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Leafy Vegetables Production, Processing and Marketing

Training Manual

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

AGRI-JOBS 4 YOUTH!

GFA CONSULTING GROUP

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GFA Consulting Group GmbH.

On behalf of the:

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Foreword

The Agriculture industry in Kenya is the engine of its economy, employing 60% of the country's labour force, directly and indirectly generating more than half of the county's GDP. Kenya's agri-food sector is the country's biggest job creator and contributor to export earnings. Three-quarters of the Kenyan population is below 35 years of age with over 70% living in rural areas. Every year, an additional 1 million job seekers enter the labour market. At the same time, it is estimated that only 850,000 new, predominantly informal jobs are created each year. While the overall unemployment rate is around 7.2%, the youth unemployment rate however is estimated to be substantially higher than the overall rate. It is widely acknowledged, that a flourishing agriculture sector could create both formal and informal employment and business opportunities for millions of young Kenyans, improving livelihoods and reducing poverty at scale.

But in contrast, young Kenyans who represent more than one third of the national labour force remain almost entirely excluded from the country's most significant industry. According to government statistics, only 10% of young people are directly participating in the agriculture sector. Despite a national median age of approximately 20 and an average life expectancy of 66, the average age of a farmer in Kenya according to the Census 2019 is 59 years whereas the mean age for the consumer is 17 years. A steady population growth of 9.9 million over the last 10 years means that venturing into agribusiness is a guaranteed source of income presently and for the future.

The provision of quality education and training in Agriculture is fundamental to the Government of Kenya's overall strategy for social-economic development through food security and gainful employment. Quality education and training will contribute to the achievement of the country's development blueprint and Sustainable Development Goals (SDGs). However, many young people are excluded from agricultural vocational training and education owing to a myriad reasons. Key among this being the fact that for a long time, the vocational training has not adequately addressed the demands of a sector in need of commercialisation and modernisation, let alone deliver training effectively.

In order to facilitate the process of effectively inculcating knowledge, skills and attitudes necessary for catapulting the nation to a globally competitive country a paradigm shift in TVET programs was initiated by the Government. This shift embraced Competency-Based Education and Training (CBET) to address the mismatch between training offered in TVET institutions and skills demanded by the industry towards increasing the global competitiveness of the Kenyan labour force.

This training manual has been developed to support the implementation of competency-based training on select leafy vegetable value chains and is intended to guide the trainee/trainer through the learning process. It is my conviction that this manual will play a critical role in supporting the development of a competent human resource for the agriculture sector's growth and sustainable development.

Principal Secretary,

State Department for Crop Development,
Ministry of Agriculture and Livestock Development.

Preface

For the youth to successfully venture into agri–entrepreneurship, it is important for them to be equipped with the right knowledge, skills and attitudes through training using the right training materials. It is against this backdrop that a project dubbed 'Agri-Jobs **4 You**th Initiative' was commissioned to support an integrated and holistic approach to youth employment promotion through select agricultural value chains. These value chains have been identified based on their pronounced youth-friendliness and high potential for income generation and employment creation. One of the key value chains identified was the leafy vegetable value chain; specifically on six popular varieties of African Leafy Vegetables (ALVs) alongside spinach and kales.

The 'Agri-Jobs **4 You**th Initiative' project is implemented by the German development agency *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ), in partnership with the Ministry of Agriculture and Livestock Development. GIZ has been commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) to implement the initiative.

The project acquired training materials previously developed by other projects on production and processing of leafy vegetables. However, through a desk review, it was established that the materials had information gaps that made it inadequate for the intended knowledge and skills transfer. Key among the identified gaps were: inadequate information to guide the learner on the step-by-step processes involved in production and processing of leafy vegetables; lack of integration of gender-sensitive training approaches; and, inadequate mainstreaming of climate relevance and Climate Smart Agriculture (CSA) practices.

It is against this background that GIZ engaged GFA to develop this training manual following review and improvement of the previous learning materials on behalf of the Agri-Jobs **4 You**th Project. I am grateful to the technical experts and trainers involved in its development.

Ralf Barthelmes,

Project Manager,
Agri-Jobs **4 You**th, GIZ.

Acknowledgement

This training manual is intended to support the implementation of Competency-Based Education and Training (CBET) along the Leafy Vegetables value chain in Kenya. It has been developed by GFA Consulting Group GmbH which was contracted to implement the ATVET and Extension component of the Agri-Jobs **4 You**th Initiative on behalf of the German development agency *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ). The Initiative was commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and is implemented in partnership with the Ministry of Agriculture and Livestock Development.

We recognise the critical role of experts the production, processing and marketing of leafy vegetables drawn from the private sector, government institutions, and national technical and vocational colleges in the list of contributors. These experts were very dedicated in providing their technical inputs during the development of this manual. The content of this manual is heavily borrowed from earlier versions previously developed with support from the GIZ-implemented Agricultural Technical and Vocational Education and Training (ATVET) Project under the Comprehensive Africa Agriculture Development Programme (CAADP).

Special gratitude goes to national consultants contracted by the GFA Consulting Group GmbH, for successfully guiding the development of this manual especially in ensuring that it is aligned to standard occupational practices, embraces CSA practices, and is sensitive to gender diversity.

Finally, we convey our sincere appreciation to the management of private sector farms and industries including their employees for allowing and authorising the use of photographs, to complement the technical content in this training manual.

Ralph Rothe,

Team Leader, ATVET and Extension Component,
GFA Consulting Group.

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Acronyms and Abbreviations

AFA	Agriculture and Food Authority
CAADP	Comprehensive Africa Agriculture Development Programme
CAN	Calcium Ammonium Nitrate
CBET	Competency Based Education and Training
CSA	Climate Smart Agriculture
DAP	Di-ammonium phosphate
DSP	Double Superphosphate
FAO	Food and Agriculture Organisation of the United Nations
FYM	Farm Yard Manure
GAP	Good Agricultural Practices
GIZ	*Deutsche Gesellschaft fur Internationale Zusammenarbeit*
HACCP	Hazard Analysis Critical Control Points
IPM	Integrated Pest Management
KEBS	Kenya Bureau of Standards
KEPHIS	Kenya Plant Health Inspectorate Services
KNQF	Kenya National Qualification Framework
KRA	Kenya Revenue Authority
LCD	Liquid Crystalline Display
NPK	Nitrogen Phosphorous and Potassium
PHI	Post-Harvest Interval
PPE	Personal Protection Equipment and Apparel
SMART	Specific, Measurable, Attainable, Relevant, and Time-bound
SWC	Soil and Water Conservation
TVET	Technical Vocation Education and Training
YEA	Youth Employment in Agri-food sector

Background Information

This training manual will enable the trainee acquire competencies to practically produce, and process leafy vegetables. The manual contains simplified content, illustrations and self-assessment questions to guide the trainee in the learning process. It also has web-links and references for further reading as well as model responses to the self–assessment questions. The manual further provides suggested methods of training delivery for use by the trainer.

This manual has been developed by GFA Consulting Group GmbH which was contracted to implement the ATVET and Extension component of the Agri-Jobs **4 You**th Initiative on behalf of the German development agency *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ). The Competency-Based Education and Training (CBET) system informed the development of this manual so as to ensure that the learning outcomes and competencies imparted are in line with the demands of the agricultural industry. These competencies will enable the trainee to plan and prepare land, produce leafy vegetable seedlings, produce African leafy vegetables, produce spinach and kales, and, process and market leafy vegetables.

Purpose of developing this Manual

The training manual for production, processing and marketing of leafy vegetables has been developed with the aim of creating awareness of the broader agribusiness ventures possible within the leafy vegetable value chains especially opportunities offered by new technologies and innovative business models. This is in a bid to dispel the notion of Agriculture being a subsistence-only, unattractive, backbreaking and traditional venture. It also seeks to show that with correct approach and use of technology, agriculture is very profitable both at large and small scale even with reducing land sizes and challenges of climate change. The learning outcomes in this manual aim at proving that everyone including youth and women can obtain gainful employment by engaging in agribusiness along the leafy vegetable value chain.

Layout of the Manual

Beyond this background information section, the training manual is organised into five chapters. The first chapter is an introductory chapter covering the general practices around farm planning and land preparation including soil testing, water and soil conservation. In the second chapter, aspects of sustainable production of leafy vegetable seedlings are covered. The third chapter is about the production practices around six select varieties of ALVs in terms of planting, field management and harvesting. The six ALVs are: Black night shade *(Managu)*, Cowpea *(Kunde)*, Jute mallow *(Murenda)*, Spider plant *(Sagaa/Saget)*, Slender leaf/Crotolaria/Sunn hemp *(Mitoo)* and Amaranth *(Mchicha/Terere)*. Chapter four focuses on production practices of Kales and Spinach. Finally, the fifth and last chapter elaborates on processing, value addition and marketing of the leafy vegetables covered in Chapter three and four.

Each chapter presents the introduction of the unit of learning and a summary list of the learning outcomes. For each learning outcome, the following components are presented in this manual:

- **Learning objectives**

These are the statements that clearly describe what the trainee is expected to achieve as a result of instruction either by an instructor or by following the guidelines in this manual on their own. The learning objectives describes what learners should know or be able to do at the end of the learning outcome session(s) that they couldn't do before.

- **Suggested training delivery**

This section is meant to advise the trainer on the methodology of imparting knowledge, skills and attitude to the trainee with regards to the standard practices of achieving a learning outcome. It is deliberately structured to put emphasis on trainee-acquisition of competency in an environment where the learner plays an active role. It also gives the resources and time required to effectively deliver training for a specific learning outcome.

- **Information sheet**

The information sheet is a section under each learning outcome that provides the subject matter in relation to the definition of key terms, methods, processes/procedures/guidelines, content, illustrations (photographs, pictures, video, charts, plans, digital content and simulations) and case studies.

- **Tools, equipment materials and supplies**

This guide also presents tools, equipment, supplies and materials required for each learning outcome as guided by the performance criteria in the occupational standards and content in the curriculum.

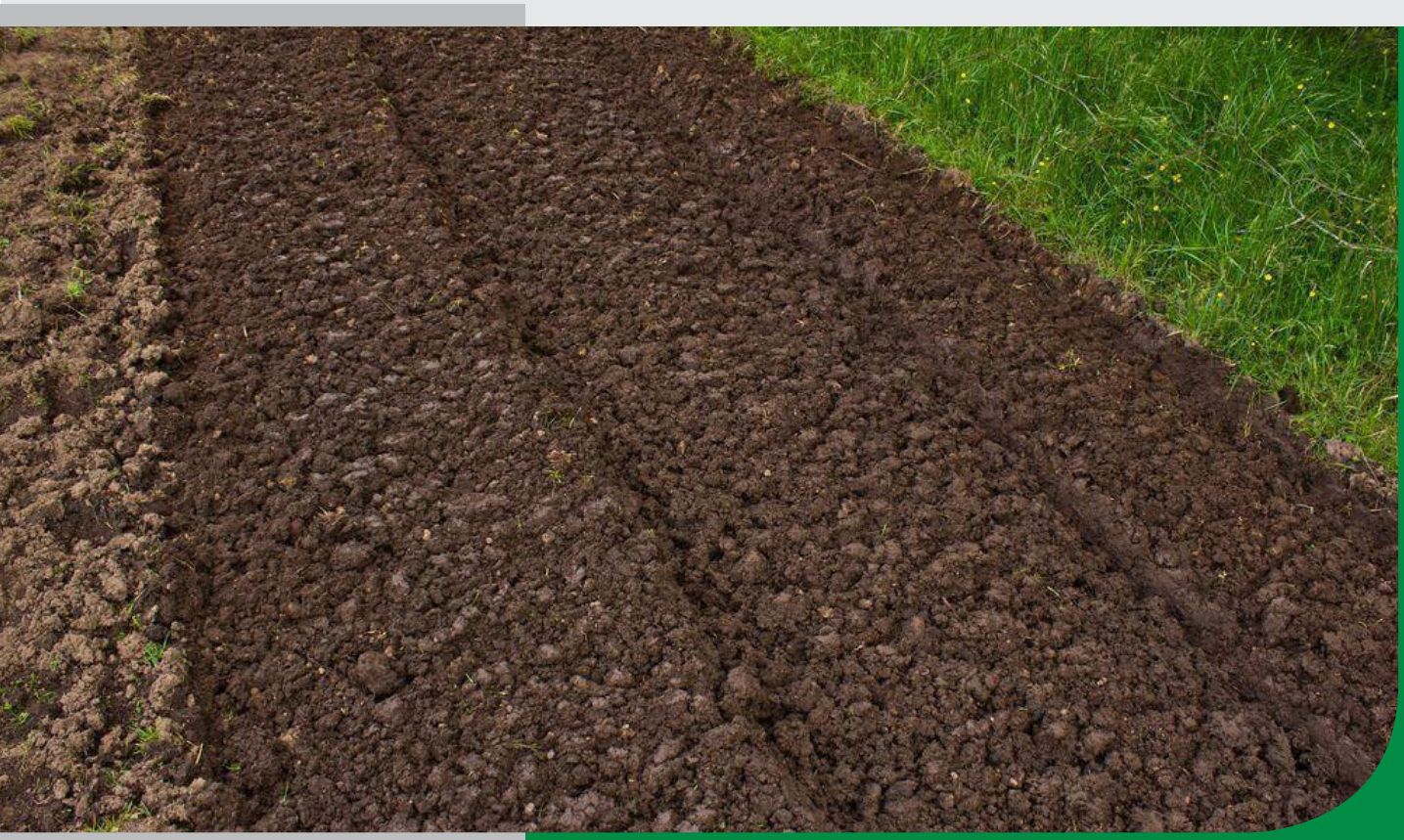
- **Self-assessment questions**

Self-assessment is linked to the performance criteria, required knowledge, skills and the range as stated in the occupational standards. This section poses questions and assignments to trainees to help them gauge whether they have acquired the required competencies and gives them an opportunity to reflect on what they have learnt.

- **References**

References, relevant web-links and addendums are provided for further study.

At the end of each chapter, the responses to self-assessment questions for all the learning outcomes within the chapter are presented. The section provides model answers to the self-assessment questions and assignments earlier presented to the trainees.



1 Farm Planning and Land Preparation

1.1 Introduction to the Chapter

This chapter specifies the competencies required to plan and prepare land in readiness for production of vegetables. It involves planning to produce vegetables, site selection, soil sampling and testing, land tillage, construction of soil and water structures and setting up of irrigation structures.

1.2 Summary of Learning Outcomes

The content of this this chapter will enable the trainee or farmer to;

- Plan leafy vegetable agri-enterprise venture.
- Carry out site selection.
- Prepare the land.
- Set up home gardening structures.
- Set up soil and water conservation structures.
- Set up irrigation structures.

1.2.1 Learning Outcome 1:
Plan Leafy Vegetable Agri–Enterprise Venture

1.2.1.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify business opportunities along the leafy vegetable value chain
- Develop an effective crop calendar
- Identify relevant enterprise records
- Prepare a simple business plan.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying suitable business opportunities along vegetables value chain	• Lead a group discussion where trainees share their experiences, challenges and possible solutions in starting and managing a leafy vegetable agri-enterprise • Engage the students in a brainstorming session to generate innovative ideas for business opportunities along the leafy vegetable value chain • Organise a field trip to an active agri-enterprise or cooperative society along the leafy vegetable value chain implementing Climate Smart Agricultural (CSA) practices	• Training manuals on production and processing of leafy vegetables with emphasis on CSA practices • White boards • Flip charts • Sticky notes • Marker pens • Display boards
• Preparing a crop calendar	• Present a short PowerPoint presentation on how to prepare a crop calendar • Give individual assignments to trainees to prepare a leafy vegetable crop calendar	• Flip charts • Marker pens • Computer • LCD projectors
• Identifying variousenterprise records	• Allow trainees to brainstorm about benefits and challenges of record keeping in an agri-enterprise • Organise group discussions to identify types and uses of important records in a leafy vegetable agri-enterprise • Display samples or templates of relevant records and digital tools used for record keeping in a vegetable agri-enterprise.	• Samples or templates of relevant records • Digital record keeping tools • Flip charts • Marker pens
• Developing a simple business plan for the vegetable agri-enterprise	• Engage the trainees on the key components of a basic business plan followed by a discussion session. • Give assignments to trainees (in groups of around five) to develop a simple business plan for different agribusiness ventures along the leafy vegetable value chain	• Business plan templates and guideline • Handbooks, manuals • Online resources to check different samples of business plans • Laptop/ computer • LCD projector
• **Duration: 6 hours**		

1.2.1.2 Information Sheet

Definition of terms

Below are the meanings of various terms in the context of leafy vegetables;

Agri-enterprise records: Systematic and organised documentation of information associated with the production, processing and marketing of leafy vegetables as a business.

Agri-enterprise: A business venture or initiative that focuses on the production, processing and marketing of leafy vegetables.

Business plan: A written document that outlines the goals, strategies, and operational design related to the production, processing and marketing of leafy vegetable agri-enterprise.

Crop calendar: Schedule or timeline of farming activities that outlines the various stages involved in establishing, managing, and harvesting vegetables.

Leafy vegetables: Edible plant leaves that often require cooking before eating or can sometimes be consumed raw.

Leafy vegetable value chain

The leafy vegetable value chain includes several segments: inputs, production, packing, storage, processing, distribution and marketing. The most important inputs for production in this industry are seeds, fertilisers, agrochemicals (herbicides, fungicides and pesticides), farm equipment, and irrigation equipment. The figure below illustrates the entire value chain.

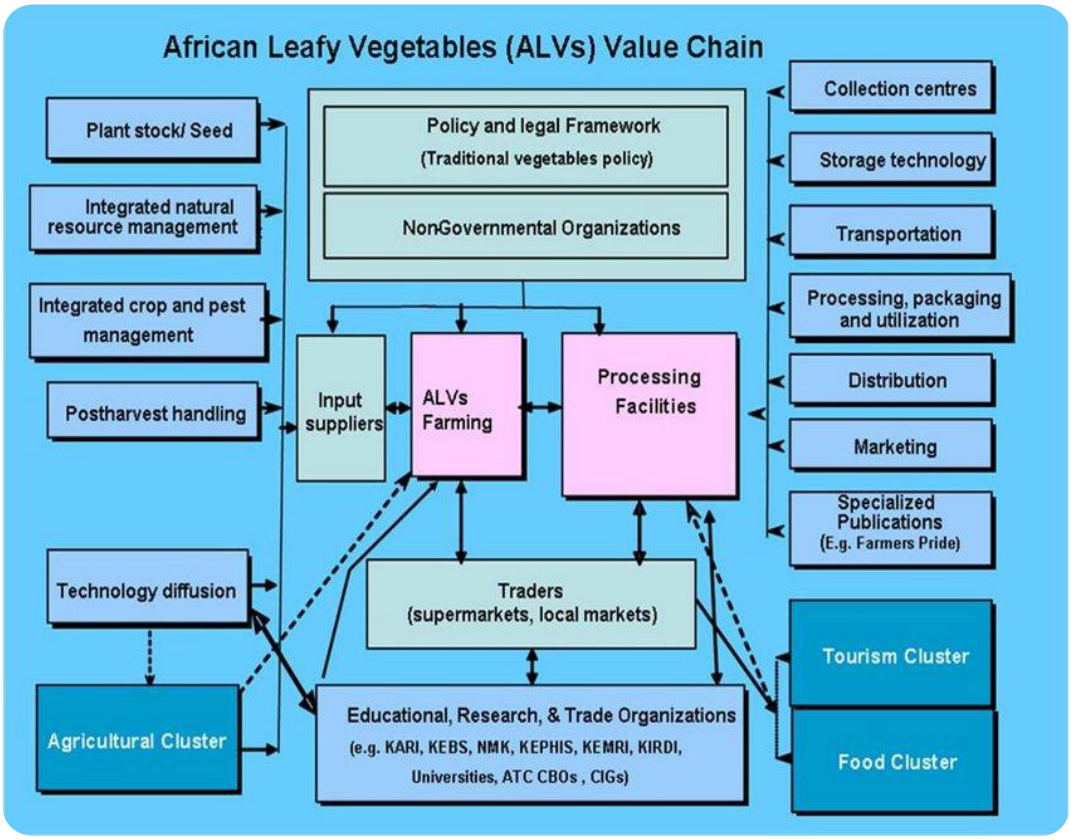


Figure 1: Leafy vegetable value chain

(Adapted from Nono-Womdim, et al, 2012)

Economic importance of leafy vegetables

The following reasons make farming of leafy vegetables to be attractive;

- Leafy vegetables are healthy foods that contribute to a balanced diet and help in achieving weight loss. They are typically rich in nutrients and fibre and low in calories and fat. Nutritionists recommend that adults vary their vegetable intake and aim to fill half their plate with vegetables and fruits.
- It can be practiced both at a small scale and at large scale.
- It is profitable for farmers with small pieces of land since it can be grown in a greenhouse or in vertical gardens.
- Leafy vegetables are short season crops which give several crop cycles per year. This can give an opportunity for the farmer to maximise on profits from local and export markets.

Business opportunities and ideas along leafy vegetable value chain

As an enterprise the production, processing and marketing of leafy vegetables provides opportunities for sustainable agriculture and economic development.

You can identify a viable business venture along the leafy vegetable value chain by following the steps in the figure below;

Step 1: Market scan

Conduct a market scan to identify high demand leafy vegetable products by gathering information from consumers, retailers, wholesalers, and other stakeholders. collect information on consumer preferences, purchasing behaviour, price sensitivity and market trends of different vegetables at a particular season.

Step 2: Supply and production trends

Check on the supply trends and production patterns of the identified vegetable product to warrant selection.

Step 3: Select suitable business

After processing the information collected in steps 1 and 2 above, choose the suitable leafy vegetable product and agri-enterprise business idea to venture into.

Figure 2: Identifying a viable agri-business

Some business ideas that are possible to venture into include the following;

- Condensed vegetable farming in vertical gardens or greenhouses.
- Hydroponic vegetable farming.

Figure 3: Hydroponic garden

Source: Nature Zedge photo grid

- Intensive vegetable farming under irrigation.

Figure 4: Vegetable fields under irrigation

- Organic vegetable farming business.
- Vegetable wholesale supply company.
- Roadside/market vegetable retail shop.
- Online fresh vegetable order delivery platform.
- Door-to-door vegetable delivery.
- Vegetable processing business.

Crop calendar

Developing an effective crop calendar for vegetables involves;

- Understanding of local climate trends considering the climate forecasts,
- Crop requirements,
- Market dynamics and risk management.

By carefully considering these factors, one can optimise productivity, improve resource management, and enhance the overall profitability and sustainability of leafy vegetables production.

Table 1: Crop calendar for leafy vegetables (rain-fed)

	Monthly farming activities					
	August	**September**	**October**	**November**	**December to March**	
Week 1	Land preparation	For direct field establishment; tilth rows that are 30-40 cm apart Apply manure (8 tonnes/acre) or DAP fertiliser (75 Kg / acre) at planting	Top dress with CAN or SA fertiliser at 15 g/ metre after second weeding	Harvest vegetables 60 days after direct sowing	**Peak demand for leafy vegetables because of low supply**	Land preparation
Week 2	Seedbed preparation Make seedbed of 1 metre width and a convenient length Make drills on the seedbed at a spacing of 10 - 20 cm apart Thinly sow and cover with soil and mulch Seed rate is 50 g / acre	Transplant when seedlings are 10 -15 cm high. Note: Takes 30 days before transplanting. Spacing of 30 cm between rows and 10 -15 cm between plants using fertiliser rate as above	Carry out weed, pest and diseases control	Harvest vegetables 30 days after transplanting		Establishment of rotational legume
Week 3	Watering	Carry out weed, pest and disease control	Irrigate if needed	Harvesting and marketing of produce can continue up to 6 - 7 months		
Week 4	Weed control and watering	Irrigate if needed	Irrigate if needed			

Note:

Crop calendar varies depending on agro-ecological areas

Factors to consider when developing a crop calendar

Consider the following factors when developing a crop calendar;

1. Seasonality: it is important to understand the local climate and weather patterns so as to determine the appropriate seasons for planting, growth, and harvest of leafy vegetables. With the realities of climate change and variabilities, consider the climate forecast to inform timing of the rainy season, dry season, and any extreme weather conditions that may affect crop growth.
2. Crop selection: select leafy vegetables varieties that are well-suited to the local conditions and market demand. Select crops that are easy to grow, have shorter maturity periods, and require minimal inputs.
3. Planting dates: Determine the optimal planting dates for each selected leafy vegetable variety based on their growth requirements and climatic conditions. Identify the ideal time for sowing seeds or transplanting seedlings.
4. Succession planting: Plan for successive plantings to ensure a continuous supply of leafy vegetables throughout the year. Stagger planting dates to have multiple crops at different stages of growth. It helps maintain a steady harvest and meet market demand consistently.
5. Crop rotation and intercropping: Incorporate crop rotation and intercropping practices to optimise land use and minimise pest and disease build-up. Rotate vegetables with different plant families or non-host crops. Intercrop companion crops to maximize yield and utilise resources efficiently
6. Basic agronomic practices: Consider key agronomic practices such as land preparation, seedbed establishment, fertilisation, irrigation, and weed management.

Note:

Companion crops with leafy vegetables are garlic, onion and coriander.

Agri-enterprise records

The recommended records should provide insights into financial health, production efficiency, market trends, and compliance status. By effectively managing and utilising these records, one can enhance the overall success and sustainability of the leafy vegetable enterprise.

Types of agri-enterprise records

The following are relevant records to keep in a leafy vegetable agri-enterprise

1. Activity diary

This is a record of the daily activities at the agri-enterprise. It is possible to identify weaknesses/ strengths in the agri-enterprise with this record. An activity diary keeps track of all activities like crops planted, crop yields, seed quantity, harvest date, inputs, vegetable processing outputs and supplied products.

Table 2: Farm activity diary template

Week	Date	Activity	Resources	Responsibility	Remarks
1					
2					

2. Inventory

This is a record that contains the list of agri-enterprise assets and resources. It contains details of assets such as buildings, machinery, implements, equipment and tools. This record also includes the quantity, types and conditions of equipment/tools/inputs etc.

Table 3: Farm inventory template

LEAFY VEGETABLE INVENTORY						
Name of the farm.....						
Date of assessment.....						
S/no	Farm inputs/tools/ equipment	Quantity	Good condition/ usable	Needs repair	Not functional/ not usable	Comments
Responsible officer.....						
Signature						

3. Input records

This record provides information on the quantity of inputs used on the leafy vegetables agri-enterprise such as fertilisers, the quantity of seeds used, labour, agro-chemicals etc. It also gives the proportional cost of each input.

Table 4: Input records sample

S/No.	Inputs	Crops			
		Spinach		Spider plant *(Sagaa)*	
		Cost (Kshs)	% Cost	Cost (Kshs)	% Cost
1	Labour	5900	43	29700	62
2	Fertiliser	1100	8	4700	10
3	Agro-chemicals	500	4	4900	10
4	Machinery	3600	26	3400	7
5	Water	700	5	500	2
6	Miscellaneous	1900	4	4500	9
	Totals	**13700**	**100**	**47800**	**100**

4. Production records

This record measures the farm productivity and the success of agricultural operations in general. It indicates whether a particular crop is thriving or not. It shows the production activities of the farm in detail.

Table 5: Production records template

Season/year	Leafy vegetable	Expected yield	Total yield	Remarks (challenges and required changes)

5. Sale records

This record shows the sales from the leafy vegetables agri-enterprise. It also informs a farmer of his/her income.

Table 6: Sales record template

SALES RECORD						
Agri-enterprise Name:						
Date						
S/No.	Type of Leafy Vegetable	Unit	Quantity	Unit Cost	Totals	Comments
Totals						
Name of person responsible:						

6. Consumption records

Most leafy vegetables are grown or processed for sale but in some instances, farmers produce some for home consumption (cooking, medicinal, seed multiplication etc). This book documents the number of leafy vegetables collected and consumed by the farmer and his family, or given away but not sold.

Table 7: Consumptions records template

Consumption Record Name.....Date.....						
S/No.	Leafy vegetable	Quantity	Unit	Unit cost	Total	Remarks
1						
2						
3						
4						
Totals						

7. Profit and loss account

This account record is in form of a table with two main sides. The left side relates to liabilities and payments (purchases and expenses), whereas the right side relates to assets and revenue (sales and receipts). This record is initiated at the start of the agri-enterprise year's farming period and is closed at the end of the production period.

Table 8: Profit and loss account sample

PROFIT AND LOSS ACCOUNT **For Leafy Vegetables Agri-Enterprise as at.....**				
Purchase and expenses		**Sales and receipts**		**Remarks**
Open valuation (stock, cash)		Sale of black nightshade seeds		
Bought seeds		Sale of spider plant leaves		
Bought fertilisfertiliser		Sale of spinach		
Bought agrochemicals		Sale of black nightshade seedlings		
Rent		Sale of kales		
Casual labour		Sale of kale juice/salad		
Depreciation of machines				
Interest of....		Closing valuation		
Total				
Profit = (closing-totals)				

Developing a simple business plan

A business plan outlines the findings of a market survey, main enterprise activities, target market and financial projections i.e the estimated production / processing and marketing costs and expected income. It serves as a roadmap for your leafy vegetables agri-enterprise and can be further expanded as the business grows. Regularly, review and update the plan to reflect new opportunities, challenges, and objectives.

Basic steps to develop a basic business plan for an agri-enterprise

1. **Executive summary**: Provide overview of your enterprise, including your goals, target market, and the value proposition of your leafy vegetables agri-enterprise.
2. **Product offering and market analysis:** Describe the specific vegetables varieties you plan to grow and sell. Highlight their nutritional benefits and popularity in the local market.
3. **Production and operations**: Outline the steps in producing vegetables.
4. **Marketing and sales strategy**: Describe ways to promote and sell your leafy vegetable by identifying potential customers, such as local markets, restaurants, or individuals.
5. **Financial plan**: It includes start-up costs, revenue projections, and expenses.

1.2.1.3 Tools, Equipment, Supplies and Materials

Equipment	Supplies and materials
• Weather stations • Soil testing kit • Laptop • Computer • LCD projector	• Market reports • Seed catalogues • Climate data and weather forecasts • Sample crop calendar • Record samples • Calendar or date planner • Flip charts • Marker pens

1.2.1.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What are some of questions you need to ask yourself before investing in leafy vegetables enterprise?
2. Name any four factors to be considered when preparing a crop calendar under leafy vegetables enterprise?

3. State any three records that should be maintained when running leafy vegetables enterprise?
4. What are the benefits of preparing a business plan in an agri-enterprise of leafy vegetables enterprise?

Notes:

1.2.1.5 References

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1.2.2 Learning Outcome 2:
Carry out Site Selection

1.2.2.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify factors influencing site selection.
- Identify soil sampling methods.
- Identify and assemble tools and equipment for soil sampling.
- Sample the soil.
- Collect and package sampled soil and submit for testing.
- Select a suitable site.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
1. Identifying factors influencing site selection.	• Guide a brainstorming session on the factors to consider when selecting a planting site for leafy vegetables.	• Flip charts • Marker pens
2. Identifying soil sampling methods.	• Facilitate a question-and-answer session on different soil sampling methods. • In groups, allow the trainees to discuss and present on each of the sampling methods. Give a final presentation on the common methods and accompanying procedures of soil sampling.	• Flip charts • Marker pens • Computer • LCD projector
3. Carrying out actual soil sampling.	• Organise a practical for trainees to identify and assemble all the tools, equipment and materials needed to perform soil sampling. Use a question-and-answer session to discuss and demonstrate the uses of the tools, equipment and materials. • Give instructions to trainees as they perform soil sampling.	• Soil sampling tools and equipment • Photos of other unavailable sampling tools and equipment • Flip charts • Marker pens
4. Selecting suitable site	• Lead the trainees on a farm visit / excursion to identify probable planting sites.	• Farm field
• **Duration: 8 hours**		

1.2.2.2 Information Sheet

Definition of terms

Site selection-the process of choosing the most suitable location for growing crops.

Soil sampling- the process of taking a small quantity of soil from the field to act as a representative sample of the soil in that particular field**.**

Soil testing- informs the farmers of the imbalances in the soil and guides them in adopting specific fertilisers or soil conditioners to deal with the diagnosed issues.

Factors influencing site selection

The following factors should be considered when selecting an ideal site for establishing leafy vegetables:

- Previous cropping: The site should not have been used for Leafy vegetables cultivation for the last season.
- Surface slope should be gentle.
- No history of serious diseases, pest incidence or weeds of leafy vegetables.
- Well-drained soils/fertile and deep.
- Security: Where it is safe for farmers and workers, accessible and fenced.

Soil sampling methods

The following are some of the methods used to sample soil.

1. Random method/zigzag

Sub-samples are collected by travelling in a zig-zag pattern collecting sub-samples at each location indicated by the numbered points in the figure below (start from 1 and end at 12). Ideally, zig- zag sampling tests each soil type equally.

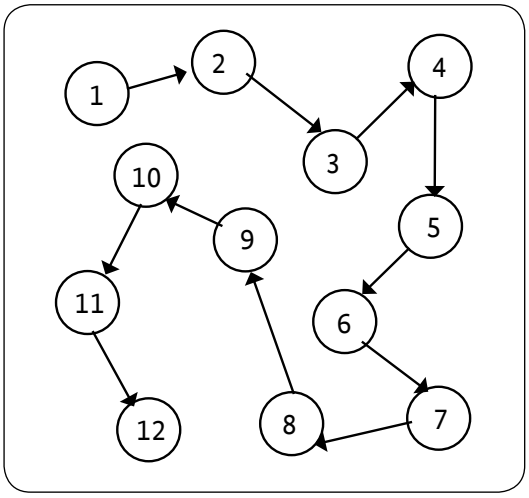

Figure 5: Random soil sampling method

2. *Diagonal/traverse methods*

In traverse method, four corners of the field are determined and sampling is done diagonally as shown in the figure below (collect samples at each of the cross points).

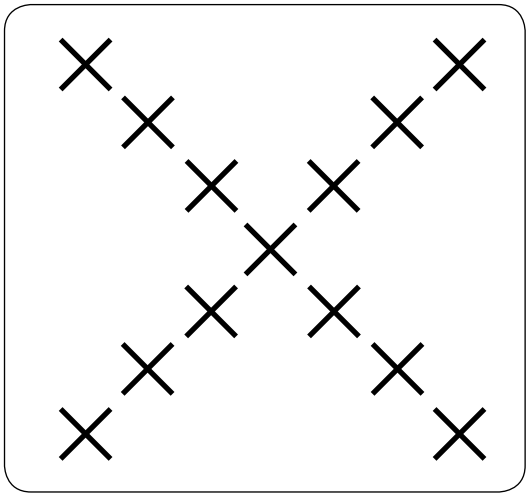

Figure 6: Diagonal soil sampling method

Soil sampling procedure

To sample soil, the following steps are followed:

1. Step 1 – Prepare the field for soil sampling

- Randomly select 4 sampling sites per acre of land and mark with pegs.
- Remove trash from the sampling sites.

2. Step 2 – Collect soil samples

- Dig out 20 cm depth of soil using a panga or auger tool in sections A.
- Place in a bucket.
- Repeat procedure in other sites (B,C and D respectively) and place in same bucket.
- Mix soil samples uniformly to form a composite.

Figure 7: Soil auger

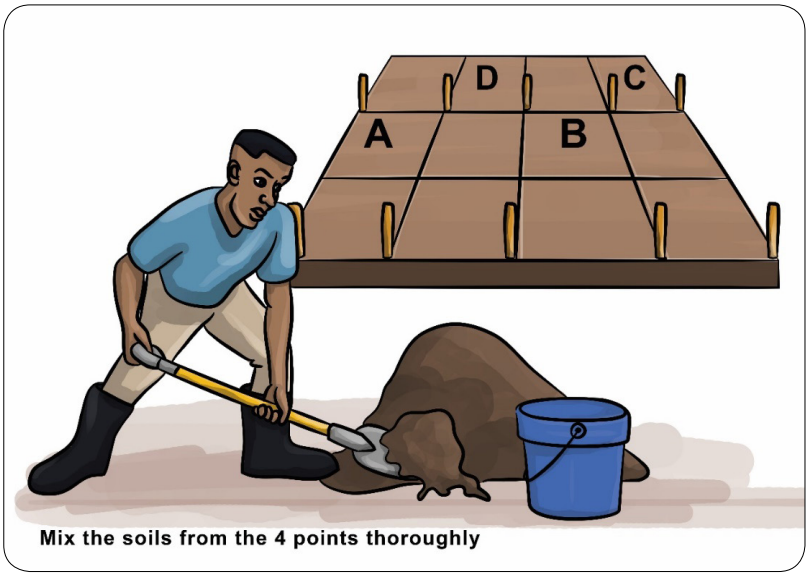

Figure 8: Soil sample mixing

3. Step 3- Package sampled soil and submit for testing

- Package ½ kg of the composite sample into a khaki paper bag.
- Label the package with the following: name of farmer, collection date, site coordinates, depth of soil sample and desired crop. This information can be contained in a data sheet attached to the package.
- Address the package to the laboratory and send.

Soil Sampling Data Sheet

On the data sheet provided present the following information

Date of sampling .....

Name of farm .....

Identification of the site .....

Contacts of the farmer .....

Address the package to the laboratory and send

Sampler's name .....

Recent history on use of the site

Crops grown .....

Yields .....

Fertilizers used .....

The reasons for the analysis requested .....

A sketch plan showing farm layout and mark sites sampled.

Note:

Use the recommendations from the soil test report alongside the factors to consider when siting to select the most suitable site to establish leafy vegetables.

1.2.2.3 Tools, Equipment, Supplies and Materials

Tools	Supplies and materials
• *Panga*	• Package materials
• Auger	• Labels
• Bucket	• Pens
• Spade	• Line String
• Tape measure	• Wooden pegs

1.2.2.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Name two common methods of soil sampling
2. State the factors influencing site selection
3. List the tools and materials used in soil sampling

Notes:

1.2.2.5 References

Chowdhury, M. A. H., & Hassan, M. S. (2013). Handbook of agricultural technology. *Bangladesh Agricultural Research Council, Farmgate, Dhaka*, *230*.

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Vanderwal, L., Rautiainen, R., Kuye, R., Peek-Asa, C., Cook, T., Ramirez, M., and Donham, K. (2011). Evaluation of long-and short-handled hand hoes for land preparation, developed in a participatory manner among women vegetable farmers in The Gambia. *Applied ergonomics*, *42*(5), 749-756.

1.2.3 Learning Outcome 3:
Prepare the Land

1.2.3.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify various tools and equipment of land preparation.
- Perform selective land clearing using appropriate tools and equipment.
- Perform tillage operations.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying various tools and equipment of land preparation.	• Organise a practical for trainees to identify and assemble all the tools, equipment and materials needed for land preparation then a discussion on their uses.	• Flip charts • Marker pens • Land preparation tools, equipment and materials
• Performing selective land clearing.	• Give instructions to trainees/ demonstrate as they clear land selectively for tillage operations. • Facilitate a question-and-answer session on the importance of land clearing.	• Land clearance tools, equipment and materials (Note: CSA tools recommended)
• Performing tillage operations.	• Organise a practical for trainees to perform primary tillage operations. • Give instructions to trainees/ demonstrate as they perform secondary tillage operations with emphasis on conservation agriculture tillage practices. • Facilitate a question-and-answer session on the importance of tillage operations.	• Tillage tools, equipment and materials • Flip charts • Marker pens
• **Duration: 14 hours**		

1.2.3.2 Information Sheet

Definition of terms

Selective land clearance: It is the choosy removal of vegetative cover from the surface before land is cultivated.

Seedbed: It is a piece of land of varying size that has been prepared to receive seed or planting material.

Land preparation: Refers to a series of activities involved in attaining a suitable seedbed, changing the soil condition with a tool for the benefit of man.

Selective land clearance

Land clearance is done to prepare land for cultivation and as a method of land reclamation. It is important to clear land selectively leaving some trees for shade and micro-climate in the farm. Land clearing is necessary under the following conditions;

- When opening up a virgin land.
- Where a stalk growing crop was previously planted such as maize.
- Where land was left fallow for a long time.
- Where the interval between primary and secondary cultivation is long such that the land has reverted to the original virgin state.

Methods of land clearance

- Selective felling of trees. Power saws, axes, pangas, mattocks and jembes are usually used to cut down trees that are harmful to crops while leaving agroforestry trees standing. Bulldozers and mechanical root rakes can be used in felling trees on a large scale. Removal of stumps and trash follows later.
- Selective burning. The vegetation cover is set ablaze. The method should be discouraged as it destroys the soil organic matter, soil microorganisms and plant nutrients.
- Slashing. This is done to cut small bushes, long weeds and grasses using hand held slashers /*pangas* or tractor-drawn mowers.

Figure 9: Land clearance by slashing

- Use of chemicals. Environmentally-friendly agrochemicals / herbicides can be used to eliminate notorious weeds.

Note:

- Unprotected falling of trees is harmful to our environment, plant more agroforestry trees that you do not require to cut to plant crops.
- Use chemicals only when there is serious need (killing notorious weeds), otherwise, practice conservation agriculture.

Tillage operations

a) Primary tillage

This refers to the first cultivation practices carried out on a piece of land after selective land clearance. It is done for the following reasons.

- To remove weeds.
- To bury organic matter for easy decomposition.
- To facilitate water infiltration and aeration.
- To destroy soil-borne pests by exposing them to predators and the sun.
- To make planting easy.

Methods of primary tillage

Primary tillage can be carried out using the following methods;

- **Manual digging:** This is done by use of jembes, mattocks and fork *jembes* to cut and turn the soil slices.

Figure 10: Manual primary tillage by digging

- **Mechanical cultivation:** This is the use of tractor-drawn implements such as mouldboard and disc ploughs.

Figure 11: Mechanical tillage by tractor

- **Use of an ox plough***:* This is the use of ploughs drawn by oxen, donkeys or camels. It's common in areas where land is fairly flat.

