip irrigation are preferred when water is in short supply. If the irrigation water contains dissolved salts, drip irrigation is particularly suitable as less water is applied to the soil than with surface methods. Also sprinkler systems are more efficient than surface irrigation methods in leaching out salts. As far as water quality is concerned, surface irrigation is preferred if the irrigation water contains much sediment. Sediments may block the drip or sprinkler irrigation systems.

(f) Costs and benefits

In choosing an irrigation method, an estimate must be made on the costs and benefits of the available options. On the cost side, not only the construction and installation but also the operation and maintenance costs should be taken into account. These costs should then be compared with the expected benefits.

(g) Required labour inputs

Surface irrigation often requires a much higher labour input for construction, operation and maintenance than sprinkler or drip irrigation. Surface irrigation requires accurate land levelling, regular maintenance and high level of farmers' organisation to operate the system. Sprinkler and drip irrigation require little land levelling. In terms of system operation and maintenance, sprinkler and drip irrigation are less labour intensive.

(h) Level of technology and capital required

Type of technology affects the choice of irrigation method. In general, drip and sprinkler irrigation are technically more complicated methods. Also the purchase of equipment requires high capital investment. To maintain the equipment, high level of technical know-how has to be available together with a regular supply of fuel and spare parts. Surface irrigation systems particularly in small-scale schemes, require less sophisticated equipment for both construction and maintenance unless pumps are used. The equipment needed are often easier to maintain by using a relatively smaller capital.

Activity 10.5

1. Explain how surface, sub-surface, drip and overhead irrigation methods can be practised for managing soil water deficits in your area. Summarise your responses and share them in class.
2. (a) Identify other irrigation methods practised in your area in managing soil water deficits.
   (b) Explain how each of the identified methods can be practised.
   (c) Outline the strengths and challenges of each method identified above.
   (d) Explain how each of the challenges can be solved. If they can be solved differently, explain why you think so.
   (e) Share your responses in class.

3. Highlight the lessons that you have learnt about the methods of managing soil water deficits and record those lessons in your portfolio.
4. With assistance from your teacher, practise a method of irrigation suitable in your area in your school farm.

Exercise 10.2

1. What is irrigation?
2. Why irrigation is important in crop production?
3. For each of the following, state two advantages and two disadvantages:
   (a) Surface irrigation
   (b) Sprinkler irrigation
   (c) Drip irrigation
4. Explain the factors to consider when using sprinkler irrigation method.

Management of excessive water levels in the soil

During rain or irrigation, the fields become wet. Water infiltrates into the soil and is stored in its pore spaces. When all the pore spaces are filled with water, the soil is said to be saturated and no more water can be absorbed. When rain or irrigation continues, pools may form on the soil surface. Part of the water present in the saturated upper soil layers flows downward into deeper layers. This part is normally replaced by water infiltrating from the surface pools. When there is no more water left on the soil surface, the downward flow continues for a while and air re-enters in the pore spaces of the soil. This soil is not saturated anymore. Conversely, saturation may have lasted too long as part of the water present in the saturated upper soil layers is no longer flowing downward into deeper layers. When this happens, the crop plant's health (with an exception of few crops such as paddy and taro which withstand saturated soil for long periods) will be at risk. Apart from damaging the crop, very wet soil makes the use of machinery difficult or impossible.

In soil saturation, the groundwater reservoir is usually fed by water flowing from the saturated soil downward to deeper layers. In soil saturation, groundwater level rises. Therefore, following heavy rainfall or continuous over-irrigation, the

groundwater table may even reach and saturate part of the root zone (refer Figure 10.6 (a) and (b)). If this situation lasts too long, the plants may suffer. Thus, measures to control the rise of water table are necessary.

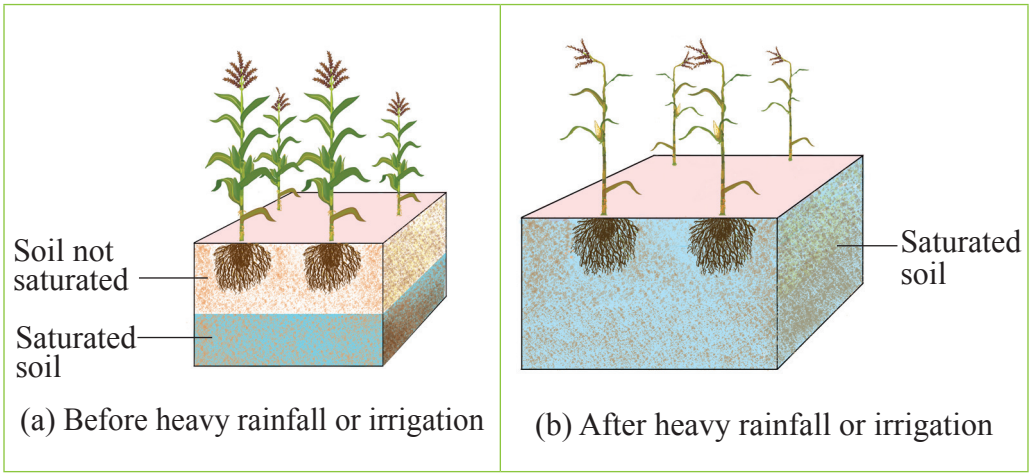


Figure 10.6: Changing of groundwater table

It is worth noting that the major sources of excess water that make removal of excess water necessary may be seepage losses from reservoirs or canals, deep percolation loss from irrigated lands, flooding of low lands and flow of groundwater towards waterlogged lands in the arid regions. Due to these factors, soil may need artificial removal of excess water because water table is high or because of excess surface water. In both cases, all the pore spaces are filled with water thus causing poor aeration. This can result to reduced root development and possibly an accumulation or concentration of ions such as manganese.

The removal of excess water, either from the ground surface or from the root zone, is called drainage. The term drainage may be defined as the means by which soil and sub-soil water is controlled in and removed from the root zone in relation to health and vigour of the crop. Excess water can either be drained out into the canal or to a distant place to be used as irrigation water. However, this process has to be done with proper salinity-checking devices.

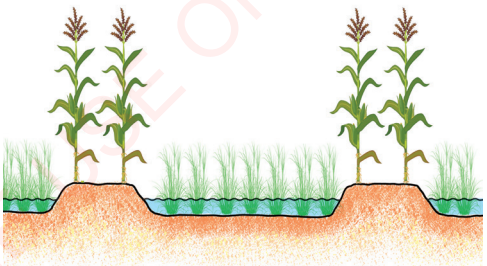
Methods of drainage

Adequate drainage of crop-producing lands requires a general increased lowering of shallow water tables. This can be achieved by eliminating or controlling sources

of excess water, improving natural drainage facilities or providing man-made artificial drainage systems. In view of these factors, there are several methods of drainage. Some of these methods are described here.

Use of open ditches: This is the most widely used method of removing excess water from the field. "U" or "V" shaped open ditches are dug or constructed. The ditches allow water to flow in by gravity to a waterway thereby lowering the water table. The ditches must be deep and wide enough in order to be effective. With these ditches, large quantities of water can easily be drained (refer to Figure 10.7(a)). The method is cheaper to use. However, the method has high maintenance costs as it requires constant removing of silt in ditches after a certain period of use. The ditches also interfere with the mechanisation of certain operations. In addition, soil erosion may arise if the ditches are not well designed. The ditches also take off valuable land space which could have been used for planting crops, however, they may be constructed in a way which allows water loving crops such as paddy to be planted on them. Figure 10.7 (b) shows a cross-section view of open ditches used to plant paddy.

(a) Open ditch



(b) Open ditches used to plant paddy

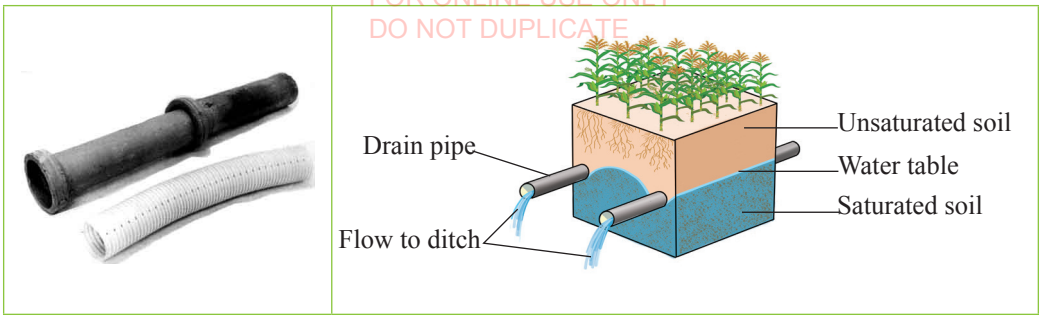
Figure 10.7: Open ditches

Use of cambered beds: Cambered beds are raised beds which are constructed on the poorly drained soils (refer Figure 10.8). The beds are usually used in combination with ditches. Water collects and drains into spaces between the beds by gravity. This allows crops which are not water loving to grow well on the aerated soils on the beds. Water loving crops may be inter-planted in the furrows if intercropping is suitable.

Figure 10.8: The cambered beds

The cambered beds are capable of intercepting water that flows laterally down the slopes. Also it is the easiest and cheapest method of draining swampy areas and make them suitable for crop farming. However, the method is associated with high maintenance cost due to constant repair. Perennial weeds can establish themselves in the drains. There are difficulties in using farm machinery and it can form a breeding place for mosquitoes.

Use of underground drain pipes: These are perforated pipes which are laid underground. Water then seeps from the surrounding area into the pipes and flows to a waterway. Such drains do not interfere with field operations. Drain pipes could be made of steel, concrete or plastic materials. The method is effective in removing excess water from the root zone of plants. However, it is expensive. Figure 10.9 (a) shows the drain pipes and Figure 10.9 (b) illustrates the working of the underground pipes.

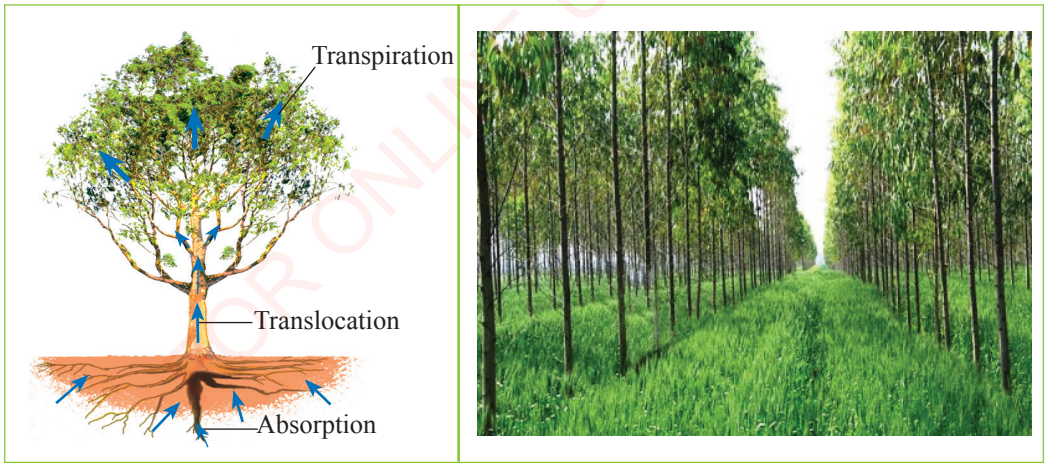


(a) Drain pipes (b) Working of the underground drain pipes

Figure 10.9: The underground drain pipes

Pumping out the excess water from the soil: This method involves the use of pumps to pump away water from low-lying areas to other areas where it may be needed. It is, however, a very costly method of drainage. Therefore, it is done where other methods of drainage are not suitable.

Bio-drainage: In this method, deep rooted and quick growing plants which transpire at a very high rate are grown in the marshy areas. Their roots penetrate deep in the soil creating waterways for water to seep through. The plants also take up a lot of water which is then lost through transpiration. In return, plants drain excess water from the soil. Eucalyptus is one of the plants which is commonly used for this purpose. Figure 10.10 (a) illustrates the bio-drainage process while figure 10.10 (b) shows trees planted for bio-drainage.



(a) Illustration of bio-drainage (b) Trees planted for bio-drainage

Figure 10.10: Bio-drainage

Activity 10.6

1. (a) Identify the drainage methods practised in your area in managing excess soil water, if any.
   (b) Explain how each of the identified method can be practised.
   (c) Outline the advantages and disadvantages of each method identified above.
   (d) Explain how each of the weaknesses can be solved. If they can be solved differently, explain why you think so.
   (e) Summarise your responses and share them in class.
2. Highlight the lessons that you have learnt about the management of excess water in soils and record those lessons in your portfolio.
3. With assistance from your teacher, practise a method of drainage suitable in your area.
4. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise 10.3

Answer the following questions.

1. What does the term drainage mean?
2. Why is draining excess water in the soil important in agricultural land?
3. State advantages and challenges of using the following methods of drainage:
   (a) Open ditches
   (b) Cambered beds
   (c) Underground water pipes

Chapter Eleven

Pests and their control in crop production

Introduction

Pests are of great concern in crop farming because of the damage they cause to crops; both in the field and store. In this chapter, you will learn about the concept of pest in crop production as well as types and identification of crop pests. You will also learn about the methods of pest control including integrated pest management. The competencies developed from this chapter will enable you to practise the methods involved to control pests properly and timely so as to maximise production.

The concept of pest in crop production

Crop pest refers to a living organism that harms crops directly or indirectly. Crop pests include insects, rodents, mites, nematodes, birds and large animals including monkeys, elephants and wild pigs. Crop pests also include weeds, bacteria, fungi and viruses. Pests harm directly by causing physical damage to the crop plant or produce and indirectly by introducing disease-causing organisms, that is, pathogens into the plant. Domestic animals, if not taken care of, can also become crop pests. Large animals that destroy crops are also referred to as vermin.

Pests damage quality and quantity of crops in the field and even in stores. The following are some harmful effects of crop pests:

(a) Eat plant leaves and tender stems thus lowering the photosynthetic area. This results to retarded growth and reduced yields.

(b) Damage crop roots and tubers causing wilting and death to plants. This is done by pests such as nematodes, termites and moles.

(c) Dig up the planted seeds resulting in low plant population. This is done by pests such as squirrels and mice.

(d) Infest flowers and fruits thus lowering their quality and quantity. This is done by pests that are flower eaters.

(e) Pierce and suck plant sap resulting in retarded growth because the affected plant is deprived of its food.

(f) Destroy the embryo of seeds thus lowering their germination potential.
(g) Transmit crop diseases and/or open up the plant thus exposing it to secondary infection.
(h) Reduce marketability of crop produce by lowering its economic quality. This applies both to field and storage pests.
(i) Increase costs of production since some amounts of liquid capital is spent on measures for controlling them, for example, in buying pesticides and spraying equipment.
(j) Endanger food security and safety. Serious pest infestation lowers crop yields. Where food crop is concerned, it leads to food shortage. Similarly, improper use of chemicals to control pests result into residue of those chemicals in crop products. This may lead to potential health hazards that are threat to food security and safety.

Activity 11.1

In groups, perform the following tasks:

1. Discuss the harmful effects of crop pests in your area.
2. Identify the beneficial effects of crop pests, if any, in your area.
3. Summarise your responses and share them in class.

Types and identification of crop pests

Grouping crop pests is important in determining the basic information about the pest. Similarly, proper identification of crop pest is the key factor in getting rid of pest infestations right after pests have been detected. Correct identification of the pest makes controlling it easier and often more effective. Identification of pests enables the farmer to determine the basic information about the pest including its life cycle especially for insect pests as well as the time that it is most susceptible to be controlled. Crop pests can be identified by using personal experience. It can also be done by assistance of field extension workers. Alternatively, the actual pest or its photograph can be taken then further identified. Basically, there are insect and non-insect crop pests. The insect pests are of great importance as they comprise a large part of all crop pests. The non-insect pests include mites, nematodes, rodents, birds, molluscs and large animals. These categories of pests are explained in next sections.

Insect pests

Insects are important and major pests. Insect pests have either a complete or incomplete life cycle as it is shown in Fig 11. 1. The damaging stages of different insect pests are larvae, nymph and adult stages.

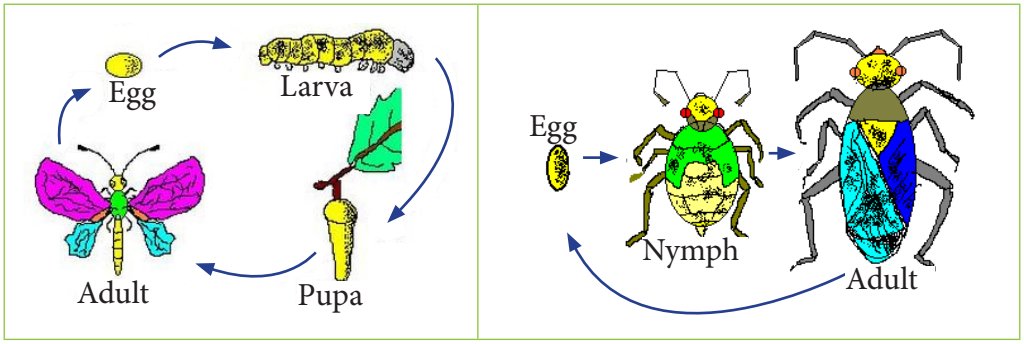


Figure 11.1: Life cycles of insect pests

The insect pests are categorised into various groups based on their mode of feeding. These groups are biting and chewing, piercing and sucking as well as boring insect pests. The biting and chewing insects have strong mouth parts called mandibles and maxillae which enable them to bite and chew plant foliage. Examples of these insect pests are locusts, grasshoppers, leaf worms, termites and some beetles. The piercing and sucking insect pests possess strong mouth parts called proboscis which enable them to pierce through plants and suck liquid contents from plant tissues. Examples of these insect pests are aphids, stainers, mealy bugs, scales, white flies and capsids. The boring insect pests including their larvae are capable of boring into plant parts and destroying the tissues of the plants including stems, fruits and seeds. Examples of these insect pests are weevils, some beetles and stem borers.

The insect pests can also be categorised based on the place they are found or habitat. On this basis, there are insect pests which infest crops in the field or the products in the store. The insect pests that infest crops in the field are referred to as field pests. Examples of these pests include locust, grasshoppers, army worms and mealy bugs. Those insect pests that infest the crop products in the store are called storage pests. Examples of these pests are weevils and flour beetles.
The following are some of the crop pests:

Cut worms: These are larvae of moths that lie hidden in the soil or at the base of seedlings. Their presence is indicated by fallen seedlings. If the soil at the base of the fallen seedling is removed, tiny smooth shiny worms will be seen curled around the seedling. They normally damage seedlings of crops in the nursery and main field. Figure 11.2 shows the cut worm and a seedling cut by the worm.

