

HORTICULTURE PRODUCTION MANUAL



Horticulture Production Manual

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Overview of the book

Purpose of this book

The main purpose of this book is to guide and assist farmers, extension specialists as well as Horticultural advisors with the knowledge required to optimise their production as well as build their business skillset to overcome commercial challenges.

Everything Starts With the Market First!

Farmers have to start by understanding the needs of their target market (volumes and quality standards) and find the practices listed in this book that would best assist them in achieving the market requirements, including managing nurseries, soil management and best practices for post-harvest activities. Farmers who apply the technical and business skills explained in this book will find more success to access and deliver good quality and increased quantity to new and diverse markets. Farmers should constantly engage industry role players, including input suppliers, extension service providers, commercial and large scale producers, government institutions, off-takers and agents to familiarise themselves with changes that take place in the market and opportunities that might arise.

The book is written so that readers can easily understand the explanations of the basics regarding Horticulture.

The book is divided into eight parts.

- Chapter 1 provides information on how agroforestry can be used in your farming setting. It gives a basic overview of the INCREASE model and how this model can be utilised in your farming practices. Furthermore, the smart climate methods are explained in some detail.
- Chapter 2 is an introduction to nursery management. You will learn about nurseries in more depth and the importance of managing a nursery in the correct way. The different types of nurseries will be explained and you will understand the importance of choosing a suitable site for maximum production which will result in increased productivity. Furthermore, seedling management will be discussed in detail, this includes understanding the importance of buying good quality seedlings from a reputable supplier. Bad quality seedlings may affect production negatively and could result in lower yield levels and uneven bulb sizes.
- Chapter 2 looks at the different types of vegetable and fruit crops that will grow well in Solwezi based on the temperature conditions, soil conditions and rainfall. Each crop thrives in different conditions, some crops require loamy soil and others clay soil. Each crop and the preparatory processes that come with it will be explained in this chapter. Furthermore, different crops are best sown in a certain period of time, when adhering to these conditions, you are optimising maximum yields.
- Chapter 4 focuses on the different types of fertilisers that can be used in crop production. Fertilisers can either be organic or chemical and it is easy to use organic fertilisers which is readily accessible. Furthermore, it is advisable to apply fertiliser after heavy rains so that they don't wash out.

- Chapter 5 looks at the different pests and diseases that crops can be affected by and how diseased crops will have a negative impact on crop yield as well the income a farmer makes. Poor quality crops will result in low production rates and using the right pesticides and fungicides can help control diseases in plants.
- Chapter 6 analyses the different irrigation methods that you can make use of in crop production. Each irrigation method is explained in detail – as well as how an injection of fertiliser can also be added to enrich the water.
- Chapter 7 covers various post-harvest activities as well as basic information on how marketing and value-adding works and discusses the economics of crop production as well as the transporting of crops is discussed.
- Chapter 8 discusses the costs, income from and profitability of crop production, as well as basic budgeting techniques that you can make use of.
- Chapter 9 looks at beekeeping and how bees have become a useful commodity in crop production.

Chapter 1

Importance of Agroforestry in Crop Production

1.1 Introduction

What is agroforestry? Agroforestry is a technique where trees or shrubs are integrated with crop production. This produces a more diverse agricultural operation. There are a few practices that you should consider when integrating agroforestry in crop production.

When properly used, agroforestry systems also yield proven strategies for long-term soil enrichment. Good agroforestry can reduce stress to crops as well as enhance yields and retain soil moisture. For example, the moist shaded microclimate under certain crop trees is beneficial for shade-tolerant horticultural crops such as spinach.



Figure 1.1: Agroforestry

1.2 What is Agroforestry?

Growing or keeping trees with crops and/or animals on the same piece of land. This can be at the same time or one after the other. The trees and crops or animals need to work together so more benefits are produced than if they were working separately.

Examples of working together are providing shade, improving soil, providing fodder, timber, charcoal, fruits, medicine, honey, caterpillars and so on. Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.

■ Advantages of agroforestry

Some advantages of agroforestry include:

- Improve soil fertility (leaves and roots)
- Provide food (Fruits, leaves, pods)
- Produce livestock fodder
- Provide bee fodder (Nectar & pollen)
- Fuel wood (Charcoal & firewood)
- Medicine (*Moringa*, Neem)
- Rehabilitation of degraded sites
- Wind breaks
- Support pest management as the trees block the pest and disease from spreading fast.
- Repelling some insects and diseases (Tephrosia)
- Used to support other crops e.g. Leucaenasticks can be used to support growing tomato

1.3 Alley cropping

Alley cropping is a technique used in farming, where trees are planted as well as shrubs (you choice) to create alleys within where horticultural crops are produced. These could be fruit trees, i.e. orange trees or could be softwood wood species which can also be used for wood fibre production.

An example of this farming technique is shown in the image below.



Figure 1.2: Alley Cropping

■ Benefits of alley cropping

Benefits include:

- Cultivation of food, forage or specialty crops between rows of trees
- Labour savings in biomass transfer you can cut and put the biomass in the next alley
- Income diversification: Crop and tree production incomes
- Helps in pest management as the trees block the pest and disease from spreading fast.
- Marginal land improvement by planting trees
- Shelter: reduces wind speed (wind erosion) Creates micro-climates (Improves yield and quality of crops)
- Wildlife: creates new habitat for beneficial predators
- Improved aesthetics: enhanced environmental beauty

■ Checklist

Before starting with agroforestry, make sure to check the following:

- Soil type: how healthy is your soil? Bad soils take more years to improve with agroforestry, but they can be improved and give more yields than conventional farming.
- Slope: is your land on a slope? Even a small slope? You will need to stop erosion with ridging and contour farming.
- Water logging: Agroforestry is not good on waterlogged land. If you have no other place, you will need to dig drainage canals and a deep pit to collect and keep water for the dry season.
- Livestock movements: a big problem for all types of conservation farming and agroforestry. Live fencing or agreements with traditional leaders are necessary.
- Fire: The enemy of conservation farming and agroforestry. Make a fire break.
- Farm planning: Agroforestry is not year to year planning but 3 to 5 years planning and even longer, depending on the system. Plan together with your family; they also have ideas!
- Your own experience: yours and that of your family is important. It is your farm. Please change what you think should be changed.
- Agroforestry is not a magic solution: it is a living system that needs to be checked every day. It can fail with extreme weather, pests or bad management.

1.4 Different Agroforestry Models

There are different agroforestry models and each model is suited to a specific way of farming. For the purposes of this manual – we will look at the INCREASE model in more detail. Furthermore, the model shows the type of planning that needs to be done as well as how much profit you can make with each model is also shown, this will help you make informed decisions about which model will work best for you based on the type of land and crops that you are planning to harvest.

■ INCREASE Model

Below is an example of the INCREASE model. As a farmer, you can utilise your land to the maximum. For example, you can grow several types of crops at the same time as well as trees and legumes which can be a value add for your business.

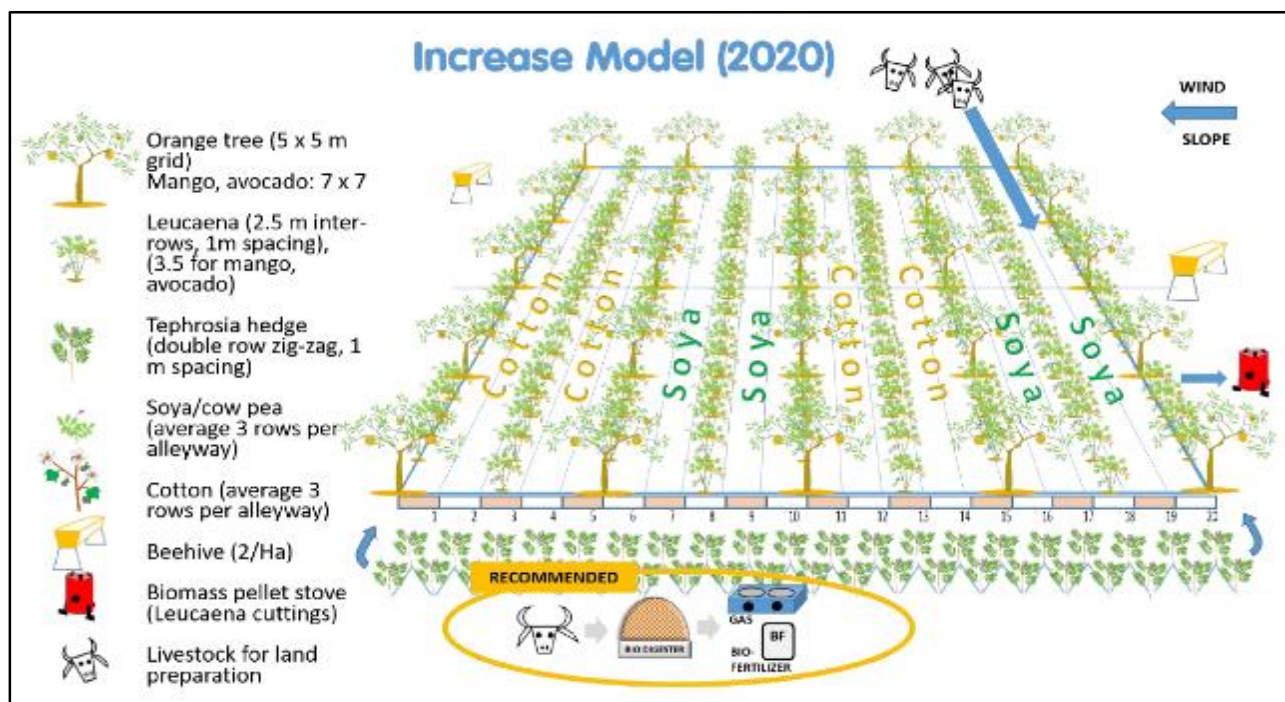


Figure 1.3: INCREASE Model

■ INCREASE Model Calendar

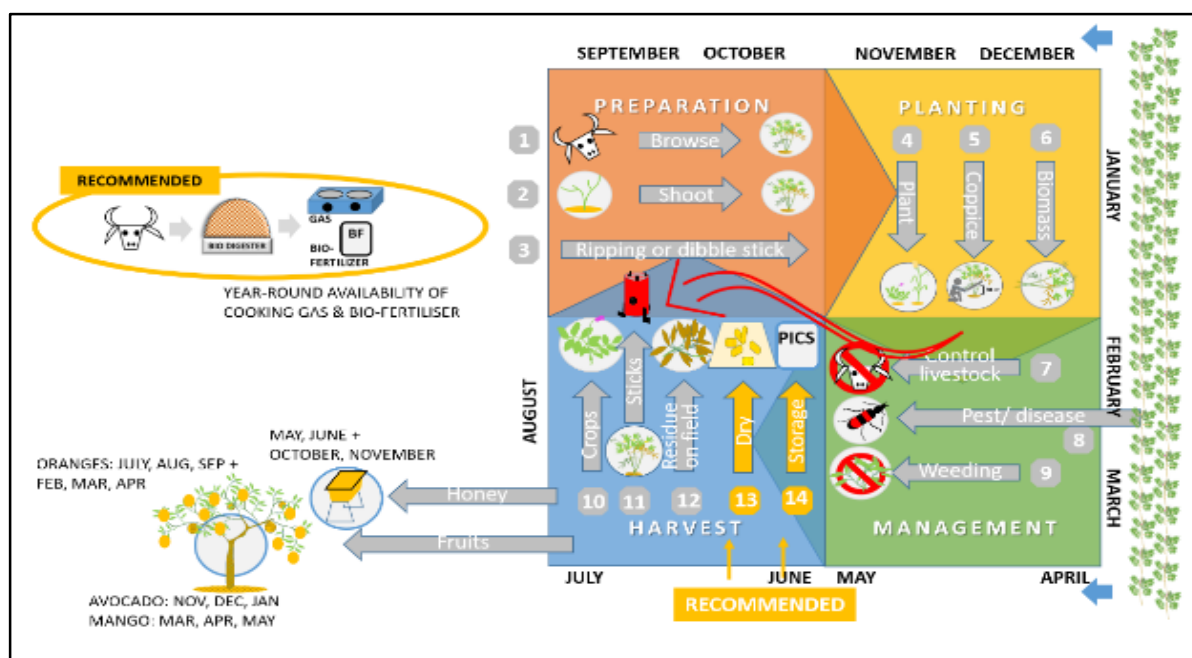


Figure 1.4: INCREASE Model Calendar

Let's break the calendar into four terms, the section below will look at each period in more detail.

- Preparation
- Planting
- Management

■ Harvest

Preparation

The following activities should be done from September through October (the **preparation period**):



1. Livestock should be allowed to graze on the crop residue and Leucaena in the field.

2. Livestock defecates and urinates in the field, thereby adding more nitrogen on to the soil.

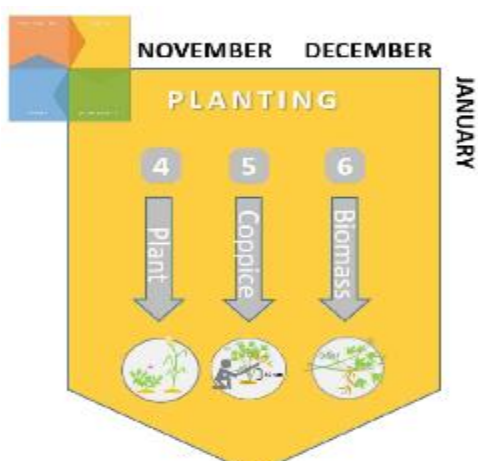
3. Leucaena should then be allowed to sprout out

several weeks before planting.

4. Land preparation should be done by ripping or dibble stick

Planting

The following activities should be done from November through January (the **planting period**):



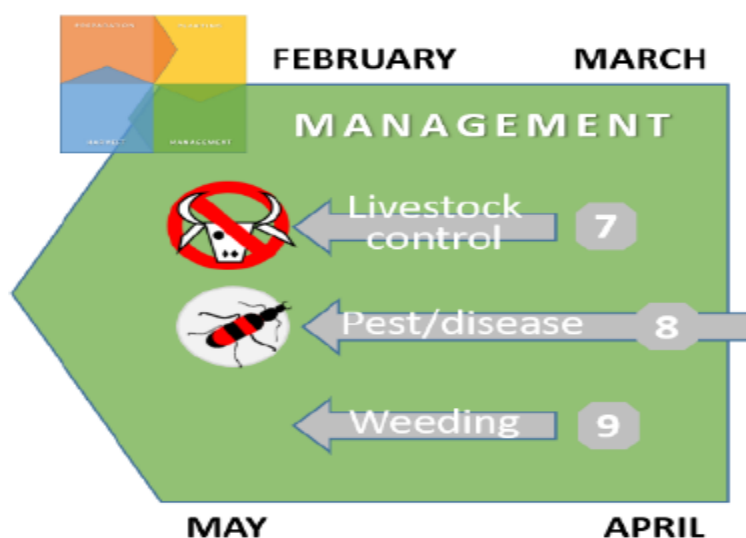
5. Plant with the first rains. Follow right spacing and correct seed rate.

6. As you walk through the field, cut the Leucaena trees 30cm from the Ground.

7. After cutting spread the cut branches in the alleys where the non-legume (for example, vegetable crops) will be planted.

Management

The following activities should be done from February through May (the **management period**):



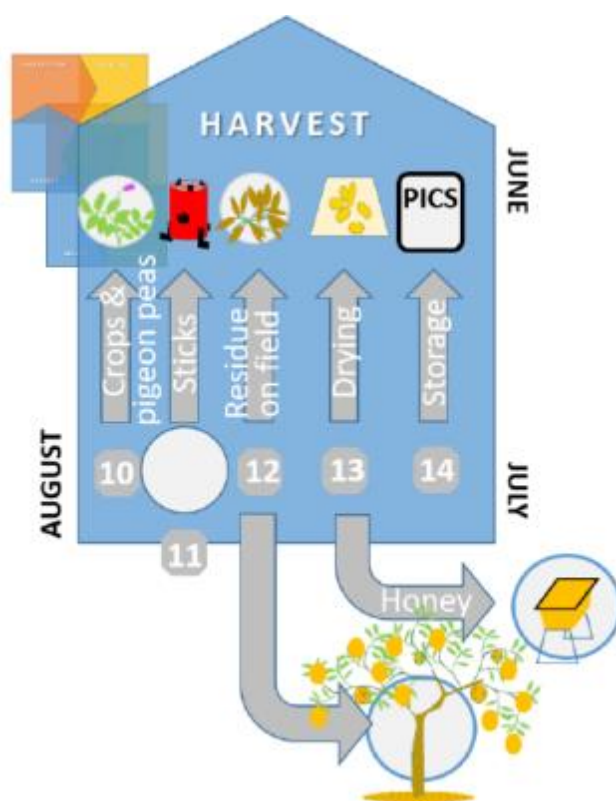
8. Prevent livestock from entering the field.

9. Integrated pest and disease control

10. Keep your field free of weeds using appropriate weeding methods.

Harvest

The following activities should be done from June through August (the **harvest period**):



10. Harvest the cowpeas and /or the soya bean

11. The Leucaena sticks can be used in improved stoves and gardening (e.g tomato)

12. Residue is left on the field

13. The crops are sun dried to obtain optimum moisture content

14. The grains are stored in PICS bags and cotton in Hessian bags.

15. Harvesting of honey is done during this period

16. Harvesting of oranges is also done during the same period.

■ Profitability

The image below is an estimate of how much of a profit you could make when using the INCREASE model.

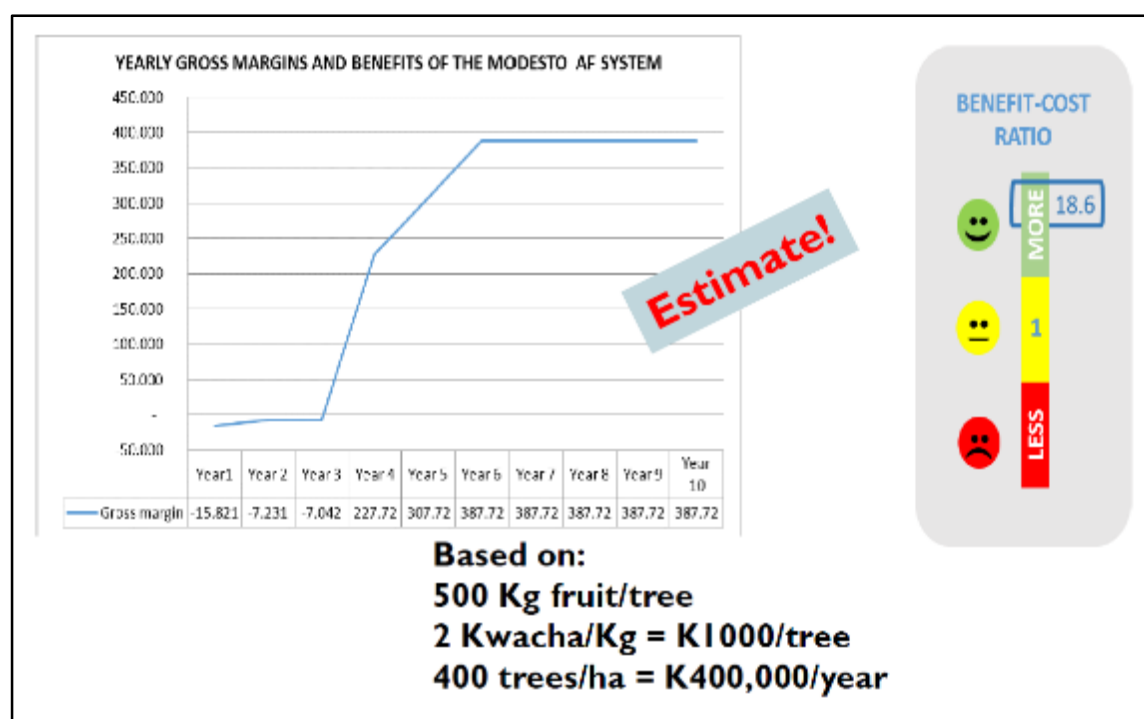


Figure 1.5: INCREASE Model: What Can You Earn?

1.5 Smart Climate Practices

What do climate smart methods of horticultural crops entail?

These are listed below:

- Minimum soil disturbance (minimum tillage)
- Use of improved (drought tolerant) seed
- Early planting
- Correct plant population (thinning and gapping)
- Crop rotation / intercropping with legumes
- Proper weed management
- Integrated pest management
- Appropriate use of herbicides
- Appropriate use of fertilizers, including agroforestry

Crop production will be more stable and yields will become higher again, because soil fertility will go up and intercropping protects against disease. As farmers, you should consider changing from conventional to climate smart of horticulture crop production because of the following reasons;

- Increasing droughts and erratic rainfall
- Increasing levels of pests/diseases,
- Acidification of soils due to overuse and improper use of chemicals.
- Increase in soil erosion and nutrient depletion
- Conventional cotton production depletes soil nutrients and requires many chemical fertilizers, herbicides and pesticides
- All this is leading to lower yields, contributes to greenhouse gases and pollution

ISFM - a type of Climate Smart method

Integrated Soil Fertility Management (ISFM) is defined as a set of agricultural practices adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity. It includes the use of fertilizers, organic inputs and appropriate germplasm combined with the knowledge of how to adapt these practices to local conditions aiming at optimizing agronomic use efficiency of the applied nutrients and improved crop productivity.