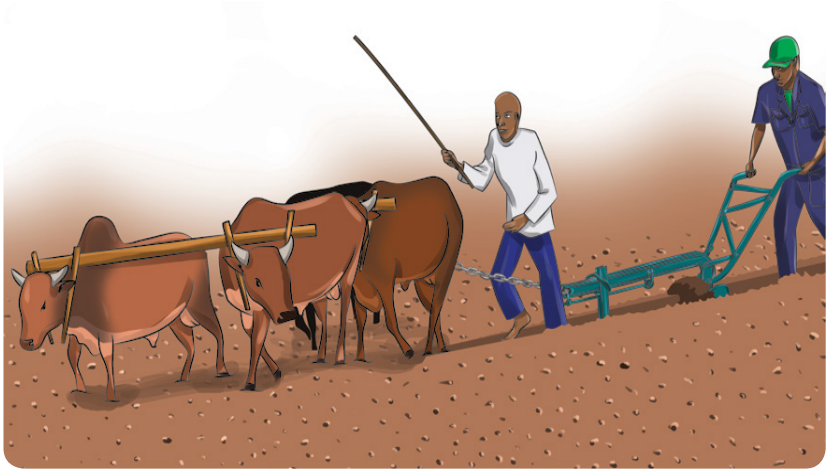

Figure 12: Tillage using an ox plough

b) Secondary cultivation

This is land cultivation activities that are carried out after primary tillage to further prepare the land for crop establishment. It can involve refinement of the soil tilth for seed sowing or seedling planting. On large scale operations, it is usually achieved by use of tractor-drawn implements such as disc harrows. However, small scale farmers can use *pangas*, *jembes*, fork-*jembes*, and garden rakes to break the soil clods and pulverise the soil.

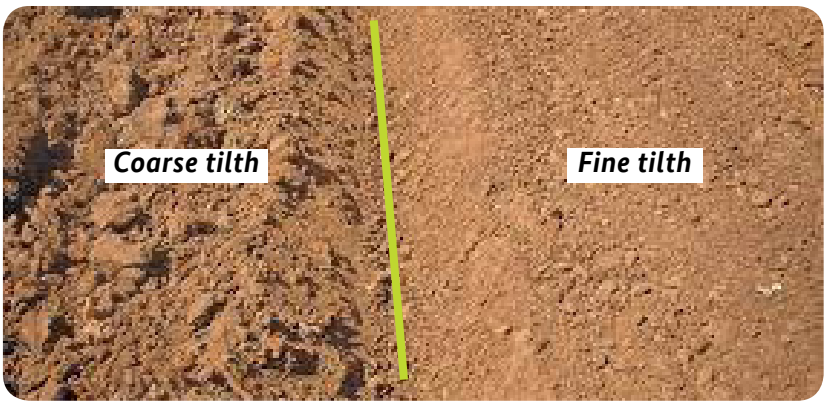

Figure 13: Coarse (left) versus fine (right) soil tilth after secondary tillage

Importance of secondary cultivation

The following are some of the importance of secondary tillage,

- To remove any weeds that might have germinated immediately after primary cultivation.
- To break the soil clods into small pieces for easy planting.
- To level the field so as to obtain the uniform depth of planting.
- Incorporate organic matter into the soil in order to encourage decomposition before planting.

c) Tertiary land preparation operations

These are operations carried out to meet the needs of certain crops. They are conducted after land clearing, primary and secondary cultivations. They include;

i) Ridging

This is the process of digging soil in a continuous line and heaping it on one side to form a ridge (bund) and a furrow.

- Ridges facilitate root penetration.
- They help to conserve soil and water.

Figure 14: Ridging

(Source: Agromachines)

ii) Levelling

This is making the soil surface even and uniform to promote easy germination of small-seeded crops.

Figure 15: Land levelling using a rake

Source: Celec gallery

Note:

A tractor fitted with levelling machine can be used in large scale farms.

iii) Rolling

This is done to compact the soil which is loose or of fine tilth and also to increase seed soil contact.

Figure 16: Soil rolling

Source: CanStock

Minimum tillage

This is the use of a combination of farming practices that least disturb the soil. These farming practices include;

- Application of herbicides in controlling weeds.
- Timing cultivation/timely weeding of the previous crop.
- Mulching. Mulch prevents weeds from growing.
- Restricting cultivation to the area where seeds are to be planted. Minimum tillage equipment are used.
- Establishing a cover crop on the field.

Reasons for carrying out minimum tillage

The following are reasons why minimum tillage is carried;

- Reduce the cost of cultivation. By reducing the number of operations.
- To control soil erosion.
- To maintain soil structure.
- To conserve soil moisture. Continuous cultivation exposes the soil to sun's heat hence evaporation of soil moisture.
- To prevent root and underground structures disturbance.
- To prevent exposure of humus to adverse conditions such as sun's heat that cause volatilisation of nitrogen.
- To reduce soil compaction by tillage implements.

Note:

Liming can be done at the land preparation stage for acidic soils mainly informed by soil test results.

Figure 17: Field liming

1.2.3.3 Tools, Equipment, Supplies and Materials

To achieve a well-prepared land, the following tools and equipment are used,

Tool	Image	Maintenance practices
Tractor-drawn plough		Cleaning, greasing and repair
Animal-drawn plough		Cleaning, greasing and repair
Harrows		Cleaning, greasing and repair
Ripper		Cleaning, sharpening and repair
Mowers		Cleaning, greasing and repair

Other tools, equipment supplies and materials		
• Rake • *Jembe* • Machete • Axe • Slasher	• Sprayers	• Herbicides • PPEs

Note:

- Minimise use of heavy machinery on wet soils
- Use small machinery which utilises green energy e.g. solar-powered tractors.

1.2.3.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. List five tools used in land clearing.
2. State four reasons for cultivating land before planting.
3. What is minimum tillage
4. What are the benefits of minimum tillage?

Notes:

1.2.3.5 References

Reicosky, D. C., & Saxton, K. E. (2007). The benefits of no-tillage. *No-tillage seeding in conservation agriculture*, 11-20.

FAO (2014). Community seed banks - Junior Farmer Field and Life School - Facilitator's guide. Accessed from: *http://www.fao.org/3/a-i7110e.pdf*

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1.2.4 Learning Outcome 4:

Set up Home Gardening Structure

1.2.4.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Understand the importance of home gardening.
- Determine factors to consider when setting up home gardens.
- Identify tools and materials used in setting up home garden structures.
- Identify different types of home gardens.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Understand the concept of home gardening. • Identify factors to consider when setting up home gardens.	• Facilitate a question-and-answer session on the importance of home gardens. • Engage trainees to brainstorm on the factors consider when setting up home gardens. • Divide the trainees in groups for discussions.	• Marker pens • Flip charts • LCD projector • Computer
• Set up home gardening structure.	• Organise a practical for trainees to identify and assemble all the tools, equipment and materials required to set up home gardening structures. • Use a question-and-answer session to identify their uses. • Organise a practical for trainees to observe and differentiate between the different types of home gardens. • Give instructions to trainees/ demonstrate as they construct a home garden type of choice.	• Flip charts • Marker pens • Application tools • Application equipment
• **Duration: 10 hours**		

1.2.4.2 Information Sheet

Definition of terms

Home garden: is any convenient size of a plot or structure located in or near a homestead, where a variety of crops are grown mostly for home consumption and generating income from sale of surplus produce.

Biodegradable: A material that will eventually break down or naturally decompose under the right conditions – such as with the help of bacteria, fungi, and oxygen. Organic matter is biodegradable.

Importance of home gardens

The following factors make home gardens beneficial;

- A reliable source of green leafy vegetables.
- Production of safe, fresh and affordable foods that is easily accessible at household level.
- Generates income from the sale of surplus produce.
- They act as a safety net during lean season when staple foods are depleted and before new crop is ready.
- It strengthens family bonds i.e. shared space and physical activity that encourage both children and adults to spend time together.
- Helps to save expenditure on the purchase of vegetables.
- Home gardening technologies use recycled materials like plastic containers hence contributing to environmental conservation.

Figure 18: An example of a home gardening structure

Factors to consider when setting up home gardens

Before putting up a home garden, you need to consider the following;

- Who will be responsible for maintaining the garden.
- What inputs will be required.
- What will be grown i.e. preferences of crop variety considering diversity for human nutritional needs.
- What is the available space and sunshine direction?
- How the garden layout will be done.
- What technologies are appropriate?
- Is adequate clean water available?

Types of home gardens

The following are the most common types of home gardens;

i. Cone garden

It is a vertical farming method that limited space to create gardens stacked on each other.

Figure 19: Cone gardens

Advantages of cone gardening

The following are advantages of cone gardening;

- Great water utilisation.
- Low soil temperatures.
- Better root penetration.
- Good aeration for high crop yields.

Materials required to lay cone gardening

The following are materials are required while laying of cone gardening;

- Heavy polythene sheet (PVC)
- Tape measure
- Scissors
- Pins
- Soil
- Compost manure
- Seeds/seedlings

How to install cone gardens

To observe how cone gardens are constructed, you can follow the following link:
https://www.youtube.com/watch?v=-PIthFXuiJ0

Note:

- Material used to construct the cones should ideally be biodegradable in the long run.
- It is recommended that any wastes from construction of home garden structures be either recycled or safely disposed with regard to minimise environmental pollution.

ii. Sack mound

This is a home gardening technology where plants are planted on sack held by sticks from outside or a strong stick in the mid to support the sack.

Figure 20: Gunny bag sack mound

Advantages

Sack mound has the following advantages;

- Takes less space, ideal for urban and peri-urban households.
- Provides healthy vegetables for a long time.
- Affordable to make.
- Production can be done throughout the year with minimal water requirement.
- Capacity to hold many stems depending on choice of plant.
- Considerable pest control achieved by intercropping.

Materials required

The following are materials required to construct sack mound;

- Area required to place sack mound: 2 ft x 2 ft.
- 4 poles, each 2 m long with a 2" diameter.
- 1.5 m polythene tube, 90 kg nylon cereal bag or large plastic basin.
- 4-L empty hollow tin gallon or paint tin 1 wheelbarrow ballast (stones or rocks).
- 7 wheelbarrows of soil and manure/compost.
- Organic foliar feed 1 lt.
- Plenty of water.
- 250 seedlings (50 exotic, 200 local).
- Sharp knife.

Construction procedure:

Follow the procedure to install sack mound;

- Measure area 2 ft long by 2ft wide (70 cm x 70 cm) and dig 1 ft deep (30.5 cm) if the garden is to be established on the ground.
- Place the hollow tin (bottom cut out) at the center of the area.
- Secure the 4 poles at each corner of the square.
- Insert the polythene tube 60 inches wide around the 4 poles or to size of gunny bag.
- Fill the hollow tin with ballast.
- Mix manure and topsoil or compost and then put the mixture between the hollow tin and the edges of the bag.
- Gradually fill in the mixture making sure not to interfere with tin.
- Once soil reaches top of tin, lift the tin without moving from the center position and refill with ballast.
- Fill in layer by layer of the soil and manure mixture, keeping the tin in the centre until the bag is full.

Figure 21: Shade netting sack mound

- Water the soil moderately between each layer.
- Punch holes spaced 6"x 6" diagonally into the bag (about 9 rows with 16 holes each).
- Plant the seedlings while ensuring that the soil around each seedling is moderately firm.
- Water through the central core of stones or rocks until soil is soaked, top dress, and leave overnight to set.
- Apply foliar feed (organic liquid fertiliser) directly to leaves of plants as necessary, and provide water (20 lt) every other day.

For more information on construction, you can follow this link:
https://youtu.be/P2E3whMDvNc

iii. Mandala garden / Key hole garden

A mandala garden is an ingenious solution garden allowing families to capture precious run-off water and grow plentiful vegetables. Round in design, they are used on small plots of land, usually with shallow or compacted soil.

Advantages

Mandala garden has the following advantages;

- High plant population hence higher yields/unit area.
- Deeper penetration due to double dug beds.

- One can water entire garden from a single point.
- Effective sprinkler irrigation due to the garden's round shape.
- Ideal garden in areas without enough water for irrigation.
- Has aesthetic value due to beautiful patterns.
- Requires minimal maintenance.

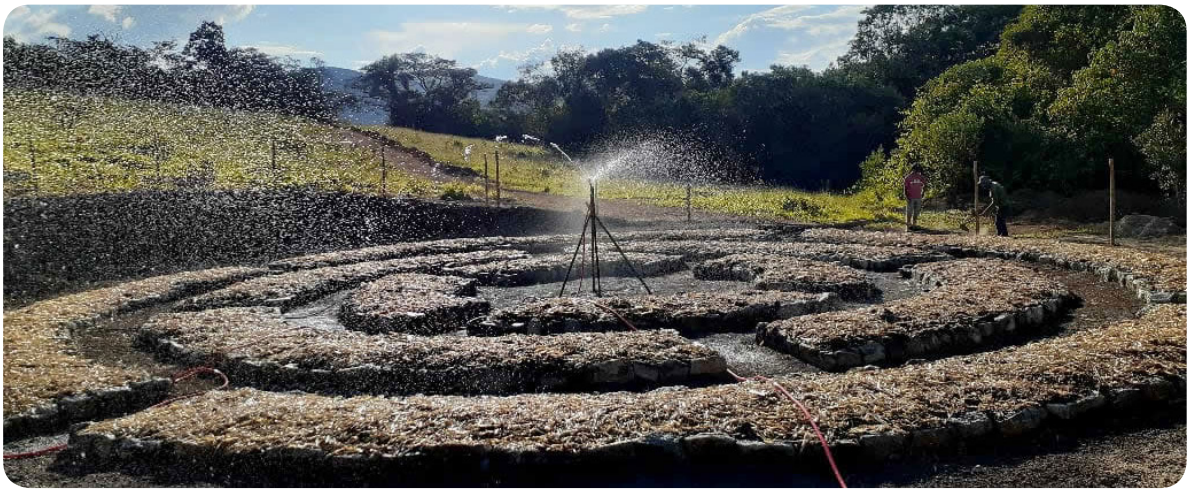

Figure 22: Mandala garden ready for planting

Source: Lua do Acro-iris

Materials required

The following materials are required to construct Mandala structure;

- Wheelbarrow, forked jembe (garden rake) and mattock.
- Well-decomposed manure/compost.
- Top soil.
- Twine, tape measure, and marking pegs.
- Labour - 10-man days.
- Water source – from roof catchment, ground water run-off or detergent-free waste water from the kitchen.

Construction procedure:

Construction of Mandala garden follows the following procedure;

1. Choose your site: Best is near the homestead or a water source located on the upper side of the garden.
2. Lay out the beds: Make at least 3 circular beds of 1.3 m to 1.5 m width beginning from the central pit (1 m wide and 1 m deep). Leave a space of 0.3 m to 0.5 m as a path between every 2 beds.
3. Spread a thick cover of well decomposed manure on the bed. 1 *debe* per metre square should be sufficient.

4. Starting from one end of the bed, measure out a narrow strip 60 cm wide.
5. Dig the strip, mixing the compost into the topsoil.
6. Remove the soil you have just dug and take it to the end of the bed. Put it outside the bed on the far end.
7. Make sure that you have removed all the topsoil. You will know this when your jembe hits a harder layer at the bottom or when the soil changes colour from dark brown to reddish brown.
8. Then dig this compact subsoil deeply. When the whole strip is completed, level out the loose subsoil.
9. Apply another layer of manure or chopped green vegetation on the levelled subsoil.
10. Measure out another strip of 60 cm; dig the top soil again, mixing it well with the compost you had applied on the surface.
11. Again, remove all the top soil but this time put on the top of the subsoil of the previous strip.
12. Continue to dig as step 8.
13. Measure out another strip; continue to dig as step 9 and 10.
14. Continue like this until the whole topsoil is dug and removed in order to allow a second digging of the bottom compact subsoil. This is why the technique is called double digging.
15. The finished bed is then raked and mulched in preparation for planting.

Manage Mandala garden

The following are some of the management practices of Mandala garden;

- Practice crop rotation.
- Always weed and harvest produce while standing on the paths to avoid compacting the soil.
- Every 2-3 years, renew the Mandala garden by following these steps:
  i. Fertilise the top soil with compost.
  ii. Dig out the topsoil to a 30 cm depth.
  iii. Then loosen the subsoil to a 30 cm depth and level.
  iv. Add a layer of manure to the subsoil.
  v. Replace the topsoil, level off, mulch, then plant.

iv. Hanging garden

This involves planting of leafy vegetables on hanging containers/basket.

Advantages

The following are advantages of hanging gardens;

- Suitable for household where land, labour and time is constrained.
- Growing of different vegetables and fruits is possible at the same time.

- Possible to grow crops on clean root media even in polluted areas.
- Income generation from sale of surplus produce.
- Efficient water utilisation.
- More production in a small area.
- Height makes it secure from theft and flooding.
- Time-saving and can be made to be moveable.
- Continuous harvesting and replanting is easy.
- Design is flexible and applicable at ground level, balconies, rooftops.
- Have aesthetic outlook and can be incorporated in landscaping.
- The youth particularly enjoy this type of gardening technology.

Figure 23: Hanging gardens

Materials required

The following are the materials required in construction of hanging garden;

- Planting media.
- Planting buckets or similar-sized containers.
- 2.5 m central wooden post.
- 3 pairs of 3” by 4” timber of 1 m, 2 m, and 3 m length respectively.
- 2 kg of 4” nails.
- Labour for construction.
- Seeds or seedlings.

Construction procedure:

Follow this procedure to construct hanging gardens;

1. Select site: It must receive at least 6 hours of sunlight throughout the day.
2. A 3 m x 3 m space is required. Design may also vary depending on the space available.
3. A vertical 3 m high strong post is firmly fixed at the center.
4. Cross bars or stair cases are fixed on the post at 1m intervals above the ground.
5. The containers filled with planting media are hung on the bars or placed on the stair cases and balanced to ensure stability of the stand.
6. Plant the seedlings/seeds in the containers.
7. White containers are recommended because they reflect the sun rays and reduce evaporation.

For more information on construction, you can watch a video using the link below:

https://www.youtube.com/watch?v=G6OsBBsEQQ4

v. Banana trunk garden

This is system of gardening where vegetables are planted on cut banana trunk.

Figure 24: Banana trunk/stalk gardens

Advantages

Banana stalk garden has the following advantages;

- Conserves moisture.
- Retains water, and productive even during dry spell.
- Suitable for urban areas.
- Affordable to install.
- Requires minimal maintenance.
- Recycles banana trunks.

Materials required

The following materials are required to install banana trunks;

- Banana trunks.
- Well-decomposed manure (compost).
- Machete.
- Leafy vegetable seeds/seedlings.
- *Jembe*.

Construction procedure:

Use the procedure below to make a banana trunk garden;

1. Dig a shallow trench and arrange banana trunks.
2. Using a sharp knife or machete, cut holes into the trunk.
3. Fill holes with mixture of topsoil and compost.
4. Plant seedlings or seeds.

vi. Tyre garden

Involves establishment of leafy vegetables on used tyres.

Figure 25: Used tyre garden

Advantages

The following are advantages of tyre garden;

- Good for the environment (recycling of used tyres).
- Can stack to grow long rooted vegetables.
- Can rearrange to suit needs of the season (spread out or stack tyres).

Materials required

The following are materials required in laying out tyre garden;

- Strong knife to cut the tyre.
- Various sized tyres.
- Container garden soil.

Construction procedure:

Follow the procedure to lay out tyre garden;

- Find a suitable tyre. Use any size tyre with the metal rim removed. You may also use a knife with a long blade to cut into the tyre.
- Clean the tyre with soap and water. Use a sponge to help clean inside the tyre. Rinse the tyre off with a good spray from the hose.
- Place landscaping cloth or mulch on the spot where you plan to put the tyre garden.
- Placing the landscape cloth or mulch down first deters weeds from growing up through the tyre.
- Fill the tyre with your prepared soil and compost.
- 1 part soil, 1 part organic compost, and 1 part composted kraal/animal manure for an extra nitrogen boost.
- Add the soil, compost and manure, and mix well with your hands.
- Break up any big clods of dirt with your hands or a trowel and then push the soil into the grooves of the tyre.
- Let the soil settle for a few days and add more if necessary.
- To prevent ants and other crawlies from getting to your veggies, apply grease to the lip of the tyre with your fingers.
- Plant vegetables and ensure to plant chives, garlic and onions around the perimeter to prevent insect damage.
- Water regularly and mulch if need be.

1.2.4.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Forked *jembe* • Mattock • Knife • Spade • Marking pegs • Shovel	• Tape measure • Wheelbarrow • Drill machine	• Polythene tube • Compost manure • Banana stalks • Wooden posts • Stones • Top soil • Dry grass

• Tins • Hammer		• Compost manure • Rope • Pipes (4-inch diameter) • Timber • Nails

1.2.4.4 Self-Assessment Questions

1. State the importance of home gardens.
2. List factors to consider when setting up home gardens.
3. Identify different types of home garden.
4. Name the tools and materials used in setting up a cone garden.

Notes:

1.2.4.5 References

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1.2.5 Learning Outcome 5:

Set up Soil and Water Conservation Structures

1.2.5.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify importance of soil and water conservation.
- Identify tools used in setting up simple soil and water conservation.
- Identify different types of soil and water conservation.
- Select and set up suitable soil and water conservation.
- Maintain soil and water conservation structures.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Determine the importance of soil and water conservation.	• Lead trainees to brainstorm on the importance of soil and water conservation, and populate one list.	• Flip charts • Felt pens • White boards
• Select suitable soil and water conservation structure.	• Conduct a field excursion with trainees and lead them in selecting suitable structures for given plots. • Lead trainees in a discussion on factors to consider when selecting a suitable structure. • Validate the trainees' findings in a plenary.	• Biro pens • Notebooks • Felt pens • Flip charts
• Set up and maintain soil and water conservation structures.	• Group trainees with respect to the number of selected structures. • Demonstrate to the trainees how selected structures are construct and maintained. • Supervise the trainees while setting up the structures. • Assess the work done and award the best group. • Give recommendations for further improvement.	• Meta plan cards • Demo plots • Spade • Transparent pipe • Water • Grass • Stones • Stationery • *Pangas* • Pick axe
• **Duration: 14 hours**		

1.2.5.2 Information Sheet

Definition of terms

Available water holding capacity: The amount of water a soil profile can hold for plant uptake. It depends on soil depth, texture, structure and organic matter content.

Embankment: A wall or bank of earth or stone built to prevent a river flooding an area.

Gully: A deep channel created as a result of severe soil erosion, usually caused by running water.

Soil: Soil is the loose surface material that covers the land surface.

Soil and water conservation (SWC): Activities that maintain or enhance the productive capacity of land in areas affected by or prone to soil erosion.

Soil erosion: The movement of soil from one part of the land to another through the action of wind or water.

Soil moisture: Water held in the soil and available to plants through their root system, also called soil water.

Surface runoff: Excess rainfall which runs off the surface of the land, it includes both overland flow and stream-flow.

Water conservation: The control, protection, storage, management and utilisation of water resources in such a way as to optimise productivity.

Benefits of soil and water conservation

The following are the benefits of soil and water conservation;

- Increase in soil cover.
- Enhances soil moisture.
- Provides permeable barriers.
- Increases infiltration.
- Maintains soil fertility.
- Stabilise mechanical structures.
- Productive use of land occupied by conservation works.

Soil and water conservation structures

Soil and water conservation structures include all mechanical or structural measures that control the velocity of surface runoff and thus minimise soil erosion and retain water where it is needed. Suitability of SWC structure depends on:

- Climatic conditions and the need to retain or discharge the runoff.
- Farm sizes.
- Soil characteristics (texture, drainage, and depth).
- Availability of an outlet or waterway.
- Labour availability and cost.
- The adequacy of existing agronomic or vegetative conservation measures.

Factors to consider in selection of soil and water conservation structures

Factors considered in selecting and designing soil construction measures include;

- Slope of the land.
- Soil characteristics e.g. Erodibility, texture and drainage depth.
- Cropping pattern or system e.g. annual or perennial crops.
- Farm size e.g. large or small scale farming.
- Climate conditions and the need to retain or discharge water.
- Labour availability and costs. It can be skilled or unskilled.
- Availability of materials for construction e.g. stones, plants residue e.t.c.
- Adequacy of the existing or agronomic or vegetative construction measures.

Types of soil and water conservation structures

They include, but not limited to;

- Terraces
- Stone lines
- Trash line
- Cut-off drains
- Check dams
- Gabions/ retaining wall
- Retention ditch
- Grass strips
- Sandbags
- Semi-circular buds.

Construction and maintenance of soil and water conservation structures

The following are physical soil and water conservation structures:

1) Terraces

The soil is put on the lower side of the contour trench. Terraces are used to conserve soil and divert water. The resulting embankment can be used to grow fodder.

The following are the two major types of terraces in Kenya:

a) ***Fanya juu terrace***

This is constructed by digging soil and placing it on the upper side the trench.

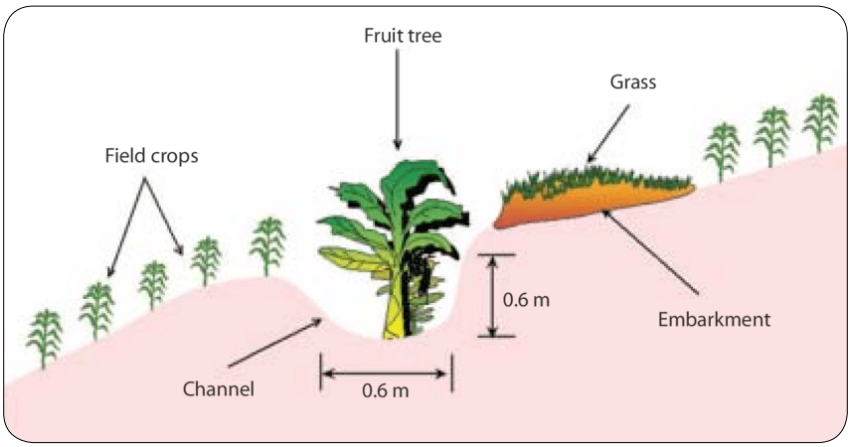


Figure 26: Fanya juu terrace

Source: ResearchGate

How to install and maintain *fanya juu* terrace

Follow the following link to understand how to construct *fanya juu* terrace
https://www.youtube.com/watch?v=v1k6BKsTELc

Note:
Fanya juu terrace is not recommended for tap rooted leafy vegetables.

b) Fanya chini terrace

This is constructed by digging soil and placing it on the lower side of the trench.

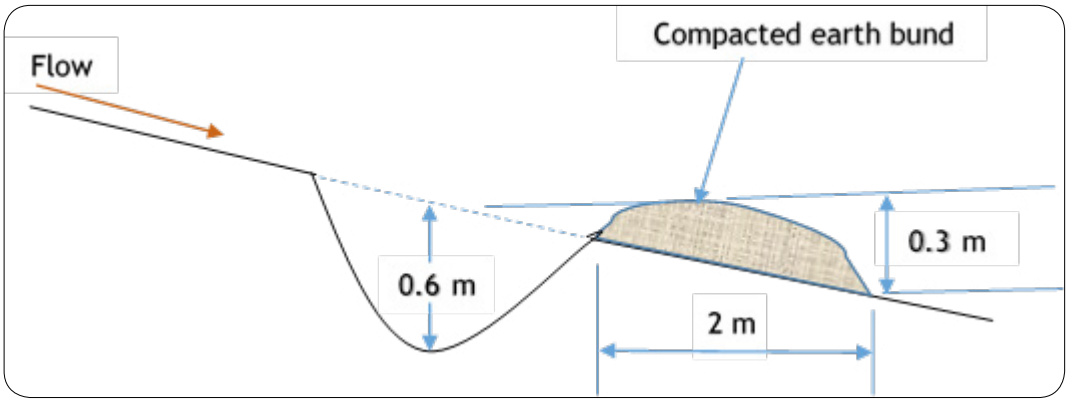


Figure 27: Fanya chini terrace parameters

Construction procedure

Lay out the terrace as follows;

- Loosen soil for excavation (forked hoe, ox-drawn plough).
- Dig a long ditch across the slope (using hoes and shovels) and heap the soil on the lower side to form a trench measuring 0.6 m deep and about 0.6 m wide
- Levelling and compacting bund.
- Dig planting holes for grass.
- Create splits of planting materials such as Napier grass.
- Apply manure onto the planting holes, mix with the soil then plant the grasses. All activities are done manually before the rainy seasons start (usually around March and October). Thereafter, plant grasses at the onset of rains.
- Duration of establishment: usually, the terrace becomes fully effective within one year.

Maintenance

The following are maintenance practices done on the constructed terrace;

- Desilting the trench and throwing silt up-slope.
- Repairing breaches in embankment where necessary.
- Building up embankment annually.
- Cutting grass to keep low and non-competitive, and provide fodder for livestock.
- Maintaining grass strips weed-free and dense.

Caution:
Trench dug poses a hazard to livestock.

2) Stone lines

Stone lines are stones placed along contour lines to slow down runoff. With time, the soil builds up on the upslope side of the stone line and a natural terrace is formed. Stone lines are 35-40 cm wide and approximately 25 cm high.

Where suitable:

1. Gentle to moderate slopes (less than 10%).
2. Low annual rainfall areas (200 - 750 mm).

Figure 28: Stone line

Source: United Nations Convention to Combat Desertification

Construction of stone lines

To install stone lines, the following procedures are followed;

- Dig a shallow foundation trench of 5-15 cm made along the natural contour.
- Lay larger stones on the downslope side of the trench
- Lay small stones on the upper side of the trench to form walls along the contour lines.
- Reinforce the stone lines with earth or crop residues.
- Space the stone lines 15-30 m apart; spacing maybe reduced for slopes greater than 10%.

Note:

Any soil that is eroded behind the stone terrace is held back by the stone terrace and after 4-5 years as in the case of *Fanya Juu*, level ground is formed between two stone bunds.

Maintenance

The structure is maintained as follows;

- Replace the stones once carried away.
- Reinforce the stone layer by use of crop residues.

Caution:

Avoid big stones on the farm, big stones destroy farm implements.

3) Trash line

This makes use of plant residues such as maize stover, dry fodder grass, bushes and banana leaves.

- A barrier strip is made by laying a row of trash along the contour.
- As the material decomposes, other plant species will crop up through the trash and this has the advantage of making the barrier even more effective in controlling erosion.

Figure 29: Conservation trash lines

Source: Infonet Biovision

Construction procedure

The following procedures are followed in laying out trash lines;

1. Trash lines (typically ±50 cm wide and ±30 cm high) are constructed mainly from crop residues such as sorghum or millet stovers, which, compared to maize decompose slowly and are of low palatability to livestock.
2. Spacing between trash lines is 5 - 10 m, depending on the slope. Trash lines can be left in place for four seasons before they are ploughed into soil.

Maintenance

Replace trash within the trash lines once depleted.

Caution:

Poorly kept trash harbours pests and diseases.

4) Cut-off drains

These are earth structures constructed across a field to intercept and divert surface run-off from the slope above and drain it to a safe outlet. A diversion should be laid out according to its main objective i.e. just above the area to be protected, or in an area where it can intercept as much run-off as possible.

The structures are installed to;

- To protect cultivated lands, roads or farm buildings at the foot of slopes by diverting hillside run-off.
- To safeguard conservation-treated areas at the foot of slopes.
- To collect water for ponds or other storage schemes.
- To control the development of gully heads.

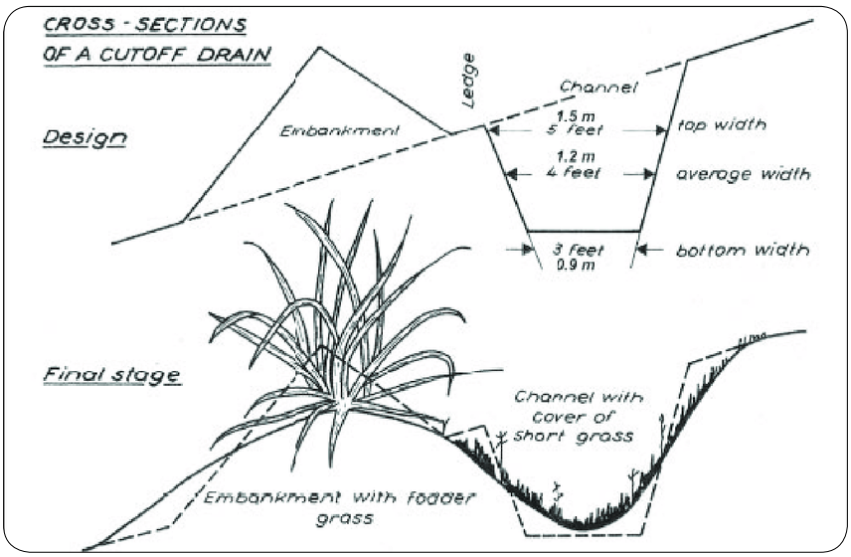


Figure 30: Cut off drain

Source: Research Gate

Note:

The diversion should be connected to a safe outlet, a waterway, a protected area or a storage area to prevent flooding.

Procedure of laying out cut-off drains

The following is the procedure of laying out cut-off drains;

- Clear all stumps and vegetation from the proposed site.
- Compact the fill (embankment) at the lower side, layer by layer and should be constructed higher than planned to allow for settling (about 10% of the fill).
- Use extra soil from the lower side to strengthen the embankment.
- Do a final check of the bottom gradients and the embankment top. Any deviation should be put right immediately.

.

Protection and maintenance

Consider the following maintenance on cut-off drains;

- The trench or channel should be planted with a rhizome-type low grass or can be partially ballasted, depending on designed velocities.
- The embankment facing downslope should also be planted with rhizome grass for protection purposes.
- Deposits in the trench or channel must be cleared regularly to ensure that the water flows freely all the time.

5) Retention ditch

Retention ditches are designed to catch and retain incoming runoff and hold it until it infiltrates into the ground. They can be an alternative to waterways in high rainfall areas, but they are most often used in semi-arid areas to harvest water.

Figure 31: Retention ditches

Procedure for construction

During construction of retention ditch consider the following;

- Choose a suitable site.
- Assemble the required resources.
- Excavate a 30 cm wide by 30 cm deep ditch (ditches can be constructed of any size, if desired).
- Form the banks by cutting a slanting wall at each side
- A live barrier is necessary above the upper edge to prevent filling with soil.
- Observe a reasonable distance between ditches on hillsides of a given slope.
- The ditches should be dug with a 1% slope to drain excess water.
- Construct a protected drainage way measuring 1 to 2 m wide that collects all the water from the retention ditches. This drainage way should have a slightly steeper slope, (1-2%) to facilitate drainage.
- Care should also be taken not to drain excess water into neighbouring fields, houses, or other areas which may result in problems.

Protection and maintenance

The following are maintenance done on retention ditches;

- The risers of the ditch can be either seeded, or temporarily covered with bushwood and dead leaves before natural vegetation starts to grow.
- It is necessary to maintain the proper height of the ditch's edge in order to avoid overflowing. Any settling of the edge should be repaired or strengthened.
- The barriers or dykes that separate the trenches should be kept lower than the edge of the ditch to allow for easy drainage.

Caution:

An unsecured ditch poses risks to livestock and children.

6) Grass strips

Strips of grass (up to 1 m wide) planted along a contour can reduce soil erosion and runoff. Silt builds up in front of the strip and over time benches are formed. On gentle slopes the strips should be widely spaced (20-30 m apart), and on steeper slopes narrowly spaced (10-15 m apart). The grass needs to be trimmed regularly, to prevent it competing with crops.

Figure 32: Conservation grass strips

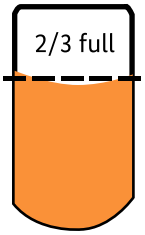
Source: Research Gate

7) Sandbags

Sandbags correctly placed in appropriate locations around the leafy vegetables farm to reduce the impact of flooding. Sandbags will not stop the water completely but can reduce the amount of water entering planted area.

How to fill the sandbag

- It is preferable that you only use sand to fill the bags.
- Sandbags only need to be filled to 2/3 full.
- Do not over fill as they will be too heavy to carry.
- Do not tie the top of the bag. The top of the bag may be tied for transport purposes only.



How to lay sandbags

- Place down a layer of plastic sheeting to act as the water proofing membrane.
- Lay sandbags like brickwork on top of the plastic sheeting.
- Start at one end and work to the other end.
- Ensure the unfilled top part of the bag is covered by the next bag.
- Tuck flap under the bag at the end of the row.
- Stagger rows so that the joins do not line up.

Tip 1:

Flattening down the sandbag row before adding the next row will help you to build a better structure.

Figure 33: Sandbags

What to do when finished with the sandbags

- Sandbags that have been exposed to floodwater need to be thrown away.
- Care should be taken when handling wet sandbags; sturdy gloves should be worn as floodwater can contain chemicals, harmful waste and contaminates.
- Sandbags should not be reused if they have been in contact with floodwater.
- Sand from used sandbags, not exposed to floodwater or other contaminants can usually be scattered on laws or gardens as topsoil, where it will not wash into stormwater drains.
- Consult local authorities for advice on how you can dispose-off contaminated sandbags.

Rainwater harvesting

Rainwater running off land surfaces can be harvested, stored and utilised using a technique called ***rainwater harvesting*** instead of being wasted in rivers, lakes and the sea.

Figure 34: Using harvested water for irrigation

Source: Greecon - Kenya

The following are ways in which water can be harvested for irrigation.

- A **roof catchment system** can be used to harvest water for irrigation. The system consists of gutters fixed to the roof which drain the rainwater into a storage tank.

Figure 35: Roof water harvesting

- A **pond or an earth dam** for irrigating leafy vegetables, solar pumps can be used to abstract the water

Figure 36: Water pan

Source: Amiran

- A **hand-dug well** may supply good quality water for irrigating leafy vegetables if sunk into shallow ground water level.

Figure 37: Hand-dug well

Source: Infonet Biovision

- In situ harvesting of rainwater by use of zai pits, trapezoidal bunds, cut off drains, check dam, retention ditches and contour.

Figure 38: Zai pits

Source: Greener Land

Note:
A drop harvested is a crop harvested.

Limitations of soil and water conservation structures

Challenges faced in establishment of soil and water conservation structures are;

- Reduction in land size.
- Change of land use.
- Poor designs of the structures.
- Lack of man power.
- Unpredictable change in technology.
- Strict rules and regulations governing land use.

1.2.5.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • Tape measure • Machete/ *panga*	• Watering can • PPEs • Hand level • Wheelbarrow	• Transparent 8 mm water hose, 10 – 20 m long • Two poles • Flip charts

• Rake • Slasher • Spade • Trowel • Pangas • Spade • *Jembe* • Hammer	• Spirit level	• Felt pens/permanent markers • Stones • Pegs • Manure / fertiliser • Cement • Ballast • Line level boards • Sand • Sisal twine • Staffs • Clean water

1.2.5.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Water pan is a water harvesting structure, ☐ True or ☐ False?
2. What is a shelterbelt?
3. Which structure is used to collect water flowing down slope and divert it to safe area?
4. Which is the common method used to mark and measure contours.
5. Which of the following is not a physical soil and water conservation structure?
   - ☐ A. Cut off drain
   - ☐ B. Retention ditch
   - ☐ C. Contour planting
   - ☐ D. Gabion

Notes:

1.2.4.5 References

FAO manuals 2015-2017 on soil and water conservation.

Goerge N. Karuku ,2018, Soil and Water Conservation Measures and Challenges in Kenya; Department of Land Resource and Agricultural Technology, University of Nairobi, Kenya

Namirembe et al,2015. A guide for selection of the right soil and water conservation practices for small holder farming in Kenya, ICRAF NAIROBI, Kenya Thomas, D. B. (1997). Soil and water conservation manual for Kenya.

1.2.6 Learning Outcome 6:

Set Up Irrigation Structures

1.2.6.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify different sources of water for irrigation.
- Identify and select suitable method and systems of irrigation.
- Identify and select the effective source of energy for water pumping.
- Identify tools used in setting up suitable irrigation structures.
- Install irrigation system.
- Maintain irrigation structures.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify water sources and the source of energy used pump/ convey the water for irrigation.	• Project several selected videos of existing irrigation farms. • Ask students to list sources of water and energy utilised for irrigation in the videos. • Validate and recommend the best water sources. • Lead a discussion on climate smart energy sources used in irrigation and recommend the best source.	• Projector • Laptop • Whiteboard • Felt pens • Biro pens • Note books • Pointers
• Identify and select a suitable irrigation method/system	• Lead a brainstorming session on the factors considered in selecting suitable irrigation method. • Validate the responses. • Project videos of existing irrigation system. • Lead a discussion on the advantages and disadvantages/limitation of the systems. • Lead trainees to choose suitable irrigations methods.	• Projector • Pointers • Whiteboard • Felt pens • Notebooks • Laptop
• Identify tools for setting up irrigation system. • Install and maintain an irrigation system.	• Take trainee for a field trip to irrigation constructions firms. • Lead trainees in identifying various tools used in installing an irrigation system • Direct trainees to classify tools in scale of operation.	• Facilitation fee • Notebooks • Biro pens • PPEs • Demo plots

	• Validate the classification and select the most useful ones. • Group trainees into four groups. • Direct each group to choose one irrigation system • Demonstrate to trainees how to set up and maintain the chosen systems • Supervise each group in setting up the systems after demonstration. • Award the best group and offer feedback for improvement.	• Plumbing tools • Meta plan cards • Farm tools • Complete irrigation kits • Water source
• **Duration:12 hours**		

1.2.6.2 Information Sheet

Definition of terms

Irrigation: Irrigation is artificial application of water to soil for the purpose of supplying the moisture essential for plant growth.

Rainfall: This is nature's artificial process but it does its work through precipitation, which is water failing from the sky to the soil.

Irrigation management: This is defined as the actions to be taken by an irrigation engineer, agronomist and the cultivator, to achieve a large number of socio-economic objectives, such as production of more food, optimum use of natural water resources, raising of living standards of the farmers and the society.

Fertigation: Application of nutrients through an irrigation system.

Irrigable area {acres, ha}: Area capable of being irrigated, principally based on availability of water, suitable soils, and topography of land.

Importance of irrigation

Irrigation is important for the following reasons;

- Increases crop yield.
- Improves the quality of crops.
- Ensures continuous crop production.
- Reduces/regulates high soil salinity, high soil salinity levels can be natural occurrences which is the case in many semi-arid locations or as a result of poor agricultural practices and ineffective drainage.
- Cools the soil and atmosphere to provide a suitable surrounding.
- Reduces hazards of soil piping.
- Softens the tillage pan.

Sources of water for irrigation

Irrigation water can be abstracted from;

- Boreholes,
- Springs or wells,
- Rivers and lakes,
- Water harvesting structures (water tanks, water pans, dams, retention ditches),
- Community/municipal piped water.

Irrigation

The following are steps followed before applying irrigation water to avoid water wastage:

- Determine the level of soil moisture e.g. by use of soil moisture meter or other appropriate method (by hand).
  - Pick a handful of soil and roll the soil into a ball using hands.
  - Check the results of the rolling action If the findings are as follows:
    - Soil forms a ball – it indicates the soil does not require irrigation.
    - Soil not forming a ball – it indicates the soil requires irrigation.
- Estimate the amount of water to be applied.
- Determine the appropriate irrigation method.
- Apply the irrigation water.