Figure 11.2: Cut worm

Army worms: These are larvae stages of certain moths. They feed on crop leaves. They move in large swarms and eat up almost all the vegetation during their invasion. They are non-selective, therefore, they infest a wide variety of crops including pastures and fodder crops. Figure 11.3 shows the army worms.

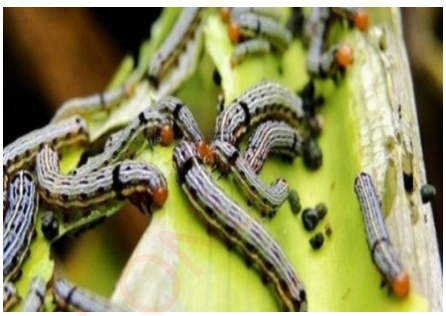


Figure 11.3: Army worms

Potato tuber moth: the larvae stage of moths causes serious damage to plants, for example, potato tubers. Potato tuber moth caterpillars burrow the tubers making black tunnels filled with solid waste materials. Other plants that are attached by this larvae are egg plants, tomatoes and tobacco. Figure 11.4 shows a caterpillar of potato tuber moth and a section of the damaged tuber.

Figure 11.4: Caterpillar of potato tuber moth

Locusts: These cause a considerable damage to crops in their nymph and adult stages. They eat exclusively all vegetation including leaves, shoots, and even barks of tree crops. They migrate in large swarms. They destroy all types of crops. Figure 11.5 shows the locust swarm.

Figure 11.5: Locusts

Mealy bugs: There are many types of mealy bugs, for example, the coffee mealy bug and pineapple mealy bug. They pierce and suck sap from plant leaves. In so doing, they transmit viruses. Figure 11.6 shows the pineapple mealy bugs.

Figure 11.6: Pineapple mealy bugs

Boll worms: These are larvae of certain moths. These larvae are known as caterpillars. They feed on leaf tissue thus reducing the photosynthetic area. They infest crops such as cotton, beans, maize, peas, peppers, citrus and many other crops. They mainly bore flower buds, pods, bolls, seeds and fruits and feed on their contents. They are of many types such as spiny, red and American boll worms. Figure 11.13 shows boll worm.

Figure 11.7: American boll worm

Aphids: These are small insects found in clusters around stems and young shoots on the leaf's underside. There are various species of aphids such as green aphid, brown aphid and black aphid. They pierce and suck sap from plants and their attack is more serious during periods of low moisture. They also transmit viral diseases such as groundnut mosaic virus. They infest crops such as cabbage, bean, groundnut and citrus. Figure 11.8 shows an aphid and aphid colony on a leaf.

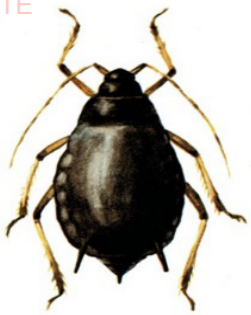


Figure 11.8: Aphid and aphid colony

Stalk borers: These are larva of moth. The larvae bore into the stems of crops such as maize, rice, sugar cane and feed on the stem tissue. In maize, holes can be seen on the funnel leaves. Death of central leaves is noticeable and small blackish caterpillars may be found in the maize funnel. Pictures on Figure 11.9 show maize stalk borers and the affected maize plant.

Figure 11.9: Maize stalk borers and its effects

Leaf miners: These are larvae of tiny white moths. They make holes in the palisade tissue of leaves forming mines which appear as irregular brown blotches on the leaves' upper surface. They infest crops such as coffee trees causing premature leaf fall. Figure 11.10 shows leaf miners.

Figure 11.10: Leaf miners

Stainers: These are most destructive at their nymph and adult stages. The adults are brightly coloured with red brown, black and white stripes on their abdomen. There are many types of strainers which infest different crops. They pierce and suck sap from plant tissues. They commonly infest crops such as cotton and okra. They also transmit diseases. Figure 11.11 shows cotton stainers.

Figure 11.11: Cotton stainers

Loopers: These are larvae of certain flies and they are green in colour. They feed on the leaves of plants thus reducing the photosynthetic area. They commonly infest crops such as coffee and cabbage. Figure 11.12 shows the looper on the damaged cabbage leaf.

Figure 11.12: A looper

Fruit flies: These are most destructive at their larval stage. They infest mainly citrus fruits making tunnels in them and causing rotting of the fruit. The unripe infested fruits turn yellow and drop off prematurely. They can also be recognised by the presence of small dark spots on the fruit. They also infest fruits such as mangoes, oranges, guavas and coffee. Figure 11.13 shows larvae of orange and mango fruit flies.

Figure 11.13: Larvae of fruit flies

Thrips: These are small, slender and yellow-black insects. Both larvae and adults pierce and suck sap from lower surface of plant leaves, flowers and fruits. In banana plants, for example, thrips can be recognised by the presence of silvery or brown patches on fruits and cracks on the skins of banana fruits. They commonly infest crops such as banana, tea, coffee, onion, pyrethrum, tomato, eggplant, pepper, bean, cotton, citrus, cacao and cereals. Figures 11.14 (a) and (b) show the thrips and the damaged crop parts, respectively.

(a) Thrips

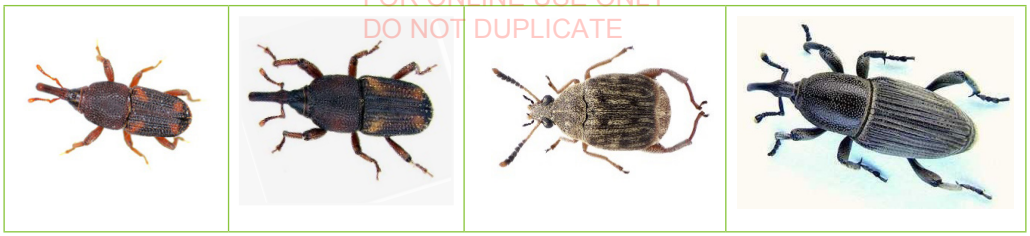
(b) Damaged crop parts

Figure 11.14: Thrips and the damaged crop parts

Beetles: These are destructive both at larvae and adult stages of their life. They feed by chewing and cause damages such as holes, notches, tunnels and chewed plant parts. The common destructive one is rhinoceros beetle. It is large, black and shiny with a horn on its head. It damages unopened leaves at the growing point. The dusty brown beetles infest tea leaves making holes on them. Figure 11.15 shows the rhinoceros beetle.

Figure 11.15: Rhinoceros beetle

Weevils: These are beetles characterised with elongated snouts. They are destructive both in their larvae and adult stages. They use their curved snouts to bore into the seed or grain and feed on the contents. There are many species of weevils which infest various crops such as bean, maize, mango, banana and groundnut. Among these pests, bean and maize weevils are the most common ones. Figure 11.16 shows different weevils.



Rice weevil | Maize weevil | Bean weevil | Banana weevil

Figure 11.16: Weevils

Scales: These are immobile insects which are found in clusters. They are circular-shaped. Others are oval-shaped while others have elongated bodies. There are various types of scales such as red scales, soft green scales, soft brown scales and mussels. They infest leaves, stems and fruits by piercing and sucking cell sap from them causing premature leaf fall, die back and stunted growth in trees. They commonly infest citrus, coffee, sisal and sugar cane. Figure 11.17 shows different types of scales.

(a) White scales on citrus | (b) Brown scales on coffee | (c) Scales on sugar cane

Figure 11.17: Scales

Mites

The mite pests are organisms like insects but have soft bodies. They differ from insects in that they lack wings and antennae, have four pairs of legs and two body divisions which are cephalothorax and abdomen. Their abdomen is not distinctly segmented. They have red or pale yellow colour. Their mouth parts are adapted for piercing and sucking. They suck the sap from plant and attack various crops. The most common ones are spider mites. Figure 11.18 shows spider mites on plant leaf.

Figure 11.18: Spider mites

Nematodes

Nematode pests that attack plants are microscopic roundworms. Some nematodes are parasitic in plants while others are free-living. The parasitic nematodes are of great importance in crop production. They have piercing and sucking mouth parts which are used for penetration of host plant tissues. They pierce different parts such as roots, stems, leaves and bulbs and suck the sap from them. When piercing the plant parts, some nematodes inject toxic saliva leading to formation of galls in plants. This causes stunting of roots by limiting water and mineral nutrients uptake by the plant. This may result in wilting of the plant. Nematode infestation may also cause secondary infection through the wounds caused on the plant tissue. Nematode infestation is generally characterised by retarded growth of shoot of affected plants, discolouration of leaves, wilting of the plant, reduction of root system particularly in banana plants and presence of galls in roots of the infested crops. Since most of nematodes live in the soil and are microscopic, they are difficult to detect, identify and control. Figure 11.19 (a) shows root knot nematode and Figure 11.19 (b) shows damaged crops.

(a) Root knot nematode (b) Damaged crops

Figure 11.19: Nematodes and crop roots damaged by root knot nematodes

Molluscs

Mollusc pests are soft-bodied invertebrates which are either aquatic or terrestrial in habitat. They are of a wide range, however, snails and slugs are the most mollusc pests infesting crops. Snails have shells they carry around on their back which act as their house while slugs have no shell. Since they prefer succulent foliage or flowers, snails and slugs mainly infest seedlings and herbaceous plants. Terrestrial or land snails and slugs feed on succulent vegetables, seeds, seedlings, tuber crops, tender leaves and fruits that are close to the ground; and leave unpleasant slimy tracks on the injured parts. Their damage to seedlings often results in the death of plants. Snail and slug damage can be confused with damage caused by other pests such as caterpillars or other chewing insects. Figures 11.20 (a) and (b) show a snail and slug and the infested plant parts, respectively.

(a) Snail and affected cabbage (b) Slug and affected tomato

Figure 11.20: Snail and slug and the damaged crop parts

Birds

These pests include various birds which infest crops especially grains and fruits. However, not all birds are pests as some are beneficial in controlling various insect pests by eating them. Examples of bird pests are Sudan dioch or *Quelea quelea* birds, weaver birds, mouse birds and domestic fowls which are not properly reared. Of these birds, *Quelea quelea* is the most destructive. They move in large numbers like locusts and infest crops causing heavy damage. They eat both developing and dry cereal grains in crops such as finger millet, rice, sorghum, bulrush millet, maize, wheat and barley. Weaver birds also damage cereal crops. Mouse birds feed on fruits such as tomato, guava and papaya. Figure 11.21 shows these different types of birds.

(a) Quelea quelea bird (b) Weaver bird (c) Mouse bird

Figure 11.21: Bird pests

Rodents

These include a wide range of animals, however, the most important rodent pests are rats, moles and squirrels. Other rodent pests are porcupines and hedgehogs. Rats destroy crops both in the field and those in stores particularly cereals. Moles are quite destructive to tuber crops such as potatoes, cassava, underground yams and taro. They also infest other crops such as sugar cane. Squirrels and rats also dig up and eat the planted seeds. In case of an outbreak of rodent pests, farmers are advised to seek advice from extension workers. Figure 11.22 shows some important rodent pests.

(a) Rat (b) Mole (c) Squirrel

Figure 11.22: Rodent pests

Large animals

Large animal pests include wild animals which infest crops. These animals include, among others, elephants, buffaloes, monkeys, apes, wild pigs, antelopes and hippopotamus. Domestic animals, if not well looked after, can infest crops and cause a considerable loss.

Activity 11.2

1. Visit your school farm as well as the areas nearby your school and home which you can easily and safely reach to detect the common pests present. Note the pest/crop associations found. You may collect samples or take their photos.
2. Identify the pests by common local names and English names. Record your observations and findings in your portfolio.
3. Develop a list of pests which are commonly found in crop fields in your area. Consider to note the following in your list:
   (a) Local/English name of the pest
   (b) Brief description of salient characteristics of the pest including its category/class
   (c) Keep the list in your portfolio.
   (d) Share your work/findings in class.
   (e) Outline the lessons you have learnt from this activity.

Methods of pest control

Pests have to be controlled effectively so as to attain the desired quality and quantity of crop produce and products. There are several methods of controlling

crop pests. Basically, these methods are grouped into cultural, physical or mechanical, biological and chemical methods.

Cultural pest control

This involves the use of farming practices to alter the environment so as to make it unfavourable for the survival of pests hence allowing the crops to escape harmful effects. The basic principle of cultural control is the disruption of the development of life cycle of the pests by exposing them to adverse conditions. Those conditions may either kill the pests or deny them food, thus, minimising their harmful effects to the crops. Cultural practices used to control pests include:

(a) Use of clean planting materials

Planting seeds or vegetative materials which are free from pests help in establishing pest free crops. This practice helps to prevent introduction and spreading of crop pests. It is very effective in controlling pests such as banana weevils. To achieve this, use certified seeds or vegetative planting materials.

(b) Timely planting

This involves growing of crops early before pests build up. This enables the crop to escape pest infestation hence grow healthy. For example, maize planted early may escape stalk borer infestation.

(c) Proper seedbed preparation

Seedbed preparation should be thorough and preferably cultivated in dry season. This will expose the pests, particularly which are soil borne such as white grubs, chafer grubs and nematodes. These pests once exposed, are scotched by the sun or eaten by birds and other predators. This creates safer environment for the crop to be planted.

(d) Trap cropping

Trap cropping involves planting of border strips of a crop which attract pests thus diverting them from the main crop. For less attractive trap crops, it is advised to plant them before the main crop and for the most attractive trap crops, they can be planted along the main crop.

(e) Close season

This is the period when a susceptible crop is not grown in order to control a certain pest or group of pests. The principle of this method is that the pests will

starve to death during the absence of that particular crop. During close season, crop residues can be collected and disposed off to ensure maximum destruction of the pest. Examples of pests which can effectively be controlled by this method are pink bollworms in cotton.

(f) Crop rotation

Crops which are more susceptible to a particular pest are rotated with others which are not susceptible to it. Therefore, this helps to control pests by depriving them of their host plants. For example, maize and beans, which are susceptible to nematodes, are rotated with groundnuts and bambara-groundnuts which are not susceptible to nematodes.

(g) Use of resistant crop varieties

Plant breeders have developed crop varieties which have natural protective mechanisms against pests attack. For example, the hairy cotton against jassid bug, goose necked sorghum against birds and highly tillering sorghum against shoot fly attack. There are some varieties of onions and lemons which produce substances that are repellent to pests.

(h) Observing field hygiene

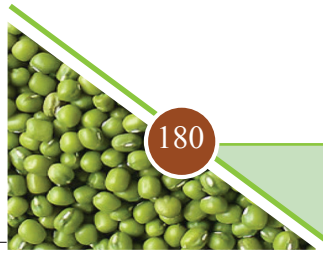
This involves keeping the field free from any materials which harbour pests. It includes removal or burning of crop residues of previous seasons. This helps especially to control some pests which can harbour in crop residues, for example, bollworms in cotton and cereals.

(i) Destruction of alternative hosts

Some plants particularly weeds act as alternative hosts to crop pests. The removal of such weeds reduces pest infestation. A good example is mallow weed which harbours cotton stainers.

(j) Alteration of environmental conditions

This involves the creation of certain micro-climates that are not conducive to some pests. For example, open pruning in coffee discourages antestia bugs while mulching reduces thrips.



(k) Proper spacing

When crops are properly spaced it becomes difficult for pests to move from one plant to other. However, closer spacing in groundnuts discourages aphids.

(l) Observing proper crop nutrition

Application of fertilisers and manure help crops to grow strong and be able to withstand or escape pests' attacks. Moreover, organic manure such as farmyard manure where they are available, has been found to discourage various pests particularly nematodes. However, excessive application of nitrogen should be avoided because it makes crop plants excessively succulent and hence susceptible to pest infestation.

(m) Timely harvesting

Harvesting crops at proper time prevents serious attacks by pests. For example, infestation of some pests such as grain weevils, rats and mice as well as brown scales is higher with late harvesting. Therefore, timely harvesting will enable crops to escape pest attacks.

Activity 11.3

In groups, perform the following tasks.

1. Discuss the suitability of cultural pest control methods you have learnt, if applied in your area.
2. Identify other methods for cultural pest control used in your area.
3. Identify the kinds of pests/crop associations the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity.

Physical or mechanical pest control

These involve using physical or mechanical means to kill pests and create barriers to prevent pests from getting into contact with their target crops. The methods involved include:

(a) Flooding and overhead irrigation

Flooding suffocates pests such as cutworms and army worms. Underground

pests such as moles may also be killed by flooding. Overhead irrigation weakens aphids from cabbages.

(b) Hand picking, trapping and killing

This involves catching or trapping the pests followed by killing them. It is effective in controlling pests such as rats, moles, birds and giant loopers using special traps.

(c) Physical barriers

Physical barriers include materials that prevent pests from getting to the crops. For example, rat proofing in the store or using metal plates fixed on posts for raised silos. It also includes construction of fences around the fields and trenches to control large animals.

(d) Scaring pests

Large animal-pests can be scared by using scare crows or distress calls. The scare crows are objects with human-like figure which are used to scare away bird and large animal-pests from the fields of crops. Animal pests such as monkeys and squirrels have been successfully controlled by using scare crows. Distress calls involve using sounds of a captured pest or that of its predator which is recorded and replayed from a loud speaker to scare away pests.

(e) Proper drying of produce before storage and proper storage

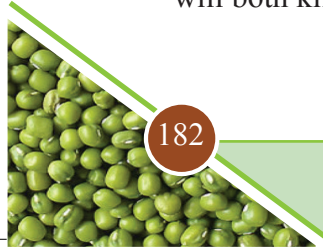
Drying of grains makes them too hard for pests to penetrate and discourages the growth of moulds. Grains should be dried to a moisture content of about 11-13%. Well dried grains should be stored in air-tight containers. Alternatively, storage bins which are filled with carbon dioxide have to be used. These inhibit pests' multiplication or survival through suffocation.

(f) Use of lethal temperature

This involves creation of high or low temperature conditions to discourage or kill some insect pests. An example can be the use of hot water treatment to control pink bollworm in cotton.

(g) Use of explosives

This involves throwing explosives at breeding places of bird pests at night. This will both kill and scare them off.



Note: Physical/mechanical pest control measures have the merit of not causing environmental pollution and the demerit of having cost implication. Some of these measures require a high level of skills to be effective.

Activity 11.4

In groups, perform the following tasks.

1. Discuss the suitability of the methods for physical/mechanical pest control you have learnt and applied in your area.
2. Identify the other methods for physical/mechanical pest control used in your area.
3. Identify the kinds of pest/crop associations the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity.

