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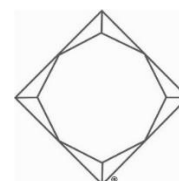
SUSTAINABLE CROP PRODUCTION

Sustainable Crop Production

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Introduction

Overview of the book

Purpose of this book

The main reason for this book is to help you with information to develop your farm. Weather does change, rain, wind, and temperatures are not the same every year. The focus for this book is to develop your farm and your crops to be ready for changes in the weather. We need to be ready for season changes and changes over years as every year can be different.



Hope for the Best, Plan for the Unexpected

EVERYTHING STARTS WITH THE MARKET FIRST!

What does your market need? How much produce, and at what quality level?

How your farm will help you grow enough produce for your market but also at the right quality, the quality that your market expects. This book will help you prepare for changes in the weather, help make your farm and farming sustainable. If you enter a drought, you can have a dam that can help water your household, your crops and your animals. With good farming practices anticipating changing weather we can still deliver enough produce at the right quality for market.

The book is written so that students can easily understand the basic steps towards climate resilience.

The book is divided into four chapters:

- Chapter 1 looks at the need for sustainable production and the process of using experience to adapt to weather changes and enhance farming practices.
- Chapter 2 explains three different Sustainable Crop Production Models that can contribute to building resilience.
- Chapter 3 Sustainable Crop Production Practices
 - Crops, soil and field preparation, water management, pest, mechanization, Climate Resilient Infrastructure, harvesting, post-harvesting
- Chapter 4 Entrepreneurship and Record Keeping



Chapter 1

Importance of Climate Resilience

1.1 Introduction

■ Climate Resilience

Climate resilience is the ability to anticipate, plan, prepare for and respond to hazardous events, trends, or changes related to the weather, climate. To add to this, we need to successfully cope with and manage the impacts of climate changes over the short term and the long-term preventing the impacts from growing worse.

There are 2 approaches that need to be developed to create a climate resilient farm.

1. We need to learn from our experience as farmers
2. And we need to take our experience and develop climate-smart agricultural techniques.

Plants will grow, trees will bear fruit, animals will reproduce but in the field of agriculture and farming we guide the process with inputs to deliver best yields, production, quantity, at the correct quality standards for the market.

With lessons learnt from experience and climate-smart agricultural techniques we can optimise our production and quality, enriching our soil, placing less stress on our plants and animals and saving water, using water wisely.

The value for the climate resilient farmer is mainly to balance and anticipate the plant's cycle with the climate and its changes through the seasons. Plants and animals flourish in optimal conditions, conditions that are not stressed. Stress is created at extremes, drought, flood, wind, fire, pests, disease, weeds.

Inputs in climate resilient farming focuses on experience and your changing farming practice.



No or low inputs = no or low outputs.



Medium to high inputs = medium to high outputs.

1.2. Successful Climate Resilient farming follows an improving process cycle

Climate resilient farming is the result of numerous micro-processes, developing your farm's infrastructure, wind breaks, water harvesting and collection, drought resistance and fire prevention. Furthermore, you need to follow climate-smart agricultural techniques, minimum tillage, using improved seed, early planting, correct plant population per square meter (m^2), crop rotation, proper weed management, appropriate herbicides and fertilizers. To achieve all the micro-processes, we need to become aware and implement a model of process thinking and action with improvements and lessons being learnt.

To get something done, preparing a field, planting seedlings, setting up an irrigation system, we need a process. The process that is recommend looks as follows:



Figure 1.1: Process Cycle

The task that must be performed must be defined. What are you going to do? Prepare the field, lay water pipes, build a dam, harvest a crop.

The Plan: here we create a mental bridge. When must the task happen? Some tasks must be done more regularly than others. What are you going to need? Pipe, sprinklers, drippers, fittings, scissors, pliers, wire, spanners, the task will help you build a kit list for the doing. You also have to plan how many people are needed to get the task done. Planting can might be done with a machine, but the harvesting can be by hand, you will need more people for hand harvesting than machine harvesting.

Development: get the resources, list of equipment and people for the doing of the task.

Do: Roll up your sleeves and at the right time do the task.

Assess: How did it go? Was the task completed? Was it done correctly? Is the product, produce at the correct quality and quantity for the market?



We all have experience in farming. Every season has been assessed, good years and bad years. We all learn lessons and adapt for improvement.

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Reflect: What can we improve?

Learn from mistakes. Learn from your successes so that you can repeat these good actions when doing the task again.

Character: Beliefs, values, attitude, and behaviour.

As we follow this process you will become a better farmer. You will learn to become more **aware** of your environment, weather changes and the needs of your crops, you will start **anticipating** weather and environmental changes and the needs of your plants and the people working with you. With good **Awareness and Anticipation** your plants and environment can provide you with **Abundance**. Remember to always remain **adaptable**, you must continually improve and learn from your mistakes and successes.

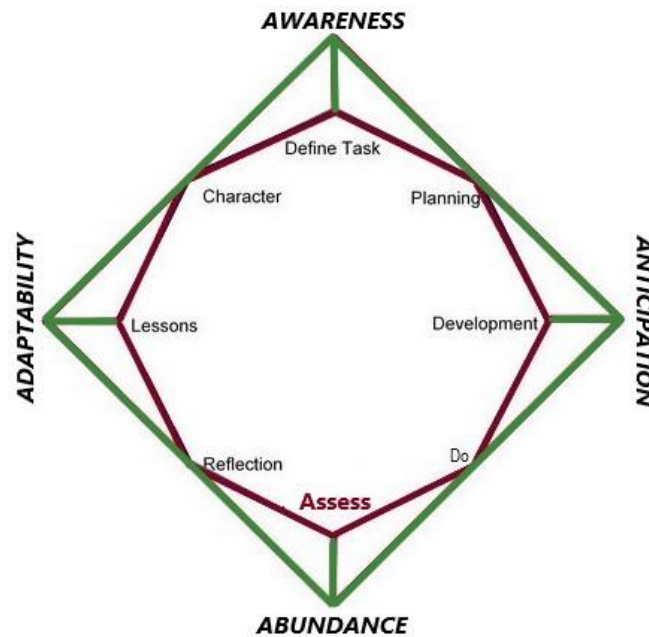


Figure 1.2: Four A's towards effective task completion

And so, as your production and farm grow and improve you can expand your farm and provide for more people. The provision of your farming is not only in terms of production but also employment and later empowerment as you teach and train others from the lessons you have learnt and the experience you have gained.

A good way to see your farming is as several interlocking **Process Cycles**. planting, growing, harvesting and post harvesting and preparation for the next season.

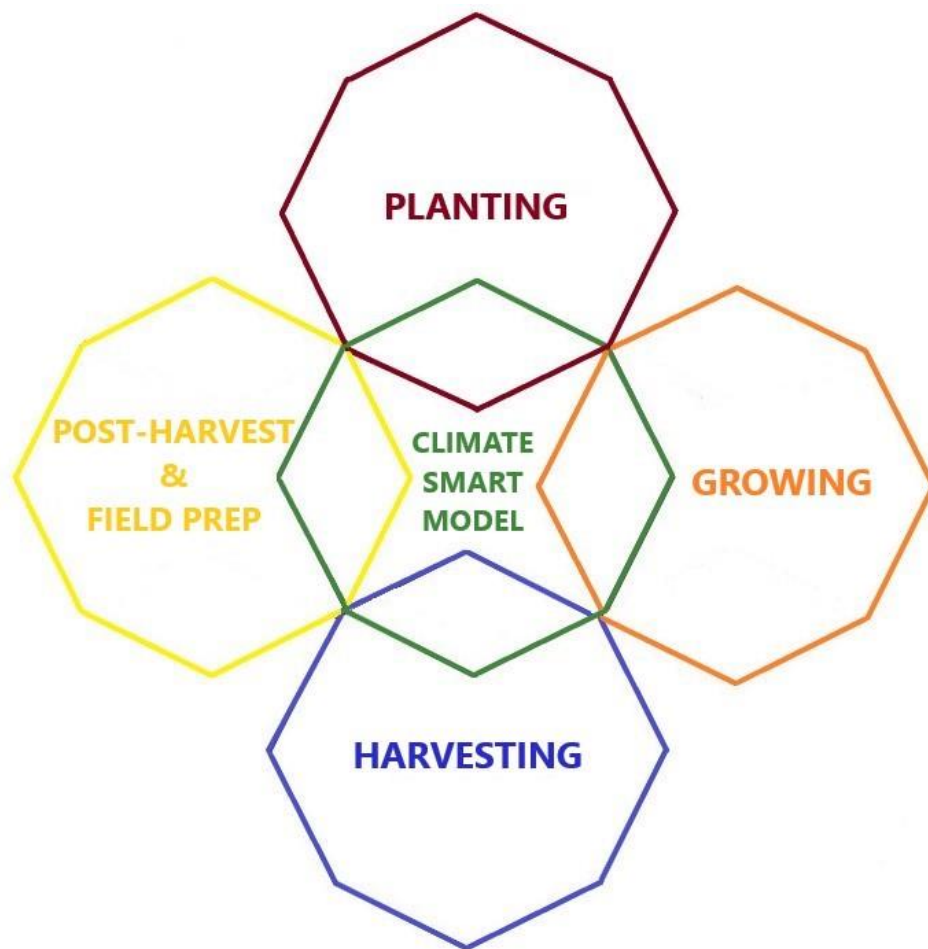


Figure 1.3: Crop Production Processes Interlock

A good plan of action regarding each aspect of your crop production process can make all the difference. We are not in the business of gardening but rather as a lifestyle, improving our own lives and that of our communities at large.

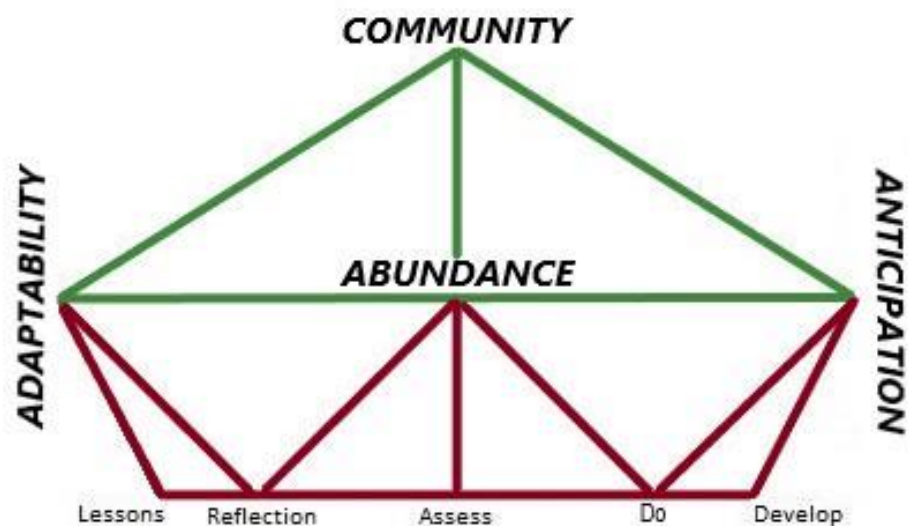


Figure 1.4: Improvement of self and community

Becker, C. 2011. Diamond Theory 101. KindleDirectPublishing.

1.3. How can we become more climate resilient?

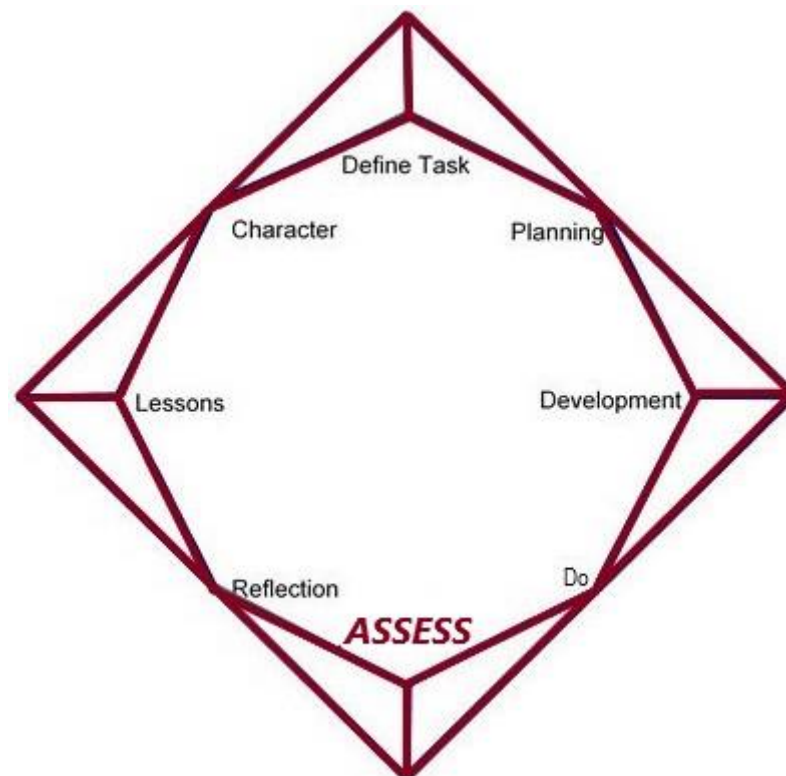


Figure 1.5: What is the current situation?

From years of farming, we have experience. Our experience can help us assess our local climate conditions, droughts, floods, extreme temperatures and changing rainfall patterns. From the assessment we can adapt our farming through reflection and lessons learned.

In the case of drought, we can build contour bunds. To help prevent erosion from flooding we can build erosion walls. Extreme temperatures can be balanced through the creation of microclimates in an agroforestry system. Changing rainfall patterns may force us to adapt our timing for field preparations, planting, field management (irrigation and pest management), and harvesting.

Using Climate Data, forecasts and historical data, we can plan and develop our farming practice.

Knowledge and experience of how your farm works within the larger systems of your environment you can create and implement the best Climate Smart Model and Practice.



Climate Smart Models and Practices can be blended to get the best results for your farm

Assess your practices: regular assessment of the effectiveness of your practices can help you adapt. If it has rained you might decide to reduce irrigation. If you have experienced a hot and dry period, you may need more irrigation time.

Record keeping is important. Keep records of weather patterns, yields and farming interventions. Good records can help with learning lessons and future decision make choices.

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and adapt our and anticipate how different conditions may affect our farm and our production.

Our world is full of information and experience. A good place to learn from other farmers' experience is through talking to other farmers. Joining your local Agricultural Cooperative brings several farmers together who experience similar challenges within an area. Through the cooperative you can share your successes and learn from other farmers' resources, knowledge and experience to become more climate resilient and better farmer in all areas of the agricultural process.

Climate Smart Models to Enhance Climate Resilience

2.1. Climate Smart Models

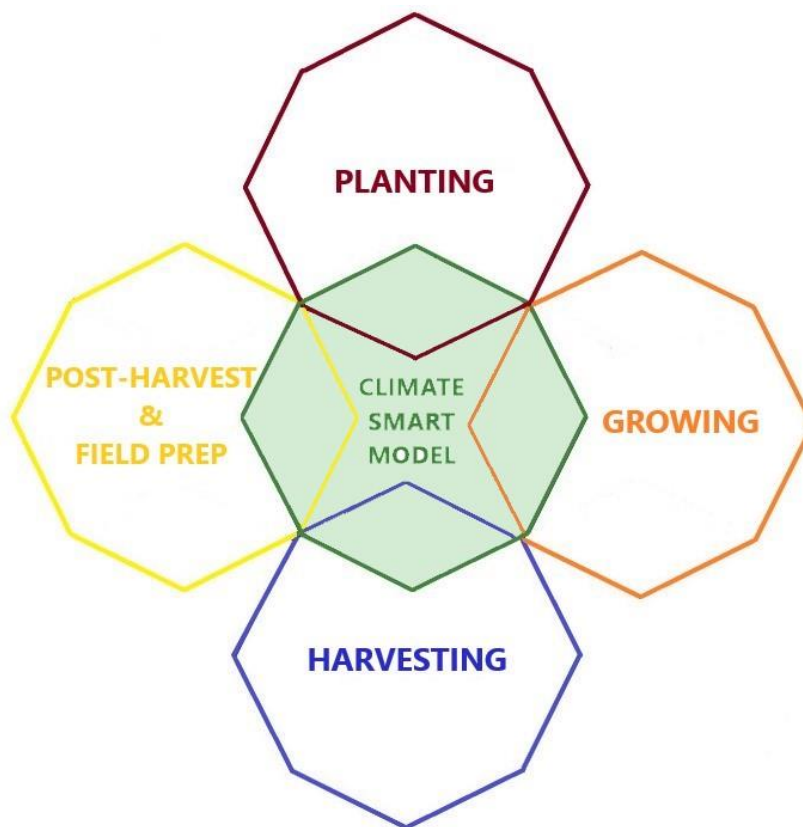


Figure 2.1: Climate Smart Model at the Centre

Agriculture, whether talking about plants or animals, is *plant, grow, harvest* and *post-harvest with preparation for the new season*.

In crop production it starts with soil preparation (till or no till, fertilizer), planting, growing (irrigation, fertilizer and pest management), harvesting and post harvesting with soil preparation which takes us to the new season.

In animal production your point of starting might be different, some farmers deal with fertilizing, gestation, birthing, growth (animal management) and harvesting (milking, livestock sales, wool, eggs). Certain farms focus on certain aspects of the process and still make their profit, sale of calves or spring chicks.

As stated earlier climate resilience balances two aspects your experience and your climate smart model.