Types of irrigation

The following are the most common types of irrigation.

i) Furrow irrigation

Furrow irrigation is a method of laying out the water channels in such a way where gravity plays the role of providing just enough water for suitable plants to grow.

Figure 39: Irrigating using furrow system

Source: Hybrid veggies

ii) Sprinkler irrigation

Sprinkler irrigation is a method of providing rainfall-like irrigation to the crops.

Figure 40: Sprinkler irrigation system using a rain gun (L) and watering can (R)

Source: Getty photos

iii) Drip/trickle irrigation

Drip irrigation involves placing tubing with emitters on the ground alongside the plants. The emitters slowly drip water into the soil at the root zone.

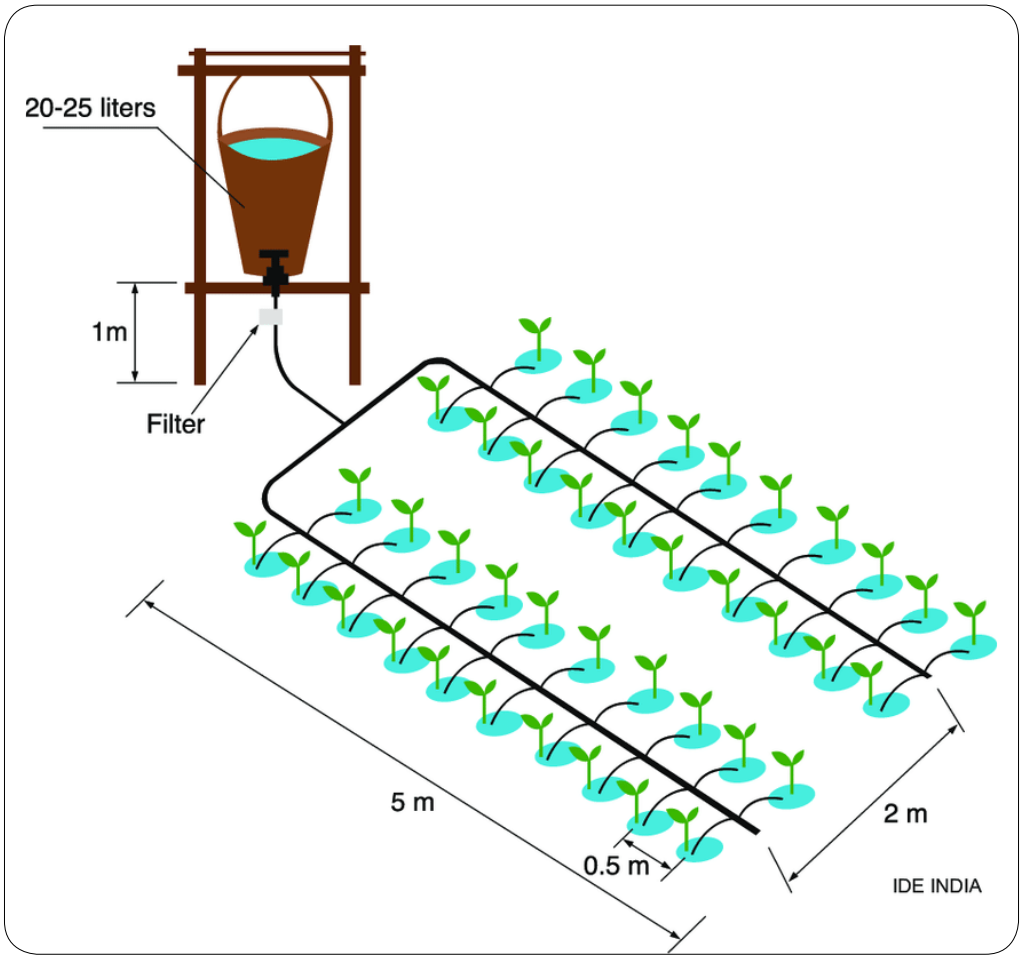


Figure 41: Drip irrigation system

Source: Research Gate

iv) Bottle/wig irrigation

A filled, open bottle can be placed with its neck into the soil next to a plant, so it stands upside down. The dense soil hinders the water from leaving the bottle immediately. In some instances, a bottle can be placed at the centre of given crops and a wig is used to transport water to the plant roots.

Figure 42: Bottle irrigation

v) Pitcher irrigation

With pitcher irrigation, round porous clay pots are buried into the soil near the crop and filled with water. The water seeps out slowly through the porous material irrigating the nearby leafy vegetables.

Figure 43: Pitcher irrigation

Source: The Hindu

vi) Perforated pipes

This is a system of irrigation whereby irrigation water oozes out of perforated pipes irrigating surrounding crops. The irrigating radius depends on water pressure.

Figure 44: Perforated pipe system

Source: India MART

Factors influencing choice of irrigation system

The following are factors influencing the choice of irrigation system.

- Natural conditions - soil type, slope, climate, water quality and availability.
- Type of crop.
- Type of technology.
- Previous experience with irrigation.
- Required labour inputs.
- Costs and benefits.

1.2.6.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • Tape measure • Machete/*panga* • Rake • Slasher • Trowel	• Watering can • PPEs • Hand level • Wheelbarrow • Spirit level • Irrigation • Pump	• Transparent 8mm water hose, 10 – 20 m long • Two poles • Flip charts • Felt pens/permanent markers • Stones • Pegs • Fertiliser

• Shovel • *Jembe* • Hammer	• Plumbing tools/ equipment • Pressure regulator	• Line level boards • Sisal twine • Staffs • Clean water • Timber • Nails • Assorted irrigation kits • Pipe and pipe fitting accessories

1.2.6.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What are the most common green energy sources used to run irrigation pumps?
2. What are the instances where sprinkler irrigation is not suitable?
3. Which is the most effective irrigation system for a hilly and uneven area?
4. What are the reasons of having furrow lengths in sandy soils that are shorter than those in clay soil.
5. What are the components of a drip irrigation system?

Notes:

1.2.6.5 References

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1.3 Model Responses to the Self-Assessment Questions

1.2.1 Learning Outcome 1:

Plan Leafy Vegetable Agri-enterprise Venture

1. What are some of questions you need to ask yourself before investing in leafy vegetables enterprise?
   - **Your investment level**
   - **Skills and knowledge**
   - **Goals**
   - **Market trends for leafy vegetables**
   - **Competition and middlemen influence**
   - **Training and support**

2. Name any four factors to be considered when preparing a crop calendar under vegetables
   - **Climate and seasonality - Use climate information such as seasonal forecast, monthly, weekly or daily weather forecast**
   - **Crop selection**
   - **Pest and disease management**
   - **Seed sourcing and quality**
   - **Succession requirement**

3. State any three records that should be maintained when practising vegetables enterprise.
   - **Farm diary**
   - **Farm inventory**
   - **Production record**
   - **Sale records**
   - **Profit and loss account**

4. What are the benefits of preparing a business plan in vegetables agri-enterprise
   - **Provides a clear road map and sets specific goals and objectives**
   - **Helps conduct a comprehensive analysis of the market, competition target customers and available resources**
   - **Helps estimate the start-up costs, operational expenses and potential revenue streams**
   - **Helps identify potential risks and challenges that may arise in the vegetable agricultural enterprise**

1.2.2 Learning Outcome 2:

Carry Out Site Selection

1. Name two common methods of soil sampling
   - **Random/zigzag sampling**
   - **Diagonal sampling**

2. State the factors influencing site selection
   - **The site should not have been used for vegetables cultivation for the last season**
   - **Surface slope should be gentle**
   - **No serious cowpeas diseases/pest incidences**
   - **Well drained soils which are fertile and deep**
   - **Accessible and fenced.**

3. List the tools and materials used in soil sampling
   - ***Panga***
   - **Augur**
   - **Bucket**
   - **Labels**
   - **Packaging materials**

1.2.3 Learning Outcome 3:

Prepare the Land

1. List five tools used in land clearing
   - ***Jembe***
   - **Machete**
   - **Slasher**
   - **Axes**
   - **Mowers**

2. State four reasons for cultivating land before planting.
   - **To improve soil aeration**

- **To improve germination**
- **Destroy weeds**
- **Incorporate organic matter in the soil.**

3. What is minimum tillage
   - **It is a situation in which least possible cultivation operations are carried out in crop production.**

4. What are the benefits of minimum tillage?
   - **Lower fuel usage**
   - **Less soil erosion**
   - **Maintains soil structure**
   - **Improved water penetration**
   - **Enhanced soil health**
   - **Promotes soil conservation and helps farmers achieve high crop yields.**

1.2.4 Learning Outcome 4:

Set Up Home Gardening Structures

1. State the importance of home gardens
   - **A reliable source of green leafy vegetables**
   - **Production of safe, fresh and affordable foods that is easily accessible at household level**
   - **Generate income from the sale of surplus produce**
   - **It strengthens family bonds i.e. shared space and physical activity that encourage both children and adults to spend time together**
   - **Helps to save expenditure on the purchase of vegetables**
   - **List the factors to consider when setting up home garden.**

2. List factors to consider when setting up home gardens
   - **Who will be responsible for maintaining the garden**
   - **What inputs will be required**
   - **What will be grown preferences, diversity for nutritional need**
   - **What is the available space and sunshine direction**
   - **How will the garden layout be done**
   - **What technologies are appropriate**
   - **Is adequate clean water available.**

3. Identify different types of home garden.
   - **Sack garden**
   - **Hanging garden**
   - **Keyhole garden**
   - **Mandala garden**
   - **Tyre garden**
   - **Cone garden**

4. Name the tools and materials used in setting up a cone garden.
   - **Knife**
   - **Heavy polythene sheet**
   - **Pins**
   - **Seed/seedlings**
   - **Compost manure**
   - **Spade**
   - ***Jembe***
   - **Soil**

1.2.5 Learning Outcome 5:

Set Up Soil and Water Conservation Structures

1. Water pan is a water harvesting structure.

   (True)

2. What is a shelterbelt?

   A strip of trees planted to check the wind movement to protect soil

3. Which structure is used to collect water flowing down slope and divert it to safe area?

   Cut-off drain

4. Which is the common method used to mark and measure contours.

   Use of transparent water tube

5. Which of the following is not a physical soil and water conservation structure?

   C. Contour planting

1.2.6 Learning Outcome 6:

Set Up Irrigation Structures

1. What are the most common green energy sources used to run irrigation pumps?
   - **Solar**
   - **Biogas**
   - **Wind**

2. What are the instances where sprinkler irrigation is not suitable?
   - **Capital investment is low**
   - **No skilled manpower for operation and maintenance of the system**
   - **Areas with high winds that can drift away the droplets**
   - **Areas with very high temperatures where evaporation losses can occur since the droplets can be small**
   - **In soils with low infiltration rates (less than 4 mm/hr-1)**
   - **Only dirty water is available - since clean water is mandatory to reduce or eliminate clogging and in some cases wear of the nozzles (becoming larger)**
   - **Not suitable for crops requiring large amounts of water e.g. paddy rice**
   - **Irrigating plants susceptible to soil borne diseases since they can be easily spread onto the upper parts of the plants due to splashing**
   - **Good designers are not available since the system is more sensitive to design**

3. Which is the most effective irrigation system for a hilly and uneven area?
   - **Drip irrigation**

4. What are the reasons of having furrow lengths in sandy soils that are shorter than those in clay soil.
   - **On sandy soils, water infiltrates rapidly therefore furrows should be short (less than 110 m) so that water will reach the downstream end without excessive percolation losses**
   - **On clay soils, the infiltration rate is much lower than in sandy soils therefore furrows can be much longer on clayey than on sandy soils.**

5. What are the components of drip irrigation system?

The components of drip irrigation system are;

- **The pumping unit**
- **The control head**
- **Mainlines, sub mains and laterals**
- **Emitters or drippers.**

2 Leafy Vegetable Seedling Production

2.1 Introduction to the Chapter

This chapter specifies the competencies required to produce leafy vegetable seedlings. It involves establishing of nursery beds and managing the seedlings.

2.2 Summary of Learning Outcomes

The content of this Chapter will enable the trainee or farmer to;

- Establish nursery beds.
- Manage nursery beds.

2.2.1 Learning Outcome 1: Establish Nursery Beds

2.2.1.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select a suitable nursery site.
- Identify the various nursery structures (shade nets, greenhouse and nursey beds).
- Identify certification requirements for commercial seedling production.
- Identify the various growing media.
- Sterilise the growing media.
- Set up a suitable nursery beds (flat, sunken, raised or sky).
- Sow seeds in nursery beds or propagation trays.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Select a nursery site.	• Lead trainees in a field excursion to identify probable nursery site. • Group trainees into two groups to identify the appropriate site. • Facilitate a question-and-answer session on criteria of selection.	• Flip charts • Marker pens

• Identify of nursery structures.	• Lead trainees to a field trip to identify the various nursery structures. • Show trainees photos of various nursery structures and let them identify the various structures.	• Laptop/computer • LCD projectors • Printer • Photo printing papers
• Identify nursery certification requirements.	• Invite a guest speaker to elaborate on nursery certification requirements. • Show trainees samples/ photos of licenses and certificate for nurseries.	• Guest speaker • White board • Marker pens • Samples of licenses and certificates • LCD projectors • Computers/ laptops
• Identify and sterilise growing media.	• Organise a practical for trainees to identify the various growing media followed by a class discussion on their characteristics. • Give instructions to trainees/ demonstrate as they mix the growing media to the right proportion. • Organise a practical for trainees to sterilise the planting media.	• Samples of various growing media • Flip charts • Marker pens
• Prepare nursery beds.	• Organise a practical for trainees to identify and assemble all the tools, equipment and materials needed to prepare a nursery bed, then hold a discussion on their uses. • Give instructions to trainees as they prepare nursery beds.	• Flip chart • Maker pen • Tools for nursery bed preparation
• Sowing of vegetable seedlings.	• Give instructions to trainees/demonstrate as they sow seeds • Show trainees videos on sowing of seeds in nurseries.	• Vegetable seeds • Laptops/computer • LCD projector • Videos showing sowing seeds in nurseries
• **Duration: 10 hours**		

2.2.1.2 Information Sheet

Definition of terms

Nursery bed - This is a special type of a seedbed prepared for raising seedling before transplanting. It should be 1 m wide and of any convenient length.

Seedling bed - This is a special type of a nursery bed used for raising seedlings, which have been removed from the nursery bed due to overcrowding before they are ready for transplanting. This is called pricking out.

Planting - Is the placement of planting materials in the soil for regeneration in order to produce more of the plant species.

Planting media - Medium used for planting seedlings. This can be soil, manure, sand, coco peat, peat moss etc.

Importance of a nursery in vegetable crop propagation

The following are importance of crop propagation;

- It facilitates the planting of small seeds that develop into strong seedlings that are easily transplanted.
- Routine management practices are easily and timely carried out in the nursery than in the main seedbed.
- Ensures planting of only the healthy and vigorous growing seedlings.
- Seedlings raised in the nursery bed take a shorter time to mature than ones established directly.
- It is possible to provide the ideal conditions for growth such as watering, fine tilth and shade to the plants.
- It facilitates the production of many seedlings in a small area.
- Nursery can be prepared in unfavourable season.
- It reduces labour on the care of seedlings since the area is small.

Selection of suitable nursery site

The following factors should be considered when selecting an ideal site for establishing a vegetable nursery.

1. Availability of water source. The site should be accessible to enough water sources throughout the year since the seedlings require watering once or twice a day.

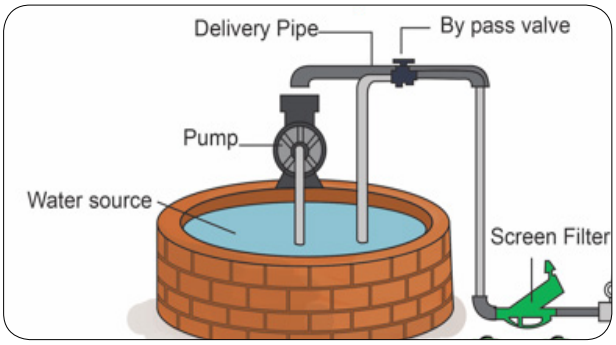

Figure 45: Water source

2. Security. The area should be well protected from theft and destruction by animals.
3. Access by customers and owner which enable easier flow of inputs and outputs into and out of the nursery.
4. Soil conditions. Soils should be deep, well structured, pulverised, pH range between 5.5 -7.0.
5. Wind breaks. It is necessary to prevent strong winds, which can destroy nursery structures, uproot the seedlings, and cause excessive evaporation. The site should however be well exposed to sunlight.

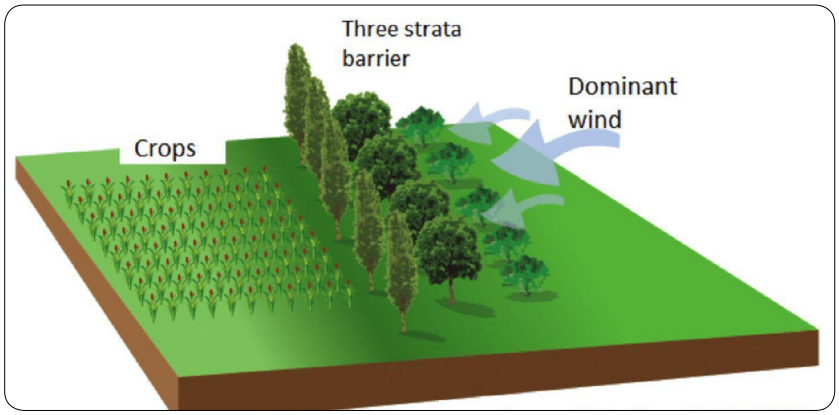

Figure 46: Wind break illustration

Source: Adopted from SAGARPA (2012)

6. Past use of the site: Avoid sites with previous crop family.
7. Topography: The surface topography should be gentle.

Nursery structures

The following nursery structures are used to raise vegetable seedlings.

a) Greenhouse

A greenhouse is a structure that is used to raise vegetable seedlings from the outside environment to create optimum conditions for plant growth. It's ideal for cold areas.

Figure 47: Galvanized steel nursery tunnel greenhouse

Note:

Greenhouses involves a higher investment and greater risk than normal field production.

b) Shade net

A shade net is a structure that is framed and made using materials such as wood. The house is covered by a net made of 100% polyethylene and the threads are specialised to stabilise the incoming ultraviolet (UV) radiation. The shade creates a cool microclimate and therefore, suitable for vegetables that thrive in weak solar radiation such as kales and spinach.

Figure 48: Shade net

Types of nursery beds

There are four types of nursery beds that can be used to raise vegetable seedlings. These are:

a) Raised nursery bed (for rainy season)

This type of nursery bed is useful during rainy season. Raised up beds are made with 10-15 cm ridges to allow free drainage. The width should be 1 m and length as per need.

Figure 49: Raised nursey bed

b) Sky nursery bed (for rainy season)

Sky nursery beds are prepared in the rainy season for producing seedlings of winter vegetables. By raising the nursery from the ground, the seedlings will not be affected by the water running on the ground surface in times of rain, and it helps to prevent damaging leaves of the seedling from direct rainfall to it, by making the roof of clear plastic sheet.

How to prepare Sky nursery beds

i. Prepare the nursery bed is using wooden or bamboo stalks driven on ground.

ii. Erect the bamboo sticks about 60-70 cm above the ground with 1 m wide and length as per the necessity and

iii. Place 15-20 cm thick layer of planting media on the planks or bamboo fibers.

iv. If it rains, the nursery bed should be roofed by plastic sheet; whereas it can also be removed if it is not raining.

Figure 50: Sky bed

Source: JICA

c) Sunken beds

Beds are kept slightly below the general ground level, common in areas with long dry hot weather. Such beds can be easily irrigated, during dry season. These beds can be in an open, under a shade or in a greenhouse.

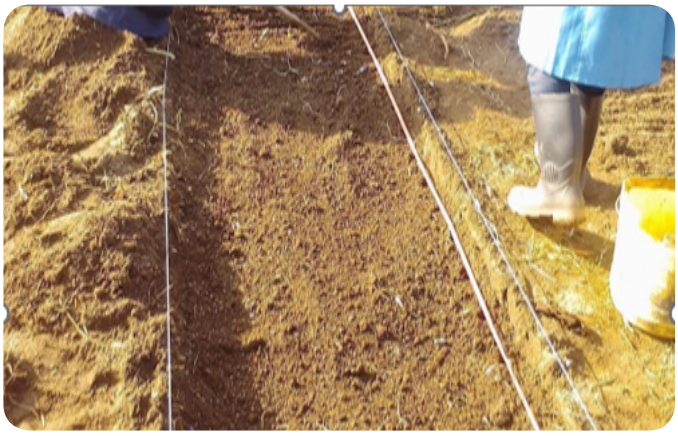

Figure 51: Sunken bed

d) Flat beds

Beds are same level with the ground. (The path and the beds are on the same level). Its suitable where soil conditions are fair and water availability is not an issue. These are commonly used for raising tree seedlings.

Figure 52: Flat bed

Source: Sikana

Nursery certification requirements

Commercial vegetable nurseries must be certified by Kenya Plant Health Inspectorate Service (KEPHIS) in order to operate lawfully. The certification is obtained as follows:

- Collect and submit soil and water samples to certified laboratories for testing analysis in order to find out if they meet the required standards stipulated by KEPHIS.
- Invite local Agricultural Food Authority (AFA)/KEPHIS officials to carry out nursery inspection at your proposed nursery site to assess if all other requirements are met.
- If both assessments above are satisfactory, then KEPHIS will issue a certificate of compliance.

Growing media

Characteristics of growing medium

A good growing medium should have the following characteristics;

- The medium must have adequate aeration, drainage and water-holding capacity.
- It must not be too heavy to lift.
- The medium must be slightly acidic to neutral, i.e., pH of 6 – 6.5 being satisfactory in most cases.
- It must be free of weeds, pests and pathogens.
- It must be easily available.
- It must not be too expensive.

Types of growing media

1. *Garden soil*

Light and sandy loam soil must be used as a growing medium, while silty or clayey soils are not preferred due to poor aeration and stickiness. The soil contains both organic and inorganic matter. The soil is easily available and comparatively a cheaper medium used in a nursery. The only disadvantage is that it may contain disease-causing pathogens, along with weed seeds, which is a serious problem in growing crops. It's important to use virgin soils.

2. *Sand*

It's large particle size makes this medium more porous, aerated and well-drained. Generally, it is mixed with soil and used as a well-drained porous medium.

Figure 53: Sand mound

3. *Compost*

Compost is formed due to the decomposition of organic matter. Leaves, litter, wood waste, rice husk, sawdust and farmyard manure are some of the common ingredients used for preparing compost. Compost contains nutrients that plants need for growth. Vermicompost is a supplement that is added to a growing medium.

Figure 54: Compost manure

4. *Coir peat or coco peat*

Coir peat is obtained from coir's fibre dust. It is acidic in nature and has a pH of about 5. It has a high-water retention capacity. When in use, the pH should be adjusted.

Figure 55: Coco peat

5. *Vermiculite*

Vermiculite consists of rocks. It is porous in nature and light in weight, and has adequate water-holding capacity.

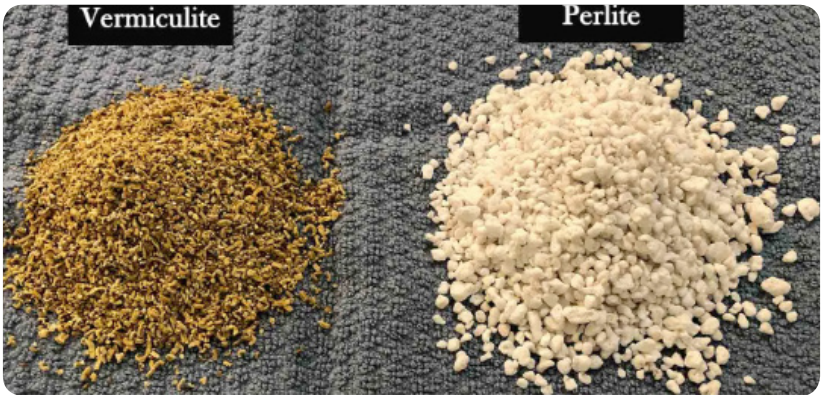

Figure 56: Vermiculite and Perlite

Nursery bed preparation

One needs the following basic tools and equipment in order to prepare a nursery bed;

Table 9: Tools and equipment used in nursery preparation

Tool or equipment	Use
Wooden pegs	Marking the field
Measuring tapes	Marking the correct dimensions
Layout strings	Demarcating the field
Rake	Levelling the bed and collecting trash
Jembe	Digging the field
Wheelbarrow	Transportation of manure, fertiliser etc.
Slasher	Clearing the land to remove weeds
Fork *jembe*	Breaking the hardpans and digging root stamps
Slasher	Clearing the land to remove weeds
Spade	Digging as well as to moving loose, granular materials

Setting up of nursery bed

When setting up a nursery bed, consider the following;

- Get designs of the nursery bed you intend to construct either sunken, raised, flat or sky.
- Measure and mark the nursery bed on the ground 1 m wide and appropriate length.
- Measure the diagonals to ensure that the lengths are equal.

Note:

Nursery bed should always be oriented North-South to ensure maximum availability of light to the seedlings.

Figure 57: Preparation of a nursery bed

Figure 58: Demarcating a nursery bed

- Clear the nursery site and remove all trash.
- Plough the site for the nursery beds to remove all weeds and stumps left after clearing.
- Excavate the top soil to a depth of about 10 cm deep and heap it somewhere separately. Top soil holds most of the organic matter which improves the nutrients and structure of the soil. It is kept separately and mixed with manure and sand to improve drainage. The top soil acts as the substrate for planting.
- Excavate the subsoil and also heap it separately to be used later when mixing the nursery media.
- Remove any stones and roots in both soils, ideally by sieving.
- Return the topsoil into the dug trench of the nursery bed.
- Mix 3 parts of soil with 2 parts of manure or compost and 1 part of sand (if available) to assist in drainage.
- Level the soil in the sunken, flat or raised bed in readiness for planting seeds.

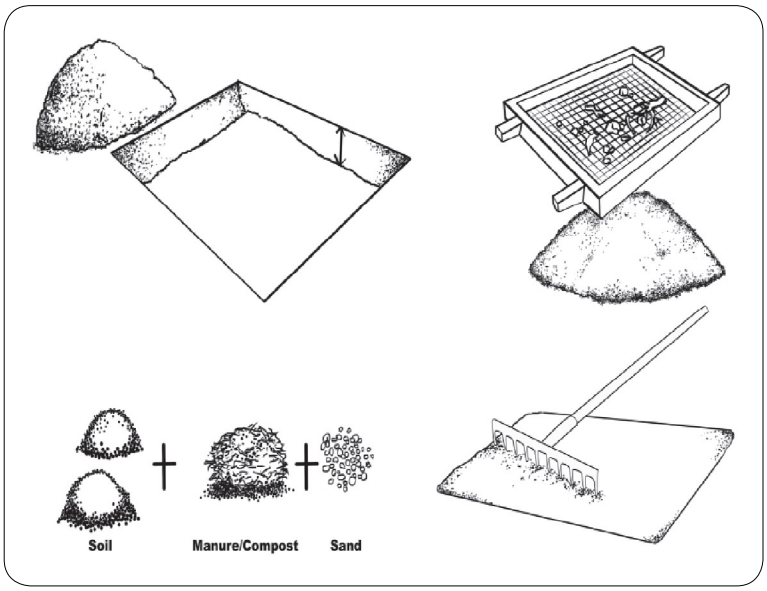

Figure 59: Steps in nursery bed preparation

Sterilising nursery beds

It is necessary to sterilise nursery beds so as to reduce losses associated with loss of seedlings due to pests and diseases like damping off. Sterilisation of nursery beds can be achieved by chemicals or solar heat. Use of chemicals can be hazardous and expensive.

Soil sterilising methods

a) Solarisation

Solarisation procedure

i. Apply water to moisten nursery soil.

ii. Cover the soil with transparent plastic sheets for 3-4 weeks (bury the edges of the sheets in the soil) By the third week, the temperatures under the sheet will have risen and destroy soil micro-organisms.

iii. After 3-4 weeks, remove the plastic sheets and plough the soil.

iv. About 2-3 days later, level the soil and sow the seeds.

Figure 60: Nursery bed sterilisation by solarisation

Source: Research gate

b) Steaming soil sterilisation

Hot steam heats up the substrate to temperatures that kill or inactivate weed seeds, nematodes, fungi, bacteria, and viruses by destroying cell structure and proteins.

Figure 61: Sterilisation of soil by steaming

Note:

It is only recommended when using containers and seedling trays.

Sowing of seeds

Before sowing, a farmer should consider the following;

Seed selection

Selecting high-quality seeds can save farmers time (labour) and money. Look for seeds that;

- Are not mixed with any other seeds,
- Have a high germination rate (85 out of 100 seeds are able to germinate),
- Produce healthy seedlings, and are not damaged.

Caution on seed quality

a. No pest and disease damage.
b. From reliable sources
c. Container labels should have;
    i. Variety name
    ii. Purity percentage (%)
    iii. Vendor- producer/distributer
    iv. Batch number
    v. Official quality certification from KEPHIS.

Caution on selecting the variety

a. Disease resistance/tolerance;
b. Customer demands

Steps in sowing seeds in the nursery bed

The following steps should be considered in sowing seeds in the nursery bed;

1. Mark lines on the nursery bed across the nursery at a spacing of 10-20 cm apart.
2. Using the stick, make furrows that are up to 3 cm deep.
3. Drill the seeds using your fingers into the furrows.
4. Then using the stick, cover the seeds in the furrows by levelling the furrow surface.
5. After that, place the mulching materials on the surface of the nursery bed and water using the watering can.
6. Continue watering every three days in case there is no rain or as the soil conditions dictate.
7. Remove the mulch material when 70% of the seedlings have emerged.

Figure 62: Sowing of seeds in nursey bed

Source: School for Africa.org

Figure 63: Watering a nursey bed

Source: Gardenery

Sowing in seedling trays

High-value and hybrid seeds are preferred to be sown in plug-trays (pro-trays) instead of open field nursery beds. Pro-trays are made of soft plastic having shallow plugs. These plugs are filled with planting medium. Coco peat, a by-product of the coir industry having high water-holding capacity, is commonly used as a medium in pro-trays.

Figure 64: Seedlings established using seedlings trays

Preparing seedling trays

When preparing for seedling trays, consider the following;

- Source for the seedling containers and preferable media.
- Clean seedling containers and expose them to sunlight or disinfect using disinfectants.
- Use medium that drains well, such as commercial potting soil, or a mixture of locally available materials such as soil, well-decomposed compost and sand in a 3:2:1 ratio. The medium should be steamed at 120 °C or for 45 minutes, or watered and heat-sterilised in covered soil sterilisers for 6-12 hours, or sterilised through solarization for 3-4 weeks to minimise levels of soil-borne pathogens, nematodes and insect pests.
- Soak overnight and rinse soilless media to attain a neutral pH e.g., coco peat.

- Place the seedling containers on raised benches
- Fill the seedling containers such as poly bags, pots, trays, petri-dishes with the sterilised media.

Procedure for sowing in plug trays

Consider the following procedure when sowing on trays;

1. Fill the trays/plugs with coco peat.
2. Depressions of 0.5 to 1 cm are made at the centre of the plugs with the help of fingertips for sowing the seeds.
3. One seed is sown in each plug. The seeds are placed in the depressions and covered with coco peat.
4. These pro-trays are covered with a polythene sheet and kept like that for a few days or till germination starts.
5. After germination, the polythene sheet is removed and water is sprinkled with a fine nozzle can. Annual seeds are commonly sown in pro-trays filled with coco peat or other growing media.

Figure 65: Pricking out seedlings from trays

Good nursery practices for safety, hygiene and sanitation

For good nursery practices and environment conservation at the nursery site, carry out the following;

- Dispose-off all litter after work in the appropriate designated areas.
- Avoid excessive watering at the nursery. Water should not be allowed to settle on the paths or collect at the waste pits and compost pits.
- Continuously guard the nursery site to keep away animals and unauthorised entrants.
- Do not leave cleared weeds and bushes uncollected as they will start decomposing and may lead to spread of diseases and pests.
- Clean tools and equipment after use.
- Drain waste water to a soak pit.

2.2.1.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • *Panga* • Rake • Slasher • Spade • Watering can • *Jembe* • Mixing buckets • Wheelbarrow	• Knapsack sprayer • PPEs • Wooden pegs • Measuring tape • Layout string	• Chemicals • Organic manure • Forest soil • Pesticides • Sand • Coco peat/vermiculite • Viable vegetable seeds • Dry mulch • Clean water

2.2.1.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Match the following tools used during nursery bed establishment.

Tool	Uses
Rake	Used for breaking the hardpans and digging root stamps
Jembe	Used for clearing the land to remove weeds
Wheelbarrow	Used for levelling the bed and collecting trash
Slasher	Used for digging the field
Fork *jembe*	Used for transportation of manure, fertiliser etc.

2. A nursey bed can be of any length. What is the recommended width of a nursey bed?
   - ☐ A. 60 cm
   - ☐ B. 45 cm
   - ☐ C. 100 cm
   - ☐ D. 50 cm
3. Name the different types of nursery beds?
4. What factors are considered when selecting a vegetable nursery site?
5. What are the steps followed in sowing vegetable seeds in a nursery?
6. What are some of the qualities of a good growing media?

Notes:

2.2.1.5 References

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2.2.2 Learning Outcome 2:
Manage Nursery Beds

2.2.2.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Mulch, water, apply fertiliser and thin seedlings in the nursery.
- Identify tools and equipment for controlling weeds, pests and diseases.
- Identify and control weeds, pests and diseases that attack seedlings in the nursery.
- Harden seedlings.
- Sort, prick out and package seedlings.
- Manage nursery wastes.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Carry out mulching, watering, thinning and application of fertiliser.	• Facilitate a question-and-answer session on the importance of mulching and thinning. • Lead a class discussion on methods of irrigation. • Trainees to practice watering of seedlings. • Show the trainees how thinning of seedlings is done as they practice. • Guide the trainees as they apply foliar feeds.	• watering, thinning and fertiliser application tools • White board • Marker pens
• Control of weed, pests and diseases.	• Facilitate a question-and-answer session on the importance of weeding. • Organise a practical for the trainees to identify the tools and equipment for controlling pests and disease or show trainees photos of tools and equipment. • Guide the trainees as they scout for pests and diseases. • Simulate or show trainees videos of how to spray fungicides and pesticides. • Engage the trainees in a class discussion on other methods of controlling pests and diseases.	• LCD projector • Laptop/computer • Tools and equipment for controlling pests and diseases • Photos of applicable tools and equipment • Video clips of fungicides and pesticide application

• Hardening seedlings.	• Show trainees a video on hardening of seedlings. • Guide the trainees as they harden seedlings.	• Video clips on hardening of seedlings • LCD projector • Laptop/computer
• Sorting, pricking out and packing of seedlings.	• Give instructions to trainees as they sort the vegetables. • Show trainees video on packaging of seedlings. • Show the trainees the pricking out and packaging procedure and allow them to practice.	• Video clips on packaging of seedlings. • Packaging materials • LCD projector • Laptop/computer
• Management of nursery waste	• Guide a brainstorming session on the types of wastes generated from vegetable seedling production. • Show trainees videos of waste management procedures. • Give instructions to trainees as they apply waste management procedures.	• Flip charts • Marker pens • LCD projector • Laptop/computer • Video clips of waste management procedures
• **Duration: 10 hours**		

2.2.2.2 Information Sheet

Definition of terms

Mulching - This is the placement of materials organic or inorganic on the ground next to the growing crop.

Thinning - The removal of excess seedlings or plants per planting hole to create more space for the remaining seedlings.

Pest - An insect or a small animal which damages crops.

Disease - This is any alteration in the state of the plant which interferes with the proper performance of its functions.

Nursery maintenance practices

1. Irrigation/ watering

The regular supply of clean water is essential to plant growth. Water the seedlings in the morning and evening. Do not overwater the seedlings as this causes rotting of the seedling/damping off disease. It is expensive in terms of labour and water costs. Watering can be done using the following;

- Watering cans/bucket,
- Hose pipe,
- Pumps,
- Plastic bottle with small holes on the lid for spraying water.

Water quality

Water used in raising seedlings should be clean and free from any kind of waste that is harmful to human health. This is because the waste is taken into the plant stem and leaves and will end up in the body, which is harmful to human health and can cause diseases.

To ensure good water quality;

- Do not dispose-off waste near water bodies (lakes, rivers, and dams),
- Do not water your plants with water that may contain industrial waste, pesticides, or human and animal waste,
- Cover water storage tanks to avoid contamination.

2. Mulching

After nursery establishment, a light mulch should be applied on the nursery bed. However, it should be removed as soon as the seedlings start to emerge (70%) and replaced with a shade.

Importance of mulching

- Reduces scorching effect on seedlings.
- Prevents excessive evaporation.
- Moderates soil temperature.
- Reduces the runoff thus preventing soil erosion.
- Suppresses growth of weeds.
- Organic materials decompose to form humus, which improves soil structure and water-holding capacity of the soil.

Step-by-step procedure for mulching

Follow the steps below when mulching;

i. Gather adequate mulching materials for the nursery bed.

ii. Remove any foreign materials by cleaning/shaking the mulch material.

iii. Cover the nursery bed with mulching materials gently and evenly 3-5 cm thick. If using a shade net, place it gently on top of the nursery bed. Firm edges of the shade net with weight to protect it from being blown off.

iv. After this water the nursery bed gently using a sprinkling container.

Figure 66: Mulching on a nursery bed

Caution:

- Avoid mulch from crop residue that has seeded.
- Green or non-dried grass/straws or broad-leaved materials or seeded grass should never be used for mulching.
- Do not compact the nursery bed so that when seedlings sprout, they emerge easily.

3. Shading

Shading can be done to protect the young plants from direct sunlight. The mulching material may include dry grass or straws from the small cereal crops.

Procedure for nursery bed shading

When shading the nursery bed consider the procedure below

i. Measure and dig holes 60 cm deep for the poles along the nursery bed edges.
ii. Cut the poles to the desired size/height of about 1-1½ m.
iii. Place the poles in the holes and compress firmly using soil.
iv. Cut the rafters to the desired length.
v. Place and nail/tie the rafters on top of the poles to form a mesh.
vi. Place your shading material firmly on top of the rafters e.g. dry seedless grass.

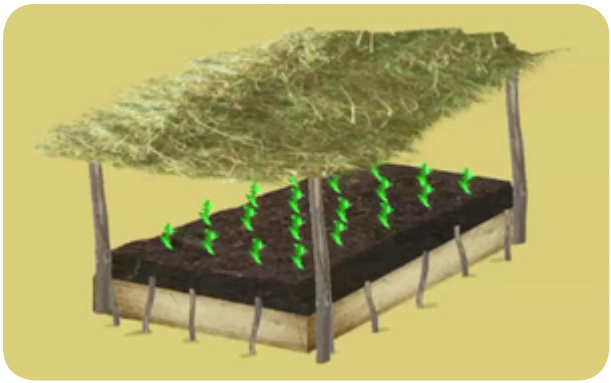

Figure 67: Shading over vegetable seedlings in a nursery bed

4. Thinning

Thinning refers to removal of overcrowded seedlings. Where seedlings are overcrowded some should be removed and planted in a seedling bed. This is done to allow the seedlings to grow strong and healthy and reduces competition.

Step-by-step procedure for thinning

i. Scout and identify areas requiring thinning.

ii. Water the nursery bed to loosen the media for ease of thinning.

iii. Remove the excess seedlings using a garden trowel or dibbler for the seedlings to have a lump of soil.

iv. Transplant excess seedlings to another seedbed, trays, or individual containers for transplanting to the field later or for sale to other farmers.

Figure 68: Thinning spinach

Source: The spruce

5. Fertiliser application

The seedlings are sprayed once with foliar feeds two weeks after germination. This helps the seedlings to grow strong and healthy.

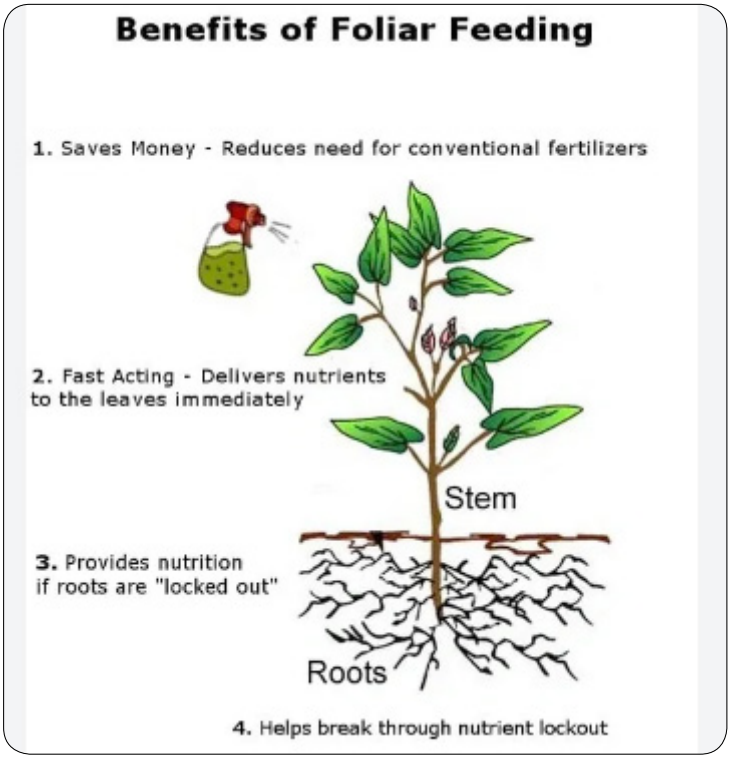

Figure 69: Foliar fertiliser application

Source: Eleva Soils

6. Weed control

Weeds compete with the seedlings for nutrients, space, light and water causing significant losses. Some act as alternate hosts for insect pests and for other diseases. e.g., Blackjack for aphids. Weeds may prevent easy grading out and packaging before moving the mature seedlings for transplanting. It is therefore important to keep vegetable nursery bed weed free. Weeds should be removed manually through uprooting.

Figure 70: Manual weeding of seedlings

Source: Hobby Farms

1. Control of pests and disease vegetable seedlings

Tools, equipment, and material for controlling pests and diseases

- Goggles – Protecting the eyes from getting into contact with agrochemicals.
- Face mask – Prevents inhaling the chemicals while spraying.
- Knapsack sprayer- Applying agrochemicals by spraying.
- Gloves – The elbow length gloves protect the hands and wrist from the pesticides.
- Aprons - Offer excellent protection against spills and splashes of liquid formulations.
- Gumboots - Protects the legs and ankles when handling or applying moderately or highly toxic pesticides.