Biological pest control

This involves the use of living organisms which are natural predators to control pests. Examples include parasitic wasps preying on whitefly in citrus and coffee mealy bugs, lady bird beetle preying on aphids and cottony cushion scale, preying mantis preying on giant looper, *Majimoto* ants preying on white scales, chicken preying on stainers, chameleons preying on most insects, and cats preying on rats, mice and moles, wasps and poultry preying on bollworms, and weevils preying on aphids. Biological pest control methods are advantageous in that they are self-continuing, cause no environmental pollution and save labour. However, the process is a bit slow in some cases.

Activity 11.5

In groups, perform the following tasks.

1. Discuss the suitability of biological pest control method you have learnt in your area.
2. Identify other methods for biological pest control used in your area.
3. Identify the kinds of pest/crop associations the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons you have learnt from this activity.

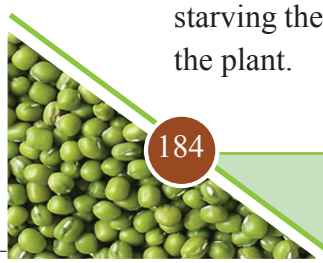
Chemical pest control

This involves the use of chemicals which are collectively termed as pesticides. These chemicals can be applied through various ways including spraying, dusting, and fumigation of the soil and crop plants. Pesticides are generally categorised on the basis of formulation, target pest and mode of action. Basing on formulation, pesticides are grouped according to the form in which they are available. These forms are soluble powders, wettable powders, fumigants, aerosol dusts, liquids, pastes, granules and emulsions. On the basis of target pest, pesticides are categorised according to specific pests killed by a particular pesticide. For example, insecticides kill insect pests, nematocides kill nematodes, and rodenticides kill rodents.

Basing on mode of action, pesticides are categorised according to the way they function. On this basis, pesticides may be grouped into stomach poisons, systemic poisons, contact poisons, suffocants, anti-feedants and repellents. Stomach poisons kill pests when a part of plant sprayed or dressed with the pesticide is eaten by the pest. Biting and chewing insect pests are controlled by this group of pesticides. Stomach poisons are relatively selective in that they only kill those pests which actually ingest the crop.

The systemic poisons are pesticides that are circulated to all parts of the pest body once ingested a sprayed or dressed part of the plant. They kill by inhibiting vital processes of the pest. These pesticides are more selective in that only those pests with systems that can circulate them are killed. The contact poisons are pesticides which kill the pests when they are absorbed in the body through skin or cuticle. They are either sprayed on the pest or on the crop. However, they are most effective when applied directly on the target pest. Contact poisons are not selective and may kill many beneficial organisms such as predators, pollinators, decomposers, birds and small mammals.

The suffocants are the pesticides which kill by interfering with the breathing system of a pest after being inhaled. Majority of them change into gaseous form after being applied. Pests with a tough cuticle which makes it difficult for contact poison to penetrate can be killed by the use of suffocants. The anti-feedants are pesticides which inhibit or prevent the pest from feeding on the plant thus starving them to death. Repellents are pesticides which keep the pests away from the plant.



Effectiveness of pesticide in controlling pests: Effectiveness of pesticide refers to its ability to kill the intended pest upon application. It is influenced by several factors. These include concentration, timing of application, weather conditions at the time of application, persistence and pest resistance. The concentration factor is important when the farmer has to make solutions or suspensions from powder and liquid forms of pesticides. Correct concentration will be more effective in killing the targeted pests. The time of application is an important factor as the pesticide should be applied at the stage of development when the pest is most susceptible. For example, most insect pests are more susceptible to pesticides at larval and nymphal stages than at the pupal and adult stages. At pupal and adult stages, some pests become resistant to pesticides.

Pesticides application should be timed so that there is no likelihood of rain falling soon after pesticide application. Rain falling immediately after the application of pesticide washes off or dilutes the pesticide, thus reducing its effectiveness. Moreover, to ensure persistence, pesticides should remain effective long enough to achieve all desired effects. For this purpose, pesticides which have long residual effect are more effective in killing pests. This is because such pesticides retain their strength for long before breaking down into constituent compounds which are harmless to pests. Furthermore, pest resistance influences effectiveness as some pests have developed resistance to certain pesticides. This challenge necessitates the use of multiple methods in a single programme of controlling crop pests as well as rotating the types of pesticides used.

Merits and demerits of chemical pest control: Generally, chemical control of pests is faster compared to cultural and biological methods. Also, the results of chemical control are more predictable than most other methods. However, pesticides are expensive and their use require care and skill in handling and application. Moreover, most of pesticides are non-selective thus, kill useful insects such as pollinators and pest predators. In addition, most pesticides are toxic to human beings, livestock and other unintended animals. Unselective use of pesticides can end up interfering with the ecosystem. Furthermore, some pests can easily develop resistance to some pesticides and therefore becoming a bigger problem than before applying them.

Safety precautions in use of pesticides: Pesticides are toxic chemicals and should be handled with care. Therefore, when using pesticides, you should take the following precautions:

(i) Check the expiry date of the pesticide.

(ii) Carefully, read manufacturer's instructions and follow them.

(iii) Wear protective gears such as overall, breathing mask, goggles, gloves and boots.

(iv) Avoid inhaling the pesticide. This may occur when spraying or dusting along the wind. It is better to observe wind direction.

(v) Avoid pesticide drift to unintended crops and other plants. This can be achieved by avoiding spraying on windy days.

(vi) Never allow drift to feeds, food materials and water, thus avoid using food vessels like cups in measuring pesticides.

(vii) Wash your body and clothes thoroughly after handling pesticides.

(viii) Never smoke, eat or drink anything while spraying or dusting before thoroughly washing your body.

(ix) Never blow or suck blocked nozzles.

(x) Dispose properly any left-overs and empty pesticide containers. Bury them deeply where they cannot contaminate water sources. Do not throw them in gardens, bushes or pasture land.

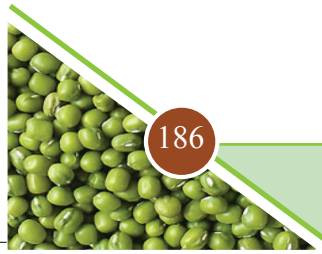
(xi) Clean the spraying equipment thoroughly after using particular pesticide since they may be used for applying different pesticide. This will help to protect the crop from being sprayed by unintended pesticide, for example, herbicide left in the spraying equipment that can harm the crop.

(xii) Wash the spraying equipment away from water sources which are used by animals and humans.

(xiii) Store all chemicals in safe and cool places, out of reach of children and away from food/feed store.

(xiv) Adhere to withdraw period, thus, allow the correct time to elapse before harvesting any sprayed crop or treated produce so that the chemical applied breaks down to safe levels.

(xv) Keep proper records of all chemical applications. This helps to avoid re-applying the chemicals to a crop that had already been treated. You also need to know the proper time to harvest and consume crop produce.



Activity 11.6

In groups, perform the following tasks.

1. Discuss the suitability of chemical pest control you have learnt, if applied in your area.
2. Through library search, teacher, local field extension worker or other resource persons, find out the most suitable pesticides for controlling pests you have listed in activity 11.2. Explain how safely they can be applied.
3. Summarise your findings in your portfolio and share them in class.
4. Outline the lessons that you have learnt from this activity

Integrated pest management

Integrated pest management is an optimum combination of control methods to reduce pest populations to an economical acceptable level with a few harmful effects as possible on the environment and non-target organisms. The combination of methods include cultural, biological, physical or mechanical and/or chemical controls. As such, integrated pest management programmes use current and comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage.

The general principles to be followed in practising integrated pest management are:

(a) The crop habitat should be manipulated by utilising some biological differences between crops and pests. This is essential in placing the crop in a competitive advantage over the pests.

(b) Measures should be directed to reduce the survival mechanism of pests in the soil.

(c) The cultural or agronomic practices of weed control should be incorporated to discourage the establishment of short-term and long-term pests.

(d) Any individual technique of pest control should be environmentally friend, that is, it should not be harmful to crop plants, soil, air and water as well as people including producers and consumers.

(e) Pest control practices should be flexible according to the need, that is, able to respond to seasonal conditions.

In implementing integrated pest management, it is advisable to start using the least invasive and often most effective means. These include prevention or cultural practices, mechanical/physical control methods and naturally occurring biological control methods, that is, use of native predators. Thereafter, consider using non-native predators. Finally, use chemical control methods sparingly as the last possible alternative. In using chemical control, always start using naturally occurring materials, for example, extracts from wild tobacco, *Tephrosia* and neem plants, wood ash and dried chillies. Then, go for biodegradable organic pesticides made by plants that are only toxic to pests, for example, pyrethrins from pyrethrum.

Benefits of integrated pest management

(a) It promotes natural pest control methods.
(b) It protects human health.
(c) It minimises negative impacts to non-target organisms.
(d) It enhances the general environment.
(e) It is most likely to produce long-term and beneficial results.
(f) Sometimes, it is easy and efficiently implemented.
(g) It is cost-effective in short and long-term basis.

Activity 11.7

1. (a) From your portfolio, recall the methods found suitable for cultural, biological, physical or mechanical, and chemical pest control in your area. Then, suggest various programmes possible for practising an integrated pest management in your area.
   (b) Summarise your findings in your portfolio and share them in class.
   (c) As class, practise the most viable integrated pest management options in your school farm. You may also practise them in your family farm.
   (d) Outline the lessons you have learnt from this activity.

2. (a) Using the pest list you have prepared in activity 11.2 and with guidance of teacher, local field extension worker or other resource persons, collect as many pest specimens as possible, and preserve them properly to conserve their colour and other important distinguishing features.

(b) On each pest specimen you have collected, write the following details:
   (i) Common name (Local/Kiswahili/English) and scientific name
   (ii) Date collected and name of collector
   (iii) Where it is commonly found/crops associated with
   (iv) Salient characteristics of the pest
   (v) Way(s) of controlling the pest

(c) Make an exhibition of the preserved pest specimens in class or other suitable place.

(d) Keep your preserved pest specimens properly for further use.

3. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What is the first thing you should do when you detect the presence of a pest that you think you may need to control?
2. How can pest identification help you to develop a good pest control method?
3. Describe pest classification and explain how it can be important to pest control method.
4. Define "integrated pest management" and explain its benefits.
5. You applied a pesticide but it did not control the pest. State three reasons why your control effort might have failed.
6. What can you do to keep the pests, you are trying to control, from becoming resistant to the pesticides you are using?

Chapter Twelve

Weeds and their control in crop production

Introduction

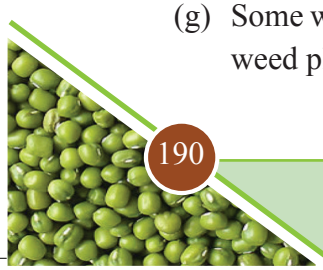
Weeds and weed control are of great significance to crop farming since they have extensive influence on land productivity. In this chapter, you will learn about the concept of weeds in agricultural production and identification of weeds. You will also learn about the basic principles and methods of weed control including integrated weed management. The competencies developed from this chapter will enable you to practise the principles and methods involved to control weeds properly and timely for improved quality and quantity of farm produce.

The concept of weeds in agricultural production

A weed is any plant growing where it is not required and which its economic disadvantages outweigh the advantages. Crop plants that grow without having been planted in the field are also weeds. For example, volunteer bean plants growing in a plot of maize are referred to as weeds.

Weeds have various characteristics and survival mechanisms which enable them to compete with crop plants and survive over several generations of the crop. Generally, weeds have the following key characteristics:

(a) Weeds have ability to produce large quantities of seeds.
(b) Weed seeds can remain viable in the soil and water for a long time waiting for conducive germination conditions.
(c) Most weed seeds can be easily and successfully dispersed by water, wind and animals, among other agents.
(d) Some weeds have ability to reproduce both sexually (by seed) and asexually (by vegetative structures).
(e) Weeds have extensive root systems that facilitate effective nutrient absorption and water uptake.
(f) Weeds have ability to survive even where there is limited nutrients supply.
(g) Some weeds have short life cycle such that if the rain regime is restricted, the weed plants can still be able to complete their life cycle.



Weeds have harmful effect in farming. The effects caused by weeds can be seen in various ways and seriously affect various agricultural processes. Weeds cause great losses to farmers in the following ways:

(a) They compete with crop plants for nutrients, soil moisture, space and light thus, reducing crop yields.

(b) Some weeds are parasitic to cultivated crops.

(c) Weeds lower the quality of agricultural produce. This happens when weed seeds get mixed up with produce.

(d) Some weeds harbour insect pests and disease causing organisms.

(e) Some weeds are allelopathic, that is, they release chemical substances which suppress or inhibit germination of crop seeds or growth of crop plants when they come into contact.

(f) Some aquatic weeds can block irrigation channels making it difficult for water to flow freely in the irrigated land. They may also increase the rate of water loss through transpiration thus reducing irrigation efficiency.

(g) Aquatic weeds may also deprive fish and other aquatic organisms of oxygen causing them to die.

(h) Weeds lower the quality of pastures by reducing the palatability of herbage. They, therefore, reduce the carrying capacity of most pasture fields and feed intake for animals.

(i) Some weeds irritate workers when the plant leaves get into contact with any part of their bare skin thus reducing the efficiency of farm labour.

(j) Weeds increase the cost of production through increased labour costs, purchase of herbicides, cleaning and/or sorting of contaminated produce, or impediment in harvesting of crops.

(k) Weedy areas can host rodents that later attack crops.

Despite the harmful effects, there are some weeds which are beneficial to farmers. Some of the benefits include:

(a) Some weeds are edible to both human beings and livestock. They provide human beings with vegetables and succulent herbage to livestock.

(b) Some weeds have medicinal effects. They provide herbal medicine to both human beings and livestock.

(c) Weeds provide soil cover thus conserving soil moisture by preventing or

minimising loss of soil water through evaporation. They also prevent the removal of top soil by erosion agents. However, this is only beneficial if the weeds in question have a different rooting system which does not compete with the main crop plant for nutrients. Such weeds are encouraged to grow in between widely spaced crops or along the contours.

(d) Weeds add organic matter and nutrient elements to the soil when they die and decompose.

(e) Leguminous weeds may fix nitrogen in the soil.

(f) Some dead dry weeds may be used as mulch for crops.

(g) Some weeds serve as raw materials for compost making.

(h) Some weeds have bio-pesticidal properties and can be used for biological control of other pests such as disease-causing pathogens.

Activity 12.1

1. In groups, list the harmful and beneficial effects of weeds found in your area. Give examples to justify your answer.
2. Summarise your deliberations and present them in class.

Identification of weeds

It is important that identification of weeds should be accurate to allow appropriate weed control measures to be taken. If a farmer notices a new weed in his/her field, it is important to identify it immediately so that action can be taken to prevent it from spreading. Proper weed identification also helps in selecting the correct herbicide to control a particular weed, where chemical weed control is preferred.

Identification of weeds can be achieved through several ways. These include personal experience with the weeds, use of aids such as textbook illustrations, special publications dealing with weeds and/or assistance from resource persons including field extension workers and researchers. Weeds can be identified by individual botanical and common names and the latter can be in English, Kiswahili or vernacular languages. However, vernacular names are limited to small communities. Taxonomically or botanically, weeds like other plants are classified by family, genus and species. Individual weeds are identified using common and botanical names. Botanical names are preferred because they are

recognised internationally. Botanical names are written in a conventional way of naming living organisms. Each plant is given two names. The first name refers to the genus name and the second name is for the species to which the plant belongs. They are underlined or typed in italics, for example, Bidens pilosa or *Bidens pilosa*. Some weeds that are commonly found in various areas of Tanzania are shown in following figures:

Black jack
(Bidens pilosa)

Mexican marigold
(Tagetes minuta)

Oxalis
(Oxalis spp)

Double thorn
(Oxygonum sinuatum)

Couch grass
(Digitaria scalarum)

Thorn apple
(Datura stramonium)

Nut grass
(Cyperus rotundus)

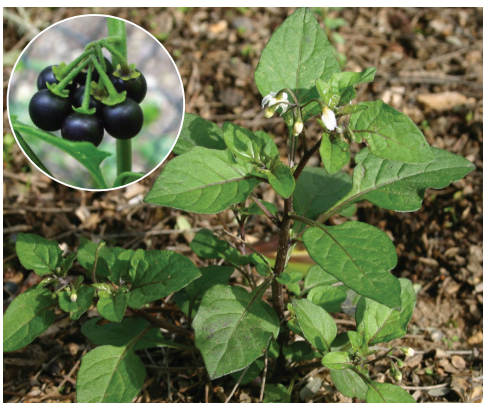
Wandering jew
(*Commelina benghalensis*)

Devil's horsewhip
(Achyranthes aspera)

Sow thistle
(Sonchus oleraceus)

Gallant soldier/Macdonald's eye
(Galinsoga parviflora)

Sodom apple
(Solanum incanum)



Black night shade
(Solanum nigrum)

Chinese lantern
(Nicandra physalodes)

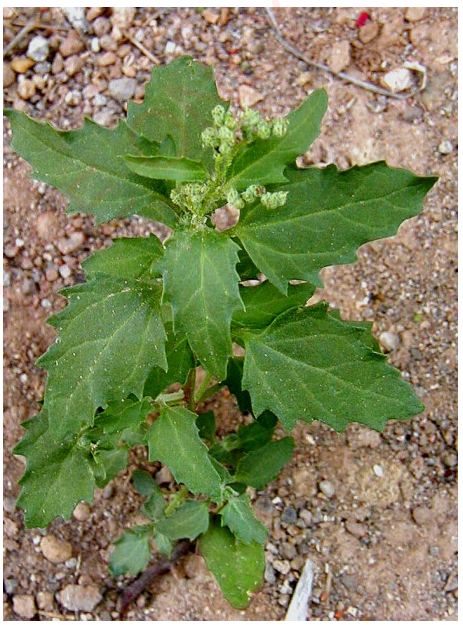
Bracken fern
(Pteridium aquilinum)

Creeping indigo
(Indigofera spicata)

Wild oats
(Avena fatua)

Tick berry
(Lantana camara)

Bristly foxtail
(Setaria verticillata)



Goosefoot/Fat hen
(Chenopodium murale)

Cleavers
(Galium spurium)

Mallow
(Malva verticillata)

Water hyacinth
(Eichhornia crassipes)

Stinging nettle
(Urtica massaica)

Rape weed
(Brassica napus)

Pigweed
(Amaranthus spinosus)

Witch weed
(Striga spp*)*

Activity 12.2

1. Pay a visit in your school farm as well as in the areas nearby school and home where you can easily and safely reach to detect the common weeds present. Note the weed-crop associations commonly found in those areas.
2. Identify the weeds by common local language names and botanical names.
3. Record your observations and findings in your portfolio.
4. Develop a list of weeds which are commonly found in crop fields in your area and keep it in your portfolio. Consider to note the following in your list:
   (a) Local/English name of the weed
   (b) Botanical/scientific name of the weed
   (c) Brief description of salient characteristics of the weed
5. Share your work/findings in class.
6. Outline the lessons you have learnt from this activity.