ISFM entry points

The **first entry point** of ISFM is focusing on the agronomy of crops and inorganic fertilizers. Interventions on germplasm involve the selection of varieties, spacing and planting dates. Interventions on fertilizer use target the formulation, placement, rate and timing of inorganic nutrient inputs.

The **second entry point** of ISFM targets interventions on organic resource management including the return of crop residues, manure, compost and other types of organic wastes, next to rotation or intercropping with legumes and use of plant growth promoting micro-organisms.

The **third and last entry point** of ISFM deals with any other amendments that may be needed to lift limitations to productivity such as soil acidity, micronutrient deficiency, erosion, soil compaction or pests and diseases.



2.1 Introduction to Nursery Management

What comes to your mind when we speak of a nursery?

A nursery is a place where planting material such as cuttings, saplings and seedlings are planted, raised and grown in large numbers under favourable conditions such as sufficient sunlight, fertile soil and the correct amount of rainfall.

Solwezi, which falls in zone 6 of the Zambia's livelihood zones trades mainly in agricultural products. Over time, mining activities have increased in this area, as a result, has provided a source of employment and market for agricultural produce. However, smallholder farmers in Zambia do face challenges such as the lack of business skills, not sufficient production and challenges when it comes to post-harvest activities. There is a huge scope for smallholder farmers to provide both formal and informal markets with key horticultural crops, but production levels are still way below the required optimum levels.

This chapter will therefore introduce the concept of nurseries and its importance.

2.2 Nurseries and Their Importance

A nursery is where the plant life begins. Therefore, it is important to lay the correct foundation for maximum production. Seeds are normally sown in well-prepared nursery beds – each type of horticultural crop has its own specifications when it comes to preparing a nursery bed. (This will be discussed in Chapter 2 in more detail).

Most horticultural crops are grown through seed. Pots, tray and wooden pots are normally used for expensive, costly seeds which results in easier management and better care of the seed.



Figure 2.1: Seedlings in a Plant Nursery

Since the nursery provides an area in which seeds are raised and nourished until they are ready to be transplanted elsewhere or ready for sale, it is important to highlight the importance of good nursery management:

- It is possible to grow and maintain a large number of horticultural seedlings per unit area.
- Nurseries provide the infrastructure for small and expensive hybrid seeds which can be raised more effectively due to better care and management.
- When seeds are sown in seedbeds, their germination percentage increases and the quality of the seedlings also improves.
- The management of seedlings can be done in a better way with minimum care, cost and maintenance as the nursery area is small.
- Manipulation of growing conditions for plants becomes much easier.
- Better and uniform crop growth can be obtained by the controlled conditions in a nursery, i.e., choosing healthy seedlings.
- Off-season sowing of seeds becomes possible, this results in fetching more yields.
- The seed requirement of nursery raised crops is less as compared to direct seed sowing of the same crop due to better management.
- Sowing seeds in a nursery allows additional time for doing preparatory ploughing or digging in the main plot. Harvesting of previous crops can also be prolonged, if needed.
- Management of insect-pests, diseases and weeds is easy in a nursery.

2.3 Site Selection for Nursery Management

There are several factors that contribute to the selection of a suitable nursery site. Some of these factors are discussed in the section below.

Note: Spending some time looking at a suitable site which covers all or most of the factors mentioned in this section could result in healthy seedlings and better harvest.

Location

Nurseries should be in a pollution-free environment, for example, industries that produce smoke, dirt roads that causes dirt and dust to settle on the plants. This covers the foliage and reduces the photosynthetic efficiency of plants but also gives them a dull look. Ensure that the nursery site gets adequate sunlight. However, care must be taken that the plants are protected against severe heat and sunlight.



Figure 2.2: An Area Not Ideal For A Nursery

■ Land topography

The topography of land at the nursery site must be even. If the surface is not smooth and it is gravelly, this must be levelled. In hilly areas, it may be divided into levelled terraces.

■ Soil

The soil must preferably be loam or sandy loam with large quantity of Organic Matter. The pH of the soil must be near neutral, on a pH scale, it should be 6.5 – 7.5. The soil type must have adequate water retention and aeration. Aeration is a natural process where water and air come into close contact, removing dissolved gases such as carbon dioxide from the soil.

To measure the pH of soil, you use a pH scale. There are different types of scales that you can use. These scales vary in size and costs and some scales can measure soil moisture as well. See below for some examples of pH scales that are on the market.



Figure 2.3: pH Scales

■ Water

Water quality plays a big role in how a nursery operates. Saline and polluted water should not be used. Also, horticultural plants need to be watered on a regular basis therefore there needs to be an adequate water supply for irrigation. It is wise to choose a nursery location close to a water source so that there is no scarcity of water during the course of growing the plants.

In Solwezi, water is not scarce. It is one of the towns that receive a high amount of rainfall on a yearly basis, up to 2000 ml of rainfall annually. The driest month is in July where an average of 0 mm of rainfall occurs. The wettest weather occurs in December/January where an average of 273 mm of rainfall occurs. The image below shows the average rainfall throughout the year in Solwezi.

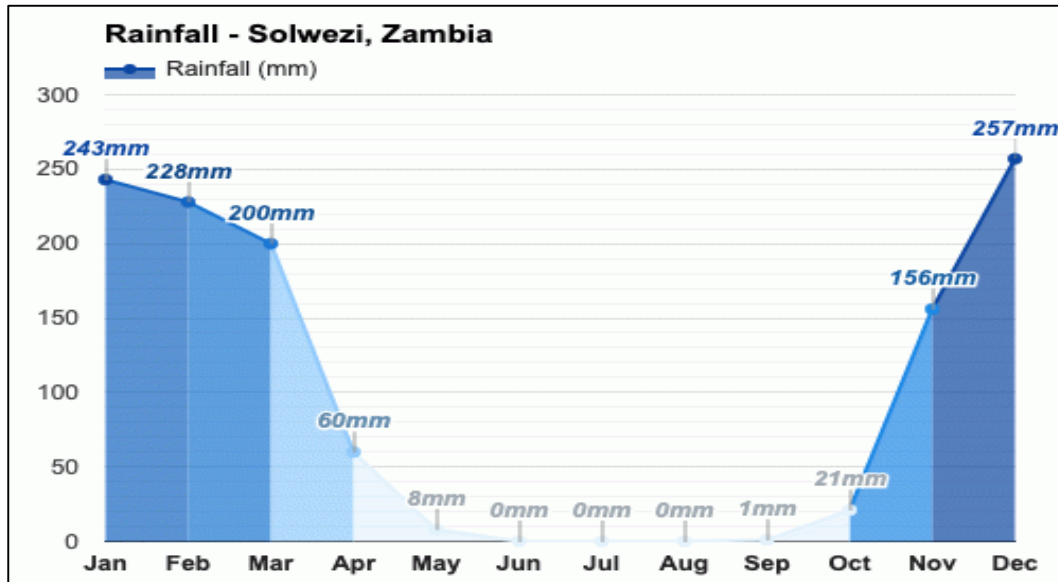


Figure 2.4: Average Rainfall in Solwezi, Zambia

■ Drainage

The nursery site must have proper and adequate drainage, it should also be free from waterlogging. Water should not stagnate at any time. Poor soil drainage will result in a water-logged saturated soil, this affects the growth of the plant and it affects the ability of the plant to absorb water through its roots.

Water-logged soils also causes plants to have less resistance to pathogens and pests.



Figure 2.5: Water-Logged Soil

■ Transportation

The nursery site must be accessible by road. It must not be far from potential markets so that there is no damage to the seedlings during transportation.

■ Labour

As nursery work is labour-intensive, the nursery site must have enough number of labourers.

■ Protection from animals

The nursery area must be protected by enclosures so as to prevent damage to the plants by stray animals.

■ Market needs and size

Market plays an important role in the success of nursery business.

Inputs such as seeds, pesticides, polybags, agricultural implements and other miscellaneous items required in the nursery must be easily available in the nearby market so that it eliminates the need to travel long distances to purchase these inputs.

2.4 Types of Nurseries

Nurseries are classified on the basis of duration, plants produced and structures used. This section will look at the types of nurseries in more detail.

■ Temporary nursery

This type of nursery is developed with the purpose of fulfilling seasonal requirement. This type of nursery is small in size, and it is set up only for a short period of time. Temporary nurseries are mainly used for:

- Raising seedlings of vegetables.
- Raising seedlings of flower crops.

Features

The following are some features of this type of nursery:

- It is constructed for a short period of time and it is small in size.
- It is usually located close to the planting site, therefore the distance between the nurseries and planting site is less thus resulting in less transportation costs.
- Intensive fertilization and manuring is not required as horticultural crops grown in this type of nursery would be in soil rich in hummus and excessive supervision is not required for the maintenance of this type of nursery.

Advantages

Advantages include the following:

- The initial investment (capital) required for a temporary nursery is less when compared to a permanent nursery.
- Seedlings have less of a distance to cover between the plant site and nursery making it less susceptible to mortality or seedlings getting damaged.

Disadvantages

The one disadvantage that can be mentioned is because this is a temporary nursery, there may be a lack of facilities such as adequate water supply. Arrangements should or may need to be made in order to keep the seedlings healthy and in good condition.

■ Permanent nursery

As the name suggests, a permanent nursery houses seedlings and plants for a much longer time. Horticultural crops and seedlings are nourished and kept for a longer period of time until replanted in the plant site. The area of this type of nursery is much bigger than a temporary nursery.



Figure 2.6: Example of a Permanent Nursery

Features

Some features of this nursery include the following:

- Requires a much larger area compared to a temporary nursery and must be well connected by road.
- More intensive supervision and management required.
- The initial investment (capital) to get this type of nursery started is much higher compared to the temporary nursery.
- Most permanent nurseries comprise of the following facilities:
 - Nursery beds
 - Office
 - Protected structures
 - Irrigation facilities
 - Packing yard
 - Cattle and machinery shed
 - Manure (for fertilization)

Advantages

Advantages of this type of nursery include the following:

- Although the initial investment and production costs may be high in the beginning, the profits do go up over the course of time.
- This type of nursery has better supervision and management mainly due to staff being easily available and in most cases are permanent staff.
- It becomes a source for planting material for many years as this type of nursery is more permanent in nature.

Disadvantages

There are some disadvantages associated with this type of nursery, these include:

- The initial capital cost is high.
- Transportation costs are higher when compared to a temporary nursery.
- Skilled resources are required for this nursery to be successful, also, it requires intensive labour management.
- Needs to have a large market for the sale of plants and seedlings.

The type of plants produced

This section will focus on the type of plants that is produced and how this impacts the type of nursery that should be selected.

Vegetable nursery

Planting material such as seedlings of vegetables, or rooted cuttings (for example, sweet potato), rhizomes (i.e., ginger or turmeric), tubers (potato) and bulbs like for example onion garlic are raised and conserved in such a nursery.



Figure 2.7: Vegetable Nursery

Fruit plant nursery

This nursery houses seedlings and cuttings of rootstocks, budded plants and cuttings of fruit trees are raised then conserved, like for example:

- Mango
- Lychee
- Guava
- Sapota

Structures used

Nurseries can be categorised according to the type of structure the horticultural crops are housed in. Let's learn more about this in this section.

Open field nursery

This type of nursery is established in an open area without any permanent structure. These nurseries usually have raised, flat or sunken seedbeds. The disadvantage of this type of nursery is that it is susceptible to bad weather, or natural environmental conditions.

■ Hi-tech nursery

This type of nursery is established under a protective structure/s. This could be in the form of:

- Thatched roof: A thatched roof is constructed over the nursery beds, this protects the seedlings from damage caused by extreme weather conditions such as heat, wind or even rain.
- Shade-net: Shade-nets are designed to provide shade to plants, each horticultural crop has its own shade requirements, and the nets are made according to different colours and mesh sizes in order to fit these specific requirements.



Figure 2.8: An Example of a Hi-Tech Nursery

Poly-tunnel

This nursery is covered with a plastic film or sheet which forms a tunnel. It looks more or less like a greenhouse and produces greenhouse-like effect. It is easy to construct and dismantle and does not cost much to set it up.

Seedlings are protected from extreme weather conditions, and due to the modified conditions, the germination and plant growth is much better. These structures are ventilated and may have temperature and humidity controlling devices. An example of this type of structure can be seen in Figure 2.9.



Figure 2.9: A poly-tunnel

2.5 Seedling Management

Excellent seedling management will result in the production of high-quality seedlings. This is why you need to pay close attention to all phases of nursery management. Seedling management is one of them. This includes the preparation of nursery beds, soil management, planting procedures, use of fertilizers, irrigation and pest control.

In this section, the primary focus will be on seedling management.

■ Nursery beds

A nursery bed refers to land which is free of weeds, stones, pebbles and unwanted debris. This type of land is used for the sowing of seeds and to raise seedlings as well as multiply different horticultural plants through asexual means.

Preparation of nursery beds

Nursery beds can be prepared in three different ways, these are explained below.

SUNKEN BED

A sunken bed is prepared in the following way:

- The soil of the seedbed has to be sterilised with chemicals or by the use of soil solarisation in order to avoid contamination of pests and diseases, like for example termites.
- The soil of this type of nursery bed is mixed thoroughly with rotten farmyard manure.
- If it is a water scarcity area, like for example, in the months of June and July, Solwezi does not have much rainfall – this type of bed helps to conserve the moisture of the soil.
- Prepared in dry and windy areas.
- Facilitates the deposition of water from irrigation or rainwater for a much longer period.
- Easily irrigated during dry months.

LEVEL BED

A level bed is prepared in the following way:

- The soil of the seedbed has to be sterilised with chemicals or by the use of soil solarisation in order to avoid contamination of pests and diseases, like for example termites.
- After soil preparation, the recommended dose of manure and fertilisers is mixed with the nursery bed.
- Irrigation channels are prepared between the rows of beds through which each bed is connected. These channels can also act as a drainage channel.
- Adequate drainage provision has to be made.



Figure 2.10: Example of a Level Bed

RAISED BED

The following are some things to note when preparing a raised bed:

- This nursery management is best prepared during the rainy season.
- The land is levelled and made smooth. Weeds, stones, pebbles and so on are removed.
- Raised beds are also made up of wood.
- The soil of the nursery bed is thoroughly mixed with 5–10 kg per sqm of well rotten farmyard manure.
- This type of bed is prepared about 15 cm high from the ground level. The width is kept at 1-1,5 m and length 3–5 m. This enables sufficient drainage during rains.



Figure 2.11: An Example of Raised Bed.

Precautions

A nursery bed needs to be prepared carefully so that healthy seedlings are produced and obtained for transplanting. The following are some precautions that should be taken when preparing a nursery bed:

- As you have learnt, a nursery bed is used to germinate sown seeds or rootings and cuttings. Therefore, sufficient moisture, nutrition and aeration should be considered and supervised as this affects seedling growth.
- Nursery beds should be prepared in fertile soil which is rich in organic matter. Soils that have higher retention capacity do not require frequent irrigation.
- Too much watering can result in the rotting of seeds or seedlings especially in a sunken bed. Remember – watering of the bed depends on the type of soil, for example, sandy soil requires more frequent water.
- If soil is not treated properly initially, soil-borne infections caused by insects and pathogens will destroy the seedlings or affect the quality of the seedlings.
- The width of the nursery bed should not be more than 1m and the length of the nursery bed should be according to the slope of the soil. This is so that when irrigation takes place, water reaches every corner of the bed and each section of the bed gets sufficient irrigation.
- Direct sunlight facing sites should be avoided as seedlings are still tender and can be prone to heat shock. So, nursery beds should be prepared in a site that receives partial shade.

■ Soil treatment

Soil or any planting medium could be contaminated by soil contaminants or various pests. Pests could result in huge losses in seedlings and the infection caused by pests could be transmitted to the plant site when seedlings are transplanted if not treated.

This is why it is absolutely necessary that the planting medium should be free of soil contaminants. Soil preparation will be explained in more detail in Chapter 2.

The different methods used for soil treatment is explained below.

Soil solarisation

This method is environment-friendly and is used to control soil-borne pathogens, for example, bacteria, fungi, insect pests and weeds.

Sunlight increases the temperature of the soil (increases “Heat Units” of the soil), this does help control various soil-borne pathogens. Soil solarisation should be done in hotter months as treatment causes physical, chemical and biological changes in the soil.

The procedure to carry out soil solarisation is as follows:

- Dig soil at a site where seedbeds are to be prepared.
- Remove all weeds, stumps, stones, pebbles, etc., from the soil.
- Break the clods as you level the soil to increase germination potential.
- Level the site to prepare seedbed.
- Irrigate the site thoroughly, then cover the site with polythene film of 200 gauge for 5–6 weeks during the hotter months, as wet soil will conduct heat better than dry soil. This results in soil-borne pathogens being killed by the heat that is generated,
- The nursery bed may be prepared at the treated site or soil may be used for filling pots or poly bags.



Figure 2.12: Soil Solarisation

Soil treatment by insecticide

Insecticide, such as Chloropyriphos with the measurements of 2 ml/litre of water should be applied to a depth of 15–20 cm in the soil which is used to kill insects, including ants, white ants and their eggs, nematodes (we can use a Nematicide called Nemabloc at 1lt per hectare drenched at 3-5cm at different point in the field), and so on.

Soil treatment by fungicide

Fungicides like Captan or Thiram at 5 g/m² is used to control soil-borne pathogens. These fungicides can also be used as soil drench by preparing a solution of 2,5–3 ml per litre and drenching the solution at 4–5 litre/m².

Formalin solution treatment

Take note of the following when making formalin solution:

- The formalin solution is used to sterilise soil. This solution can be prepared by adding 2,5 ml commercial grade formaldehyde per litre of water and the soil is drenched at 4.5 litres of solution per m² to saturate the top soil surface up to a depth of 15–20 cm.
- The drenched area is covered with a polythene sheet of 200 gauge so that the fumes of formalin penetrate into the soil to kill the pathogens.
- The polythene cover is removed after 48 hours.
- The soil is raked so that the fumes of formaldehyde gas escape from it.

Use of bio-agents

Certain biological agents like Trichoderma are used to control soil-borne pathogens. Bio-agents of 10–25 g/m² is mixed in the soil and after 2–3 days, the seeds are sown.

■ Seed management

To keep the seeds free from pathogens, fungicides like Captan, Thiram or Carbandazim is applied with the measurements of 2,5–3 g/kg seed and mixed thoroughly with the seeds to disinfect the surface of the entire seed lot.

Taking care of seedlings

Plants grown in a nursery are still very fragile and need to be handled with care. The quality of seedlings depends on how the following activities are carried out in a nursery.

SHADING

Seedlings should be protected from too much sunlight or extreme weather conditions. Shade can be provided using shade-nets and polythene sheets.

THINNING

It is important to ensure that seedlings receive enough air and light. When you see weak and diseased seedlings, it is wise to remove these damaged plants which allows healthy seedlings to grow properly.

WATERING

Nursery beds should be watered carefully, too much water can also be detrimental for plant growth. Watering should be done according to the crop type and its requirements.

WEEDING

Weeding is the process of removing all unwanted plants from the nursery. Removal of weeds is beneficial for seedlings as seedlings do not have to compete with weeds for nutrients, water, air, space and sunlight.

Weeds can also breed insects and disease carrying organisms. Weeds have been known to reduce yields in certain crops like Corn up to between 15 and 45%. Use your hands to remove weeds. If there is a large number of weeds present, herbicides can be sprayed after the seeds have been sowed.

There are different methods of weed control - hand weeding, mechanical weeding, chemical weeding control, a combination of the above.

- Hand weeding
 - As a guide one hand weeding per fortnight
 - There are “no small weeds in between the crops”
 - The first 30 days are critical in the avoidance of yield loss due to weed control.
- Mechanical weeding
 - May be conducted one or two times before the crop canopy closes
 - Mechanical weeding will almost always complement hand weeding and will only control the weeds between the rows.
 - The implements used as mostly ridges and cultivators

HERBICIDES

Herbicides, also commonly known as weed killers, are substances used to control unwanted plants. This is the least preferred weed management option. Selective herbicides control specific weed species, while leaving the desired crop relatively unharmed, while nonselective herbicides (sometimes called total weed killers) wipe out all the plants in the field

In an integrated weed management program, herbicides are typically considered to be the least preferred management option. Reasons for this include expense and the potential for these chemicals to be used contrary to the label directions.

Some simple precautions will help you minimize the risk of chemical use, while maximizing the effectiveness of herbicides as part of your integrated management strategy.

PRECAUTIONS WHEN USING HERBICIDES

Identify the weed - Since not all products are effective on all weed species, it is important to identify the weed species to be managed and to check the herbicide labels to determine which product(s) will be effective.

Read the label - Because of the variety of plants and planting situations in the home landscape, it is impossible to find one herbicide that is suitable to manage all weeds in all situations.

It is very important to ALWAYS READ THE LABEL before you buy a product in order to find an appropriate product for your situation. When selecting a product, check the label to be certain that the site (i.e., vegetable garden, field crops) where you want to use the herbicide is listed and that the product will be effective on the weed in question. The label will also give usage rates and precautions for your safety and to protect desirable plants.

Selecting an herbicide contact vs. translocated herbicides. There are two main types of herbicides: Contact herbicides, which only kill tissues that are directly contacted by the spray, and translocated herbicides, which are taken up by the plants and moved throughout the plant tissues. Contact herbicides can provide adequate control of annual and biennial plants but will only give “top kill” of perennials and other weeds which can resprout from the roots. Translocated herbicides, when used correctly, are typically the better choice for controlling perennial weeds.