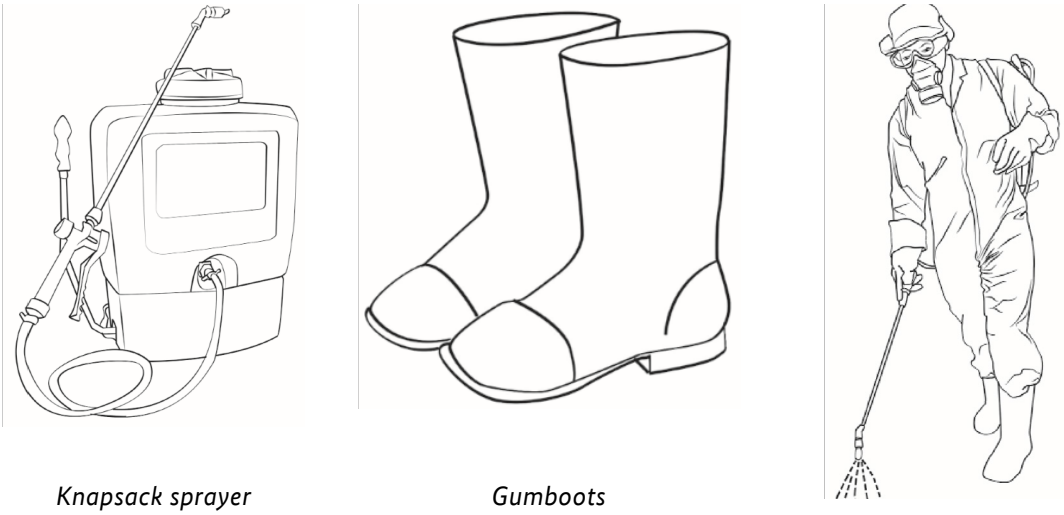

Figure 71: PPEs used during applications of agrochemicals

Scouting procedure

Regular inspections of the seedlings should be carried out in the nursery to identify various pests, diseases and their threshold levels. This is referred to as scouting. In case of high threshold levels above 70%, control pests/diseases appropriately.

Steps in scouting

The following steps should be followed when scouting;

Figure 72: Scouting procedure

i. At least once every day, take a walk in the nursery to monitor pest and disease development trends. (carry a magnifying glass).
ii. Pick a starting point near the corner of your nursery and walk from there in a zigzag fashion, ensuring that the entire field is represented by the time the last scouting location is sampled.
iii. Observe both the upper and underside of leaves and soils.
iv. Sample all plants in a small block of the same crop/for a large block, at least 50 leaves in a field should be sampled.
v. Remember to remove any weeds seen.
vi. Observe the major pests present and their numbers.
vii. Observe the major beneficial insects and their numbers.

Common diseases in nursery plants

The following are common nursery beds;

1. Damping-off

It is a common and serious disease in nursery plants, which can even cause their death. Damping-off is a pre-emergence and seedling disease caused by fungi. These fungi attack at the time of seed germination.

Symptoms

The signs of damping-off are as follows;

i. Root decay of stems at or near the soil line near the base of the seedlings.

ii. Infected seedlings collapse due to rotting in the collar region.

Preventive measures

Adhere to the measures below in order to prevent damping-off;

i. Maintain a dry soil surface, which helps reduce the sowing density and thins out the seedlings, leading to improved aeration.

ii. Uproot infected seedlings.

iii. Spray with appropriate fungicide in cases of severe infection.

Figure 73: Seedling affected by damping-off disease

Source: Research gate

2. Wilt

Symptoms

Wilt disease in leafy vegetable seedlings has the following signs;

i. Plants often show discoloured and wilted appearance.

ii. Leaves become yellow.

Control measures

Make sure that you observe the measures highlighted below in order to control wilt in seedlings;

i. Avoid watering seedlings when moisture is high or during wet conditions.
ii. Use resistant varieties.
iii. The disease is controlled by drenching the soil with copper-based fungicides.

3. Leaf spot

This disease is very common since one can often notice small to big black or brown spots on vegetable leaves. The disease is controlled by spraying the plants with Mancozeb agrochemical at a rate of 3 g per litre of water.

Figure 74: Leaf spot disease

Source: Plant village

3. Anthracnose disease

Anthracnose diseases attacks all plant parts at any growth stage. Warm and wet weather favours infection and disease development.

Symptoms

The main symptom of Anthracnose disease is appearance of small and irregular spots on leaves that are either yellow-brown, dark-brown or black in colour. The spots can expand and merge to cover larger areas on the leaf.

Figure 75: Anthracnose disease on kales

Source: Research gate

Control/preventive measures

Anthracnose disease can be controlled by;

i. Uprooting infected seedlings to reduce spread of the diseases.
ii. Avoiding water logging on the nursery bed.
iii. Spraying seedlings with fungicides if infection is high.

Common pests of leafy vegetable seedlings

Nursery plants are tender and vulnerable to attack by various insect-pests as shown in Table 10.

Table 10: Common pests of leafy vegetable seedlings

Name and photo of pest	Symptoms of damage	Control measures
 *Cutworm*	Damage is on young seedlings which are cut near the ground. Black larvae are found in the soil near the cut plant.	• Dig around the collapsed plant to get the cutworm and kill it. • Flood the area to suffocate the larvae in the soil. • Mix equal quantities of sawdust, bran and molasses with water to make mixture sticky and spread around the base of the plants in the evenings.
 *Aphids*	Adults and nymphs damage the growing tips of the plant and leaves by feeding on them. Under heavy infestation, the leaves curl and become discoloured.	• Plant early and scout regularly for aphids and destroy. • Rogueing to remove infested plants. • Destroy all volunteer crops and weeds. • Practice crop rotation. • use of sticky traps (blue/ yellow). • Spray soapy solution (10-15 tablespoonful of liquid soap in 20lt of water). • Use overhead irrigation to knock aphids off the leaves.

 *Cabbage saw fly (larval stage)*	They feed on the blade of the leaves often leaving only the main veins and midrib	• Rogueing • Hand pick and crush or dip in hot water. • Use of pheromone traps. • Use biopesticides (Neem-based 50 ml/20 l/ground chilli 100 g mixed with ash 2 kg/20 l water). • In severe infection use insecticides.
 *Whiteflies*	The larvae and adults pierce and suck the sap from leaves. Yellowing of leaves, and wilting of the plant is observed when pest is present in large numbers.	• Mount yellow sticky traps to trap adults. • Spray with pepper at rate of 30 chopped peppers put in 1 l warm water • Conserve natural enemies e.g. Ladybirds. • Intercrop with onions and garlic. • In severe cases spray with insecticides.

Source: www.sweetfarmprofits.com

Other pests of leafy vegetable seedlings include:

- Diamond back moth
- Army worm
- Red spider mites.

Good Agricultural Practices (GAPs) to be observed while spraying

While using a toxic pesticide, insecticide, fungicide or any other chemical spray on plants, the following precautions should be taken:

i) Chemical should be applied on a day that is not windy. On a rainy day, it may be washed off too quickly.

ii) Chemical should be used strictly according to instructions on the product. Less dosage may not be useful; more may be harmful to the plants and environment.

iii) A person spraying the pesticides should wear (PPE) safety gloves, mask, goggles, garden apron, and they should stand according to the wind direction to keep the direction of the spray away from the body.

iv) Hands must be washed carefully with soap immediately after application.

v) The chemical should be labelled and kept away in a safe place and distinctively marked as poisonous.

vi) Chemicals should be applied in the morning or late evening; if used during hot hours, it may endanger the foliage.

vii) The container and the sprayer should be washed with clean water immediately after and before use and disposed properly.

Figure 76: GAPs to be observed during spraying

Table 11: Emergency procedures while handling pesticides

In case of fire 	• Act immediately. • Evacuate the area. • Telephone emergency services and indicate that the fire is in a pesticide store. • Have stock sheets available when the emergency services arrive. • Contact person responsible for the farm.
In case of personal contamination 	• Act immediately. • Remove contaminated clothing and contain them in a plastic bag. • Wash the contaminated area with large quantities of water and find the trained first aider. • Contact person responsible. • Where possible, make sure that label information is available for doctors.

In case of spillage

- Act quickly and carefully.
- Wear protective clothing.
- Ventilate the area.
- Cover liquids with sand to contain them.
- Contain solid materials and keep dry.
- Contact the person responsible for the farm to receive instruction for safe disposal.

Precautions!

- Wear gloves or wash hands with water afterwards, because bleach is toxic.
- Wear PPE when using chemicals.
- Follow instructions on product label such as dosage, time of application, maximum number of sprays, restricted re-entry intervals and the pre-harvest interval (**PHI**)
- Do not empty pesticide mix or washings into drains.
- Always consult recent list of registered pesticides Pest Control Products Board (PCPB).
- Keep your nursery site free of weeds.

Hardening off

Hardening off allows plants to adapt from being in a protected, stable environment to changeable, harsher outdoor conditions. If suddenly placed outside, the shock can severely check a plant's growth. Although plants usually recover eventually, hardening off is thought to be preferable to a sudden shock.

Consider the following steps in hardening seedlings

i. Prepare for hardening process when the seedlings are 6 to 7 weeks old (42 to 50 days) after sprouting.

ii. Day 1; Saturate the beds completely and open the shade for a period of 1 hour then place back the shade.

iii. Day 2; Reduce the amount of water and open shade for 2 hours.

iv. Day 3; depending on how the physical condition of the seedlings you may skip watering but open shade for 3 hours.

v. Day 4 to day 7; Irrigate on alternate days while further reducing the volume of water applied. Further reduce shading by increasing the open hours by 1 hour extra each day.

vi. After 7 days remove the shade completely and apply just enough water to sustain the seedlings before transplanting.

Note:

Hardening takes 6 to 9 days before transplanting.

Figure 77: Hardening off

Source: Prudent Garden

Sorting of vegetable seedlings

Procedure for sorting vegetables is as follows;

- Remove and dispose-off damaged seedlings.
- Remove and dispose-off diseased/ pest-infested seedlings.
- Remove and dispose seedlings with flower buds or flowers.
- Isolate and separate the weak seedlings from the strong seedlings. The weak seedlings may be allowed more days to strengthen and be dispatched later for transplanting.
- Uproot the desired quality and quantity of ready seedlings and package ready for dispatch.

Pricking out and packaging seedlings

During pricking out the following tools and equipment are necessary;

- Sisal twine/old banana leaves
- Trimming knives
- Crates/cartons
- Marker pens
- Labels
- Sharp stick

Pricking out procedure

Prick out the seedlings as follows;

- Water seedlings on the nursery before uprooting for packaging. This is done to ensure the seedlings hold the media and keep the seedlings moist. Water 3-4 hours before lifting the seedlings.
- Gently loosen the soil around the seedlings using a sharp stick.
- Carefully lift the seedlings using a garden trowel with a ball of soil.
- Wrap the seedlings at the base in handful bunches in old banana leaves/and tie using the sisal twine or banana leaves.
- Place the bunched seedlings upright in the crates/cartons.
- Place the seedlings under shade ready for dispatch.

Precautions!

The seedlings should be thoroughly watered before leaving the nursery; this will provide them with the largest possible reserve of water and minimise the risk of soil being lost out during the packaging process.

Nursery waste management

The production of seedlings, sorting and packaging result in materials that are removed and not shipped to the consumer or transplanted into the field. There are five main principles of waste management. These are: reduce, reuse, recycle, transform and rebuy.

Preparing site for biodegradable waste disposal

The procedure below is usually followed when preparing the site;

i. Identify a site to dispose waste at one of the corners of the nursery.
ii. Measure the dimension of the desired pit depending on the size of the nursery e.g., 1m wide by 2 m long by 1 m deep.
iii. Peg the measured dimensions.
iv. Excavate the soil and place it in a convenient place for reuse.

Steps in biodegradable waste disposal

Consider the following when safely disposing waste;

i. Always separate biodegradable and non-biodegradable wastes.
ii. Place the segregated waste on wheelbarrow or buckets/sacks and transport to their designated pits.
iii. Put them in their designated pits.
iv. Cover the waste with a little soil to fasten degradation.
v. Reuse the resultant manure in other farms or ornamental gardens.

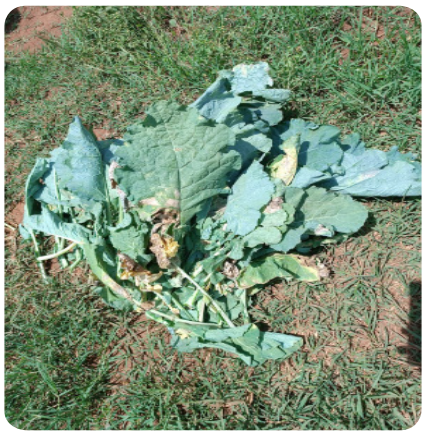


Figure 78: Recycling of waste leafy vegetables into manure

Note:
The seedling stems and leaves can also be fed to the animals.

Non-biodegradable waste disposal

Below are the main steps of safely disposing non-biodegradable waste

i. Segregating reusable from non-reusable waste.
ii. Placing reusable and non-reusable wastes in separate labeled bins.
iii. Transfering non-reusable waste to waste collection points.
iv. Reuse reusable wastes but do use containers that had pesticides to handle food.
v. Pour waste water into a septic tank not in rivers, lakes, dams or other water sources.

2.2.2.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Watering cans • Bucket • Plastic bottle • Strings • Shovel • *Jembe* • Mattock • Garden trowel • Wheelbarrow • Rake • Waste bins	• Hose pipe • Pumps • Knapsack sprayer • Tape measure • Pegs	• Crates • Carton • Marker pen • Labels • PPEs • Water

2.2.2.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. A disease is any alteration in the state of the plant which interferes with the proper performance of its functions.
   - ☐ A. True
   - ☐ B. False

2. Which of the following is not a PPE used in spraying of vegetable seedlings?
   - ☐ A. Goggles
   - ☐ B. Scarf
   - ☐ C. Gumboots
   - ☐ D. Face mask

3. Which are the common pests that attack vegetable seedlings?

4. What precautionary measures should you observe while spraying agrochemicals in vegetable nurseries?

5. Why is it important to mulch a nursery bed?

6. Why should the seedlings be weeded?

Notes:

2.2.2.5 References

Butt, S. J., Varis, S., Nasir, I. A., Sheraz, S., & Shahid, A. (2015). Micro propagation in advanced vegetable production: a review. *Advancements in Life Sciences*, *2*(2), 48-57.

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2.3 Model Responses to the Self-Assessment Questions

2.2.1 Learning Outcome 1:

Establishing Vegetable Nursery Beds

1. Match the following tools used during nursery bed establishment.

Tool	*Use*
Rake	***Used for levelling the bed and collecting trash***
Jembe	***Used for digging the***
Wheelbarrow	***Used for transportation of manure, fertiliser etc.***
Slasher	***Used for clearing the land to remove weeds***
Fork jembe	***Used for breaking the hardpans and digging root stamps***

2. A nursey bed can be of any length. What is the recommended width of a nursey bed?

C) 100 cm

3. Name different types of nursery beds?

- **Flat**
- **Raised**
- **Sunken**
- **Sky bed**

4. What are the factors to consider when selecting a vegetable nursery site?

- **Availability of a water source. The site should be accessible to enough water source throughout the year since the seedlings require watering once or twice a day.**
- **Security. Should be well protected from theft and destruction by animals.**
- **Access by customers and owners which enable easier flow of inputs and outputs into and out of the nursery.**
- **Soil conditions. Soils should be deep, well-structured, pulverised, pH range between 5.5 -7.0.**
- **Wind breaks. Necessary to prevent strong winds, which can destroy nursery structures, uproot the seedlings, and cause excessive evaporation. The site should however be well exposed to sunlight.**
- **Past/previous use of the site: Avoid sites with previous crop family**
- **Topography: The surface topography should be gentle.**

5. What are the steps followed in sowing vegetable seeds in a nursery?
   i. **Mark lines across the nursery bed at a spacing of 10-20cm apart.**
   ii. **Using the stick make furrows that are up to 3cm deep.**
   iii. **Drill the seeds using your fingers into the furrows.**
   iv. **Then using the stick, cover the seeds lightly in the furrows by levelling the furrow surface.**
   v. **After that place the mulching materials on the surface of the nursery bed and water using the watering can.**
   vi. **Continue watering every three days in case there is no rain or as the soil conditions dictate.**
   vii. **Remove the mulch material when 70% of the seedlings have emerged.**

6. What are the qualities of a good growing media?
   - **The medium must have adequate aeration, drainage and water-holding capacity.**
   - **It should not be too heavy to lift.**
   - **The medium must be slightly acidic to neutral, i.e., pH of 6 – 6.5 being satisfactory in most cases.**
   - **It should be free of weeds, pests and pathogens.**
   - **It should be easily available.**
   - **It must not be too expensive.**

2.2.2 Learning Outcome 2:

Manage Nursery Beds

1. A disease is any alteration in the state of the plant which interferes with the proper performance of its functions.
   A) True

2. Which of the following is not a PPE used in spraying of vegetable seedlings?
   B) Scarf

3. Which are the common pests that attack vegetable seedlings?
   - **Aphids**
   - **Mealy Bugs**
   - **Spider mites**

- **Thrips**
- **Cut worms**

4. What precautionary measures should you observe while spraying agrochemicals in vegetable nurseries?
   - **Chemical should be applied on a day that is not windy. On a rainy day, it may be washed off too quickly.**
   - **Chemical should be used strictly according to instructions on the product.**
   - **A person spraying the pesticides should wear safety gloves, mask, goggles, garden apron.**
   - **Hands must be washed carefully with soap immediately after application.**
   - **The chemical should be labelled and kept away in a safe place and distinctively marked as poisonous.**
   - **Chemicals should be applied in the morning or the late evening.**
   - **The container and the sprayer should be washed with clean water, immediately after use and also before use.**

5. Why is it important to mulch a nursery bed?
   - **Reduces scorching effect on seedlings.**
   - **Prevents excessive evaporation.**
   - **Moderates soil temperature.**
   - **Reduces the speed run-off thus preventing soil erosion.**
   - **Smothers weeds hence suppressing their growth.**

6. Why should the seedlings be weeded?
   - **Reduce competition for nutrients, space, and light.**
   - **Some weeds act as alternate hosts for insect pests and others for diseases.**

3 African Leafy Vegetable Production

3.1 Introduction to the Chapter

This chapter specifies the competencies required to produce African Leafy Vegetables (ALVs). It involves production practices regarding cultivating the following ALVs; Black nightshade (*Managu*), Cowpea (*Kunde*), Jute mallow (*Murenda*), Slender leaf/Crotolaria/Sunn hemp (*Mitoo*), Spider plant (*Sagaa/ Saget*), and Amaranthus (*Mchicha/Terere*).

3.2 Summary of Learning Outcomes

The content of this Chapter will enable the trainee or farmer to;

- Produce Black nightshade (*Mnavu, Managu, Lisucha, Osuga, Sochoot* or *Namasaka*).
- Produce Cowpea (*Kunde, Likhubi* or *Boo*).
- Produce Jute mallow (*Mrenda, Murenda, Murere* or *Apoth*) and Slender leaf/ Crotolaria/Sunn hemp (*Marejea, Mitoo* or *Miroo*).
- Produce Spider plant (*Mgagani, Sagaa, Saget, Chisaka* or *Dek*).
- Produce Amaranthus (*Mchicha, Terere, Chimboka, Tsimboka, Ododo* or *Chepkarta*).

3.2.1 Learning Outcome 1:

Produce Black Nightshade *(Managu)*

3.2.1.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select appropriate variety of Black nightshade.
- Source quality seed/seedlings of Black nightshade.
- Sow seeds/transplant seedlings to the seedbed.
- Manage the crop.
- Harvest the crop.
- Carry out post-harvest handling practices.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying various varieties and importance of Black nightshade.	• Guide a brainstorming session on the varieties and uses of Black nightshade. • Facilitate a lecture using photos/videos to elaborate on varieties and importance of Black nightshade. • Provide samples of different varieties of Black nightshade and ask trainees to identify them.	• Flip charts • Marker pens • LCD projector • Computer • Different varieties of Black nightshade

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying tools, equipment and supplies for Black nightshade production with their uses.	• Facilitate a lecture using photos/videos to elaborate on various tools, equipment and supplies and their uses. • Facilitate a visit to the farm store and allow trainees to identify tools, equipment and supplies used in Black nightshade production.	• Flip charts • Marker pens • LCD Projector • Computer • Photos • Farm store
• Establishment of Black nightshade	• Demonstrate on how actual establishment of Black nightshade is carried out on the seedbed. • Ask the trainees to establish Black nightshade on the seedbed.	• Seeds • Seedlings • Fertilisers • Manure • Watering can • *Jembe* • Planting lines • Mineral water bottle
• Carrying out field management practices.	• Lead a demonstration on how scouting for pests and diseases is done. • Demonstration on how to place pheromone and sticky traps, surveillance and recording. • Ask trainees to place pheromone and sticky traps in the field, do surveillance and record. • Ask trainees to carry out scouting for pests and diseases on the field. • Facilitate a lecture using photos/videos to elaborate on various pests and diseases and their management practices. • Facilitate a field visit/trip to where Integrated Pest Management (IPM) is practiced to observe different IPM strategies. • Lead a demonstration on weeding, thinning, watering, mulching and crop rotation. • Ask trainees to perform weeding, thinning, watering, mulching and crop rotation.	• Scouting program • Flip charts • Marker pens • LCD projector • Computer • Photos • Various specimen • *Jembe* • Magnifying glass • Mulching materials • Pheromone traps • Sticky traps • Stationery
• Harvesting of Black nightshade.	• Demonstrate on ways and how to harvest Black nightshade and seeds. • Ask the trainees to harvest Black nightshade, weigh and record the harvest and seeds.	• Weighing machine • Gunny bags/ crates • Tarpaulin • Stationery

Training Activities	Training Delivery Methods and Description	Resources Required
• Carrying out post-harvest handling of Black nightshade.	• Guide a brainstorming session on the importance of post-harvest handling practices. • Lead a demonstration on cleaning, sorting grading, packing, carrying and storing of Black nightshade harvest and allow trainees to practice.	• Gunny bags/ crates • Tarpaulin • Basin • Labels • Sieve
• **Duration: 24 hours**		

3.2.1.2 Information Sheet

Introduction

There are many species of African nightshade grown for their edible leaves. The leaves when consumed provide many health benefits to the body such as proteins, calcium, iron, phosphorus and magnesium, beta-carotine, vitamin E, folic acid and ascorbic acid.

Figure 79: Black nightshade

Health benefits

It soothes sore throat - It soothes the sore throat. Public speakers and the singers should include this in their diet.

Works as a natural laxative agent - Black nightshade is naturally rich in fibre content and it acts as a natural laxative agent to prevent constipation.

Helps digestion - Black nightshade supplies all the required nutrients of the body. If it is included daily in the diet, it helps to digest the food easily.

Remedy for fever - It contains phosphorus, vitamin A, B, C, iron, calcium and other micro nutrients. People suffering from body heat can consumes the cooked black night shade leaves to soothe their body heat and best remedy for skin allergies too.

Good sleep - The seeds of Black nightshade are air-dried and ground into powder and mixed with milk and taken during the night, it promotes good sleep and soothes the body tiredness. The seeds are good for Tuberculosis patients and diabetic people if included daily their diet.

Other benefits

- It plays an important role in traditional medicine in Africa.
- They have high demand in high-end hotels, thus a source of income to farmers.

Types and varieties of Black nightshade

Types of nightshade

There are two main types of nightshade. These are;

i) Bitter and small leaf types, generally preferred by adults, and;

ii) Big leafy types, generally sweeter and preferred by children and the youth.

Varieties of nightshade

The common varieties of Black nightshade in Kenya are highlighted in the table below

Table 12: Varieties of black nightshade

Variety	Characteristics	Maturity & yield potential
 *Solanum villosum*	Grows up to 1.3 m high with hard spreading branches. The stem is green in colour with purplish nodes. The leaves are small, green in colour with light green networked veins. Sepals are green, ovate and deflexed away from the berry, the petals are white in colour and anthers yellow in colour. Berries are orange in colour and remains attached to the plant when ripe.	Annual yield of 8-16 tonnes of leaves per acre.
 *Solanum acrocarpon*	Grown for both its leaves and fruits. Immature fruits are green in colour but turn red when mature. The fruits and leaves are harvested together and cooked together in Kenya.	Leaf yield 2.9 kg per m^2 Total yields up to 11.6 tonnes/acre annually.

 *Solanum americannum*	Relatively thin branches, small, glossy leaves, small, shiny green fruits turning purple black when ripe.	Yields are estimated at 4-8 tonnes/acre annually
 *Solanum eldoretii*	Small fruits with course leaves. Mature fruits are green in colour and fruits fall of easily.	Annual yields are estimated at 4-8 tonnes/acre
 *Solanum nigrum*	Leaves are ovate with smooth margins, pointed apex, dark green in colour with purple networked veins. Flowers are white in colour and fused at the base. It has purple to black berries which remain stuck on plant when ripe.	Yields of up to 7 tonnes /acre are probable annually
 *Solanum scabrum*	Commonly known as Garden huckleberry. It has broad leaves, and the flowers are white or yellowish while berries are purple black. The berry is juiced, has many seeds are flat and black in colour.	Yields are 4 -12 tonnes/acre

Sourcing of quality seed/seedlings of Black nightshade

Use quality seeds of a recommended variety. Quality seeds are a fundamental requirement for good production. These seeds can be sourced from research institutions such as KALRO, Kenya Seed Company and authorised agrovets. Home-processed seed can also be of good quality if it is well processed and stored.

Importance of quality seeds:

- Lower seeding rate.
- Higher seedling emergence, usually above 85%.
- Vigorous seedlings.
- More uniform plant stand.
- Faster growth rate.
- Better resistance to pests and diseases.
- Uniformity in maturity.
- The plant is more tolerant to drought.

Quality seed should be of uniform size, colour and shape. It should also be free of foreign matter such as weed seed, chaff and should be pest- and disease-free.

Establishment of Black nightshade

Planting using seeds

Black nightshade is propagated by seeds on a well-prepared seedbed with a fine tilth. The procedure of planting Black nightshade seeds is as follows;

i) Prepare land to a fine tilth, then make furrows/drills at 30 cm apart using a layout string, a tape measure and a Jembe.

ii) Apply well-decomposed manure at the rate of 1-2 kg/meter but in case of scarcity 0.5kg can be used.

iii) Place the recommended amount of fertiliser (one bottle top of planting fertiliser (NPK, Mavuno or DAP)/meter and mix with soil and manure using a stick.

iv) To ensure uniform distribution, mix the seed with soil or sand at a ratio of 1:4 using a basin or a large container.

v) Put the mixture in a large plastic bottle and make a hole in the bottle top.

vi) Plant the seeds 1 cm deep in the furrow and cover lightly with soil.

vii) Water the seeds after planting in case of planting during dry season.

viii) Seed germination takes place between 4 – 7 days.

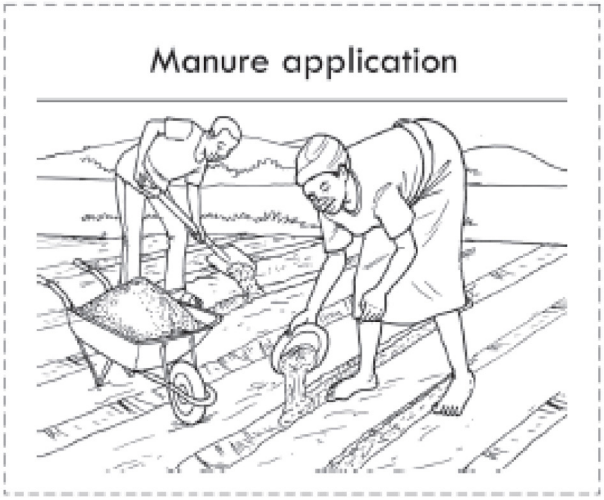

Figure 80: How to apply manure on planting furrows

Establishment of Black nightshade using seedlings

i. Prepare the land and incorporate manure/compost into the soil 1 – 2 weeks before transplanting.

ii. Before transplanting, ensure the soil has adequate moisture, either through irrigation or at the onset of the rains

iii. Source healthy seedlings from your nursery for transplanting that are 4 weeks old, pencil-thick, 10-15 cm long and have 4-6 true leaves.

iv. Transplant the seedlings in the evening or very early in the morning when it is cool to reduce transplanting shock.

v. Plant one seedling at a spacing of 30 cm between rows and 10 – 15 cm between plants. And cover the roots with soil up to the level they were covered in the nursery.

vi. Water the planted seedlings if its dry.

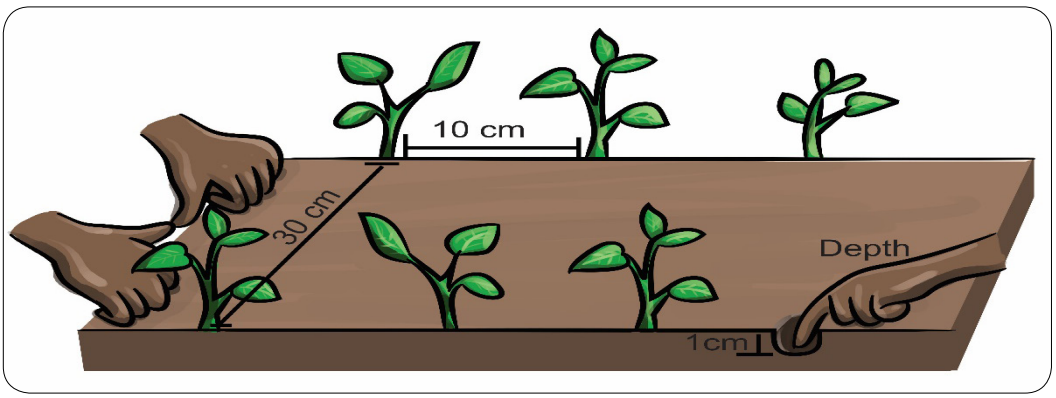

Figure 81: Spacing of Black nightshade

Seed rate

The amount of seed required depends on the variety, seed size, cropping system, and viability. Generally, the recommended seed rate is 2-4 kg/acre.

Crop management

a) Weeding

Use hoes/*jembe* to remove unwanted plants to avoid competition for nutrients. Remove weeds as they emerge in order to keep your vegetable crops weed free to achieve high yields. Common weeds include Blackjack, Oxalis, Mexican marigold, MacDonalds eye, Wandering jew and grasses.

Blackjack

Oxalis

Mexican marigold

MacDonald's eye

Wandering jew

Star grass

b) Mulching

Done to conserve and maintain moisture in the soil, check soil erosion and also control weed growth. Ideal types of mulching material to be used include dry beans, maize stover, dry grass or wild sunflower (Tithonia).

Figure 82: Mulching Black nightshade

Importance

- Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.
- It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.
- As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.
- Mulching reduces the growth of weeds as it deprives them of sunlight.

c) Irrigation

Ensure the crop is well watered especially during dry periods for proper establishment (refer to learning objective on irrigation). Common irrigation methods include; drip irrigation, sprinkler, or bottle irrigation.

d) Thinning

This is the removal of seedlings that emerged from drilling seeds so as to attain a spacing of 15 cm between the plants.

- Thin seedlings during first weeding to attain a spacing of 15-20 cm between the plants.
- During thinning the weak seedlings, off-types and diseased plants are removed. The good quality thinned plants can be transplanted in new plots, used for gapping, sold or consumed at home.

e) Gapping

This refers to the filling of empty spaces in the field occasioned by plant that failed to take off (plants that died).

- Five days after transplanting the Black nightshade seedlings in the field, scout and count for seedlings that failed to take off.
- Source an equal number of seedlings from initial dealer ensuring they are of the same variety.
- Using a stick, prepare a planting hole of 1cm depth at the site where the Black nightshade failed to take off.
- Place the seedling and cover shallowly with soil and water.

Note:
Proper thinning and gapping ensures that the plants are healthy by reducing competition from weeds and fellow plants.

Figure 83: Healthy Black nightshade vegetables

Pest and disease management

Pest and disease management should be a continuous effort by the farmer to ensure early intervention in case of an outbreak. Both cultural and use of safe organic pesticides can be used to control pests and diseases. This should be done through continuous scouting of the field crop.

Scouting

i. Prepare a program for pest and disease scouting.
ii. Determine the frequency of scouting, say, once every 2 days.
iii. During every scouting visit, identify pests and diseases observed and note them down.

iv. Consult experts and other knowledgeable farmers and present your sample collections.

v. Discuss and seek advice on the management options to manage the pests or diseases –cultural, using bio-pesticides, chemicals or combination of these.

vi. Prepare a management program for identified pest and diseases.

vii. Source materials for pest and disease control.

viii. Assemble the tools and equipment for management of pest and diseases.

ix. Manage the pest and diseases.

x. Evaluate the management results and note down points to consider in next season pest and diseases management

Pests of the Black nightshade

The major economic pests of Black nightshade include:

i. Root-knot nematode

ii. Cutworm

iii. Flea beetle

iv. Aphids

v. Spider mite

Table 13: Pests affecting Black nightshade

Pest	Signs and symptom	Control
 *Aphids*	Leaves curl and become unattractive to customers. They also feed on the plant sap.	• Use foliar sprays with neem products e.g. Neemroc (1-3%) • Monitoring regularly the crop.
 *Spider mites*	Spider mites are severe during the dry season. They damage leaves and growth tips leading to a reduced number of seeds, and length of berries.	• Avoid using pyrethroids which lead to spider mites' outbreak. • Use overhead irrigation to knock off mites and destroy their webs.

Cut worm

Damage is on young seedlings which are cut near the ground. Black larvae are found in the soil near the cut plant.

- Dig around the collapsed plant to get the cutworm and kill it.
- Flood the area to suffocate the larvae in the soil.
- Mix equal quantities of sawdust, bran and molasses with water to make mixture sticky and spread around the base of the plants in the evenings.

Root-knot nematodes

Symptoms include stunting, yellowing, wilting and formation of galls on host roots. Infected plants occur in patches in the field.

- Crop rotation.
- Intensive use of manure.
- Ensure proper field hygiene.

Diseases of the Black nightshade

The major diseases include:

- Bacterial blight.
- Early blight.

Table 14: Diseases affecting Black nightshade

Disease	Signs and symptoms	Control measures
 *Bacterial blight*	The disease is characterised by small, round, water-soaked spots, which eventually turn dark brown to black and become hard and dry.	• *Use certified disease-free seeds.* • *Practice crop rotation* • *Practice good field hygiene*

 *Early blight*	Brown, and often show a circular pattern which distinguishes this disease from other leaf spots. Leaf spots first appear on the oldest leaves and progress upwards on the plant. Entire plant could be defoliated and killed.	• Crop rotation. • Practice good field hygiene. • Certified disease-free seeds.

Safe and effective use of pesticides

- Pest and disease management should be a continuous effort.
- Both organic and inorganic pesticides can be used to control pests and diseases.
- It is recommended to always seek advice from an agriculture extension worker on pest and disease identification and management.

Note:
The farmer should monitor the field to ensure quick action is taken in case of break out of pests and diseases.

Figure 84: Spraying using a mechanical knapsack sprayer

Source: Agcenture

Harvesting

African nightshade is ready for harvesting starting from 45 days after germination for direct seeding or 30 days after transplanting. The crop can be harvested in two ways:

- Uprooting; This is mostly done in commercial production by uprooting the whole plant.
- Cutting tender stems; The tender stems are plucked every 1-2 weeks. Harvesting can continue for up to 5 months during the wet season and for 4 months during the dry season. Regular removal of flowers ensures longer harvesting period.

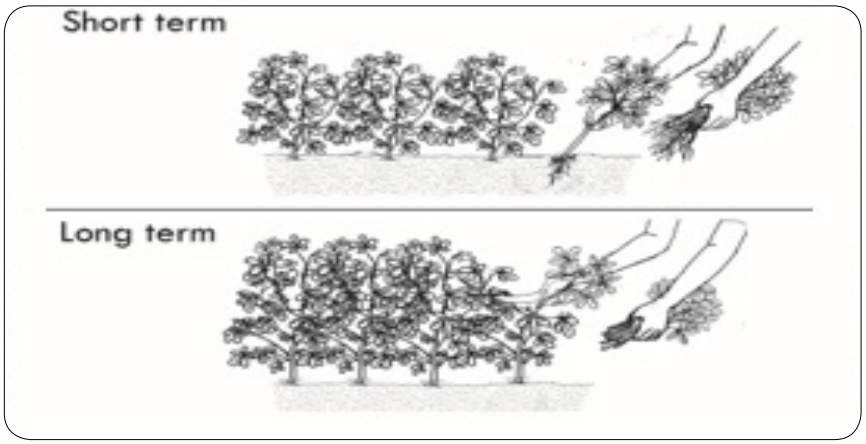

Figure 85: Harvesting Black nightshade

Yield

The yields of black nightshade range from 4.8 tons to 8 tons of foliage per acre depending on the variety and management.

Post-harvest handling

The following activities can be conducted, after harvesting

i. Sorting

Black nightshade should be sorted to remove insects and yellow or damaged leaves before packing. Airing of the harvested leaves is done to remove field heat.

ii. Cleaning

Leaves should be thoroughly washed with portable water.

iii. Grading

Grade the leaves by size, bunching those of the same size and tying in small bundles before packing in well-ventilated container for transportation to markets.

3.2.1.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • Machete/*panga* • Rake • Slasher • Spade • Garden line • Tape measure • Pegs	• Watering can • Knapsack sprayer • PPEs • Wheelbarrow • Gunny bags • Tarpaulin • Buckets • Weighing scale • Magnifying glass • Plastic crates • Mineral water bottles • Measuring cylinders	• Chemicals • Organic and inorganic fertiliser • Pesticides • Sand • Quality Black nightshade plant seeds/seedlings • Clean water • Pheromone traps • Sticky traps • Stationery

3.2.1.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What are common pests that attack Black nightshade?
2. What is the importance of mulching in Black nightshade?
3. What are the two methods of establishing Black nightshade?
4. What are the uses of the following tools in Black nightshade production?

	Uses
Jembe 	
Garden line 	

Pegs

Notes:

3.2.1.5 References

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3.2.2 Learning Outcome 2:
Produce Cowpea *(Kunde)*

3.2.2.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select appropriate variety of cowpea.
- Source quality cowpea seeds.
- Sow seeds on the seedbed.
- Manage the crop.
- Harvest the crop.
- Carry out post-harvest handling practices.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying the use of cowpea plant and their varieties.	• Divide class into groups of five members, allow members to brainstorm on uses of cowpea and present their findings to the class. • In class/field provide samples of different cowpea varieties and allow trainees to identify the different cowpea varieties as discussed in class.	• Flipchart • Marker pen • LCD projector • Computer • Different varieties of cowpea seeds/ plants
• Identifying of tools equipment and supplies in cowpea production.	• Facilitate a visit to the farm store and allow trainees to identify different tools equipment and supplies with their uses. • Facilitate a demonstration using photos/ printouts/videos on various tools, equipment, and supplies in cowpea production.	• Flipchart • Marker pen • LCD projector • Computer • Printouts • Photos • Farm store
• Planting of cowpeas.	• Lead a demonstration on how to establish cowpea on the seedbed. • Ask the trainees to perform actual planting on already prepared plots/seedbed.	• Seeds • Manure • Inorganic fertiliser • Watering can • Planting line • *Jembe*

• Carrying out field management practices.	• Display charts/printouts with common pests of cowpeas and allow trainees to identify. • Lead a demonstration on how scouting for pest and diseases is conducted. • Ask trainees to carryout scouting of pest and disease on their field. • Facilitate a lecture using photos/videos on various symptoms and control measures of the various pests and diseases. • Demonstrate to trainees on how to place pheromone traps and sticky traps surveillance and recording. • Ask trainees to place the pheromone traps and sticky traps on the field do surveillance and record the pests captured using the traps. • Facilitate a field visit to a nearby IPM center to see how IPM is practiced. • Lead a demonstration on gapping, weeding, watering, and crop rotation. • Ask trainees to perform the management practices on their fields.	• Magnifying glass • Scouting programme • *Jembe* • Mulching materials • Watering can • LCD projector • Computer • Charts with common pests • Sticky traps • Pheromone traps • Stationery
• Harvesting of cowpea.	• Facilitate a demonstration on how to harvest cowpea leaves and pods. • Ask trainees to harvest mature cowpea from the field, weigh and record their produce.	• Gunny bags • Weighing scale • Canvas • Stationery
• Carrying out post-harvest handling.	• Lead a brainstorming session on the importance of carrying out post-harvest handling practices in cowpea. • Facilitate a demonstration on how to conduct cleaning, threshing, winnowing sorting, grading and storing of mature cowpea seeds. • Ask trainees to harvest mature cowpea and perform cleaning, threshing, winnowing sorting, grading and storing of the produce.	• Gunny bags • Canvas • Basin • Labels • Sieve
• **Duration: 24 hours**		

3.2.2.2 Information Sheet

Introduction

Cowpeas common names in Kenya include *Kunde* (Swahili), *Mathoroko* (Kikuyu), *Likhuvi* (Luhya), *a lot-bo* (Luo), *Nthooko* (Kamba), *Egesare* (Kisii), are basically annual crops grown for their leaves and seed as well as its residues can be used as livestock fodder.

Characteristics of cowpeas

It can withstand drought, short growing period and its multi-purpose use makes it an attractive alternative for farmers in marginal, drought-prone areas with low rainfall.

- The crop is usually grown at subsistence level as an intercrop/companion crop with maize, sorghum, millet and/or cassava. It also plays an important role in soil fertility improvement, suppression of weed, supply of vegetables and dry grain after maturity.
- The growth habit is climbing, spreading or erect.
- The main cowpea growing areas in Kenya are Kitui, Kisii, Migori, Kakamega, Bungoma, Machakos, Makueni, Kwale, Kilifi and Tharaka Nithi.

Figure 86: Cowpea plant

Source: Dutable

Health benefits

- It provides good amounts of iron which helps the body revive its red blood cell count and reduce anaemia.
- Improves bone health because it is rich in calcium and other minerals like Iron, Manganese and Magnesium.
- Low in calories and cholesterol, which helps healthy weight loss.

Common cowpea varieties

Properties of some common cowpea varieties grown in Kenya are highlighted in the table below;

Table 15: Common cowpea varieties in Kenya

Variety: Machakos 66 (M66)

Description:

- Dual-purpose and erect variety with smooth creamy brown seeds having a small eye. It has some tolerance to aphids and thrips. It is also tolerant to cowpea yellow mosaic virus and scab.
- Potential yields: 3.5 - 7.5 bags of 90 kg each per acre.
- Maturity duration: 80 – 95 days.