When discussing climate resilience, we must look at the 4 primary elements of our environment and how the climate may cause extremes for each:

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- Air, wind
- Fire
- Earth (drought and micro-organisms)
- Water (flooding)

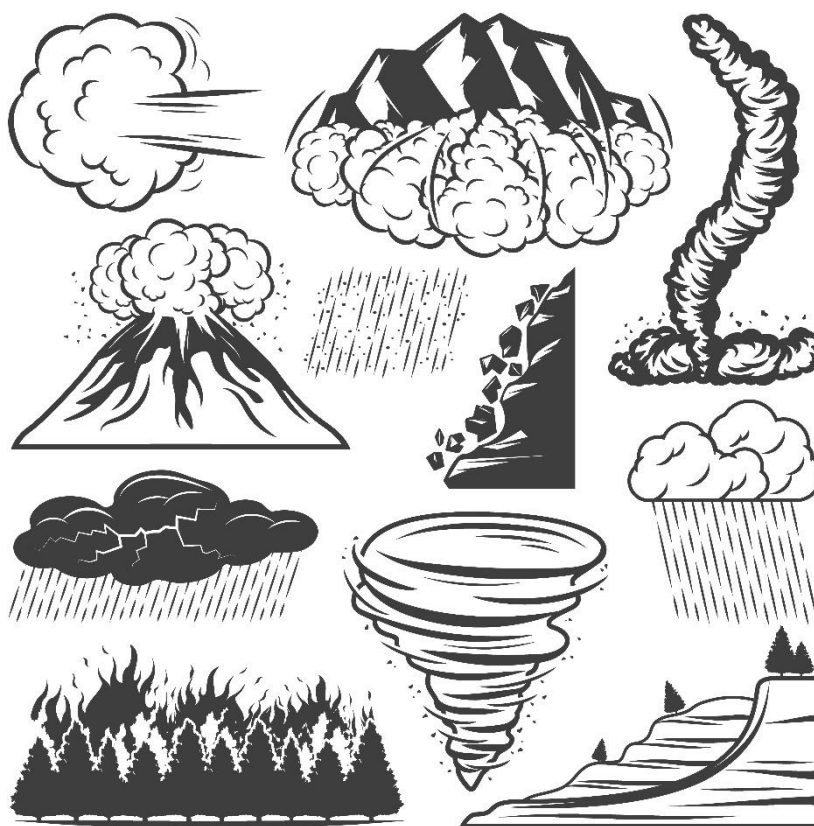


Figure 2.2: Elements of Change
(freepik.com)

The Climate Smart Model we use can help us manage each of these aspects when they are at their extremes.

Wind can be helpful for pollination, but excessive strong winds can blow pollen away and affect insect pollination on certain plants. Wind also speeds up evaporation this can affect our irrigation process, dry out our soil faster and provide stress to plant growth.

Fire is a natural phenomenon resulting from lightning strikes. This risk is higher with the first rains after the dry season when the grasslands and trees are drier. Ash from fires is a natural source of potassium and trace elements for your soil. Ash can also have a liming effect, what this means is that it can be a remedy for excessively acidic soils.

Soil management is the basis of all agriculture. It involves 7 essential practices:



Figure 2.3: Soil management practices

(https://www.researchgate.net/figure/Sustainable-soil-management-and-the-factors-of-soil-quality_fig1_349403211)

Water is a necessity for good farming production. All life needs good quality water. Too much water, flooding, can be stressful to your plants. Flooding can also affect soil nutrition levels washing away micronutrients. Too little water, drought, is similarly stressful as plants need water to maintain structure, transport energy and nutrition up and down the stem and branches of the plant.

Many Climate Smart Models exist, for the purposes of this training manual we are going to look at 3:

- Agroforestry
- Integrated Crop and Livestock
- Crop Rotation and Intercropping

2.2. Agroforestry

Agroforestry is a sustainable land-use management system that combines trees, shrubs, or other woody perennials with crops, livestock, or both, on the same land. This integration creates a more diverse, productive, and sustainable approach to agriculture. Agroforestry systems are designed to optimize the use of land by leveraging the complementary interactions between components to benefit the environment, biodiversity, and human livelihoods.

Key Components of Agroforestry

1. Trees and Shrubs:

- Provide shade, shelter, and nutrients for crops and animals.
- Offer products like timber, fruit, nuts, and firewood.

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2. Crops:

- Include staple grains, vegetables, or other cultivated plants.
- Benefit from improved soil quality and microclimatic conditions created by trees.

3. Livestock:

- Can graze in silvopastoral systems, benefiting from shade and forage provided by trees and shrubs.

Types of Agroforestry Systems

- **Alley Cropping:** Planting crops in rows between lines of trees or shrubs.
- **Silvopasture:** Integrating trees and shrubs into pastures for livestock.
- **Forest Farming:** Cultivating high-value crops under a forest canopy.
- **Windbreaks:** Planting trees or shrubs to protect crops and soil from wind erosion.
- **Riparian Buffers:** Planting vegetation along waterways to prevent erosion and improve water quality.

Benefits of Agroforestry

1. Environmental:

- Reduces soil erosion and improves soil fertility.
- Enhances biodiversity and carbon sequestration.
- Improves water quality and reduces runoff.

2. Economic:

- Diversifies income sources through timber, fruits, nuts, and other tree products.
- Reduces the need for external inputs like fertilizers and pesticides.

3. Social:

- Strengthens food security and resilience to climate change.
- Promotes sustainable rural development.

By mimicking natural ecosystems, agroforestry systems contribute to sustainable agriculture and help address challenges like climate change, deforestation, and land degradation.

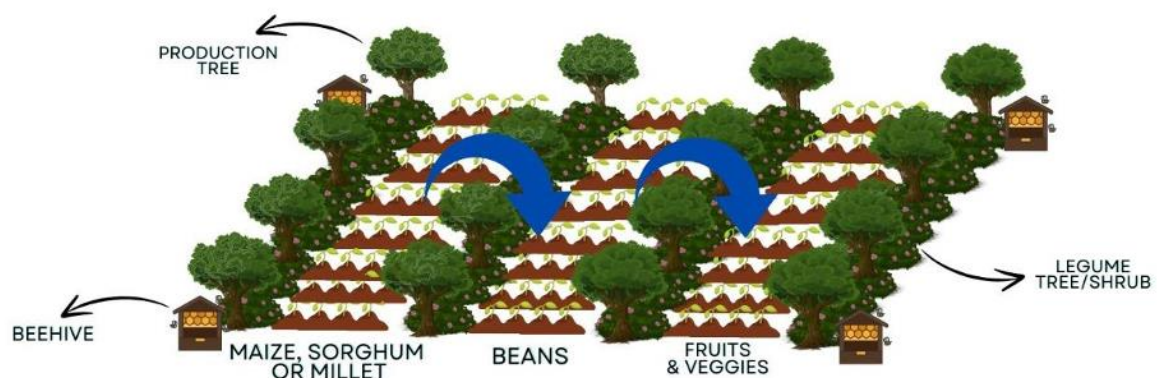


Figure 2.4: Depiction of Agroforestry
(Impuls Africa)



Figure 2.5: Picture of Agroforestry
(Impuls Africa)

2.3. Integrated Crop and Livestock Production

An **Integrated Crop and Livestock Production Model** is a farming system that combines the production of crops and livestock on the same farm or land. This approach aims to create a mutually beneficial relationship between the two, enhancing productivity, sustainability, and resource efficiency.

How It Works:

1. Crops and Livestock Together:

- Farmers grow crops and raise animals on the same land.
- Animals can graze on crop residues, reducing waste.
- Livestock manure is used as a natural fertilizer for crops.

2. Rotation and Integration:

- Crops are rotated with forage crops (grasses or legumes) that animals can eat.
- Livestock are rotated through different parts of the farm, improving soil health and reducing pests.

3. Resource Sharing:

- Water, land, and nutrients are efficiently shared between crops and animals.
- Livestock provide power for farming (e.g., plowing) in some traditional systems.

Benefits:

1. Environmental:

- Improves soil fertility by adding organic matter from manure.
- Reduces the need for synthetic fertilizers and pesticides.
- Enhances biodiversity and reduces greenhouse gas emissions.

2. Economic:

- Diversifies income sources (crops, milk, meat, eggs, wool, etc.).
- Reduces costs by reusing farm byproducts (e.g., feeding crop residues to animals).

3. Sustainability:

- Builds resilience against climate changes.
- Reduces dependency on external inputs (like chemical fertilizers or feed).

Example:

A farmer grows maize and raises cattle. After harvesting the maize, the cattle graze on the leftover stalks in the field. The cattle's manure fertilizes the soil, which helps the next crop grow better.

This model is widely used to create sustainable farming practices that are productive and environmentally friendly.



Figure 2.6: Crop and Livestock Production (AI generated)

2.4. Crop Rotation and Intercropping

Crop Rotation

Crop rotation is a farming practice where different types of crops are grown in a specific sequence on the same piece of land over time. Instead of planting the same crop repeatedly, farmers change the crop every season or year to maintain soil health and improve farm productivity.

Benefits of Crop Rotation:

1. **Improves Soil Fertility:** Certain crops, like legumes, fix nitrogen in the soil, benefiting the next crop.
2. **Reduces Pests and Diseases:** Pests and diseases specific to one crop are less likely to thrive when the crop is rotated.
3. **Prevents Soil Depletion:** Alternating crops with different nutrient needs prevents overuse of specific soil nutrients.
4. **Enhances Yield:** Healthier soil leads to better crop growth.

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Example:

- Year 1: Plant corn (a heavy feeder).
- Year 2: Grow soybeans (a nitrogen-fixing crop).
- Year 3: Plant wheat (less demanding on soil nutrients).

Intercropping

Intercropping is the practice of growing two or more different crops together on the same field at the same time. The crops are chosen to complement each other, making better use of available resources like sunlight, water, and nutrients.

Types of Intercropping:

1. **Mixed Intercropping:** Crops are grown together without a specific pattern (e.g., maize and beans).
2. **Row Intercropping:** Crops are planted in rows (e.g., alternate rows of corn and soybeans).
3. **Relay Intercropping:** A second crop is planted before the first crop is harvested (e.g., planting wheat among maturing corn).
4. **Strip Intercropping:** Different crops are grown in alternating strips.

Benefits of Intercropping:

1. **Efficient Resource Use:** Different crops use resources like light, water, and nutrients at different rates and times.
2. **Pest and Weed Control:** Some crops repel pests or suppress weeds for their companions.
3. **Soil Health:** Diverse plant roots and residues improve soil structure and fertility.
4. **Risk Management:** Reduces the risk of total crop failure if one crop performs poorly.

Example:

- Plant maize and beans together:
 - Maize provides support for bean vines to climb.
 - Beans fix nitrogen in the soil, benefiting the maize.

Both practices are used to create sustainable, productive, and environmentally friendly farming systems.



Figure 2.7: Intercropping

(<https://www.researchgate.net/figure/Maize-Cowpea-intercrop>)

3.1. Climate Smart Methods

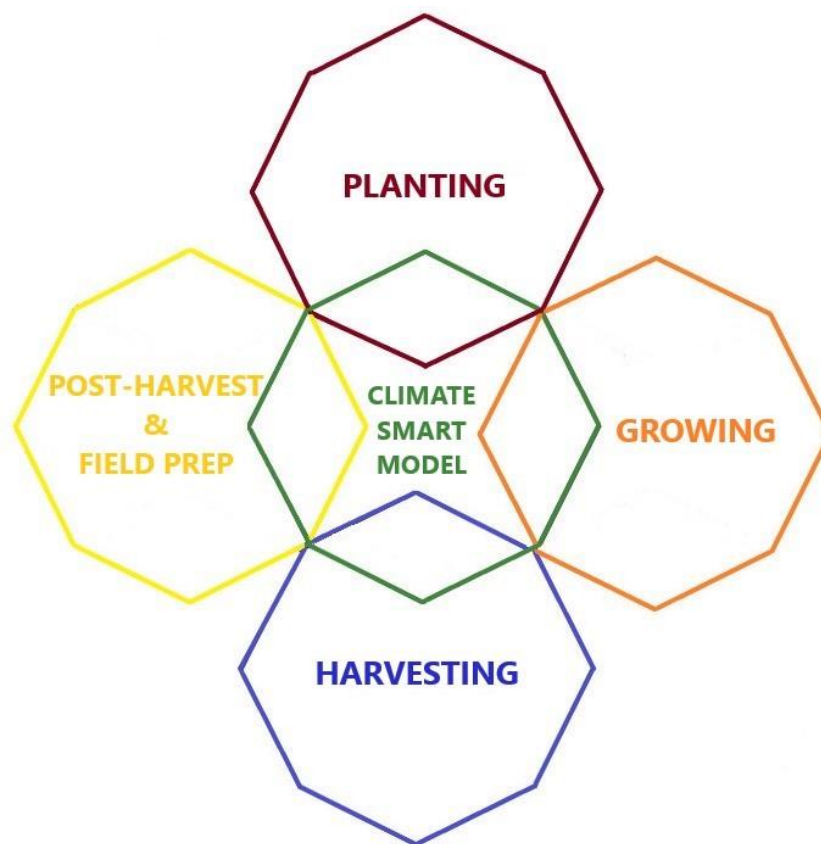


Figure 3.1: Crop Production Processes Interlock

When looking at Climate Smart Practices we must focus on:

- Our crop selection and
- The stages of the crop's development, planting, growing, harvesting and post harvesting activities which brings us back to field preparation for the next production cycle.

Selecting your crop requires experience. You need to look at which crops are adapted to your local environment and climate. With seed production we have been able to create crop varieties that are more tolerant to drought, heat and pests.



ANTICIPATION is Key. You need to anticipate changes in your crop, and the needs for the development of your crop. Anticipate how the weather changes and affects your crop.

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Once you have selected your crop you can start preparing the soil. Different crops have different requirements, Anticipation is the word to remember in agriculture. We need to anticipate the development and needs of our crop as the crop grows.

The preparation stage deals with soil preparation and the installation and maintenance of required field infrastructure which can include our water harvesting methods, water storage (dams and tanks) and irrigation system. Evaporation needs to be minimised so that the most water reaches and is utilised by the plants and the crops development.

Our planting method must ensure we maintain soil health.

The growing season makes use of the irrigation system we have decided on and then the management of our field in terms of pests, diseases and weed management. We have a choice regarding how we are going to manage and use natural or chemical fertilizers, herbicides and pesticides. Crops are generally healthier with less chemical intervention as the crop is more resilient which means that the fruit or produce will be healthier for human and/or animal consumption.

Harvesting is the process of collecting our produce from the field. This can be one of the most labour intensive seasons on the farm depending on the crop and the harvesting technique you have to use.

Climate smart methods include the following:

- Minimum soil disturbance (minimum tillage)
- Crop rotation / intercropping with legumes
- Correct choice of irrigation system
- Use of improved (drought tolerant) seed
- Early planting
- Correct plant population (thinning and gapping)
- 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 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 crop production depletes soil nutrients and requires many chemical fertilizers, herbicides and pesticides
- All this is leading to lower yields, contributing to environmental damage, greenhouse gases and pollution.

3.2. Crops

3.2.1. Cereals

These guidelines provide information on Cereal cultivation, covering essential aspects from land preparation to harvesting to support farmers in achieving optimal yields and managing potential challenges effectively.

3.2.1.1. Maize (*Zea mays*)



Figure 3.2: Maize
(Impuls Africa)

Varieties:

- Early Maturing
- Medium Maturing
- Late Maturing

General Conditions:

- Maize grows well in warm temperatures (between 20°C to 30°C)
- Requires well-drained soils with a pH of 5.5 to 7.0
- Adequate sunshine and moderate rainfall are essential for good growth

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Planting:

- Plant maize seeds at a depth of 3-5 cm in rows spaced 75 cm apart
- Sow 2-3 seeds per hole and later thin to one healthy plant per hole
- Planting can begin at the onset of the rainy season when soil moisture is adequate

Fertilization:

- Apply basal fertilizers like NPK (e.g., 23:21:0) at planting to provide essential nutrients
- Top-dress with nitrogen-based fertilizers at the 4-leaf stage and again at the 8-leaf stage to support plant growth

Important Pests:

- Armyworms: Monitor fields regularly and apply appropriate insecticides when necessary
- Aphids: Use selective insecticides and promote natural predators like ladybugs
- Stem borers: Employ pheromone traps, biological controls, or resistant maize varieties

Diseases:

- Maize streak virus: Plant disease-resistant varieties and control the vector, the maize-carrying leafhopper
- Downy mildew: Avoid planting in high humidity areas and use fungicides preventatively
- Grey leaf spot: Rotate crops, practice good field hygiene, and use resistant varieties

Harvesting:

- Maize is ready for harvest when the cobs turn golden-yellow and the kernels are hard
- Harvest by hand-picking cobs or use machinery for large-scale operations
- Dry the harvested maize to reduce moisture content before storage

3.2.1.2. Sorghum (*Sorghum bicolor*)



Figure 3.3: Sorghum

(<https://foodtank.com/news/2018/04/icrisat-millet-sorghum-forgotten-foods-future/>)

Varieties:

- Sweet Sorghum
- Grain Sorghum
- Forage Sorghum

General Conditions:

- Sorghum thrives in hot temperatures ranging from 25°C to 32°C
- Well-adapted to semi-arid conditions and can withstand drought
- Requires well-drained soils with a pH of 6.0 to 7.0

Planting:

- Plant sorghum seeds at a depth of 2-5 cm and 15-20 cm apart in rows
- Sow seeds when the soil temperature reaches 18°C to ensure germination
- Plant at the onset of the rainy season for optimal growth

Fertilization:

- Apply basal fertilizers such as NPK (e.g., 10:20:10) at planting to provide essential nutrients
- Consider the soil nutrient status and sorghum variety when determining fertilizer needs
- Top-dress with nitrogen fertilizers during the growing season as required

Important Pests:

- Sorghum midge: Monitor fields and use pheromone traps to detect and control this pest
- Sorghum shoot fly: Use resistant varieties or treat with appropriate insecticides
- Aphids and stem borers: Implement integrated pest management practices to manage these pests effectively

Diseases:

- Anthracnose: Plant disease-resistant varieties and employ crop rotation practices
- Downy mildew: Ensure good air circulation and practice field sanitation to reduce disease

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incidence

- Ergot: Avoid planting sorghum in areas with a history of ergot and practice crop rotation

Harvesting:

- Sorghum is typically harvested when the grains are hard, and the crop has dried down
- Use sickles or combine harvesters to harvest sorghum
- Dry sorghum thoroughly before storage to prevent mould growth and ensure quality

3.2.1.3. Millet (*Pennisetum glaucum*)



Figure 3.4: Millet

(<https://www.foodforlife.com/grain-and-seed/millet>)

Varieties:

- Pearl Millet
- Finger Millet
- Foxtail Millet

General Conditions:

- Millet thrives in warm temperatures between 25°C to 35°C
- It can grow in marginal soils but prefers well-drained soils with a pH of 6.0 to 7.0
- Adequate sunlight and moderate rainfall are essential for optimum growth

Planting:

- Plant millet seeds at a depth of 2-5 cm and space seeds 15-30 cm apart in rows
- Sow seeds at the start of the rainy season or when soil temperature is above 18°C
- Plant early maturing varieties if there is a risk of early-season drought

Fertilization:

- Apply balanced fertilizers such as NPK (e.g., 10:20:10) at planting to provide essential nutrients
- Consider top-dressing with nitrogen-based fertilizers during the growing season
- Monitor plant nutrient requirements throughout the growth stages and adjust fertilization as needed

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Weed Control:

- Use pre-emergent herbicides or manual weeding before planting to control weeds
- Hand-weed around millet plants to reduce competition for nutrients and water
- Apply post-emergent herbicides selectively to target weeds without harming millet

Important Pests:

- Millet head miner: Monitor fields regularly and consider using chemical or biological controls
- Shoot fly: Use resistant varieties and appropriate insecticides if necessary
- Stem borers and cutworms: Implement integrated pest management strategies to manage these pests

Diseases:

- Downy mildew: Practice crop rotation and field sanitation to minimize disease pressure
- Blast: Plant resistant varieties and avoid excessive nitrogen fertilization
- Ergot: Remove infected plants promptly and avoid planting in areas with a history of ergot

Harvesting:

- Millet is typically harvested when the grains are firm and mature
- Harvest by hand or use mechanized methods for larger-scale operations
- Thoroughly dry millet grain before storage in well-ventilated areas to prevent mould

These guidelines provide a detailed framework for successful millet cultivation in Zambia, covering essential aspects from land preparation to harvesting to support farmers in achieving optimal millet yields and managing potential challenges effectively.