Take note of the following:

- To get the best results from an herbicide application, it is important to time it properly in relation to the weed’s life cycle. This requires some familiarity with the weed and its life cycle.
- All weeds are most easily managed when they are seedlings. It is essential to manage annual weeds before they produce flowers and seed.

- Biennial weeds are most easily managed in the first season, when they are seedlings or small rosettes and have not produced flowers or seeds.
- Timing of chemical management of perennial weeds often depends on the species.
- The best time to manage perennial weeds is when they are seedlings, but chemical applications just prior to blooming, during early stages of flowering, and during the Autumn re- growth period (when sugars are being translocated to the root system for winter storage) can also be effective. In all cases, read and follow label instructions in order to get the best, and safest, results.
- Herbicides will damage or kill plants just as easily as they damage or kill weeds. Damage can result from direct contact as well as from physical drift of spray, runoff of treated soil, and vapor drift (drift of fumes of the herbicide).
- Always use caution when applying herbicides around desired plants. Do not spray in windy conditions. In some cases, it may be necessary to screen desirable plants with plastic to protect them from the herbicide. To minimise risk to desired plants, use a separate sprayer for applying herbicides.
- Do not use the same equipment that you will use for application of insecticides, fungicides, fertiliser, etc., as traces of herbicide can remain and cause damage to desirable plants.
- If the herbicide label directs you to apply a specific amount of the product per unit area (e.g. 5g./10 metres), calibrate your sprayer or spreader to make sure you are using the right amount of herbicide.
- Too little herbicide will be ineffective and may contribute to a weed developing resistance to an herbicide.
- Too much herbicide will waste money and could cause damage to surrounding vegetation and the environment.

HARDENING OF SEEDLINGS

Seedlings should be hardened-off in some shade before being transplanted in the planting site. This is so that these seedlings can survive the environmental conditions that it can be exposed. Over-hardening of seedling should be avoided.

DE-SHOOTING/ DE-SUCKERING

De-shooting is the removal of all side shoots from the base of the plant. The reason why de-shooting is done is so that energy of the plant can be focussed on the development of its shoots or buds.

Transplanting seedlings

After the planted seedling is ready and big enough, you can transplant them into the soil.

The following are some tips to take note of when transplanting seedlings:

- Do not damage the seedlings roots, so be careful when handling seedlings. Plant when it is a rainy day or rain is expected on the day. Never decide to transplant seedlings on a dry, humid day.
- Remove the seedling from the tray. Make sure there is still lots of soil on the roots of the seedling. Plants such as tomato – keep a ball of soil on the roots.
- Place the plant into the hole that you have prepared.
- Transplant seedlings gently. Plant large seedlings with a trowel and smaller seedlings with a pointed stick.
- Press the seedling into the soil gently and spread soil around the stem
- Once you have done transplanting, water the seedlings on a regular basis. Keep the soil moist by watering the soil in small amounts.
- The seedlings will die if the soil dries out or if the soil is too wet.



Figure 2.13: Lettuce Plant Ready for Transplantation

Propagation

Propagation or the multiplication of plants by using seeds is called sexual propagation. This is an old method and it is widely used for the propagation of fruits and vegetables. It is an easy method to use and plants propagated using seeds live longer and are more tolerant to pests and diseases. Plants propagated through this method have a longer gestation period which could result in a delay in production.

Asexual propagation is also known as vegetative propagation. The vegetative part of the plant, i.e., the stem, leaf or root is used for propagation. Fruits and vegetables that cannot be propagated through seeds use this method. This method requires a specialised skillset, so it is an expensive type of propagation. Also, plants propagated using this method can be prone to environmental stresses.

3.1 Introduction to vegetable production

Vegetables is a source of important nutrients and it is vital for the general good health of human beings. Vegetables provides essential minerals, nutrients and fibres for our bodies to fight against diseases and other medical conditions.



Figure 3.1: Some Common Vegetables

Good horticultural crop production is not easy to achieve, there are several things that you need to ensure for your vegetable production to be successful.

Solwezi has a high demand for vegetables however the demand is still not met by local supply. The market is also much more favourable in Solwezi when compared to an area such as Chingola, for example a 50 kg of maize will fetch a price of ZMK 120 in Chingola, the same will fetch a price of ZMK 300 in Solwezi due to it being a mining town.

There is ample opportunity for growth to expand and increase vegetable production in Solwezi. This chapter will look at the different types of vegetables and key aspects you need to take note of and apply during each phase during the planting process or production cycle.

3.2 Types of vegetables

For the purpose of this manual, the focus will only be on the following vegetables:

- Cabbage
- Lettuce
- Peppers
- Broccoli
- Tomato

- Onion
- Butternut
- Eggplant
- Watermelon
- Green beans
- Spinach
- Rape

■ **Cabbage**

There are different types of cabbage. To give you an idea, cabbage comes from the family of vegetables called Brassicaceae and its scientific name is Brassica oleracea. Other vegetables in this family are:

- Several types of cabbages
- Chinese head
- Kale
- Rape
- Broccoli
- Cauliflower

The table below shows the different types of cabbages.

Table 3.1: Cabbage types

Type of cabbage	Image
Ordinary cabbage	

Type of cabbage	Image
Chinese cabbage	
Savoy cabbage	

Preparation

The following should be noted when planting cabbage:

- Cabbage is propagated from seeds.
- Make sure the land is clean and ploughed deeply. The planting site should be cultivated at least 8 weeks before planting. Soil treatment, i.e., any fumigation should occur at least two weeks before the planting time in order to control nematodes.
- Cabbage can be planted by direct-seeding or transplanting seedlings. If direct seeding is used, 2kg of seed per hectare is required. A farmer should aim to achieve a plant population of 40,000/Ha.

- When direct seeding, increase the seed rate to cater for loss due to non-germination, disease and insect damage.
- Cabbage grows best in cool and humid climates, the optimum temperatures for cabbage growth is 18°C to 20°C. Cabbage is tolerant to frost and can survive extreme cold temperatures like 3°C.
- You can grow cabbage throughout the year as it adapts to different climatic conditions quite easily.
- Seedlings should be transplanted as soon as the desired size is reached. Transplanting should only be done in moist soil.
- In wet-areas, cabbage should be planted in raised beds in order to prevent root rot and water-logging.
- Spacing affects the head size, shape and yield of cabbage. It is said that when cabbage seeds/seedlings are planted close to each other, this will result in smaller and slightly more pointed heads.
- It is recommended that large-headed cultivars should be planted 40cm to 60cm apart between rows and 45 cm apart within rows. Smaller-headed varieties are planted 6 by 30 cm X 60cm apart.



Figure 3.2: Cabbage Produce

Ordinary cabbages have a high demand as they are a direct substitute of other leafy vegetables and does not wilt easily (hence the longer shelf-life). The demand for cabbage and prices for cabbage is affected by the availability of the other vegetable types, i.e., rape.



Figure 3.3: Farmer Holding an Ordinary Cabbage

Chinese cabbage and savoy cabbage are two popular cabbage types as they are mainly used in salads and the demand is usually from more upmarket suppliers.

■ Lettuce

Lettuce comes from the daisy family called Asteraceae. It is a leafy vegetable and mostly used in salads but can be used in other types of dishes such as sandwiches, soups and wraps. The scientific name for lettuce is *Lactuca sativa*.

There are different types of lettuce, some of these types are tabulated below.

Table 3.2: Different types of lettuce

Type of lettuce	Image
Crisp head	A close-up photograph of a crisp head lettuce, showing its characteristic ruffled, layered green leaves. The leaves are vibrant green and appear fresh.

Butter head	
Romaine	
Loose-leaf	

Lettuce requires low temperatures to grow and these plants have a height and spread of about 15 cm to 30 cm, the leaves are mainly green however, you can find yellow and blue-teal varieties of this leafy plant.

Preparation

The following should be noted when planting lettuce seeds or seedling:

- Propagation of lettuce is by seed.
- Planting is done by direct seedling of the seedbed.
- Raised beds are ideal for lettuce production. These seeds are sown directly in the plant site to a depth of 10 to 15 mm.
- Lettuce seedlings for transplanting are planted on 10 cm to 12 cm raised seedbeds consisting of three to five rows 20cm to 30 cm apart of plants spaced from 15cm to 20 cm apart in the rows and transplanted after five weeks of sowing.
- Lettuce grows best in cool seasons – temperatures of 12 °C to 20 °C is ideal for proper lettuce growth. Temperatures of above 27°C can affect the head development as well as the quality of the crop.
- It grows well in a wide variety of soils – from light sand to heavy. A pH between 5.5 and 7 is ideal for this type of crop.



Figure 3.4: Lettuce Planting

■ Peppers

Peppers come in different colours and come from the family called Solanaceae. The scientific name for pepper is *Capsicum annum* and consists of several family members such as:

- Tomato
- Eggplant
- Potato
- Chilli peppers

Bell peppers are the most popular type of peppers and come in different colours such as green, yellow, orange and red. Red bell peppers are ripened green bell peppers, however more expensive.

Peppers are used in salads or pizza toppings and in other dishes. The bell pepper is the only member of the *Capsicum* family that is not spicy or causes a strong burning sensation when eaten.

Table 3.3: Types of peppers

Type of pepper	Image
Bell peppers	
Chilli peppers	
Scotch bonnet peppers	

Type of pepper	Image
Birds eye chillies	
Mbuzi chillies	

Preparation

The following should be noted when planting peppers:

- Pepper is a warm season crop; therefore it cannot handle frost. Pepper crops will not survive in conditions under 12 °C, therefore this needs to be taken into account before planting takes place. Optimum temperatures for this type of crop are 20 to 25 °C.
- It needs about 2000 mm of rain annually which makes Solwezi an ideal area for Pepper production.
- Soil used for plant beds should have had no peppers grown in it for 4 or 5 years, preferably never before.
- Bell peppers prefer well drained fertile soil. Soil should have good water holding capacity and the drainage should be good in order to prevent root rot.
- pH levels of the soil should be between 6,0 to 7,0.
- Propagation is done usually by direct planting.

- Seedlings are produced by sowing seed in seed trays under greenhouse or shade-cloth conditions.
- 10 to 12 seeds can be planted 45 cm apart on rows that are 75 cm apart and later thinned when 8 to 10 cm tall to 2 plants per stand.
- Pepper seedlings are ready to be transplanted after 6 to 8 weeks when the seedlings are 150 to 200 mm tall.



Figure 3.5: Pepper Seedlings

Broccoli

Broccoli is an edible green plant which comes from the Brassicaceae family. Cauliflower, Cabbage, kale, Brussel sprouts are all members of the Broccoli family.

It can be eaten raw or cooked and consists of large flower heads which are usually dark green with a thick stalk. The structure of this vegetable almost has a tree-like structure as shown in the image below.



Figure 3.6: Broccoli

Preparation

The following should be noted when planting broccoli:

- Soil should be prepared to a depth of 30 to 50 cm.
- Broccoli grows best in soil that is slightly acidic to slightly **alkaline soil** with a pH of 6,5 to 7,5.
- Broccoli propagation is by seed.
- Some farmers sow the seeds directly but the most successful way to plant Broccoli is by making seedlings in seed trays and once the seedlings are about 150 mm in height then they are transplanted into the plant site.
- Broccoli plants should be spaced 40 cm to 50 cm apart in rows that are 50 cm apart. This is between 30 000 and 40 000 plants per hectare.
- Broccoli seedlings needs full sun or light shade.
- After four to five weeks after the seeds have been planted, the Broccoli seedlings should be ready to be transplanted.
- Broccoli seeds are usually sown during the low temperature months.



Figure 3.7: Young Broccoli Plants

(https://commons.wikimedia.org/wiki/File:Young_broccoli_plants_with_snail_damage.jpg)

■ Tomato

There are different types of tomatoes which come from the Solanaceae family. The scientific name for tomato is *Solanum lycopersicum*. Family members include the following:

- Green pepper
- Eggplant
- Chillies
- Potato

Tomatoes are actually a type of fruit also referred to “fruit vegetable” however it is eaten and prepared like a vegetable. Tomatoes are red in colour; however, they can come in a variety of colours such as yellow, orange and green. Tomatoes are used in a variety of dishes as well as in salads.

The table below shows some popular tomato types.

Table 3.4: Types of tomatoes

Type of tomato	Image
Jet star tomatoes	 A photograph of a tomato field. In the foreground, a red sign with the text 'Jet Star' and an image of a tomato is placed in the soil. The background shows rows of tomato plants with green leaves and some ripening fruit. A wooden stake is visible on the right side of the frame.
Cherry tomatoes	 A close-up photograph of a large pile of ripe, red cherry tomatoes. The tomatoes are small, round, and have a glossy surface, indicating they are fresh and ready for consumption.

Preparation

The following should be taken note of when preparing for tomato plantation:

- Tomatoes are best grown in summer and during frost free months.
- Tomatoes are probably the most used vegetable commodity in Zambia.
- This is a warm-season crop which is sensitive to frost. An average temperature of 20 ° to 24 °C is optimum for growth, yield and product quality.
- Tomatoes are propagated from seed.
- Seedlings are raised in seedbeds then transplanted to the plant site/field.
- Direct seeding is usually done when the crop is going to be mechanically harvested or processed.
- Seedlings are usually ready for transplanting three to four weeks after sowing and they should be transplanted on moist soil.
- Seedbeds should be irrigated after sowing and it should be done regularly until the seedlings reach a height of 5 to 7 cm.



Figure 3.8: Tomato Seedlings



Figure 3.9: Tomato Drop Starting To Ripen

■ Onion

Onions is a very common type of vegetable which is used in almost every dish, including salads. They come from a family called Amaryllidaceae and the scientific name for this vegetable is *Allium cepa*. Family members include Garlic and Leeks.

Onions can be cultivated all year round but favour cooler temperatures with well drained soils. Heavy clay soils are not ideal unless you culture them to adapt to the crop.

There are open pollinated old varieties which yield close to 60Mt but modern technology with hybrid varieties perform a lot better reaching yields of above 90Mt/ha.

Zambia experiences a shortage of inions from December through to March every year. Farmers with good production cycles and those who have good storage facilities should take advantage of this.

Onions contain chemical substances which may cause irritation to the eyes when chopped.

Table 3.5: Onion types

Type of onion	Image
Yellow onion	
Red onion	
Shallots	

Preparation

The following are some points to note when preparing for onion plantation:

- Loamy soils are best suited for onion plantation, these rows should be deep and drained to a depth of 45 to 60 cm.
- Seed and variety selection is the initial stage of success in the production process.
- Secure healthy seeds with high viability as this will lead to high yield and quality production.
- pH levels should be between 5,5 and 6,5.

- Onions grow best in moderate temperature conditions from 18 °C to 22 °C.
- Onions can be sown directly or the seedlings can be transplanted. Sow directly by drilling in furrows 5mm deep or raise seedlings in nursery.
- Transplant during the cool parts of the day to avoid wilting.
- Space Onion at 5cm by 20cm(X5 rows) and leave 100cm walk way space.
- Most ideal production period is from February to May. You may spill over to June if you have sufficient source of water.
- After transplantation, you should keep the soil moist for 5 days in order to prevent transplanting shock.

An example of an onion plantation is shown below.



Figure 3.10: Onion Plantation

Butternut

Butternut known as *Cucurbita moschata* scientifically comes from the family of Curcibitaceae. Members in this family include:

- Gem squash
- Pumpkin
- Watermelon
- Baby marrow

Although butternut is a fruit, is mainly used as a vegetable in dishes – for example, in soups and pies. In some places, it is regarded as pumpkin.

Some types of butternuts are shown in the table below.

Table 3.6: Butternut types

Type of butternut	Image
Butternut fruit	
Butternut squash	
Pumpkin	

Preparation

The following can be said of butternut planting:

- Butternut can be grown both in the wet and dry seasons.
- The optimum monthly average temperature for good growth is from about 18 °C to 27°C.
- These crops do not do well with frost and will die when exposed to frost conditions.
- This type of horticultural crop survives in most soil types however, a soil pH of 5,6 to 6,5 is recommended.
- Butternut grows well in well-drained soils, and sandy loamy soils are idea however they do grow well in clay soils as well.
- These crops are propagated by seed, but they can be reproduced using cuttings.
- These seed sare usually sown direct on the main field.
- Minimum tillage is required for this type of crop, then furrow the field at 2 m apart. Furrows are made to a depth of 15 cm.
- Plant seed 2,5 cm to 3,75 cm deep in moist soil.

■ Eggplant

Eggplant also known as brinjal or aubergine comes from the family of Solanaceae. Its scientific name is *Solanum melongena*.

It is a fruit however it is typically used as a vegetable in cooking. Family members include:

- Tomato
- Potato
- Chilli peppers

There are a few eggplant varieties out there, even though each eggplant may look different on the outside, on the inside, they are all identical.

The table below shows some common eggplant varieties.

Table 3.7: Eggplant types

Type of eggplant	Image
Globe eggplant	

Type of eggplant	Image
Sicilian eggplant	
White eggplant	

Preparation

Take note of the following when planting eggplant:

- Eggplants are propagated by seed.
- Seedlings should be planted in trays with then transplanted or can be sown in small pots.
- Before planting – seeds do contain many empty shells (aborted seeds), these are darker in colour and should be removed before planting.
- Keep seedlings moist but not wet – it is advisable to use a water spray can to water these seedlings.
- Eggplants thrive in soil with a high humus content.
- Because only a few plants are needed, it is better to prepare only the planting spot. Each spot should have a diameter of 30cm to 40 cm. The planting spots should be about 75 cm apart.
- Transplant into the plant site when seedlings are 10 to 12 cm tall. Do not plant weak, damaged or long- stemmed seedlings. The soil should be wet.



Figure 3.11: Eggplant Seedlings (Deposit ID 466850816)

Watermelon

Watermelon is a type of fruit that comes from the Cucurbitaceae family. Its scientific name is *Citrullus lanatus* and family members include:

- Butternut
- Gem squash
- Cucumber
- Baby marrow

Watermelon is green on the outside with pink fleshy skin on the inside with many black seeds. Seedless varieties also exist. This fruit can be eaten raw or even used in pickles. There is a variety of watermelons that exist, these are tabulated below.

Table 3.8: Watermelon types

Type of watermelon	Image
Picnic watermelon	A photograph showing several large, round watermelons with green and yellow stripes growing in a field. The watermelons are surrounded by green leaves and vines. The image is a close-up shot, focusing on the watermelons and the surrounding foliage.

Type of watermelon	Image
Yellow/Orange watermelon	
Seedless watermelon	

Preparation

The following can be said about watermelon planting:

- Watermelons grow best in non-saline sandy loam soil.
- The soil should have a pH of 5,5 to 6,5.
- Watermelon propagation is from seed. Seed can be planted directly into the soil or seedlings can be made in seed trays then transplanted after the seedlings are ready.
- They are sensitive to cold temperatures and even a mild frost and can severely damage the crop.
- The temperature range for optimum watermelon production during the growing season is between 18°C and 35°C.
- Plant sites should be prepared thoroughly by ploughing and harrowing and removing the different types of plant debris. It should also be pulverised and levelled; rows should be made 2 m apart.

- Watermelons are planted on flat beds 1.5 - 2 m wide and 20 cm to 30 cm high. In direct-seeded plantings, seed is placed 1,2 cm to 1,9 cm deep. Also, seedlings should be planted at least 50 to 75 cm apart.



Figure 3.12: Watermelon Ready for the Market

Green beans

Green beans scientifically known as *Phaseolus vulgaris* comes from the family of Fabaceae. Family members include:

- Dry beans
- Navy beans
- Kidney beans
- Pinto beans

There are so many varieties of beans. Green beans can be eaten raw, steamed, baked or even stir-fried. Green beans are also known as French beans or string beans.

Some common green bean types are shown below.

Table 3.9: Green bean types

Type of beans	Image
Fine beans	A close-up photograph showing a large, dense pile of fresh green beans. The beans are long, slender, and have a vibrant green color. They are piled together in a way that shows their texture and shape.

Type of beans	Image
Red beans	
Green beans	

Preparation

Green beans can be successfully planted by taking note of the following:

- This type of crop is best cultivated in soils which can range from sandy to heavy clay soils.
- A pH level of 6,0 to 6,5 is recommended.
- Green beans cannot grow in temperatures below 10°C and is very sensitive to frost.
- The optimum temperature for green bean production is between 16°C and 24°C.
- This crop is propagated by seeds and can grow well by direct sowing.
- The best spacing for bush beans is 60 cm between rows and 5 cm between plants in a row.
- For runner beans a wider spacing is used: rows are 1 m apart and plants are spaced 10 cm apart in each row.



Figure 3.13: Green Bean Plantation

Spinach

Spinach scientifically known as *Spinacia oleracea*) is a leafy green vegetable part of the *Amaranthaceae* family. The leaves are a common edible vegetable which can be eaten raw or cooked. It is a flowering plant and there is a variety of spinach types available.

Some examples are shown below.

Table 3.10: Types of spinach

Type of spinach	Image
Savoy spinach	

Type of spinach	Image
Red carnival	 https://specialtyproduce.com/produce/Red_Spinach_677.php
Tyee	 https://www.grow-it-organically.com/growing-spinach.html

Preparation

The following can be said about spinach planting:

- Spinach is grown in a variety of soils – sandy loamy soil is most preferred.
- Spinach is very sensitive to high soil conditions or acidic soil.
- A pH level of 6,5 to 6,5 is recommended.
- Spinach is propagated by seed.
- Soil will have to be ploughed to a depth of at least 20 cm.
- The seed is sown in rows on wide beds. Spacing should be 50 to 60 cm between the rows and 15 to 20 cm between the plants in a row.
- If the spinach crop is directly seeded, the planting depth should be about 20 mm



Figure 3.14: Spinach Plantation

Rape

Rape also known as Covo has the scientific name *Brassica napus* and comes from the family of Brassicaceae. Family members include:

- Different classes of cabbage
- Cauliflower
- Broccoli
- Brussels sprouts



Figure 3.15: Cauliflower-Part of the Rape Family

It is one of the most preferred leafy vegetable on the market in Zambia. Though it does very well during the cooler seasons, it can be produced the whole year round. Common cultivars in Zambia are Giant Rape, Rape Hobson, English Giant and Nanga Rape.