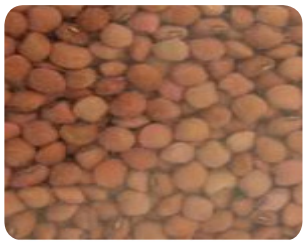


Photo source (Infonet biovision)

Variety: Kunde - Tumaini

Description:

- Deep brown grain color. Large-sized grains, early maturing and semi-erect.
- Potential yields: 6.6 – 9.4 bags of 90 kg each per acre.
- Maturity duration: 70 - 80 days.

Variety: Kunde - Tamu

Description:

- Eye-like pattern with greenish-brown ring around the hilum. Flowers within 45 - 50 days. Tender and sweet leaves when cooked. Semi-erect habit, and dual-purpose i.e. used both as a grain and as a vegetable.
- Potential yields: 2.5 - 8.8 bags of 90kg per acre.
- Maturity duration: 70 - 80 days.

Variety: KAT – Kunde

Description:

- Creamy brown grain colour. Semi-erect crop with dual purpose i.e. used both as a grain and as a vegetable.
- Potential yields: 6.2 - 8.8 bags of 90 kg each per acre.
- Maturity duration: 80 – 90 days.

Variety: Kunde - Soko

Description:

- Creamy brown grain colour for large-sized grain types. Medium grain types have an eye-like pattern and greenish-brown. Both types grow semi-erect.
- Potential yields: 6.2 – 8.4 bags of 90 kg per acre.
- Maturity duration: 80 – 90 days.

Variety: Katumani 80 (K80)

Description:

- Dual-purpose with semi spreading growth. The seeds are smooth and creamy brown with a small eye. It is resistant to aphids and moderately tolerant to thrips, pod-borers and leafhopper. It is also moderately resistant to foliar fungal disease and mosaic virus.
- Potential yields: 3.5 - 8 bags of 90 kg each per acre.
- Maturity duration: 75 – 85 days.

Photo source: (Infonet)

Variety: KVU-419

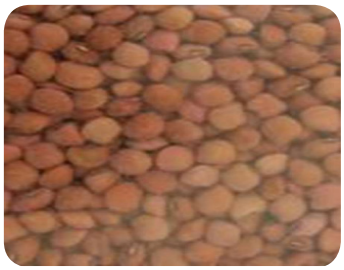
Description:

- It is mainly grown for use as grain and not much as a leafy vegetable. Grains are smaller than both M66 and K80. Tolerant to cold and recovers very fast from drought.
- Potential yields: 4.4 - 6.6 bags of 90 kg each per acre.
- Maturity duration: 65 – 72 days.

Variety: KVU 27-1

Description:

- Dual-purpose with a semi spreading growth. Grains are dark red in colour. Moderately tolerant to aphids and thrips, pod-borers and leafhoppers. It is also moderately resistant to foliar fungal disease and mosaic virus.
- Potential yields: 3.5 - 8 bags of 90 kg each per acre.
- Maturity duration: 70 – 90 days.



Variety: KVU HB 48E10

Description:

- Used more as a leafy vegetable and less as a grain.
- Potential yields: 4.8 - 6.6 bags of 90 kg each per acre.
- Maturity duration: 80-95 days.

Variety: Kunde 1

Description:

- Dual-purpose.
- Potential yields: 5.3 - 11.1 bags of 90kg each per acre.
- Maturity duration: 75 – 90 days.

Variety: KCP 022

Description:

- Drought-tolerant
- Potential yields: 4.4 - 9.4 bags of 90kg each per acre.
- Maturity duration: 60 - 75 days.

Variety: MTW 63

Description:

- Pest-tolerant
- Potential yields: About 11 bags of 90kg each per acre
- Maturity duration: 60 days

Variety: MTW 610

Description:

- Large grains
- Potential yields: About 11 bags of 90 kg each per acre.
- Maturity duration: 60 days.

Seed sourcing and selection

Sourcing and selection of cowpea varieties depends on the ecological conditions, purpose (either edible grains or leaves) and growth habits of the crop. The target market may also dictate the variety to grow as consumers may prefer a specific variety for vegetable.

Note: Quality seeds may be obtained from certified agro-dealers or from reputable research institutions. Good quality cowpeas seeds should have the following properties:

i. High germination percentage.
ii. Uniform plant stand:
    - Pure: All seeds are of the same variety, the same size color and shape.
    - Clean: not mixed with foreign matter such as stones or dirt, or other seeds.
iii. Uniform in maturity.
iv. Free of foreign matter, not damaged: broken, shrivelled, or insect-damaged;
v. Pest- and disease-free, not rotten, mouldy or discolored.

Figure 87: Good seeds for planting (a) and bad seeds for planting (b)

Source: www.iita.org

Cowpea establishment

Site selection

To ensure high cowpeas production, a suitable site should be selected. This activity has been comprehensively covered in the earlier sections of the manual - Refer to the Learning Outcome 2 of Chapter 1.

Soil fertility

i. Organic fertilisers

Cowpea fixes its own nitrogen. Too much fertiliser will result into heavy vegetative growth and reduce grain production. Use of at least 2 tons/acre of well decomposed compost or farmyard manure is recommended especially in areas where soils are low in organic matter content. This is best applied under dry conditions and then mixed with the topsoil, about one week prior to planting.

ii. Inorganic fertilisers

Cowpea requires more phosphorus (P) than nitrogen. About 60 kg/acre of phosphorus is recommended for cowpea production. Examples of phosphatic fertilisers include diammonium phosphate (DAP), single super phosphate (SSP), triple super phosphate (TSP) and NPK.

Note:

Inorganic fertilisers should be applied based on soil testing recommendation and availability of fertiliser.

iii. Intercropping/Companion cropping

Cowpeas can be intercropped with other crops including maize or sorghum and because it is a leguminous plant and it helps in fixing nitrogen in the soil, thus improving soil fertility, thereby enhancing yields.

Figure 88: Intercrop of maize and cowpeas

Source: www.researchgate.net

Planting cowpeas

Farmers plant different cowpeas variety, mostly based on the following;

- Varieties determined by market demand (rural and urban markets),
- Suitability for processing,
- Yield,
- Agro-ecological requirements,
- Soil type,
- Seed availability within a particular region.

Cowpeas should be planted at the onset of rains for early maturing varieties, planting at the beginning of the rains is advised so that the sensitive stages of the crop avoid the peak activity of insect pests and this reduces the use of chemicals in management of pests and diseases incidences.

Spacing

If grown alone in the seedbed the recommended spacing for erect/semi-erect and spreading varieties is 60cm × 20cm and 50cm x 75cm respectively. Row planting is recommended so that the correct plant density may be established. When intercropping with cereals, the recommended method is to have one cowpea row between the cereal rows at 20cm within the row, two seeds per hole. Seeds should be spaced 2.0 to 5cm below the soil surface.

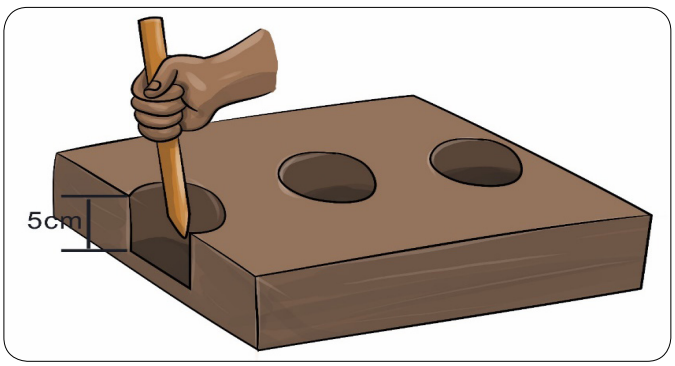


Figure 89: Hole depth for planting cowpeas

Note:

Cowpeas can be established using home garden technologies such as Mandala gardens, conical gardens, and vertical gardens at a spacing of 30 cm by 30 cm as highlighted in Chapter 1 on land preparation.

Seed rate

The amount of seed required depends on the variety, seed size, cropping system, and viability. Generally, the recommended seed rate is 8-10 kg/acre.

Field management practices for cowpeas

1. Weeding

Weeds cause losses in cowpea production through nutrient and moisture competition. Losses of up to 100% have been experienced where weeds have been left uncontrolled. Care should be taken to avoid damaging the shallow roots especially during the first weeding. Cultivation during flowering time is discouraged, to avoid flower shedding and when the field is wet to avoid spread of diseases and soil compaction. Major weeds affecting cowpea include; black jack (*Bidens pilosa)*, pig weed (Amaranthus), couch grasses, clover, wandering jew, sow thistle, star grass and devil's thorn.

Couch grass *Sow thistle* *Devil's thorn*

Figure 90: Common weeds of cowpea crop

Weed control methods

Methods of weed control include:

a) Mulching

Mulching can be done using dry grass, maize stovers, and groundnut husks,

Importance of mulching:

- Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.
- It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.
- As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.
- Mulching reduces the growth of weeds as it deprives them of sunlight.

Figure 91: Mulching cowpeas

b) Manual weeding

This is done by use of a hoe/*jembe*, and great care needs to be done to prevent damage to the cowpea crop. Shallow weeding is encouraged in dry conditions to reduce soil moisture loss.

c) Hand pulling

Should be done at late stages of maturity to prevent injuring the cowpea roots. Weeds such as *Bidens pilosa*, can be hand-weeded.

Note:

Weeding should be done before weed seeds mature to reduce weeds in the subsequent season.

2. Gapping

Process of gapping

i. Seven days after planting the cowpea in the field, scout and count for seeds that failed to germinate.
ii. Seek or source an equal number of seeds from initial dealer ensuring they are of the same variety and quality.
iii. Using a stick or machete/panga dig a planting hole of 2-5 cm depth at the site where the cowpea failed to germinate.
iv. Place the seed and cover shallowly with soil and water as you did when planting initially.

3. Watering /irrigation

Watering /irrigation is an essential practice especially in areas receiving low rainfall or if planting has been done during dry seasons and arid and semi-arid lands (ASALS). Watering /irrigation can be done by use of drip, furrow or sprinkler irrigation.

4. Crop rotation

This practice is recommended to avoid pest and disease build up. Rotation is mainly done with cassava, maize, sorghum or any other non-leguminous crop.

SEASON 1	SEASON 2
 *Cowpeas*	 *Onion*
 *Onions (Amaryllidaceae)*	 *Cabbages/kales*
 *Cabbages/kales (Brassicas)*	 *Cereals*
 *Cereals (grass family)*	 *Cowpeas*

Figure 92: Crop rotation cycle for cowpea

Crop protection

Controlling pests and diseases

Diseases and pests contribute to low productivity in cowpea. Incidences and severity vary between seasons because of environmental conditions and management practices. IPM and using environmentally-safe strategies is recommended.

IPM is the use of a combination of various strategies for management of pests and diseases. These practices use plant resistance, physical, cultural, biological, chemical and exclusion options to maintain pest populations below economic injury levels, with minimal impacts on non-target organisms, food safety, terrestrial and aquatic environments. In IPM, scouting of pests and establishment of action thresholds to guide application of management strategies are very important.

Note:

Before of any pest and disease management is applied it's advisable to carry out scouting as indicated on the figure below.

Figure 93: Scouting plan for pests and diseases

Table 16: Common pests affecting cowpeas

Pest	Symptoms	Control measures
 *Cutworm*	• Damage is on young seedlings which are cut near the ground. Black larvae are found in the soil near the cut plant.	• Dig around the collapsed plant to get the cutworm and kill it. • Flood the area to suffocate the larvae in the soil. • Mix equal quantities of sawdust, bran and molasses with water to make mixture sticky and spread around the base of the plants in the evenings.
 *Pod-borers (African bollworm, legume pod-borer)*	• Damage is shown as defoliation in early stages with the larva's head alone inside the pods and the rest of the body hanging out as shown.	• Handpick and destroy the caterpillars • Use biopesticides (neem-based 50 ml/20 l/ground chilli 100g mixed with ash 2 kg/20 l water) should be applied early to avoid entry of caterpillars into pods.
 *Aphids*	• Adults and nymphs damage the growing tips of the plant and leaves by feeding on them. Under heavy infestation, the leaves curl and become discoloured.	• Plant early and scout regularly for aphids and destroy. • Rogueing to remove infested plants. • Destroy all volunteer crops and weeds • Practice crop rotation. • Use of sticky traps (blue/yellow), • Spray soapy solution (10-15 tablespoonful of liquid soap in 20 l of water), • Use overhead irrigation to knock aphids off the leaves.
 *Army worm*	• Damage by the worms comprises of singular or grouped shaped holes on the leaves of infested plants.	• Rogueing. • Hand pick and crush or dip in hot water. • Use of pheromone traps. • Use biopesticides (neem-based 50 ml/20 l/ground chilli 100g mixed with ash 2 kg/20 l water). • In severe infection use insecticides.

 *Bruchids*	• They are small grey or brown to reddish-brown beetles (3-5 mm) which damage cowpea seeds by boring holes to lay eggs.	• Early harvesting. • Solar drying of cowpeas before storage • Before storage, treat or mix stored seed with a mixture of pesticidal plant parts (e.g. neem, lantana, pyrethrum).
 *Whitefly*	• The larvae and adults pierce and suck the sap from leaves. • Yellowing of leaves, and wilting of the plant is observed when pest is present in large numbers.	• Mount yellow sticky traps to trap adults. • Spray with pepper at rate of 30 chopped peppers put in 1 lwarm water. • Conserve natural enemies e.g. Ladybirds. • Intercrop with onions and garlic. • In severe cases, spray with insecticides.

Source: ICRISAT

Cowpea disease management

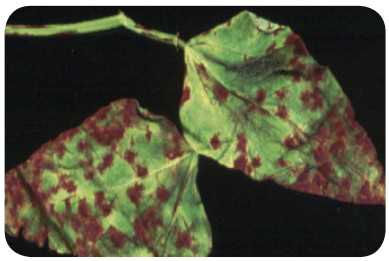
Table 17: Common diseases affecting cowpeas

Disease	Symptoms	Control measures
 *Soft rot*	• Grey to green water-soaked rot on the stems. • The pods are covered by a white mass of mycelium.	• Plant in well-drained soil or make ridges when planting in cases of soils with poor drainage.
 *Powdery mildew*	• White powdery spots which merge to form a powdery coating on leaves, stems and pods. Under heavy attack, the colour of the powdery mass turns dirty white.	• Practice early planting • Crop rotation with non-legumes for 2-3 seasons. • Observe high field hygiene, • Uproot and destroy severely infected plants. • Avoid overhead irrigation to reduce humidity.

Brown rust

- Many brown, dry and raised spots on the leaf surface and common on leaves in the mid to upper canopy as shown.
- When the disease is severe, spots coalesce and leaves become yellow and fall off prematurely.

- Destroy infected plant residues and use disease-free seed. (Rogueing).
- Avoid field activities when the foliage is wet.
- Spray with copper-based fungicides in severe cases.



Anthracnose

- The disease attacks all aerial part, and at any stage of plant growth.
- Symptoms include circular, black, sunken spots with dark centre and bright red-orange margins on leaves and pods as shown.

- Crop rotation with non-legume /host crops.
- Use certified seed.
- Avoid unnecessary movement in the infected areas to minimise spread of the disease.
- Spray with fungicides.

Cowpea yellow mosaic disease

- Mild scattered yellow spots on young leaves which gradually enlarge on some leaves turning them completely yellow.
- Stunted growth in severe infection.

- Use certified/disease-free seeds.
- Seed treatment with Imidacloprid at 5 ml/ kg.
- Uproot infected plants and destroy by burying or burning.
- Clear the bushes and weeds around the farm that act as alternate host for the whitefly vectors.
- Spray with fungicides.

Photo source: ICRISAT

Harvesting

Piecemeal harvesting

Piecemeal cowpea harvesting starts immediately 2-3 weeks after establishment for leaves production depending with variety and ecological zone.

Complete harvesting

Complete harvesting entails the entire plant being uprooted completely for leaves production and dry cowpea should be harvested when the plants turn yellow to light brown and the leaves start to fall off.

Harvesting is done by hand picking the pods since they mature unevenly. When the entire plant is physiologically mature the plant is uprooted.

Note:

Harvesting should be prompt, as delay in harvesting encourages weevil infestation in the field and seed shattering. Also during harvesting of leaves, do not compact them in the gunny bags as this reduces their market quality.

Figure 94: Harvesting of cowpea pods

Source: www.spring-nutrition.org

Yield

The yield potential varies from one variety to another and is also affected by the general crop maintenance and the ecological conditions. However, under good maintenance, the yield ranges from 800-1800kg per acre.

Post-harvest management

1. Drying of cowpeas

The lower the moisture content, the better the quality of grains in storage. Cowpea grains and pods are often sun-dried for several days before storage to reduce pest infestations in storage. This strongly reduces infestation from the main storage pest, the cowpea weevil. Dry the pods on a clean surface such as mats, plastic sheet, or tarpaulin, or on a raised platform. Do not dry the pods directly on the soil. Leaves can be dried and then stored for use in the dry season. Leaves should be sun-dried for 1-3 days.

Figure 95: Drying of cowpeas

Source: www.flickr.com

2. Threshing and winnowing

Cowpea can be threshed manually by beating the plants on a cement floor, or beating bagged pods with sticks once they are dry enough. Various types of threshing machines are available in different sizes, powered by petrol, diesel, or electricity, for small, medium, and large-scale threshing of cowpea. Irrespective of the method used, cowpea grain can be easily damaged if threshed too roughly or when too dry.

Figure 96: Manual threshing of cowpeas

Source: One Acre Fund

Once done with threshing, the chaff needs to be separated from the seed through winnowing. This can be done manually or by using a machine.

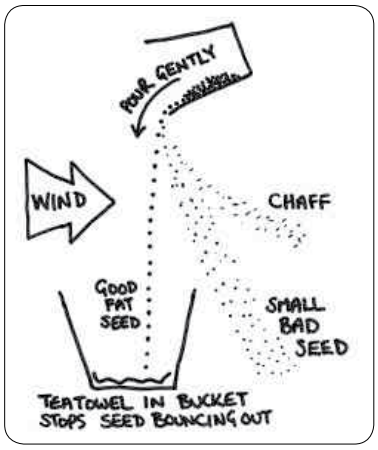


Figure 97: Manual winnowing of cowpeas seeds

Figure 98: Machines used for threshing (L) and winnowing (R) of cowpeas

Note:

Modern machines can perform both threshing and winnowing simultaneously either at large or small scale.

3. Sorting and grading

Sorting and grading should separate broken seeds from full seeds and remove foreign matter, discoloured or diseased or rotten grain, pest-damaged grain, and immature or shrivelled grain. These characteristics are the basis for grading the grains. This improves market quality for the seeds.

4. Moisture content before storage

Threshed grain should be dried on mats, plastic sheets or wire mesh trays raised on a platform. The seed should be spread thinly on the drying surface to allow air to pass through it and turned regularly to avoid overheating.

Test the grain to see if it is dry enough for storage or market. Testing can be done using either of the methods below;

i) Moisture meter

It is done using a digital probe inserted into the grains in a container/sack to measure the moisture reading. It is a very accurate method of gauging moisture level in the grains.

Figure 99: Moisture meter

ii) Visual observation

It is done by biting the seed or pinching with the fingers in order to observe state of dryness. This method can be subjective and needs experience to master.

Figure 100: Grain moisture testing by biting or pinching

iii) Glass and salt method

This method is applied as follows;

- Get 20 g (3 bottle tops) of salt and 160 g (handful) of seeds.
- Mix the two together and put in a glass bottle.
- Shake vigorously for 2 minutes.
- Allow to settle for 15 – 30 minutes.
- If the walls of the glass bottle become foggy or cloudy, then the moisture content is still more than 15% continue drying the grains. If it is clear, moisture content is less than 15%.

Storage and packaging of seed

Usually, the dry cowpeas are stored in treated gunny or hematic bags which help to prevent major damages caused by storage pests. A serious insect during storage is cowpea weevil. Clean the store thoroughly before a new crop is brought in. Old residues should be burnt. Only well-dried and properly cleaned grains should be stored. A well dried cowpea should have less than 10% moisture content with 8-9% moisture content recommended for long term storage. Stack bags on

a raised platform or wooden pallet away from the wall. Avoid direct contact of storage bags with the ground. Inspect and remove infested or rotting grains regularly

Figure 101: Hematic bags

Source: www.picsnetwork.org

Production records

Records of all inputs put into production and all outputs (yield) realised from production can be compiled to realise profits per unit area.

Table 18: Sample of farm production record

Activity	Date	Unit cost	Unit price (Kshs)	Quantity	Total cost (Kshs)	Remarks
Land preparation						
Planting						
Cost of inputs						
Weeding						
Pest and disease management						
Harvesting						
Totals						

3.2.2.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork	• Watering can	• Chemicals
• Hoe/jembe	• Knapsack sprayer	• Organic manure
• Machete/*panga*	• Measuring cylinder	• Inorganic fertiliser
• Rake	• PPEs	• Pesticides
• Slasher	• Wheelbarrow	• Quality cowpea seeds
• Spade	• Water jerrycan	• Clean water
• Trowel	• Basins/plastic crates	• Mulching materials
• Garden line	• Gunny bags	• Pheromone traps
• Tape measure	• Weighing scale	• Sticky traps
• Pegs	• Tarpaulin/canvas	• Canvas
• Mineral water bottles	• Weighing scale	• Stationery
	• Magnifying glass	

3.2.2.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What are the common pests in cowpea production
2. Which five management practices are applied in cowpea production
3. Why is mulching important in cowpea production
4. What are the common diseases in cowpea production
5. Which are the five-cowpea variety commonly established
6. Which of the following is not a cultural practice used in control of pests in cowpeas
   - ☐ A. Use of traps
   - ☐ B. Use of stickers
   - ☐ C. Use of natural enemies
   - ☐ D. Use of chemicals
   - ☐ E. Hand picking
   - ☐ F. Use of bio(organic) pesticides
   - ☐ G. Planting of warm wood to control aphids

Notes:

3.2.2.5 References

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3.2.3 Learning Outcome 3:

Produce Jute Mallow *(Mrenda)* and Slender Leaf/Crotolaria *(Mitoo)*

3.2.3.1 Introduction to the Learning Outcome

This learning outcome specifies the competencies required to produce Jute Mallow and Slender leaf. It involves production practices regarding cultivation of Jute mallow (commonly known as *Mrenda, Murenda, Murere* or *Apoth*) and Slender leaf/Crotolaria/Sun hemp (commonly known as *Mitoo*).

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select appropriate varieties of Jute mallow and Slender leaf.
- Source quality seeds.
- Sow seeds in the seedbed.
- Manage the established crops.
- Harvest the crop.
- Carry out post-harvest handling practices.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Select appropriate varieties.	• Display certified seed varieties charts with suitable areas. • Farm visit to a model farm producing Jute mallow and slender leaf to see performance of each variety. • Make an academic trip to the nearest ASK show to see and appreciate performance of various varieties. • Carry out field demonstration by planting various varieties in the farm and assess performance of each. • Conduct market survey to the nearest fresh produce market to find out the most preferred varieties by consumers. • Video displaying common seed varieties and their desirable attributes.	• Certified seed varieties charts • Means of transport • Fuel • Demonstration plot • Appropriate tools/equipment/ materials • Assorted seed varieties • Pen • Notebook • Video link • Projector • Laptop

• Source quality seed	• Invite guest speaker from seed certifying agency (KEPHIS) to give a lecture on quality seed and approved sources, and their importance. • Display common seed varieties for learners to differentiate between local and certified seeds.	• Manilla paper • Assorted felt pens • Funds • Samples of certified seed varieties • Flip charts • Laptop • Projector
• Establish Jute mallow and Slender leaf	• Direct instruction by demonstrating how sowing is done then allow learners to do it in the field. • Simulate some activities in case of limited resources.	• Appropriate tools/materials/ equipment • Appropriate seed varieties • Demonstration plots • ALV Production Manual
• Harvest Jute Mallow and Slender leaf	• Play a video on harvesting while learners are watching and listening. • Direct instruction by demonstrating how harvesting is done then allow learners to do it in the field. • Simulation by using a similar/related vegetable if the Jute mallow and slender leaf are not available at that particular time. • Organise for an academic trip to a model farm for learners to see how harvesting is done in the farm.	• Appropriate tools/materials/ equipment • ALV Production Manual • Video link
• Carry out post-harvest handling practices.	• Organise for an academic trip to a model farm/nearest fresh produce market for learners to see how post-harvest handling is done • Play a video on preparation of harvested produce for market. • Group discussions and presentations on what learners observed. • Demonstrate and allow trainees to practice precooling, sorting, grading, cleaning, packaging, storing and selecting appropriate mode of transport.	• Appropriate tools/materials/ equipment • Video link • Flip charts • Assorted felt pens • Felt pen ink
• **Duration: 10 hours**		

3.2.3.2 Information Sheet

Definition of terms

Maturity indices – Signs of maturity.

Mulching - The application of a layer of organic material over the surface of soil.

Post-harvest handling – A series of operations that fresh vegetables undergo immediately after harvesting until they reache the ultimate consumer.

Pre-harvest interval – Recommended period (usually in days) between spraying and harvesting.

Introduction

- Jute mallow and Slender leaf are important African leafy vegetables commonly grown in western Kenya and around the Lake Victoria region.
- They are eaten with starchy foods like ugali, a staple food for most communities in Kenya.
- Once established the crops have deep tap root that helps them tolerate water deficit conditions.
- Plants do not have dense foliage, and as such are unable to compete with weeds

Figure 102: Jute mallow (Left) and Slender Leaf (Right)

The ecological requirements of both crops are similar as shown in the table below

Table 19: Ecological requirements of Jute mallow and Slender leaf

Rainfall	600 – 2000 mm per year
Soils	Fertile, well drained and rich in humus
Temperature	25 – 32°C
Soil pH	4.5 – 8.2
Light	They do not perform well under shade

Both crops have high nutritional benefits as highlighted below

Table 20: Nutritional benefits of Jute mallow and Slender leaf

Jute Mallow	Slender Leaf
• Nutritious leaves high in vitamins A, C, E, K • Rich in potassium, calcium and magnesium. • Packed with beta carotene and Iron.	• Leaves are rich in minerals especially calcium and iron. • High in vitamins A, B and C but are low in carbohydrates.

Growth behaviour

- Easier to grow in comparison to other exotic vegetables.
- Can produce seed under tropical conditions unlike the exotic vegetables.
- They have a short growth period with most of them being ready for harvesting within 3-4 weeks.
- Respond very well to organic fertilisers.
- Most of them have an ability to withstand and tolerate drought / harsh environmental conditions, pest and disease attack.
- They can also flourish under sustainable and environmental-friendly cropping conditions like intercropping and companion cropping.
- Slender leaf fixes nitrogen into the soil hence improves soil fertility.
- Generate high income per unit area per unit time enabling the poorest people in the rural communities to earn a living.

Varieties of Jute mallow and Slender leaf

There is one variety of Jute mallow cultivated in Kenya. For the Slender leaf however, there are two common varieties;

i) The big and plump pod Slender leaf variety with a mild taste.

ii) Longer and narrower pods Slender leaf variety with a bitter taste.

Figure 103: Big and plump pod Slender leaf variety

Figure 104: Longer and narrower pod Slender leaf variety

Selecting appropriate varieties

When selecting appropriate variety, consider the following factors:

- High yield per unit area.
- Early maturing.
- Resistance to disease and pest attack.
- Adapted to the prevailing conditions.
- Taste and preference by consumers.
- Drought tolerant.
- High profitability.
- High market demand.

Sourcing quality seed

Quality seed is seed that is certified and performs highly. It can be obtained/bought from:

- Agrovets (certified shops that sell agricultural inputs)
- Research institutions, such as KALRO.
- Seed companies that distribute seeds through retailers such as agro dealers and cooperatives.
- Seed agents (wholesalers).
- National Cereals and Produce Board (NCPB).
- Ministry of Agriculture and Livestock Development offices.
- KFA (Kenya Farmers Association).
- Certified seed bulkers.

Importance of quality seeds

- Pest- and disease-free
- High-yielding.
- High purity percentage.
- High germination percentage.
- Uniform growth.
- Vigorous growth.
- Adapted to a wide range of ecological conditions.

Sowing of seed

Jute mallow and Slender leaf are propagated using seed. Seed is directly sown in the seedbed. About 4 g of seed per m^2 or 4 kg per Ha is required. Planting is done at the onset of the rains.

Sowing procedure

- Apply 2 kg/ m^2 of farm yard manure or compost manure.
- Make shallow furrows/drills 30 cm apart and 1 cm deep.
- The seed is mixed with sand or dry fine soil at a ratio of 1:10 respectively.
- Mix the seeds with the soil mixture in a bowl and tip it into a bottle.
- Tip the seed/soil mix from the bottle along the furrows/drills.
- Then cover with 1-1.5 cm of soil.
- Mulch seeds lightly using dry material.
- Water the seeds lightly but do not use excess water as it may cause the seeds to rot or washed away.
- Emergence (sprouting) of seed occurs from 6 to 8 days after sowing.

Note:

- Only thoroughly decomposed manure should be used to avoid possible introduction of cutworms in the field
- The NPK fertiliser should be mixed thoroughly with the soil to avoid possible scorching of the seeds.

Field management practices

i) Mulching

Types of mulching materials

Maize stovers, straw, dry grass, dry banana leaves, tree bark, sawdust, wood shavings bark, and plastic/synthetic can be used.

Dry grass

Straw

Dry tree leaves

Saw dust

Figure 105: Ideal mulching materials

When choosing mulching material, consider the following factors;

- Pest- and disease-free.
- Well-dried.
- Non-toxic to the soil and crops.
- Weed-free.
- Environmentally-friendly (undergoes decomposition).
- Readily available.
- Cheap in relation to the value of the produce.

Note:

Do not use wet or green material for mulching since they undergo decomposition generating heat that may damage roots.

Consider the following when mulching your crops;

- Cut mulch material into pieces of 10-12 cm using a machete.
- After weeding around the plants, place mulching material between rows and 3-5 cm away from base of plants
- Avoid direct contact with plants as wet mulch which is placed directly against stems may bring about diseases.
- Cover the soil completely with a 2-5 cm layer of mulching material
- Carry out mulching when soil is moist.

Importance of mulching

- Reduces soil erosion caused by heavy rains, which means that the most fertile top soils are maintained.
- Creates shade and cools the soil, allowing tender roots and young plants to thrive in hot conditions.

- Reduces costs (weeding and irrigation).
- Suppresses growth of weeds.
- Reduces moisture loss from the soil thus allowing farmers to reduce the number of times they need to water their crops, improving soil structure.
- When they decompose, they add organic matter to the soil which is a source of nutrients.
- Keeps fruits and vegetables clean and of high quality.

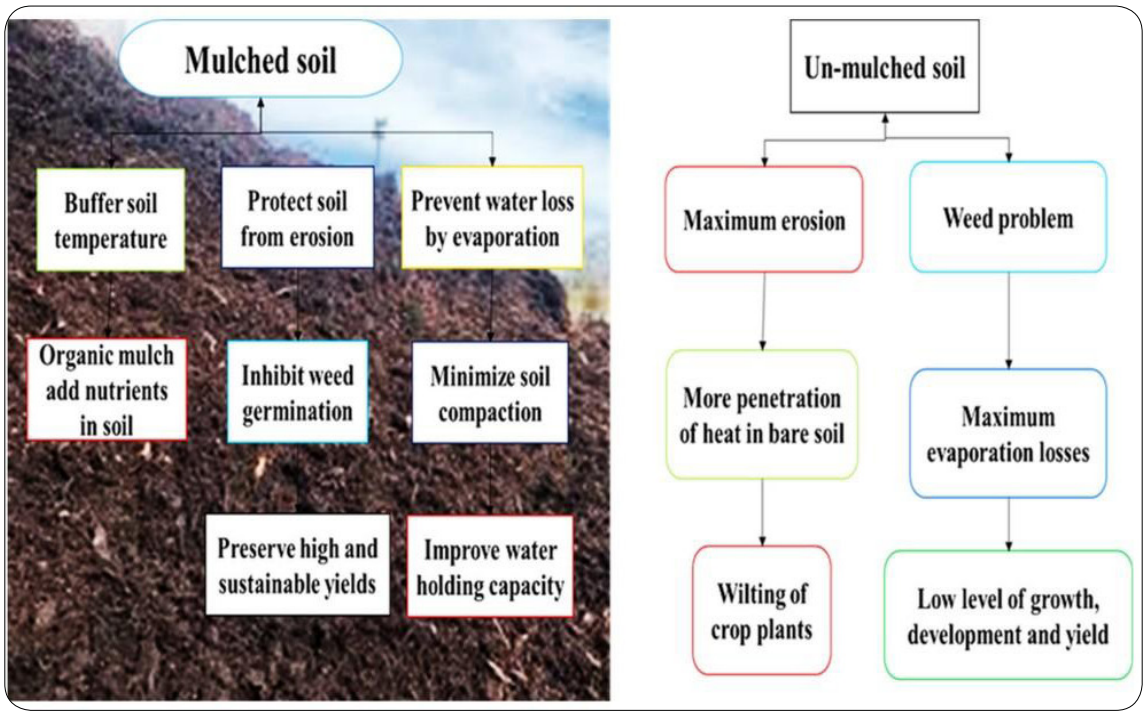

Figure 106: Benefits of mulching

ii) Thinning

- Carry out thinning manually three weeks (21 days) after emergence (sprouting) leaving 10 to 15 cm between plants.
- It should be done carefully when soil is moist to avoid root damage.
- Thinned plants are transplanted to another prepared seedbed.

Importance of thinning

- Prevents competition for light, moisture and nutrients.
- Results in strong and healthy plants.
- Minimises incidences of pest and disease attack.
- Results in high quality produce.

iii) Weed control

Seedbeds should be kept weed-free at all times, especially during the first six weeks.

Methods of weed control

- Mulch the crops to suppress weeds.
- Shallow cultivation.
- Hand-pulling of weeds.
- Early planting.

iv) Watering

Jute mallow and Slender leaf are usually grown as a rainfed crops. When irrigation is in place, Slender leaf and Jute mallow can be planted throughout the year. It is done during dry periods when rainfall is inadequate. Water management can also be achieved through use of drought tolerant varieties.

Many irrigation systems are very affordable to farmers with small farms, for example watering by bucket, hose pipes, channel, drip irrigation and sprinkler irrigation (Refer to Chapter 1). Drip irrigation methods are preferred since they are water-saving and require less labour especially when automated.

When to irrigate

- It is better to irrigate in the early in the morning, late afternoon (after 5 p.m.) to avoid loss of moisture from the soil surface caused by strong heat from the sun. This helps to save/conserve water.
- It is important to water the right amount for each crop. Watering too little reduces the size and quality of crops and when plants are watered too much;
  - Plants grow too slow,
  - Nutrients and pesticides are washed out of the soil into waterways,
  - Diseases and weed seeds spread with the overflowing water, and
  - It is expensive in terms of labour and water costs.
- While specific recommendations for each ALV are provided, a general rule of thumb for watering ALVs is that once there is a uniform growth, give around 2 l per m^2 every time you irrigate then increase the amount of water to around 3 l per m^2 when the growth increases and up to 4 litres per m^2 just before harvesting.

Quality of water

Water used in ALV production should be clean and free from any kind of waste that is harmful/ toxic to the crops and human health.

Common pests and disease and their control

Pest and disease management should be part of farmers' daily routine. Checking fields regularly allows farmers to take swift action as problems appear. The most critical issue for profitable management of pests and diseases is getting the correct diagnosis. Extension workers can advise on pest and disease identification and management. Jute mallow and Slender leaf do not suffer much from diseases and even less from pests. However, it is important to take note of the following;

- Under wet conditions, the whole crop may however be destroyed by blight just before it starts flowering.
- Aphids and thrips can be observed, but are rarely a serious menace.
- During fruit development, pod borers may enter and interfere with seed development.
- The holes in the pods will allow rain to enter and destroy the seeds further through rot.

The most common diseases seen in Jute mallow and Slender leaf in Kenya are indicated in the table below;

Table 21: Common diseases of Jute mallow and Slender leaf

Disease	Signs and symptoms	Control measures
1. *Blight* 	First appear on leaves as small, water-soaked spots, light green areas, or both. As these spots enlarge, the tissue in the center dies and turns brown.	Use resistant varieties, plant certified disease-free seeds.
2. *Leaf spots* 	Are small (less than 0.25 inch in diameter), water-soaked leaf spots on the older leaves of the plant. These lesions are typically bordered by leaf veins and angular in shape. Lesions quickly turn black (a diagnostic characteristic of this disease).	Use resistant varieties, plant certified disease-free seeds

Prevention and control measures

Diseases and pests of Jute mallow and Slender leaf can be prevented and controlled by practicing the following;

- Crop rotation.
- Use of shade nets.
- Timely planting.
- Use of clean and quality seeds.
- Proper site selection.
- Proper drainage.
- Cleaning and sterilising tools and equipment before and after use.
- Field hygiene.
- Rogueing infected plants.
- Use of pest and disease-tolerant varieties.

Harvesting

Harvesting of Jute mallow and Slender leaf is carried out once maturity indices are observed on the crops. The main indicator of maturity is time i.e. both crops grow quickly and are ready for the first cutting in about 60-70 days after sowing and when the stems are about 40 cm in height.

Harvesting procedure

Carry out harvesting by;

- Obtaining a good harvesting container which should be clean, well-ventilated, easy to clean, portable and should not retain moisture.
- Pull whole plants (20–30 cm tall) from soil with roots, or,
- Pick young tender leaves and shoots every two to three weeks. In this regard, harvest by cutting the upper 15 cm of growth.

Figure 107: Harvesting young tender leaves of Jute mallow

Note:

- Clean and sterilise tools and harvesting containers.
- Harvest carefully to avoid injuring the produce.
- Determine yield per unit area (kg/m^2, tonnes/acre or tonnes/ha).
- Only harvest exact amount needed according to market demand.

The preferred time is during coolest part of the day, usually in the early morning or late afternoon to avoid loss of water from the produce. This is particularly important for most leafy vegetables.

Post-harvest handling

Immediately after harvest, prepare your produce for market as follows;

- Damaged, discoloured and decayed parts are removed to make the produce more attractive and prevent infection from the diseased parts.

Figure 108: Decayed, discoloured and damaged leaf

- Grade the produce basing on:
  - Uniformity in size.
  - Same variety.
  - Same length.
- Washing is necessary to remove extraneous materials from the field such as dirt, insect pests and pesticide residues. Use only clean, running water for washing.
- **Note:** Avoid washing with used or stagnant water because it can quickly become heavily contaminated with decay organisms, leading to heavy rotting of the washed produce.
- The washed produce should be spread out in a single layer on raised racks of mesh or slats, in the shade but exposed to good ventilation to aid rapid drying.

Storage

The fresh leafy vegetables are highly perishable and hence should be appropriately stored. Storage structure should be;

- Rodent-proof
- Leak-proof.
- Clean and disinfected.
- Cool and well-ventilated.

Seed production

Seeds can also be harvested from healthy and vigorous growing plants after picking the leaves during the final harvest.

Harvest when slightly dry pods turn slightly black and no longer stick to the pod. Seeds are black in colour (Jute mallow) and yellowish brown in colour (Slender leaf).

Figure 109: Jute mallow seed

Figure 110: Slender leaf seeds

Seed processing

- After drying pods 2-3 days in the sun, they are lightly beaten to crush the pods.
- After drying, the seeds are winnowed (they are thrown in the air to blow the outer part of the seeds and any dirt away).
- The seeds are put in a woven basket or any other suitable container.
- Store seed in airtight containers in cool and dry place.
- Storage period should not exceed 2 years to maintain seed viability.

3.2.3.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe/*jembe* • Machete/*panga* • Rake • Slasher • Spade • Trowel • Garden line • Tape measure • Pegs • Mineral water bottles	• Watering can • Knapsack sprayer • Measuring cylinder • PPEs • Wheelbarrow • Water jerrycan • Basins/plastic crates • Gunny bags • Weighing scale • Tarpaulin/canvas • Weighing scale • Magnifying glass	• Chemicals • Organic manure • Inorganic fertiliser • Pesticides • Quality Jute mallow and Slender leaf seeds • Clean water • Mulching materials • Pheromone traps • Sticky traps • Canvas • Stationery

3.2.3.4 Self-Assessment Questions

Use the following questions to assess your knowledge on this learning outcome:

1. Which factors should be considered when selecting appropriate variety for Jute Mallow and Slender leaf?
2. What are the benefits of Jute mallow and Slender leaf?
3. Why is it important for farmers to use quality seed?
4. Three of the following are certified sources of quality seed. Which is NOT?
   - ☐ A. KALRO
   - ☐ B. Agrovets
   - ☐ C. Supermarkets
   - ☐ D. NCPB
5. How is Jute mallow established in the seed bed?

6. Using arrows, match each tool with its respective correct use/function in the table below.

Tool/equipment	Functions/Uses
1. Trowel	Breaking soil clods and leveling soil surface
2. Wheel barrow	Laying out activities and tying plants onto stakes
3. Garden line	Uprooting seedlings for transplanting
4. Rake	Transporting seedlings, soil, produce, compost or other farm inputs within the farm

7. Which cultural practices are employed to control pests and diseases in Jute Mallow and Slender leaf?
8. How is Jute mallow and Slender leaf harvested?
9. Which criteria is used when grading Jute mallow and slender leaf after harvest?