3.2.2. Legumes

These guidelines aim to provide support for successful legume cultivation, covering essential aspects from land preparation to harvesting to help farmers achieve optimal yields and effectively manage potential challenges throughout the production cycle.

3.2.2.1. Soybeans (Glycine max)



Figure 3.5: Soybeans
(Impuls Africa)

General Conditions:

- Soybeans grow well in warm temperatures ranging from 20°C to 30°C
- Requires well-drained soils with a pH of 6.0 to 7.0
- Adequate sunshine and moderate rainfall are crucial during the growing season

Planting:

- Plant soybean seeds at a depth of 3-5 cm and space seeds 5-10 cm apart in rows
- Sow seeds when the soil temperature is above 20°C for optimal germination
- Plant at the start of the rainy season or when soil moisture is adequate

Irrigation Management:

- Soybeans require consistent soil moisture but are sensitive to waterlogging
- Irrigate when necessary, especially during critical growth stages like flowering and pod development
- Use efficient irrigation methods like drip irrigation to optimize water use

Fertilization:

- Apply balanced fertilizers like NPK (e.g., 20:20:0) at planting to provide essential nutrients
- Top-dress with nitrogen-based fertilizers during flowering to promote pod development
- Consider foliar fertilization for quick nutrient uptake in case of deficiencies

Important Pests:

- Aphids: Monitor fields and use insecticides or introduce natural predators for control
- Pod borers: Implement pheromone traps, biocontrol agents, or resistant varieties
- Whiteflies: Manage through cultural practices, such as planting early or using reflective mulches

Diseases:

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- Soybean rust: Monitor fields regularly and apply fungicides preventatively if needed
- Root rot: Ensure proper drainage and practice crop rotation to reduce disease pressure
- Leaf spot: Use disease-resistant varieties and maintain plant health through appropriate nutrition

Harvesting:

- Soybeans are ready for harvest when 80% of the pods have turned yellow
- Harvest using combine harvesters or by hand-picking, depending on the scale of production
- Dry soybean pods thoroughly post-harvest to reduce moisture levels for storage

3.2.2.2. Groundnuts (*Arachis hypogaea*)



Figure 3.6: Groundnuts
(<https://bizbwana.com/orgs/good-nature-agro>)

General Conditions:

- Groundnuts thrive in warm temperatures ranging between 25°C to 35°C
- Prefers well-drained sandy loam soils with a pH of 6.0 to 7.0
- Requires moderate rainfall for growth but can be supplemental irrigated during dry spells

Planting:

- Plant groundnut seeds 5-10 cm deep, spacing seeds 10-15 cm apart in rows
- Sow seeds after the last frost date or at the start of the rainy season
- Choose planting dates based on soil temperature and moisture availability

Fertilization:

- Apply balanced fertilizers like NPK (e.g., 10:20:10) at planting to meet initial nutrient requirements
- Top-dress with nitrogen fertilizers during flowering to enhance pod development
- Monitor plant growth and nutrient uptake to adjust fertilization practices as needed

Important Pests:

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- Aphids: Monitor fields and use insecticides when aphid populations exceed threshold levels
- Thrips: Employ cultural practices and selective insecticides to manage thrip infestations
- Termites: Implement control measures such as barrier methods and insecticidal baits

Diseases:

- Leaf spot: Practice crop rotation and use disease-resistant varieties to manage leaf spot
- Late leaf spot: Apply fungicides preventatively and practice good field hygiene
- Root rots: Ensure proper drainage and avoid overwatering to minimize root rot incidence

Harvesting:

- Groundnuts are ready for harvest when the leaves turn yellow and pods mature
- Harvest by hand-picking pods carefully to avoid damaging the plants
- Allow harvested pods to dry in a well-ventilated area before threshing and storage

3.2.2.3. Dry Beans (*Phaseolus vulgaris*)



Figure 3.7: Dry Beans
(Impuls Africa)

General Conditions:

- Dry beans grow well in warm temperatures ranging from 20°C to 30°C
- Require well-drained soils with a pH of 6.0 to 7.0
- Optimal growth occurs with moderate rainfall or supplemental irrigation

Planting:

- Plant dry bean seeds at a depth of 3-5 cm, spacing seeds 5-10 cm apart in rows
- Sow seeds at the beginning of the rainy season for best germination

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- Choose planting dates based on soil temperature and moisture availability

Irrigation Management:

- Provide supplemental irrigation during dry spells or critical growth stages
- Ensure proper drainage to prevent waterlogging, which can lead to root diseases
- Utilize efficient irrigation methods such as drip irrigation to conserve water

Fertilization:

- Apply balanced fertilizers, such as NPK 10:20:10, at planting to provide essential nutrients
- Top-dress with nitrogen-based fertilizers during flowering for pod development
- Monitor plant nutrient requirements and adjust fertilization practices accordingly

Important Pests:

- Aphids: Monitor fields and use insecticides if aphid populations become problematic
- Bean Beetles: Hand-pick beetles off plants or use insecticidal soap to control infestations
- Thrips: Implement cultural and chemical control methods to manage thrips effectively

Diseases:

- Common Bean Rust: Monitor for rust symptoms and apply fungicides preventatively
- Anthracnose: Use disease-resistant varieties and practice crop rotation to reduce disease pressure
- Fusarium Wilt: Avoid planting in fields with a history of Fusarium and practice good field sanitation

Harvesting:

- Dry beans are ready for harvest when pods start to dry and turn yellow
- Handpick dry bean pods carefully to avoid damage
- Allow harvested beans to fully dry before threshing and storage

3.2.2.4. Pigeon Peas (*Cajanus Cajan*)



Figure 3.8: Pigeon Pea

(<https://wikifarmer.com/library/en/article/harvesting-drying-processing-and-storage-of-pigeon-pea>)

General Conditions:

- Pigeon peas grow well in warm temperatures between 20°C to 30°C
- Prefer well-drained sandy loam soils with a pH ranging from 6.0 to 7.5
- Require moderate rainfall or supplemental irrigation, especially during flowering and pod development stages

Land Preparation:

- Plow the land to a depth of 15-20 cm to create a suitable seedbed
- Incorporate organic matter like compost or farmyard manure to enhance soil fertility
- Conduct soil tests to determine nutrient levels and adjust soil pH if necessary

Planting:

- Plant pigeon pea seeds at a depth of 3-5 cm, spacing seeds 10-15 cm apart in rows
- Sow seeds at the beginning of the rainy season or when soil moisture is adequate
- Choose planting dates based on temperature considerations and water availability

Fertilization:

- Apply balanced fertilizers like NPK (e.g., 10:20:10) at planting to meet initial nutrient requirements
- Top-dress with nitrogen-based fertilizers during flowering for optimal pod development
- Monitor plant nutrient requirements and adjust fertilization according to crop growth stages

Important Pests:

- Pod Borers: Implement pheromone traps and biocontrol agents to manage pod borer infestations
- Aphids: Monitor fields and use insecticides if aphid populations are high
- Pod Sucking Bugs: Regularly inspect plants and use appropriate insecticides for control

Diseases:

- Fusarium Wilt: Rotate crops and ensure proper drainage to prevent fusarium wilt

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- Phytophthora Blight: Use disease-resistant varieties and fungicides as preventative measures
- Leaf Spot: Practice good field hygiene and use fungicides when necessary

Harvesting:

- Harvest pigeon peas when the pods turn yellow and the seeds are fully developed
- Time harvesting to avoid seed shattering
- Thoroughly dry harvested pods before threshing for storage or processing

3.2.2.5. Cowpeas (*Vigna unguiculata*)



Figure 3.9: Cowpea

(<https://wikifarmer.com/library/en/article/complete-guide-to-growing-and-harvesting-cowpeas-planting-tips-and-care>)

General Conditions:

- Cowpeas thrive in warm temperatures between 25°C to 35°C
- Prefer well-drained sandy loam soils with a pH of 5.5 to 7.0
- Require sufficient rainfall or supplementary irrigation during dry periods

Planting:

- Plant cowpea seeds at a depth of 3-5 cm, spacing seeds 10-15 cm apart in rows
- Sow seeds after the last frost date or at the onset of the rainy season
- Choose planting dates based on soil temperature and water availability

Irrigation Management:

- Provide supplemental irrigation during critical growth stages such as flowering and pod development
- Avoid overwatering to prevent waterlogging and root diseases

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- Utilize efficient irrigation methods like drip irrigation to conserve water

Fertilization:

- Apply balanced fertilizers, such as NPK (e.g., 10:20:10) at planting to meet initial nutrient requirements
- Top-dress with nitrogen-based fertilizers during flowering for improved pod development
- Adjust fertilization practices based on plant growth and nutrient uptake

Important Pests:

- Aphids: Monitor fields and use insecticides if aphid populations exceed threshold levels
- Thrips: Implement cultural and chemical control measures to manage thrips infestations
- Pod Borers: Employ biological control methods and pheromone traps to reduce pod borer damage

Diseases:

- Cowpea Mosaic Virus: Use disease-resistant varieties and control aphid vectors to manage this viral disease
- Root Rot: Ensure proper soil drainage and avoid overwatering to prevent root rot infections
- Powdery Mildew: Use fungicides preventatively and practice good field sanitation to control powdery mildew

Harvesting:

- Harvest cowpeas when the pods are filled and seeds are mature but still tender
- Handpick pods carefully to avoid damaging plants
- Allow harvested cowpeas to dry before threshing and storage

3.2.3. Oilseeds

These production guidelines cover essential aspects of sunflower cultivation, providing detailed instructions from land preparation to harvesting and emphasizing pest and disease management strategies to support farmers in maximizing sunflower yields effectively.

3.2.3.1. Sunflower (*Helianthus annuus*)



Figure 3.10: Sunflower

(<https://www.moananursery.com/2023/08/15/from-seed-to-bloom-your-comprehensive-guide-to-growing-sunflowers/>)

General Conditions:

- Sunflowers thrive in warm temperatures averaging 20°C to 30°C
- Require well-drained soils with a pH of 6.0 to 7.5
- Adequate sunlight and moderate rainfall are essential during the growing season

Land Preparation:

- Plow the land to a depth of 15-20 cm to create a suitable seedbed
- Incorporate organic matter like compost or manure to improve soil fertility
- Conduct soil tests to determine nutrient deficiencies and adjust soil pH if needed

Planting:

- Plant sunflower seeds at a depth of 2-5 cm, spacing seeds 20-30 cm apart in rows
- Sow seeds when the soil temperature is above 18°C for optimal germination
- Plant in well-drained soil after the last frost date

Irrigation Management:

- Sunflowers are moderately drought-tolerant but benefit from supplemental irrigation
- Provide water during critical growth stages, especially during flowering and seed development
- Employ efficient irrigation methods such as drip irrigation to conserve water

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Fertilization:

- Apply balanced fertilizers like NPK (e.g., 10:20:10) at planting to provide essential nutrients
- Top-dress with nitrogen-based fertilizers during the growing season to support plant growth
- Adjust fertilization based on soil conditions and plant nutrient requirements

Weed Control:

- Use pre-emergent herbicides or manual weeding before planting to control weeds
- Mulching can help suppress weed growth around sunflower plants
- Post-emergent herbicides may be necessary to manage weeds during the growing season

Important Pests:

- Sunflower Moth: Monitor and use insecticides if necessary to control sunflower moth infestations
- Banded Sunflower Moth: Employ pheromone traps and insecticides for banded sunflower moth management
- Sunflower Stem Weevil: Use chemical control methods and agronomic practices to reduce stem weevil damage

Diseases:

- Downy Mildew: Practice crop rotation and use resistant varieties to manage downy mildew
- Rust: Monitor for rust symptoms and use fungicides preventatively
- Verticillium Wilt: Avoid planting sunflowers in fields with a history of Verticillium wilt and practice good soil management

Harvesting:

- Harvest sunflowers when the backs of the heads turn yellow and the seeds are mature
- Cut sunflower heads and allow them to dry before seed extraction
- Thresh seeds and store them in well-ventilated containers for further processing

3.2.4. Horticulture

3.2.4.1. Cabbage (*Brassica oleracea*)



Figure 3.11: Cabbages
(Impuls Africa)

Type of Plant: Cabbage (*Brassica oleracea*) is a cool-season leafy vegetable that produces heads of thick leaves. Other types are Chinese Cabbage and Savoy Cabbage

Other Family Members:

Other family members of cabbage in the Brassicaceae family include broccoli, cauliflower, Brussels sprouts, kale, and collard greens.

General Conditions:

- **Climate:** Cabbage thrives in cool to moderate temperatures between 15°C to 25°C.
- **Soil:** Well-draining, fertile soil with a pH of 6.0 to 7.5 is preferable for cabbage cultivation.
- **Water:** Consistent moisture is crucial for cabbage growth, especially during the head development stage.

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Planting:

- Spacing: Plant cabbage seedlings 30-45 cm apart in rows with 45-75 cm spacing between rows to accommodate plant growth.
- Method: Start seeds indoors in seed trays or seedbeds 6-8 weeks before the last frost, then transplant the seedlings.

Fertilization:

- Pre-Planting: Incorporate well-decomposed compost or aged manure into the soil before planting to enrich soil fertility.
- Side-Dressing: Apply a balanced fertilizer during the growing season, focusing on nitrogen, phosphorus, and potassium to support cabbage growth.

Important Pests:

- Cabbage Worms: Common pests like cabbage loopers and diamondback moths that feed on cabbage leaves.
- Aphids: Small insects that can infest cabbage crops, leading to stunted growth and potential disease transmission.
- Cabbage Root Maggots: Larvae that attack cabbage roots, causing wilting and decreased plant vigour.

Diseases:

- Black Rot: Bacterial disease causing V-shaped lesions on cabbage leaves, leading to plant decline.
- Clubroot: Soilborne disease resulting in deformed roots and stunted growth in cabbage plants.
- Powdery Mildew: Fungal infection characterized by a white powdery growth on cabbage leaves, affecting plant health.

Harvesting:

- Maturity: Harvest cabbage heads when they are firm, compact, and have reached the desired size, typically 50-100 days after planting.
- Cutting: Use a sharp knife to cut the cabbage head at ground level, ensuring a clean and precise cut.
- Storage: Store harvested cabbage heads in a cool, humid environment to maintain freshness and longevity.



Figure 3.12: Diamondback Moth
(Photograph by Lyle Buss, University of Florida)

3.2.4.2. Lettuce (*Lactuca Sativa*)



Figure 3.13: Lettuce
(Impuls Africa)

Type of Plant: Lettuce (*Lactuca sativa*) is a leafy green vegetable that is grown for its edible leaves. It is a fast-growing, cool-season crop.

Other Family Members:

Lettuce belongs to the Asteraceae family, which includes other vegetables like chicory, endive, and radicchio.

General Conditions:

- **Climate:** Lettuce thrives in cooler temperatures between 10°C to 24°C. Hot temperatures can lead to bolting (premature flowering).
- **Soil:** Well-draining, fertile soil with a pH of 6.0 to 7.0 is ideal for lettuce cultivation.
- **Water:** Adequate and consistent moisture is crucial for lettuce growth, but avoid waterlogged conditions.

Planting:

- **Spacing:** Plant lettuce seeds or seedlings 20-30 cm apart in rows with a spacing of 30-45 cm between rows to allow for proper growth and air circulation.
- **Method:** Directly sow seeds or transplant seedlings into the garden in early spring or fall for best results.

Fertilization:

- **Pre-Planting:** Incorporate organic matter such as compost or well-aged manure into the soil before planting to improve soil fertility.
- **Side-Dressing:** Apply a balanced fertilizer, providing a steady supply of nitrogen, phosphorus, and potassium throughout the growing season.

Important Pests:

- **Aphids:** Small insects that can damage lettuce by feeding on the leaves and spreading diseases.
- **Slugs and Snails:** These pests can feed on lettuce leaves, leaving behind holes and damage.
- **Cutworms:** Larvae that chew on the base of young lettuce plants, causing them to wilt and die.

Diseases:

- **Lettuce Drop:** Fungal disease that affects the roots and can cause lettuce plants to collapse.
- **Downy Mildew:** Fungal infection that appears as yellow lesions on the undersides of lettuce leaves.
- **Botrytis Rot:** Fungal disease that causes brown spots and decay on lettuce leaves.

Harvesting:

- **Leaf Lettuce:** You can start harvesting individual leaves when they reach a usable size, or you can cut the entire plant about 1 inch above the soil level.
- **Head Lettuce:** Harvest head lettuce by cutting the entire head at the base of the plant.
- **Romaine Lettuce:** Harvest by cutting the outer leaves as needed, allowing the inner leaves to continue growing.