Preparation

Take note of the following regarding rape planting:

- Can be cultivated in different soil types, however it is best suited to clay-loam soils. Sandy soils should be avoided.
- Good soil drainage is important for this crop to thrive.
- A soil pH level of 5.5 to 6.5 is recommended.
- The Rape seed is very small, therefore the seedbed should be fine.

- Do not plant Rape in dry soil, it will not grow as it needs soil with moisture.
- Rape is planted in 15 to 45 cm spaced rows under irrigation and 15 to 50 cm during dry conditions.
- Evenly spaced plants will optimise yields.
- These seeds should not be planted more than 3 cm deep and adequate moisture should always be present in the soil.



Figure 3.16: Rape Plant

During the hot season, they are easily attacked by sucking (aphids) and chewing insects (caterpillars) and grasshoppers. Spraying with **Cutup Hydrochloride** 30g/16 litre sprayer will eliminate these pests.

Harvesting should be seven days after spraying this chemical. If similar infestation is noticed in other leafy crops the same chemical and dosage should be applied.

■ Sowing of vegetable seeds

Each type of vegetable has a specific time period when it should be sowed so that you can obtain maximum production. The table below shows the recommended sowing times for the vegetables you have learnt about.

It is important that you ensure that the soil is well prepared and each row is ploughed to the correct depth and the soil is levelled before any planting can take place. It is also advised to make small trenches so that when watering the crops, the water will flow along the trenches.

Also note that it is important to add sufficient amount of manure and fertiliser and work that in the soil. Try to prepare the soil at least a week before planting.

BROADCAST METHOD

The broadcast method can be considered an old-school method when sowing seeds. However, this method works well for big plant sides and works well for small seeds such as Lettuce and Rape.

To use the broadcast method:

- Sprinkle the seeds lightly over the soil.

- For your seeds to make good contact with the soil – press then lightly with a board then sprinkle more soil and compost over the pressed seeds.
- Water the seeds on a regular basis and ensure that it is receiving frequent and light watering.
- The disadvantage with this method, is that more quantity of seeds is required making it expensive.

LINE SOWING

Line sowing is one of the best methods you can use to sow seeds in a nursery. Sowing seeds in a line improves germination as well as the quality of the seedlings is not compromised. Each seed receives its own space, water and nutrients.

Also, diseased seedlings and weeds can be more easily managed.

To use the line sowing method:

- On a levelled bed, trenches of certain depths are made.
- Small seeds are sown at shallow depths with small spaces between the rows.
- The trenches are then covered with soil and watered.

■ Precautions taken during seed sowing and planting

The following are some precautions you should take note of during seed sowing and planting:

- Seeds should be healthy and free from any infection.
- Seeds must be sown at the correct depths.
- Seeds should be sown with enough spacing between them so that each seedling receives sufficient sunlight, nutrients, water and air.
- Ensure that the moisture in the soil is correct (not too wet and not too dry), this will avoid rotting of the seeds or seedlings.
- During planting, healthy seedling should be selected.
- Seedlings should be treated with fungicides so that soil-borne infections can be prevented.
- Transplanting should not be carried out during very hot and humid conditions. This depends on the type of seedlings being transplanted, cool weather favours transplanting most seedling plants.

3.3 Soil preparation

Soil should always be thoroughly prepared and should be loosened before any planting takes place. Previous crop residues (Debris) should be well-rotted. Due to the high rainfall in Solwezi, it is recommended to use raised beds as waterlogging can occur if other types of nursery beds are used. Burning of leftover stover is not recommended as this destroys the humus and micro=organisms. Other vices include exposing the soil to erosion by different agents like wind and water.

This section will look at soil preparation in more detail.

Soil quality

There are different types of soil and proper soil is important for a plant's growth activity. You can evaluate soil based on these properties:

- Structure

- pH level
- Nutrients
- The different types of soil are **Sand, Loam** and **Clay**.

STRUCTURE

Structure of the different types of soil are:

- Clay is heavy and sticky.
- Sand is light and dry.
- Loam is a combination that is balanced and made up of clay and sand as well as loam.

NUTRIENTS

Plants need nitrogen as it provides nourishment for stems and foliage (growth), phosphorus provides sustainability for the roots and flowers. Potassium promotes food production. Nutrients are usually found in the soil, this is why it is important to have these essential elements present for plant growth.

PH LEVEL

The correct soil pH allows the plant root system to absorb these nutrients. A pH scale runs from 0 to 14.

Here are some points to take note of when it comes to pH levels:

- A pH level of 7.0 is neutral.
- Any pH below 7.0 is acidic, the further below the more acidic.
- A pH above 7.0 is basic, or alkaline, and like acids, the farther from 7.0 the more basic.
- Most horticultural crops require a pH level of 6.0 to 7.0.

The pH of soil is critical factor in the importance of soil quality. Different horticultural crops require different amounts of elements and trace elements, the pH of the soil determines the elements, plants can absorb.

The optimum pH for most plants is **6.5**. **Acidic soils** can be made more neutral by adding lime which is easily available. Of late **Liquid Lime** is also available and more user friendly compared to using the powdered agricultural lime. Agricultural lime is bulky making it difficult to transport to needy areas, it will be expensive in the end. **5-10 litres** of liquid lime is all a farmer needs for a hectare. It can be sprayed on the crop directly or on the soil surface of the seed bed. Action or results will start to show within seven days from spraying. Peat can be used to make acidic soils more alkaline.

Acidic soils make plants roots not to access the required nutrients from the soil.

It cannot be stressed enough that the quality of the soil plays a huge role in plant growth and the yields. Ensuring that quality soil is used will reap better results in the future.

Soil preparation

How do you prepare soil for planting?

Refer to Chapter 1.5 to learn more about treating the soil before any preparation can take place.

The soil needs to be cleaned and all weeds and roots should be removed. Leaving weeds in unattended will cause the weeds to spread, thereby competing with crops for water and other nutrients. Most soils lack the essential nutrients, therefore an important step is after cleaning the

field, to add compost and fertilizer. Compost has many benefits as already discussed while fertilisers will have an immediate effect on the good growth of the plants.

We have touched on the different types of soil, i.e., **sandy, clay** and **loamy**. Sandy Soils cannot hold water and during any extreme windy conditions, blowing sands could cause damage to the seedlings. Clayey soils on the other hand hold too much water and does not allow enough air to enter the soil.

Vegetables need well drained soil with good Organic Matter. To see if soil is good, squeeze some soil in your hand, if it forms a hard ball – it lacks moisture, however, if it crumbles easily, this is an indication of good planting soil.



Figure 3.17: Crumbling Soil

Whether you have clay or sandy soil, it can be improved. This is done by adding Organic Matter. Organic Matter can:

- Loosen tight Clay soils allowing air circulation for microbes.
- Makes soil easier to dig.
- Adds nutrients.
- Helps Sand soil to hold more water.

Fertilizers and compost types will be explained in more detail in Chapter 3. However, to give you an idea of some common organic matter additives, these are listed below:

- Plant materials: This includes leaves, straw and old grass clippings. You should work the material into the soil several months before planting for it to allow time to decompose. This is normally done during winter months.
- Manure: Use composted manure and mix it well into the soil ahead of planting. Do not use fresh manure – this can introduce diseases and insect pests which can destroy the seedlings.
- Sawdust: Never use un-composted sawdust, this can rob the soil of nitrogen which can cause a nutrient deficiency in the plant.
- Heavy Clay soils can benefit from the addition of gypsum. Not only does it loosen the clay soil but also provides some extra nutrients like Calcium.

Tilling

Tilling is the process of digging the plant site to prepare the seedlings for planting.

Soil should be tilled as deeply as possible (about 20 cm to 25 cm), deep tilling loosens the soil and allows the vegetable roots to grow deeper especially those with **tap root** system. You should till when the soil is moist and not wet. Add Organic Matter every year during the soil preparation in order to build and maintain the soil. Before planting, always rake the soil and level it. Clean the field and make sure it is free of sticks, rocks and other debris.



Figure 3.18: Farmers tilling the ground
(https://commons.wikimedia.org/wiki/File:Women_tilling_the_land.jpg)

No Till (Zero Tillage) Preparation

No till or zero tillage preparation is another method that you can make use of. A no-till method is a type of soil preparation where the soil is not dug up and turned to prepare the land. Organic components such as compost and fertilizers are layered over the soil to create a nutrient rich base to plant seedlings.

Zero tillage could be less labour intensive compared to the tilling method and could improve soil matter.

No till (Zero tillage) preparation does have a few benefits such as:

- Reduced farming costs, as it is not as labour intensive, you can reduce labour costs as well as improve soil function.
- Crop residue: Crop residues from the previous season remains and protects the soil from the impact of rain and wind. It can also provide nutrients in the form of carbon.
- Healthy soil: No till preparation improves soil quality and organic matter, which protects the soil from erosion and structural breakdown.

3.4 Plant nutrition

These six essential nutrients are Nitrogen, Phosphorus, Potassium, Magnesium, Sulphur and Calcium.

Let's look at each nutrient in more detail:

1. Nitrogen: Nitrate (the form of nitrogen that plants use) helps plant foliage grow strong by positively impacting the plant's leaf development. It is also responsible for giving plants their green colouring by helping with chlorophyll production.
2. Phosphorus: Phosphorus helps with the growth of plant roots and flowers. This nutrient also assists plants combat environmental stresses and extreme weather conditions.
3. Potassium: Potassium strengthens plants, contributes to early growth and helps retain water.
4. Magnesium: Magnesium gives the green colouring of plants
5. Sulphur: Sulphur helps plants resist disease as well as contributes to the plant's growth and the formation of seeds. They also aid in the production of amino acids, proteins, enzymes and vitamins.
6. Calcium: Calcium aids in the growth and development of cell walls. This is important because strong and well-developed cell walls helps the plant fight against disease. It is also necessary for metabolism and the absorption of nitrogen by the plant.

4.1 Introduction

Fertilisers are used in crop production to increase productivity and are used by horticulturists to increase crop yield. Fertilisers contain nutrients such as Nitrogen, Phosphorus and Potassium and other important secondary elements which provides the soil with the necessary nutrients. These elements help with plant growth and is used to build resistance against crop pests.

In addition to carbon, hydrogen and oxygen, which plants get from the atmosphere and water, crops need 14 essential nutrients for their growth and health, which is where fertilisers become useful and provides to plants. These are:

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Sulphur (S)
- Magnesium (Mg)
- Calcium (Ca)
- Iron (Fe)
- Manganese (Mn)
- Zinc (Zn)
- Copper (Cu)
- Boron (B)
- Molybdenum (Mo)
- Chlorine (Cl)
- Nickel (Ni).

Additional elements may be essential to a few plant species, e.g., Sodium (Na) and Cobalt (Co).

This chapter will focus on the importance of fertilisers and how it can be used for your horticultural plant production.

4.2 Application of fertilisers

There are different types of fertilisers, these can be organic or inorganic, and they both provide nutrients to soil as well as provides nutrients to plants. In order to benefit from the use of fertilisers and manures, it should be applied at the proper time in proper quantities and in the right manner.

The main types of nutrients soil needs is Phosphorous, Nitrogen and Potassium.

The method of applying fertilisers depends on the type. This section will look at the different types of fertilisers in more detail.

■ Organic and chemical fertilisers

Organic fertilisers can be classified as decomposed organic matter which comes from plants and animals, i.e., manure. Organic fertilisers provides plant nutrients as well improves the biological activities in the soil such as structure, colour, aeration and water-holding capacity of the soil. Manures are slow in decomposing, which means they release plant nutrients slowly and at a gradual pace making it an excellent organic fertiliser for horticultural crops.



Figure 4.1: Manure Used For Crops

Chemical fertilisers on the other hand are plant nutrients that are manufactured commercially from inorganic chemicals. These fertilisers are ready to use and contain more nutrients than organic fertilisers, therefore, they should be used in smaller quantities. Also, chemical fertilisers get easily washed off through irrigation or rainwater and become unavailable at many instances. There are a few advantages and disadvantages of chemical fertilisers. These are tabulated below.

Table 4.1: Advantages and disadvantages of chemical fertilisers

<i>Advantages</i>	<i>Disadvantages</i>
Easily available	Washes out or infiltrated with rains or irrigation water
Calculated amount of nutrients can be applied	Harmful to crops if applied more than the required quantity
Easy to apply	Can cause water and soil pollution
Fertilisers are available in different formulations and concentrations	Has to be stored carefully

Organic fertiliser mixtures

Organic fertilisers can be classified into manures of plant origin, animal origin or a composite derived from both plants and animals.

MANURES OF PLANT ORIGIN

Oil cakes: The solid residue that is left after the extraction of oil from seeds is known as 'oil cake'. Oil cakes are applied to soil to give it nutrients as well as improve soil structure.

Plant residues: Straw, husks, stalks, saw dust and wood ash also add nutrients to the soil.

Green manures: Green manure crops are grown then turned into the soil for decomposition. Green manure improves the physical structure of the soil and improves soil fertility.

MANURES OF ANIMAL ORIGIN

This includes animal's settled dry sludge, fish manure bonemeal, various types of animal dung such as cow dung, sheep dung, pig manure, poultry manure and so on.

COMPOSITE MANURES

This is made up of material from both plant and animal origin.

Farmyard manure (FYM): This is a well-decomposed dung of cattle, urine along with litter. The dung of animals is collected and placed in a trench which is covered with soil. Only after two to three months, then only can it be used for crop production.

Compost: Plant waste such as sugarcane trash, plant debris, weeds and other waste materials are used by farmers to get compost.

Vermicompost: This type of manure is developed using earthworms. Earthworms consume organic matter and excrete it as cast. This cast is used as vermicompost. This is rich in plant nutrients and contains beneficial bacteria for soil and crop production.

■ Application of fertilisers

Generally, organic manures are applied while you are preparing the soil for planting the crops. This is so that they improve the structure and water-holding capacity of the soil.

Fertilisers are normally applied just before or soon after planting. The frequency and amount of application depends on the type of crop you are planting, type of soil and the season.

With concentrated manures such as fish manure, oil cakes and bloodmeal – these manures should be applied early on before planting happens as they are not available easily and still have to be broken down by soil microbes to make it useful for the crops.

With FYM that is well-rotten, you can apply just before sowing. Partially rotten FYM has to be applied 20–30 days before sowing. Usually, 10–20 tonne FYM is applied per hectare. It is advisable to make sure that FYM is applied at least two weeks before sowing – this is to avoid immobilisation of nitrogen.

Cottonseed meal

Cottonseed meal is the by-product of oil extraction from cotton seeds and contains plenty of nitrogen and it also contains fair amounts of phosphorus and potassium. The disadvantage of cottonseed meal is that it works slowly, and it is only available in places that produce cotton. This fertiliser is useful especially before cover crops are planted. This gives the cottonseed meal time to break down fully so that the nitrogen present is readily available when the crops are planted.

■ Corn gluten meal

Corn gluten meal proves to be a very effective fertiliser and contains about 10% nitrogen. It is also slow releasing and takes about two months to break down in the soil. Corn gluten meal does

not have a significant effect on soil pH levels which makes this a good fertiliser if you trying to maintain neutral soil.

■ Soybean meal

Soybean meal is a high nitrogen fertiliser which also contains some amounts of phosphorous and calcium. Local growing conditions tend to affect how fast this fertiliser is absorbed into the soil. This type of fertiliser is useful as a long-term soil conditioner.

■ Cow manure

Manure in general has a high mass to nutrients ratio. It contains large amounts of nitrogen, phosphorus, and potassium. Cow manure works well and releases nutrients at a moderate rate of speed. One disadvantage is that it could speed up the growth of weeds as some weed seeds may survive being digested by the cows in question and this can cause obvious problems.

Note: Try and avoid any manure leftovers from industrial operations as it contains a lot of salt.

4.3 Bioslurry as a fertiliser

What is bioslurry? Bioslurry is a is the liquid discharged at the biodigester outlet after gas has been tapped for energy, this liquid is fed daily with a mixture of cow manure and this is kept in the digester for several months (2 to 3 months) before it can be discharged as bioslurry. Bioslurry is made up of 93% water and 7% dry matter. The dry matter contains Nitrogen (N), Phosphorus (P) and Potassium (K), the required nutrients to grow healthy crops.



Figure 4.2: Bio Digesters Used For Farming

How is bioslurry made?

Organic matter is put into a closed container or structure called a biodigester (or bioreactor) where it is consumed by anaerobic bacteria to produce biogas, a combustible mixture of mainly methane and carbon dioxide.

Biodigester technology is a decentralized, environment-friendly technology based on the decomposition of organic materials in the absence of oxygen.

The image below is an example of a typical biodigester and how it can be used in your farming setting.



Figure 4.3: Biodigester Technology

Bio-slurry is odourless, does not contain pathogens and also does not attract flies. It is definitely a healthy fertiliser for plants as it also repels termites and other pests which are normally attracted to raw cow dung. The bioslurry process in the biogas digester kills organisms that can cause diseases in plants. This fertiliser is applied both to a variety of horticultural crops both vegetable and fruit crops. Bioslurry is an excellent soil conditioner; it adds humus and enhances the soil's capacity to retain water.

Good quality fresh/wet bioslurry has the following features:

- Fluidly porridge-like texture
- Greenish brown in colour
- Relatively odourless, unlike animal dung
- No foreign materials (maggots, leaves, rubbish, etc.)

How to install a biodigester?

The farmer should follow the following steps:

1. Get in touch with a biogas mason or biodigester construction enterprise
2. Sign a construction contract with mason or biodigester construction enterprise
3. Prepare materials (such as bricks, sand and stones) and for payment for labour
4. Biogas mason moves on site to commence construction.

Uses of bioslurry

Bioslurry production is an excellent farming practice and can also be useful in the following ways:

- Soil conditioning -Bioslurry is an excellent soil conditioner, adding humus to the soil.
- Organic fertiliser -Bioslurry has many essential nutrients and contains trace elements plants and livestock need.
- Starter for composting -Bioslurry can be used to accelerate decomposition when making compost

- Insect repellent application –Bioslurry can repel insects and plant pests.
- Water retention –Bioslurry improves the soil's capacity to retain water.
- Enrichment with industrial fertilisers such as Urea and Phosphate
- Seed treatment -Coating seeds with bioslurry before they are sown helps them germinate faster and get nutrients. It also helps prevent the seeds and seedlings from being attacked by diseases and pests.
- Safe to handle –Bioslurry is relatively pathogen-free, the anaerobic fermentation process killing most organisms that can cause disease.
- Unlike farmyard manure, bioslurry does not attract weeds, the digestion process usually making the seed eaten by livestock nonviable.
- Bioslurry repels termites and pests that are attracted to raw dung.

The quality of bioslurry depends on the species and age of the animal from which the dung was taken from as well as the quality of the water that is used when mixing the manure as well as the use urine/not along the manure, storage, treatment and application of the slurry.

Modes of application

There are many ways of using bioslurry on horticultural crops. This ranges from direct application as a liquid to solid application (which is done through drying or composting).

Other methods include the following:

- Foliar (Liquid Manure)
- Irrigation –Through pipes
- Solid –Compost making
- Dry/Solid application after composting
- Seed coating
- Animal feed formulation or supplementation –Fish, chicken, pigs

As organic fertiliser, bioslurry can be used wet or dry. The slurry can be used directly by mixing it with irrigation water.

Wet application is rather cumbersome; therefore, farmers prefer to use dry slurry in their farms.

For the dry use, composting of the slurry is highly recommended.

Bioslurry can be applied to e.g. crops to fertilise the soil and increase yields either directly as liquid (wet) bioslurry or as composted bioslurry.



Figure 4.4: Bioslurry Fertiliser Being Used

Application of bioslurry in the growing horticultural crops

GROWING STAGE

1. Dig a canal around the plant roots, 60 -90 cm from the stem.
2. Canal size; 30 cm (wide) x 30 cm (deep)
3. Fill canal with either liquid or bioslurry compost.
4. Cover with soil, then mulch.

APPLICATION

Application of 4,000-8,000 kg per acre or 20 litres of liquid bioslurry per plant is suggested in order to produce a significant impact on yields and resistance to diseases.

Control of insect pests (insect repellent)

1. Mix 1 (Liquid bioslurry): 2 (water).
2. Filter mixture to remove impurities.
3. Spray the mixture onto the crops.

■ Application of bioslurry in Semi-liquid form:

- ☐ The most economical way to apply slurry is by means of gravity, either by a network of small slurry furrows or by mixing slurry in the irrigation system.
- ☐ Both options require a gradient of at least 1% (for irrigation water) and 2% (for slurry distribution), sloping from the biogas plant's overflow point to the fields.
- ☐ Choosing the best and least labour-intensive use of the slurry is an important planning parameter.

■ Application of bioslurry in dried form:

- ☐ The high-water content of the slurry makes it heavy and causes difficulties in transporting it to the farms.
- ☐ Drying should be done by spreading out the slurry under shade.