Notes:

3.2.3.5 References

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3.2.4 Learning Outcome 4:

Produce the Spider Plant *(Sagaa)*

3.2.4.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select appropriate variety of Spider plant.
- Source quality Spider plant seeds/seedlings.
- Sow seeds/transplant seedlings to the seedbed.
- Manage the crop.
- Harvest the crop.
- Carry out post-harvest handling practices.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying various varieties and importance of Spider plant.	• Guide a brainstorming session on the varieties and uses of Spider plants. • Facilitate a lecture using photos/videos to elaborate on varieties and importance of Spider plant. • Provide samples of different varieties of Spider plant and ask trainees to identify them.	• Flip charts • Marker pens • LCD projector • Computer • Different varieties of spider plant
• Identifying tools, equipment and supplies for Spider plant production with their uses	• Facilitate a lecture using photos/videos to elaborate on various tools, equipment and supplies and their uses. • Facilitate a visit to the farm store and allow trainees to identify tools, equipment and supplies used in Spider plant production.	• Flip charts • Marker pens • LCD projector • Computer • Photos • Farm store
• Establishment of Spider pant	• Demonstrate on how actual establishment of Spider plant is carried out on the seedbed. • Ask the trainees to establish Spider plants on the seedbed.	• Seeds • FertilisFertilisers • Manures • Watering can • *Jembe* • Planting lines • Mineral water bottle

• Carrying out field management practices.	• Lead a demonstration on how scouting for pests and diseases is done. • Demonstration on how to place pheromone and sticky traps, surveillance and recording. • Ask trainees to place pheromone and sticky traps in the field, do surveillance and record. • Ask trainees to carry out scouting for pests and diseases in the field. • Facilitate a lecture using photos/videos to elaborate on various pests and diseases and their management practices. • Facilitate a field visit/trip to where IPM is practiced. • Lead a demonstration on weeding, thinning, watering, mulching and crop rotation. • Ask trainees to perform weeding, thinning, watering, mulching and crop rotation	• Scouting program • Flip charts • Marker pens • LCD projector • Computer • Photos • Various specimen • *Jembe* • Magnifying glass • Mulching materials • Pheromone traps • Sticky traps • Stationery
• Harvesting of Spider plants.	• Demonstrate on ways and how to harvest Spider plants and seeds. • Ask the trainees to harvest Spider plants and seeds, weigh and record the harvest.	• Weighing machine • Gunny bags/crates • Tarpaulin • Stationery
• Carrying out post-harvest handling.	• Guide a brainstorming session on the importance of post-harvest handling practices. • Lead a demonstration on cleaning, sorting grading, packing, carrying and storing of Spider plant harvest	• Gunny bags/crates • Tarpaulin • Basin • Labels • Sieve
• **Duration: 24 hours**		

3.2.4.2 Information Sheet

Introduction

The spider plant is a widely consumed indigenous vegetable by a majority of the rural and urban population.

- The plant has edible leaves; each leaf has up to 7 leaflets spreading like fingers, the leaves and tender stems are highly nutritious with protein and vitamins.
- The leaves eaten as a cooked green vegetable, have a mildly bitter taste.
- Fresh leaves are used as ingredients in other mashed foods, and the dried leaves are ground and incorporated in weaning foods.
- Spider plant is believed to replenish blood and referred to as a “traditional meat”.

Figure 111: Spider plant

Health benefits of Spider plant

- Contain good amounts of protein; Vitamins A, B, E, and C; calcium; phosphorus; and iron and very high levels of folic acid.
- The leaves have anti-oxidant and anti-inflammatory properties.
- Traditionally, Spider plant is given to women before and after birth to support pregnancy and recovery with iron.

Selection of Spider plant variety

The variety should be selected depending on the target market and preferences.

Spider plant varieties

Variety	Characteristics	Maturity & yield potential
 *Cleome monophylla*	The leaves are alternate, while the flowers are pink to purple in colour. The seeds are flattened, brown in colour with low transverse ridges.	3500 kg per acre.
 *Cleome rutidosperma*	This is an erect, branched, annual and grows up to 15-100 cm tall with angular stems and trifoliate leaves on stalk. Each leaflet is somewhat diamond-shaped while the flowers are small with upward pointing purple petals. The fruits are dry, dehiscent called capsules. The seeds are brown to black and have a ribbed surface.	Yield between 2800 kg - 3500 kg per acre.
 *Cleome hirta*	This is a bushy annual short-lived perennial plant with an erect, much-branched stem, growing up to 1.5 meters tall which produces flowers that are purple in color.	Yield over 3500kg/ acre.

Sourcing of Spider plant seeds

- Quality and certified seeds should be sourced from certified agro dealers
- Quality seed should be of uniform size, colour and shape. It should also be free of

foreign matter such as weed seed, chaff and should be pest- and disease-free

Importance of quality seeds

- They have a lower seeding rate.
- There is a higher seedling emergence, usually above 85%.
- Vigorous seedlings.
- More uniform plant stand.
- They have a faster growth rate.
- Better resistance to pests and diseases
- There is uniformity in maturity.

Crop establishment

- The seeds should be planted in a well-drained and fertile soils (sandy, loamy, alkaline, or saline), with a soil pH of 6.0-7.5.
- It requires between 500-1,500 mm of rainfall in the growing season and cannot withstand waterlogging.
- It also requires sunny and partially shaded areas. The temperatures should be 18-25 °C. Does not like temperatures below 15 °C, it grows up to altitudes of 2,400 m and is less common in very humid climates. It can be grown alongside African nightshade or amaranth.
- Spider plant is sensitive to cold, therefore planting between August and September should be avoided. Planting at the onset of rain is advisable for rainfed farms, with irrigation Spider plant can be planted throughout the year.
- Spider plant seeds should be planted in a well-prepared seedbed, the soils should be fine since the seeds are small. Planting furrows are made using a string and pegs at a spacing of 30-50 cm apart at a depth of 1 cm.
- Apply well-decomposed manure at the rate of 1-2 kg/m. When using inorganic fertilisers place the recommended amount of fertiliser (one bottle top of planting fertiliser (NPK or DAP)/m and mix with soil and manure using a stick.
- The seeds should be mixed with sand/manure in the ratio of 1:4. Put the mixture in a large mineral water bottle and make a hole in the bottle top and drilled along the furrows and then covered with a thin layer of soil.
- Water adequately depending on the weather conditions.
- The seed rate generally recommended is 2-4 kg/acre.

Figure 112: Spider plant planting process

Crop management

i) Weeding and thinning

Thin plants when they have four to five leaves or 3 weeks after emergence as follows;

- Allow 10-15 cm between plants in rows. During thinning the less vigorous, off-types or relatives and diseased plants are also removed. The good quality thinned plants can be sold or consumed at home.
- Rouging of off-types should be done at flowering and at fruiting (early maturity) when it is easy to identify the off-types.
- Weeds need to be controlled particularly in the first month, but after that, crop shading can control most weeds if a thick stand is maintained. Shallow cultivation or hand-pulling of weeds should be practiced. This crop grows rapidly and requires weeding only in the open space between the rows. Spider plant responds well to well-decomposed manure.

Importance of timely weeding

- Timely weeding will lead to increased yield.
- Timely weeding minimises competition for food and lights between weeds and the crop.
- Weeding also reduces pest and disease infestation at the early stages which will again lead to increased yields.
- Weeding should be done as soon as weeds emerge and before the flowering of weeds. This will reduce the risk of the weeds spreading.

ii) Watering

Plants require water two or three times a week. Periods of drought will hasten development of flowers and lower the yields. Otherwise, at other times, adjust frequency according to the rainfall.

Watering rules for different soils

- Sandy soils that dominate northern and eastern Kenya require more watering (up to 5 times a week).

- Loamy sandy soils are often found in central Kenya and require moderate watering (twice a week).
- Clay soils are common in Nyanza and the Rift Valley and drain slowly and hold more water (once a week).
- It is important to water the right amount for each crop. Watering too little reduces the size and quality of crops and when plants are watered too much; plants grow too fast, nutrients and pesticides are washed out of the soil into waterways, diseases and weed seeds spread with the overflowing water, and it is expensive in terms of labour and water costs.

When using irrigation, consider;

- The source of available water,
- The size of the land to be irrigated, and
- Availability of financial resources.

There are many types of irrigation which include; drip, furrow, sprinkler/overhead and using bottles.

Figure 113: Spider plant under drip irrigation

Source: https://www.researchgate.net/publication/353702325

iii) Mulching

Spider plants can be mulched using dry plant materials like grass, maize stalks etc.

The reasons for mulching include;

i. Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.
ii. It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.
iii. As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.
iv. Mulching reduces the growth of weeds as it deprives them of sunlight.
v. Mulching creates shade and cools the soil, allowing tender roots and young plants

to thrive in hot conditions.

Note:

Top dressing is required fortnightly at the rate of one teaspoonful of CAN per metre along the rows. The amounts are very variable due to variation of nutrients in the soil.

Integrated Pest Management (IPM) in Spider plant production:

- IPM is an effective and sustainable approach to managing pests in leafy vegetables.
- It involves combining various pest control strategies to minimise the use of chemical pesticides while maximising the production of healthy crops.
- IPM focuses on long-term pest management, reducing environmental impact, and maintaining economic viability.

Importance of IPM in spider plant production:

- Reduces use of chemical pesticide.
- Reduces chances of pest resistance to chemicals.
- Preservation of beneficial organisms such as predators and pollinators in maintaining ecological balance.
- It is a cost-effective approach

Application

IPM is carried out as follows;

a) *Monitoring and scouting:*

- This can be done through visual inspection, pheromone traps, sticky traps.
- Early detection helps in identifying pest species, their population levels, and potential risks.

b) *Pest identification and threshold setting:*

- Accurate identification of pests is essential for implementing appropriate control measures.
- Determine the economic threshold level, i.e., the pest population at which intervention is necessary to prevent economic losses.
- This prevents unnecessary pesticide applications and allows for more targeted pest management.

c) *Cultural practices:*

- Implement cultural practices that discourage pest infestations.
- These include crop rotation, proper spacing, and timing of planting, appropriate nutrient management, and good sanitation practices to reduce pest breeding sites.

d) *Biological control:*

- Encourage the presence of natural enemies, such as predatory insects, parasitoids, and insect-pathogenic microorganisms, to control pests.

Figure 114: Predatory insect

Source: ThoughtCo

e) *Use of resistant varieties:*

- Resistant varieties can significantly reduce pest damage and the need for pesticide applications.

f) *Targeted pesticide application:*

- Consider the use of pesticides as a last resort.
- Select pesticides that are specific to the target pests, have low toxicity to non-target organisms, and follow label instructions carefully to minimise risks.

g) *Record keeping and evaluation:*

- Regularly evaluate the effectiveness of IPM strategies implemented and make adjustments as necessary to improve pest management practices.

Safe use of chemicals in Spider plant production

Note:

By following safety precautions, vegetable producers can minimise the potential risks associated with pesticide use and ensure the safe and responsible management of pests in their crops.

The following precautions are important when pesticides have to be used:

1. Read and follow label instructions:
   - Read and follow the recommended dosage, application methods, safety precautions, and any restrictions or waiting periods before harvest.

2. Choose appropriate pesticides:
    - Select pesticides that are specifically formulated for the target pests in vegetable crops.
    - Consider their effectiveness, selectivity, and compatibility with the crop and other beneficial organisms.
3. Handle and store pesticides safely:
    - Store pesticides in a secure location away from food, feed, and water sources.
    - Keep them in their original containers with intact labels.
    - Store pesticides at recommended temperatures, ensuring they are not exposed to extreme heat or cold.
    - Follow proper disposal guidelines for empty pesticide containers.
4. Use personal protective equipment (PPE):
    - Wear appropriate PPE, such as gloves, goggles, long-sleeved overall, and respiratory protection/spraying masks, gumboots
5. Time applications carefully:
    - Apply pesticides during the recommended stages of crop growth and at the appropriate time of day.

Pests and diseases identification and management

Figure 115: Scouting plan for pests and diseases

Pest and disease management

Table 22: Pest and disease management in Spider plant

Pest / Disease	Signs and symptom	Management
 *Aphids*	• Honey dew substance • Leaves turn pale yellow.	• Spray using insecticidal soaps or strong stream of water to wash off. • Introduce natural predators such as lady bug beetles. • Use of recommended insecticides containing chlorpyrifos and pyrethroids such as cypermetrin.
 *Mealybugs*	• Coats leaf surfaces. • In severe infestations, plants die.	• Crop rotation
 *Whiteflies*	• Honeydew left on its own can cause fungal diseases on leaves.	• Mount yellow sticky traps to trap adults • Spray with pepper at rate of 30 chopped peppers put in 1 l warm water. • Conserve natural enemies e.g. Ladybirds. • Intercrop with onions and garlic • In severe cases spray with insecticides
 *Spider Mites*	• Feeds on plant parts. • Leaf surfaces turn yellow.	• Crop rotation.

Root rot

- Rotting of the root base

- Prevent by simply watering your plant correctly.
- Use of resistant varieties.

Note:

Crop rotation can also be used to control pests and diseases as indicated in the chart below;

Table 23: Spiderplant crop rotation chart

SEASON 1	SEASON 2
	
Spider plant	*Onion*
	
Onions (Amaryllidaceae)	*Cabbages/kales*
	
Cabbages/kales (Brassicas)	*Cereals*
	
Cereals (Grass family)	*Spider plant*

It is recommended to always seek advice from an agriculture extension worker on pest and disease identification and management.

Harvesting

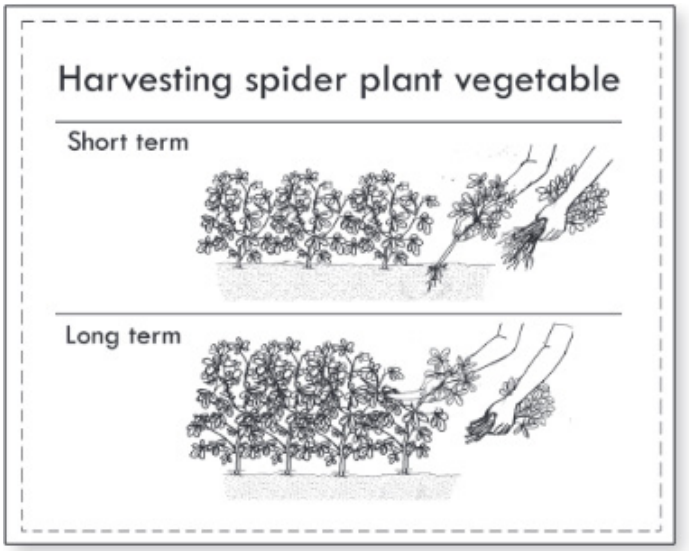

Figure 116: Spider plant harvesting techniques

Source: www.africasoilhealth.cabi.org

The first harvests consist of thinned plants. The whole young plant can be uprooted after 5-6 weeks and re-sowing can be done straight away or pinching the terminal bud is done to accelerate branching and delay flowering. Young leaves and stems can be regularly harvested as the plant grows so that new leaves are produced. Harvesting is repeated several times, depending on the soil fertility and moisture conditions. If only part of the plant is harvested each time it will keep producing edible leaves for up to 4 months after sowing.

Harvesting of seeds

1. **Step 1:** Hand-pick and gently remove the pale brown pods. One can also cut the whole plant at the base.
2. **Step 2:** Spread the pods on clean flat surface under minimum sunshine.
3. **Step 3:** Thresh on a clean hard surface to remove the seed from the pods. The dry pods are soft enough that rubbing hands together can also break them.
4. **Step 4:** Discard the broken pods, stems and leaves. Any light debris still remaining can be removed through winnowing by pouring the seed onto a clean surface.
5. **Step 5:** Store clean seed in a cool, well-ventilated and dry place.

Before storage, make sure the seeds are well dried to the right moisture content.

To determine if seeds are properly dry, pinch with fingers or use the salt method to determine the

moisture content as follows:

- Get 20g (3 bottle tops) of salt and 160 g (handful) of seeds.
- Mix the two together and put in a glass bottle or polythene bag and tie.
- Shake vigorously for 2 minutes.
- Allow to settle for 15 – 30 minutes.
- If the walls of the container or polythene bag become foggy or cloudy, then the moisture content is still more than 15%.
- Continue drying the seeds.

Post-harvest handling

The harvest should be placed in clean gunny bags or plastic crates and placed on a canvass under a shade.

The following activities can be conducted, after harvesting:

i) Sorting

- Any dirt/ weeds should be removed.
- Spider plant should be sorted to remove insects and yellow or damaged leaves before packing.
- Airing of the harvested leaves is done to remove field heat

ii) **Cleaning**

- Leaves should be thoroughly washed with running water.

iii) Grading:

- Grade the leaves by size, bunching those of the same size and tying in small bundles before packing in a well-ventilated container for transportation to markets.

Note:

The harvest should be transported properly without any contamination ad placed under a shade or under refrigeration for preservation.

iv) Local refrigeration

- This is a 1 m high construction made of bricks with 2 separate walls and sand/ charcoal dust between the walls, preferably under a shade. Add an elevated water tank and use a small pipe to allow water to keep the sand/charcoal dust moist. The vegetables should be placed inside the structure on racks.

v) Preservation using a pot

- Spider plant vegetables can also be stored for future consumption by placing harvested vegetables in a pot under a shade. Pile sand or charcoal dust around the pot and continue to keep the sand charcoal moist by regularly adding water. Do not pour water in the pot.

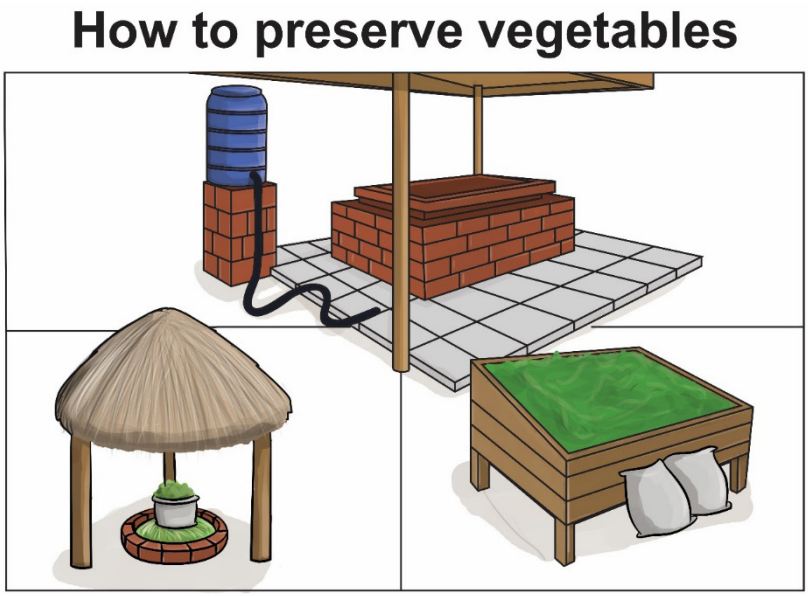

Figure 117: Preservation of vegetables

Production records

Records all inputs put into production and all outputs (yield) realised from production.

Table 24: Sample of a farm production record

Activity	Date	Unit price (Kshs)	Quantity	Total cost (Kshs)	Remarks
Land preparation					
Planting					
Weeding					
Harvesting					
Totals					

3.2.4.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe/*jembe* • Machete/*panga* • Rake • Slasher • Spade • Garden line • Tape measure • Pegs	• Watering can • Knapsack sprayer • PPEs • Wheelbarrow • Gunny bags • Tarpaulin/canvass • Buckets • Weighing scale • Magnifying glass • Plastic crates • Mineral water bottles • Measuring cylinders	• Chemicals • Organic and inorganic fertiliser • Pesticides • Sand • Quality Spider plant seeds • Clean water • Pheromone traps • Sticky traps • Stationery • Drip lines

3.2.4.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What is the importance of using quality seeds in planting Spider plant?
2. List any three important pests in Spider plants.
3. What is spacing between the drills/furrows for planting Spider plants?
4. What is the importance of mulching?
5. Sorting and grading are important in post-harvest handling of Spider plant, ☐ True or ☐ False

Notes:

3.2.4.5 References

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3.2.5 Learning Outcome 5: Produce Amaranthus *(Mchicha/Terere)*

3.2.5.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select appropriate variety of Amaranthus.
- Source quality seed/seedlings of Amaranthus.
- Sow seeds/transplant seedlings to the seedbed.
- Manage the crop.
- Harvest the crop.
- Carry out post-harvest handling practices.

Suggested Training Delivery Methods

Training Activities	Training Delivery Methods and Description	Resources Required
• Identifying the use of Amaranthus plant and their varieties.	• Divide class into groups of four to five members, allow members to brainstorm on uses of Amaranthus and present their findings to the class. • In class/field provide samples of different Amaranthus varieties and allow trainees to identify them as discussed in class.	• Flip chart • Marker pen • LCD projector • Computer • Different varieties of Amaranthus
• Identifying of tools equipment and supplies in Amaranthus production.	• Facilitate a visit to the farm store and allow trainees to identify different tools equipment and supplies with their uses. • Facilitate a demonstration using photos/ printouts/videos on various tools, equipment, and supplies in Amaranthus production.	• Flip chart • Marker pen • LCD projector • Computer • Printouts • Photos • Farm store
• Planting Amaranthus.	• Lead a demonstration on how to establish Amaranthus on the seedbed. • Ask the trainees to perform actual planting on already prepared plots/seedbed.	• Seeds • Manure • Inorganic fertiliser • Watering can • Planting line • *Jembe*

• Carrying out field management practices.	• Display charts/printouts with common pests and diseases of Amaranthus and allow trainees to identify. • Lead a demonstration on how scouting for pest and diseases is conducted. • Ask trainees to carry out scouting of pest and disease on their field. • Facilitate a lecture using photos/videos on various symptoms and control measures of the various pests and diseases. • Demonstrate to trainees on how to place pheromone traps and sticky traps, surveillance and recording. • Ask trainees to place the pheromone traps and sticky traps on the field, do surveillance and record the pests captured using the traps. • Facilitate a field visit to a nearby IPM center to see how IPM is practiced. • Lead a demonstration on gapping. weeding, watering, and crop rotation. • Ask trainees to perform the management practices on their fields.	• Magnifying glass • Scouting programme • *Jembe* • Mulching materials • Watering can • LCD projector • Computer • Charts with common pests • Sticky traps • Pheromone traps • Stationery
• Harvesting of Amaranthus.	• Facilitate a demonstration on how to harvest Amaranthus leaves and seeds. • Ask trainees to harvest mature Amaranthus from the field, weigh and record their produce.	• Gunny bags • Weighing scale • Canvas • Stationery
• Carrying out post-harvest handling.	• Lead a brainstorming session on the importance of carrying out post-harvest handling practices in Amaranthus. • Facilitate a demonstration on how to conduct cleaning, threshing, winnowing sorting, grading and storing of mature Amaranthus seeds. • Ask trainees to harvest mature Amaranthus and perform cleaning, threshing, winnowing sorting, grading and storing of the produce.	• Gunny bags • Canvas • Basin • Labels • Sieve
• **Duration: 24 hours**		

3.2.5.2 Information Sheet

Introduction to Amaranthus

Amaranthus/Amaranth is a member of the *Amaranthaceae* family. Amaranthus species can be distinguished by either the size of the plant, the color of the leaves or flowers or the presence or absence of spines. Amaranth can be used as a leafy vegetable or as a high-protein grain. The leaves are cooked alone or combined with other local vegetables, such as Spider plant or pumpkin.

Figure 118: Amaranthus plant

Health benefits of Amaranth

- It has high content of minerals than most vegetables. The leaves and grains are rich in calcium, iron, phosphorus, vitamins A, B and C, and carotenoids.
- Amaranth is a great source of lysine, an important amino acid with protein content comparable to that of milk that is more easily digested
- In combination with other vegetables Amaranthus has been used to boost immunity for people with suppressed immunity.

Selection of Amaranthus variety

The variety should be selected depending on the target market and preferences.

Table 25: Common Amaranth varieties in Kenya

Variety	Characteristics
 *Amaranthus cruentus (hybrids)*	This variety has long leaves whose colour range from green to reddish-purple. It has a large flower head and will be found growing on waste disposal sites like livestock manure sites and roadsides

Amaranthus hybridus

Amaranthus hybridus

- Stems: erect, green or sometimes reddish purple,
- Leaves are alternate with long stalks
- Yield: up to 12 to 24 tons/acre.

Amaranthus dubius (A. dubius)

Its leaves are triangular with a flat base.

- Grown commercially and sold in city markets.
- Grows up to 150 cm tall. Stems are slender to stout, branched upwards, with short to rather long hairs.
- Maturity period: 3 – 4 weeks after sowing.
- Yield: 7.5 – 12.5 tons/acre (uprooted crop).

Amaranth blitum

Has relatively small leaves with a notch at the tip and often has a dark spot the middle. This species is appreciated for the soft taste.

Amaranthus cruentus
(Grain amaranth)

- Mainly grown for grain production but young leaves can also be cooked.
- It is a traditional, highly productive, nutritious vegetable.
- Cooked grain is an excellent diet for weaning, the elderly and boosts immunity.
- Grain Amaranth is a potential source of nutrition in the arid areas.

Amaranth tricolor

Amaranthus tricolor

- It is used as a cooked leafy vegetable.
- It is fast-growing and easy to produce.
- However, it is much more susceptible to drought than other vegetable amaranths.
- Water shortage causes early flowering, which reduces the yield and the market quality.

Sourcing of quality seed/seedlings of Amaranthus

It is important to source quality seeds / from certified or authorised agro-dealers. These seeds can be sourced from agricultural research institutions such as KALRO, agricultural universities (Jomo Kenyatta University of Agriculture and Technology - JKUAT, Maseno and Egerton) and seed companies e.g. Kenya Seed Co.

What is quality seed?

Quality seed is viable, uniform size, colour and shape. It should also be free of foreign matter such as weed seed, chaff and should be pest- and disease-free.

Figure 119: Amaranth seeds

Importance of quality seeds

- Lower seeding rate.
- Higher seedling emergence, usually above 85%.
- Vigorous seedlings.

- More uniform plant stand.
- Faster growth rate.
- Better resistance/tolerance to pests and diseases.
- Uniformity in maturity.
- Gives better and high yields.
- More income.

Crop establishment

Amaranth is an herbaceous that crop grows well under the following conditions;

- Temperatures ranging from 22-35 ^{0}C.
- Altitude of 0-2400 m above sea level.
- The crop is fairly drought tolerant crop and can performs well in both arid semi-arid areas compared to other vegetables.
- The optimal amount of rainfall required for Amaranth during the growing period is 500mm, however, it can be grown all-year-round under irrigation.
- The crop requires deep, well-drained soils with high organic matter and with a soil pH of 6.0-7.5. However, shallow, stony, crusty clay soils with waterlogging should be avoided.
- The land for planting Amaranthus should not have been used for growing Amaranthus or any other vegetable in the same family in the previous seasons to avoid disease and pest build-up.
- For better and increased vegetable yields, sow seeds at the onset of rains when there is adequate moisture in the soil.
- Direct seeding enables the plant to establish well and faster which leads to good production.

Planting Amaranthus

Amaranthus seeds should be planted in a well-prepared seed bed, the soils should be fine since the seeds are very small. Planting furrows are made using a string and pegs at a spacing of 20 - 30 cm apart at a depth of 1 cm.

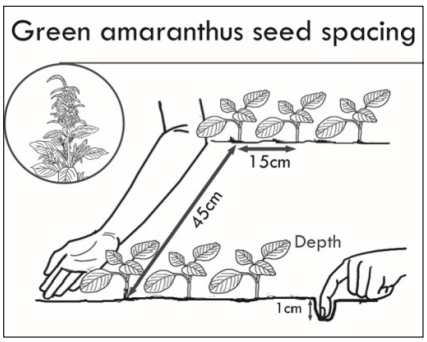

Figure 120: Amaranth spacing and planting depth

Planting should be done at the onset of the rains. Planting is mainly by direct seeding. Apply well-decomposed manure at the rate of 1-2 kg/m. When using inorganic fertilisers place the recommended amount of fertiliser (one bottle top of planting fertiliser (NPK or DAP)/m and mix with soil and manure using a stick.

The seeds should be mixed with sand/well decomposed manure in the ratio of 1:4. Put the mixture in a large mineral water bottle and make a hole in the bottle top and drill along the furrows and then covered with a thin layer of soil.

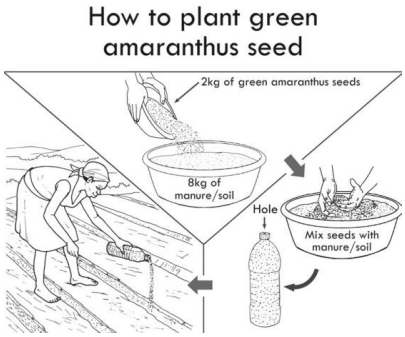

Figure 121: Amaranth seed sowing

Direct sowing

Carry out direct sowing using the steps below;

- Planting should be done at the onset of the rains.
- Planting is mainly by direct seeding.
- For drilling, make furrows 0.5 to 1.0 cm deep, at a spacing of 20-30 cm between rows.
- Drill the seeds in the furrows thinly and cover lightly with soil mixed with compost.
- Cover lightly with soil.
- If its dry irrigate the planted area.

Crop management

i) Thinning

This is the removal of seedlings that emerged from drilling seeds.

- Thin the crop three weeks after germination at 6-8 true leaves to attain a spacing of 10-15 cm between plants in a row.
- Scout and look for seedlings that are congested and remove the weak ones.
- Place the weak ones in a nursery or use them to gap where seedlings never took off.

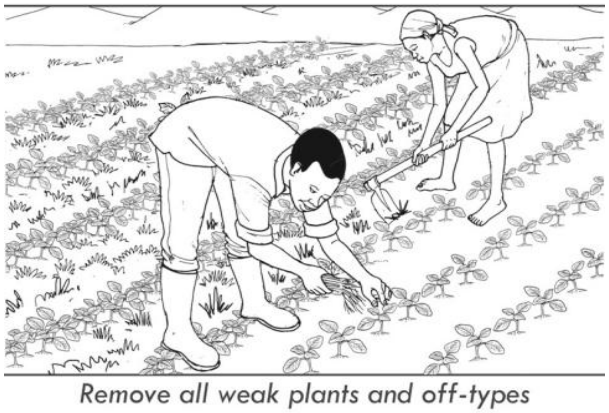

Figure 122: Amaranth weeding and thinning

ii) Weeding

Ensure that you use appropriate tools that will not damage the plant roots. Weeds need to be controlled particularly in the first month, but after that, crop shading can control most weeds if a thick stand is maintained. Shallow cultivation or hand-pulling of weeds should be practiced. This crop grows rapidly and requires weeding only in the open space between the rows. Amaranthus responds well to well-decomposed manure.

Importance of timely weeding

- Timely weeding will lead to increased yield.
- Timely weeding minimises competition for crop nutrients and light between weeds and the crop.
- Weeding also reduces pest and disease infestation at the early stages which will again lead to increased yields.
- Weeding should be done as soon as weeds emerge and before the flowering of weeds. This will reduce the risk of the weeds spreading.

Rouging of off-types should be done at flowering and at fruiting (early maturity) when it is easy to identify the off-types

iii) Gapping

- Five days after planting the Amaranthus, you need to scout for areas which require gapping.
- Count for seedlings that failed to take off.
- Source an equal number of seedlings of same variety from initial dealer.
- Using a stick make holes of 1 cm depth at the site where the Amaranth failed to pick.
- Place the seed and cover shallowly with soil and water as you did when planting initially

iv) Watering

Plants require water two or three times a week. Periods of drought will hasten development of flowers and lower the yields. At other times otherwise adjust frequency according to the rainfall.

Note:

Use different watering programs depending on type of soil as highlighted below;

- Sandy soils that dominate coastal, northern and eastern Kenya require more watering (up to 3 times a week).
- Loamy sandy soils are often found in central Kenya and require moderate watering (twice a week).
- Clay soils are common in Nyanza and the Rift Valley and drain slowly and hold more water (once a week).

It is important to water the right amount for each crop. Watering too little reduces the size and quality of crops and when plants are watered too much, they grow too fast, nutrients and pesticides are washed out of the soil into waterways, diseases and weed seeds spread with the overflowing water, and it is expensive in terms of labour and water costs.

Note:

When using irrigation, consider;

- The source of available water,
- The size of the land to be irrigated, and
- Availability of financial resources.

Mulching

Amaranthus is mulched to conserve and maintain moisture in the soil, check soil erosion and also control weed growth. Types of mulching material to be used include dry bean or maize stover; dry grass or wild sunflower (Tithonia).

Importance

Mulching has the following benefits for the Amaranth;

- Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.
- It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.

- As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.
- Mulching reduces the growth of weeds as it deprives them of sunlight.
- Mulching creates shade and cools the soil, allowing tender roots and young plants to thrive in hot conditions.

Amaranthus can be established as a kitchen garden using cone, multi-storey, Mandala e.t.c as described in Chapter 1, and can be intercropped with other crops for pest and disease management.

Overall pests and diseases identification and management plan

Pest and disease management should be a continuous effort by the farmer to ensure early intervention in case of an outbreak. Both cultural and use of safe organic pesticides can be used to control pests and diseases. This should be done through continuous scouting of the field crop. In order to identify the pests and diseases, first prepare a program for pest and disease scouting to determine the frequency of scouting – usually once every 2 days. Thereafter, the steps below can follow;

- During every scouting visit, identify pests and diseases observed and note them down.
- Consult experts and other knowledgeable farmers and present your sample collections.
- Discuss and seek advice on the management options to manage the pests or diseases –cultural, using bio-pesticides, chemicals or combination of these.
- Prepare a management program for identified pest and diseases.
- Source materials for pest and disease control.
- Assemble the tools and equipment for management of pest and diseases.
- Manage the pest and diseases.
- Evaluate the management results and note down points to consider in next season pest and diseases management.

The farmer should regularly monitor the field to ensure quick action is taken in case of break out of pests and diseases.

Pest identification and management

The main pests that attack Amaranth are Spider mites, aphids and leaf caterpillars. A range of control measures are available, however, application of IPM is recommended. The table below highlights management of common pests of the Amaranth crop.

Table 26: Management of pests affecting Amanranthus

Pest	Signs	Control
 *Cutworm (Agrostis species)*	• Cutworms chew through plant stems at the base. • They also cut off the plant from the roots causing the plant to shrivel and die.	• Hand pick and destroy • Crop rotation
 *Leaf miners*	• Transparent patches (cuticle) appear on the underside of the leaves.	• Spray general pesticide on the infected plants.
 *Aphids*	• Sucks fluids from the plant leaving a honey dew substance behind. • Leaves turn pale yellow as a result.	• Spray using insecticidal soaps or strong stream of water to wash off. • Introduce natural predators such as lady bug beetles. • Use of recommended pesticides containing chlorpyrifos and pyrethroids such as cypermetrin.
 *Red spider mites*	• Puncture and suck leaves leading to reddish or pale discoloration of leaves. • Plants lose vigour and become weak. • Heavy mite infestations stunt plants and cause premature leaf drop.	• Avoid using pyrethroids which lead to spider mites outbreak • Use overhead irrigation to knock off mites and destroy their webs.
 *Weevils (larval stage)*	• Larvae bore through stems to the root, hollowing into stems making them more susceptible to wind breakage. • Plants wither and lodge easily.	• Uproot and destroy attacked plants. • Practice appropriate weed control. • Establish seedlings in well-drained soil in an area with good ventilation.

Stink Bugs

- Can cause severe damage to flowering head and seeds especially during the critical seed fill stage.
- Spray with permethrin or cypermethrin.

Disease identification and management

The most common diseases affecting Amaranthus crops in Kenya are the damping off and Choanephora blight diseases.

Table 27: Management of diseases affecting Amaranthus

Disease	Symptoms	Management
 *Damping off (Pithium species)*	• This disease is characterised by stunted plants. • Yellow lower leaves. • Wilting and eventual collapse and death of older plants.	• Avoid over-watering. • Practice crop rotation.
 *Choanephora blight*	• Characterised by leaves turning yellowish and developing greyish brown spots. • Is spread by air currents and infected seeds. • Warm moist conditions favour disease development.	• Use resistant varieties. • Plant certified, disease-free seeds.

Note:

Crop rotation can also be used to control pests and diseases as suggested in the chart below.

Table 28: Crop rotation chart for Amaranthus crop

SEASON 1	SEASON 2
 *Spider plant*	 *Onion*
 *Onions (Amaryllidaceae)*	 *Cabbages/kales*
 *Cabbages/kales (Brassicas)*	 *Cereals*
 *Cereals (grass family)*	 *Spider plant*

Harvesting of Amaranthus crop

i) Leaf harvesting

Harvesting is usually done within 4-6 weeks after sowing.

- Plants may be harvested at once or leaves and tender shoots harvested several times.
- A single harvest is for short-maturing and quick growing varieties like “Amaranthus tricolor”. whole plants are pulled from soil with roots.
- With multiple harvests, young leaves and tender shoots are picked once a week until onset of flowering.
- Frequent harvest prolongs the harvest period and delays onset of flowering.
- Harvesting can continue for 4 months, especially if local varieties are used.
- Harvesting should be done during cooler periods of the day.
- Sorting is done to remove insects, yellow or damaged leaves and soil.
- Airing of the harvested leaves is done to remove field heat.
- Leaves are cleaned and graded.

ii) Grain harvesting

Harvesting green Amaranthus seed starts at 15 weeks after planting. The number of fruits produced per plant depend on the size of the plant.

- Amaranth grain shutters easily, therefore harvest as soon as the colour of the panicle/heads turns from green to golden brown and seeds drop on light shaking of the plant.
- Cut off the panicle with a knife or sickle to detach it from the main stem and place into the harvesting container.

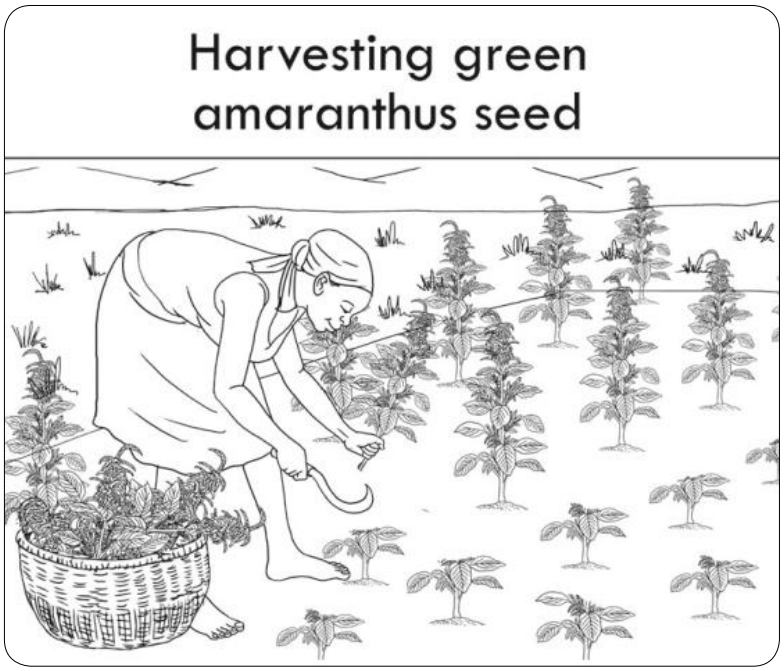

Figure 123: Amaranth seed harvesting

- The panicles may also be detached from the plant by breaking by hands
- Keep the seeds on the vine until they have fully matured. When mature, the fruits will fall easily when shaken. Harvest only the mature fruits for seed and avoid seeds that are diseased or rotting.
- Premature harvesting causes shrinkage of seed, loss in germination vigour and difficulty in harvesting and processing.
- Delayed harvesting causes loss in seed quality, damage by pests, rain damage, and secondary disease infestation.
- It is recommended to hand pick seeds since there is uneven maturity of fruits and seed for most indigenous vegetables. When a small area is to be harvested, extra care is necessary.
- Store harvested fruit in a cool place on a mat to avoid contamination by soil.

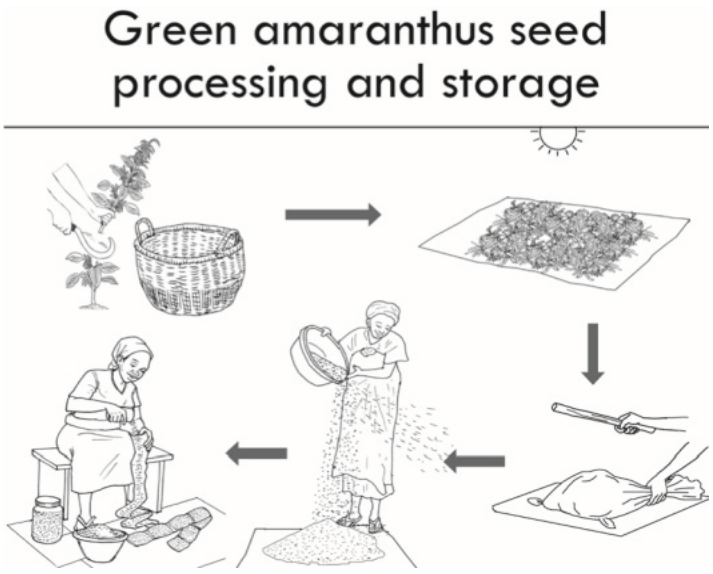

Figure 124: Amaranth seed processing

Green Amaranthus seed processing and storage

Follow the steps below to harvest green Amaranthus seed:

a) **Step 1:** Identify mature seeds by shaking the finger and the seeds will fall easily. Cut the whole plant from the bottom with a sickle.

b) **Step 2:** Place the harvested fingers/plants on a clean tarpaulin and place under direct sunlight. Check if seed is dry by rubbing between palms. If seed sticks on your palm, then need further drying, if it does not stick then it is dry. Alternatively use a moisture meter.

c) **Step 3:** Pack the dry fingers into a light pack and hit the pack gently until the seed separates from the husks.

d) **Step 4:** Thresh to remove chaff using clean containers.

To determine if seeds are properly dry, pinch with fingers or use the salt method to determine the moisture content as follows:

- Get 20 g (3 bottle tops) of salt and 160 g (handful) of seeds.

- Mix the two together and put in a glass bottle or polythene bag and tie.
- Shake vigorously for 2 minutes.
- Allow to settle for 15 – 30 minutes.
- If the walls of the container or polythene bag become foggy or cloudy, then the moisture content is still more than 15%.
- Continue drying the seeds.

e) **Step 5:** Clean and package seed in a cool, well-ventilated and dry place.

- Well stored seed will maintain the quality in size and a high germination capacity with vigour until it is required for use.
- The main factors determining the storage life of seed are the moisture content and temperature.
- Seed may be treated to protect it against infestation by insects and infection by seed-borne and/or soil-borne disease-causing microorganisms (plant pathogens) prior to and during germination and seedling establishment. This operation is referred to as seed dressing or seed treatment. The ideal chemical for seed treatment should be:
  - Highly effective against pathogenic organisms.
  - Relatively non-toxic to plants.
  - Harmless to humans and livestock even if misused.
  - Stable for a relatively long period of time during seed storage.
  - Easy to use.
  - Cost-effective.

Packaging, labelling and sealing

Packaging material should be durable, free from defects and allow seed to retain viability.

- Treated seeds are packaged in clean bags and containers of various sizes according to the customers' demand.
- Seeds of all classes must bear the official label on to each bag or container, which shows the lot number, type of crop, name of variety, class of seed, germination and purity levels and the packing date.
- Containers should be fastened or sealed according to national requirements.