3.2.4.3. Peppers (*Capsicum annuum*)



Figure 3.14: Different types of peppers
(freepik.com)

Type of Plant: Pepper plants (*Capsicum annuum*) are warm-season vegetables known for producing fruits in various colours, sizes, and levels of spiciness.

Other Family Members:

Peppers belong to the Solanaceae family, which includes other popular crops like tomatoes, potatoes, and eggplants.

General Conditions:

- **Climate:** Peppers thrive in warm to hot temperatures between 20°C to 30°C with plenty of sunlight.
- **Soil:** Well-draining, fertile soil rich in organic matter with a pH of 6.0 to 6.8 is ideal for pepper cultivation.
- **Water:** Peppers require regular watering, especially during flowering and fruiting stages, but avoid

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waterlogged conditions.

Planting:

- **Spacing:** Plant pepper seedlings 40-60 cm apart in rows with row spacing of 60-90 cm to allow for proper growth and airflow.
- **Method:** Start seeds indoors 8-10 weeks before the last frost date for transplanting or directly sow seeds in well-warmed soil.

Fertilization:

- **Pre-Planting:** Incorporate compost or well-rotted manure into the soil before planting to provide essential nutrients.
- **Side-Dressing:** Apply a balanced fertilizer rich in phosphorus and potassium during the growing season to support flower and fruit development.

Important Pests:

- **Aphids:** Small insects that can damage pepper plants by sucking sap and spreading viruses.
- **Spider Mites:** These pests can cause yellowing and stippling on pepper leaves, affecting plant health.
- **Pepper Maggots:** Larvae that bore into pepper fruits, leading to fruit rot and spoilage.

Diseases:

- **Blossom End Rot:** Physiological disorder caused by calcium deficiency, resulting in dark, sunken spots on pepper fruits.
- **Powdery Mildew:** Fungal disease that appears as a white powdery growth on pepper leaves, affecting photosynthesis.
- **Bacterial Spot:** Bacterial disease causing dark, sunken lesions on pepper fruits and leaves.

Harvesting:

- **Maturity:** Harvest peppers when they have reached the desired size and color, usually 60-90 days after planting.
- **Cutting:** Use sharp pruners or scissors to cut peppers from the plant, leaving a short stem to prevent damage to the fruit.
- **Storage:** Store harvested peppers in a cool, dry place or refrigerate them to maintain freshness and prolong shelf life.

3.2.4.4. Tomato (*Solanum lycopersicum*)



Figure 3.15: Tomato sorting and packing
(Impuls Africa)



Figure 3.16: Tomato vines
(Impuls Africa)

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Type of Plant: Tomato plants (*Solanum lycopersicum*) are warm-season, tender perennials cultivated as annuals for their edible fruits.

Other Family Members:

Tomatoes belong to the Solanaceae family, which includes other crops like peppers, eggplants, and potatoes.

General Conditions:

- **Climate:** Tomatoes thrive in warm to hot temperatures between 20°C to 30°C with at least 6-8 hours of sunlight daily.
- **Soil:** Well-draining, fertile soil enriched with organic matter, having a pH range of 6.0 to 6.8, is ideal for tomato cultivation.
- **Water:** Tomatoes need consistent moisture, especially during fruit setting, without waterlogging.

Planting:

- **Spacing:** For determinate varieties, plant tomatoes 45-60 cm apart in rows with a spacing of 60-90 cm. For indeterminate varieties, increase spacing to 60-90 cm between plants.
- **Method:** Plant tomatoes from transplants instead of seeds directly in the ground to ensure a healthy start.

Fertilization:

- **Pre-Planting:** Mix compost or well-rotted manure into the soil before planting to provide essential nutrients.
- **Side-Dressing:** Apply a balanced fertilizer high in phosphorus and potassium during the growing season to support flowering and fruit production.

Important Pests:

- **Tomato Hornworm:** Large green caterpillars that feed on tomato plants, defoliating them rapidly.
- **Aphids:** Small insects that extract sap from tomato plants, weakening them and spreading diseases.
- **Whiteflies:** Small white insects that cause damage by feeding on tomato plant leaves and transmitting viruses.

Diseases:

- **Early Blight:** Fungal disease causing dark concentric rings on tomato leaves, leading to defoliation.
- **Late Blight:** Destructive fungal disease resulting in brown lesions on leaves, stems, and fruits.
- **Blossom End Rot:** Physiological disorder triggered by calcium deficiency, causing black sunken areas on tomato fruits.

Harvesting:

- **Maturity:** Harvest tomatoes when they reach ripe colors (red, orange, yellow, etc.) and have firm texture, typically 60-85 days after planting.
- **Picking:** Gently twist or cut ripe tomatoes from the stem using pruning shears, leaving a small portion of the stem attached.
- **Storage:** Store harvested tomatoes at room temperature until fully ripe, then refrigerate to prolong shelf life for a few days.

3.2.4.5. Onion (*Allium cepa*)



Figure3.17: Onions field
(Impuls Africa)

Type of Plant:

Onions (*Allium cepa*) are cool-season, biennial plants grown as annuals for their edible bulbs.

Other Family Members:

Onions belong to the Amaryllidaceae family, which includes other crops like garlic, leeks, and chives.

General Conditions:

- **Climate:** Onions prefer cooler temperatures between 13°C to 24°C for optimal growth.
- **Soil:** Well-draining, fertile soil with a pH of 6.0 to 7.5 is suitable for onion cultivation.
- **Water:** Onions require consistent moisture but can be sensitive to waterlogging.

Planting:

- **Spacing:** Plant onion sets or seedlings 10-15 cm apart in rows with a spacing of 25-30 cm.
- **Method:** Onions can be grown from seeds, sets, or transplants, with sets being the most common method in commercial production.

Fertilization:

- **Pre-Planting:** Incorporate well-decomposed compost or aged manure into the soil before planting to provide essential nutrients.
- **Side-Dressing:** Apply nitrogen-rich fertilizer during the growing season to support leaf development and bulb formation.

Important Pests:

- **Onion Thrips:** Small insects that suck plant juices, causing damage to onion leaves and reducing yield.
- **Onion Maggots:** Larvae that feed on onion roots, leading to wilting and poor bulb development.

- **Onion Leaf Miners:** Larvae that tunnel inside onion leaves, creating white or brown trails and affecting plant health.

Diseases:

- **Botrytis Neck Rot:** Fungal disease causing a watery rot at the neck of onion bulbs, leading to storage losses.
- **Downy Mildew:** Fungal infection characterized by grey or purple lesions on onion leaves, affecting plant vitality.
- **Pink Root:** Soilborne disease resulting in pink discoloration and decay of onion roots, leading to stunted growth.

Harvesting:

- **Maturity:** Harvest onions when the tops have fallen over and started to dry, typically 100-120 days after planting.
- **Curing:** Pull onions from the ground and let them dry in a well-ventilated area for 2-3 weeks to enhance storage quality.
- **Storage:** Store cured onions in a cool, dark, and dry place with good air circulation to prevent decay and prolong shelf life.

3.2.4.6. Butternut and Pumpkin



Figure 3.18: Pumpkin Sorting Area
(Impuls Africa)

Type of Plant:

- **Butternut Squash (*Cucurbita moschata*):** Butternut squash is a type of winter squash with a sweet, nutty flavour, and it belongs to the Cucurbitaceae family.
- **Pumpkin (*Cucurbita pepo* or *Cucurbita maxima*):** Pumpkins are a type of winter squash known for their large, round shape and vibrant orange colour. They also belong to the Cucurbitaceae family.

Other Family Members:

Butternut squash and pumpkins are part of the Cucurbitaceae family, which includes other plants like zucchini, cucumber, and melons.

General Conditions:

- Climate: Butternut and pumpkin plants thrive in warm temperatures between 18°C to 27°C with full sun exposure.
- Soil: Well-draining loamy soil rich in organic matter, with a pH level of 6.0 to 7.0, is ideal for butternut and pumpkin cultivation.
- Water: These plants require regular watering, especially during flowering and fruit development, while avoiding waterlogging.

Planting:

- Spacing: Plant butternut and pumpkin seeds or seedlings 60-90 cm apart in rows with a spacing of 120-180 cm.
- Depth: Sow seeds at a depth of 2.5-5 cm in well-prepared soil for optimal germination.

Fertilization:

- Pre-Planting: Incorporate organic matter like compost or well-aged manure into the soil before planting to improve soil fertility.
- Side-Dressing: Apply a balanced fertilizer or a nitrogen-rich fertilizer during the growing season to support plant growth and fruit development.

Important Pests:

- Squash Bugs: Insects that feed on plant sap, weakening the plant and causing damage to fruits.
- Vine Borers: Larvae that burrow into stems, leading to wilting and plant collapse.
- Cucumber Beetles: Pests that feed on leaves, transmit diseases, and can affect plant health.

Diseases:

- Powdery Mildew: Fungal disease that appears as a white powdery coating on leaves, reducing photosynthesis.
- Downy Mildew: Fungal infection causing yellow lesions on leaves, weakening plant vitality.
- Anthracnose: Fungal disease resulting in dark lesions on leaves and fruits, leading to rot.

Harvesting:

- Maturity: Harvest butternut squash and pumpkins when they have reached full size and the rinds are hard, typically 80-120 days after planting.
- Cutting: Cut the fruits from the vine using a sharp knife or pruning shears, leaving a short stem attached to the fruit.
- Curing: Cure harvested butternut squash and pumpkins in a warm, dry area for 10-14 days to improve flavour and storage quality.

3.2.4.7. Watermelon



Figure 3.19: Watermelon harvesting
(Impuls Africa)

Type of Plant: Watermelon (*Citrullus lanatus*): Watermelon is a popular summer fruit that belongs to the Cucurbitaceae family, known for its sweet, juicy flesh and high water content.

Other Family Members:

Watermelon is part of the Cucurbitaceae family, which also includes cucumbers, pumpkins, and squash.

General Conditions:

- **Climate:** Watermelons thrive in warm to hot temperatures between 24°C to 32°C with plenty of sunlight.
- **Soil:** Well-drained, fertile soil rich in organic matter with a pH of 6.0 to 6.8 is ideal for watermelon cultivation.
- **Water:** Watermelons need regular watering, especially during fruit development, while avoiding waterlogged conditions.

Planting:

- **Spacing:** Plant watermelon seeds or seedlings 120-180 cm apart in rows with a spacing of 180-240 cm.
- **Depth:** Sow seeds at a depth of 2.5-5 cm in well-prepared soil for optimal germination.

Fertilization:

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- **Pre-Planting:** Mix compost or aged manure into the soil before planting to provide essential nutrients.
- **Side-Dressing:** Apply a balanced fertilizer or a phosphorus-rich fertilizer during the growing season to support flowering and fruit set.

Important Pests:

- **Aphids:** Small insects that feed on plant sap, causing leaf curling and reducing plant vigor.
- **Spider Mites:** Tiny pests that damage leaves by sucking sap, leading to webs and reduced photosynthesis.
- **Cucumber Beetles:** Pests that feed on leaves and transmit diseases, affecting plant health.

Diseases:

- **Powdery Mildew:** Fungal disease appearing as a white powdery layer on leaves, affecting photosynthesis.
- **Fusarium Wilt:** Soilborne fungal disease causing yellowing, wilting, and eventual death of plants.
- **Anthracnose:** Fungal infection resulting in dark lesions on leaves and fruits, causing rot.

Harvesting:

- **Maturity:** Harvest watermelons when they reach maturity based on the variety's expected days to maturity and external signs like the development of a creamy patch on the underside.
- **Cutting:** Cut watermelons from the vine using a sharp knife or pruning shears, leaving a short stem attached to the fruit.
- **Curing:** Cure harvested watermelons in a warm, dry place for a few days for improved sweetness before consumption.

3.2.4.8. Green Beans (Legume)



Figure 3.20: Green beans on the vine

(<https://www.dripworks.com/resources/growing-guides/green-beans-growing-guide>)

Type of Plant:

Green beans, also known as string beans or snap beans, belong to the legume family and are cultivated for their tender, edible pods.

Other Family Members:

Green beans belong to the Fabaceae family, also known as the Leguminosae family. Other members include peas, lentils, and chickpeas.

General Conditions:

- **Climate:** Green beans thrive in warm temperatures between 18°C to 27°C with plenty of sunlight.
- **Soil:** Well-drained soil rich in organic matter with a pH level of 6.0 to 7.0 is ideal for green bean cultivation.
- **Water:** Green beans require consistent moisture, especially during flowering and pod development, avoiding water stress.

Planting:

- **Spacing:** Plant green bean seeds or seedlings 5-8 cm apart in rows with a spacing of 45-60 cm.
- **Depth:** Sow seeds at a depth of 2.5-5 cm in loose, well-drained soil for optimal germination.

Fertilization:

- **Pre-Planting:** Mix compost or well-decomposed manure into the soil before planting to improve soil fertility.
- **Side-Dressing:** Apply a balanced fertilizer or a nitrogen-rich fertilizer during the growing season to promote healthy plant growth and pod development.

Important Pests:

- Aphids: Small insects that can damage green bean plants by sucking sap and causing distortion of plant tissues.
- Bean Leaf Beetle: Pests that feed on leaves and pods, leading to reduced plant vigor and yield.
- Cutworms: Larvae that may cut down young green bean plants at the base, affecting crop establishment.

Diseases:

- Powdery Mildew: Fungal disease that manifests as white powdery spots on green bean leaves, impacting photosynthesis.
- Anthracnose: Fungal infection causing dark lesions on leaves and pods, leading to rot and reduced yield.
- Bean Common Mosaic Virus: Viral disease resulting in distorted leaves, stunted growth, and reduced bean pod development.

Harvesting:

- Maturity: Harvest green beans when they reach the desired length (usually 10-15 cm), before the seeds inside the pods fully develop.
- Picking: Gently pick green beans by hand or use pruners to avoid damaging the plant, continuing to pick regularly to encourage new pod production.
- Storage: Store freshly harvested green beans in a cool, humid environment or refrigerate them to maintain freshness for a few days.

3.2.4.9. Spinach (*Spinacia oleracea*):



Figure 3.21: Spinach field

(<https://www.greenlife.co.ke/spinach-nutrition/>)

Type of Plant:

Spinach (*Spinacia oleracea*): Spinach is a leafy green vegetable rich in vitamins and minerals, belonging to the Amaranthaceae family.

Other Family Members:

Spinach is part of the Amaranthaceae family, which includes crops like Swiss chard and beets.

General Conditions:

- Climate: Spinach grows well in cool to moderate temperatures between 10°C to 24°C.
- Soil: Well-drained, fertile soil with a pH of 6.5 to 7.0 is suitable for spinach cultivation.
- Water: Spinach requires consistent moisture, especially during the growing season, while avoiding waterlogged conditions.

Planting:

- Spacing: Plant spinach seeds or seedlings 15-30 cm apart in rows with a spacing of 30-45 cm.
- Depth: Sow spinach seeds at a depth of 1-2 cm in loose, well-drained soil for optimal germination.

Fertilization:

- Pre-Planting: Incorporate compost or well-rotted manure into the soil before planting to improve soil fertility.
- Side-Dressing: Apply a balanced fertilizer or a nitrogen-rich fertilizer during the growing season to support leafy growth.

Important Pests:

- Aphids: Small insects that can damage spinach by sucking sap and causing leaf distortion.
- Leaf Miners: Larvae that tunnel inside spinach leaves, leading to leaf damage and reduced plant vigour.
- Caterpillars: Larvae that feed on spinach leaves, causing holes and reducing the plant's photosynthetic capacity.

Diseases:

- Downy Mildew: Fungal disease causing yellow spots on spinach leaves, leading to leaf wilting and rot.
- Powdery Mildew: Fungal infection appearing as a powdery white substance on spinach leaves, affecting plant health.
- Fusarium Wilt: Soilborne fungal disease causing yellowing, wilting, and decline in spinach plants.

Harvesting:

- Maturity: Harvest spinach leaves when they reach the desired size, typically 4-6 weeks after planting.
- Cutting: Harvest outer leaves first by cutting them at the base, allowing the inner leaves to continue growing for multiple harvests.
- Storage: Store harvested spinach leaves in a cool, humid environment or refrigerate them to maintain freshness and extend shelf life.

3.2.4.10. Rape



Figure 3.22: Rape field
(Impuls Africa)

Type of Plant:

Rape (*Brassica napus* L): Rape, scientifically known as *Brassica napus* L, is an oilseed crop cultivated for its oil-rich seeds. It is a member of the Brassicaceae family.

Other Family Members:

Other members of the Brassicaceae family include crops like mustard, cabbages, broccoli, and Brussels sprouts.

General Conditions:

- **Climate:** Rape thrives in temperate climates but can adapt to cool to moderate temperatures ranging between 10°C to 25°C during the growing season.
- **Soil:** Well-drained, fertile soil with a pH level between 6.0 to 7.5 is ideal for growing Rape in Zambia.
- **Water:** Adequate moisture is essential, and proper drainage practices are required to prevent waterlogging.

Planting:

- **Spacing:** Plant the seeds of Rape at a spacing of around 10-20 cm apart in rows. Maintain row spacing of 45-75 cm to provide sufficient room for growth and airflow.
- **Depth:** Sow the seeds at a depth of approximately 1-2 cm in well-prepared soil to ensure successful germination and establishment.

Fertilization:

- **Pre-Planting:** Improve soil fertility by incorporating well-rotted organic matter such as compost or manure before planting.

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- Side-Dressing: Apply a balanced fertilizer with a higher nitrogen content during the growing season to support vegetative growth and seed formation.

Important Pests:

- Flea Beetles: These small insects can cause damage to seedlings by creating small holes in the leaves.
- Cabbage Worms: Larvae that feed on Rape leaves, leading to reduced plant vigor and photosynthesis.
- Aphids: Sap-sucking insects that distort plant growth and can transmit diseases.

Diseases:

- Sclerotinia Stem Rot: A fungal disease causing white mold on stems, resulting in wilting and plant death.
- Blackleg: A fungal infection causing dark lesions on stems and leaves, negatively impacting plant health.
- Clubroot: A soilborne disease leading to root swelling and stunted growth in Rape plants.