- If dried under the sun, the available nitrogen, particularly ammonium, is lost by evaporation (volatilization).
- Therefore, the time factor must be considered while applying the slurry and, in this regard, immediate use can be a way of optimizing the results.
- Alternatively, recently dried slurry can be packaged for longer storage or sale.
- Utilisation of slurry after composting:
 - The difficulties of nitrogen evaporation can be overcome by composting the bioslurry.
 - Composting is done by mixing wet slurry with various dry organic materials such as dry leaves, straw, etc.
- The following are some advantages of using slurry after composting:
 - The dry waste materials around the farm and homestead can be utilised.
 - One part of the slurry will be sufficient to compost about four parts of the plant materials.
 - Increased amount of compost will be available in farm.
 - Water contained in the slurry will be absorbed by dry materials.
 - Thus, the manure will be moist and pulverized. The pulverized manure can be easily transported to the fields.

■ Cost of installing, time taken and where to find

The cost of installing a bio digester depends on the type and size of the bio digester and availability of local materials. Domestic bio digesters promoted by SNV in Zambia range from about 4 m³ to 21 m³. Costs of smaller sizes range between **8000 - 10000 kwacha per unit** (including masonry work, pipes and stove).

The period it takes to install a bio digester depends on the bio digester size. For the fixed dome bio digesters being promoted by SNV, constructing a bio digester takes between 7 to 12 days to complete and commence initial feeding. Portable and plastic biodigesters take a day or so to install.

SNV in Zambia has been promoting bio digesters since 2014 helping biogas technicians and other local enterprises to establish bio digester construction enterprises (SNV will provide the contact numbers of biogas technicians near you).

4.4 Application of solid fertilisers

Application of solid fertilisers include:

- Broadcasting
- Placement
- **Broadcasting**

Basal application is done depending on the crop. The broadcasting of fertiliser is carried out before sowing and planting of the crops and just before the last ploughing is done in the field.

With top dressing, fertilisers are broadcast in the standing crop. In this method, nitrogenous fertilisers and micronutrients are applied in dense sown flower crops.

■ Placement

With the placement method, place the fertiliser in well-prepared soil before sowing, regardless of where the seeds are positioned. Two types of fertiliser placement techniques exist.

Deep placement

Nitrogenous and phosphatic are used in dry land agriculture.

Ring placement

The amount of fertiliser per plant is calculated and applied at some depth around the plant circle.

■ Application of fertilisers in liquid form

This section will look at how liquid fertilisers can be used for crop production.

Foliar application

Foliar application is used with fertiliser nutrients that are easily soluble in water. This method is also applied when there is a soil fixation problem.

In this method, it is difficult to apply enough major elements. Nutrient concentration of 1% to 2% can be applied without causing any damage to the crops. Foliar application is commonly used only to apply minor elements or to supplement the major elements.

Fertigation

Fertigation is done through the application of fertilisers through irrigation water.

Nitrogen is the main nutrient commonly used for this method. Other elements include potassium and highly soluble forms of zinc and iron can also be readily applied this way.

However, it is not recommended to use this method as phosphorus and anhydrous ammonia may form a precipitate in water with high calcium and magnesium content.

Normally, this method is utilised through drip irrigation, and liquid fertilisers containing all three major nutrients are normally used.

Crop rotation

Crop rotation is the practice of planting different crops sequentially on the same plot of land. This is done to improve soil health, maximise nutrients in the soil as well as get rid of pests and weeds.

A simple rotation can consist of two or three crops, and complex rotations will consist of a dozen or more crops grown together.

As a horticulturist, when you plant the exact same crop in the same field or plot of land every year, this is known as conventional farming. This farming method draws the same nutrients out of the soil every year which gives pests and diseases ample room to thrive as their preferred food source is guaranteed.

With this farming method – an increase of chemical fertilizers and pesticides become necessary to keep yields high while keeping diseases and pests at a minimum.

Crop rotation can help return nutrients to the soil without the need for too many synthetic inputs.



Figure 4.5: Beans in Crop Rotation

For example, let's say you have planted a field of tomatoes. When the tomato harvest is finished, you might plant beans, since tomatoes consumes a lot of nitrogen and beans return nitrogen to the soil thus breaking any pest and disease cycles as well as improves soil health.

Intercropping

Intercropping is the practice of growing two different types of crops in at the same time. The objective of intercropping is to produce a greater yield in a plot of land by making use of resources that would normally be used by one type of crop. Benefits include improvements in soil fertility and nutrient cycling.



Figure 4.6: Intercropping Practice

Chapter 5

Pest and disease management

5.1 Introduction

There is a vast array of pests such as spiders, mites, ticks and aphids that can cause immense damage to your plants if not dealt with properly. According to the NCSU Extension, out of the 800,000 - 1,000,000 species of insects that are found, not more than 1,000 (about 1/10 or 1%) can be regarded as serious pests (Taken from Smallholder Horticultural Production and Business Training Manual).

However, with this said, horticulturists still battle with identifying pests and diseases and because of this lack of knowledge, it affects the produce and the quality of the produce. The solution is not spraying poisonous chemicals on crops to eliminate pests as this could have a long lasting impact on the produce.

Through training and effective knowledge transfer, this can help enhance the current knowledge and the ability for horticulturists to have an effective pest management system in place.

5.2 Integrated Pest Management

Integrated Pest Management (IPM) is also known as integrated pest control (IPC). It is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below a threshold that would negatively affect sales.

The UN's Food and Agriculture Organization defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.

IPM emphasizes the growth of a healthy crop with the least possible disruption to agro ecosystems and encourages natural pest control mechanisms.

■ Principles of IPM

Acceptable pest levels - The emphasis is on control, not eradication. IPM holds that wiping out an entire pest population is often impossible, and the attempt can be expensive and unsafe.

Preventive cultural practices - Selecting varieties best for local growing conditions and maintaining healthy crops is the first line of defence. Plant quarantine and 'cultural techniques' such as crop sanitation are next, such removal of diseased plants, and cleaning pruning shears to prevent spread of infections. Monitoring Regular observation is critically important. Observation is broken into inspection and identification. Visual inspection, insect and spore traps, and other methods are used to monitor pest levels.

Record keeping is essential, as is a thorough knowledge of target pest behaviour and reproductive cycles. Since insects are cold blooded, their physical development is dependent on area temperatures. Many insects have had their development cycles modelled in terms of degree days. The degree days of an environment determines the optimal time for a specific insect outbreak. Plant pathogens follow similar patterns of response to weather and season.

5.3 Common diseases in plants

Different diseases affect different types of crops. This section will look at some of these diseases in more detail.

■ Damping-off

Damping-off as the name can suggest is a problem that happens during the wet seasons when light levels and temperatures are high. Seedlings grow very slowly during this period.



Figure 5.1: The Impact of Damping-Off

Damping-off is a fungal disease that affects seedlings and causes growing seedlings to collapse. This disease fast spreads under high levels of humidity and poor air circulation.

It targets all types of vegetable seedlings such as onion, pepper and tomatoes.

■ Fusarium wilt

This disease is commonly found in tropical banana growing areas. This disease mainly affects crops at the roots, roots bases, rhizomes and leaf bases. Older leaves turn yellow and within a month or so, most of the leaves of the plant will turn yellow, wilt, dry out then collapse. Eventually the affected crop/s will die, also, the soil will be affected which prevents future plantations from happening.



Figure 5.2: Wilted Crops

This affects tomatoes, sweet potatoes and mainly bananas.

■ Late blight

This is a fungal disease that causes greyish green water soaked abrasions on the leaves, which causes the leaves to turn black. Late blight may infect either the upper(young) or lower (old) leaves of the crop plant and forms irregular, greenish black blotches which gives the crop plant a frost damaged appearance. This disease mainly affects eggplant and tomatoes.



Figure 5.3: Late Blight

■ Leaf-spot or early blight

Early blight is one of the most common diseases found in tomatoes as well as in eggplant. Dark reddish-brown concentric spots found first on the lower most leaves cause defoliation. Blight

causes skin injuries to fruit as well as premature loss in lower leaves of crops. Yields can be affected negatively and poor crop quality is seen in the produce it affects, i.e., tomatoes.



Figure 5.4: Blight on Crop Leaves

■ Powdery mildew

Powdery mildew occurs during dry weather with high relative humidity. It is also a very common type of leaf-infecting disease which affects crops mainly during dry summer conditions.

This fungal disease can cause the leaves of crops to twist and buckle. Initially, powdery mildew appears as white and can form on the surfaces of leaves, shoots as well as on fruit. These white spots spread slowly over a large area of the leaves and stems. This then results in yellow patches on leaves but little powdery growth.

Severely infected crops may have reduced yields. This results in shortened production times as well as less income to you as the horticulturist.

This disease targets crops such as beans, eggplant, peppers, tomatoes and pumpkins.



Figure 5.5: Powdery Mildew on a Crop

5.4 Insect pests in a nursery

Insects affect crops in different ways. The table below shows the different types of pests that can affect your crop production.

Table 5.1: Pests in crops

Pest	Description	Image	Crops it affects
Diamond-back Moth (DBM)	Mainly found in the dry season. They vary from 8 to 12mm in size, colour varies from light brown at hatching and becomes dark green when fully grown. You can find them under the leaves between veins.		These insects mainly feed on the leaves of cabbage, broccoli, cauliflower and rape.
Aphids	These are small insects found under the leaves of crops. There are different types of species and attacks the leaves and shoots of crops. They suck sap on leaves, stems, petioles, flowers and pods. Heavy infestation causes death of young seedlings, stunted growth and delayed flowering, especially on the older plants. They secrete honeydew as they feed which encourages the formation of sooty moulds and are vectors of viral diseases.		Mainly affects lettuce crops especially in the hotter summer and spring months.

Pest	Description	Image	Crops it affects
Cutworm	There are different types of cutworm species. Cutworms attack a variety of crops. Small cutworm infestations do not cause much harm however heavy infestations of cutworms will cause complete defoliation of crops. This will cause a reduced produce thus a reduced yield.		Beans, cabbage, lettuce, peppers and tomatoes.
Leafminers	Leafminers are insects that feed on the upper and lower layers of leaves. They can be very problematic especially in leafy crops such as spinach and can cause severe damage to crops.	 <i>Leafminer tria</i> 	Affects all types of vegetables such as spinach, peppers, cabbage, lettuce and tomatoes.
Thrips	These are sap sucking pests that are mainly found on the leaves or flowers of crops. These pests can cause damage to crops and will affect the cosmetic appearance of the vegetable or fruit. Thripes cause major damages on flowers and flower buds. The attacked flower buds turn brown and die eventually while the flowers become distorted, discoloured and malformed, eventually falling off. Infected pods are also malformed.		Thripes are a major pest found in onions as well as peppers.

Pest	Description	Image	Crops it affects
Fruit fly	Fruit flies are mainly found in African countries and can be found wherever food is rotting or fermenting. Female flies lay eggs in ripening fruits and vegetables causing the fruit to ripen prematurely, rot then drop to the ground. Causes produce to be inedible.		Butternut
White flies	These are white insects which suck plant sap and secrete honeydew as they feed which facilitates the development of sooty mould. Attacked leaves curl, become distorted and drop.		Beans, tomatoes and eggplant

■ Aphid control

- Control should only be considered where large infestations are threatening the crop or when viral infections have been observed.
- The decision to treat for aphids is based mainly on visual counts and the stage of crop development
- Several commercial pesticides are available to control aphids, of which the most effective are systemic pesticides. The organic Neembicide works very well.
- In some cases, heavy rain may reduce the number of aphids
- Hot temperatures (higher than 30°C) frequently inhibit build-up of large densities of aphid.

5.5 Methods of pest control

■ Biological methods

As a farmer, you want to limit the amount of chemical exposure your crops are exposed to as much as possible. This is where biological methods become useful. Try and opt for more “organic” methods to control pests and diseases so that the produce is limited to minimal chemical exposure.

Natural biological processes and materials can provide control, with acceptable environmental impact, and often at cost. The main approach is to promote beneficial insects that eat parasites and target pests. Biological insecticides, derived from naturally occurring microorganisms or plants. For example, using Tephrosia leaves or Solanum as an insecticide.

Using effective microorganisms (EM) to make an insect repellent

An Effective Microorganisms (EM) mic is a non-toxic chemical free pest repellent. This can be used to prevent pests and diseases in your crop production.

It acts by creating a barrier around the plant thereby protecting it from insects. The mix can be further enhanced by adding garlic, hot peppers or aloe vera. These should be chopped or mashed before adding it to the mix.

Preparation of EM solution

The solution is made up of:

- Mixing Warm water (chlorine free) 300 ml
- Molasses 50 ml
- Natural vinegar 50 ml
- Ethyl alcohol 50 ml
- EM liquid concentrate 50 ml

Select a suitable sized container for the mixing, some plastic bottles with caps for storage and a funnel.

- Add the molasses to the warm water and stir till thoroughly mixed.
- Then add the vinegar, ethyl alcohol and EM concentrate.
- Pour the mix into the plastic bottles and add small quantities of chopped garlic, pepper and so on.
- Seal as tightly as possible and leave in a warm dark place (20°C-30°C-). Make sure to release any build-up of any gas at least twice daily by releasing the cap.

The EM mixture is ready for use when the production of gas has stopped and the mixture has a sweet fruity smell. The mixture can be stored in a dark cool place for up to 3 months. Do not store this in the fridge.

Procedure

To use the mixture as an insect repellent, you will have to dilute 20 ml of the mixture in 2 litres of clean water in a spray bottle and spray enough of the mix to wet the crop. Spraying can be done when crops are still seedlings or before pests and diseases can be seen. Use 30 ml of solution in 2 litres of water if plants seem to be infested with pests. Spray weekly either in the morning or after heavy rains for best results.

It can also be used in the soil and this can be done when you apply the compost or fertiliser. Apply the EM diluted mixture with organic matter the organic matter before transplanting the seedlings. This will also kill any pests or diseases found in the soil.

■ Chemical control

Chemical control is made up of pesticides and fungicides. Use pesticides that are legal to use in Zambia and use with caution as these chemical alternatives are more poisonous.

Fungicides function as protectants, eradicants, or both. A protectant fungicide prevents new infections from happening and can also kill new infections from occurring. Horticulturists can use Thiovit 80WG, Topas 100EC and Alto 100SL.

A disease such as Fusarium Wilt cannot be controlled using fungicides or fumigants.

■ Mechanical control

Should a pest reach an unacceptable level, mechanical methods are the first options. They include simple hand picking, barriers, traps, vacuuming and tillage to disrupt breeding.

Prevention of pests or their damage through a combination of techniques mechanical, biological, cultural and chemical methods.

5.6 Natural remedies

The table below shows some natural remedies that you can make use of to control pests in your farm.

Table 5.2: Selected natural remedies

Name of insecticide	What pests can be controlled by it?	How to make it?	How to use it
Neem oil insecticide, fungicide	Powdery mildew, aphids, Thrips and Whiteflies	Start out with a basic mixture of 2 teaspoons Neem oil and 1 teaspoon of mild liquid soap shaken thoroughly with 1 quarter of water. Neem oil can be extracted from the seeds of the Neem tree.	Spray on the affected plant foliage. It is capable of disrupting the life cycle of insects at all stages (adult, larvae, and egg). Neem oil acts as a hormone disruptor and as an "antifeedant" for insects that feed on leaves and other plant parts.
Soap spray insecticide	Mites, aphids, earwigs, leafhopper, spider mites, whiteflies, beetles, and other hungry little insects	Mix 1 1/2 teaspoons of a mild liquid soap (such as castile soap) with 1 quarter of water	Spray the mixture directly on the infected surfaces of the plants. It is always recommended to NOT apply it during the hot sunny part of the day, but rather in the evenings or early mornings.
Oil spray insecticide	Aphids, mites, thrips	Mix 1 cup of vegetable oil with 1 tablespoon of soap (cover and shake thoroughly), and then when ready to apply, add 2 teaspoons of the oil spray mix with 1 quart of water, shake thoroughly.	Spray directly on the surfaces of the plants which are being affected by the little pests. The oil coats the bodies of the insects, effectively suffocating them, as it blocks the pores through which they breathe.
Garlic insecticide spray	Different insects: aphids, ants, borers, caterpillar, slugs, whiteflies	Take 2 whole bulbs (not just 2 cloves) and puree them in a blender or food processor with a small amount of water. quart of water. Let the mixture sit overnight, then strain it into a quart jar, adding 1/2 cup of vegetable oil (optional), 1 teaspoon of mild liquid soap, and enough water to fill the jar.	Spray directly on the surfaces of the plants which are being affected by the little pests.
Tephrosia insecticide	Different insects: aphids, ants, borers, caterpillar, slugs, whiteflies.	Pound fresh about 0.5 kg Tephrosia leaves and mix it with 20 litres of water. Let the mixture sit overnight, then strain it into a quart jar.	Spray directly on the surfaces of the plants which are being affected by the little pests.

6.1 Introduction

Water is one of the most important resources in optimum plant production. Solwezi is home to many perennial Rivers and Streams, and it has a high rainfall. Irrigation and rainfall are the two main ways in which crops receive water. This chapter focuses on irrigation. Irrigation is a method of supplying water in a controlled way to specific areas, for example crop- and vegetable farming. It uses pipes, sprays and pumps. Irrigation is especially used in areas where there is rain shortage or drought.



Figure 6.1: Farmer Irrigating Plants

There are several types of irrigation systems:

- Overhead
- Micro
- Drip irrigation
- Centre-pivot irrigation system
- Portable irrigation system
- Sub-surface
- Solar powered

■ Furrow

The type of irrigation system a horticulturist uses depends on how the water should be distributed throughout the plant site and the type of crop being irrigated.

Let's look at the different types of irrigation systems in more detail.

6.2 Types of Irrigation

This section will focus on each type of irrigation in more detail, this could help you make a decision on which type of irrigation system will best suit your needs.

■ Overhead irrigation

Overhead irrigation is similar to a lawn sprinkler and works according to the same principle. Water is pumped under pressure and then sprayed in a form of fine mist above the plants. The water is supplied by a network of PVC pipes that covers the total area that must be irrigated. The main PVC supply line is sized according to the total amount of water required. Figure 5.2 shows an example of an overhead irrigation system.



Figure 6.2: Overhead Irrigation System

Overhead irrigation systems are particularly useful when you need to water a large area of land. Table 5.1 gives some advantages and disadvantages of overhead irrigation.

Table 6.1: Advantages and disadvantages of overhead irrigation systems

Advantages	Disadvantages
It covers a large area.	It waters both weeds and crops.
It has a long product life.	It has a higher chance of causing surface run-off and erosion.
It has low maintenance costs.	It has a higher likelihood for evaporation and wind drift issues
	When used on Solanaceae crops, the spraying regime increases causing extra costs.
	Requires huge reservoirs of water source.
	Initial cost for centre pivots is prohibitive.

■ Micro-irrigation

Looking at micro-irrigation, this specifically refers to systems used where small amounts of water are frequently applied directly above and below the surface of the soil. This can be done through tiny drops coming from pipes where the flow in the pipe is time-controlled, for example one drop every few seconds. Or it can refer to continuous drops or even a tiny stream.

Following are some of the advantages of micro-irrigation.

- Micro irrigation can be described as a system that uses water at a low pressure and with minimal water used. This is very good for high value crops. Keep the costs as low as possible.
- Water use can be decreased if the system is managed and controlled properly. It can also decrease labour costs, fertiliser costs. It will also increase the production.
- Micro-irrigation will apply water where it is most needed, at the roots of the plant. Water is not wasted because of accurate watering methods.
- Micro-irrigation can be used on land that slopes. Or in irregular shaped areas.
- Fertiliser that is water soluble can easily be used by micro-irrigation systems a system called **fertigation**.

■ Drip irrigation

Drip irrigation systems deliver the right amount of water and nutrients directly to the plant roots at the correct time.

This system uses small diameter pipes that have outlets called emitters. These emitters drip water onto the soil at extremely low rates, which can range from 2 – 20 litres per hour. This water is applied very close to the plants so that only part of the soil that has the growing gets wet.



Figure 6.3: An Overhead Plastic Pipe with Drip Emitter and a Ground Drip System

In most cases, drip irrigation pipes are laid along the ground as can be seen in the photo on the right-hand side. The pipes are linked to an appropriate water source and provide a slow and steady flow of water.

The main advantage of this type of system is that you can control the amount of water the plant receives. With a normal sprinkler system, the amount of water is measured in litres per minute, whereas in a drip system the water is measured in litres per hour, which means that the water flows so slowly that it is easily absorbed into the ground.

Following are some of the advantages of using drip irrigation on a farm.

- Minimal fertiliser or nutrient losses because the water is applied where it is needed.
- The water is applied very efficiently

- Not required to level the field.
- Can irrigate irregular shaped areas.
- Recycled water can be used
- The correct amount of water can be applied to the root area
- The soil type does not have an effect on the irrigation frequency.
- Soil erosion is eliminated.
- Even distribution of the water is determined by the nozzle output
- Labour cost is low
- Pressure and flow variation scan be controlled by valves and nozzles.
- Fertilisers are not wasted when added to the water
- Only the roots are watered keeping the leaves and stalks dry, this will minimise disease.
- Energy costs are reduced because a lower pressure is required for irrigation.

The disadvantages are:

- Can initially be more expensive than overhead drip systems.
- Sun can cause damage to the tubes and pipes used for irrigation.
- If there are no filters in the system, or the system is not well maintained, the drippers, pipes can block up.
- When top dress fertilisers are used or herbicides, there might not be adequate water.
- If installed incorrectly can cause a waste of time, labour and materials.
- If a lighter soil is used, it might cause germination problems. The amount of water might not be enough to wet it deep enough.