Note:

Poor methods of processing contribute to rapid seed deterioration for example beating of harvested fruits and storing them on wet floor.

3.2.5.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe/jembe • Machete/*panga* • Rake • Slasher • Spade • Garden line • Tape measure • Pegs	• Watering can • Knapsack sprayer • PPEs • Wheelbarrow • Gunny bags • Tarpaulin/canvass • Buckets • Weighing scale • Magnifying glass • Plastic crates • Mineral water bottles • Measuring cylinders	• Chemicals • Organic and inorganic fertiliser • Pesticides • Sand • Quality Amaranth seeds • Clean water • Pheromone traps • Sticky traps • Stationery • Drip lines

3.2.5.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What is the importance of using quality seeds in planting Amaranthus?
2. List any three important pests in Amaranthus.
3. Why is crop rotation important in Amaranthus production?
4. What is the spacing between the drills/furrows and between plants in Amaranthus production?
5. Why harvest Amaranthus grains on time?

Notes:

3.2.5.5 References

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3.3 Model Responses to Self-Assessment Questions

3.2.1 Learning Outcome 1:

Produce Black Nightshade

1. What are common pests that attack Black nightshade
   - **Root-knot nematode**
   - **Cutworm**
   - **Flea Beetle**
   - **Aphids**
   - **Spider mites.**

2. What is the importance of mulching in Black nightshade
   - **Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.**
   - **It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.**
   - **As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.**
   - **Mulching reduces the growth of weeds as it deprives them of sunlight**

3. What are the two methods of establishing Black nightshade?
   - **Using seeds during direct seeding,**
   - **Use of seedlings during transplanting.**

4. What are the uses of the following tools in Black nightshade production?

Tool			Uses
1	***Jembe***		**It is used for digging/ tilling the ground and making holes/furrows for planting.**
2	**Garden line**		**Used to prepare planting uniform holes/furrows with tied knots at the correct spacing.**

3	**Pegs**		*For anchoring the garden line on the ground during planting.*

3.2.2 Learning Outcome 2:

Produce Cow Pea

1. What are the common pests in cowpea production
   - **Aphids**
   - **Brunchids**
   - **Whiteflies**
   - **Army worm**
   - **Pod borer**

2. Which five management practices are applied in cowpea production?
   - **Weeding**
   - **Watering/irrigation**
   - **Crop rotation**
   - **Gapping**
   - **Crop protection**

3. What are the common diseases in cowpea production
   - **Leaf spot**
   - **Powdery mildew**
   - **Anthracnose**
   - **Soft rot**
   - **Brown rust**

4. Which are the five-cowpea varieties commonly established
   - **Katumani 80 (K80)**
   - **KVU 27-1, 419**

- **Kunde 1**
- **MTW 63, 610**
- **Machakos 66 (M66)**
- **Kitui black eye**

5. Which of the following is not a cultural practice used in control of pests in cowpeas?

   D. Use of chemicals

3.2.3 Learning Outcome 3:

Produce Jute Mallow and Slender Leaf/Crotolaria/ Sunn Hemp

1. Which factors should be considered when selecting appropriate variety for Jute mallow and Slender leaf?
   - **High yield per unit area.**
   - **Early maturing.**
   - **Resistance to disease and pest attack.**
   - **Adapted to the prevailing conditions.**
   - **Taste and preference by consumers.**
   - **Drought-tolerant.**
   - **High profitability.**
   - **High market demand.**

2. What are the benefits of Jute mallow and Slender leaf?
   - **Easier to grow in comparison to exotic vegetables.**
   - **Can produce seed under tropical conditions unlike the exotic vegetables.**
   - **They have a short growth period with most of them being vegetables ready for harvesting within 3-4 weeks.**
   - **Respond very well to organic fertilisers.**
   - **Most of them have an ability to withstand and tolerate drought / harsh environmental conditions, pest and disease attack.**
   - **They can also flourish under sustainable and environmental-friendly cropping conditions like intercropping and companion cropping.**
   - **Slender leaf fixes nitrogen into the soil hence improves soil fertility.**
   - **Generates high income per unit area, per unit time enabling the poorest people in the rural communities to earn a living.**

3. Why is it important for farmers to use quality seed?
   - **Pest- and disease-free.**
   - **High yielding.**
   - **High purity percentage.**
   - **High germination percentage.**
   - **Uniform growth.**
   - **Vigorous growth.**
   - **Adapted to a wide range of ecological conditions.**

4. Three of the following are certified sources of quality seed. Which is NOT?

   C. Supermarkets

5. How is Jute mallow established in the seed bed?
   - **Apply 2kg/m2 of farm yard manure.**
   - **Make shallow furrows/drills 30 cm apart and 1 cm deep.**
   - **The seed is mixed with sand or dry fine soil at a ratio of 1:10 respectively.**
   - **Mix the seeds with the soil/manure mixture in a bowl and tip it into a bottle.**
   - **Tip the seed/soil mix from the bottle along the furrows/drills then cover with 1-1.5cm of soil.**
   - **Mulch seeds lightly using dry material.**
   - **Water the seeds lightly but do not use excess water as it may cause the seeds to rot or washed away.**
   - **Emergence (sprouting) of seed occurs from 6 to 8 days after sowing.**

6. Using arrows, match each tool with its respective use / function in the table below.

Tool/equipment	Functions/Uses
1. Trowel	**Uprooting seedlings for transplanting.**
2. Wheelbarrow	**Transporting seedlings, soil, produce, compost or other farm inputs within the farm.**
3. Garden line	**Laying out activities and tying plants onto stakes.**
4. Rake	**Breaking soil clods and leveling soil surface.**

7. Which cultural practices are employed to control pests and diseases in Jute mallow and Slender leaf?
   - **Thinning**
   - **Weed control**

- **Crop rotation**
- **Observe field hygiene**
- **Use of insect nettings**
- **Timely planting**
- **Ensure proper drainage**
- **Clean and sterilise tools and equipment before and after use**
- **Use of biopesticides**
- **Use of pest and disease resistant varieties**
- **Use quality seed**
- **Dispose plant residues away from the field.**

8. How is Jute mallow and Slender leaf harvested?
   - **Whole plants (20–30cm tall) are pulled from soil with roots.**
   - **Young tender leaves and shoots are picked every two to three weeks.**
   - **Harvest by cutting the upper 15 cm of growth.**

9. Which criteria is used when grading Jute mallow and slender leaf after harvest?
   - **Uniformity in size.**
   - **Same variety.**
   - **Same length.**

3.2.4 Learning Outcome 4:

Produce Spider Plant

1. What is the importance of using quality seeds in planting spider plant?
   - **Lower seeding rate.**
   - **Higher seedling emergence, usually above 85%.**
   - **Vigorous seedlings.**
   - **More uniform plant stand.**
   - **Faster growth rate.**
   - **Better resistance to pests and diseases.**
   - **Uniformity in maturity.**

2. List any three important pests in spider plants
   - **Aphids**

- **White flies**
- **Spider mites**
- **Mealy bugs**

3. What is spacing between the drills/furrows for planting spider plants

   The spacing is 30-50 cm

4. What is the importance of mulching
   - **Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.**
   - **It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.**
   - **As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.**
   - **Mulching reduces the growth of weeds as it deprives them of sunlight**
   - **Mulching creates shade and cools the soil, allowing tender roots and young plants to thrive in hot conditions.**

5. Sorting and grading are important in post-harvest handling of Spider plant - **True**

3.2.5 Learning Outcome 5:

Produce Amaranthus

1. What is the importance of using quality seeds in planting Amaranthus
   - **Lower seeding rate.**
   - **Higher seedling emergence, usually above 85%.**
   - **Vigorous seedlings.**
   - **More uniform plant stand.**
   - **Faster growth rate.**
   - **Better resistance to pests and diseases.**
   - **Uniformity in maturity.**

2. List any three important pests in Amaranthus
   - **Aphids**
   - **Leaf miner**

- **Spider mites**
- **Cut worms**

3. Why is crop rotation important in Amaranthus production?
   - **Crop rotation can also be used to control pests and diseases.**

4. What is the spacing between the drills/furrows and between plants in Amaranthus production?
   - **The spacing is 20-30 cm between the drill/furrow and 10 cm between the plant**

5. Why harvest Amaranthus grains on time?
   - **Amaranth grain shutters easily, therefore harvest as soon as the colour of the panicle/heads turns from green to golden brown and seeds drop on light shaking of the plant.**

4 Kales and Spinach Production

4.1 Introduction to the Chapter

This chapter specifies the competencies required to produce the kales and spinach. It covers knowledge and skills required in sourcing for planting materials, establishing, managing (in the field) and harvesting kales and spinach.

4.2 Summary of Learning Outcomes

The content of this this Chapter will enable the trainee or farmer to;

- Establish kales and spinach.
- Manage kales and spinach.
- Harvest kales and spinach.

4.2.1 Learning Outcome 1: Establish Kales and Spinach

4.2.1.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Obtain kales/spinach seedlings.
- Prepare planting area for transplanting kales/spinach seedlings.
- Apply appropriate fertiliser
- Transplant seedlings.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Obtaining seedlings.	• Conduct a brainstorming session on importance of using quality seedlings. • Share pictorials of the right stage of kale/ spinach seedlings for transplanting. • Lead trainees on an excursion in an established nursery to identify quality kale/ spinach seedlings for transplanting.	• Computer • Printer • Printing paper • Established nursery
• Preparing planting area.	• Play a video demonstrating preparation of planting area for transplanting. • Practice by trainees in the field.	• Computer • Internet access • Prepared land area

• Applying appropriate fertiliser.	• Lead group discussion and plenaries on various choice of fertiliser. • Conduct a simulation on correct procedure for applying fertiliser.	• Flip chart • Marker pens • Soil test report • Sand to use in simulation as fertiliser
• Transplanting kale/spinach seedlings.	• Conduct a demonstration on correct procedure of transplanting kale/spinach, followed by practice by trainees.	• Kale/spinach seedlings • Tools and equipment used in transplanting • Water
• **Duration: 10 hours**		

4.2.1.2 Information Sheet

Definition of terms

Seedling - a young plant grown on a nursery bed for transplanting.

Transplanting - refers to the act of moving seedlings from the nursery bed to their final growing area.

Furrow - narrow trench made on the ground for planting.

Organic fertiliser - decomposed solid waste from animals and plants used to nourish soil.

Inorganic fertiliser - mineral-based nutrients manufactured for application to plants.

Sourcing of kale/spinach seed/seedlings

If a farmer wishes to prepare their own seedlings, they should obtain quality and certified seeds from reputable agro dealers. Quality seed should be;

- Uniform size, colour and shape.
- Free of foreign matter such as weed seed, chaff e.t.c.
- Pest- and disease-free.

When a farmer does not plan to raise own seedlings, they should obtain good quality seedlings from certified nurseries. There are established nursery operators specialised in seedling production where farmers can source for seedlings.

Importance of quality seedlings

i. High uptake after transplanting.
ii. Vigorous growth.
iii. More uniform plant stand.
iv. Faster growth rate.
v. Better resistance to pests and diseases.
vi. Uniformity in maturity.

Spacing recommendations

- Kale/spinach seedlings are normally transplanted at a spacing of 60 cm between rows and 40 – 60 cm between plants depending on the variety.
- Large head varieties require more spacing: 60 cm x 60 cm, 60 cm x 45 cm for medium-sized and 30 cm x 30 cm for small head.
- There should be enough space for each plant to allow them receive adequate sunlight and air circulation.
- The spacing should also allow easy management and harvesting.

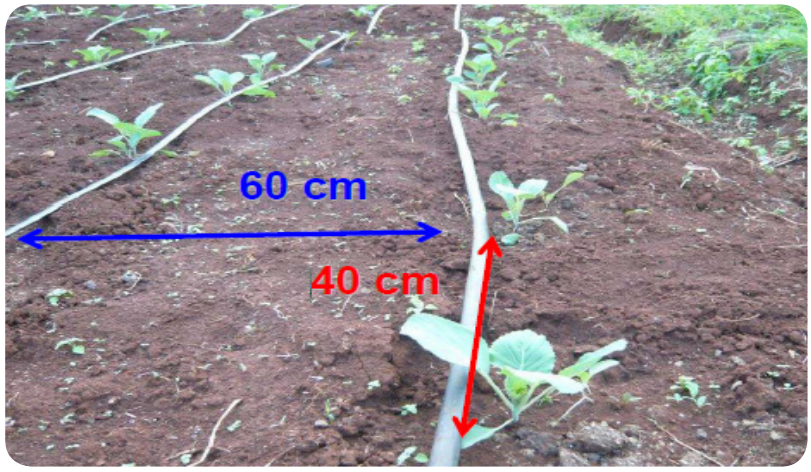

Figure 125: Spacing recommendations for kales and spinach

Making planting holes/furrows

- Make rows at 60 cm apart using a layout string, a tape measure and a jembe.
- Along the rows, using a dibbler, make holes at 40 cm apart and 5 cm deep.
- Use a hoe or shovel to create furrows in the prepared soil 15-20 cm apart, depending on the variety of kales you are planting and a depth of 1-3 cm.
- In mechanised farms, an animal/tractor-drawn ridger can be used to prepare ridges.
- You can also opt for wide rows while preparing planting beds (raised or sunken depending on water availability) but ensure that the bed width does not exceed 1m for ease of management.

Note:

Kales/spinach can also be grown in furrows/ridges especially where furrow irrigation will be utilised.

The spacing adopted depends on the variety of kale/spinach.

Fertiliser application

Both organic and inorganic fertiliser can be used in transplanting kale/spinach seedlings.

Figure 126: Heap of compost manure

Manure

- Manure is made from plant or animal wastes. Manures help improve soil organic matter Common examples of organic manure are farm yard manure and compost manure.
- Preparation of compost manure on the farm is a good way of utilising farm wastes since kales and spinach does well in soils high in organic matter.
- The quantity of manure to apply depends on the soil test recommendations. Apply between 10 - 15 tons of manure per acre. Only thoroughly composted manure should be used to avoid possible introduction of pests and diseases in the field.
- It is recommended to apply organic manure 1-2 weeks before transplanting. The manure is broadcasted and incorporated into the soil using a hoe.
- If the manure is being used at the time for transplanting, then apply 1-2 handfuls in each planting hole and mix with soil.

Inorganic fertilisers

- DAP/TSP/NPK or any other phosphatic fertiliser is used when transplanting kales/spinach because they encourage root development and health of the plant.
- Apply about 1 tablespoonful per hole (10 g) of the fertiliser in the planting holes.
- The fertiliser should be mixed thoroughly with the soil to avoid possible scorching of the seedlings.

Note:

- Manures are preferred for leafy vegetables such as kale/spinach because they are cheaper and lead to longer harvesting of quality leaves.
- Apply soil test recommendations when deciding on type and quantity of fertiliser to use.

Transplanting kale/spinach seedlings

Kale/spinach seedlings are normally ready for transplanting 30 days after germination.

Characteristics of quality seedlings for transplanting:

- Show no visible signs of disease and pests.
- Should be about 10-15 cm tall.
- Have 3-5 true leaves.
- Deep green in colour.
- Roots should not be exposed from soil.

Figure 127: Spinach seedlings ready for transplanting

Appropriate time for transplanting

- Transplanting should be done either early in the morning or late in the evening when the weather is cool.
- It is preferable to transplant in the evening because the seedlings will have more time to adjust during the night (cooler temperatures).
- At night, the quantity of water lost through the leaves is less than the water absorbed though the roots.

Procedure for transplanting

- Carry the seedlings to the planting site using a bucket or wheelbarrow.
- If the seedling is still in containers (seedling trays, polysleeves etc.) carefully remove it from the container, holding it by the leaves and avoiding damage to the stem or roots.

- Place a single seedling in each planting hole based on recommended spacing making sure that the seedlings' roots reach the bottom of the hole.
- Cover the seedling base with soil firmly while ensuring that you don't compact the soil.
- Water the transplanted seedling thoroughly.

Note:

Do not burry the leaves/stem of your seedling while transplanting. Ensure that the top of root ball of your transplanted seedling is level with the soil surface.

Figure 128: Planting depth

Good companion crops for kales/spinach are onions, coriander (*Dania*) and garlic. They produce compounds that repel most of the insect pests and offer little competition to the main crop

Home gardening technologies

There are many gardening technologies for production of kales/spinach. Preparation of the technologies is covered in Chapter 1 of this learning guide. The procedure for establishing kales/spinach in the gardens is given below.

Figure 129: Sack mount (left), and conical garden (right)

- When using containers, they should be at least 30 cm in diameter and 30 cm deep to allow root development.
- Fill the containers with planting soil leaving a few inches at the top.
- Make planting holes at the centre of the container.


Figure 130: Kales planted in containers

4.2.1.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Watering can • Bucket • Pegs • Layout string	• Wheelbarrow	• Kale/spinach seedlings • Water • Fertiliser

4.2.1.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Which of the following is not an essential considering when sourcing kale/spinach seedlings for transplanting.
   - ☐ A. Number of true leaves
   - ☐ B. Height of the seedling
   - ☐ C. Presence of potting container

2. Which of the following statements is **true**?
   - ☐ A. When handling seedlings hold it by the roots
   - ☐ B. Kale/spinach seedlings for transplanting must have more than 5 true leaves
   - ☐ C. Raw manure can introduce pests and diseases to your plants

3. You should transplant seedlings in the _____ to reduce stress to the plant. Immediately after transplanting _____ the transplanted seedling thoroughly (fill the blank spaces).

4. Why is it important that you mix fertiliser with soil before planting your seedlings
   - ☐ A. To avoid scorching
   - ☐ B. To suppress weeds
   - ☐ C. To increase water infiltration

5. Which of the following statements is **false**?
   - ☐ A. Good quality kale/spinach seedlings result in more uniform growth
   - ☐ B. Smaller spacing when transplanting kale/spinach seedlings increases yields
   - ☐ C. Phosphatic fertiliser should be used for transplanting.

Notes:

4.2.1.5 References

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4.2.2 Learning Outcome 2:
Manage Kales and Spinach

4.2.2.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify crop management tools, equipment, materials and supplies.
- Perform gapping of kales and spinach.
- Identify proper methods for weed control.
- Manage weeds.
- Identify and manage pests and diseases.
- Manage soil moisture requirements.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Perform gapping of kales/spinach.	• Identify a kale/spinach plot that requires gapping. • Assemble required resources. • Demonstrate step-by-step the procedure by gapping 1 or 2 empty spaces. • Issue at least one seedling to each trainee and ask them to plant the seedlings as you observe. • Correct any mistakes and allow an opportunity to repeat (in case there are only few holes to gap, use any other plot to practice).	• Seedlings • Dibbler/stick with sharp end • Water • Watering can
• Identify proper methods for weed control.	• Lead a class discussion on methods of weed control. • Use “think-pair-share method” for them to determine when each method is most suitable. • Group trainees in teams of five and ask them to identify the suitable weed control method for an allocated plot. Allow them to present their recommendations with reason.	• Notebooks/ meta plan cards • Marker pens/ pens

• Manage weeds.	• Lead trainees into an established kale/ spinach plot. In groups of 5: • Ask them to scout and determine if plot requires weeding. • Ask them to estimate required resources. • Ask trainees to implement weeding as appropriate (uprooting, tillage or mulching).	• Writing materials • Hoe • *Panga* • Mulching materials
• Identify pests and diseases.	• Present pictures of major pests of kales/ spinach and a description of their characteristics. • Using "find and match" method, form 4-5 groups and issue each group with a photo of the major pests and a description for a different one. Ask them to match their pest with the right description by looking for the right description from among the other groups. • Repeat the same for diseases.	• Photos of major pests • Descriptions of pest on meta plan cards • Writing materials • Diseased kales/ spinach or their leaves • Photos of kale/ spinach diseases
• Manage pests and diseases.	• Ask trainees to develop an IPM strategy for the kales/spinach at start of cropping season. • Lead trainees in setting up sticky and pheromone traps within the kale/spinach plot. • Ask trainees to routinely observe the traps, record their observations and guide them in determining time to institute control measures. • Display the crop protection PPEs and lead the trainees in identifying each and its importance. • Guide one trainee to wear the PPEs properly as the rest observe. Allow each to practice. • Ask trainees in groups of five to scout and identify any pest/diseases and need to manage the pests. • Ask the groups to identify an effective control method with reasons. • Ask them to implement appropriate management method. • In case of chemical control, demonstrate to learners how to clean the spray equipment and store remnants of pesticide.	• Knives • Hand gloves • Pheromone/ sticky traps • Writing materials • Knapsack sprayer • Organic and inorganic pesticides • PPEs
• **Duration: 30 hours**		

4.2.2.2 Information Sheet

Gapping of kales and spinach

The following steps are followed during gapping:

i) Five days after transplanting the kales/spinach field, scout and count for seedlings that dried.

ii) Seek or source an equal number of seedlings from a kales/spinach nursery ensuring they are of the same variety.

iii) Using a stick or dibbler, drill planting holes of 5cm depth at the field sections needing gapping.

iv) Place the seedlings in the planting holes and cover to appropriate depth, and irrigate immediately.

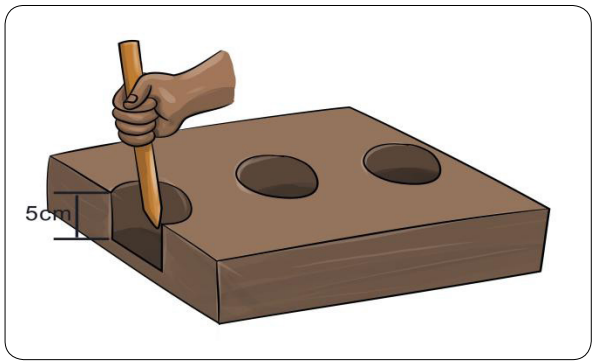

Figure 131: Depth of planting holes for kales and spinach

Benefits of gapping

The following are the benefits of gapping.

- Ensures efficient use of inputs provided in the field.
- Ensures that yields are maximised.
- Attain 100% plant population.

Weed management

Weeds refer to any undesirable plants that may grow in the kale/spinach field. Weeds compete with the crop for nutrients, water and sunshine. They also harbour pests and diseases.

Importance of weed control

- Reduces competition for nutrients – weeds use food and water that kales/spinach plants need to grow.
- Reduces competition for space – weeds occupy the space meant for crops.
- Reduces competition for water – they compete for moisture with crops.
- Reduces need for pest and disease management – some weeds act as alternate hosts for pests.

Methods of weeding

Weeds need to be removed as they germinate. The following methods may be used:

- **Manual or mechanical** e.g. uprooting, weeding using a panga, hoe or shallow weeder. This leaves the weeds on the surface with the roots exposed so that they dry.
- **Use of chemicals;** In case the kales/spinach field is infested with grass weeds, selective herbicides can be used e.g. selective herbicides that contain 150 g/l Fluazifop-p-butyl
- **Cultural method;** e.g. timely planting, water management and mulching.

Figure 132: Shallow weeder

Procedure of weed management

i) Scout the kale/spinach field to identify weed intensity and size.

ii) Choose the appropriate control method- mechanical, chemical or cultural. The method will depend on the type and size of weed, soil moisture and available technology and resources.

iii) Acquire the necessary materials /equipment for weed control.

iv) Control the weeds appropriately.

v) Use only recommended herbicides in case of chemical control.

Caution:

- Use weeding tools carefully to avoid injury.
- Read manufacturer's instructions on herbicides carefully.
- Avoid spilling the pesticide.
- Dispose-off herbicide remnants and used containers carefully.
- Clean the spray pump after use.
- Wash thoroughly after applying herbicides.
- Wear safety clothing when spraying.

Identification and management of pests and diseases

Various pests and diseases attack kales/spinach and if not controlled, they can reduce yield by 60 – 80% thereby reducing profitability of the crop.

Planning for pests and diseases

- Prepare a program for pest and disease scouting.
- Determine the frequency of scouting.
- During every scouting visit, identify pests and diseases observed.
- Determine thresholds through sample collections.
- Determine pest and disease control methods.
- Prepare a control program for identified pest and diseases.
- Source materials for pest and disease control.
- Assemble the tools and equipment for control of pest and diseases.
- Control pest and diseases. An integrated approach is preferred.

Integrated Pest Management (IPM) in kale production

- IPM is an effective and sustainable approach to managing pests in kale/spinach.
- It involves combining various pest control strategies to minimise the use of chemical pesticides while maximising the production of healthy crops.
- IPM focuses on long-term pest management, reducing negative environmental impact, and maintaining economic viability.

Application of IPM in kale/spinach production

i) Monitoring and scouting:

Regularly monitor kale/spinach crops for signs of pest infestations. This can be done through visual inspection, pheromone traps, sticky traps, or by using automated pest monitoring systems. Early detection helps in identifying pest species, their population levels, and potential risks.

ii) Pest identification and threshold setting:

Accurate identification of pests is essential for implementing appropriate control measures. Determine the economic threshold level, i.e., the pest population at which intervention is necessary to prevent economic losses.

This prevents unnecessary pesticide applications and allows for more targeted pest management.

iii) Cultural practices:

Implement cultural practices that discourage pest infestations.

These include crop rotation, proper spacing, and timing of planting, appropriate nutrient management, and good sanitation practices to reduce pest breeding sites.

iv) Biological control:

Encourage the presence of natural enemies, such as predatory insects, parasitoids, and insect-pathogenic microorganisms, to control pests.

v) Use of resistant varieties:

Choose kale varieties that exhibit resistance or tolerance to common pests. Resistant varieties can significantly reduce pest damage and the need for pesticide applications.

vi) Targeted pesticide application:

If pest populations exceed the established threshold, consider the use of pesticides as a last resort. Select pesticides that are specific to the target pests, have low toxicity to non-target organisms, and follow label instructions carefully to minimise risks.

vii) Record keeping and evaluation:

Maintain detailed records of pest monitoring, control measures, and their outcomes. Regularly evaluate the effectiveness of IPM strategies implemented and make adjustments as necessary to improve pest management practices.

Safe use of chemicals in kale/spinach production

By following safety precautions, vegetable producers can minimise the potential risks associated with pesticide use and ensure the safe and responsible management of pests in their crops. The following precautions are important when pesticides have to be used:

1. Read and follow label instructions:
    - Always carefully read and follow the recommended dosage, application methods, safety precautions, and any restrictions or waiting periods before harvest.
2. Choose appropriate pesticides:
    - Select pesticides that are specifically formulated for the target pests in vegetable crops.
    - Consider their effectiveness, selectivity, and compatibility with the crop and other beneficial organisms.
3. Handle and store pesticides safely:
    - Store pesticides in a secure location away from food, feed, and water sources.
    - Keep them in their original containers with intact labels.
    - Store pesticides at recommended temperatures, ensuring they are not exposed to extreme heat or cold.
    - Follow proper disposal guidelines for empty pesticide containers.
4. Use personal protective equipment (PPE):

    Wear appropriate PPE, such as gloves, goggles, long-sleeved clothing, and respiratory protection, as indicated on the pesticide label.

Figure 133: Recommended PPEs for applying pesticides

5. Time applications carefully:
    - Apply pesticides during the recommended stages of crop growth and at the appropriate time of day.
    - Avoid application when bees and other beneficial insects are actively foraging.
    - Consider weather conditions, such as wind speed and direction, to prevent drift and unintended exposure.
6. Calibrate and maintain equipment:
    - Regularly calibrate and maintain application equipment, such as sprayers, to ensure accurate and uniform pesticide application.
    - This helps minimise overuse, underuse, and uneven distribution of pesticides, reducing potential risks.
7. Practice IPM: Implement IPM strategies to
    - minimise pesticide use.
    - Monitor pest populations, establish economic thresholds, and utilise alternative control methods such as cultural practices, biological control, and resistant crop varieties, before resorting to chemical pesticides.
8. Follow pre-harvest intervals (PHIs):
    - Adhere to the specified pre-harvest intervals mentioned on the pesticide label. PHIs indicate the minimum waiting period between pesticide application and harvest to ensure residue levels are within acceptable limits.
9. Consider environmental impact:
    - Avoid applying pesticides near sensitive areas, such as schools, hospitals, and water sources.

10. Dispose-off pesticides properly:

- Dispose off unused or expired pesticides according to local regulations or return them to the supplier.
- Avoid pouring pesticides down drains, toilets, or in open fields.
- Contact local waste management authorities for guidance on proper disposal methods.

Common/major pests of kale/spinach in Kenya

Kale is generally more pest & disease resistant than other crops in the *Brassicas* family

The following are the major pests of kale /spinach in Kenya:

i) Diamond back moth (DBM)

ii) Cabbage sawfly

iii) Aphids

iv) Cutworms.

Diamond back moth (DBM)

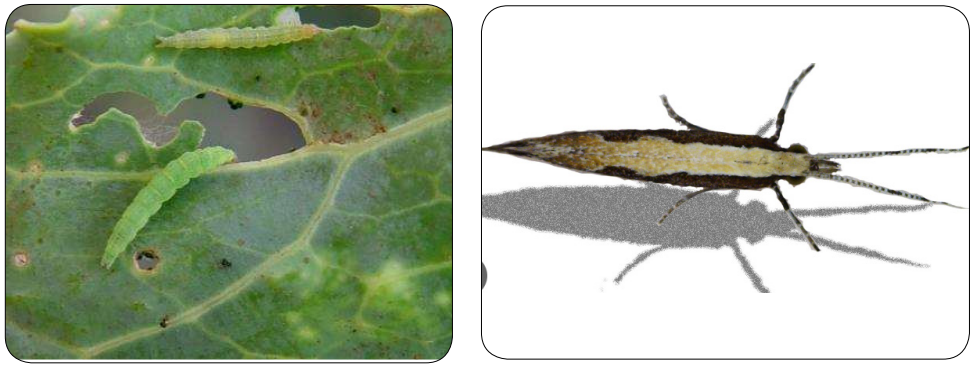

Figure 134: Diamond back moth larvae (Left) and moth (right)

(Source: Infonet Biovision)

Identification:

- The adult is a small grey moth whose wings form a characteristic diamond pattern at the back when closed.
- Larvae are pale yellowish-green to green caterpillars covered with fine, scattered, erect hairs.
- When disturbed, the larvae will wriggle backward violently and may drop from the plant, suspended by a silken thread.

Damages:

- Windows on leaves from feeding by larvae.
- If larvae are numerous, they may eat the entire leaf, leaving only the veins.
- Infestations are normally serious in drier months.

Control:

Control can be through use of cultural practices, use of home-made organic pesticides, commercially available pesticides or inorganic pesticides. Specific methods for control of DBM include:

- Crop rotation: With crops that are different from the kale/spinach family. These include beans, sunflower and maize.
- Intercropping with repellents: Involves planting other crops within the kales/ spinach. e.g. Tomato, onions, coriander or garlic.

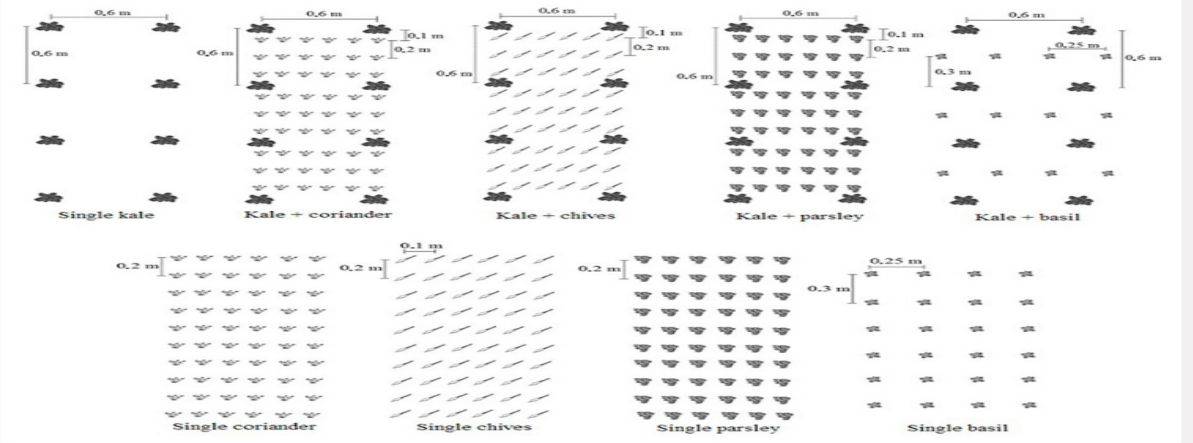

Figure 135: Kales intercropped with coriander, chives, parsley and basil

(Source: Revista Caatinga)

- Use of trap crops e.g. Indian Mustard reduces DBM destruction on kale. The trap crop is intercropped with kales/spinach.

Figure 136: Indian Mustard crop

(Photo by Rose Kennedy)

- Use of biological pesticides, such as those that contain *Bacillus thuringiensis*: The post-harvest interval (PHI) is one day.

- Use of inorganic insecticides.
- Use of natural enemies. There are commercial formulations that feed on the eggs and larval stages.

Note:

Cultural and Biological control methods are preferred since they are friendlier to the environment, are less toxic to users and livestock and have a short PHI.

Cabbage sawfly

Identification:

- Adult insect resembles a fly except for the presence of 2 pairs of membraneous wings with dark head and thorax, and a bright abdomen
- Eggs are laid singly inside the leaf.
- The larvae are greyish green with a black head and more than six pairs of legs.

Figure 137: Cabbage sawfly

(Source: Infornet Biovision)

Damage:

- Windows on leaves from feeding by larvae.
- They feed on the blade of the leaves often leaving only the main veins and midrib.

Management:

- Destruction of wild plants in the Cruciferae (kale) family.
- Use of appropriate pesticides such as those containing methoxyfenozide (at a rate of 240 g per litre) with a PHI of 10 days.
- Use of pyrethrins usually at a rate of 40 g per litre.

Aphids

Identification:

- Aphids are pale green or light green to yellowish green and are usually covered with a light dust of mealy powder, though some types of aphids do not form mealy powder.
- They suck plant sap from the central part of the plant and near the base of leaves.

Figure 138: Aphids on underside of a kale leaf

(Source: Infonet biovision)

Damage:

- Aphid attack results in curled, discoloured and distorted leaves.
- Large colonies of aphids are found on the underside of kale leaves during dry spells causing stunted growth.

Control:

- Field hygiene through removal and destruction of crop residue and alternative wild hosts
- Use of insecticides, such as:
  i) Lambdacyhalothrin with a PHI of 3 days.
  ii) Thiamethoxam with a PHI of 7 days.
  iii) Deltamethrin with a PHI of 1 day.
- Biological control can also be used.

Figure 139: Syrphid fly larva feeding on cabbage aphids

(Source: G. Higgins)

Cutworms

Identification:

- The larvae are greyish black and curl up tightly when disturbed.
- They are often found hiding in soil near the cut seedlings.

Damage:

- They feed and cut-off young seedlings at ground level during the night dragging them into the tunnel in the soil and feed on them during the day.

Figure 140: Cutworm

Symptoms:

- Cut stems.
- Attacked plants wilt and die.

Control:

- Non-chemical methods including the following;
  - i) Hand removal since the pest is easily found near the damaged plant, especially at the beginning of infestation.
  - ii) Early weeding destroys sites for egg laying.
  - iii) Flooding of the field for a few days before sowing or transplanting can help kill cutworm caterpillars in the soil.
- Chemical control: Drench at the base in the evenings. Examples of recommended chemicals include:
  - i) Lambda-cyhalothrin 25 g/l with a PHI of 3 days.
  - ii) Halothrin with a PHI of 3 days.
  - iii) Alpha-cypermethrin with a PHI of 3 days.

Note:

- Seed treatment should be done using chemicals recommended by a reputable agrovet.
- Drenching of the insecticide should be done late in the evening for effectiveness.

Major diseases

Disease infection leads to reduction in quality and quantity of produce. The following are the major diseases of kale and spinach in Kenya:

- Black rot.
- Black leg (Dry rot canker).
- Ring spot.
- Downey mildew.
- Powdery mildew.

i) Black rot

General descriptions:

- This is a seed-borne bacterial disease.
- Black rot infection and spread is favored by wet conditions and high temperatures (20 – 30 ^{0}C).
- Crowded plants provide conditions that are ideal for bacterial spread to nearby plants.

Symptoms:

- In early stages, yellowish-brown V-shaped lesions are observed on the leaf margins of affected plants.
- On the margins of mature leaves, the veins become distinctly black.
- The lesions extend into the leaf, killing large areas of affected leaves.
- A cross-sectional cut of infected stem reveals a characteristic black ring.
- Seedlings that are infected systemically become yellow, drop lower leaves, and may die.

Figure 141: Black Rot

(Source: Infonet Biovision)

Control:

- Use certified planting material.
- Use of tolerant varieties e.g. collards.
- Practice field sanitation (hygiene).
- Minimum two-year crop rotation.
- Spray with copper fungicides when the first symptoms are seen.

ii) Black leg (Dry rot canker)

General descriptions:

- This is a seed-borne disease caused by a fungus.
- The inoculum is spread by infected plants, garden tools and crop debris.

Symptoms:

- Leaves have light brown spots which may be circular and which later develop ash-grey centres with many black spots.
- Severe stem infection results in a dark dry rot above the soil line which extends below and kills the roots.
- Affected plants wilt abruptly and die.

Figure 142: Symptoms of Black leg in kales

(Source: www.ecoport.org)

Control:

- Use of certified seed.
- Avoid use of side shoots as they come with the disease.
- Avoid nursery beds where kales and related crops have previously been planted.
- Practice field sanitation (hygiene) by removing and destroying infected material and weeds.
- 3 - 4-year crop rotation with non-brassica crops e.g beans, maize, sweet potato e.t.c
- Disinfect farm tools with bleaches containing Sodium Hypochlorite.
- Uprooting and burning of infected plant.
- Ensure proper drainage and prevent of surface run water that would spread the disease.
- Use of Trichoderma-based products.

iii) Ring spot

Figure 143: Ring spot

Source: Infonet Biovision

General descriptions:

- This is a seed-borne fungal disease.
- Infected compost is the source of the inoculum and it is spread by wind.

Symptoms:

- Circular brown grey spots on the leaves which are often bordered by a green margin and with black – specked concentric zones.

Control:

- Use of certified seeds
- Practice field sanitation - remove and destroy infected plants.
- Crop rotation for at least 2 years.
- Use of fungicides such as those containing Copper Oxychloride with a PHI of 3 days.

iv) Downey mildew

General descriptions:

- This is a seed-borne fungal disease.
- Spread by wind, rain, and overhead irrigation.
- It is severe at high elevations where the conditions are cool and wet.

Symptoms:

- Fluffy fungal growth on the underside of leaves which later produce brown to black spots on the upper surface.

Figure 144: Downey mildew

(Source: Infonet Biovision)

Control:

- Remove infected plant parts from affected plants in the farm and bury.
- Disinfect farm tools with bleaches containing Sodium Hypochlorite.
- Ensure proper drainage.
- Uproot and destroy by burning or burying infected plants 2 feet/60 cm deep.
- Enhance air circulation to reduce humidity in the field.
- Use recommended soft and safer (WHO Class III) fungicides with low PHI levels (e.g. Iprodione-based fungicides).
- Use of pesticides containing Metalaxyl+Mancozeb with a PHI of 7 days.

v) Powdery mildew

General descriptions:

- This is a fungal disease that affects a wide range of plants.
- Powdery mildews are severe in warm and dry climates.

Symptoms:

- Appears as white, powdery spots that may form on both surfaces of leaves.
- Leaves infected with Powdery mildew may gradually turn completely yellow, die, and fall off.

Figure 145: Powdery mildew

(Source: Infonet Biovision)

Management

- Crop rotation for 2-3 seasons with non-brassicas.
- Use recommended spacing to avoid overcrowding and enhance aeration.
- Observe field hygiene.
- Uproot and destroy severely infected plants and bury deep (2 ft/60 cm) or burn.
- The disease is transmitted through splash water (when it is raining), wind and residues of affected crops. To reduce transmission, consider applying mulch.
- Avoid overhead irrigation to reduce splash.
- Spray plants with baking powder solution (0.5 teaspoon in 1 l of water) at initial stages
- Spray with sulphur or azoxystrobin-based chemicals.

Top dressing

This is the addition of foliage boosting fertiliser in order to increase foliage/vegetative growth of the plant. Top dressing has the following advantages:

- Enables kales/spinach to produce good quality broad leaves,
- Ensure continued growth and development,
- Maintains vigour healthy leaf growth and to ensure unlimited photosynthetic growth.

It is recommended to apply top dressing fertiliser 3 weeks after transplanting. If organic manures were used at planting, top dressing may be delayed to the fifth week.

Figure 146: Ring application of top dressing fertiliser

How to apply top dressing fertiliser

The following are the common methods of applying top dressing fertilisers

- Banding – This is where fertiliser is applied between the rows.
- Ring application – This is where fertiliser is applied in a ring around an individual plant along the canopy line.

Steps in top dressing kales and spinach

i) Acquire the recommended type of fertiliser /manure/ foliar.

ii) Gather the tools and equipment needed for measuring and applying fertiliser/ manure.

iii) Apply a teaspoonful (5 g) of CAN per plant/NPK 5g per plant (1 teaspoon).

iv) For manure, apply two handfuls of well-decomposed manure around each plant.

v) For foliar feeds, apply as per the manufacturer's instructions.

vi) Cover the fertiliser with some soil and water.

Benefits of top dressing

Top dressing has the following benefits

- It improves crop vigour.
- Increases the size and quality of leaves.
- Increases yield.

Types of top dressing fertilisers

The following fertilisers may be used for top dressing:

- CAN - 26:0
- NPK - 23:23:0
- Manure - farmyard/compost
- Inorganic/organic foliar fertiliser.

Foliar application

This involves use of foliar feed by spraying on leaves.

Rates of fertiliser application

Two (2) split applications of top dressing fertilisers are recommended to replenish soil nutrients status.

If CAN is to be used:

- First top dressing - Apply CAN at rate of 5 g per plant (1 teaspoonful), 3 weeks after transplanting or when the crop is 20 cm tall.
- Second top dressing – Apply NPK at rate of 10g per plant (1 tablespoonful) 8 weeks after transplanting.

If manure is to be used:

- Two handfuls of well-decomposed manure should be spread around the plant base.
- Application may be done in the 3rd week and done once.

If foliar is to be used:

- Follow manufacturer's recommendations.

Caution:

Too much nitrogen causes the vegetables to have a deep-green coloration which is undesirable.

Mulching

Mulching is the application of organic or inorganic material over the surface of the planted field. Mulching is an important management practice as it helps in smothering weeds, conserving moisture in the soil and also helps in keeping the kales/spinach leaves clean (free from dust). It is best done after first top dressing.