Harvesting:

- Maturity: Harvest Rape seeds when they have reached maturity but are not fully dried. Ensure they are firm and not easily crushed.
- Cutting: Harvest Rape plants close to the ground when the seeds are ready for harvesting. Use appropriate tools and machinery for efficient harvesting.
- Storage: Store the harvested Rape seeds in cool, dry conditions to maintain their quality and prevent spoilage.

3.2.4.11. Impwa (*Solanum aethiopicum*)



Figure 3.23: Impwa

(<https://www.facebook.com/photo/?fbid=3840922632692400&set=pcb.3840922942692369>)

Type of Plant:

Impwa (*Solanum aethiopicum*): Impwa is a leafy vegetable commonly grown in Zambia for its edible leaves and fruits. It belongs to the Solanaceae family.

Other Family Members:

Other members of the Solanaceae family include crops like tomatoes, bell peppers, eggplants, and potatoes.

General Conditions:

- Climate: Impwa thrives in warm to hot climates, with temperatures ranging from 20°C to 30°C during the growing season.
- Soil: Well-drained, fertile soil with organic matter content is preferred. A pH level around 6 to 7 is suitable for Impwa cultivation.
- Water: Adequate moisture is essential for the growth of Impwa. Ensure consistent watering, especially during dry periods.

Planting:

- Spacing: Plant Impwa seedlings or seeds at a spacing of around 30-40 cm apart in rows to allow for proper growth and development.
- Depth: Plant seedlings at the same depth as they were in the nursery trays for successful establishment.

Fertilization:

- Pre-Planting: Incorporate well-decomposed compost or manure into the soil before planting to improve soil fertility.
- Side-Dressing: Apply a balanced fertilizer during the growing season to provide necessary nutrients for healthy plant growth and higher yields.

Important Pests:

- Aphids: Small insects that feed on plant sap, causing distortion in plant growth and potential disease transmission.
- Flea Beetles: These pests can cause damage by feeding on the leaves, resulting in small holes and reduced plant vigor.
- Cutworms: Larvae of certain moth species that can cut down young Impwa plants at the stem base. Protect seedlings with cutworm collars.

Diseases:

- Early Blight: Fungal disease causing dark spots on leaves, affecting plant health and reducing yields.
- Powdery Mildew: Fungal infection leading to white powdery growth on leaves, hindering photosynthesis and plant growth.
- Bacterial Wilt: Bacterial disease causing wilting and yellowing of leaves, leading to plant death if not managed.

Harvesting:

- Leaf Harvesting: Harvest Impwa leaves as needed once they have grown to a desirable size, typically from the outer parts of the plant to encourage continuous growth.
- Fruit Harvesting: Harvest Impwa fruits when they have reached a mature size and color for consumption. Use pruning shears to avoid damaging the plant.
- Storage: Store harvested Impwa leaves and fruits in a cool, dry place or refrigerate them to maintain freshness for an extended period.

3.2.4.12. Eggplant (*Solanum melongena*)



Figure 3.24: Eggplant
(<https://pafeplantscenter.com>)

Type of Plant:

Eggplant (*Solanum melongena*): Eggplant is a popular vegetable in Zambia, known for its edible fruit. It belongs to the Solanaceae family.

Other Family Members:

Other members of the Solanaceae family include Impwa (*Solanum aethiopicum*), tomatoes, bell peppers, and potatoes.

General Conditions:

- **Climate:** Eggplant thrives in warm to hot climates, with temperatures ranging from 20°C to 30°C during the growing season in Zambia.
- **Soil:** Well-drained, fertile soil with adequate organic matter content is preferred for Eggplant cultivation. The pH level of soil should be around 6 to 7.
- **Water:** Eggplants require consistent moisture, especially during the growing season. Proper watering practices are crucial for healthy plant development.

Planting:

- **Spacing:** Plant Eggplant seedlings or seeds approximately 50-60 cm apart in rows to allow sufficient space for growth and development.
- **Depth:** Plant Eggplant seedlings at the same depth as they were in the nursery trays to ensure proper establishment and growth.

Fertilization:

- **Pre-Planting:** Prior to planting, incorporate well-decomposed compost or manure into the soil to improve soil fertility and provide essential nutrients for Eggplant growth.
- **Side-Dressing:** Apply a balanced fertilizer during the growing season to support healthy vegetative growth and fruit development in Eggplant.

Important Pests:

- **Aphids:** Sap-sucking insects that can damage Eggplant plants by feeding on the plant sap and potentially transmitting diseases.
- **Spider Mites:** These tiny pests can cause stippling on leaves, affecting the overall health of Eggplant plants.
- **Fruit Borers:** Larvae that tunnel into Eggplant fruits, leading to fruit damage and reduced yields.

Diseases:

- **Early Blight:** Fungal disease characterized by dark spots on leaves, affecting plant health and productivity.
- **Verticillium Wilt:** Fungal infection causing wilting and yellowing of leaves, leading to plant decline if not managed.
- **Bacterial Spot:** Bacterial disease resulting in dark lesions on leaves and fruit, impacting the quality of Eggplant produce.

Harvesting:

- **Maturity:** Harvest Eggplant fruits when they have reached a mature size and color suitable for consumption. Fruits should be firm and have a glossy appearance.
- **Cutting:** Use pruning shears to harvest Eggplant fruits, cutting the stem carefully to avoid damaging the plant.
- **Storage:** Store harvested Eggplant fruits in a cool, dry place to maintain freshness and quality for an extended period.

3.2.4.13. Ocra (*Abelmoschis esculentus* L)



Figure 3.25: Ocra

(<https://thefarmersjournal.com/okra-production-guide-step-by-step/>)

Type of Plant:

Okra: Okra, also known as lady's fingers or ochro, is a warm-season vegetable with edible green pods. It belongs to the Malvaceae family.

Other Family Members:

Other members of the Malvaceae family include crops like cotton and hibiscus.

General Conditions:

- **Climate:** Okra thrives in warm to hot climates, with temperatures between 25°C to 35°C during the growing season in Zambia.
- **Soil:** Well-drained, loamy soil rich in organic matter is optimal for Okra cultivation. The soil pH should ideally be around 6.0 to 7.0.
- **Water:** Okra plants require consistent soil moisture, especially during flowering and fruiting stages. Adequate watering is crucial for proper growth.

Planting:

- **Spacing:** Plant Okra seeds or seedlings approximately 30-40 cm apart in rows to allow ample space for plant development and harvesting.
- **Depth:** Plant Okra seeds at a depth of about 1-2 cm in well-prepared soil with good drainage to promote germination.

Fertilization:

- **Pre-Planting:** Incorporate well-rotted compost or manure into the soil before planting to improve soil fertility and provide essential nutrients for Okra plants.
- **Side-Dressing:** Apply a balanced fertilizer high in potassium during the growing season to promote flowering and fruit development in Okra.

Important Pests:

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- Aphids: Sap-sucking insects that can damage Okra plants and lead to the spread of diseases.
- Okra Leafhopper: Small insects that feed on Okra leaves, causing yellowing and wilting.
- Pod Borers: Larvae that tunnel into Okra pods, leading to fruit damage and reduced yields.

Diseases:

- Powdery Mildew: Fungal disease that appears as white powdery growth on Okra leaves, affecting plant health.
- Fusarium Wilt: Fungal infection causing wilting and yellowing of Okra plants.
- Leaf Spot: Bacterial or fungal diseases resulting in dark spots on Okra leaves, reducing photosynthesis.

Harvesting:

- Timing: Harvest Okra pods when they are young and tender, around 3-4 inches long, for the best eating quality.
- Frequency: Check Okra plants regularly as the pods grow quickly, and it's important to harvest them every 2-3 days to encourage continuous production.
- Handling: Use pruning shears or a sharp knife to cut Okra pods from the plant, being careful not to damage the stems. Harvest into a basket or container to avoid bruising.

3.3. Field Preparation

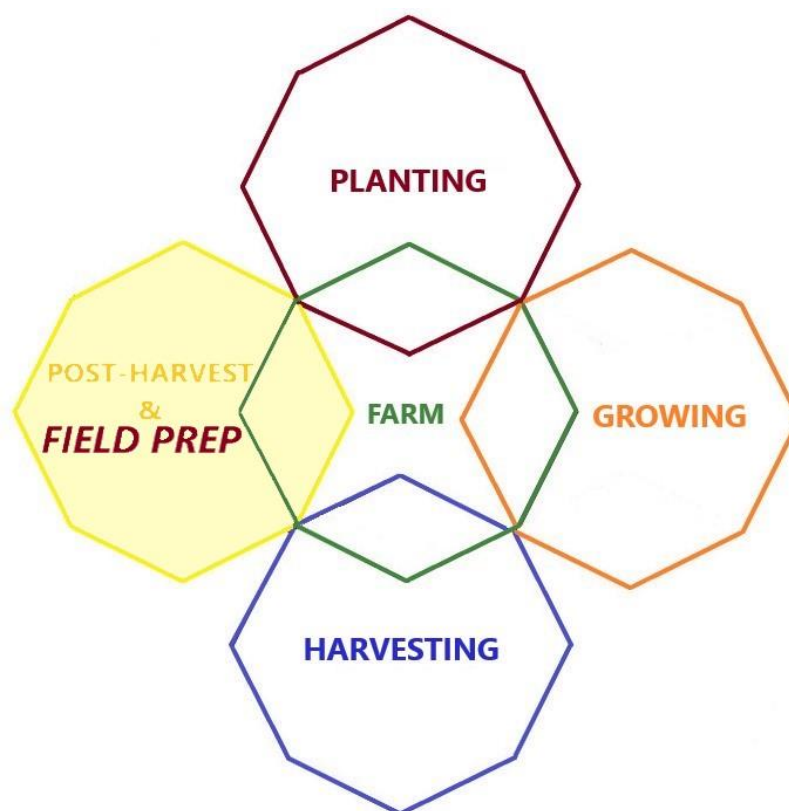


Figure 3.26: Field Preparation in the Crop Production Process

As stated earlier, field preparation includes your soil management, water harvesting, storage and irrigation. This is also a good time of year to ensure that all maintenance is done on your machinery and equipment.

3.3.1. Soil Management

The entry of organic matter or humus to the soil is one of the most important areas of soil formation. Organic material comes mainly from fallen leaves and other dead material from plants as well as from animal remains and manure. This then rots by the activities of many micro-organisms of the soil fauna (earthworms and insects) along with bacteria and fungi. During the rotting (decomposing) process the organic matter blends with the soil, making it more fertile. Humus is ready when the decay process is complete, and no remains can be identified. Humus is very important in the soil: it is a major store of nutrients, helps to bind the soil, holds water, and affects the texture of the soil. These are important factors for agriculture because humus makes the soil more fertile and easier to work.



Figure 3.27: Different types of soils (SlidePlayer 2018)

Soils can vary from place to place because some vegetation types decay more easily than others. Environmental conditions influence the speed at which decomposition takes place with organisms and other biological activities, which is more rapid in warmer, moist climates. Regions such as the boreal forests (forests north of 50° north latitude) have low compost production because the vegetation itself is slow to decompose and, because of low temperatures biological activity is low. By contrast, in the forests of temperate zones (equator and tropics) the vegetation decomposes easily, and rapidly as climatic conditions favour decomposition. Therefore, compost levels are higher in these soils, which tend to have a good texture and high fertility. After clearing they are suitable for agriculture.

Organic Farming

Organic Farming is a production system that avoids or largely excludes the use of synthetically produced fertilisers, pesticides, growth regulators, and livestock feed additives. It relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes and aspects of biological pest control to maintain soil productivity and tillage to supply plant nutrients, and to control insects, weeds, and other pests.

Organic farming methods are widely used in underdeveloped and developing countries, largely because of economical reasons and the lack of chemicals. However, they are becoming more widely accepted in developed countries as a reaction to intensive or factory farming conditions.

Soil Management: This is the basis of all scientific agriculture, which involves six essential practices: proper tillage; maintenance of a proper supply of organic matter in the soil; maintenance of a proper nutrient supply; control of soil pollution; maintenance of the correct soil acidity; and control of erosion.

Tillage

The purpose of tillage is to prepare the soil for growing crops. This preparation is traditionally accomplished by using a plough that cuts into the ground and turns over the soil, removing or killing any weeds growing in the area, loosening and breaking up the surface layers of the soil, and providing a bed of soil that holds sufficient moisture to permit the planted seeds to germinate. Traditional tillage may harm the soil if the same practice is applied continuously over many years, especially if the fertile topsoil layer is

thin.

Today, many farmers use a programme of minimum or reduced tillage to conserve the soil. In this form of tillage, all the dead plant material that remains on the ground after the crop is harvested is left on or near the surface of the soil, rather than being ploughed deeply into the ground as in traditional tillage; this helps to keep moisture within the ground and protects the soil from erosion.

Ploughs, which are the chief mechanical implements used for tillage in all parts of the world, may be designed for several purposes. It can range from to simply cut a furrow through the ground or to the complete reversal (turning over) of soil, usually to a depth of 15 to 20 cm (6 to 8 in). In certain areas and for certain purposes the plough is replaced as a primary tillage instrument by various types of harrows, tools that scratch the surface of the ground without digging deeply into it. In most areas these implements are used to break up the soil after ploughing. Harrows or tools of the same general design are almost universally used for the cultivation of the ground between rows of growing crops.

Deep ploughing and subsequent harrowing are necessary in areas where the soil is compact and very difficult for water and plant roots to pass through. Too much tillage may however, result in the worsening of soil structure, particularly if performed in wet soil. This problem is more serious in fine textured soils than in sand and loam, which normally require less tillage. Climate also plays its part in determining the quantity and the time of tillage. In areas with high rainfall, tillage should be done during the dry season to prevent soil erosion. In dry areas tillage should be just before the rain to be sure that the maximum amount of water is absorbed.



Figure 3.28: Cover crops can limit erosion
(Impuls Africa)

The importance of tillage includes:

- The aeration of soil and exposing it to the air as a result from pulverisation. The aeration of soil provides a free circulation of oxygen and water and results in increased biological activity in the soil, including that of organisms that generate atmospheric nitrogen.
- Contributing to the health of plants by inhibiting plant diseases and by discouraging the

development of various types of insects that harm plants.

The type of tillage affects the loss of soil through erosion by wind and water. When furrows are ploughed in an uphill-and-downhill direction, water tends to flow down the furrows, carrying away small particles of the top layers of soil as it flows. By ploughing across the slope instead, the water stays in the furrows and sinks into the soil rather than running off. Tillage of this type is commonly known as contour ploughing because the furrows follow the natural contours of the land.

The kind and quantity of cultivation between the rows of growing crops is determined by the soil's character. Heavy, waterlogged soil benefits from the loosening and aeration of soil. Hard compact soils may also require cultivation to permit them to absorb the moisture that the crops need. For soils that are in good physical condition, however, the primary purpose of cultivation of crops is to permit weed control.

3.3.2. Water Resources and Irrigation

Water is one of the most important resources in farming. The 2 primary sources of water are –

- Surface water, and
- Underground water.

Surface water is generally found in the form of rivers, stream, pools, lakes or pans. Underground water occurs in wells, boreholes, fountains, infiltration galleries and well points.

3.3.2.1. Rivers and Streams

Water from rivers and streams can be used but you must ensure that you have all your Water Rights in place (Legal Aspects). The Department of Water Development & Sanitation keeps close tabs on water usage to ensure that the entire watercourse is available to numerous farmers, industries and citizens.

Other aspects to consider when using a river or stream is catchment area, rainfall and flow of the river during dry seasons. We have a responsibility towards our environment. Purity of the water is also crucial especially for domestic use and the watering of stock.

3.3.2.2. Underground Water

Underground water is usually rainwater that has sunk into the ground. The water usually sinks down vertically until it reaches an impermeable or dense layer of rock and then moves along the slope of the dense layer. It accumulates in hollow places in the dense formation, or where the formation cuts across dykes or faults in the rock. Springs occur where a dense layer makes contact again with the surface.

Since underground water supplies are replenished by rain, farmers should take care of the catchment areas by avoiding overstocking the veld, veld burning and soil erosion. Erosion is an issue as the water that should be infiltrating the ground is running off towards streams and rivers. The application of good soil conservation measures will increase the infiltration capacity of your soil this in turn will ensure an improvement of your ground water supply.

Be aware that underground water sources can be polluted by other filtration systems like septic tanks, ash pits, French drains and even fossil fuel and chemical runoff from garages and work areas. When planning your farm keep these potential pollutants far away from your water sources.

3.3.2.3. Water Extraction

Pumps are generally the method of choice for the extraction of water, whether surface water or underground water. Your pump of choice will depend on the purpose of the water. How much water you need for how much work. Filling a domestic 2500ltr tank is a whole lot smaller than a pump station for numerous hectares of maize.

3.3.2.4. Water Storage

The water's purpose will determine how you store your water. If it is a watering point for grazing livestock the farmer may set up a watering trough with **concrete dam** and solar pump to keep the concrete dam full. The trough is then filled by an automatic float valve system (like the float valve system in a toilet tank)

Domestic water is generally stored in a **water tank** close to the house or office. This system runs on gravity so the water pressure drops the further you are from the tank, but the water supply can remain consistent. My father-in-law makes use of a wind pump to maintain the water level in the domestic water tank with an overflow system into the farmyards concrete dam.

Earth dams are also very popular. They are relatively easy to construct and relatively easy to maintain. They are generally used for stock watering or crop irrigation. The dam is primarily built to catch rain runoff before it either filters into the soil or joins a stream or river. Earth is a very vulnerable building material, and a dam should be designed and built well to avoid the potential risks to life and property.

The location of your dam is of optimal value. If the dam is for stock watering, try to place the dam central to your pastures or rotation system. On the other hand, if the purpose of the dam is for irrigation, try to put the dam at a higher elevation so that your fields can be irrigated by gravity.

We need to prepare for times of drought when rainfall isn't available for replenishing surface and underground water sources. We need to maximise water harvesting and storage.

3.3.2.5. Water Harvesting

Water harvesting is the process of collecting, storing, and managing rainwater, surface runoff, or other forms of water for future use. This practice is especially useful in areas where water resources are scarce, or rainfall is seasonal. It helps ensure a steady water supply for drinking, irrigation, livestock, and other purposes.

Types of Water Harvesting

Rainwater Harvesting:

- Collecting and storing rainwater from rooftops, paved areas, or land surfaces.
- Common systems include rooftop catchments, storage tanks, and underground reservoirs.