■ **Centre pivot irrigation systems**

Centre-pivot systems are normally used to irrigate very large areas. A centre-pivot irrigation system consists of pipe segments that are connected and with sprinklers along their length. The sprinklers are connected to a water source at their pivot point. These lengths are joined, supported by trusses, which are mounted on wheeled towers that move in a circle. Centre-pivot irrigation system can either be water-powered or powered by electric motors.

When using centre-pivot irrigation, you must keep the water pressure constant so that the whole area gets enough water. To make sure that the water is equally distributed along the length of the pivot, the inner nozzles must be smaller and further apart than the outer nozzles.



Figure 6.4: Centre-Pivot Irrigation System

With modern technology, you can now pair or connect a centre-pivot irrigation system with a device like a cell phone. This allows you to remotely control the system.

A centre-pivot system must remain in a straight line. If it does not remain straight, the pipes can bend or even break. This can be overcome by installing detectors that cut electricity to the pumps to stop the system.

■ Portable sprinkler systems

A portable sprinkler system sprays water based on where you need it the most. It sprays water into the air from where the water falls down like rainfall. As the name suggest, this irrigation system can be easily moved from one area to another.

With the correct operating pressure and nozzle sizes, the amount of water can be applied uniformly across the area being irrigated. Portable sprinkler systems are made up of laterals, a plumping plant and portable main lines as shown in Figure 6.5.



Figure 6.5: Portable Sprinkler System

■ Sub-surface irrigation

Sub-surface irrigation makes use of pipelines underneath the ground to apply water to soils directly under the surface. With subsurface irrigation, water is distributed in a series of ditches about 0,6 -0,9 metre deep and 0,3 metre wide having vertical sides. These ditches are spaced 45 - 90 metres apart.

The cost of irrigation method is high; however, you will save on water and crop yield is said to be more improved. This technology may not suit our small-scale farmers in Zambia who depend on growing crops on the same piece of land. During land preparation, there will be high risk of damaging the instalment underground.

■ Solar powered irrigation

Solar powered irrigation makes use of the sun's energy to power a pump which supplies water to the crops. In a single hour, the amount of power from the sun that strikes the Earth is far more than the power the world consumes in one year.

However, it is only over the last few years with the price of solar photovoltaic (PV) panels decreasing and the use of sun energy for running water pumps has been made available to small-scale farmers.

Solar energy is free and in abundance and can be particularly useful when crop require water during the dry months. Horticulturists can reap huge benefits by pumping water to the plant sites and into elevated tanks during the day while the sun is the strongest.



Figure 6.6: Farm that uses solar powered irrigation (<https://www.flickr.com/photos/iwmi/49651383817>)

6.3 Irrigation Management

Irrigation scheduling refers to regulating or determining the amount of time and frequency with which you water the crops. Applying an incorrect amount of water to crops can kill the crops, which will reduce the number of crops produced. Therefore, irrigation scheduling is important.

Irrigation schedules maximise the use of available water in the most effective way for plant growth. There are several irrigation scheduling factors to consider:

- How quickly (millimetre per hour) the irrigation system sprays water.
- The consistency with which the sprinkler sprays water.
- Water infiltration rate into the soil.
- How deep the roots are of the plants being irrigated?
- The amount of water required by the plants.
- The available time for irrigation per day, as well as water and labour availability.
- Rainfall predictions.
- The worst and the best times of the different seasons.

Intuition of the growers

Accurate irrigation schedules have positive, and at times negative, effects on crops. If the scheduling is not done accurately or not adapted when required, over-irrigation or under-irrigation can happen.

Under-irrigation may negatively affect the quality of the product produced, which means it will be sold at a lower price.

Over-irrigation leads to excess water usage (loss of water) and additional electricity use for pumping purposes. It increases nitrogen leaching, which has a negative effect on the growth of the plants and causes unnecessary labour. You can measure soil moisture or the amount of water in the soil in different ways. These methods are explained below.

■ Water content measuring

It is important to measure soil water potential (SWP) content, and water content, as it helps with irrigation management. These measurements help manage irrigation in the following ways:

- They indicate when you must water the soil.
- They indicate when there is excessive water in the soil, which can lead to waterlogging.
- Not all the water present in soil is available to plants. You should understand soil-water measurements and apply them to irrigation scheduling as it helps with irrigation management and crop production.
- There are three terms that you must understand when learning about measuring water content in the soil:
 - Water potential
 - Water content
 - Plant available water (PAW)

Water potential and water content are not the same. Water content indicates the total amount of water present in the soil and does not indicate the amount of water available to the plant. Water potential is the amount of energy required to extract water from the soil, and it is also a measure of how much water is available to the plant. PAW is the maximum amount of water that the soil can hold and the wilting point where the plant can no longer extract water from the soil.

This section discusses different water content techniques and devices used for soil-water measurements and how they can improve irrigation scheduling.

■ Soil water potential

SWP (Soil Water Potential) can be used to help determine the irrigation schedule. It can be easily measured using various methods. These methods will depend on factors such as the need for accuracy, the cost and how easily the information can be interpreted and used.

This unit discusses two of the methods for measuring SWP, namely gypsum block and **tensiometer**.

Gypsum blocks

The Gypsum Block is a popular water potential measuring device, consisting of two electrodes that measure the water potential in the soil. These electrodes are connected with wires to a handheld reader. The resistance between the electrodes is indirectly proportional to the amount of water present in the soil. This means that more water present in the soil, reduces the resistance, while less water increases it.

Gypsum Blocks are inexpensive; however, they are unstable and not very accurate. They are also sensitive to salts in the soil.

Soil Water Tension

Soil water tension (SWT) is the force required for plants' roots to extract water from the soil. Measuring soil water tension is also a method used to schedule irrigation.

A Tensiometer is an instrument used to measure soil moisture and how much tension the plant roots need to extract water from the soil.

Tensiometers consist of sealed water-filled tubes that have a porous ceramic tip at the bottom and a vacuum gauge at the top. When testing soil moisture, the tensiometer must be inserted in the plant root zone. After being inserted, the water then moves between the tip of the Tensiometer and surrounding soil until equilibrium is reached. The moisture tension is then registered on the gauge, which shows readings that indicate the amount of water available in the soil.

A Tensiometer produces very accurate measurements. However, it also requires high maintenance to keep it in a good working condition. May not be very ideal for our Small Scale farmers in Zambia. Figure 6.8 shows an example of how a tensiometer is used.

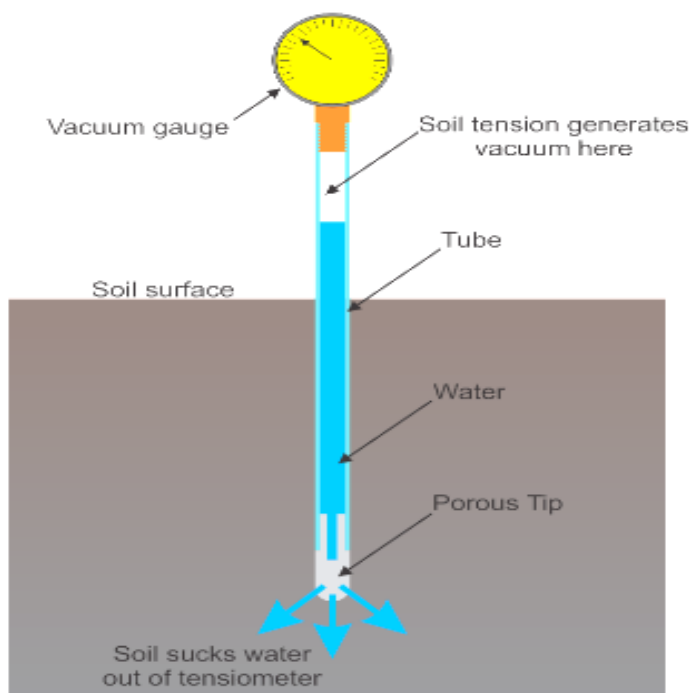


Figure 6.7: Tensiometer

■ Water content

There are different methods to determine soil water content. Some methods are more accurate than others, but all have some advantages. Gravimetric water analysis is one of the most effective ways to measure soil water content. However, gravimetric analysis is slow because it requires soil samples from each area. It also needs qualified people to interpret the results and make improvements if needed.

Some of the newer methods and instruments for measuring soil water content are:

- Frequency Domain Refractory (FDR), which consists of electronics with an oscillating circuit.
- Time Domain Reflectometry (TDR), which detects the impulse transmitted through the soil.
- Neutron moisture gauges with a method called neutron scattering.
- Soil resistivity, which detects the soil resistance. The less water, the higher the resistance.
- Galvanic cells, which detect the voltage that the soil produces as water acts as an electrolyte.
- Soil moisture meter, which is a handheld device used to measure soil moisture accurately. Figure 5.4 shows an example of a handheld soil moisture meter.
- In a place like Solwezi where we have abundant water sources and reserves, farmers may have very little need for moisture measurement. Ways of reducing waterlogging should be emphasised instead of the opposite.



Figure 6.8: Handheld Moisture Meter

8.1 Introduction

All vegetable and fruit crops are biological organisms making them susceptible to change after harvesting. Crops have a respiratory system similar to humans and even after being harvested, crops still continue with their living processes.

Depending on their respiration rate and ethylene production, horticultural crops (with examples) can be classified into the following groups:

- Low respiration rate: Apples, Citrus, Onion, Garlic and Grapes.
- Moderate respiration rate: Banana, Cherries, Cabbage, Tomato, Pepper and Lettuce.
- High respiration rate: Avocado and Cauliflower.
- Extremely high respiration rate: Broccoli, Peas and Spinach.

Ethylene is a natural by-product of plants and it is produced by the tissues of all horticultural crops. Ethylene is what ages and ripens fruit and vegetable crops. Horticultural crops can be classified according to the following groups based on the amount of ethylene they produce:

- Low ethylene production: Cherry, Cauliflower, Citrus, Potato, Leafy Vegetables, Eggplant, Pepper, Watermelon and Pumpkin.
- Moderate ethylene production: Banana, Guava, Mango and Tomato.
- High ethylene production: Apples, Avocado, Kiwi and Pears.

All fruits and vegetable crops contain about 65 to 95% of water. What happens to them during post-harvest depends on the rate at which they use up their stored food reserves as well as the rate of their water losses. When food and water reserves are exhausted the

Produce dies and decays, this is when the crop becomes useless for the farmer.

Losses can occur at any stage of the post-harvest process as you are dealing with perishables.

To give you an idea of the post-harvest process, see the image below.

This chapter will look at all these activities in some detail. However, before that, let us look at the following scenarios.



Figure 8.1: Post-Harvest Activities

A farmer that is growing fruits and vegetables at home for his family does not need to worry about any bruises the crops may endure if it is not properly transported as this is purely for a personal use and his family will not mind the bruises on the crops. However, the same farmer, if he is growing his crops to transport to the nearby market for an income – he needs a different attitude as quality and look of the produce does affect his return. This is why he needs to package his produce properly so that very little damage occurs to the crops.

How does this relate to post-harvest handling?

The farmer has two options in front of him:

Option 1: If he knows his market and their needs, he can judge how important the appearance and quality of the produce should be when it gets to the market. This is affected by proper harvesting and the farmer knowing the correct time to harvest his crops.

Option 2: The farmer needs to decide if he needs to invest in better packaging and whether this investment will give him more income. It is pointless to invest in better packaging if the crops are not harvested correctly and if the bruises or damage to the crops happen before the packaging phase. In this case, the farmer has to change his attitude and focus on better harvesting methods – changing the packaging of the produce does not improve the appearance or quality of the produce.

This is where post-harvesting activities come into play, it is important to understand the importance of each activity and the role it plays until the produce hits the market. Farmers need to apply the correct technology in each phase – this will help minimise losses and maintain quality.

The following are some aspects, farmers need to be aware of when dealing with post-harvest activities:

- Their buyers and market requirements.
- Cultivation practices.
- Transport.
- Market handling.
- Shelf-life of the crops.
- Packing and handling of the crops from the plant site.
- Harvesting and plant site handling.
- Storage and refrigeration.

During post-harvest, there are five main reasons that causes spoilage in vegetable and fruits these are metabolic changes, bruising and mechanical injury, moisture loss of transpiration, physiological breakdowns and vegetables and fruits rotting.

8.2 Post-Harvest Activities

In this section, you will learn more about post-harvest activities in more detail.

■ Post-harvest technology procedures

Temperature and humidity are two factors that play a huge role in the shelf-life of vegetable crops. Temperature management is a tool that is used to prolong the life of horticultural crops and if done properly, you can extend the shelf-life of your produce.

Temperature management starts with removing the field heat from the crops by using any of these methods:

- Hydro cooling.
- Top icing.
- Room cooling.
- Forced air cooling.
- In package ice.

Cold storage facilities should be well equipped and working efficiently at all times. This is achieved by ensuring that:

- There is enough refrigerated coil surface.
- Appropriate stacking of produce.
- Strong floors.
- Good construction and insulation.
- All controls are working correctly.

Controlling relative humidity

Relative humidity (the correct amount) is important to control the following:

- Loss in water
- Decay development
- Uniform ripening

Proper relative humidity should be 85-95% for the majority of the fruits and 95-98% for vegetables (except dry onions at 70-75%).

Relative humidity can be controlled by:

- Addition of moisture to air by humidifiers.
- Wetting the floor of the storage room.
- Adding crushed ice.

Ripening crops with ethylene

Ethylene plays a role in the aging of crops, sometimes it is beneficial as it can improve quality of the produce by uniform ripening and sometimes it can play a negative role where crops will ripen too quickly which results in a reduced shelf-life.

You need special rooms that are secure and will not allow the gas to escape with an amount of 100ppm of gas. Higher gas concentration will not speed up the ripening process and can cause an explosion.

Post-harvest wastage causes

Both environmental and metabolic factors affect the shelf-life of crops, here are some common reasons why wastage occurs:

- Loss in water.
- Diseases and pests.
- Damages to the crops (in physical form)
- Temperature related damages.

The table below looks at some important standards that you should be aware of.

For your produce to be marketed even in a local market, you need to maintain a certain level of quality.

Table 8.1: Standard used in post-harvesting

Standard	Description
Standardisation	This describes fresh produce and its quality characteristics. Quality is determined by time and distance as these two parameters are constant and produce deteriorates over time. Produce can leave your farm as Grade 1 however on arrival in the market, it will be Grade 2. This could be due to a lack in good packaging, bad handling or poor transportation.
Quality	Quality of horticultural crops is a combination of a variety of aspects, properties and attributes. Consumers consider produce to be of good quality when it looks good in appearance, good edible quality and has a nutritional value.
Grading standards	These are a set of rules and regulations set by countries for export purposes. Produce can be categorised into four classes or grades. Each class is determined by appearance, shape and colour.

Let's look at quality in more detail.

Quality components

Produce can be graded according to the following quality criteria:

- **Colour:** Consumers look at the colour of the produce – the correct colour of the crop determines if the consumer will purchase the crop or not.
- **Shape:** Shape differs for each crop, however, consumers will look at the shape of the crop and if it is the desired shape of that specific crop.
- **Size:** Size is a widely used parameter – consumers have a specific height, weight and width in mind.
- **Conditions of the crop which causes the crop to be less attractive in the market:**
 - Wilting of leaves.
 - Blemishes on the skin of the vegetable.
 - Fruits are shrivelled.
 - Surface contamination.
- **Texture:** Flavour and texture of crops make a big difference, if a crop does not taste good, i.e., lacks flavour – it could be considered below quality.

How can quality be maintained?

Quality starts from the beginning even before crops are harvested. However, during harvest time, the farmer should double check on the harvest maturity of the crop as well as ensure that the produce conforms to market and storage requirements.

During the transport phase – produce should be handled with care and checked for any cosmetic bruises before it gets to the market.

■ Harvesting

As a farmer, your primary goal is to maximise yields of your crops. Your time, effort, labour and capital are rewarded during the marketing phase. For you to obtain maximum yields, it depends on the following:

- Quantity: The more crops you produce, the more of a return you can make. This depends on factors such as crop selection, consumer demand and production practices.
- Quality: The quality of fresh produce cannot be improved after harvesting. You can however improve the colour and flavour in controlled conditions but this is also dependent on the pre-harvest conditions

Your selling price is determined by the quality and conditions of your produce that is sent to the market. Your objectives should be:

- Harvest good quality crop.
- Keep harvested produce in good condition.
- Crop/s should be sold to a buyer as soon as it reaches the market after harvesting.

Harvesting happens when crops are considered to be commercially mature and when consumers feel that the crop is most desirable. If you harvest crops too early, it may lack flavour and may not ripen uniformly. If harvested too late, produce could be over-ripe and have a shorter shelf-life.

The following will be discussed in more detail in this chapter.

- Handling
- Storage
- Processing
- Packaging
- Transportation
- Marketing

Let's look at how each vegetable discussed in Chapter 2 is harvested.

Table 8.2: Vegetables and their harvesting times

Vegetable	When should you harvest?	Notes
Cabbage	■ Harvest at 60 to 90 days after transplanting depending on variety of cabbage.	Harvesting may be for a period of 15 to 20 days
Lettuce	■ Lettuce is harvested by hand by cutting off the lettuce head just above the soil surface to keep most of the outer leaves around the head. ■ Harvesting should be done very early in the morning because lettuce leaves wilts quickly. ■ The heading types are harvested when the heads are fully grown and firm while the loose-leaf types are picked when the leaves have reached the required size.	n/a
Peppers	■ Green pepper can be harvested 2 to 3 months after planting depending on variety, with regular pickings at intervals of 1 to 2 weeks for a period of 3 months. ■ Harvesting is done by hand using a garden pruner. Mature peppers are firm, shiny in appearance and have a fresh green calyx and stem.	■ Peppers can be stored at 4.5°C to 7°C for 3 to 4 weeks.
Broccoli	■ Harvest the main broccoli head when it stops growing. ■ Harvest in the morning before the soil warms up for broccoli to have good taste. ■ Broccoli should be harvested when the florets are deep green in colour. ■ Use a sharp knife and cut off the broccoli head about 12.5 cm below the stem.	■ The first sign that broccoli is ready to harvest is the head should be firm and tight. ■ The broccoli head will be about 10 to 18 cm in size before harvesting.
Tomato	■ Tomatoes can be harvested at different stages, i.e., pale green stage, light red stage, red or ripe stage. ■ They are usually ready to harvest about 90 days after planting. ■ Tomatoes should be picked early in the morning and this can be done by hand.	■ Tomatoes are graded according to size, colour and quality.
Onion	■ Harvesting should be done when the weather is dry.	■ After harvesting the onions should be arranged in rows and left in the field to cure for up to 10 days.

Vegetable	When should you harvest?	Notes
	■ Harvesting can be done mechanically by using a lifter or by hand with the use of garden forks.	
Butternut	■ Butternuts are ready to harvest 110 to 120 days from planting depending on variety. ■ Harvesting is done using a sharp knife and a short stem should be left attached to the fruit so that no pathogens can enter the fruit. ■ You will know that butternut is ready to harvest when the skin has become hard and you cannot pierce the skin easily.	■ Butternuts can be stored for up to 7 months at 15°C and 60% relative humidity. ■ If butternut is harvested when it is wet and muddy, make sure to wash and dry the fruit before packing it.
Eggplant	■ Harvest of eggplant usually starts 75 to 90 days after planting. ■ The skin should be glossy but the seeds should not be enlarged and mature for the vegetable to be harvested. ■ Use gloves and a long sleeve top when cutting the eggplant from the stem. This is because the stem has thorn like prickles.	■ Eggplant is a very fragile vegetable, therefore, always treat it gently as it bruises can occur easily.
Watermelon	■ Watermelons ready for harvest 65 to 90 days after sowing depending on the variety. ■ When watermelons are ready to harvest, the vine tendrils will begin to turn brown and slowly die off. If the tendrils are green the watermelon is not ripe. ■ Use a sharp knife to cut the watermelon from the vine.	■ Limit water for a week in advance of the harvest to concentrate sweetness in watermelons. ■ Watermelons do not continue to ripen after they have been cut.
Green beans	■ Harvesting is done by hand, and it is done 14 days after flowering or 50 days after planting. This period lasts for 3 to 4 weeks. ■ Harvesting should be done before the seeds have fully developed and the pods be as thick as a pencil. ■ Gently pull the pods away from the vine when harvesting beans.	■ Harvesters should have clean hands and have good sanitary behaviour when handling crops like fine beans. ■ Beans can be stored at 2°C to 7°C and 95% relative humidity for up to 7 to 10 days without losing quality.
Spinach	■ Most spinach varieties are ready to harvest mature within 45 days. ■ Spinach leaves should be removed before they get yellow and within a	■ Spinach decays quickly since the leaves do not last long. ■ Make sure to wash the leaves well in order to remove dirt and discoloured

Vegetable	When should you harvest?	Notes
	week of formation – they should be harvested. ■ Harvesting is done by simply cutting off the leaves at the stem with a pair of scissors or using your hands.	leaves. This could help to preserve the leaves for longer.
Rape	■ Rape leaves are ready to harvest 60 days from planting. ■ The rape leaves are harvested by hand. Use a sharp knife to cut the leaf/s away from the stem.	■ Leaves should be harvested when they are 25 to 30 cm long. ■ Harvesting can be done 6 to 8 times during the year,

■ Storage, packaging and marketing

Table 8.3: Storage, packaging and marketing aspects of crop production

Vegetable	Storage	Packaging	Marketing
Cabbage	The optimum storage temperature for cabbage is 0 °C and relative humidity of 90 % to 95 %. Cabbage should be mature and disease-free. It should not have been exposed to prolonged frost or cold. Further trimming could be required, mainly to remove the discoloured butt upon removal from storage	Cabbage is packed in mesh pockets or sold loose.	Cabbage is sold in Zambian fresh produce markets or sold directly to retailers
Lettuce	Lettuce can be stored for three weeks if kept at 0,5 °C to 4 °C and 95 % relative humidity. It should not be stored with products that give off ethylene, such as apples, pears or cantaloupes, because ethylene increases russet spotting. The crisp head lettuce types have a longer shelf life than the butterhead and the loose-leaf varieties.	Packing may be done in the field or in a packing shed. Lettuce is packed in two-or four-layered crates or cartons and packed according to size of the lettuce groups.	Lettuce is marketed in the fresh produce markets or sold directly to retailers
Peppers	Store sweet peppers at 7°C to 12 °C and 90 to 95% relative humidity. Bell peppers are subject to cold damage at temperatures below 7 °C, and temperatures above 12 °C encourage ripening and spread of bacterial soft rot. Bell peppers should not be stored longer than 2 to 3 weeks even under the most favourable conditions.	Cartons are used to house peppers which are approximately 12 to 14 kg of fruit. Some growers of specialty bell peppers pack the fruit into smaller cartons. Peppers are usually packed according to the preference of the particular market or buyer.	Peppers are fresh produce markets or sold directly to retailers. Rapid precooling of harvested peppers is important in reducing marketing losses, and this can be achieved by forced-air cooling, hydrocooling or vacuum cooling.