Classification of weeds

Weeds are classified for the purpose of giving clues which are normally needed for their control. Weeds are classified based on various characteristics. Some of such characteristics include life cycle, morphology, habitat, degree of undesirability or noxiousness, growth habit, and scientific taxonomy. Some of the ways are explained herein.

(a) Classification on the basis of life cycle

On the basis of life, weeds are classified as annual, biennial or perennial. Annual weeds are the ones that complete their life cycle, that is, from seed germination to seed production, in one year or season. Examples of annual weeds are Mexican marigold, black jack, pig weed. Biennial weeds are the ones that require two seasons or years to complete their growth. Examples of biennial weeds are wild carrots, spear thistle, ragwort, wild parsnip and burdock. Perennial weeds are those which live for more than two years. Examples of perennial weeds are sedges, tick berry, wandering jew, couch grass and Sodom apple.

(b) Classification on the basis of plant morphology

On the basis of plant morphology, weeds are classified as broad-leaved and narrow-leaved weeds. The broad-leaved weeds are annuals or perennials commonly

found on arable land or new pasture lays. Specifically, all dicotyledonous weeds are broad-leaved weeds. They include weeds such as thorn apple, black jack, pig weed, wandering jew, and oxalis. The narrow-leaved weeds are also perennial or annual grasses. Specifically, narrow-leaved weeds come under the family Poaceae. They have long narrow spiny leaves. They are usually difficult to control. They include weeds such as couch grass, nut grass, spear grass, wild finger millet, wild sorghum and star grass.

(c) Classification on the basis of degree of undesirability or noxiousness

On this basis, weeds are either classified as common weeds and noxious or notorious weeds. The common weeds are annuals, biennials or simple perennials that can be readily controlled by ordinary good farming practices. The noxious weeds are those weeds which are difficult to control because of extensive perennial root system or because of other characteristics that make them persistent.

Activity 11.3

Classify the weeds you have listed in the activity 11.2 based on their characteristics.

Basic principles of weed control

Weed control refers to those actions that seek to restrict the spread of weeds and destroy or reduce their population in a given area. There are basic principles to consider in controlling weeds. These are:

(i) The weed should be killed before it has a chance to produce seeds. For this reason, the land that is left fallow should be ploughed at intervals in order to kill weeds before they produce seeds.

(ii) Weeding should be done before the crop begins to suffer from competition with weeds.

(iii) Perennial weeds should be removed at the beginning of the rainy season when the amount of reserved food present in them is minimal.

(iv) The cost of controlling weeds on a crop should be weighed against the expected loss in yield and quality if weeds are not controlled.

(v) Crops should be properly spaced so that when the crops are fully grown, the ground is completely covered thus depriving the weeds from getting sunlight. Sunlight suffocation can result into slow growth or death of weeds.

Methods of weed control

Weeds have to be controlled effectively so as to attain the desired quality and quantity of crop produce. Generally, there are several methods for controlling weeds. These are basically grouped into cultural, physical/mechanical, biological, and chemical methods.

Cultural weed control

This involves the use of agronomic practices which prevent or minimise introduction of weeds in the farm or reduce their effects. Cultural methods of weed control include:

(a) *Use of clean seeds/planting materials:* This method prevents the introduction of weeds into the field.

(b) *Use of clean seedbed:* This method enables the crop to start growing and establishing itself before weed competition intensifies. This can be achieved by harrowing or spraying herbicide in a recently ploughed seedbed just before planting. Deep ploughing then harrowing is also vital in exposing perennial weeds such as couch grass and nut grass to harsh conditions thus killing them.

(c) *Timely planting:* This method gives crops an advantage to grow and establish faster before weeds emerge thus smothering them.

(d) *Mulching:* This method helps to cut out sunlight from reaching the weeds thus preventing or reducing their growth. Most of broad-leaved weeds can be effectively controlled by mulching.

(e) *Use of cover crops:* This method restricts weeds for widely spaced crops. The effects of cover crops are similar to those of mulch in smothering weeds.

(f) *Proper spacing of crops:* This method provides adequate crop cover and little space for weed growth due to forming of a canopy which, in turn, supresses weeds.

(g) *Adopting crop rotation:* This method controls weeds which only grow well when in association with certain crops. This works well in controlling parasitic weeds, for example, witch weed (*Striga* spp) by rotating cereals which are its host with non-cereal crops. When host crops for a particular parasitic weed are rotated with crops which are not the host, the germination and/or growth of the weed can be reduced.

(h) *Flooding:* This method discourages growth of all non-aquatic weeds. Flooding kills these weeds by depriving them of oxygen. This method is

mainly practised in fields of crops which withstand waterlogged condition such as paddy and taro.

(i) *Applying adequate quantities of manures or fertilisers:* This method allows crops to grow and establish well thus enabling them to compete with weeds.

Activity 12.4

1. In groups, discuss the suitability of the methods for cultural weed control you have learnt and applied in your area.
2. Identify other cultural weed control methods used in your area.
3. Identify the kinds of weed and crop associations the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity.

Physical or mechanical weed control

This involves the suppression or removal of weeds manually or by mechanical means. Thus, tools such as hand hoes, slashers, machetes, mattock and mechanical weeders are used. Physical or mechanical operations involved in controlling weeds include:

(a) *Hand pulling:* This is mainly done where the weeds are scattered or where the crop plants are too close to allow mechanical cultivation or hand hoeing. It is particularly used in controlling weeds in cereal crops such as paddy that are traditionally broadcasted. It is also used in small-scale horticultural crop farming.

(b) *Hand hoeing:* This method of weed control is used after the weeds have emerged but before they get too tall to interfere with hoeing operations. Hoe weeding is applicable to both annual and perennial weeds. It is a faster method of weed control, if compared to hand pulling.

(c) *Slashing or mowing:* This is removal of weed shoots from weeds mechanically by using power-mounted mowers or manually by using a slasher, machete or sickle. It is used for control of over-grown annual weeds.

(d) *Inter-tillage:* This is mechanical weeding by using weeders which are mounted to tractors or draught animals. It is mainly used in row-planted crops with sufficient space between rows.

(e) *Use of delayed and blind tillages:* Delayed tillage involves preparing the seedbed and waiting until the weeds emerge then lightly cultivating the soil again and planting the seeds. The purpose of delayed tillage is to destroy the first flush of weeds so that the subsequently planted crop can grow at a reduced weed pressure. Blind tillage is when crop seeds are planted after the usual land preparation and it is lightly cultivated after weeds have emerged but before crop emergences. However, this works well if weeds germinate much faster ahead of the crop.

Biological weed control

This method relies on the use of living organisms to control weeds. The living organisms involved either kill the weeds or supress their growth through various ways such as feeding on them. For example, goats, cattle, sheep and even human beings feed on various edible weeds. The method is not reliable on its own, therefore, it is used in combination with other methods. A good example of biological weed control method in Tanzania is the use of goats and cattle to graze on weeds in coconut and cashew plantations. It is worth noting that the method is only possible where the crops cannot be eaten by livestock.

Activity 12.5

1. In groups, discuss the suitability of the methods for physical or mechanical, and biological weed control you have learnt and applied in your area.
2. Identify other methods for physical or mechanical, and biological weed control used in your area.
3. Summarise your responses in your portfolio and share them in class.
4. Outline the lessons that you have learnt from this activity.

Chemical weed control

This is the use of chemicals called herbicides to control weeds. Herbicides are used to control weeds either by killing them out right or disrupting various life processes in the weed plant. These herbicides are grouped on the basis of the selectiveness with reference to the type of plant killed, time when they are normally applied, and movement in plants. On the basis of type of weed plants killed, the herbicides are either grouped as non-selective or selective. The non-selective herbicides are those herbicides that exert toxic effects on all plants that

may come in contact with them. The selective herbicides are those herbicides which are capable of killing only certain group of plants. They usually kill the weeds with broad leaves while leaving the weeds with narrow leaves. These are normally used to kill herbaceous weeds and all others which do not belong to grasses or sedges.

With regard to other categories, it is advisable to contact extension workers or experts in your area.

Note: The safety measures for chemical weed control are the same as those for use of pesticides already covered in the previous chapter.

Activity 12.6

1. In groups, discuss the suitability of chemical weed control you have learnt, if applied in your area.
2. Through library search, teacher, local field extension worker or other resource persons, find out the most suitable herbicides for controlling weeds you have listed in activity 12.2. Explain how safely they can be applied.
3. Summarise your findings in your portfolio and share them in class.
4. Outline the lessons that you have learnt from this activity.

Integrated weed management

Integrated weed management is neither a method nor a system of weed control. It is rather a philosophy whose goals is to use all available knowledge in weed science to manage weeds. This method enables farmers to prevent or reduce economic loss due to weeds and subsequently minimise hazards to the environment. An integrated weed management is defined as the combined use of methods of weed control such as cultural, physical, chemical and biological ones. One of the simple ways to understand the philosophy of integrated weed management is overlapping all possible and most appropriate techniques under the four major methods of controlling weeds (refer to Figure 12.1).

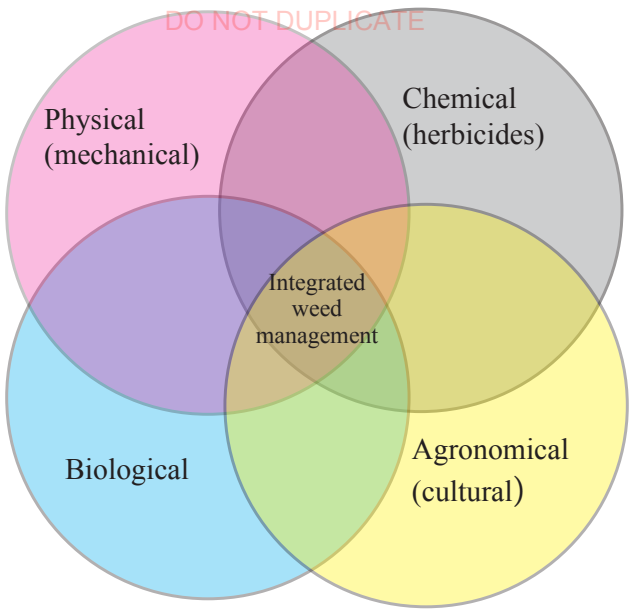


Figure 12.1: Integrated weed management approach

An example of integrated weed management in a maize field is described herein:

(a) Use a non-selective herbicide to kill all weeds in the field before planting (chemical method).

(b) When weeds die, plant maize followed by beans as an intercrop to increase the plant population and improve ground cover so as to suppress weed growth (cultural method).

(c) Remove weeds that emerge early using a hand hoe (physical method).

(d) Weeds that emerge later, which are usually scattered, are pulled out by hand (physical method).

The reasons that make the integrated weed management necessary are twofold. First, the inability of any one method of weed control to completely solve the weed problem of a given crop at all times and without adverse effects. Second, the ability of weeds to develop resistance to herbicides that are frequently used. Therefore, to alleviate these challenges in designing any integrated weed management programme in your area; you must know the nature and habitat of the weeds in your area in relation to how they react to environmental changes and how they respond to herbicides.

Integrated weed management is advantageous in that it shifts the crop-weed competition in favour of the crop, provides more efficient management for perennial weeds, prevents resistance in weeds to herbicides, eliminates or reduces environmental pollution, gives a farmer higher returns and, lastly, it is suitable for high cropping intensity, that is, higher productivity per unit of arable land during one cropping season.

Activity 12.7

1. (a) From your portfolio, list the methods found suitable for cultural, biological physical/mechanical, and chemical weed control in your area. Then, suggest various programmes possible for practising an integrated weed management in your area. Summarise your findings in your portfolio and share them in class.
   (b) Practise the most viable integrated weed management options in school farm. You may also practise them in your family farm.
   (c) What lessons have you learnt from this activity?

2. (a) Using the weed list you have prepared in activity 12.2 and with guidance of teacher, local field extension worker or other resource persons, collect the weed specimens, press and dry them properly to preserve their colour, leaves and other important distinguishing features. Mount the well-dried specimens on appropriate locally available papers to make a weed herbarium.

   (b) On each mounted weed, write the following details:
      (i) Common name (Local/Kiswahili/English) and botanical name
      (ii) Date collected and name of collector
      (iii) Where it is commonly grown/crops associated with
      (iv) Salient characteristics of the weed
      (v) Way(s) of control
   (c) Make an exhibition of the weed herbaria in class or other suitable place.
   (d) Keep your herbarium properly for further use.

3. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What do you understand by the term "weed"?
2. Explain the economic importance of weeds in agricultural production.
3. Which weeds are difficult to control? Why?
4. Briefly, explain five methods of physical/mechanical weed control.
5. State at least ten precautions a farmer should take while using herbicides.
6. Briefly, explain why weeds have to be identified.
7. Why is it important to have herbarium of local weeds?
8. Outline five basic principles of weed control.
9. (a) Why do weeds have an ability to compete highly with crop plants in field?
   (b) Explain at least 10 measures that can be employed by farmers to reverse the competition, that is, to place crop plants in a competitive advantage over weeds.
10. (a) What does it mean by biological weed control?
    (b) What are the limitations of biological weed control?
    (c) How biological means can best be used in controlling weeds?
11. (a) What is the meaning of integrated weed management?
    (b) Why farmers are insisted to practise integrated weed management?

Chapter Thirteen

Diseases and their control in crop production

Introduction

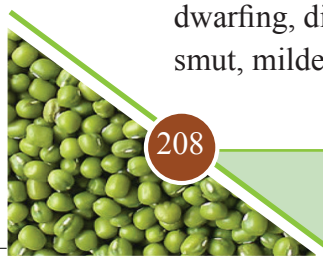
Diseases are among important constraints for yield and quality in crop production. In this chapter, you will learn about the concept of disease in crop production, symptoms of crop diseases, and causes of crop diseases. You will also learn about the methods of disease control and integrated disease management. The competencies developed from this chapter will aid in identification of crops' disease problems. Once a disease is properly identified, management options can be used to alleviate disease impact thus maximise profitable production.

The meaning of crop disease

Crop plants, like any other organism, are susceptible to diseases. Diseases are either caused by pathogens or physiological disorders. A crop becomes diseased when it is continuously disturbed by the causal agent that results in an abnormal physiological process that disrupts the plant's normal structure, growth, function or other activities. Therefore, a crop disease is a malfunction in the crop plant or crop produce in response to continuous irritation by a causal agent.

Symptoms of crop diseases

Symptoms of a crop disease are the visible effects of disease on a particular crop plant or its parts. Symptoms may include detectable change in colour, shape or function of the plant as it responds to the root cause. A diseased crop can easily be distinguished from a normal healthy one on the basis of symptoms. The symptoms provide clues to find out the nature of the disease and the causative agent on the host. You cannot actually see the disease pathogen but rather a symptom that is being caused by the pathogen. Therefore, familiarity with the way crop diseases are visually identified can help you to diagnose problems. There are various symptoms for crop diseases. Some of the crop disease symptoms include necrosis, abnormal growth and development of plant tissues, stunting or dwarfing, discolouration and gummosis. Other symptoms include phyllody, rust, smut, mildew, wilting and witch's broom.



Necrosis: This is death of the host cells, tissues and organs induced by a pathogen. The necrotic areas are called lesions. Various terms are used to describe the extent and shape of necrotic lesions such as:

(i) *Streaks or strips:* These are elongated narrow lesions (Figure 13.1 (a) shows streaks in cereal leaves).

Figure 13.1 (a): Leaf streaks

(ii) *Spots:* These are minute circular or sub-circular lesions of various colours such as brown, white, dark, orange or red. In some cases, the dead tissue of leaf spots shed, leaving circular perforations called round holes (Figure 13.1 (b) shows spots on tomato leaf).

Figure 13.1 (b): Leaf spots

(iii) *Blight:* It involves rapid discoloration followed by death of a plant organ which gives a burnt appearance. It also involves death of the entire leaf or shoot (Figure 13.1 (c) shows blight in maize).

Figure 13.1 (c): Leaf blight

(iv) *Cankers:* These are spreading sunken lesions in the stems or fruits surrounded by raised margin (Figure 13.1 (d) shows cankers in citrus stem and fruit).

Figure 13.1 (d): Cankers in citrus

(v) *Rot:* The affected tissues die and decompose to a great extent. For example, on the basis of plant part involved, there are root rot, stem rot, leaf rot, bud rot, fruit rot and others. On the basis of type of decomposition, they are soft rot, dry rot, wet rot and black rot (Figure 13.1 (e) shows soft rot in pepper).

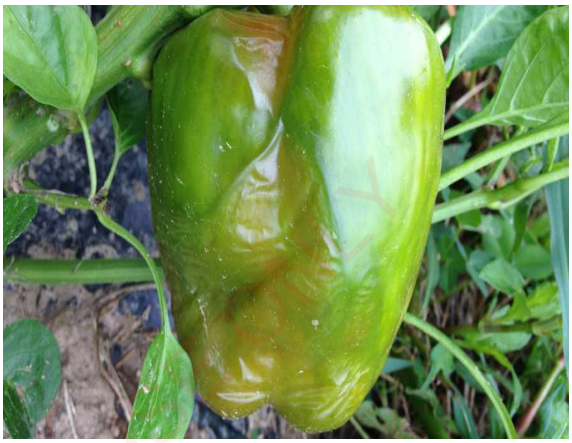


Figure 13.1 (e): Soft rot

(vi) *Damping off:* The stem of seedling is attacked near the ground level so that the seedlings collapse (Figure 13.1 (f) shows damping off in tomato seedlings).

Figure 13.1 (f): Damping off

(vii) *Burns:* These are brownish lesions in succulent organs due to high temperature. They are also termed as scald or scorch (Figure 13.1 (g) shows sun burn in beans).

Figure 13.1 (g): Burn, scald or scorch

(viii) *Die back:* This is progressive death of the affected part from the tip downwards (Figure 13.1 (h) shows die back in papaya plant).

Figure 13.1 (h): Die back

(ix) *Anthracnoses:* These are sunken lesions with raised margins on plant parts such as fruits and pods (Figure 13.1 (i) shows anthracnose in beans).

Figure 13.1 (i): Anthracnose

Abnormal growth and development of plant tissues: These symptoms result due to increased cell size and increased number of cells. Plant tissues show abnormal growth pattern which result in changed morphology and physiological functioning of the affected part or the entire plant.