An example of catching rainwater in a field would be using **Contour Ridges**.

This is a micro catchment technique. Ridges follow the contour at a spacing of usually 1 – 2 meters. Runoff is collected from the uncultivated strip between the ridges and stored in the furrow just above the ridges. Crops are planted on both sides of the furrow. The system is easily constructed by hand or machinery and can be less labour intensive than the traditional tiling of a plot.

The yield of runoff from the very short catchment lengths is extremely efficient and when designed and constructed correctly there should be no loss of runoff out of the system. Another advantage is even crop growth since each plant has approximately the same contributing catchment area.

Contour ridges for crops are not yet a widespread technique, they are being tested for crop production on various projects in Africa.

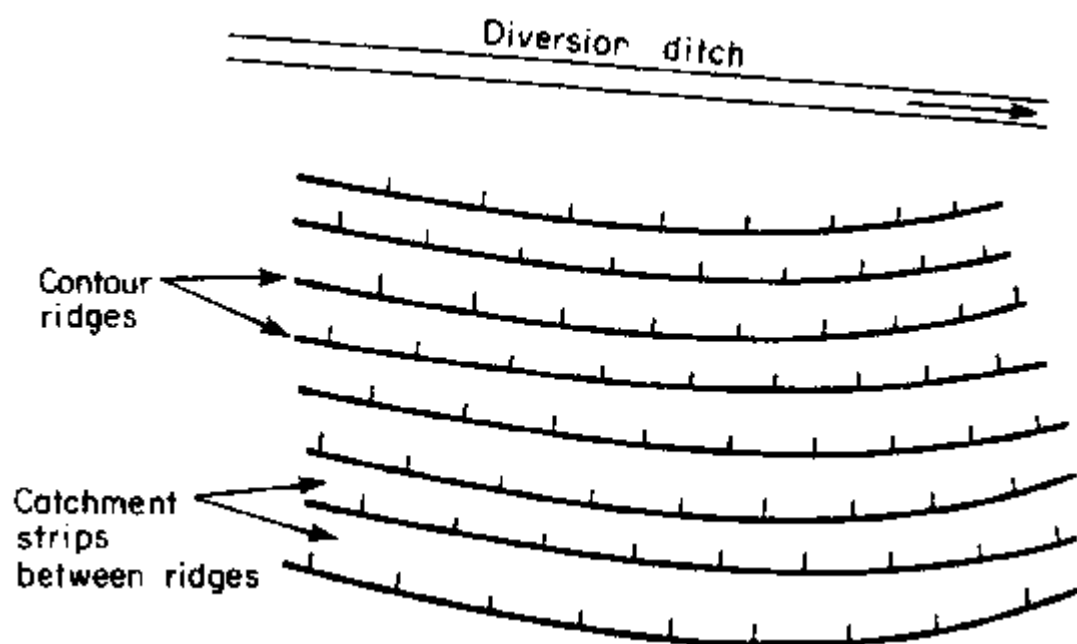


Figure 3.29: Contour ridge: field layout
(FAO 2024)

Surface Water Harvesting:

- Capturing runoff from streams, rivers, or drainage channels.
- Techniques include check dams, ponds, and reservoirs.

A good way of capturing surface water is the use of **Permeable rock dams**.

Permeable rock dams are a floodwater farming technique where runoff waters are spread in valley bottoms for improved crop production. Developing gullies are healed at the same time. The structures are typically long, low dam walls across valleys. Permeable rock dams can be considered a form of "terraced wadi", though the latter term is normally used for structures within watercourses in more arid areas.

Interest in permeable rock dams has centred on West Africa - Burkina Faso in particular - and grew substantially in the latter part of the 1980s. This technique – "digue filtrante" in French - is particularly popular where villagers have experienced the gullying of previously productive valley bottoms, resulting in floodwater no longer spreading naturally. The large amount of work involved means that the technique is labour intensive and needs a group approach, as well as some assistance with transport of stone.



Figure 3.30: 2 examples of permeable rock dams

(https://www.researchgate.net/figure/Examples-of-two-structural-practices-in-the-Farmian-dam-watershed-a-porous-gully-plug_fig4_351119386)

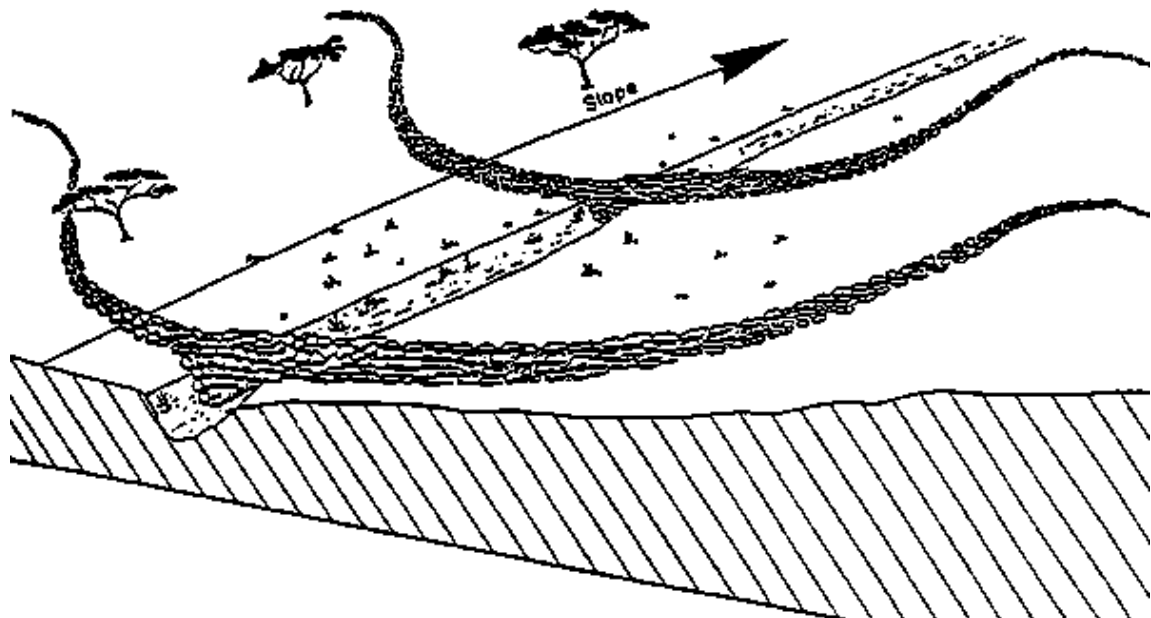


Figure 3.31: General layout

(FAO 2024)

Groundwater Recharge:

- Directing surface water into the ground to replenish aquifers.
- Methods include percolation pits, recharge wells, and trenches.

Floodwater Harvesting:

- Diverting and storing excess water from floods for later use.
- Useful for irrigation and restoring wetlands.

Benefits of Water Harvesting

1. **Water Security:**
 - Provides a reliable water source during dry periods.
 - Reduces dependence on external water supplies.
2. **Environmental Conservation:**
 - Reduces soil erosion by slowing down runoff.
 - Helps recharge groundwater and maintain water tables.
3. **Agricultural Productivity:**
 - Ensures water availability for irrigation, improving crop yields.
 - Promotes sustainable farming practices.
4. **Cost Efficiency:**
 - Reduces water bills and reliance on expensive infrastructure.
 - Minimizes the impact of droughts and water shortages.

Examples of Water Harvesting Systems

- Rooftop rainwater harvesting with gutters and tanks.
- Farm ponds for storing runoff water.
- Check dams to hold back water in small streams.
- Contour trenches on sloped land to capture and store rainwater.

Water harvesting is a simple, cost-effective solution to manage water resources sustainably and improve resilience to climate change.



Figure 3.32: Contour Ridges

(https://www.researchgate.net/figure/Tied-contour-ridges-source-Muslim-Science_fig17_337039002)



Anticipation is key to water harvesting and storage

3.3.2.6. Irrigation

Water is one of the most important resources in optimum plant production. Irrigation and rainfall are the two main ways in which crops receive water. This section 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 are rain shortages or drought.



Figure 3.33: Farmer irrigating plants
(Impuls Africa)

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.

Types of irrigation systems

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

■ Overhead irrigation

Overhead irrigation is like 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 3.34: Overhead Irrigation System
(Impuls Africa)

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

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. Keeping 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 irregularly 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 3.35: Overhead plastic pipe with drip emitter and a ground drip system
(Impuls Africa)

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.

The following are some of the **advantages of using drip irrigation on a farm:**



Figure 3.36: Advantages of drip irrigation
(Impuls Africa)

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, it 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 plants 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 (centre). These lengths are joined, supported by trusses, which are mounted on wheeled towers that move in a circle. Centre-pivot irrigation systems 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 3.37: Centre-pivot Irrigation System
(Impuls Africa)

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 like rainfall. As the name suggests, 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 3.38. Portable Sprinkler System**



Figure 3.38. 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 metres 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 crops 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 3.39: Farm that uses solar powered irrigation
(Impuls Africa)

3.3.2.7. Irrigation Management

Irrigation scheduling refers to regulating or determining the amount of time and frequency with which you water your 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 underirrigation 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

3.4. Planting

causes unnecessary labour. You can measure soil moisture or the amount of water in the soil in different ways.

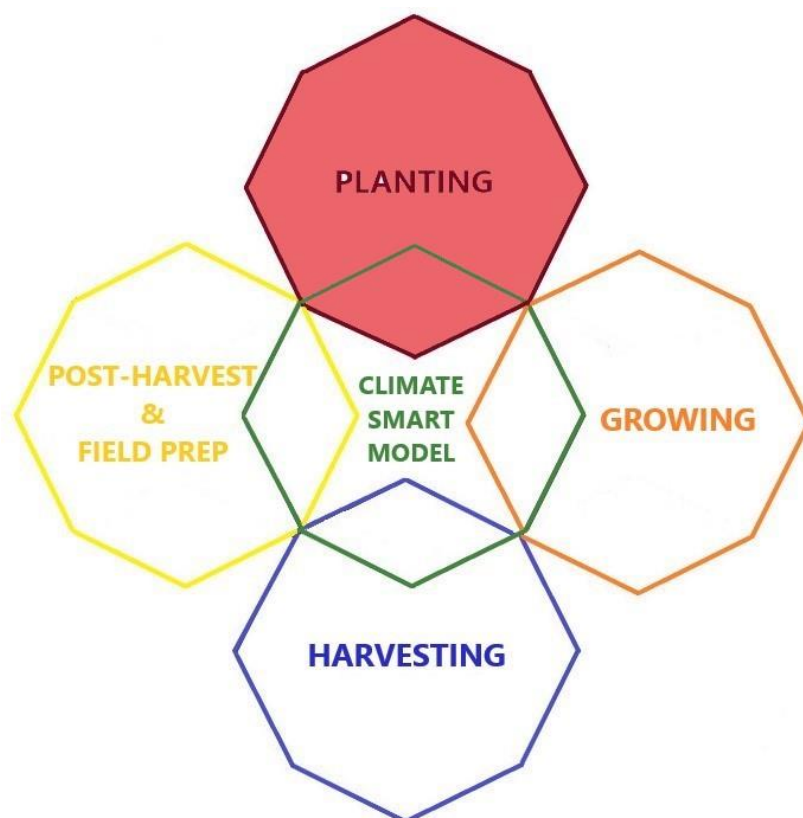


Figure 3.40: Planting

3.4.1. Soil Preparation (Field)

Soil should always be thoroughly prepared and should be loosened before any planting takes place. Previous crop residues (debris) should be well-rotted. Depending on your rainfall, if there is a risk of waterlogging, you will have to use raised beds or mounds.

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.

3.4.2. 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:

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 prevent nutrient absorption 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.

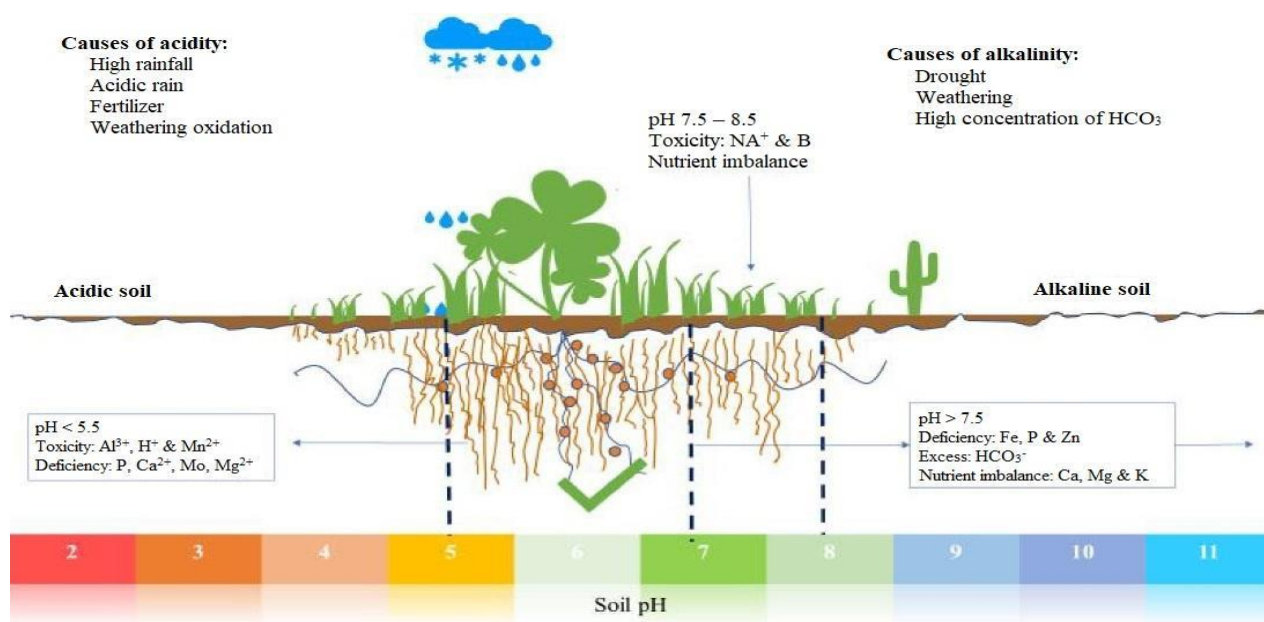


Figure 3.41: pH and soil quality
 (Impuls Africa)

Soil preparation (Quality)

How do you prepare soil for planting? 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, after cleaning the field add compost and fertilizer. Compost has many benefits while fertilisers will have an immediate effect on the good growth of 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.

Most crops 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 3.42. Crumbling Soil
 (Impuls Africa)

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 Sandy soil to hold more water.

Fertilizers and compost types will be explained in more detail in Chapter 5. 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 crop's roots to grow deeper especially those with tap root systems. You should till when the soil is moist and not wet. Add Organic Matter every year during the soil preparation 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 3.43: Farmers tiling the ground
(Impuls Africa)

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.

3.5. 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 help the plant fight against disease. It is also necessary for metabolism and the absorption of nitrogen by the plant.

3.5.1. Organic and chemical fertilizers

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. 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 provide 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 3.44: Manure used for crops
(Impuls Africa)

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.

Advantages

Easily available

Calculated amount of nutrients can be applied

Easy application

Fertilisers are available in different formulations and concentrations

Disadvantages

Washes out or infiltrated with rain or irrigation water

Harmful to crops if applied more than the required quantity

Can cause water and soil pollution

Must 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.



Figure 3.45: Composite manure mound
(Impuls Africa)

■ 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 must 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.

3.5.2. Application of solid and liquid fertilizers

Solid fertilizer

Application of solid fertilisers include:

- Broadcasting
- Placement

- **Broadcasting**

Broadcasting is as the name describes; the fertilizer is spread over the whole field. Generally, for closely planted crops like your cereals or flowers. 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, the fertiliser is placed in the soil where the planting will be taking place, think back to our tree planting section. Fertiliser is mixed with the topsoil and placed into the tree planting pit. We have two types of placement techniques:

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.

Liquid fertilizer

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.

3.6. Disease and Pest Management

By incorporating these climate-smart agriculture practices, farmers can effectively manage diseases and pests while promoting sustainable and environmentally friendly agricultural methods.

1. **Resistant Varieties:** Select and plant crop varieties that exhibit natural resistance to pests and diseases, reducing the need for chemical control measures.
2. **Crop Diversity:** Implement crop rotation strategies by alternating cereals with different crops to disrupt pest and disease cycles and enhance soil health.
3. **Biological Control:** Introduce natural predators, parasites, or beneficial insects to control pest populations in a sustainable and eco-friendly manner.
4. **Trap Cropping:** Plant trap crops near target crops to attract and divert pests away from main crops, reducing pest damage.
5. **Disease-Free Seed:** Start with high-quality seeds that have been certified as disease-free to prevent the introduction and spread of pathogens in the field.
6. **Beneficial Microorganisms:** Utilize biofungicides containing beneficial microorganisms to suppress pathogen growth and promote plant health naturally.
7. **Proper Planting Density:** Optimize plant spacing to ensure adequate air circulation around plants, reducing humidity and minimizing disease spread.
8. **Early Detection:** Regularly scout fields for early signs of diseases and pest infestations to implement control measures promptly and prevent widespread damage.
9. **Minimal Tillage:** Practice reduced or no-till farming to preserve soil structure, biodiversity, and beneficial microorganisms, enhancing overall ecosystem health.
10. **Water Management:** Implement efficient irrigation techniques to provide plants with the right amount of water at the right time, reducing stress and vulnerability to diseases.

3.6.1. Integrated pest management (IPM)

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.

3.6.2. 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 3.46: The impact of Damping-off
(Impuls Africa)

Damping-off is a fungal disease that affects seedlings and causes growing seedlings to collapse. This disease spreads fast 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 3.47: Wilted crops
(Impuls Africa)

■ 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 3.48: Late blight
(Impuls Africa)

■ 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 3.49: Blight on crops
(Impuls Africa)

■ 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 3.50: Powdery mildew
(Impuls Africa)

■ Rust

A fungal infection leading to rust-coloured pustules, leading to plant stress.



Figure 3.51: Severe Yellow Rust

(<https://www.cpm-magazine.co.uk/technical/rust-expect-the-unexpected-as-rust-evolves/>)

■ Root rot

Caused by soil-borne pathogens that rot roots, leading to wilting and plant death.