Vegetable	Storage	Packaging	Marketing
Broccoli	Store broccoli in a cold and moist place, 32°-40°F/ 0°-4°C and 95 percent relative humidity. Cold and moist storage is a challenge. Refrigerators provide the cold, but they also dry the air. Unwashed broccoli will keep in the refrigerator for about one week. Washing before storage encourages bacterial head rot.	Traditionally, the market place requires that broccoli heads be bunched - two or three small heads in a bunch. The broccoli pre-packaging is recommended in order to avoid dehydration. For this purpose they make 250 to 500g packages using plastic materials.	Fruit and vegetable markets are among the potential markets for broccoli in Zambia or can be sold directly to the retailer. It could be argued that packaging broccoli in bunches no longer conforms to present marketing and buying trends. Some markets are now known to accept single heads of broccoli, prepared and packed in a similar manner to cauliflower.
Tomato	The storage conditions are dictated by the stage of ripeness. Generally, tomatoes should be stored at 12 °C and 86% to 90 % relative humidity.	Higher grade tomatoes are packed in trays made from wooden boxes. Cartons are used for grade fruit. They can also be packed in trays made of wooden boxes or cartons. Fruits of lower grade are packed in jumble packs.	Fruit and vegetable markets are among the potential markets for tomatoes in Zambia.
Onion	Green onions will keep in the refrigerator for up to one week. Wrap them in plastic wrap. Mature bulbs should be allowed to air dry for about a week outside before being stored in a cold, dry place for up to 6 months. When the skins are dry and papery, cut the tops off about one inch above the bulb then store the bulbs in mesh bags. Do not refrigerate mature onions.	Onions are packaged in orange or black mesh bags of different sizes up to 10kgs. Green onions can be bundled and sold as a bunch in both formal and informal markets.	Onions are graded and sold to different markets in different packages. Onions are on high demand in Zambia and easily sale to both formal and informal markets including cross border trade at Kasumbalesa border.
Butternut	When storing butternut – maintain uniform temperature and relative humidity throughout the storage period. This can be achieved by keeping air movement constant by using fans placed in strategic locations within the storage.	Careful handling is important because this type of vegetable bruises very easily. Mature butternuts are packed in bags or plastic net bags.	Butternut is a popular vegetable in Zambian households and can be sold at both fruit and vegetable markets.
Eggplant	Eggplants will keep in a well-ventilated place for up to 1 week at 50°F (10°C) or slightly warmer.	Egg plants can be packaged in boxes or smaller paper trays	Eggplants are on high demand in Zambia and easily sale to both formal and informal markets.

Vegetable	Storage	Packaging	Marketing
	It is best not to refrigerate eggplant but if you do wrap the fruit in plastic to prevent cold burn. Do not wash or cut eggplants before refrigerating. Eggplant can be frozen or dried.	and rapped in a plastic. They can also be sold without any package in informal markets.	
Watermelon	Watermelons will keep in the refrigerator for up to a week if not cut or sliced, but sweetness and flavor may diminish. A cut watermelon will keep in the refrigerator for about 4 days. Wrap the melon tightly in plastic to prevent cold burn or dehydration. Watermelons can be kept in a cool, moderately moist place for 2 to 3 weeks without refrigeration.	Watermelons are graded and sold unpackaged in both formal and informal markets.	Watermelon are on high demand in Zambia and easily sale to both formal and informal markets
Green beans	Store green beans in a cool, moist place, 40°-50°F and 95 percent relative humidity. Green beans will keep for 8 to 12 days in a cool, moist place. Do not refrigerate snap beans at less than 40°F; beans are easily injured by cold developing opaque discoloration, rusty spots, and pitting.	Can be packaged in boxes or smaller paper trays and rapped in a plastic.	Green beans is very popular and is on high demand in Zambia and easily sale to both formal and informal markets
Spinach	Spinach can be stored for 10 to 14 days if stored at 0 °C and 95 to 100 % relative humidity	One or two dozen spinach bunches are packed into wax cardboard boxes.	Bunches should retain a fresh appearance on the shelves and should be appealing to the consumer's eye. Old leaves should not be marketed, this is because fibre content increases with age.

■ Transportation

When transporting produce, care should be taken that trucks are not overloaded, otherwise the bottom layers of the produce could be crushed. Generally, produce should be covered with a sheet, this will prevent frosting or even desiccation.

However, during the warmer seasons, when sweating and heating might occur, the sheet should be left off. Vegetables such as lettuce, spinach and broccoli should be transported in refrigerated vehicles – this is because these types of vegetables can wilt easily. A controlled atmosphere of 2 % carbon dioxide and 3 % oxygen is recommended if lettuce has to be shipped to long-distance markets for a month.

By reducing the temperature after harvesting – this will reduce rate of metabolism. This results in a reduction of growth of bacteria and other organisms which causes vegetables and fruit to rot. A reduction in temperature can be achieved by making use of proper management of the cold chain, i.e., using charcoal coolers in the field.

8.3 Avoiding and Assessing Losses

1. A farmer can avoid losses by harvesting the produce on time or when it is deemed ready.
 2. During packaging if it's a fruit crop, grading should be done so that similar size fruits are packed in accordance with the grades.
 3. Proper storage and good prevailing conditions like ventilation and humidity play a part in good storage attributes.
 4. Packaging methods of the crop should adhere with standards set for that particular crop, e.g., packing ripe Tomatoes in a tight non perforated plastic bag will induce damage to the skin and hasten over ripening.
- Distance from production site to the market: The shorter the distance the better for the farmer. With the poor road infrastructure in most parts of Zambia, transportation is critical when moving perishable materials from one point to another.

8.4 Value Addition Tips

Value addition is the practice of transforming the product to attract attention or create demand due to the attractiveness.

Value addition has some of the following advantages:

- The produce is attractive in the eyes of the buyer. For example, selling tomatoes one by one on the market compared to selling in a well labelled Biodegraded plastic.
- Farmers will get a better price when the produce is graded and packaged.
- There is a big chance by the farmer to get orders for his produce once this path is maintained on the market.
- The farmer gains experience in grading and providing quality produce through this system.
- Easier to form a Cooperative by farmers so that this processing is done on a large scale.
- Creation of employment to the local people.
- Farmers can learn other methods and uses of their produce as aggregators will bring in technology for value addition.

Some disadvantages of Value addition are:

- Initial cost of packaging materials may be high depending on the source and quality.
- There may need for training the farmers so that the processing is done in accordance with this new technology, e.g. vacuum packing etc.
- Some machinery for this process may require power or electricity to operate.
- Farmers may need a ready market for all of their produce to avoid losses.

In order for easy facilitation, farmers can form Cooperatives which can be registered. This will aid as a tool for accessing loans from lending institutions and beyond. If well organised, aggregators and other big buyers can support this cause so that farmers can quickly move from the base scale towards the upper market standards.

9.1 Introduction

Being a horticulturalist is not only about crop production but it is also to actively participate and thrive in any marketing ecosystem. You need to be aware of how your produce can be better accessed into markets and how to market your fresh fruit and vegetables.

When looking at Solwezi, there is so much opportunity as the demand for fresh produce in this mining town is very high. The mining boom in this town has benefited farming and the agricultural sector however, it still has not been fully grasped.

New horticulturists have very little or no competition making the market less saturated and giving you ample opportunity to make good profits and have a sustainable business.



Figure 9.1: Vegetable and Fruit Market

The demand in this town is high and it is still not met by the local supply. According to an article, people that live 200 km away from Solwezi is making use of this opportunity and providing mines with their own produce. <https://www.dandc.eu/en/article/home-grown-farming-sector-taking-root-zambias-mining-regions>

This chapter will focus on how you can be a better entrepreneur in your field of work.

9.2 Entrepreneurship in Horticulture

What is an entrepreneur? Have you ever thought about making money by selling the crops that you have worked hard to produce? Then you are already thinking like an entrepreneur.

The easiest way to define an entrepreneur is that an entrepreneur is someone who sees an opportunity to become self-employed and is then prepared to take business risks to make money. An entrepreneur does not have the security of getting a salary from someone else at the end of each month but has to work to create his/her own income.

Let's take a look at some of the concepts used in entrepreneurship in more detail.

■ Entrepreneurship

You will be called an entrepreneur if you can:

- Think of a creative way to start a new business
- Are prepared to take chances (e.g., to leave your job, use your life savings) to start up the new business
- Have good ideas about where to find the money to start the new business
- Manage the business until it is successful and is making profits
- Become an employer and give other people jobs

There are several advantages and disadvantages that come with being an entrepreneur. These are explained briefly below.

Advantages include the following:

- **Independence:** The entrepreneur is his/her own boss and has the freedom to make his/her own decisions for the business. The entrepreneur can set his/her own flexible work hours which will allow more time for family, etc.
- **Personal fulfilment:** The entrepreneur can start a business in something that he/she enjoys and is good at, in that way turning a hobby into a business, for example, someone who likes gardening and is good at it, can start a nursery. In addition, the entrepreneur experiences a lot of job satisfaction, whereas people who are employed often feel that their hard work is not being appreciated.
- **Excitement:** Entrepreneurs will get a thrill from starting their own business and seeing all their ideas come to life. There is also a lot of excitement to be gained from the exposure to risk and the rush of success.
- **Salary potential:** The entrepreneur is responsible for his/her own salary, and in a successful business more work usually leads to more money. So, we can say that the entrepreneur actually writes his/her own salary cheque.

Disadvantages of being an entrepreneur includes the following:

- **Not a constant income:** When starting up a new business the entrepreneur should realise that he/she is leaving behind the security of receiving a fixed salary at the end of every month. Sometimes even successful entrepreneurs have poor months when the business doesn't make enough money to pay them a salary.
- **Work hours:** The entrepreneur has to make all the big decisions in the workplace and this places a great responsibility on his/her shoulders. He/she is also responsible for all the administration and not only the actual running of the business. They have to handle all the staff matters and this often includes managing incompetent staff.

How does entrepreneurship feature in social development?

In broad terms “social development” refers to the economic and social upliftment of a community.

What is the role played by the entrepreneur to uplift his/her community? The most important role played by the entrepreneur is to create job opportunities for unemployed people. With high levels of unemployment in all developing countries, entrepreneurs play a big role in the economic upliftment of local communities. In countries all over the world small businesses, especially in the informal sector, create more jobs than big businesses.

Think of a horticulturist entrepreneur. This person is an entrepreneur who can create jobs in the informal sector, for example, by employing someone to plough the soil, getting someone else to do the deliveries every morning, paying another person to pick up supplies etc.



Figure 9.2: Worker in a Tomato Field

Another great advantage of entrepreneurship to the local communities is that people can now be employed in their communities and don't need to move to the cities to find jobs.

It is the entrepreneur who starts a new business; who needs to employ people; who needs capital and raw materials to let his/her business grow. Because the entrepreneurs are so important in the production process they are seen to be the way to generate wealth and a higher standard of living in the community. In other words, they are responsible for local wealth creation and empowerment of the community.

Characteristics of an entrepreneur

There are some personal characteristics that make a successful entrepreneur. Some of these characteristics are:

- Passion
- Enthusiasm

- Trustworthy
- Persistent
- Self-confident
- Seller
- Great communication skills
- Responsible
- Creative

■ **Contract farming**

A contract farming agreement is an arrangement between a farmer and a firm or organization to purchase all or part of the produce. At the moment, the most important contracts are between exporting corporations and smallholder farmers of High Value Export Vegetables (HVEV).

Two types of contracts exist in this type of agreement, these are:

- Contracts between companies and farmers, in which the company offers input and technical help in exchange for becoming the buyer.
- Contracts involving three parties, each of whom has a specific role, such as MFIs, buyers, and farmers.

Benefits of a Contracted Farmer

The following are some benefits of a contracted farmer:

- Input accessibility
- Access to formal markets long after the contract ends
- Opportunity to introduce high-value products such as mange peas, gem squash, and exquisite beans The farmer's experience and understanding of certain formal market needs such as size, MRLs, packaging, grading, and so on are priceless.
- Transportation for farmers who are far from major markets, the problem of rapid transportation of fresh produce can result in post-harvest losses of up to 40%.
- Risk transfer, losses due to crops perishing is shared.
- For new farmers, technical help is given by showing demonstrations on how to utilise the land correctly, because the threat of a land audit is constantly present. As a result, it is preferable to form partnerships with agro-industry companies as they lack adequate land.
- As a result of the vertical linkage, there are more opportunities for skilled family members to be absorbed into occupations along the value chain.

Benefits to the Contractor

- Securing produce.
- Quality control of produce.
- Ensuring that the market becomes secure for their product lines

What should you as a Horticultural Farmer Consider before signing a Contract?

- Find out more about the companies' various offerings by detecting production shortages in a given crop. Examine the track record of your business partner. How effective have

horticulture farmers been in the past in terms of early delivery of inputs, flexibility, and other factors?

- Understand your contractual obligations, such as simply selling to them, delivery, quality, and organic production.
- Recognize agro-business companies' or institutions' contractual duties.
- Farmers should often consult other farmers with relevant experience as well as local extension agencies.

9.3 Bookkeeping

Bookkeeping plays an essential role having full visibility of how your business is performing. It is recommended to learn some basic bookkeeping skills so that you are aware of the transactions within your business.

One of the main aims of every business is to make a profit. For a business to be able to keep going it needs to record a profit. Before starting your horticulture business, you need to understand certain basic bookkeeping concepts and terminology.

Budgets

A budget is simply a list of all items that you estimate:

- Income or revenue is the amount you expect to receive for each item
- Expenses are costs

Budgeting can be used in a variety of instances. You could set up a monthly budget to keep track of the income and expenses in your business and to ensure that you live within your financial means.

Budgets help small business owners to determine whether they have enough money, generate income and fund the day-to-day operations. Without a proper budget, your business runs the risk of not making enough money or even an opportunity to you.

For you to start with budgets, you can start with a spreadsheet using Excel. Here, you can draw up a table that will assist you to estimate what total amount of revenue is and what your costs are, for example fertilizers and farming tools.

An example of a budget is shown below.

Tomatoes per 1/ha of land

Income:

K10, 000 for Business X

Expenses:

Item	Description	Estimated Cost (ZMW)
Fertilizers	For the month of February	K150
Garden tools	For the month of February	K2000
Soil	For the month of February	K1200
Seeds	Tomato, peppers and green beans	K1000
Labour	Labourers	K1200

	Total	K5500
Income	Total estimated Expenses	Estimated Surplus/deficit
K10000	K5500	K2000

The gross margin refers to the income that is generated from the horticultural business and it is equal to the total gross income minus all the total variable costs.

Losses can occur in the business and in some cases, you may not be able to sell all your crops. Losses can occur due to poor harvesting methods, or even poor storage methods. The rate of loss is calculated depending on the type of crop and the distance to the market.

For a farmer to measure profit for the whole farm, the farmer uses a whole farm budget where they add all the gross margins for the different units in the farm then subtracts all the variable and fixed costs from this gross margin.

Some terminologies that you be familiar with is explained in the table below.

Table 9.1: Terminology

Term	Explanation
Total cost	Total cost is equal to quantity used multiplied by cost per unit.
Total production	Production costs include seed, fertilizer, transport and hired labour.
Variable costs	Variable costs are production costs that are required for the day to day running of the business, i.e., production costs.

Cash flow in the business

Without money or cash a business will eventually have to close its doors. Cash flow is defined as the movement of money in and out of your business. Cash inflow comes from the sale of your crops. Cash outflow is paying expenses. By projecting cash flow of your business, you can roughly estimate the amount of readily available cash during a chosen period.

Break-even point

This is the point where the amount of money received from sales is the same as the cost of the total expenses. At this point, the business makes no profit or loss as it is the point where the business covers all its costs – the break-even point.

CALCULATING BREAK-EVEN POINT

By selling 1000 kg (1 Ton) of tomatoes at K0.60/kg you can earn K600 (sale). Your costs include K350 spent on collecting and delivering the produce and another K250 on the fertilizers, nutrients, seeds and soil (total cost = K600). The break-even point is thus K600. If you earn less than K600, you will make a loss and if you earn more than K600, you will make a profit.

For your business to thrive, there needs to be a steady cash flow by implementing effective controls over money coming in and money going out.

Simplified cash flow plan for 3 months			
Item	Month		
Cash coming into the business	June	July	August
Cash you start off with each month	K800	K 800	K 800
Cash in the bank account(s)	0	K 320	K 410
Cash you expect to get from sales	K 1,700	K 2,800	K 4,000
Total cash coming in	K 2,500	K 3,920	K 5,210
Cash going out for direct material cost	K 740	K 1,250	K 1,500
Cash going out for direct Labour cost	K 120	K 240	K 360
Cash going out for variable expenses	K 550	K 1,250	K 1,400
Cash going out for fixed expenses	K 770	K 770	K 770
Total cash going out	K 2,180	K 3,510	K 4,030
Cash at the end of the month (4-9)	K 320	K 410	K 1,180

You can learn more about bookkeeping in the Resources section.

9.4 Business planning

Starting your own business is a daunting but thrilling endeavour that necessitates a great deal of hard work and dedication. Every part of the business will be covered with careful planning.

The primary market players in horticulture market systems are input providers, producers, aggregators/traders, wholesalers, retailers, consumers, and service providers, engage with horticultural products at various nodes of the chain, either directly or indirectly.

Let's look at each of these players in more detail.

■ Input providers

In a region like Solwezi, input providers are the "drivers" of horticulture production. They purchase inputs from suppliers and deliver seed, pesticides, and fertilizer to farmers (mostly on credit).

■ Producers

Horticultural market systems endure unpredictable price changes among local producers due to uncoordinated production, which has an influence on smallholder profitability. Weak vertical linkages with other chain players, such as input providers and service providers, exacerbate smallholder competitiveness.

The majority of urban horticultural input suppliers reach rural farmers through rural agro-dealers, who rarely stock enhanced horticulture varieties, fertilizer, or pesticides.

■ Aggregators

Aggregators can be found in informal trading places in Solwezi and they serve a crucial role in taking excess horticulture produce and distributing it to other marketplaces where it is needed.

■ Processors

Processors in Solwezi range from small, family-owned businesses selling local vegetables markets to multi-million-dollar food processing enterprises.

■ Wholesalers

Wholesalers are mostly involved in the bulking of agricultural products. In the bulk procurement of horticulture goods from farmers, informal and wholesale channels play an essential role.

■ Retailers

This category includes retail outlets such as large supermarkets and even informal trading businesses.

Solwezi is a retail market that sells vegetable and horticulture produce purchased at wholesale prices from farmers. Retailers can also be found in metropolitan areas, where vegetables and fruits are sold in roadside markets in residential areas, primarily to locals.

■ Consumers

There must be a need for the product for the entire marketing system to work, and horticulture actors must comprehend the market demand generated by customers/consumers. It is critical to remember that consumers demand the highest quality at the lowest cost.

High-income consumers place a premium on product quality and presentation, whereas low-income consumers prioritise price, quantity, and size. Farmers will be able to acquire the proper variety, produce, deliver, and present the right product if they first understand their target customers. A product should be offered with unique features that give it a competitive edge in terms of taste, size, colour, firmness, packaging, and shelf-life in order to meet the expectations of customers. This can help the product achieve a better pricing and move more units.

Important Aspects to Consider in Horticulture Produce Marketing

The following are some aspects you should consider when marketing your crops.