Some symptoms of abnormal growth and development of plant tissues are:

(i) *Galls:* These are abnormal fleshy or woody outgrowths; when small they are called warts, when large they are called knots (Figure 13.2 (a) shows a knot in grape stem).

Figure 13.2 (a): Gall

(ii) *Curl:* This involves puckering or crinkling of leaves (Figure 13.2 (b) shows curls in cassava leaves).

Figure 13.2 (b): Curls

(iii) *Blotches:* These are intermediate between blights and spots. They are irregular or indefinite large or small necrotic areas on leaves or fruits (Figure 13.2 (c) shows blotches in water melon).

Figure 13.2 (c): Blotch

(iv) *Hairy roots:* These are clusters of fibrous roots that appear like root hairs (Figure 13.2 (d) shows hairy roots in groundnut seedlings).

Figure 13.2 (d): Hairy roots

Stunting or dwarfing: This is a symptom of many diseases where the growth of plant is interrupted causing stunting or dwarfing. In some cases, internodes fail to elongate causing the growing of foliage which gives a rosette form that is referred to as rosetting. Figure 13.3 shows examples of rosette in groundnut plants.

Figure 13.3: Rosette in groundnut

Discolouration: This involves change of the green parts of crop plants to other colours due to various causes including infection of pathogens and some other physiological disorders such as mineral deficiency or lack of light. Figure 13.4 shows some symptoms related to discolouration.

Figure 13.4: Discolouration symptoms

Gummosis: This is the production of clear, amber-coloured exudates on the surface of the affected parts of a plant, which later sets into a solid mass, insoluble in water. Gummosis is common in peach, citrus trees, coconut and cashew. Reddish exudate is a common feature of the stem bleeding disease of coconuts and cashew nuts. Figure 13.5 shows gummosis in coconut and fruit trees, respectively.

Figure 13.5: Gummosis in coconut and fruit trees

Other symptoms include phyllody, rusts, smuts, mildews, wilting and witches' broom.

(a) *Phyllody:* This is a transformation of floral organs to vegetative organs, for example, in bulrush millet flowers convert into leaves Figure 13.6 (a) shows phyllody in bulrush millet.

Figure 13.6(a): Phyllody

(b) *Rusts:* These are coloured pustules on host surface due to fungal spores (refer to Figure 13.6 (b) which shows rusts in beans).

Figure 13.6 (b): Rusts

(c) *Smuts:* These are the plant affected areas releasing charcoal-like dusty mass of spores (Figure 13.6 (c) shows smut in paddy and maize).

Figure 13.6 (c): Smuts

(d) *Mildews:* These are the coloured superficial patches on the host surface due to fungal infection. When the superficial patches appear cottony or downy are called downy mildews and when dusty or powdery appears are called powdery mildew (Figure 13.6 (d) shows downy and powdery mildews on a grape leaf).

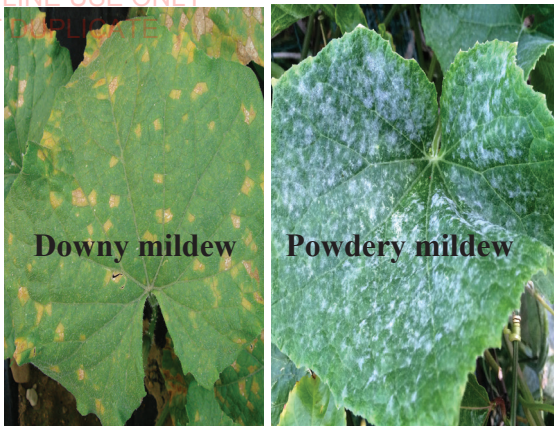


Figure 13.6 (d): Mildews

(e) *Wilting:* This is withering or drooping of whole plant due to loss of turgidity which is mainly caused by excessive transpiration, injuring to root system, toxins of pathogens and many other causes (Figure 13.6 (e) shows wilting in egg plants).

Figure 13.6 (e): Wilt

(f) *Witches' broom:* This is a deformity in a woody plant, usually a tree, where the natural structure of the plant is changed. Also, it is characterised by dense mass of shoots which grow from a single point with the resulting structure resembling a broom or a bird's nest (Figure 13.6 (f) shows witches' broom in citrus tree).

Figure 13.6 (f): Witches' broom

Causes of crop diseases

Disease causing agents are grouped into pathogens (living organisms) and non pathogens. Many of pathogens leave in the plant host in a parasitic mode of life and cause the appearance of disease symptoms. Non-pathogenic disease causing agents cause internal physiological disturbances, and/or physical injuries. They include climatic damage due to sun or lightning, mineral deficiencies or imbalances and genetic mutations. Generally, pathogenic diseases are important because they are infectious. That is, they can spread between crop plants, often rapidly and widely. Diseases have several harmful effects. Therefore, it is very important to find out all you can do about crop diseases so as to manage them properly.

Activity 13.1

1. In groups, discuss the harmful effects of crop diseases in your area. Summarise your responses and share them in your class.
2. Make visits in your school farm as well as in the areas nearby school and homestead which you can easily and safely reach to detect the common crop diseases present by symptoms. Make comparison between healthy and diseased crops. Under guidance of the teacher and by considering safety, take photos/pictures depicting all the distinguishing features. Keep the photo/ pictures for future use.
3. Identify diseases by their local names and common English names. Record your findings in your portfolio.
4. Develop a list of diseases which are commonly found in crop fields in your area. Consider to note the following in your list:
   (a) Local/English name of the disease
   (b) Brief description of salient characteristics of the disease
5. Keep the list in your portfolio.
6. Share your work/findings in class.
7. Outline the lessons you have learnt from this activity.

Control of crop diseases

Crop disease control methods can be classified into various categories. These include cultural, chemical, biological and physical methods.

Cultural crop disease control

Cultural crop disease control methods involve agronomic practices used to reduce the spread of crop diseases. They include:

(a) *Use of disease-free planting materials:* This minimises the occurrence of plant diseases in crop fields.

(b) *Quarantine regulation:* This helps to prevent introduction and spread of diseases in new fields or into the country.

(c) *Use of disease resistant varieties:* This helps to prevent crop infection from a particular disease.

(d) *Practising field hygiene:* This includes destruction of diseased crop residues using clean implements, weeding to destroy micro-habitats for disease carrying pests and rogueing.

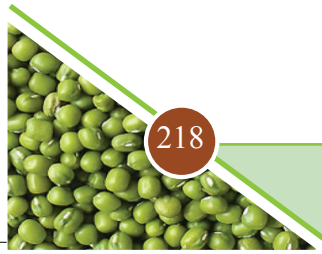
(e) *Practising crop rotation:* This helps to interfere with life cycles of most pests which act as disease vectors.

(f) *Proper seedbed preparation:* This exposes soil-borne pathogens to the sun and predators thus killing them. The method is effective in controlling fungal diseases that are soil-borne such as damping off and fusarium wilt. It is also effective in controlling armillaria root rot in tea and coffee plants.

(g) *Proper pruning:* This helps to eliminate humid micro-climate within the tree bush making it unsuitable for multiplication of disease-causing organisms. This is effective in controlling coffee berry disease.

(h) *Proper crop spacing:* This is effective in controlling some diseases, for example, groundnut rosette disease and damping off in cabbage seedling in the nursery.

(i) *Proper drying of cereals and pulses:* This helps to prevent pathogens from infestation, for example, fungal growth.



Activity 13.2

In groups, perform the following tasks.

1. Discuss the suitability of the methods for cultural control of crop diseases you have learnt and applied in your area.
2. Identify the methods for cultural disease control used in your area.
3. Identify the kinds of diseases the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity.

Biological crop diseases control

Biological crop diseases control is done through manipulation of natural and ecological factors. These include:

(a) *Planting disease-resistant varieties:* This has proved to be very successful in the control of diseases in some crops particularly for viral diseases.

(b) *Use of other organisms:* This helps to reduce inoculum load or the disease producing activities of the causative agents of diseases. For example, use of wasps in controlling cassava mosaic virus disease as it eliminates or suppresses mealy bugs which transmit virus.

Activity 13.3

1. In groups, discuss the suitability of biological disease control methods you have learnt and applied in your area.
2. Identify other methods for biological disease control used in your area.
3. Identify the kinds of diseases the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity

Physical crop disease control

These are some physical methods which can be used to kill pathogens. Some physical crop disease control methods include:

(a) Treating seeds of cereals in hot water to kill the loose smut pathogen and floating of cereal seeds to separate healthy grains from those infected by ergot.

(b) Grain smut of sorghum may be controlled by soaking seed in water for four hours to initiate germination of the fungal spores. The seed is then spread out to dry first in the shade and later in the sun, causing the germination of spores to be killed without harming the seed.

Physical methods of this kind may be widely applicable for controlling certain diseases and represent one of the more reasonable control options available to small-scale farmers.

Activity 13.4

In groups, perform the following tasks.

1. Discuss the suitability of the methods for physical disease control you have learnt, if applied in your area.
2. Identify other methods for physical disease control used in your area.
3. Identify the kinds of parasites and crop associations the methods suit the most and explain why it is so.
4. Summarise your responses in your portfolio and share them in class.
5. Outline the lessons that you have learnt from this activity.

Chemical crop disease control

This method involves the use of chemicals to eradicate the disease or kill the disease vectors. It is advisable to practise this method only when all other methods have been deemed ineffective and when it is economical. Chemical crop disease control methods include:

(a) Dressing of seeds or vegetative planting materials with appropriate fungicides to control seed-borne fungal diseases before planting. Diseases such as smuts or rust may be controlled by soaking the seeds in fungicides before sowing.

(b) Soil fumigation or sterilisation by using appropriate fumigants to control nematodes, pests and soil-borne diseases such as bacterial wilt round in potatoes.

(c) Spraying crops with appropriate chemicals as a preventive or curative measure against diseases. For example, fungal diseases are controlled by chemicals referred to as fungicides. These chemicals may be sprayed or dusted on to the seeds, young leaves, shoots or flower buds before the arrival of the fungal spores as a preventive measure. Likewise, insecticides

may be used to control insect vectors which carry diseases. This has been effective in reducing the spread of some diseases such as mosaic disease of cassava. In this way, leaf-hoppers which transmit this disease can be controlled by the use of insecticides. Moreover, repellents can be used as preventive measures. Repellents are chemicals which do not actually kill the insect vectors which carry diseases, but they repel them from coming near the crop plants.

Activity 13.5

1. In groups, discuss the suitability of chemical disease control you have learnt, if applied in your area.
2. Through library search, teacher, local field extension worker or other resource persons, find out the most suitable chemicals for controlling diseases you have listed in activity 13.1. Explain how safely they will be applied.
3. Summarise your findings in your portfolio and share them in class.
4. Outline the lessons that you have learnt from this activity.

Integrated disease management

Integrated disease management is the practice of using a range of measures to prevent and manage diseases in crops. It should therefore be based on the integration of basic concepts such as avoidance, exclusion, eradication, protection, resistance and therapy. Adoption of integrated disease management against diseases encountered in crops is of great importance because of health hazard to the consumer and the environment. Chemical control of crop diseases is associated with chemical residues, pollution to the environment and sub-soil water as well as increased problem of pathogen resistance towards the chemicals used. These have been the reasons for moving away from total dependence on the chemicals to adopt integrated disease management strategies that would involve one or more than one concepts of plant disease management. The use of such integrated approach in plant disease management is cost effective, eco-friendly and of reduced toxicity to plants as well as non-target organisms and human beings.

It is important to note that crop disease control is concerned with preventing or at least restricting the development of plant disease epidemics. Thus, integrated disease management is designed to prevent rather than to cure. It acts on the pathogen before it establishes a parasitic relationship with the host. The measures concerned with the pathogen control involve exclusion and eradication. Exclusion means that if the pathogen is not already present in an area then methods are devised to exclude it. Eradication means that if the pathogen gets in then attempts are made to eradicate it. Other measures concerned with the host involve protection and breeding for disease resistance. Protection is done or it can be done by modifying the condition under which the plant is growing so as to protect it from attack or by applying a chemical to the plant or on the growing media. Dealing with host crop by breeding entails development and use of varieties of a particular crop plant which resists attack.

Activity 13.6

1. (a) From your portfolio, recall the methods found suitable for cultural, biological, physical, and chemical disease control in your area. Then, suggest various programmes possible for practising integrated disease management in your area.
   (b) Summarise your findings in your portfolio and share them in class.
   (c) Practise the most viable integrated disease management options in your school farm. You may also practise them in your family farm.
   (d) Outline the lessons you have learnt from this activity.
2. (a) Using the pictures you have taken in activity 13.1 and with guidance of the teacher, local field extension worker or other resource persons, prepare an album.
   (b) On the picture(s) depicting symptoms of every disease, write the following details:
      (i) Common name (Local/Kiswahili/English)
      (ii) Date the picture was taken
      (iii) The crops associated with the disease
      (iv) Salient characteristics of the disease
      (v) Control methods of a particular disease
   (c) Make an exhibition of the album in class or other suitable place.
   (d) Keep your album properly for further use.
3. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. How can crop disease identification help you to develop a good control method?
2. What is the first thing you should do when you detect the presence of a disease symptom that you think you may need to control?
3. What is meant by prevention, suppression, and eradication of crop disease?
4. Briefly, explain the concept of integrated disease management. Give its usefulness in comparison to other control methods you have learnt.
5. You applied a chemical, but it did not control the crop disease. Give possible reasons that can explain the failure of your control effort.
6. What can you do to keep the crop disease(s), you are trying to control, from becoming resistant to the chemical(s) you use?

Chapter Fourteen

Special agronomic practices

Introduction

Special agronomic practices are essential in enhancing proper growth and optimum yield of particular crops. In this chapter, you will learn about the meaning of special agronomic practices. You will also learn the specific agronomic practices which are basic to various crops. The competencies developed from this chapter will enable you to carry special agronomic practices timely and in proper way so as to realise profitable yields in the respective crops.

Meaning of special agronomic practices

Special agronomic practices are tending operations done in the field to enhance proper growth and optimum yield of the specific crop. These are practices in addition to land preparation, planting, maintenance of soil water and fertility as well as pests, weeds and diseases control, however, some of them may have indirect effects on the mentioned practices. The special agronomic practices vary between crops' groups and within crops in a given group of crops.

Examples of special field agronomic practices include trellising, staking, propping, and earthing up as described herein.

Some special routine practices

Some special routine practices are covered in the subsequent sections in this chapter.

Trellising

This is a practice of providing support to crops with vines using a line held by posts at definite spacing. Posts of approximately 3m long and 15cm thick are used. Trellising is common to climbing crops such as passion fruits, tomatoes, garden or common peas, cucumber and grapes. Figure 14.1 shows trellising of passion fruits.

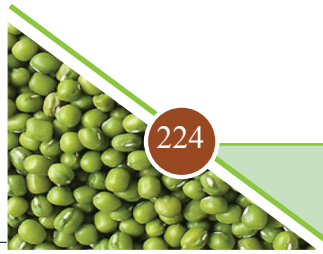


Figure 14.1: Trellised passion fruits

Staking

This is providing support to weak-stemmed plants using a stake of wood or metal rod. The stake is placed firmly besides the growing plant and the plant is tied to it in stages as it grows. Staking is practised to plants such as tomatoes, spreading bean varieties and garden peas. The main reason for staking is to keep plants and fruits off the ground. This reduces losses from fruit rots when fruits touch the soil and from sunburn when fruits are not shaded by foliage. Figure 14.2 shows a staked tomato.

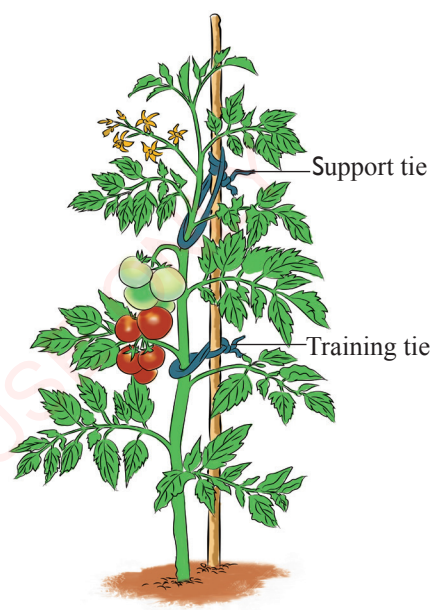


Figure 14.2: Staked tomato

Propping

This is the provision of support to stems of certain crop plants so as to prevent them from falling or breakage. It is practised in different ways depending on the nature of the crop in question. For example, in sugar cane, the plants are tied together by using bottom dry leaves and some upper green leaves. These leaves are twisted together without detaching them from plant. In that way, they form a sort of rope whereby cane stalks are tied together so that they cannot fall easily. In banana, it involves the use of forked poles to prop the plant at the time of

bearing to prevent lodging of plant due to heavy weight of bunch. Prop supports the heavy bunch from overweighing the weak stem. Figure 14.3 shows propped sugar cane and banana plants.

Figure 14.3: Propped sugar cane and banana

Pruning

This is the removal of extra or unwanted parts of a plant. The unwanted parts may be due to breakage, overcrowding or excessive vegetation, disease attack and unproductivity. The practice is done in crops like tea, coffee, orchard crops and silvicultural crops.

Advantages of pruning

(a) It regulates quantity and quality of fruits and flowers. For example, a coffee plant which is pruned produces many cherries of good quality compared to the one which is not pruned.
(b) It stops the upward growth of the plant in crops like tea. Pruning in crop allows sideways growth hence making plucking of the leaves easy during harvesting.
(c) It permits air circulation and secure more light for most parts of the crop.
(d) It creates unfavourable environment for pest and disease attack.
(e) It removes branches and fruits that rub against each other because they can cause wounds in plant and fruits hence lowering the quality of fruits.
(f) It facilitates even distribution of pesticides sprayed to the crop.
(g) It facilitates early harvesting in crops like coffee, especially when the pruning is done at the end of each cropping season.

Tools used in pruning include pruning saws, pruning knives, pruning shears and secateurs. The pruning saw is used for cutting hard branches and stems in crops

such as coffee and citrus. Pruning knife is used for cutting or pruning crops like tea and coffee. Pruning shears are used for trimming hedges while secateurs are used for pruning or cutting soft branches in crops such as coffee and citrus.

Pruning methods

There are various methods of pruning crops. These include pinching out, annual pruning as well as coppicing and pollarding.

(a) *Pinching out:* This is the removal of terminal buds after the plant attains a certain recommended height. It is commonly carried out in horticultural and silvicultural crops and in tea, coffee and tobacco. The practice is termed as capping in tea and coffee; and topping up in tobacco (refer to Figure 14 (a)).