Figure 3.52: Evaluating Root Rot

(<https://www.topcropmanager.com/evaluating-root-rot-in-pulses/>)

3.6.3. Common insect pests

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

Pest	Description	Image
Diamond-back moth	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.	
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.	
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.	

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.	
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.	
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.	
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.	

Bean beetles	Feed on leaves and pods, leading to reduced plant vigour and yield.	
Pod borers	Larvae that tunnel into pods, reducing seed development and quality.	

3.6.4. Common Diseases and Pests in Cereal Production:

1. Maize:

Diseases

- **Corn Smut:** Fungal disease causing tumorous growth on maize plants.



Figure 3.53: Corn Smut

(<https://www.npr.org/sections/thesalt/2015/08/24/433232707/scourge-no-more-chefs-invite-corn-fungus-to-the-plate>)

- **Maize Lethal Necrosis (MLN):** Viral disease leading to necrotic symptoms on leaves and yield loss.



Figure 3.54: MLN

(<https://www.cabdigitallibrary.org/doi/full/10.1079/cabicompendium.119663>)

- **Maize Streak Virus:** Virus spread by leafhoppers, causing streaking and stunting of plants.

Pests:

- **Fall Armyworm:** Larvae that feed on maize leaves, leading to significant damage.



Figure 3.55: Fall Armyworm

(<https://www.rural21.com/english/news/detail/article/most-of-africas-maize-at-risk-from-armyworm.html>)

- **Maize Weevils:** Common pests that infest stored maize grains.
- **Stem Borers:** Larvae that bore into maize stalks, reducing yield and plant health.



Figure 3.56: Stem borer

(<https://insectscience.co.za/pest/maize-stem-borer-maize/>)

2. Sorghum:

Diseases

- **Anthracnose:** Fungal disease-causing leaf spots, stalk rot, and reduced grain quality.



Figure 3.57: Anthracnose on a banana pepper

(<https://vegshotline.org/article/anthracnose-management-in-peppers-the-old-and-the-new/>)

- **Downy Mildew:** Fungal infection resulting in white to purple growth on leaves.
- **Charcoal Rot:** Soil-borne fungi causing stem and root rot in sorghum plants.

Pests

- **Sorghum Midge:** Small flies that damage sorghum flowers and grains.



Figure 3.58: Midge

<https://ipmguidelinesforgrains.com.au/pests/sorghum-midge/>

- **Sorghum Shoot Fly:** Larvae feed on sorghum plants, causing wilting and yield loss.
- **Stem Borers:** Insect pests that tunnel into sorghum stems.

3. Millet:

Diseases

- **Smut Diseases:** Fungal infections leading to black, soot-like masses on seed heads.



Figure 3.59: Smut symptoms on pearl millet

(https://www.researchgate.net/figure/Smut-symptoms-in-pearl-millet-Khairwal-et-al-2007-Symptoms-Initial-symptoms-of-pearl_fig1_349042828)

- **Leaf Spot:** Fungal disease causing circular lesions on millet leaves.



Figure 3.60: Leaf spot

(https://www.researchgate.net/figure/Pyricularia-leaf-spot-and-other-leaf-spots-will-cause-only-minimal-damage_fig6_277868415)

Downy Mildew: Fungal infection triggering yellow spots on millet leaves.

Pests

- **Millet Head Miner:** Larvae feeding on millet seeds, reducing grain quality.



Figure 3.61: Head Miner

(<https://agrilinks.org/post/natural-enemies-against-devastating-millet-head-miner>)

- **Millet Blast:** Fungal disease causing dark lesions on millet leaves and grains.
- **Millet Bug:** Insect pests that damage millet grains during storage.

3.6.5. Common Diseases and Pests in Sunflower Production:

Diseases:

- **Downy Mildew (*Plasmopara halstedii*):** Fungal disease causing yellow spots on leaves, leading to wilting and reduced yield.
- **Rust (*Puccinia helianthi*):** Fungal infection characterized by reddish-brown pustules on leaves, affecting photosynthesis and plant health.
- **Phomopsis Stem Canker (*Diaporthe helianthi*):** Fungal disease causing stem lesions, wilting, and lodging of plants.



Figure 3.62: Phomopsis Stem Canker

(<https://www.cabidigitallibrary.org/doi/full/10.1079/cabicompendium.18733>)

1. **Sclerotinia Head Rot (*Sclerotinia sclerotiorum*):** Fungal infection leading to white mold growth on sunflower heads, reducing seed quality.



Figure 3.63: Head rot

(https://en.wikipedia.org/wiki/Sclerotinia_sclerotiorum)

- **Powdery Mildew (*Erysiphe cichoracearum*):** Fungal growth on leaves and stems, hindering plant growth and nutrient absorption.

Pests:

1. **Sunflower Moth (*Homoeosoma electellum*):** Larvae feed on sunflower heads, causing damage to seeds and reducing yield.



Figure 3.64: Sunflower moth

(<https://extension.sdstate.edu/sunflower-moths-observed-south-dakota>)

2. **Sunflower Seed Weevil (*Smicronyx fulvus*):** Pests that infest sunflower seeds, reducing quality and germination rate.



Figure 3.65: Sunflower Seed Weevil

(<https://pnwhandbooks.org/insect/agronomic/sunflower/sunflower-seed-weevil>)

3. **Banded Sunflower Moth (*Cochylis hospes*):** Larvae tunnel into developing sunflower heads, leading to seed damage.
4. **Red Sunflower Seed Weevil (*Smicronyx sordidus*):** Pests that feed on sunflower seeds within the head, impacting seed quality.
5. **Wireworms:** Larvae of click beetles that feed on sunflower roots, affecting plant growth and development.

3.6.6. Common Diseases and Pests in Horticulture Production:

Tomato:

Diseases:

- Early Blight (*Alternaria solani*): Causes dark concentric spots on leaves.
- Late Blight (*Phytophthora infestans*): Leads to rapid plant collapse.
- Fusarium Wilt (*Fusarium oxysporum*): Results in yellowing and wilting of lower leaves.



Figure 3.66: Fusarium Wilt

(<https://content.ces.ncsu.edu/fusarium-wilt-of-tomato>)

- Septoria Leaf Spot (*Septoria lycopersici*): Develops small dark spots on leaves.



Figure 3.67: Septoria Leaf Spot

(<https://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/insects-pests-and-problems/diseases/fungal-spots/septoria-leaf-spot-of-tomato>)

- Bacterial Speck (*Pseudomonas syringae*): Creates small, dark raised lesions on foliage.
- Tomato Yellow Leaf Curl Virus (TYLCV): Causes leaves to curl upward and turn yellow.

Pests:

- Aphids: Small insects that cluster on plant stems, damaging plant health.
- Whiteflies: White insects found under leaves, sucking sap from the plants.
- Tomato Hornworms: Large green caterpillars defoliating the plant.
- Cutworms: Larvae cutting down seedlings near the soil line.
- *Tuta absoluta* (Tomato Leaf Miner): Larvae tunnel into the leaves, causing damage.



Figure 3.68: Tuta absoluta

(<https://neem.land/blogs/news/tuta-absoluta-in-tomatoes>)

- Spider Mites: Suck plant cells, causing stippling and webbing on leaves.



Figure 3.69: Spider mites

(<https://entomology.ces.ncsu.edu/biological-control-of-spider-mites-in-tomatoes/>)

Cabbage:

Diseases:

- Clubroot (*Plasmodiophora brassicae*): Swells roots, leading to stunted growth in plants.
- Black Rot (*Xanthomonas campestris*): Produces V-shaped lesions on leaves.



Figure 3.70: Black rot

(https://apps.lucidcentral.org/pppw_v10/text/web_full/entities/cabbage_black_rot_131.htm)

- Downy Mildew (*Hyaloperonospora parasitica*): Downy growth on leaf undersides.



Figure 3.71: Downy Mildew

(<https://krishisevakendra.in/blogs/news/measures-to-control-downy-mildew-disease-in-cabbage-crop>)

- Alternaria Leaf Spot (*Alternaria* spp.): Circular dark spots on foliage.
- Fusarium Wilt (*Fusarium oxysporum*): Shows wilted and yellowing plants.
- Powdery Mildew: White patches on leaves, affecting plant health.

Pests:

- Cabbage Worms: Green caterpillars feeding on cabbage leaves.



Figure 3.72: Cabbage worm
(<https://gardencenterohio.com/cabbage-worm/>)

- Cabbage Loopers: Caterpillars moving in a loop-like motion.
- Aphids: Small sap-sucking insects causing damage to the plant.
- Flea Beetles: Small beetles making tiny holes in leaves.
- Diamondback Moth (*Plutella xylostella*): Larvae feeding on cabbage leaves.
- Cabbage Root Maggots: Larvae tunneling into cabbage roots, weakening the plant.



Figure 3.73: Root Maggot
(<https://www.gardenia.net/pest/cabbage-maggot>)

Onion:

Diseases:

- Downy Mildew (*Peronospora destructor*): Causes whitish-gray fuzzy growth on leaves.
- Pink Root (*Phoma terrestris*): Leads to pink discoloration and decay of roots.

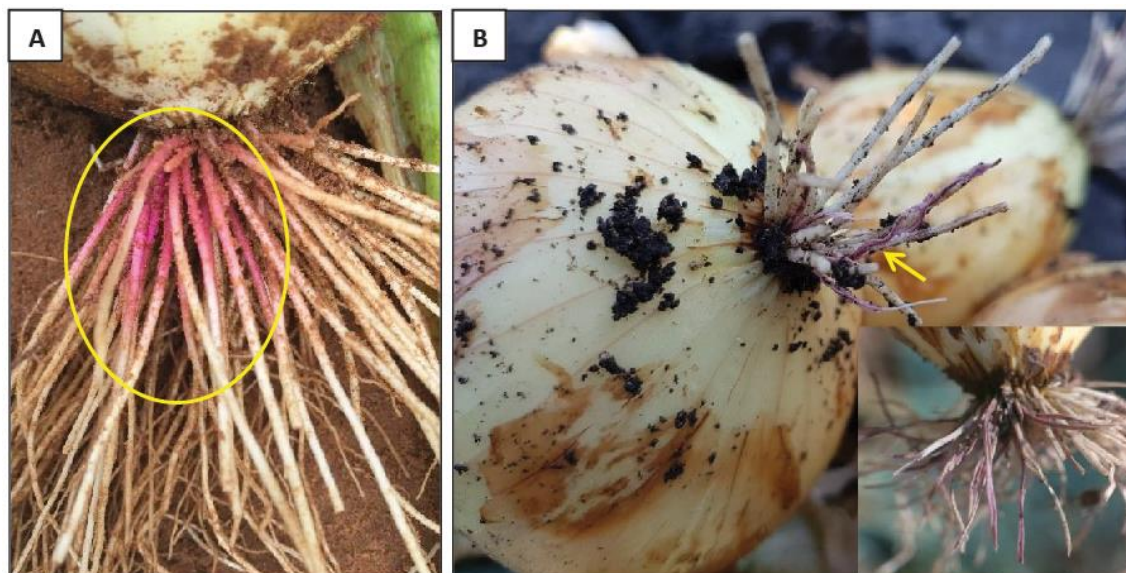


Figure 3.74: Pink Root

(<https://sakata.co.za/focusing-on-pink-root-in-onions/>)

- Onion Smut (*Urocystis cepulae*): Forms black spore masses on bulbs.



Figure 3.75: Onion Smut

(<https://plantwiseplusknowledgebank.org/doi/full/10.1079/pwkb.species.55787>)

- Botrytis Leaf Blight (*Botrytis squamosa*): Results in gray-green lesions on leaves.
- White Rot (*Sclerotium cepivorum*): Causes white fungal growth and rot in bulbs.

- Neck Rot (*Botrytis allii*): Rotting and dark discoloration at the neck of the onion bulbs.



Figure 3.76: Neck Rot

(<https://extension.usu.edu/planthealth/research/botrytis-neck-rot>)

Pests:

- Onion Thrips: Tiny insects causing silvery and scarring on leaves.



Figure 3.77: Onion Thrip

(<https://www.koppert.com/plant-pests/thrips/onion-thrips/>)

- Onion Maggots: Larvae tunnel into bulbs, leading to rot.
- Cutworms: Larvae cutting down young plants at the stem base.



Figure 3.78: Cutworm damage

(<https://abundantminigardens.com/cutworms/>)

- Root-knot Nematodes: Cause galls and stunted root growth.
- Moths: Lay eggs on plant leaves, leading to caterpillar damage.
- Wireworms: Larvae feeding on onion bulb tissue, causing damage.

Spinach:

Diseases:

- Downy Mildew (*Peronospora effusa*): Fuzzy white growth on leaf undersides.
- Anthracnose (*Colletotrichum* spp.): Causes dark sunken lesions on leaves.
- Leaf Spot (*Cercospora* spp.): Develops angular leaf spots with reddish centres.



Figure 3.79: Leaf Spot

(<https://ag.umass.edu/vegetable/fact-sheets/spinach-cladosporium-leaf-spot>)

- Fusarium Crown and Root Rot (*Fusarium* spp.): Yellowing and rotting of crown and roots.
- Powdery Mildew: White powdery patches on leaves.
- Damping-off (*Pythium* spp.): Causes seedling collapse at the base.

Pests:

- Leaf Miners: Larvae tunneling inside leaves, leaving visible trails.
- Aphids: Small sap-sucking insects deforming leaf growth.
- Spider Mites: Cause stippling and webbing on leaves.
- Leafhoppers: Jumping insects that suck plant sap.



Figure 3.80: Leafhopper

(<https://www.growingproduce.com/crop-protection/insect-control/ways-to-keep-spinach-crops-free-of-aphids/>)

- Flea Beetles: Small beetles that chew small holes in leaves.
- Grasshoppers: Feed on leaves and plants, causing extensive damage.

Peppers:

Diseases:

- Anthracnose (*Colletotrichum* spp.): Leads to sunken lesions on fruits and leaves.
- Bacterial Spot (*Xanthomonas campestris*): Causes water-soaked lesions on leaves.



Figure 3.81: Bacterial Spot

(<https://extension.umd.edu/resource/bacterial-leaf-spot-peppers/>)

- Phytophthora Root Rot (*Phytophthora capsici*): Rotting of roots and crown.
- Powdery Mildew: White fungal growth on leaves and stems.
- Verticillium Wilt (*Verticillium dahliae*): Wilting and yellowing of leaves.
- Cucumber Mosaic Virus (CMV): Yellow mosaic patterns on leaves.



Figure 3.82: CMV on Peppers

(<https://www.agric.wa.gov.au/capsicums-and-chillies/cucumber-mosaic-virus-capsicum>)

Pests:

- Pepper Weevils: Small beetles causing damage to pepper fruits.
- Aphids: Suck sap from plant tissues, leading to plant weakening.
- Flea Beetles: Small beetles causing small holes in leaves.
- Pepper Maggots: Larvae feeding inside pepper fruits.



Figure 3.83: Feeding damage from pepper weevil (left), pepper maggot (right)
 (<https://onvegetables.com/2018/08/08/pepper-weevil-or-pepper-maggot/>)

- Spider Mites: Infest plants, causing discoloration and webbing.
- Thrips: Feed on pepper leaves, causing silverying and leaf curl.

Watermelon:

Diseases:

- Anthracnose (*Colletotrichum* spp.): Causes sunken lesions on fruits.
- Fusarium Wilt (*Fusarium oxysporum*): Leads to wilting and yellowing of plants.
- Gummy Stem Blight (*Didymella bryoniae*): Causes stem cankers and fruit rot.
- Powdery Mildew: White powdery growth on leaves and stems.
- Alternaria Leaf Blight (*Alternaria cucumerina*): Develops dark spots on leaves.



Figure 3.84: Alternaria Leaf Blight

(<https://www.gardeningknowhow.com/edible/fruits/watermelon/watermelon-alternaria-leaf-spot.htm>)

- Phytophthora Blight (*Phytophthora capsici*): Results in fruit rot and plant decline.

Pests:

- Squash Vine Borers: Larvae bore into vines, causing wilting.
- Aphids: Suck sap and weaken plant health.
- Whiteflies: Small insects found on leaf undersides.
- Thrips: Feed on leaves, causing silverying and distorted growth.
- Cucumber Beetles: Feed on stems and transmit diseases.
- Spider Mites: Infest plants, leading to discoloration and webbing.

Butternut Squash:

Diseases:

- Powdery Mildew: White powdery patches on leaves.
- Downy Mildew (*Pseudoperonospora cubensis*): Causes downy growth on leaves.
- Anthracnose (*Colletotrichum orbiculare*): Results in sunken lesions on fruits.
- Phytophthora Blight (*Phytophthora capsici*): Causes rotting of fruits and damping-off.
- Fusarium Wilt (*Fusarium oxysporum*): Shows wilting and yellowing of plants.
- Cucumber Mosaic Virus (CMV): Yellow mosaic patterns on leaves.

Pests:

- Squash Bugs: Feed on leaves and damage fruits.
- Squash Vine Borers: Larvae bore into vines, causing plant decline.
- Cucumber Beetles: Chew on plants, transmit diseases.



Figure 3.85: Stripped and Spotted Cucumber Beetles

(<https://acreagenebraska.org/2020/05/05/controlling-cucumber-beetles-and-squash-bugs-without-insecticides-yes-its-possible/>)

- Aphids: Sap-sucking insects that weaken plants.
- Spider Mites: Cause discoloration and webbing on leaves.
- Whiteflies: Found on plant leaves, sucking sap and causing damage.
- **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.

3.6.7. Methods of pest control

■ Biological methods

As a farmer, you want to limit the amount of chemical exposure your crops are exposed to as. 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) mix 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.



Figure 3.86: Microorganisms

(<https://www.gardenmyths.com/beneficial-microorganisms/>)

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, eradicates, 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.

3.6.8. Natural remedies

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

Name of insecticide	What pest 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.

3.7. Mechanization

3.7.1. Introduction to Mechanization for Small-Scale Crop Farmers in Zambia

This section discusses mechanization, tailored for small-scale crop farmers in Zambia. This section aims to introduce you to the concept of mechanization, its benefits, and best practices for its adoption in small-scale farming operations. Mechanization plays a crucial role in enhancing productivity, reducing labour requirements, and improving efficiency in agricultural activities. By embracing mechanization, farmers can unlock numerous opportunities to increase crop yields, save time and labour, and ultimately improve livelihoods. This section will guide you through the fundamentals of mechanization and equip you with practical knowledge to incorporate mechanized techniques into your farming practices effectively.