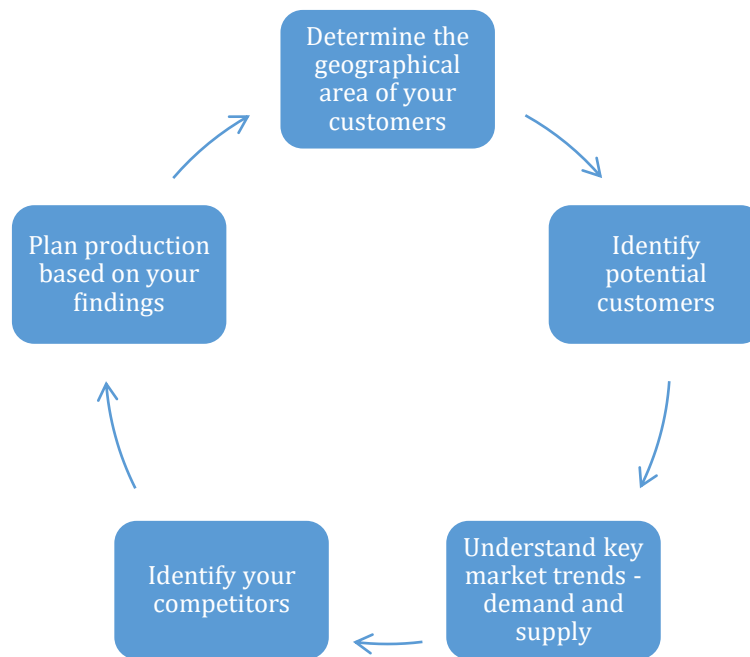
Seasonality — most crops are tough to grow all year long, an example of this would be tomatoes.

Perishability: Fresh product from horticulture is particularly perishable and requires careful post-harvest management. The following points must be taken into account:

- The market is always present, especially for crops like tomato, onion, and green vegetables.
- There are other competitive substitutes, such as cabbage for rape. Intensive production processes are usually used.
- Extreme price changes

HOW CAN YOU AS A SMALL-SCALE FARMER MARKET YOUR PRODUCE?

Before choosing on the produce and market for fresh fruits and vegetables, small-scale growers should be aware of the following information.



9.5 Recordkeeping

Recordkeeping is collecting data or information the processing this information for future decisions. For example, analysing expenses and seeing where you can save and cut out some expenses in the future.

The following are some types of records kept by horticulturists. This could either be in the form of a physical record or a financial record.

Physical records include:

- Input quantities
- Asset inventory
- Weather records
- Total yields
- Quantities sold to output markets
- Input quantities, like for example fertilisers and pesticides
- Labour costs
- Land related costs

Financial records include:

- Personal income
- Sales records
- Credit records
- Invoices and receipts
- Income from sales
- Capital investment
- Overhead costs

- Personal expenses
- Bank statements
- Bank fees
- Transactional fees

There are specific records as well. This will be explained in more detail below.

Stock record book

This shows all the stock in a farm at any specific time. The items that should be included in this log are items such as fertiliser, purchase date, price, total value of stock used and value of any remaining stock as well as buying price.

An example of this type of record is shown in the image below.

Date	Item purchased	Quantity purchased	Date item was used	Quantity of product used	Value of product used (ZMK)	Crop for item used	Total cost (K)
01/05/21	Potting soil	10 kg	04/06/21	2 kg	K 20	Eggplant (0.01 ha)	K 2
01/05/21	Basal fertilizer	5 kg	04/06/21	2,5 kg	K 100	Eggplant (0.01 ha)	K 50

Farm sales record book

This type of record book includes quantities that are harvested, quantities that are sold and the selling prices, as well as dates for sales and harvesting. The buyer's name and method of payment is also recorded.

Harvest date	Commodity	Quantity harvested (tonnes)	Sales date	Quantity of product sold	Price per unit (K)	Value for sale	Name of buyer	Notes
01/05/21	Onions	10	04/05/21	10	4700	4700	Mary	Cash payment
12/05/21	Tomatoes	5	19/05/21	5	2350	2350	Mines	EFT payment
15/05/21	Cabbage	5	21/05/21	2,5	2350	1125	Mines	EFT payment

Credit journal

This journal records how much money is borrowed, who did you borrow it from and how was it paid and the current balance.

Why is recordkeeping important?

Managing a business and its day-to-day operations plays a huge role in the success of the business. Records are kept and are required for perform this function. Some common uses of records are listed below:

- Evaluates farm profitability

- Tracks the business' performance
- To get access to more capital
- Can be shown to potential investors
- Help get extension from development agents
- Basis for price negotiation

What are the requirements for proper recording keeping?

Horticulturists that plan to make the farming a business a success needs to take recordkeeping seriously. You need to ensure the following:

- Records must be accurate and up to date.
- Records should provide detailed information which is useful.
- Records must be easy to read and not complicated.
- The time in between data collection and the actual recording should not be long as this can render the data not useful.

You will need to develop an effective filing and storage system that is logical and enables you to track and retrieve your documents and records. It is advisable to spend time every day updating your record keeping.

Inputs

Inputs are the different things that the farmer needs to grow the crop. Inputs can either be investment inputs or recurrent inputs. Examples of inputs in a horticultural business are shown in the table below.

Note: These inputs has an impact on your budget and these items can be used when budgeting.

Table 9.2: Types of inputs

Investment inputs	Recurrent inputs
■ Land ■ Land preparation: clearing, deep ripping, liming ■ Buildings: Sheds, storage tanks, cold store, packing shed ■ Machinery: Tractor, harvester, sorter, etc. ■ Establishment: Fencing, banks, trellises, drains, netting, etc. ■ Irrigation/ fertigation ■ Irrigation equipment ■ Processing: distillation, drying, etc. ■ Permits: Permits, licenses, memberships to associations ■ Working capital ■ Water supply: Development and equipment (for example irrigation systems)	■ Seed: Seeds, rootstock, cuttings ■ Irrigation/water ■ Soil preparation: Tilling, mulching, liming, etc. ■ Fertilisers: Chemicals Herbicides; pesticides ■ Crop protection Netting, trellises, covers, etc. ■ Harvesting ■ Maintenance: Fencing, banks, structures, etc. ■ Disposal: Disposal of refuse, waste, unused products ■ Levies: Annual permits, industry levies, subscriptions ■ Transport ■ Packaging

Access to markets

What will the potential profitability of your farm be? The following are a few aspects to consider:

- How many different types of crops are you planning to harvest?
- Are you planning to sell seedlings?
- What price will you consider for the crops when you are selling them?
- What price will you consider for the produce when you are selling them?
- What are your costs to grow the different types of crops per year? This includes nutrients, fertilizers and labour.

By getting all this information together, you will be able to calculate the amount of money you can make and what your profit will be. The success of your business depends on how well you manage your crops. If most of your crops die, your profit will also decrease. If the cost of looking after the crops is too high, the profit will also decrease. You should work to reach a solid middle-of-the-road approach.

Marketing is probably an area that most farmers let slip however it is important to understand your market and how you can optimise maximum access to the relevant market.

Keep in mind that Solwezi is a mining town, and you already have a readily available market, however, you need to be aware of a few things.

Small-scale growers should be aware of the following information before deciding on the produce and market of fresh fruits and vegetables.

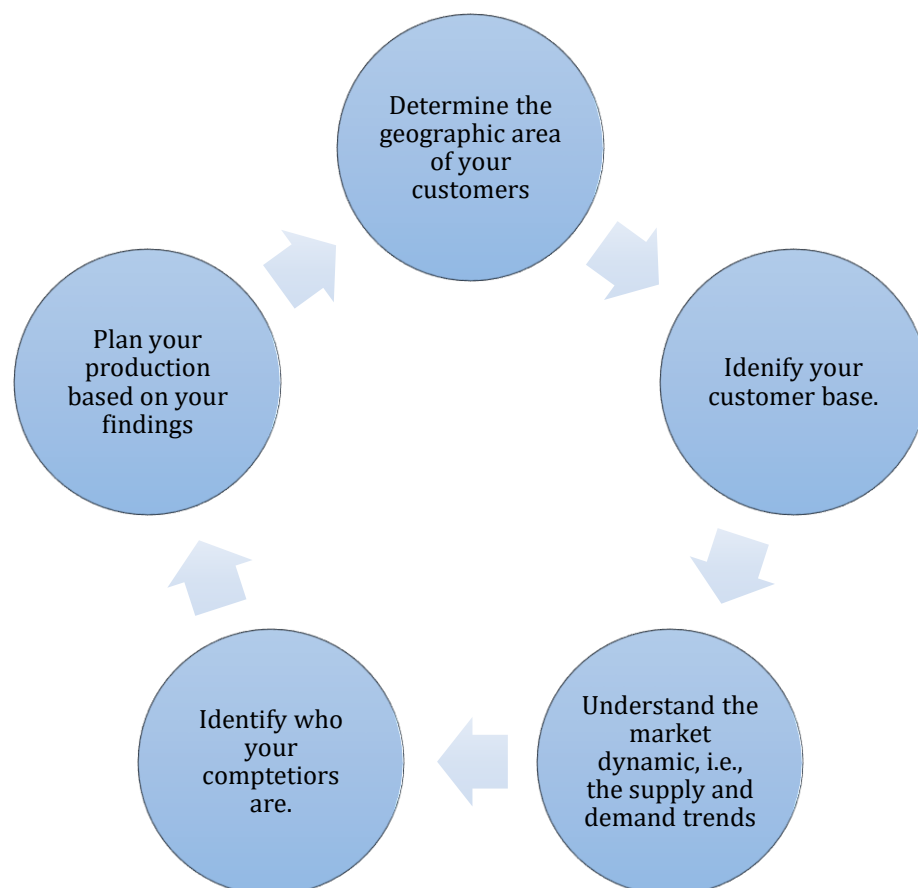


Figure 9.3: Knowing your market

The following are two ways to access the market:

- Direct channels: Here, you have no middleman.
- Indirect channels: You have various individuals carrying out various tasks. With this channel, you will make much less of a profit.

Furthermore, markets can either be formal or informal.

Formal markets are made up of supermarkets, exporters, wholesalers and processors. Informal markets are made up of informal market centres.

You can make use of either formal or informal markets to sell your produce.

Financial services

If you have a good idea for a new business and you are serious about starting your own business, there are other avenues that you can explore for funding and support. There are many sources of funding available, for example, all commercial banks have a small business loans department where you can obtain a loan as long as you have a sound business plan and some form of security (i.e. something of value, e.g. car or house that the bank can take back if you don't pay back the loan, or else someone must back you and be prepared to pay back the money to the bank if you can't).

What should be clear to you now is that there are financing and support available for the entrepreneur starting out a new business, and you are only limited by your own drive and ambition.

Some advantages and disadvantages of funding is tabulated below.

Table 9.3: Financing options and their advantages and disadvantages

Source	Advantages	Disadvantages
Internal financing	■ No interest or service charges needs to be paid (although the opportunity cost of allocating the capital should be considered). ■ No need to enter into an external contract or risk defaulting and incurring penalties and possible loss of collateral.	■ Impacts cash flow heavily - the full investment amount is removed from a business's available cash immediately. ■ By retaining earnings, less dividends can be paid out to shareholders. ■ Issuing additional shares dilutes the value of all shares at least temporarily. ■ Might not always be available.
External financing	■ Low impact on cash flow (repayments are spread over a long period). ■ Readily available, although sometimes at a very high cost.	■ High cost of interest and service charges.

Source	Advantages	Disadvantages
Funding	■ In most cases the most cost effective. Funding can range from low interest and no interest loans to funds that require no repayment at all.	■ Not always available ■ Usually have very specific requirements, up front and after completion. ■ Rarely enough to fully finance a project ■ Could add a significant administrative burden to comply with funding requirements. ■ Rebates funding require initial finance to bridge the gap until funds can be recovered.

10.1 Introduction

Beekeeping, also known as apiculture, is the study and management of honeybees. Zambia offers a wonderful environment for beekeeping. The trade of honey and beeswax provides up to 25% of total annual income for tens of thousands of households (taken from https://www.cifor.org/publications/pdf_files/livebrief/livebrief0801.pdf)

Beekeeping is important in Zambia as approximately 66% of Zambia is covered with woodlands and dry forests and *Brachystegia*, *Julbernardia* and *Isoberlinia* are all sources of nectar for bees and is found in abundance in these woodlands and dry forests. Beekeeping is a source of income for over 20 000 rural households in Zambia.



Figure 10.1: Beekeeper Bees Hive

The focus of this chapter will be on beekeeping and how beekeeping has an impact on crop production.

10.2 Beekeeping

Zambia is one of the largest exporters of bee products and only 20% of the estimated production is marketed through formal channels, i.e., supermarkets and grocery shops.

Even though Zambia is producing such a high quantity of bee products, it is still far from optimum production and full production potential. Zambia is rich in forestry this ideal for beekeeping

activities. As mentioned before, the production rate is still very low and production can be much higher.

Some challenges of beekeeping include:

- Lack of knowledge when it comes to beekeeping.
- Low productivity which results in a low produce.
- Lack in knowledge of market information.
- Not sufficient number of processing facilities.

Companies in Zambia are encouraging the locals to manage beehives, they make the beehives and give it to the locals to manage. The local people are trained to maintain these hives and the more honey a beehive makes, the more money, you get.

However, there are instances where locals cut down trees for wood and this affects the honey production. Just as bees need trees, trees also need bees to produce fruits and reproduce.

Beekeeping is an extra source of income for the local beekeepers and the use of beehives in these forests has a little to no environmental impact.

There are different types of bees, some common types are the honeybee, bumblebee, mining bee and carpenter bee.



Figure 10.2: Beehive in a Forest

■ Advantages of beekeeping

There are several advantages to beekeeping:

- Bees help the environment: Bees are pollinators which transfer pollen from one flower to the other, allowing plants to fertilize and reproduce. Bees do not only help in the vicinity where they are kept, they are capable of gathering nectar and pollen from kilometres around thus spreading diversity in the ecosystem they are part of.
- Help the economy: Fewer bees actually means lower crop yields, higher productions and higher prices for consumers. Keeping bees allows crops to be pollinated all year long.
- No need for space: Bees requires very little space. Most beehives are small and won't take much space of your property. Also, they do not require much maintenance to be well looked after.

- Honey: Not only is honey medicinal but some people claim that eating local honey can help you fight against disease and build up your immunity. Honey is said to also:
 - Cure sore throats
 - Boost memory
 - Have anti-bacterial properties
- Other bee products: Bees do not only produce honey. You can sell beewax, propolis and the bees themselves. For example, you can raise bees, and sell queen bees at a good price. Bees multiply quickly so bee production will never be stagnant.
- Hiring the beehives: Farmers make use of hiring beehives which is an efficient method of pollinating their crops.



Figure 10.3: Pollinating Bee on a Tomato Plant

10.3 Impact of Beekeeping on Crop Production

We have touched briefly on bees used in crop production in the section above. However, it is a known fact that without bees, we would not have many of the vegetables or fruits that we eat everyday.

A bee is one type of pollinator and they play an important role in crop production. Other pollinators include birds, bats, beetles and some other small insects however our primary focus in this section will be on bees.

Many vegetables and fruits rely on bee pollination to reproduce, these include the vegetables and fruits mentioned in Chapter 2.

What is pollination?

Pollination is an important part of plant production – pollen from the male part of a plant (the flower's anthers) is rubbed or dropped onto the pollinator. The pollinator then transfers this

pollen to another flower and this is where fertilization takes place. The fertilized flower later yields fruits and seeds.

This is why pollinators are very important.

Bees and crop production

Bees are important when it comes to the production of many vegetable and fruit types. Crop yields are definitely higher with pollination of bees. However, due to new agricultural practices such the introduction of pesticides in Horticulture, this can cause harm to bees.

Almost all fruits and vegetables require pollination by bees in order to yield produce. Without these pollinators, these crops can disappear from the market. Perhaps, it is wise to have a beehive close to your plant site – not only could this help in the pollination process and result in better yields but you can also earn an income from the bee by-products, i.e., honey.

Not all bees have the same characteristics – it is said that natural pollination by the right type of bee also improves the quality of the crop.

Appendix A

Glossary

11.1 Definitions

Word	Definition
Acid soil	Soil with a pH level below 7.
Alkaline soil	Soil with a pH level above 7.
Annual	A plant whose life cycle comprises a single growing season.
Aphid	Insect that sucks the juices from a plant's tissue.
Bud	The initial phase of new organs of a plant– branches, leaves or flowers.
Bulb	Encased leaf or flower bud, as an onion or tulip.
Bush	A fairly small plant with numerous branches that spring from the base, almost synonymous with shrub.
Cane	A long, often supple, woody stem.
Chlorophyll	Green colouring matter in plants, essential to photosynthesis.
Clay soil	A soil, usually heavy and poorly drained, containing a preponderance of fine particles. It is sticky when wet, and hard when dry.
Compost	Decomposed organic matter, usually used to enrich the soil.
Cultivate	To work the soil in order to break it up and/or remove weeds.
Cutting	A means of asexual propagation that consists of inserting parts (root, stem, leaf) of a plant into a suitable rooting medium; these will eventually produce roots and eventually new plants.
Direct seeding	Sowing seeds directly into the garden rather than starting seeds indoors.
Drainage	The ability of the soil to move water so that the roots of the plant do not become waterlogged, and so nutrients move through the soil.
Family	A group of plants sharing common features and distinctive characteristics; a group of related genera.
Fertile	Having the capacity to generate seed.
Fertilizer	Any material that supplies nutrients to plants.
Germinate	To develop a young plant from seed; to produce a seedling.
Germination	The beginning of plant growth from a seed.
Humus	Soil composed of decaying organic matter.
Hybrid	A cross between different species, subspecies or varieties.
Insecticide	A product that kills insects.
Integrated pest management (IPM)	A philosophy of pest management based on the idea of using escalating methods of pest control, beginning with the least damaging; incorporates the selection of resistant varieties, the use of biological and

Word	Definition
	nontoxic controls, and the application of pesticides and herbicides only when absolutely necessary.
Leaf mold	A form of humus composed of decayed leaves, often used to enrich soil.
Legume	A dry dehiscent fruit, typical of the leguminous plants, which splits open on both sides when ripe to disseminate the seeds.
Loam	A best of soil – well– drained soil, usually containing a significant amount of decomposed organic matter
Manure	Organic fertilizer of animal origin, rich in nitrogen.
Mildew	Fungal disease that produces white dust or downy tufts on leaves.
Mulch	An organic or inorganic soil covering, used to maintain soil temperature and moisture and to discourage the growth of weeds.
Nematode	Microscopic wormlike animal that may be beneficial or harmful to plants
Neutral soil	Soil having a pH of 7–neither acid nor alkaline.
Nitrogen	One of the three most important plant nutrients, needed for the production of leaves and stems. It is required for all living plants and animals since it is a component of protein. If the supply of nitrogen is good, foliage is green and the plant flourishes. Insufficient nitrogen is indicated by yellowing leaves and stunted growth. Too much nitrogen may cause excessive growth, making plants more susceptible to disease. (See also Phosphorus and Potassium).
Node	The point on a stem where the leaves arise.
Nutrients	Elements in the soil absorbed by plants for growth.
Organic gardening.	Practice of gardening without the use of synthetic chemicals.
Organic matter	Part of the soil that consists of decayed or decaying plant and animal matter (humus).
Organic	Derived naturally, from living or once –living matter.
Pesticide	A product that kills garden insects.
pH	The hydrogen ion content of soil; the symbol used to express the acidity or alkalinity of soil; if the pH is equal to 7, the solution is neutral; if it is over 7, it is alkaline, and if less than 7, it is acid.
Phosphorus	One of the three important plant nutrients and is essential in all phases of plant growth, but is particularly associated with early maturity of crops, the formation of seeds and fruits, and increased root growth. Increased resistance to disease is another benefit.
Potassium	One of the three most important plant nutrients. It is essential for the growth of plants, and plants take large amounts of it from the soil. It is not known exactly what role potassium performs in the living processes of a plant cell, but there is some evidence that it acts in enzymatic processes, especially the transformations among different kinds of sugars
Rhizome	An underground modified stem, often swollen and fleshy.

Word	Definition
Root	The part of a plant that is generally underground and anchors it in the soil absorbing the nutriment and moisture necessary for growth.
Sandy soil	Soil with a high percentage of sand, or large soil particles. Water travels through sandy soil every easily, so nutrients leach (wash) out quickly.
Seed	The reproductive organ of plants derived from the fertilized ovule and containing the embryo of a future plant.
Seeding	A young plant, especially one grown from seed.
Shrub	A woody plant with branches from the base with no obvious trunk.
Stem	The fundamental organ of a plant, above the roots, which serves to support all the other organs (branches, leaves, flowers) and to conduct the nutritive substances so that they will reach the extremities.
Thrips	Insect that rasps chlorophyll off broad leafed plants.
Transplanting	The transfer of a plant from one site to another.
Tree	A woody plant that produces normally a single trunk and an elevated head of branches.
Whiteflies	Tiny flies that suck a plant's juices; often look like a cloud of smoke
Wilt	Disease that causes leaves to turn brown; often causes sudden death of plant.

Appendix B

Resources

12.1 List of resources

The following resources were used in writing this manual.

- <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/nursery-management>
- <http://www.fdcn.nic.in/PDF/horticulture%20plant%20nursery.pdf>
- <https://www.nda.agric.za/docs/brochures/prodguidecabbage.pdf>
- https://snv.org/cms/sites/default/files/explore/download/rarp_2016-horticulture-trainers-manual.pdf
- <https://www.sciencedirect.com/science/article/pii/S2468227621003082>
- https://www.cifor.org/publications/pdf_files/livebrief/livebrief0801.pdf
- <https://www.xero.com/za/guides/farm-accounting/>
- <https://www.harvestprofit.com/blog/six-steps-to-better-farm-bookkeeping>
- <http://www.startagardeningbusiness.co.uk/bookkeeping-accounting-systems.html>