(b) *Annual pruning:* This involves the removal of branches that have borne two crops and have undesirable growth characteristics. The branches which are dry, broken, close or diseased too should be removed (refer to Figure 14 (b)).

(c) *Coppicing:* This involves cutting the tree crop down to its stump and allowing it to regrow (refer to Figure 14 (c)).

(d) *Pollarding:* This involves cutting off the tree crop at its crown, leaving it to send out new branches from the top of the remaining stem (refer to Figure 14 (d)).

Regrowth after coppicing and pollarding is vigorous because the tree root system has already been well established.

(a) Pinching out (b) Annual pruning (c) Coppicing (d) Pollarding

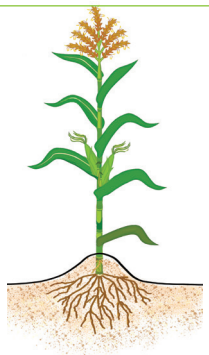
Figure 14.4: Pruning methods

Care must be taken when pruning so as not to injure the crop. Once the crop is injured, production is highly lowered as the plant utilises part of nutrients to heal the wound. The cut surfaces may become entry points to disease causing organisms.

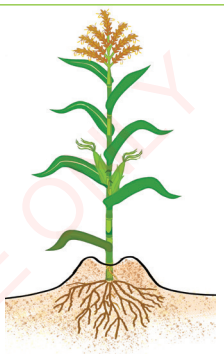
The cut surfaces must be protected from vectors such as aphids by painting special formulated antiseptic tree pastes that are water proof. Alternatively, cuts such as that of coppicing should be made obliquely or diagonally so that water cannot easily enter into the crop through the cut surface. In addition, techniques and purposes for pruning differ according to crops. Therefore, pruning should not be carried out without technical advice.

Earthing up

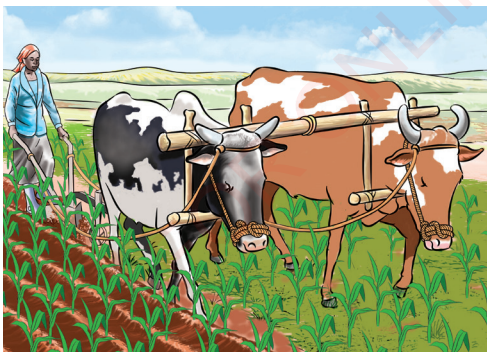
This is the placement of soil in form of a heap around the base of the plant (refer to Figure 14.5 (a)). Earthing up should not leave a sunken area around the system (refer to Figure 14.5 (b)). It is usually carried out during weeding and care must be taken not to injure the roots of the crop. Hoe or forked hoe is used in small scale while ridgers drawn by tractors or draught animals are used in large scale farms (refer to Figure 14.5 (c) and (d)).



(a) Good way of earthing up



(b) Bad way of earthing up



(c) Earthing up by oxen-drawn ridger

(d) Earthing up by tractor-drawn ridger

Figure 14.5: Earthing up

Earthing up is commonly carried out in various crops. In tuber crops such as sweet potatoes, round potatoes and cassava, it encourages tuber formation hence improves production. In groundnuts, it promotes production of seeds whereas in tobacco, it improves drainage around the plant. In maize, it provides support to prevent lodging.

Activity

1. List the crops recommended for your area.
2. Apart from land preparation, planting, maintenance of soil water and fertility as well as control of pests, weeds and diseases; identify all special agronomic practices needed to enhance growth and yield in each of the crops. For each practice, consider why, when and how has to be done.
3. Carry out the identified practices under the supervision of a teacher. Make reflection for each of the practices. Record all the proceedings in your portfolio.
4. Outline the lessons you have learnt from this activity.
5. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. With the aid of examples of crops recommended for your area, what will happen if specific agronomic practices won't be carried out timely and properly?
2. With the aid of examples of crops recommended for your area, how differently the practices can be carried out with more improved efficiency both economically and technically?

Chapter Fifteen

Harvesting and post-harvest practices in crop production

Introduction

Harvesting and post-harvest practices are of critical importance in crop production. In this chapter, you will learn about the criteria for harvesting crops, maturity stages and indices, methods for harvesting various crops as well as challenges in harvesting of crops. You will also learn post-harvest practices for different crops. The competencies developed from this chapter will enable you to harvest your crops timely by using right techniques as well as maintaining the level of crop quality which helps you to compete in the local or international market.

Criteria for harvesting crops

Removal and gathering of mature crop for processing, storage and/or marketing from where it has been planted is known as harvesting. The harvesting of a given crop is determined by various criteria which are elaborated herein.

(a) Quantity and quality of economic part

The economic part could be the leaf, grain, root, stem, or other parts for different crops. Translocation of the stored food from parts of economic importance to other parts will reduce the yield of desired products. Therefore, crops are to be harvested when the desired product is at its maximum quality and quantity.

(b) Intended use of the product

Basing on utilisation, the economic part of the product may be the same, but it may be desirable to harvest in different conditions, for example, in fresh or dry state. Crops such as maize, common bean, pigeon pea and cow pea may be harvested fresh or dry, depending on the intended use. Thus, the purpose of growing the crop determines when it is the best time to harvest it in order to have the highest quality and quantity of the desired product.

(c) Post-harvest storage

As far as post-harvest storage is concerned, the harvested produce often requires some form of storage at the site of production before its disposal especially legume and cereal grains. This is because the produce may deteriorate in storage if harvested at improper moisture content. As a result, there must be supplementary drying facilities for drying the produce to proper moisture content.

Note: The criteria for harvesting is closely related to maturity indices.

Maturity stages and indices

Various crops are harvested at different times or stages. Harvesting in proper time or stage is crucial to prevent crop loss which may occur due to various causes associated with too early or late harvesting. These losses may be caused by pests, shattering and other sorts of deterioration. For example, harvesting too early will result in a higher percentage of unfilled or immature grains, which will lower the yield and cause higher grain breakage during milling. Likewise, harvesting too late will lead to excessive losses and increased breakage in rice. The harvest time also affects the germination potential of many crops planted for seed production. Therefore, timely harvesting ensures good crop quality and high market value.

In order to realise the expected yields, the crop must be harvested when the economic product is at its optimal quantity and quality. Basically, crops are harvested when they are mature. Therefore, knowing the maturity stage of a crop is important so as to get the highest yield of the produce. Generally, crops can be harvested at physiological, harvest or storage maturity depending on the situation or intended use of the produce. These are elaborated in the following sub-sections

Physiological maturity

Physiological maturity refers to a developmental stage of a crop after which there will be no any further increase in dry matter in the economic part. A crop is physiologically mature when its development is over and the translocation of synthesised food reserves to economic part is stopped. However, in fruits and some vegetables, a plant part may continue to develop even if it is removed from the mother plant. In cereals, for example, moisture content of grains is very high during milk stage and it gradually decreases due to accumulation of synthesised food reserves. A sharp fall of moisture content from 40 to 20% is an indication of attaining physiological maturity to cereals. At this stage, the plant reaches a

maximum dry matter. The grains at this stage are of hard tough consistency. If a grain crop is harvested before its physiological maturity, it will have low dry matter, poor quality and will shrivel upon drying. For horticultural crops, the physiological maturity at harvest stage is important for the quality of products. Therefore, you must take care on when to harvest fruits and vegetables in order to attain the best quality. Various crops have different indications of physiological maturity. Table 15.1 shows indices of physiological maturity of some field crops.

Table 15.1: Indices of physiological maturity for some crops

Crop	Indices of physiological maturity
Maize	Black layer in the placental region of corn kernels
Paddy/Rice	Complete yellow to light brown colour of the grain and senescence of lower leaves
Sorghum	Black layer in the placental region of grain
Bulrush millet	Appearance of bleached penducle in some varieties
Wheat	Complete loss of green colour from glumes before physiological maturity. Centre spikes are used as indicator grains.
Barley	Loss of green colour from the glumes or penducles
Common bean	Turning of green pods to brown colour
Pigeon pea	Green pods turning brown, about 25 days after flowering
Groundnut	Development of black colour in the inner shell of the pod
Soya bean	Loss of green colour from leaves

Note: A crop is harvested at physiological maturity when there is a need to vacate the field for sowing another crop, otherwise it may be better to wait for harvest maturity.

Harvest maturity

Harvest maturity for a crop is when the economic part or produce is at best quality and is likely to give maximum yield. The important process during this period is loss of moisture from plants and grains. The general symptoms of harvest maturity are yellowing of leaves and drying of grains or pods. In cereals and pulses, for example, harvest maturity generally occurs 7 - 10 days after physiological maturity. It is advisable that you consider harvest maturity in harvesting crops. Table 15.2 shows harvest maturity indices of some crops.

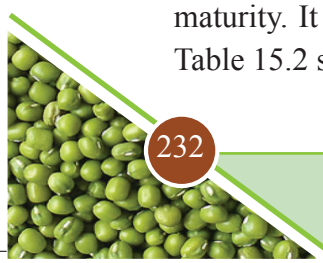


Table 15.2: Harvest maturity indices for some crops

Crop	Indices of harvest maturity
Sorghum	Yellow coloured ears with hard grains
Bulrush millet	Compact ears, upon pressing seeds come out
Paddy/Rice	Hard and yellow to brown coloured grains, golden yellowing of leaves
Finger millet	Brown coloured ears with hard grains
Wheat	Yellowing of spikelets
Pulses	Brown coloured pods with hard seeds inside pods
Groundnut	Pods turn dark and dark coloured patches inside the shell Kernels turn red or pink On pressing the kernels, oil is observed on fingers
Sugar cane	Leaves turn yellow
Tobacco	Leaves slightly yellow in colour, specks appear on the leaves

Storage maturity

The storage maturity for a crop is a stage that follows after harvesting. Storage maturity is associated with processes that can reduce the moisture content of the product to the optimum level for storage. For crops which are stored at room temperature such as cereals, pulses and other grains, they should be dried to optimum moisture before storage. You should consult your local extension workers for advice on how to determine and maintain optimum moisture content for storage.

Methods of harvesting crops

Depending on costs associated with and labour availability, manual or mechanised harvesting can be employed. Manual harvesting is most common in developing countries like Tanzania. However, even in developed countries, some crops such as delicate vegetables and fruits, are harvested manually for highest quality and premium price. Depending on the type of crop, several traditional tools and modern devices are employed to harvest produce, however, some crops are hand-picked without using any tool.

Traditional harvesting tools include sickles, knives, spades, digging rods and many others for cutting and uprooting, depending on the nature of the crops. Various modern harvesting tools are available for harvesting crops like cereals and pulses. Mechanical harvesting tools and machines are tractor mounted, power tiller operated, self-propelled walking or self-propelled riding types. In determinate crops, harvesting is done at one time while in indeterminate crops, harvesting is done at intervals as the economic products come to maturity at different periods. There are several terms used to denote harvesting of crops, for example, harvesting of cotton is termed as picking and that of tea is called plucking.

Challenges in the harvesting of crops

There are several challenges which may be encountered in harvesting of crops. Some of the challenges are briefly explained in this sub-section. Generally, the determination of harvesting time is easier for determinate than for indeterminate crops. At a given time, the indeterminate plants may contain flowers, immature and mature pods or fruits. If the harvesting is delayed for the sake of immature pods, mature pods may shatter. If harvested earlier, the yields might be less because of several immature pods. Therefore, this challenge can be overcomed by harvesting pods or ears or picking the pods periodically as they mature.

When harvesting, especially of cereals and pulses, coincides with heavy rain, there will be a challenge in harvesting the matured crops. Some of these crops may be submerged and seeds may start germinating on the plant itself. This may be overcomed by altering planting dates so that harvesting will not coincide with the period of heavy rains.

When the economic product is underground, for example, in groundnut, bambara-groundnut, cassava, yam, sweet potato, round potato, cocoyam and other edible aroids; harvesting may be difficult if the soil dries up due to lack of rains or moisture. To alleviate this, the soil moisture content during production period should be maintained by keeping good ground cover so as to avoid over-dried soil at the time of harvesting. Alternatively, the crops may be planted on ridges or mounds to simplify the harvesting process.

Activity 15.1

1. By using your experience, library search and contact resource persons; for every crop recommended to be produced in your area, determine the indices for:
   (a) Physiological maturity
   (b) Harvest maturity
   (c) Storage maturity
2. Identify the ideal time for harvesting the crops recommended in your area.
3. Record all your findings in your portfolio.
4. Outline the lessons you have learnt in this activity.

Post-harvest practices of some crops

These include the activities which are done to the crop produce at different stages after harvesting. They include those treatments carried out immediately following harvesting and the ones which may be done some days or months later. In most cases, they include alterations in the properties of crop products by physical, mechanical, chemical and/or biological means. These practices vary depending on various factors including nature or type of produce, intended final quality, state and time at which the product is to be used, stored or sold. Depending on these factors, post-harvest practices may include cleaning, sorting/grading, cooling, processing, packaging, storage and marketing.

Post-harvest practices are either done in traditional or modern way, either manually or mechanically. Post-harvest practices, especially those treatments done immediately after harvesting, largely determine the final quality, whether a crop is sold for fresh consumption or used as an ingredient in a processed product. The post-harvest treatments done immediately after harvesting are sometimes termed as post-harvest handling. Generally, good post-harvest handling is critical to reduce post-harvest losses of fresh produce, maintain quality, preserve nutrient content, and earn higher prices in the market.

Purposes of post-harvest practices

(a) To preserve crop products, that is, to reduce deterioration of products.
(b) To make handling of crop products easier, for example, by reducing bulkiness.
(c) To convert crop produce into forms that are suitable for consumer's use.

Post-harvest practices of some crops are briefly illustrated in the next sub-sections.

Post-harvest practices of cereal and pulse crops

Different cereals and pulses have different post-harvest processes. Figure 15.1 illustrates some of the post-harvest practices for cereals and pulses (e.g. maize, sorghum, finger millet, bulrush millet, rice, wheat, barley, and many others, while pulses include common beans, cow peas, pigeon peas and green grams). However, there may be slight deviations, depending on specific crop and consumer preferences.

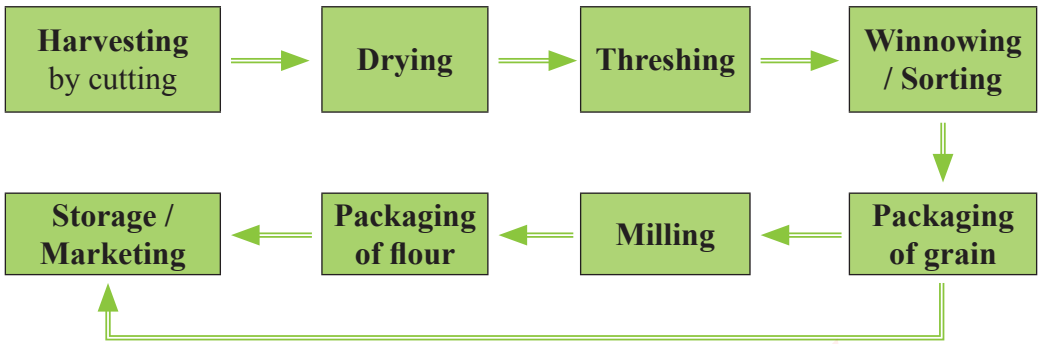


Figure 15.1: Post-harvest practices in cereal and pulse crops

Post-harvest practices of tuber crops

These may take different forms depending on the type of crop and preference of the consumers as illustrated on Figures 15.2.

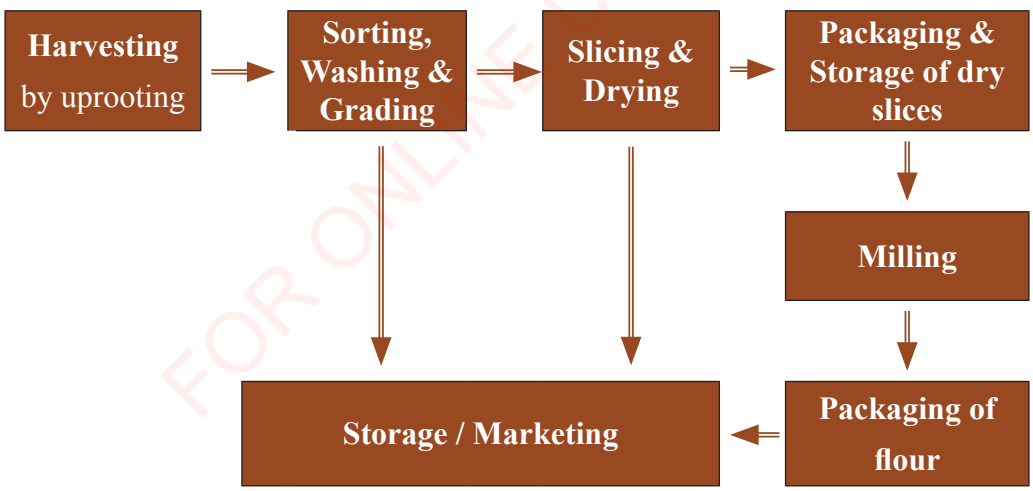


Figure 15.2: Post-harvest practices in tuber crops

Noe: Peeling after slicing of tuber crops is applicable or not applicable depending on the type of crop and preference of users or customers. The same applies to soaking or fermentation before drying of tuber crops especially cassava.

Post-harvest practices of fibre crops

Produces from fibre crops are subjected to different forms of post-harvest practices depending on the crop as illustrated on Figures 15.3 for sisal and 15.4 for cotton, respectively.

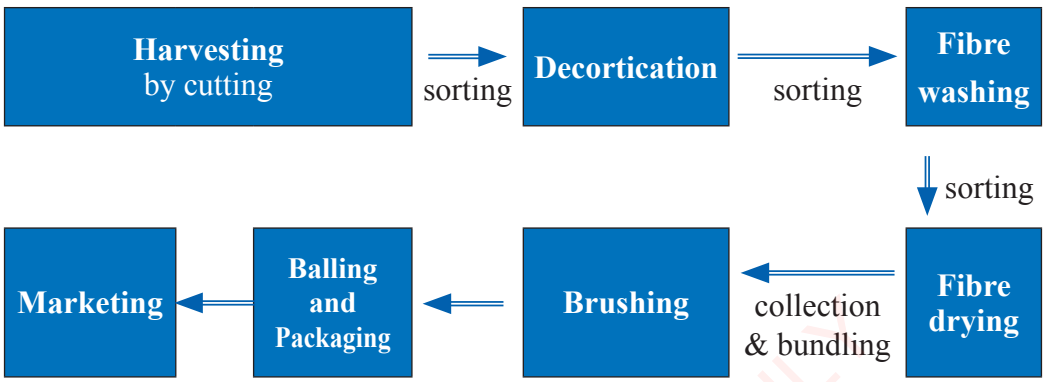


Figure 15.3: Post-harvest practices in sisal

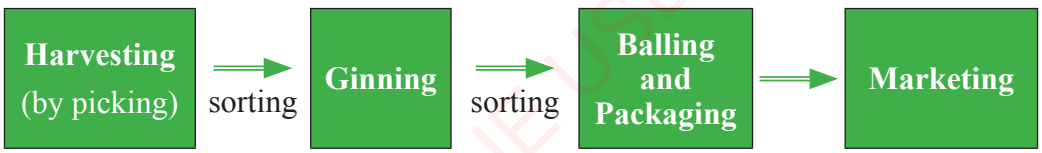


Figure 15.4: Post-harvest practices in cotton

In sisal, decortication is the removal of sisal fibre from leaves by crushing and tearing away the leaf pulp from fibres without damaging the latter. This process is followed by brushing which involves freeing individual fibres by beating fibres gently using metal beaters. In cotton, the removal of fibre, that is, lint from seeds is referred to as ginning. Bailing in fibre crops involves compressing the fibres into bales. The balled and packed fibre is ready for secondary manufacturing of various products. The manufactured products are usually sold at much higher price than the merely processed fibre.