Figure 3.87: Tractor
(Impuls Africa)

3.7.2. Understanding Mechanization

Mechanization refers to the use of machinery and equipment to perform agricultural tasks that were traditionally done manually. In the context of small-scale farming, mechanization can range from simple hand tools to motorized equipment like tractors, planters, and harvesters. By mechanizing certain farming activities, small-scale farmers can streamline operations, boost productivity, and achieve better results in a cost-effective manner. Mechanization also helps in optimizing resource utilization and coping with labour challenges. As a small-scale farmer, understanding the principles and benefits of mechanization is essential for sustainable growth and development.

3.7.3. Benefits of Mechanization

- **Increased Efficiency:** Mechanization allows farmers to accomplish tasks faster, with higher precision and consistency, leading to improved operational efficiency.
- **Enhanced Productivity:** By reducing manual labour and time-intensive processes, mechanization enables farmers to increase their crop yields and output.
- **Cost Savings:** While initial investment costs may be required for machinery, mechanization can lead to long-term cost savings through reduced labour expenses and increased production.
- **Time Management:** Mechanization helps farmers to complete tasks in a timely manner, enabling them to focus on other critical aspects of farming.
- **Quality of Work:** Machinery ensures uniformity and accuracy in operations, resulting in better quality produce and reduced post-harvest losses.



Figure 3.88: Walking Tractor
(Impuls Africa)



Figure 3.89: Backsaver planters

(<https://phosphateprice.com/greening-africa-backsaver-farming-equipment-is-helping-small-scale-farmers-more-accurately-apply-fertiliser/>)

3.7.4. Practical Mechanization Techniques

- **Land Preparation:** Use mechanized tools like tractors, rippers, and cultivators to prepare the land efficiently before planting.
- **Irrigation:** Employ mechanized irrigation systems such as drip irrigation or sprinklers to optimize water distribution and enhance crop growth.
- **Planting:** Utilize mechanized seeders and planters for precise and timely planting of crops to ensure optimal spacing and germination.
- **Weed Control:** Adopt mechanized weeding equipment like weeders or sprayers to manage weed infestations effectively.
- **Harvesting:** Use mechanized harvesters, threshers, and drying equipment to streamline the harvesting process and minimize post-harvest losses.



Figure 3.90: Solar Irrigation pump

(<https://proagri.co.za/saro-showcases-advanced-irrigation-solutions-at-staccs-event/>)

3.7.5. Conclusion

In conclusion, mechanization provides small-scale crop farmers in Zambia with a pathway to greater productivity, enhanced efficiency, and sustainable farming practices. By adopting mechanization and integrating modern farming technologies into your operations, you can improve your farm's overall performance and achieve higher yields with less labour input. This section serves as a foundation to equipping you with the necessary knowledge and skills required to successfully embark on your mechanization journey. Embrace the opportunities that mechanization offers, **adapt** to evolving agricultural practices, and leverage the power of technology to elevate your farming efforts to new heights.

3.8. Climate Resilient Infrastructure

Climate-resilient infrastructure for farming refers to systems, structures, and practices designed to withstand and adapt to the impacts of climate change, such as extreme weather, droughts, floods, and temperature fluctuations. These infrastructures ensure sustainable agricultural productivity, protect ecosystems, and support the livelihoods of farmers even in adverse conditions.

3.8.1. Key Components of Climate-Resilient Farming Infrastructure

1. Water Management Systems:

- **Rainwater Harvesting:** Collect and store rainwater for irrigation and other uses.
- **Irrigation Systems:** Drip and sprinkler irrigation for efficient water use.
- **Flood Management:** Construction of bunds, dikes, and canals to manage excess water during floods.
- **Groundwater Recharge:** Pits, trenches, and recharge wells to replenish aquifers.

2. Soil and Land Management:

- **Terracing and Contour Farming:** Prevent soil erosion on slopes.
- **Agroforestry:** Planting trees and shrubs to reduce land degradation.
- **Soil Covering:** Use of mulch or cover crops to retain soil moisture and reduce erosion.

3. Climate-Resilient Crop and Livestock Infrastructure:

- **Seed Banks:** Storage of drought-resistant, flood-tolerant, and heat-resistant seeds.
- **Shelters for Livestock:** Structures that protect animals from extreme heat, cold, and rain.
- **Diversified Farming Systems:** Integrating crops, livestock, and aquaculture to spread risk.

4. Energy and Resource Efficiency:

- **Renewable Energy:** Solar-powered water pumps and wind turbines for energy needs.
- **Biogas Plants:** Convert farm waste into energy for cooking and heating.
- **Cold Storage:** Solar-powered units to reduce post-harvest losses.

5. Information and Communication Technology (ICT):

- **Weather Forecasting Tools:** Provide timely updates to farmers about upcoming weather conditions.
- **Early Warning Systems:** Alerts for extreme weather events like cyclones or droughts.
- **Mobile Apps:** For crop advisory, pest management, and market information.

6. Structures for Crop and Livestock Protection:

- **Greenhouses and Shade Nets:** Protect crops from temperature extremes.
- **Raised Beds:** Prevent waterlogging during heavy rains.
- **Fencing:** Protect fields from wildlife or strong winds.

7. Community-Level Infrastructure:

- **Cooperative Storage Facilities:** Reduce individual investment burden and post-harvest losses.
- **Shared Irrigation Networks:** Community-run systems to maximize water use efficiency.
- **Disaster-Resilient Roads and Markets:** Ensure connectivity during extreme weather events.

3.8.2. Benefits of Climate-Resilient Farming Infrastructure

- **Increased Productivity:** Maintains yields despite changing climate conditions.

- **Economic Stability:** Reduces crop and livestock losses.
- **Environmental Protection:** Promotes sustainable resource use and ecosystem conservation.
- **Farmer Empowerment:** Equips farmers with tools and knowledge to adapt and thrive.

By investing in climate-resilient infrastructure, farming communities can better withstand the impacts of climate change while ensuring food security and sustainable livelihoods.

3.9. Harvesting

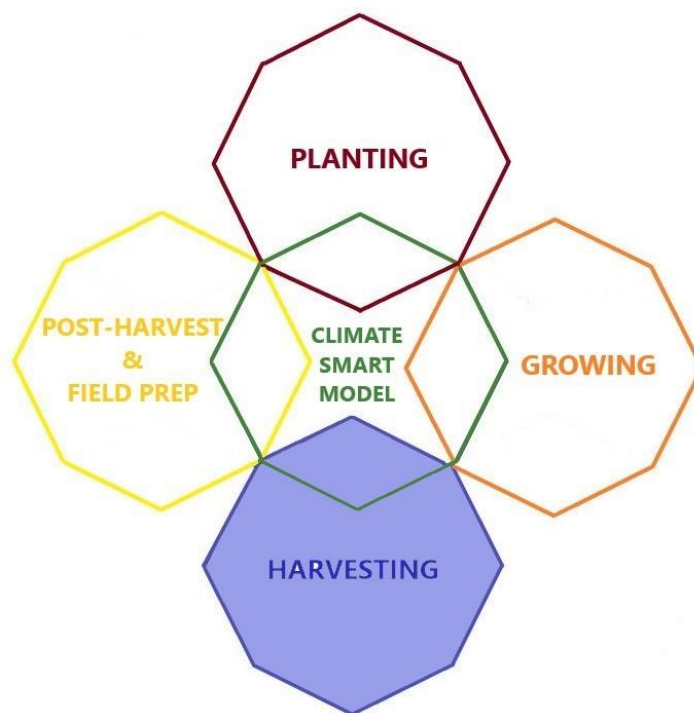


Figure 3.91: Harvesting in the Process

In agriculture, the harvest is the process of gathering mature crops from the fields. Reaping is the cutting of grain or pulse for harvest, typically using a scythe, sickle or reaper. The harvest marks the end of the growing season, or the growing cycle for a particular crop, and this is the focus of seasonal celebrations of many religions. On smaller farms with minimal mechanisation, harvesting is the most labour intensive activity of the growing season. On large, mechanised farms, harvesting utilises the most expensive and sophisticated farm machinery, like the combine harvester. Harvesting in general usage includes an immediate post-harvest handling all of the actions taken immediately after removing the crop – cooling, sorting, cleaning, packing – up to the point of further farm processing or shipping to the wholesale or consumer market.

Harvest timing is a critical decision that balances the likely weather conditions with the degree of crop maturity. Weather conditions such as frost, rain (resulting in a 'wet harvest'), and unseasonably warm or cold periods can affect yield and quality. An earlier harvest date may avoid damaging conditions but result in poorer yield and quality. Delaying harvest may result in a better harvest but increases the risk of weather problems. Timing of the harvest often amounts to a significant gamble.

Depending on your crop you will use different techniques. The major techniques are as per the following crops: seed (wheat, mielies and sunflower), fruits and vegetables and ground crops (potatoes, onions and

sweet potatoes).

3.9.1. Cereal Crops, Oil Seeds, Dry Legumes

Harvesting any crop can be done manually or with the aid of machines. The choice depends on the availability and cost of labour, and on the economics of using machines.

Harvesting is the process when you cut and collect your mature crop from the field. To get the biggest yield, reduce grain loss, and maintain seed quality, it is important to harvest at the right time. Harvesting too early or too late leads to reduced yields and less quality of your seed harvest. This reduces the value of your crop.

When harvesting a seed crop, you must pay particular attention to ensure that the harvest produces quality seeds that have strong viability. This is important to the farmer who will use your seeds because reduced quality seed results in lower germination and poor crop establishment, which will eventually produce lower yields at harvest.

Disadvantages of early and late harvesting

Early

- Large number of immature grains
- Low yield or low seed quality
- Loss of viability as seed

Late

- Longer time for attack by rodents, birds and other pests
- Lodging (crop that is lying on the ground) makes harvesting difficult and reduces yield
- Prolonged exposure of the crop to weather
- Excessive shattering

Tips for dry seeds:

- Watch your crop as you near the crop's maturation date.
- The pods will change colour as they start to dry.
- Different legumes are classified as mature at different stages. Some are mature before filling the pod, others are seen as mature once the pod has been filled by the bean.
- Pods should be firm and crisp, they should snap when you break one in half.
- Often beans are also dry, if moisture level is too high you can get mould in your produce.

3.9.2. Fruits, Vegetables and Wet Legumes (green beans)

Like all harvesting this is the most intensive part of the whole growing process. Harvesting fruits and vegetables at the right time is very important for peak flavour and good storage.

It is impossible to go through every type of fruit and vegetable but here are some tips to remember.

- Fruits are ready to be picked when they separate easily from the tree.
- Check the colour and taste of a fruit sample.
- Avoid pulling the fruit from the tree, lift and twist or snip with a scissor
- Be careful of bruising fruits and vegetables, this will lower the quality and shelf life of your produce. Lower grade produce limits your market and uses of your produce.

3.9.3. Ground Crops

Like fruits and the seed crops this is labour intensive. Most ground crops must be handled with care to avoid bruising and spoiling. The biggest disadvantage as per a ground crop is that you cannot see

underground. Examine the foliage and then dig for a sample.

To determine the maturity of the crop you will have to either dig out the crop or yank it out (carrots). Mechanisation allows for the turning of the soil and then the speedy collection of the crop.

3.10. Post-Harvest

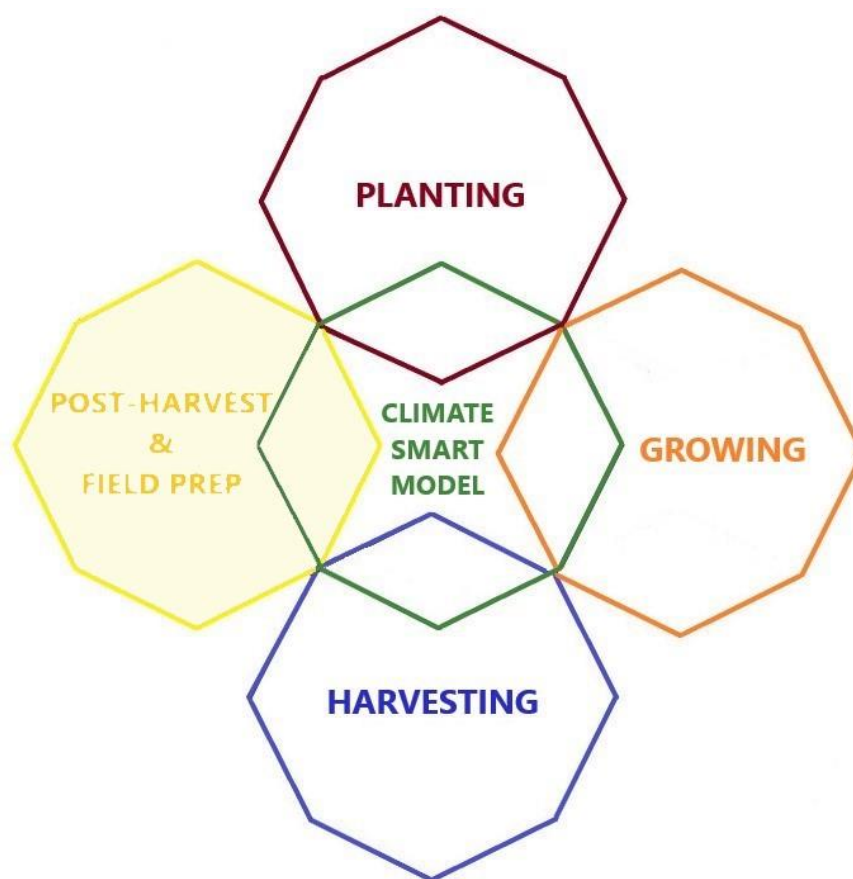


Figure 3.92: Post Harvest Process

As you have noticed we are working with dry seeds (sunflowers, cereals and legumes) and fresh produce, fruits and vegetables. Within the post-harvest process, we need to look at handling, storage, processing and transportation.

Both produce types, dry and fresh can lose water which will affect the quality of the produce. In the case of fresh produce, we need to be more careful as damage to the fruit will lower the quality of the fruit to market.

3.10.1. Post-Harvest Aspects

Scenario

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. The family can use the bruised produce before it spoils. 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. The longer the process from field to shelf to plate the more deterioration the fresh produce is going to experience. 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 must 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.

Similarly, within the harvesting of dry produce you need to be aware of debris in your seed. Combine harvesters and drum separators can still allow small particles to enter the produce, seed. The more debris mixed into your dry seed the lower the quality.

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.

Dry seed can spoil if it gets wet, mould.

3.10.2. Quality Components

Produce can be graded according to the following quality criteria (this can be for both fresh and dry produce):

- 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.

3.10.3. 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.

Entrepreneurship and Record Keeping

4.1. Market

Being a farmer 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 produce, dry produce and fresh fruit and vegetables.

New farmers 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 4.1: Vegetable and fruit market

4.2. Entrepreneurship

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 must work to create his/her own income.

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

4.2.1. 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.

4.2.2. 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 farming 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 4.2: Worker in a nursery

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.

4.2.3. 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

4.3. Record Keeping

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 farmers. 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.

4.3.1. 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)	Notes
01/05/21	Potting soil	10 kg	04/06/21	2 kg	K 20	Eggplant (0.01 ha)	K 2	N/a
01/05/21	Basal fertilizer	5 kg	04/06/21	2,5 kg	K 100	Eggplant (0.01 ha)	K 50	n/a

4.3.2. 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

4.3.3. 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.

4.3.4. 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

4.3.5. 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 the 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.

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

4.3.6. 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.

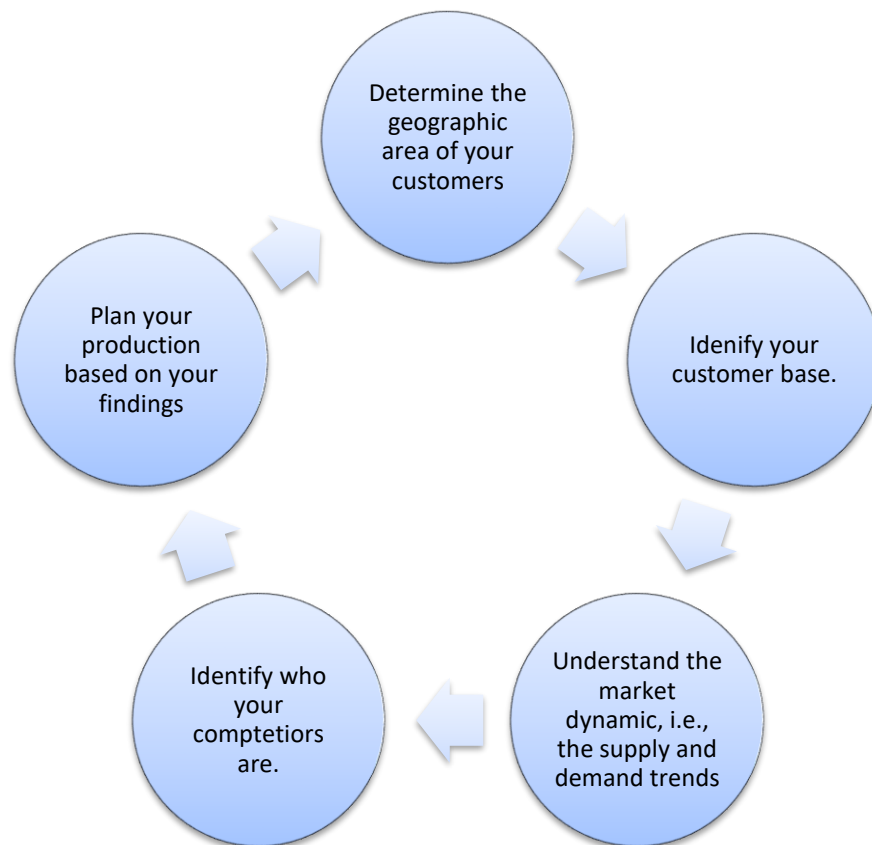


Figure 4.3: Knowing your market

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.

4.3.7. 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.

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.
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.

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