Post-harvest practices of fruits and vegetables

Most of fruits and vegetables for sale are subjected to practices like pre-cooling, cleaning or disinfecting, sorting and grading, packaging, storing and/or transportation/processing and marketing. Appropriate post-harvest treatments like refrigeration, heat treatment, and modified atmosphere packaging are used in maintaining quality and extending shelf life of fruits. Figure 15.5 illustrates some of the post-harvest practices for fruits and vegetables.

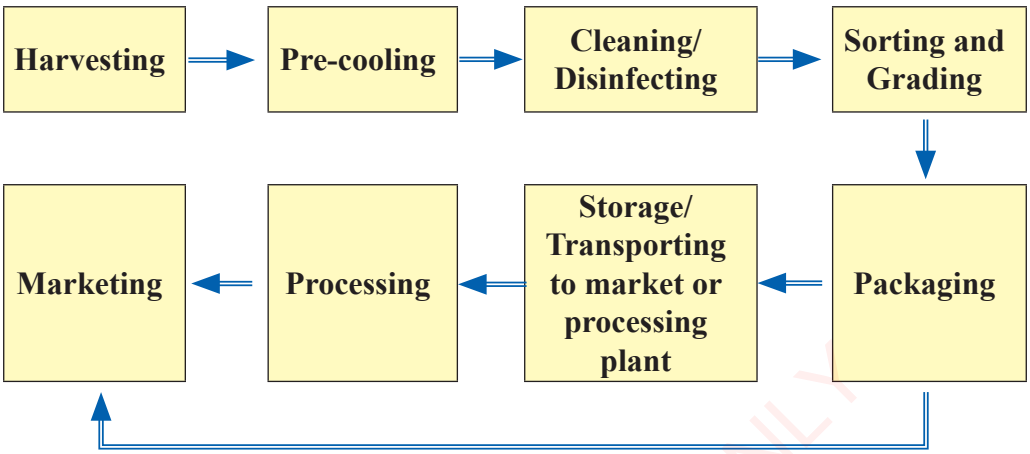


Figure 15.5: Post-harvest practices in fruits and vegetables

Pre-cooling: Field heat is usually high and undesirable at harvesting stage of many fruits and vegetables and should be removed as quickly as possible before any post-harvest handling activity. Since excessive field heat gives rise to an undesirable increase in metabolic activities, there is a need for an immediate cooling after harvesting a particular fruit or vegetable. Pre-cooling minimises the effect of microbial activity, metabolic activity, respiration rate, and ethylene production. It also reduces the ripening rate, water loss, and decay, thereby preserving quality and extending shelf life of harvested fruits and vegetables.

Cleaning or disinfection: Proper cleaning or disinfecting has to be adhered to by farmers and all produce handlers as precaution to post-harvest diseases and incidences of food-borne illnesses that can be transmitted to consumers.

Sorting and grading: Sorting involves removal of rotten, damaged, or diseased fruits and vegetables from the healthy and clean ones. The damaged or diseased ones can produce ethylene in substantial amounts which can affect the adjacent fruits or vegetables. Grading is also the process of categorising fruits and vegetables on the basis of colour, size, stage of maturity, or degree of ripening. Grading and sorting processes are vital in maintaining post-harvest shelf life and quality of harvested fruits and vegetables. Sorting limits the spread of infectious micro-organisms from affected fruits or vegetables to the healthy ones during post-harvest handling. Grading also helps handlers to categorise fruits and vegetables on the basis of some given common parameters which enable easy handling.

Packaging: This involves enclosing fruits or vegetables to protect them from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources. Packaging is also essential in putting the produce into sizeable portions for easy handling. However, using unsuitable packaging materials can cause product damage resulting in losses. Some common packaging materials mostly used in Tanzania include wooden crates, cardboard boxes, woven palm baskets, plastic crates, nylon sacks, jute sacks and bags. Most of the mentioned packaging materials do not give all the protection needed by the commodity. The packaging materials for fruits and vegetables should allow good aeration within the packaged commodity in order to prevent build-up of heat due to respiration. An ideal packaging material should not have rough surfaces and edges which may cause mechanical injuries to the produce or be of excessive heights which may create a lot of compressive forces on fruits or vegetables located at the base of the pack. Undesirable compressive forces cause internal injuries which finally result in reduced post-harvest quality of the produce. To avoid damages, it is important to consider tenderness of the produce when packaging.

Storage: This extends the shelf-life of products and helps to provide continuity of product supply in the market throughout the year. However, fruits and vegetables with high moisture content are very difficult to store at ambient temperatures for a long time. For short-term storage, some of the fruits and vegetables can be stored at ambient conditions if there is enough ventilation to reduce the accumulation of heat from respiration. For longer-term storage, ripe fruits and matured vegetables can be stored at low temperatures of about 10 - 15°C and 90 - 95% relative humidity. At these temperatures and humidity, both ripening and chilling injuries

are reduced to the minimal levels though these conditions are difficult to meet in most tropical countries.

Some fruits and vegetables can be stored for short to intermediate time by using evaporative cooling system made from woven jute sacks. To avoid losses of appreciable quantities of harvested perishable fruits and vegetables, there is a need for using appropriate storage technologies. In most cases, the production sites for many fruits and vegetables are far from the processing plants and marketing centres.

Transporting: Transporting harvested fruits and vegetables to the market requires specialised transportation like refrigerated vehicles and airplanes so as to avoid deterioration.

Processing: Processing of fruits and vegetables increase the shelf life of fruits and vegetables. It may include canning, drying, freezing as well as preparation of juices, jams and jellies. Depending on size of produce and level of technology used, processing can be done in large factories or small backyard processing plants. To find it more, consult your local agricultural extension workers or experts in food processing.

Marketing: Unprocessed fruits and vegetables are to be marketed in such a way that losses are minimised. It is important to note that the quality of any fruit and vegetable after harvest cannot be improved by the use of any post-harvest handling practices or treatment methods. However, it can be maintained by using appropriate post-harvest handling practices and treatment methods.

Activity 15.2

1. By using your experience, contact resource persons and library search, determine the ideal time for harvesting every crop recommended to produce in your area. Give justification.
2. For every crop recommended to produce in your area:
   (a) Find out the method(s) and tool(s) employed in harvesting including the precautions to adhere to while using them.
   (b) Find out all the necessary post-harvest practices. For each practice, find out why, when and how should it be done as well as precautions to be adhered to.

(c) Practise harvesting and post-harvest handling of the crops recommended to be produced in your area. Consider adhering to all the precautions in performing the tasks.
(d) Discuss the challenges you may face in performing the tasks and propose measures to overcome them.
(e) Record all your findings in your portfolio.
(f) Outline the lessons you have learnt in this activity.

3. Write a summary of what you have learnt from this chapter in your portfolio.

Exercise

Answer the following questions.

1. What do you understand by the term harvesting of crop?
2. How is an ideal time for harvesting crops determined? Give examples to justify your answer.
3. What does physiological maturity of a crop tell you, as far as harvesting is concerned? Give examples to justify your answer.
4. With the aid of an example, outline the objectives of post-harvest practices in crop production.

Chapter Sixteen

Production of cereal crops

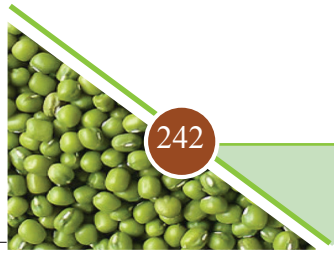
Introduction

The bulk of the world's food is supplied by cereals such as maize, rice, sorghum, millet, wheat, oat, barley and sugar cane. In this chapter, you will learn about the concept of cereal crops as well as ecology and agronomic practices of the selected cereal crops. You will also practise growing some cereal crops that are ecologically adaptive in your school area. You will further manage their post-harvest processes and compare your practices with those carried out in other places. The competencies developed in this chapter will enable you to produce the crops successfully and compete in local or international markets.

The concept of cereal crops

Cereals are crops of grass family which are grown for their edible seeds. The term cereal is applied either to the seeds or to the plant itself. Cereal crops are also known as grain crops except for sugar cane. They include crops such as maize, sorghum, paddy or rice, wheat, millets, barley and oats. Cereals are major staple foods of the largest population in both developed and developing countries. In Tanzania, for example, cereals are primary component of food eaten nearly every day by most families.

Cereals and cereal products are good sources of starch and fibre and to some extent they also provide protein, vitamins, minerals and other micro-nutrients. However, processing of cereals by removing the outer coat of the seed in crops like maize, sorghum and bulrush millet lowers their nutritive value. This is because such practice removes most of vital nutrients which are normally located just beneath the grain seed coat. This leaves grains with most starch. Cereals and cereal by-products like bran also provide a good feed for livestock for improvement of productivity. Cereals also serve as raw materials for some industrial products. Some cereal crops which are commonly grown in Tanzania are shown in following figures:



Sorghum

Paddy

Maize

Finger millet

Bulrush millet

Oat

Wheat

Activity 16.1

1. In groups, discuss the nutritional importance of at least two cereal crops that are common in your area, comparing to other places in and outside Tanzania. For each crop, consider the products and their uses.
2. Summarise your answer and present in class.
3. Record all findings you have made in your portfolio.
4. Outline the lessons you have learnt from this activity.

Ecology and agronomic practices for producing some common cereals

The production of cereal crops varies widely in different places depending, among many factors, on the nature of the soil, prevailing temperatures, the amount of rainfall and techniques applied to promote growth. It is worth noting that production of any cereal crop of your choice has to adhere to the competencies already developed in previous chapters of this book, starting from planning for crop production, harvesting and post-harvest practices. Production of cereal crops of your choice will be achieved by accomplishing all the tasks given in activity 16.2.

Note: It is advisable to carry out the recommended agronomic practices under the advice of the teacher and/or other agricultural experts.

Activity 16.2

1. With the assistance of your teacher and in groups, prepare to raise any of the cereal crops recommended in your area by accomplishing the following tasks. For each task, state why you did it in that way. Record all your tasks' proceedings in portfolios. You should also assess and evaluate your tasks periodically. Set goals for producing each of the crop and yield targets.
   (a) Set goals for producing a cereal crop of your choice and its yield targets.
   (b) Choose the suitable variety of the crop.
   (c) Identify all the resources required to raise the crop including land, labour, capital and inputs.
   (d) Choose a suitable piece of land in your school area to grow the crop.
   (e) Identify all necessary activities to be performed in raising the crop.
   (f) Determine when and how each of the identified activity will be done.
   (g) Develop a cropping calendar for the identified activities with budget estimates.
   (h) Examine the total costs of producing the crop versus the set goal and targets.
   (i) Determine how the resources for raising of the crop will be obtained.
2. Identify the kinds of records that are important for the crop and set a schedule as well as templates for record-keeping. Carry out production of the crop as per the calendar you have prepared in task 1 (g).
3. Manage the post-harvest practices for the crop.
4. Compare what you have obtained with the set goal and yield targets.
5. Compare your production operations, challenges and yields with others carried out in other places in and outside Tanzania.
6. Make reflections on all tasks done in this activity.
7. Using the experience gained from this activity, plan for and implement next production cycle of the same or different cereal crops.
8. Write a summary of what you have learnt from this chapter in your portfolio.

Chapter Seventeen

Production of pulse crops

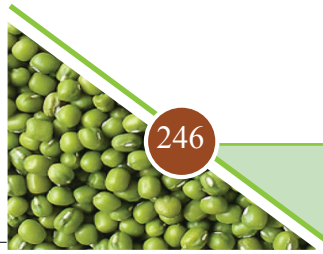
Introduction

Pulse crops are among the bulk of the world's food produced crops after cereals. In this chapter, you will learn about the concept of pulse crops as well as ecology and agronomic practices of selected pulse crops. You will also practise raising some pulse crops that are ecologically adaptive in your school area. You will further manage their post-harvest processes and compare your practices with those carried out in other places. The competencies developed in this chapter will enable you to produce crops successfully thus compete in local or international markets.

The concept of pulse crops

Pulse crops are ones which belong to the leguminoseae or fabaceae family. They are primarily grown for their edible grain seeds which are termed as pulses. Pulse crops include common beans, cow peas, pigeon peas, groundnuts, bambara-groundnuts, soya beans, garden peas, lima beans, green gram, chick peas and lentils.

Pulses form the most important grain legume in human diet in Tanzania and other tropical countries. Pulses and their products provide protein, carbohydrate and other valuable micro-nutrients. In many areas and especially in Africa, pulses are the second most important source of food after cereals as staple food. They are consumed as dry or un-dried seeds. Their leaves at tender stage are consumed as vegetable. Moreover, several food products can be made from dry pulses. Similarly, pulses can provide valuable protein concentrates for feeding livestock. Pulse crops are sometimes used as forage and cover crops. Some pulse crops which are commonly grown in Tanzania are shown in following figures:



Common bean

Pigeon pea

Cow pea plant and pods

Common/garden pea

Soya bean

Chick pea

Bambara-groundnut

Groundnut

Lima bean

Green gram

Activity 17.1

In groups, perform the following tasks.

(a) Discuss the nutritional importance of at least two pulse crops that are common in your area, comparing to other places in and outside Tanzania. Consider the products and uses of each crop.

(b) Summarise your responses and present them in class.

(c) Record all findings you have made in your portfolio.

(d) Outline the lessons you have learnt from this activity.

Ecology and agronomic practices for producing some common pulses

Pulse crops, like other crops, have ecological and agronomic requirements. Common beans, for example, require special cultural managements and attention and they are not much adaptive in coastal area. Unlike common beans, cow peas and pigeon peas are more adaptive to varying ecological conditions and are more tolerant to harsh environments such as drought. Generally, proper management is essential from planning for production, field operation to marketing.

Production of pulse crops of your choice will be achieved by accomplishing all the tasks given in activity 17.2. Moreover, the production of any of the pulse crop has to adhere to the competencies already developed in the previous chapters of this book, particularly from planning for crop production to harvesting and post-harvest practices.

Activity 17.2

1. With the assistance of your teacher and in groups, prepare to raise any of the pulse crops recommended in your area by accomplishing the following tasks. For each task, state why you did it in that way. Record all your tasks' proceedings in portfolios. You should also assess and evaluate your tasks periodically.
   (a) Set goals and yield targets for producing a pulse crop of your choice.
   (b) Choose the suitable variety for the crop.

(c) Identify all the requirements for raising the crop including land, labour, capital resources and inputs.

(d) Choose a suitable piece of land in your school area to grow the crop.

(e) Identify all necessary activities to be performed in raising the crop.

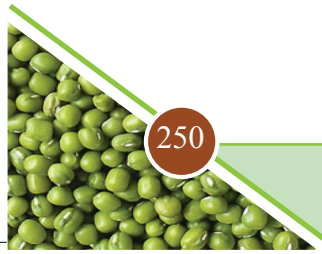
(f) Determine when and how each of the identified activity will be done.

(g) Develop a cropping calendar for the identified activities with budget estimates.

(h) Examine the total costs of producing the crop versus the set goal and targets.

(i) Determine how the resources for raising the crop will be obtained.

2. Identify the kinds of records that are important for the crop and set a schedule as well as templates for record-keeping. Carry out production of the crop as per the calendar you have prepared in task 1 (g).
3. Manage the post-harvest practices for the crop.
4. Compare what you have obtained with the set goal and yield targets.
5. Compare your production operations, challenges and yields with others carried out in other places in and outside Tanzania.
6. Make reflections on all tasks done in this activity.
7. Using the experience gained from this activity, plan for and implement next production cycle of the same or different pulse crops.
8. Write a summary of what you have learnt from this chapter in your portfolio.



Revision Exercise

Section A

Choose the correct answer from the given five alternatives to complete the following sentences.

1. In farm management, the agricultural farm is considered as
   (a) production unit with various enterprises.
   (b) production unit with fewer enterprises.
   (c) a unit of crop cultivation and raising livestock.
   (d) agricultural activities.
   (e) portion of land on which a particular farmer carries out agricultural activities for the purpose of getting profit.

2. Factors of production are resources required for production process which include
   (a) labour, land, farmer and entrepreneurship.
   (b) land, labour, capital and livestock products.
   (c) land, labour, entrepreneurship and capital goods.
   (d) harvested crops and livestock products.
   (e) labour, capital, wages, and management.

3. A soil which is able to supply the plants with their nutritional requirement adequately is said to be
   (a) infertile soil.
   (b) arable soil.
   (c) fertile soil.
   (d) well drained soil.
   (e) deficient in plant nutrient.

4. The expected rewards of entrepreneurship for its contribution to the production process is
   (a) loss.
   (b) profit.
   (c) economic growth.
   (d) capital.
   (e) money.

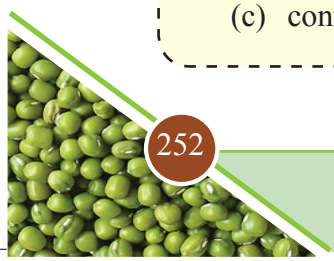
5. Macro-nutrients include only the following elements
   (a) carbon, oxygen, hydrogen, nitrogen, phosphorous, potassium, magnesium, calcium and sulphur.
   (b) carbon, oxygen, nitrogen, hydrogen and magnesium.
   (c) nitrogen, phosphorous and potassium.
   (d) calcium, sulphur, manganese, copper and zinc.
   (e) manganese, iron, boron, copper, zinc and chlorine.

6. The death of the host cells, tissues and organs induced by pathogens is referred to as
   (a) hypoplasis.
   (b) discolouration.
   (c) necrosis.
   (d) wilting.
   (e) gummosis.

7. A piece of land that is prepared for planting is referred to as
   (a) planting land.
   (b) fertile land.
   (c) suitable land.
   (d) seedbed.
   (e) soil clods.

8. Rolling has the following advantages except
   (a) creating a smooth and firm seedbed.
   (b) protecting the top soil layer and very small seeds from being carried away by wind.
   (c) enabling the soil to retain moisture for a long period.
   (d) promoting faster and uniform germination of the crops with very small seeds.
   (e) making harvesting of tuber crops and pods of ground nuts easier.

9. Factors of production are very important because they
   (a) contribute directly towards the quantity and quality of the output.
   (b) contribute indirectly towards the quantity and quality of the output.
   (c) contribute in production of inputs.



(d) are involved in production of goods and services in order to make economic decline.
(e) are usually found in nature as they are not man-made.

10. The practice of providing support to vine crops using a line held by posts at a definite spacing is referred to as
    (a) staking.
    (b) trellising.
    (c) propping.
    (d) pruning.
    (e) pinching out.

Section B

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

1. In production process, capital enables farmers to hire or to employ labour so as to increase output. _____
2. Spacing and seed rate used are among records to be kept in a crop production enterprise. _____
3. Splits are planting materials for sisal plant. _____
4. The main reason for staking is to keep plants and fruits off the ground. _____
5. All weeds are harmful because they compete with crop plants for nutrients, moisture, space, air and light. _____
6. Some nematodes introduce toxic saliva, leading to formation of galls in plants. _____
7. Blotch is a symptom of disease where tissues grow excessively. _____
8. Harvesting, fibre washing, fibre drying and packing are post-harvest practices of fibre crop. _____
9. Decision on how to produce is the choice of technique of production that will give the lowest cost. _____
10. Maintaining flexibility in production is one of the methods to overcome risks and uncertainties where farmers may enter into an agreement with customers or consumers to supply a certain quantity of goods under specific price. _____

Section C

Match the statements in Column A against the terms in Column B

1.

Column A	Column B
(i) Progressive death of the affected part from the tip downwards	(a) blight
(ii) Sunken lesions with raised margins on plant parts such as fruits and pods	(b) streak or strips
(iii) Elongated narrow lesions	(c) dumping off
(iv) Rapid discolouration followed by death of plant organ giving burn appearance	(d) die back
(v) Abnormal fleshy or woody outgrowths	(e) curl
	(f) anthracnoses
	(g) galls

2.

Column A	Column B
(i) A constituent in all tissue of living organisms	(a) molybdenum
(ii) It encourages vegetative growth in crop plant	(b) copper
(iii) Encourages the formation, development and establishment of roots	(c) phosphorous
(iv) It strengthens cell wall of plants	(d) nitrogen
(v) It is required by rhizobia bacteria for nitrogen fixation in legumes	(e) calcium
	(f) carbon
	(g) zinc

3.

Column A	Column B
(i) a swollen modified stem that runs horizontally under the ground	(a) Crowns
(ii) are small plants that grow from the base of the main stem	(b) Slips
(iii) are short and swollen underground stem protected by dry scale leaves	(a) Tubers
(iv) are born on top of the fruits and are broken off and prepared for planting	(b) Rhizomes
(v) are underground food storage organs which are thick and short	(c) Suckers
	(d) Corms
	(e) Bulbils

4.

Column A	Column B
(i) Mexican marigold	(a) *Nicandra physalodes*
(ii) Double thorns	(b) *Solanum incanum*
(iii) Gallant soldier	(c) *Solanum nigrum*
(iv) Black night shade	(d) *Galinsoga parviflora*
(v) Sodom apple	(e) *Datura stramonium*
	(f) *Tagetes minuta*
	(g) *Oxygonum sinuatum*

Section D

Fill in the blanks so as to make the following sentences complete.

1. Inputs or resources collectively used in production are termed as _____.
2. A resource is considered as a factor of production if at all it is _____.
3. All human efforts which may be physical or mental, skilled or unskilled used in the production process are called _____.
4. The most important activities to be done by a farmer or farm manager in production process is _____.

5. The process whereby data is systematically collected, organised and stored is referred to as_____.
6. A situation where there is sufficient knowledge or information for planning to be done but the outcome of implementing the plan is not exactly known is called _____.
7. The microscopic worms which infest crops by piercing the plant parts such as roots, stems, leaves, and bulbs and suck the sap from them are called _____.
8. Birds which are very destructive to cereal crops and move in large number are called_____.
9. The practice of planting border strips of crops which attract pests and divert them from main crop is termed as _____.
10. Larvae of moths that lie hidden in the soil or at the base of seedlings in the seedbed are called_____.

Section E

Answer the following questions briefly.

1. Stalk borers are insect causing destruction to different crops.
   (a) Name three crops attacked by stalk borer.
   (b) State one effect of stalk borers on the crop they attack.
   (c) Suggest one control measure for stalk borer.
2. (a) What is meant by factors of production?
   (b) Briefly, explain four factors of production.
3. A careful observation of a certain plant showed that the leaves became dry and scorched at the edges while the rest of the leaf surface became chlorotic. Identify the nutrient that was deficient in the plant and state its role.
4. (a) What is the meaning of the term irrigation as used in maintenance of soil water for crop production?
   (b) Briefly, explain four types of irrigation.
   (c) List down two benefits and challenges of each type of irrigation mentioned in (b) above.
5. The following table presents different practices observed in agricultural fields.

Field	Practices
1	Maize crop plant grown in an area with excessive nitrogen
2	Sunflower crop plant grown on wet weather condition
3	Land for planting crops is cleared by fire

Identify a problem that may arise in each case

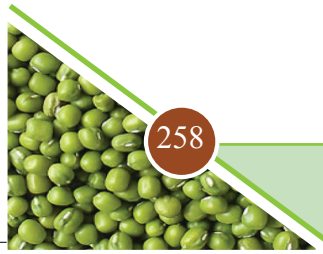
6. The Fahari farm was analysed for soil nutrient content and the result showed that the soil was deficient in phosphorous. What deficiency symptoms would you expect to observe if maize plant was to be grown on such farm? Give four points.
7. For optimal production in a crop forming enterprise, the farmer needs to consider the moisture available in the soil. In some cases he/she must consider practising irrigation. What should a farmer consider in choosing irrigation method(s)?
8. A school is planning to grow crops in its five hectares next year. Briefly, explain the basic principles of farm management to be taken by the school in order to get more produce from such a farm.
9. In crop production, there are unforeseen challenges which are beyond the farmer's control like weather hazards, fire outbreaks, pest and disease outbreak, theft, price fluctuation, change in government policy, change in technology and change in demand which cause a farmer to incur loss. Suggest six measures to be taken by the farmer to reduce or control such challenges.
10. Cassava is one of the tuber crops that farmers in Tanzania are encouraged to grow.
    (a) Briefly, describe the method for propagating cassava.
    (b) State four advantages and four disadvantages of the method.

Section F

Answer the following questions.

1. Making decision is a very important activity in any enterprise. You as an owner and entrepreneur of a particular enterprise or business, what steps you should follow when making decision. Discuss the essential steps in a sequential order.

2. For high production of crops, the farmer should control pests before and after harvesting. There are different methods of controlling pests in the field and/or during storage. Discuss how pests can be controlled by means of cultural methods.
3. Tumaini's farm is facing a problem of diseases to her crops. Advise the manager of the farm on how to carry out an integrated management of diseases and pests in her farm.
4. Crop plant is an organism like any other organisms which are susceptible to diseases. Crop plant disease is the condition of the crop plant involving abnormalities in growth and or structure. Outline any five types of crop disease based on symptoms.
5. Plants and animals need water for different metabolic activities in their body. As a scientist, explain the importance of soil moisture in the production of crops.
6. Farming business can be affected by various factors which are beyond the farmer's control leading to less or no profit. Discuss the factors showing how each affects the farming business and how its effects can be minimised.
7. Timely harvesting and proper post-harvest practices should be carried out by a farmer so as to maximise production in crop farming enterprises. With reference to a named cereal and pulse crop, what advice would you give to an unskilled farmer on timely harvesting and post-harvest practices. On each case, consider what, when, how and why should be carried out.
8. Special practices are tending operations done in the field to enhance proper growth and optimum yield of the specific crop. With an example of a specific crop, discuss what, when, how and why the practices should be done.
9. Soil fertility is an important factor that determines success or failure in crop production. Discuss its importance and the means of maintaining it for optimum crop production.
10. Record keeping should be carried by a farmer systematically on daily basis. Discuss and summarise an advice you can provide to unskilled farmer on why, what and how physical records are kept in a particular farming enterprise.



Glossary

Adaptability
the ability to cope with unexpected disturbances in the environment.

Agro-ecology
a study of ecological processes applied to agricultural production systems.

An interest
a monetary charge for borrowing money, generally expressed as a percentage.

Arable land
any land capable of being ploughed and used to grow crops.

Broadcast seeding
a method of seeding that involves scattering seeds, by hand or mechanically, over a relatively large area.

Collateral
valuable property owned by someone who wants to borrow money which they agree will become the property of the institution or person who lends the money if the debt is not paid back.

Competencies
the knowledge, skills, abilities and behaviours that contribute to individual performance.

Consumer
end user of a product (good/service) in the distribution channel of the market.

Contract
a written agreement between two people or groups that is intended to be enforced by law.

Cross pollination
pollination of flowers or plant with pollen from another flower or plants.

Decomposition
a process by which dead organic substances are broken down into simpler organic or inorganic matter such as carbon dioxide, water, simple sugars and mineral salts.

Demand
a consumer's desire to purchase goods and services and willingness to pay a price for a specific good or service.

Determinate crops
crops that grow the main stem and end with the formation of flowers or other reproductive structures and stops growing further. Determinate crops are generally of short duration.

Edible aroids
are plants that belong to the family araceae also known as arum family. They are generally considered as cocoyam or taro. Edible represents the edible tuber crops in the arum family.

Enterprise diversification
an increase in the number of enterprises operated by an individual on the same farm as a self-insuring strategy to protect against risks.

Equity requirement
the amount of money that must be

present in the borrower's account before a lender or financial institution can lend the borrower any fund.

Evaporation

a process whereby a substance which is in a liquid state turns into a vapour state.

Evapo-transpiration

a process whereby water is lost or transferred from land/soil or by transpiration of plants surface to the atmosphere.

Farm

an area of land where livestock and/or crops are raised for consumption, commercial or both purposes.

Farm layout

the location and arrangement of the fields with respect to the farmstead, size, shape and number of fields as well as other physical structures like those of water supply in such a way that there is convenience and economy of operation. An ideal farm layout is arranged in a way that there shall be a minimum of time consumed, no retracing of steps and no lost motion in doing the routine work of the farm.

Farm product processing

the alteration or modification of agricultural produce for the purpose of storage, transport or sale.

Farmer

a person who owns, manages and works on the farm.

Floral bud

a plant bud where only a flower or flowers develop.

Fungicide

a chemical also called antimycotic used to kill or inhibit the growth of fungi.

Goods

physical items that satisfy human needs or wants.

Graft

a shoot or bud inserted into a slit on the stem of a living and compatible plant from which it receives sap so that they are joined and grow together.

Greenhouse

a building with a roof and sides made up of special materials that is used for growing crops.

Growing media

materials used in a container to grow a plant(s). Growing media are often formulated from a blend of different raw materials in order to achieve the correct balance of air and water holding capacity for the plants to grown.

Habitat

the place or environment where a plant or animal naturally or normally lives and grows.

Heavy soil

the soil which contains more clay and is sticky and hard to work with.

Hectare

a unit measurement of an area of land which is equal to 10 000 m^2.

Herbicide

a substance that is toxic to plants, used to destroy unwanted vegetation.

Hydroponics

the cultivation of crops by placing

the roots in liquid nutrient solution instead of soil.

Indeterminate crop

a crop that continues to grow as it produces flowers, fruits and new growing shoots. Indeterminate crops are generally of long duration.

Infection

the invasion of an organism's body tissues by germs or disease-causing agents like viruses, protozoa, fungi and bacteria. It includes their multiplication and resulting condition in the tissues.

Infestation

the invasion by larger and complex organisms than germs, especially arthropods which reproduce on the exterior surfaces of the body. It is also used to describe the invasion of the gastro-intestinal tract by parasitic worms.

Infiltration

the downward entry of water into the soil making it available for root growth and habitat for soil organisms.

Inoculation

a process of introducing a micro-organism into a living organism in order to treat or prevent diseases.

Inoculum

a small amount of material containing bacteria, viruses, or other micro-organisms that is used to start a culture.

Inputs

items required in the production process.

Insecticide

a substance used to kill insects. Insecticides include ovicides and lavicides that are used against insect eggs and larvae, respectively.

Insurance cover

the protection that is given by an insurance company when it agrees to pay money if loss occurs due to particular risks.

Insurance

an arrangement by which a company or the state undertakes to provide a guarantee of compensation for specified loss, damage, illness, or death in return for payment of a specified premium.

Labour productivity

the total volume of output produced per unit of labour measured in terms of the number of employed persons during a given time reference period.

Land reclamation

the process of making lands suitable for more intensive use by means such as cultivation, drainage, re-vegetation, irrigation, chemical or physical modification, or the like.

Light soil

the soil which is sandy or silty, with very little clay and easy to work with.

Man-day

a unit of production equal to the work one person can produce in a day.

Market

a place or event at which people gather in order to buy and sell commodities or products. It also

refers to the people who might want to buy a commodity or part of the world where a commodity is sold. It also means the business or trade in particular commodity or product, including financial products.

Marketing costs

all expenses that the seller makes to market in selling his/her products. It is the total expenditure on the marketing activities.

Marketing margin of a product

the difference between the price at which a product is produced or bought and the price at which it is sold to the consumer through the distribution channel of the market.

Maturity indices

measurements or signs that can be used to determine whether a particular crop is matured.

Metamorphosis

the process by which young form of insects and some other animals develop into the adult form.

Micro-propagation

the practice of rapidly multiplying the stock plant material under clean and controlled environmental conditions to produce many plantlets which are genetically identical to the original plant for transfer to the field.

Mineralisation

conversion of organic compounds into inorganic compounds through various decomposition processes.

Motivation

any action done to an individual for the purpose of increasing morale and commitment.

Needs

physiological/psychological requirements for the well-being of an organism.

Nematocide

chemical agent used to control nematodes.

Nitrogen cycle

a repeating cycle of processes during which nitrogen from atmosphere moves through both living and non-living things; soil, water, plants, animals and bacteria and back to the atmosphere. In order to move through the different parts of the cycle, nitrogen must change forms.

Nitrogen fixation

the process by which atmospheric nitrogen is converted by either a natural or an industrial means to a form of nitrogen compound such as ammonia, nitrates and nitrites.

Nursery

a piece of land prepared for raising seedlings which normally would not be sown/planted directly into the field.

Open pollination

a process whereby plants pollinate naturally by the aid of external agents such as birds, insects, wind or animals.

Optimal production

the level of production when the profits of the business or an enterprise are maximised.

Percolation with respect to soil

a process by which water or soil solution moves slowly through soil pore spaces. It also refers to the ability of soil to absorb water.

Pest
any form of plant or animal or any pathogenic agent other than the beneficial organisms or any other agent which can be injurious to plant or plant part or to beneficial organisms.

Pesticide
a substance or a mixture of substances intended for destroying, repelling, mitigating, and preventing any type of pest.

Plant propagation
a process by which a new plant grows from a variety of sources such as seeds, cuttings and suckers. There are two types of propagation: sexual and asexual.

Portfolio
a collective document of student's learning activities that provides realistic evidence of the individual's efforts, skills, abilities, achievements, contributions as well as reflection and self-assessment over time.

Post-harvest handling
any process done to agricultural product(s) immediately following harvesting so as to keep the quality or add value to the produce.

Pricing
the process whereby a farmer/seller sets the price of product/services at which he/she will sell and it may be part of his/her marketing plan.

Profit
the difference between the amounts gained and spent in buying, operating or producing something.

Prop
to support something physically, often by leaning it against something else or putting something under it. It also means an object which is used to support something by holding it up.

Resource
a service or other assets used to produce goods and services to meet human needs and wants.

Reward
something that is given in recognition for some service or attainment. It also means something given in return for good thing done or offered.

Rodenticide
a chemical made and used to kill rodents.

Run off
flow of water along the ground surface following heavy rain or excessive irrigation.

Salient characteristic of a disease
recognisable characteristics of a disease that stand out and help in the identification of a particular or specific disease.

Sediments
material deposited by water, wind, or glaciers.

Seed dormancy
inability of a viable seed or planting material to germinate even if it is under favourable conditions.

Seeds as planting materials
sexually or vegetative propagated planting materials which are used for seeding and planting.

Seepage
slow escape or loss of liquid or gas through porous material or small holes.

Skilled labour
a workforce with special skill, training and knowledge to perform complicated tasks.

Services
activity rendered to satisfy human needs or wants.

Soil horizons
layers of soil which are parallel to the soil surface and whose physical, chemical and biological characteristics differ from the layer above and beneath.

Soil pH
an indication of the acidity or alkalinity of soil and is measured in pH units.

Soil profile
a vertical section of the soil that shows its horizons extending from the soil surface to the parent rock material.

Split application of fertiliser
applying the same fertiliser more than once to the crop during a growing season.

Supply
a total amount of specific good or service that is available to consumers at a specific price.

Transpiration
loss of water vapour through plant stomata.

Tuber
a swollen underground stem or root part of a plant used as food reserve. Example potatoes, yam and taro or cocoyams.

Uncertainty
the lack of certainty or sureness of an event. In accounting, uncertainty refers to the inability to foretell consequences or outcomes because there is lack of knowledge or bases on which to make any predictions.

Unskilled labour
a workforce that requires relatively little or no training experience for its satisfactory performance.

U-pick
a type of farm gate direct marketing strategy where the emphasis is on customers doing the harvesting themselves, especially preferred by customers who like to select fresh, high quality or over ripened produce at relatively lower prices. It is also termed as You-pick or Pick-Your-Own.

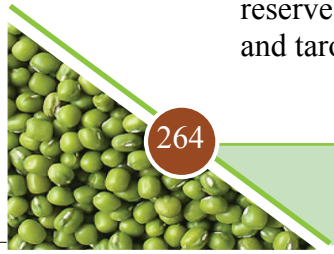
Vermin
nuisance animals that destroy crops, farm animals or game, or spread diseases.

Vines
plants with growth habits of trailing on other standing stems (climbers) or on the ground (runners).

Virgin land
the land that is still in its natural state and has not been used or changed by people.

Wants
lifestyle choices that you want but could live without them.

Water logging
the saturation of soil with water.



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