Benefits of mulching

Mulching has the following benefits to kales and spinach;

- Smothering weeds.
- Moisture retention.
- Helps in reducing dust on crop. Dust lowers leaf quality.
- Helps in preventing soil erosion by slowing down heavy rain splash.

Steps in mulching

The following steps are followed during mulching:

i) Identify suitable and available materials for mulching e.g. dry seedless grass.
ii) Gather the materials on the site.
iii) Place a thin layer of the mulch along the rows.

Figure 147: Mulched spinach

(Source: Plantura)

iv) After completion of harvest season incorporate the mulch material into the soil, this helps in improving the soil structure and boost organic matter.

Caution:

- Avoid using green plant materials as mulch.
- Avoid allelopathic plants. These are plants whose leaves suppress other plants.

Management of soil moisture

- Kales/spinach requires an optimal amount of 750 mm of rainfall during the growing period.
- In areas with lower rainfall, water deficit problems should be addressed through irrigation. Irrigation is the provision of water to the plant when the soil does not have adequate moisture.
- It is needed in areas where rainfall is inadequate or inconsistent.
- Provision of water is important as this promotes continuous growth.
- Regular watering will keep the leaves growing continuously.

What to consider when choosing an irrigation system

There are many factors that influence the choice of an irrigation system. The ideal system must satisfy the following criteria:

- Should use water efficiently.
- It must be easily manageable.
- Should require minimal maintenance.
- Must be easy to control and handle.

Steps in irrigation

i) Determine the level of soil moisture e.g. by use of soil moisture meter or other appropriate method e.g. by hand.

ii) Pick a handful of soil and roll the soil into a ball using your hands. If the findings are as follows:

- Soil forms a ball – it indicates the soil does not require irrigation.
- Soil not forming a ball – it indicates the soil requires irrigation.

Using the most appropriate irrigation method as determined in the presentation on irrigation methods in above section, apply water depending on prevailing soil water condition.

Irrigation methods

The common irrigation methods for kales/spinach include:

- Overhead /sprinkler.
- Furrow irrigation.
- Drip irrigation.

i) Overhead irrigation

This is where high pressure water is sprayed on top of kales/spinach leaves using sprinkler. The following steps are used in installing drip irrigation.

- Align pipes at different distances depending on your water pressure and sprinkler power.
- Join sprinklers at different distance depending on your water pressure and sprinkler power. Make sure the circles are able to meet at a common point.

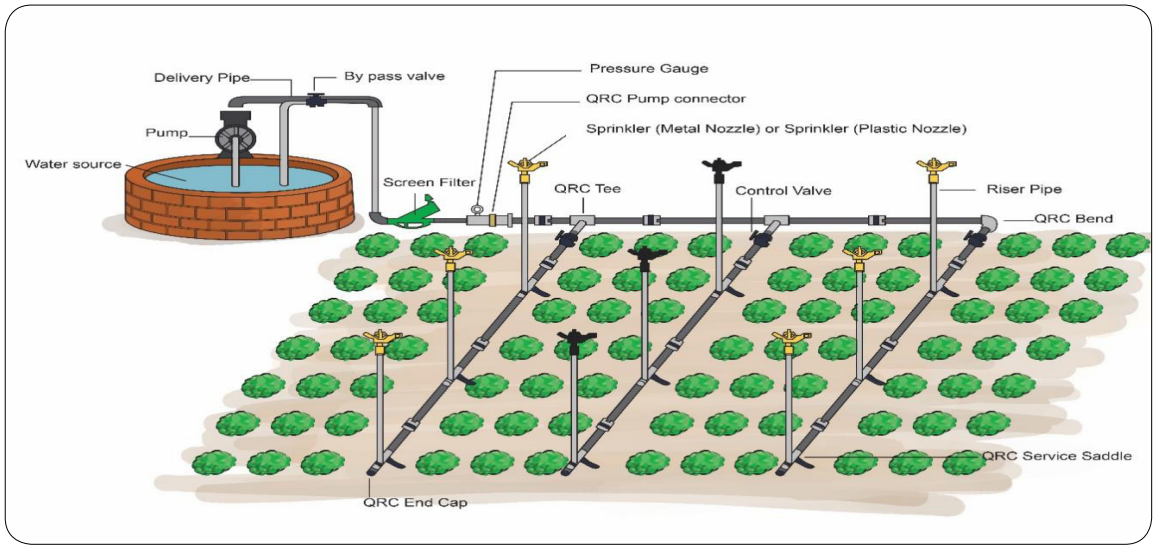

Figure 148: Overhead irrigation

Advantages of overhead irrigation

- It is faster in watering.
- Enables good water coverage on the crop.
- Needs low labour during watering.

Disadvantages of overhead irrigation

- Not economical in water usage.
- Causes fungal diseases due to excess water.
- Encourages weed emergence.

ii) Drip irrigation

Drip irrigation is micro irrigation where well-prepared beds are laid with drip line, where nutrient can be given to crops during irrigation (by use of drip lines along the rows).

- In a well-prepared bed measure and peg a width of 40 cm and length of your choice
- Align two drips at the width measured.
- Make sure all the water emitters are facing up wards.
- Tie the drip line at the end of the beds. Make sure all drip line is tightly tied.

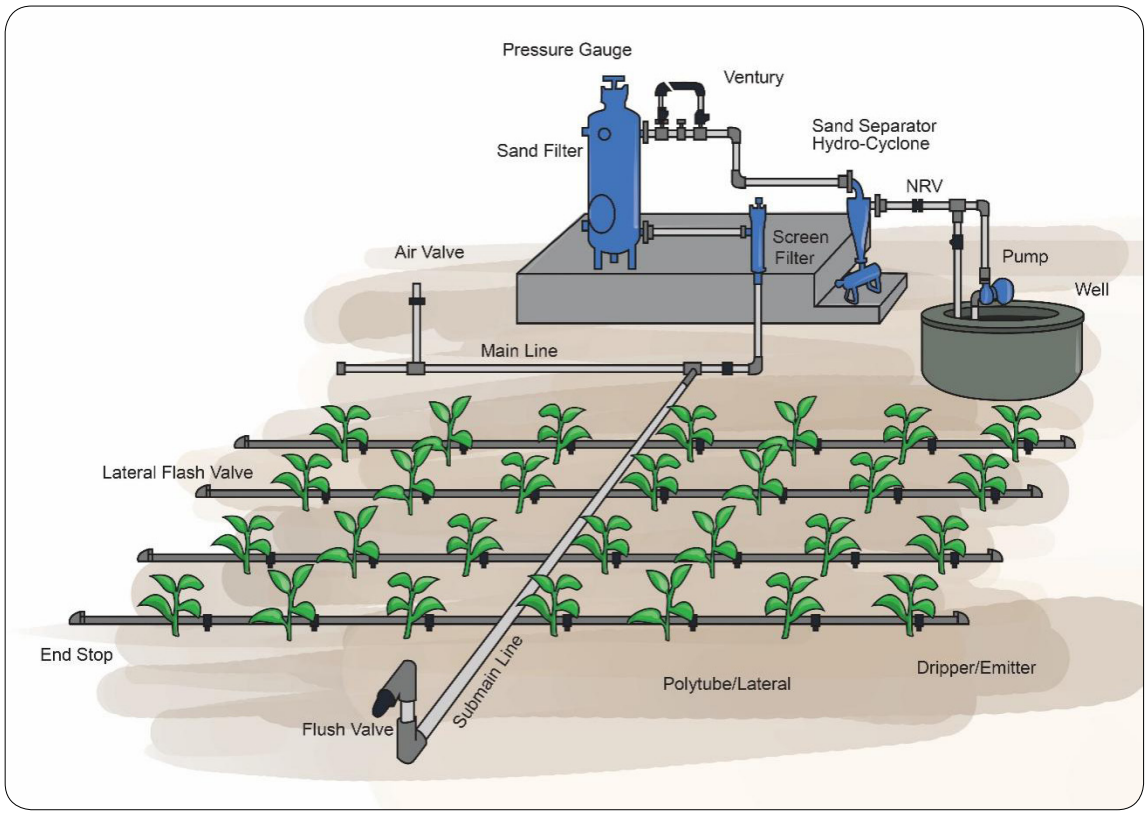

Figure 149: Drip irrigation

Advantages of drip irrigation

- Low cost of watering due to economical water use
- Needs less labour during watering.
- Efficient in water distribution.

Disadvantages of drip irrigation

- Requires skilled manpower
- High cost of installation.
- Highly affected by rodents.
- It is hard to identify suitable irrigation methods.

4.2.2.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • Machete/ *panga* • Rake • Slasher • Spade • Trowel	• Watering can • Knapsack sprayer • PPEs • Wheelbarrow • Water tank	• Pesticides • Organic and inorganic fertiliser • Clean water • Drip lines • Healthy seedlings • Hand gloves • Measuring containers e.g. bottle tops or spoons • Mulching materials • Pest and disease identification card • Magnifying lens • Pest traps • Pheromone traps

4.2.2.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1) Name three materials that you can use to mulch a kale/spinach plot.
2) What are the bad effects of weeds on kales/spinach?
3) Name the PPEs that you would put on for spraying.
4) Name four crops that you can rotate with kale/spinach to manage pests and diseases.
5) Name three cultural methods you could use to manage cutworms.
6) How can you monitor pest populations in the kale/spinach field?
7) Match the following photos with their right name.

	Cabbage sawfly

	Diamond back moth
	Cutworms
	Aphids

8) Why is it recommended to use WHO Class III fungicides?

Notes:

4.2.2.5 References

Ruth A., Anthony N., Violet K. and Lusike W. (2021) Kale Diseases fact sheet, Kenya Agricultural & Livestock Research Organisation (kalro.org)

Ministry of Agriculture and Irrigation (n.d). Training and learning guides for kales/ spinach producers. GIZ Agriculture Programme/CAADP ATVET/NEPAD

MOALF/SHEP PLUS (2019). Kale Production: "Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell"". Smallholder Horticulture Empowerment & Promotion Project for Local and Up-Scaling (SHEP PLUS). Ministry of Agriculture, Livestock and Fisheries (MOALF), Agriculture and Food Authority (Horticultural Crops Directorate (HCD)) of the Republic of Kenya and the Japan International Cooperation Agency (JICA).

4.2.3 Learning Outcome 3:
Harvest Kales/Spinach

4.2.3.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify tools and equipment used in harvesting kales and spinach.
- Determine maturity indices of kales and spinach.
- Identify appropriate methods of harvesting kales and spinach.
- Handle, transport and store harvested kales and spinach.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify tools and equipment.	• Organise a visit to the store, mark the tools and let the trainees identify them one by one. • Show trainees pictures of tools and equipment and allow them to name each tool/equipment and its function.	• Harvesting tools and equipment • Marker pens • Note book • Pictures of the tools and equipment
• Determining maturity indices.	• Conduct brainstorming session for the trainees to suggest when harvesting of kale/spinach should be done. • Organise for field trips to a kale/spinach farm for the trainees to observe the different maturity indicators for kales and spinach.	• Flipcharts • Marker pens • Access to an established a kale/spinach farm
• Identifying harvesting methods.	• Facilitate group discussion on the methods of harvesting kales. • Demonstrate the various methods of harvesting kale/spinach followed by practice by trainees.	• Sharp knife • Established kale/spinach farm • PPEs
• Handling, transporting and storing harvested kale/spinach	• Probe trainees through question-and-answer to determine proper handling, transportation and storage of kale/spinach. • Give direct instructions to the trainees on how to handle, transport and store kale/spinach as they practically undertake harvesting, handling and storage of kale/spinach.	• Harvesting tools and equipment • Established kale/spinach farm • PPEs
• **Duration: 10 hours**		

4.2.3.2 Information Sheet

Maturity indices for kales and spinach

Maturity indices are indicators used to determine when the crop is ready for harvest. Maturity for spinach and kales is determined by:

1. **Leaf size:** The leaves of kale/spinach should reach a desirable size, typically 10 to 20 cm long, before harvesting. For many varieties, leaf size of the palm or larger are preferred. Smaller leaves may lack the desired flavor and texture.
2. **Leaf color:** Kale/spinach leaves should have a deep, rich green color. Younger leaves tend to be lighter in color, while mature leaves darken.

Figure 150: Mature harvested kales and mature spinach

(Source: www.istockphoto.com/photos/kale)

3. **Leaf texture:** Mature kale/spinach leaves should be crisp and firm. Avoid harvesting leaves that are wilted or have yellowing edges.
4. **Taste:** Taste a small sample leaf to determine if the kale/spinach has developed the desired flavour. Kale/spinach can be harvested at any stage, but mature leaves tend to have a stronger taste.

Harvesting of kales and spinach

- Harvesting begins at 6 weeks after transplanting and it can go up to 4-6 months. Harvesting kale/spinach is done by cutting the lower/outer mature leaves and leaving at least four inner leaves to continue growing.
- This will allow for multiple harvests. A sharp knife or scissors should be used to cut the leaves 5 to 10 cm from the stem.

Machine harvesting can also be used for large scale farms

You can watch how this is done by accessing the link below:
https://www.youtube.com/watch?v=lpqmHwrJK78

Note:

If you see discoloured or heavily insect-eaten leaves, make sure to remove these and discard them, or add them to the compost pile. This allows the plant to put its energy into new and healthy growth. It's also a good time to check for slugs, aphids, and other damaging pests.

Handling of harvested leaves

- Handle the harvested leaves carefully to prevent damage and ensure freshness.
- Crates can be used to prevent breakages.
- Rinse them thoroughly before use, and store them properly in a cool, humid environment to maintain quality.
- You can also refrigerate to maintain their quality.

Food safety considerations

For a kale/spinach harvesting and packing operation, some of the main food safety concerns are:

- **Glove policy** – Since gloves are required, there needs to be a glove policy enforced. This means that the gloves are controlled by the company, and that they are either disposable or able to be washed, and are changed out appropriately. If the gloves are washed, the company needs to control the cleaning of the gloves.
- **Cleaning and sanitation of the harvesting knives** – Cleaning and sanitising of the knives needs to occur on a regular and frequent basis. In addition to this being on a schedule and controlled by the company, there also needs to be a knife dip to store the knives in while the workers are on break.
- **Cleaning and sanitation of the conveyor line** – Every piece of harvested product touches the conveyor line between being harvested and packed, so it needs to be cleaned and sanitised to prevent any potential cross-contamination issues to the product.

Transportation of harvested produce

- During harvesting keep the harvested leaves under a shade to avoid loss of moisture (weight).
- Package the kales/spinach in appropriate crates avoid damage to the leaves
- Transport with the available means e.g. wheelbarrow or carts to the storage or market.
- Cooling/refrigeration is necessary to prolong shelf life.

Figure 151: Crate for placing harvested produce

4.2.3.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Sharp knife	• Weighing scale	• Personal Protective Equipment (PPEs) • Water • Packaging materials • Plastic crates or buckets

4.2.3.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Which of the following is not among the tools, equipment and materials used for harvesting kale/spinach?
   - ☐ A. Sharp knife
   - ☐ B. Weighing scale
   - ☐ C. Buckets/Crates
   - ☐ D. Fork
2. What is the right time for harvesting kales and spinach?
3. How long does kales/spinach take to mature for first harvesting?
4. What are the signs for maturity of kales and spinach?
5. Explain methods used for harvesting kales/spinach?
6. How do we maintain freshness and quality of harvested kales and spinach?

Notes:

4.2.3.5 References

Gil, M.I., Tudela, J.A, Martinez-Sanshez, A and Luna MC (2012). Stewawrd Post-harvest. *https://www.researchgate.net/profile/Ascension-Martinez-Sanchez/publication/274927749_Harvest_maturity_indicators_of_leafy_vegetables/links/58e3cf590f7e9b075130763e/Harvest-maturity-indicators-of-leafy-vegetables.pdf*

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MOALF/SHEP PLUS (2019). Kale Production: "Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell"". Smallholder Horticulture Empowerment & Promotion Project for Local and Up-Scaling (SHEP PLUS). Ministry of Agriculture, Livestock and Fisheries (MOALF), Agriculture and Food Authority [Horticultural Crops Directorate (HCD)] of the Republic of Kenya and the Japan International Cooperation Agency (JICA).

4.3 Model Responses to Self-Assessment Questions

4.2.1 Learning Outcome 1:

Establish Kales and Spinach

1. Which of the following is not an essential considering when sourcing kale/spinach seedlings for transplanting?

   C. Presence of potting container

2. Which of the following statements is TRUE?

   C. Raw manure can introduce pests and diseases to your plants

3. You should transplant seedlings in the ***evening*** to reduce stress to the plant. Immediately after transplanting ***water*** the transplanted seedling thoroughly.

4. Why is it important that you mix fertiliser with soil before planting your seedlings?

   A. To avoid scorching

5. Which of the following statements is FALSE?

   B. Smaller spacing when transplanting kale/spinach seedlings increases yields

4.2.2 Learning Outcome 2:

Manage Kales and Spinach

1. Name three materials that you can use to mulch a kale/spinach plot.

   Dry grass, crop residue e.g bean or rice straw, wood chips, or plastic film.

2. What are the bad effects of weeds on kales/spinach?

   Weeds compete with crops for resources, including water, nutrients, and sunlight, and can negatively impact crop growth and yield.

3. Name the PPEs that you would put on for spraying.

   Gloves, goggles, long-sleeved overall, and respiratory protection/spraying masks and gumboots.

4. Name four crops that you can rotate with kale/spinach to manage pests and diseases.

   Beans, sunflower, cow peas, Irish potato and maize.

5. Name three cultural methods you could use to manage cutworms.
   - **Hand removal.**
   - **Early weeding to destroy sites for egg laying.**
   - **Flooding of the field for a few days before sowing or transplanting.**
   - **Chemical control.**

6. How can you monitor pest populations in the kale/spinach field?
   - **By routine scouting to check individual crops.**
   - **By use of pheromone traps to trap pests.**
   - **By use of sticky traps where pests get stuck.**

7. Match the following photos with their right name

	***Cutworms***
	***Aphids***
	***Diamond back moth***
	***Cabbage sawfly***

8. Why is it recommended to use WHO Class III fungicides?
   - **They are less toxic to the user.**
   - **They have short PHI.**
   - **They cause less harm to the environment.**

4.2.3 Learning Outcome 3:

Harvest Kales and Spinach

1. Which of the following is not among the tools, equipment and materials used for harvesting kale/spinach?

   D. Fork

2. What is the right time for harvesting kales and spinach?

   Early in the morning or late in the evening when the temperatures are low.

3. How long does kales/ spinach take to mature for first harvesting?

   It takes about 6 weeks after transplanting.

4. What are the signs for maturity of kales and spinach?
   - **Leaves should reach a desirable size of 10-20cm long.**
   - **Mature kales/spinach should be firm.**
   - **Leaves for kale/spinach should be deep-green in colour.**

5. Explain methods used for harvesting kales/spinach.
   - **Individual leaf harvesting method, involves picking individual leaves with suitable size from the plant.**
   - **Cut and come again method involves harvesting outer leaves while leaving central part of the plant intact for further growth.**
   - **Whole plant harvesting involves holding the base of the plant with one hand and use sharp knife to cut the plant just above the soil level, or uproot it gently.**

6. How do we maintain freshness and quality of harvested kales and spinach?
   - **By proper handling to prevent damage of harvested kales and spinach.**
   - **By rinsing in clean water before use and storing in a cool humid environment.**

5 Process and Market Leafy Vegetables

5.1 Introduction to the Chapter

This unit specifies the competencies required to process and market African leafy vegetables, kales and spinach. It involves setting-up African leafy vegetables, kales and spinach processing unit, sourcing African leafy vegetables, kales and spinach, preparation of African leafy vegetables, kales and spinach for processing, production of African leafy vegetables, kales and spinach products, packaging of African leafy vegetables, kales and spinach products, maintenance of quality of African leafy vegetables, kales and spinach products, management of waste from African leafy vegetables, kales and spinach processing and lastly marketing of African leafy vegetables, kales and spinach.

5.2 Summary of Learning Outcomes

The content of this this Chapter will enable the trainee or farmer to;

- Prepare leafy vegetable processing unit.
- Source leafy vegetables.
- Prepare leafy vegetables for processing.
- Produce processed leafy vegetable products.
- Package leafy vegetable products.
- Maintain leafy vegetable product quality.
- Manage processing wastes.
- Market leafy vegetable products.

5.2.1 Learning Outcome 1:
Prepare ALV Processing Unit

5.2.1.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Select AL vegetable to process.
- Identify and assemble tools/equipment/material to be used at the unit.
- Adhere to health and safety measures in the unit.
- Set up the processing unit in order of the process flow ready for use.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Select ALV to process.	• Demonstrate by trainer combined with practice by trainees on ALV selection. • Facilitate group discussion or plenary on vegetable to process.	• ALVs samples • Photo images/ videos of ALVs
• Identify and assemble tools/ equipment/ material to be used at the unit.	• Use video/images for trainees to identify tools/equipment/material to be used at the unit. • The trainees to practice assembling of tools/ equipment/material to be used at the unit.	• LCD projector • Computer
• Adhere to health and safety measures in the unit.	• Use video/images for trainees to observe health and safety measures. • The trainees to practice the use of PPEs.	• Photo images/ videos of health and safety measures
• Set up the processing unit in order of flow.	• Facilitate simulation of the trainees to set up the process unit in order of flow of activities. • Use video/images depicting the flow • Demonstrate how the preparation is done on actual terms like cleaning the unit, disinfecting, arrangement of tools and equipment into respective areas.	• Photo images/ videos of processing unit
• **Duration: 10 hours**		

5.2.1.2 Information Sheet

Introduction

Processing involves the methods and techniques used to transform harvested leafy vegetables into direct food consumption by humans.

Importance of vegetable processing

- Preserves the color, flavor, texture, and nutritional value.
- Prolong the shelf life of perishable vegetables.
- Ease marketing and distribution of vegetables.
- Eliminate microorganisms and toxins that may cause disease.
- Adds value to the vegetables.

Figure 152: Value addition of leafy vegetables

Leafy vegetable products

There are various products that can be processed from leafy vegetables. These include;-

- Fresh leafy vegetables
- Dried leafy vegetables
- Leafy vegetable seeds
- Powders/flour
- Pickles and chutney
- Cooked
- Sauces
- Purees
- Salads
- Juice

Table 29: Sample of processed leafy vegetable products

Figure 153: Packaged fresh black night shade

Figure 154: Pickled leafy vegetables

Figure 155: Dried cow pea leaves

Figure 156: Cow pea seeds

Figure 157: Amaranth flour

(Source: www.schaer.com)

Figure 158: Leafy vegetable juice

(Source: Just Made)

Figure 159: Creamed spinach

(Source: The Kitchen)

Figure 160: Frozen Jute mallow leaves

(Source: Simba Lifestyle)

Figure 161: Pre-cooked black night shade

(Source: kienyejis)

Figure 162: Leafy vegetable salad leaf

(Source: Produce processing)

- Identifying and selecting a vegetable product to process is informed by market demand and business objectives.
- The vegetable product to process further informs the kind of processing unit to set up.

Vegetable processing unit

It includes the land, buildings and structures, machinery and equipment, furniture, stationery and electrical equipment and manpower that are needed in processing of the vegetable products.

An ideal vegetable processing facility should provide for:

- Maintenance of hygiene standards.
- Enough lighting and ventilation.
- Personal safety for personnel.
- Proper waste disposal.
- Adequate working space for all processing activities. Space for amenity rooms. These include;
  - **Changing room** where clothing and shoes that are not worn for work can be stored.
  - **Separate hand-washing facilities** for staff, with soap, clean water, nail brushes and clean towels.
  - **Toilets,** which should be separated from the processing room by two doors or located outside the building.
- Office work space.
- Fully equipped first aid kits.
- Security against entry of contaminants.
- Storage of chemicals in a facility separate from the processing room.

Figure 163: Key activities in a vegetable processing unit

- There are various tools, materials and equipment needed for processing African leafy vegetables, kales and spinach products, these include;

Figure 164: Vegetable blanching equipment

Figure 165: Chest refrigerator

Figure 166: Weighing balance

- It is important to ensure safety and health measures within the processing unit by wearing PPEs and installing safety hazards signs, warnings, rules and regulations.
- Identify and acquire all the required permits and licenses to operate your vegetable processing business. These include;
  - Business registration certificate.
  - County business permit.
  - Food handler's certificate.

Table 30: Sample food handlers certificate

NAIROBI CITY COUNTY

File

Tell 020-344194, 0725-624489, 0735-825383
Email: info@nairobi.go.ke
Emergency

Bill No. MS2110-1500006 **Tel No: 0202222181** **Date Issued 10-05-2021**

CUSTOMER SERVICES OFFICE

The Customer Services Office Notifies

Simon Mwangi Wafula
That the amount shown is due to be paid at the national bank of Kenya or MPESA (Pay bill No.367776. Account No. MS211011. Amount KES1,000) at your earliest convenience.

Simon Mwangi Wafula

DETAIL OF CHARGES

NO	Account Number	Description	Amount (KESH)

- The processing unit is then set up in order of the process flow ready for use to ensure seamless operations.

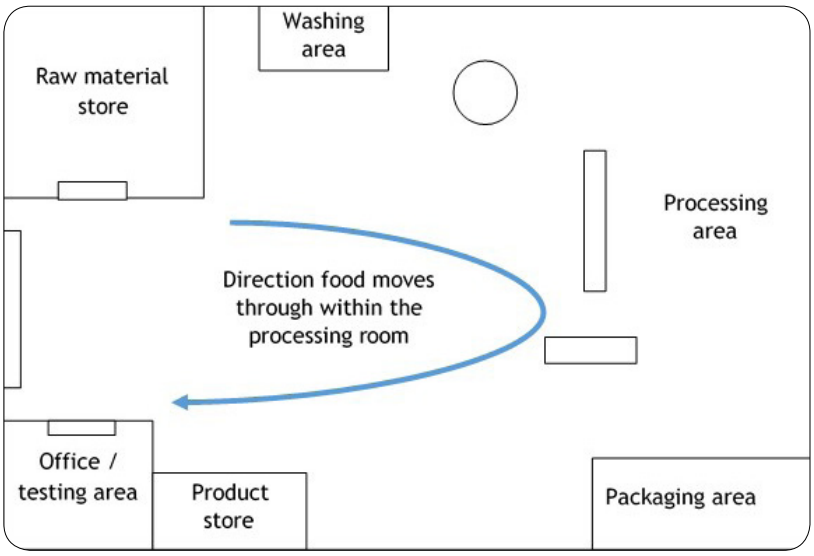

Figure 167: Sample vegetable processing unit floor plan layout

5.2.1.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Knives • Buckets • Spoons • Bowls • Basins • Soft brush • Crates • Trays • Shredders • Strainer • Dicers • Floor mops	• Weighing scales • Sealers • PPEs • Refrigerator • Trolleys • Boilers • Thermometers • Working benches • Packaging equipment • Firefighting equipment • Blenders • Juice extractors • Fire extinguisher	• Packaging materials • Leafy vegetables • Labels • Stationery • Water • Seals • First aid kits • Hand towels • Waste collection equipment • Solar drier • Refrigerator • Juicer • *Sufuria* and accessories • Basket • Energy source • Tables and working surfaces • Ingredients • Steriliser/disinfectant

5.2.1.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1 Which of the following is not among ALVs, kales and spinach products?

☐ A) Flour ☐ B) Syrup ☐ C) Cooked ready to serve ☐ D) Juice ☐ E) Nectar
☐ F) Jelly ☐ G) Sauce ☐ F) Pickles

2 How do you select a suitable ALV to process?

3 What is the importance of processing ALVs, kales and spinach?

4 What factors should you consider when setting up a vegetable processing unit?

Notes:

5.2.1.5 References

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5.2.2 Learning Outcome 2:
Source Leafy Vegetables

5.2.2.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;-

- Identify/map out potential suppliers.
- Purchase/procure quality and quantity of ALVs from the mapped-out suppliers.
- Conduct quality checks on the vegetables.
- Collect/receive ALVs for processing.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify potential suppliers.	• Conduct excursion/field visits to the potential supplier/grower areas to find out on supply availability. • Use of digital supplier sites/apps for demonstration on identifying and accessing new suppliers. • Facilitate brainstorming session on the existing suppliers within the trainees' localities	• List/database of existing suppliers • Digital supply and market apps/sites
• Procure quality ALVs from the mapped suppliers.	• Facilitate role-play in vegetable buying. • Facilitate a field visit to buying areas/ markets. • Directly instruct/demonstrate to trainees on purchasing through contract agreement by facilitating trainees to practice filling the same.	• Meta plan cards • Means of transport
• Conduct quality checks on the vegetables	• Simulate on how to conduct quality checks on vegetables. • Demonstrate to the trainees on how to conduct quality checks on vegetables. • Practice quality checks on the vegetables. • Invite a guest speaker to elaborate on conducting quality checks on vegetables • Display images and videos on conducting quality checks.	• Samples of vegetables • Vegetables Quality Standards manual • LCD projector • Guest speaker • Images/videos on quality check procedures

• Collect/ receive ALVs for processing.	• Organise a field visit to a processing facility/market to observe collecting/ receiving of vegetables for processing. • Display videos on collecting and receiving of vegetables for processing.	• Means of transport • Videos on collection and receiving of vegetables for processing
• **Duration: 6 hours**		

5.2.2.2 Information Sheet

Definition of terms

Supplier - a person or organisation that provides something needed such as a product or service.

Potential suppliers - any person or entity which has been contacted by or otherwise identified by your business as a possible supplier.

Purchase/procure - agreeing to terms and buying goods, services, or other works from an external source, often with the use of a tendering and contractual process.

Quality checks - procedure or set of procedures intended to ensure that a delivered vegetable adheres to a defined set of quality criteria or meets the requirements of the client or customer.

Bulking - is the process of creating a common pool of producers or suppliers of the vegetables towards long-term sustainability in processing. This enables you to access a steady market, have higher bargaining power, attract better pricing and expand marketing opportunities thus attracting inherent demand. This can be achieved through;

- Supplier contracting
- Cooperatives
- Farmer groups.

Identifying and selecting potential suppliers depends on the following factors as illustrated below;

Figure 168: Factors to consider while selecting potential suppliers

- Contract supplying is an agreement by which a seller promises to supply all of the specified vegetables that a buyer needs over a certain time and at a fixed price, mode of payment and delivery and the buyer agrees to purchase such vegetables exclusively from the seller during that time.

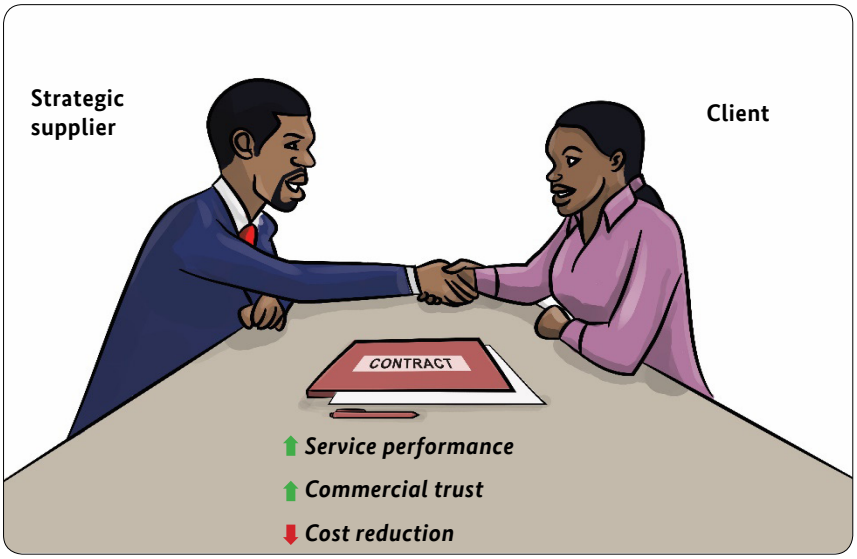

Figure 169: Supplier contracting

- Conduct quality checks for purposes of ensuring standard conformity and compliance of the expected characteristics.
- Select African leafy vegetables, kales and spinach for processing based on the criteria below:
  - Fresh, desired colour and texture.
  - Crispiness, size and uniformity.
  - Aroma and flavour.
  - Clean from any dirt, blemishes and mechanical injury.
  - Free from insect damage and debris.

Figure 170: Fresh jute mallow leaves

Collecting/receiving ALVs, kales and spinach

- The overall procedure of receiving these vegetables at the bulking centre or processing unit is as listed below:
  - Document information on the collected/received vegetables.
  - Weigh the vegetables received.
  - Grade of the vegetables received.
  - Sort out the vegetables (remove the blemished, diseased, and pest-infested).
  - Clean the vegetables ready for processing.

5.2.2.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Phone	• Weighing scale • Carrier bags • PPEs • Trays • Means of transport • Refrigerator • Trolleys • Working benches	• Purchase agreement/contracts • Pen • Record book • Calculator • Spinach • ALVs, kales and spinach

5.2.2.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What are the factors to consider when selecting a potential supplier?
2. What is the importance of supplier contracting?
3. What quality checks would you perform while collecting/receiving vegetables?
4. Which are the bulking strategies for ALVs, kales and spinach?

Notes:

5.2.2.5 References

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5.2.3 Learning Outcome 3:

Prepare Leafy Vegetables for Processing

5.2.3.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;-

- Sort and grade ALVs, kales and spinach for processing.
- Clean ALVs, kales and spinach for processing.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Sort and grade vegetables for processing.	• Demonstration by trainer on sorting and grading of the vegetables for processing. • Trainees to practice sorting and grading of vegetables. • Display images/videos on sorting and grading of the vegetables for processing. • Organise a field visit for the trainees to observe and practice sorting and grading of the vegetables for processing.	• Sample vegetables for sorting and grading. • Images and videos of sorting and grading procedures. • LCD projector.
• Clean vegetables for processing.	• Demonstration by trainer on how to clean vegetables for processing. • Trainees to practice cleaning of vegetables for processing. • Display images/videos on cleaning of the vegetables for processing. • Organise a field visit for the trainees to observe and practice sorting and grading of the vegetables for processing.	• Sample vegetables for cleaning. • Images and videos of vegetables cleaning procedures. • LCD projector.
• **Duration: 4 hours**		

5.2.3.2 Information Sheet

The following activities are carried out when preparing leafy vegetables for processing;

i) **Sorting** - involves the removal of foreign matter, shrivelled, damaged or mouldy vegetables and thus prevents contamination of processed products.

Steps in sorting

- Assemble the sorting materials, tools and equipment.
- Set up the sorting table.
- Spread the vegetables on the table.
- Remove rotten, shrivelled, damaged and mouldy vegetables.
- Weigh the sorted vegetables.
- Record the weighed vegetables.
- Dispose-off the waste generated safely.

ii) **Grading** – involves classifying leafy vegetables according to the size, shape, colour, dry matter, freshness, flavour, aroma, weight and volume.

Figure 171: Weighing leafy vegetables

Figure 172: Sorting of vegetables

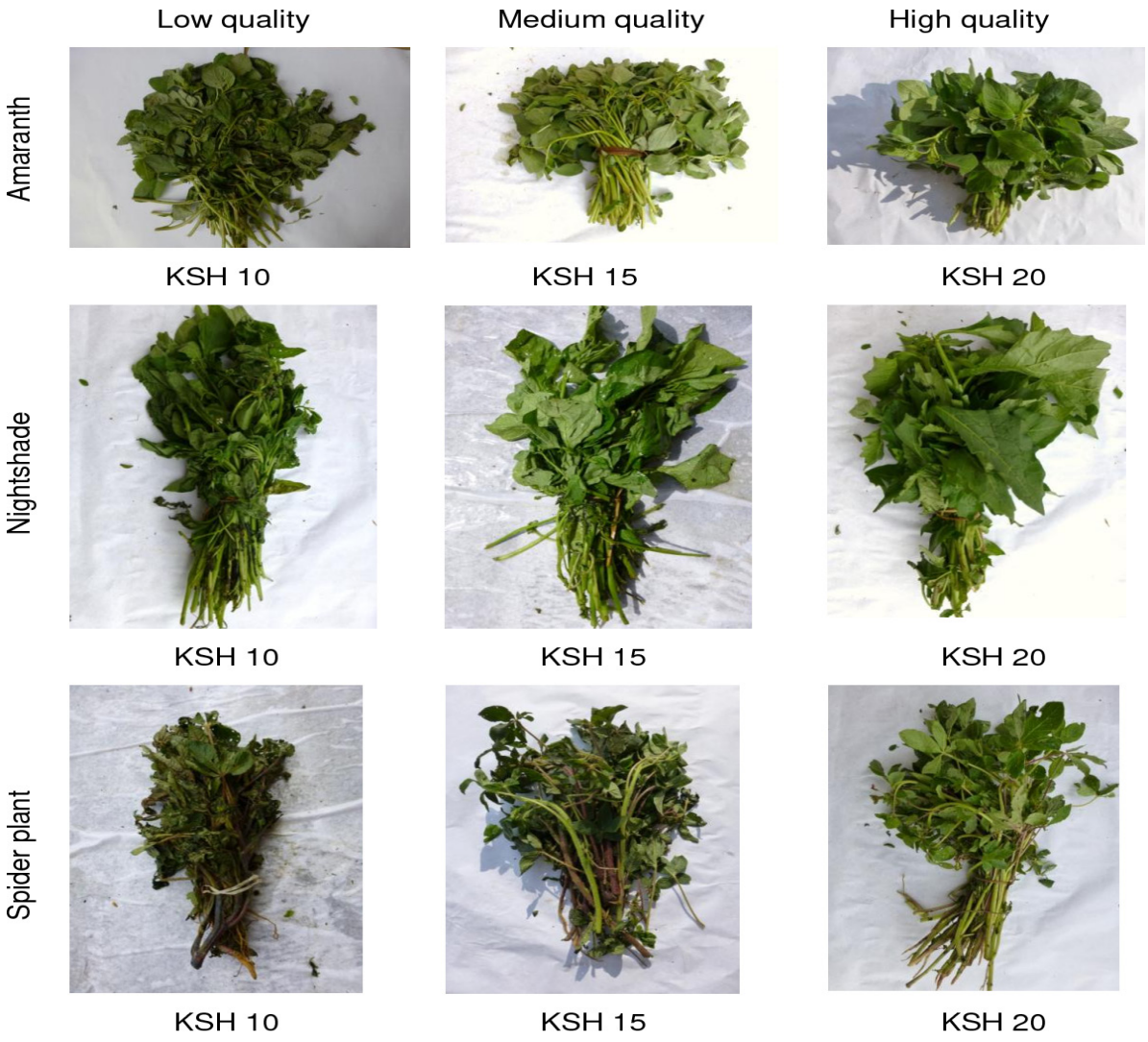

Figure 173: ALVs graded based on freshness and price

(Source: semantic schola.com)

iii) **Washing/cleaning** - water is used to remove all external dirt materials and contamination from the vegetables such as pesticide spray residue.

- This is a critical step in any processing facility – whether small scale or large scale – as part of maintaining general hygiene and reducing contamination of the final product.
- Observe the following steps when washing the vegetables:
  - Assemble the tools, materials and equipment for washing vegetables.
  - Set the working area.
  - Sanitise the equipment and working tables.
  - Wash and rinse the vegetables in clean, chlorinated water.
  - Put the clean vegetables into containers ready for processing.
  - Clean the working surface after use.

Figure 174: Washing vegetables through a strainer

5.2.3.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Knife • First Aid kit • Waste bin • Soft brush • Strainer • Dying racks	• Handwashing facility • Towel • Work space • Storage space • Basin/bucket/basket • Trays • Trolley • Vegetable strainer • Waste bin • PPEs	• Clean running water • Sample ALVs, kales and spinach • Plastic crates

5.2.3.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What steps are followed in sorting vegetables for processing?
2. Grading is the _____?
3. Cleaning vegetables is removal of external dirt materials and contamination from the vegetables. ☐ True or ☐ False?

Notes:

5.2.3.5 References

Gauthier, N., Fealko, E., & Wright, R. R. (2021). *Vegetable Production Guide for Commercial Growers, 2022-23*. University of Kentucky, College of Agriculture, Food & Environment.

Government, N. T. (March 2012). *Vegetable Growing Manual*. Northern Territory Department of Resources.

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5.2.4 Learning Outcome 4:

Produce Processed Leafy Vegetable Products

5.2.4.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to make;

- Fresh-cut vegetables.
- Dried vegetables.
- Vegetable seeds.
- Vegetable flour (seed flour)/powder.
- Vegetable pickles.
- Cooked ready-to-serve vegetables.
- Vegetable sauces.
- Vegetable purees.
- Vegetable salads.
- Vegetable juice.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Process leafy vegetable products (fresh, dried vegetables, dried seeds, flour, seed flour/powder, pickles, cooked/ ready–to-serve vegetables, sauces, purees, salads and • juice).	• Demonstration by the trainer on processing of the vegetables. • Practice by the trainees on processing of the vegetables. • Organise a field visit to a processing firm/ cottage industry, to observe and practice on processing of the vegetables. • Invite a vegetable products processing expert to elaborate on processing of the vegetables. • Display images and videos on processing of the vegetables. • Give direct instructions on processing of the vegetables.	• White boards • Marker pens • Flip charts • LCD projector • Images/videos of vegetable processing • Guest speaker • Means of transport
• **Duration: 20 hours**		

5.2.4.2 Information Sheet

Fresh-cut vegetables are fresh leafy greens whose leaves have been cut, shredded, sliced, chopped, or torn. They are well-recognised source of minerals, vitamins, and dietary fiber.

- A big challenge for marketing freshly cut green vegetables is cold storage temperatures of 0 – 5 ^{0}C and freezing temperatures of -18 - -40 ^{0}C to prevent or slow down the multiplication of harmful microorganisms and withering.
- Refrigerators are ideal facilities but are not widely affordable to most small-scale farmers, traders, processors and consumers. Additionally, electricity is unreliable, unavailable, and unaffordable to most farmers, traders, producers and consumers. As such, many farmers lack cooling facilities.
- Charcoal coolers or charcoal freezers are excellent, affordable alternative technologies to preserve the quality of freshly harvested fruits and vegetables without electricity.
  - These system designs lower the air temperature and increases the moisture inside the coolers and can keep any vegetables fresh for up to 5 days.
  - Small charcoal coolers can be used to keep produce fresh during transportation to market.
  - If you are not using your greens immediately, store them in the refrigerator in large zip-top freezer bags with a folded, dry paper towel in the bag.
  - The paper towel will absorb any excess moisture and keep the greens from getting waterlogged.
  - That same paper towel will also re-hydrate your greens if you are storing them for more than one day.

Reasons for processing

Vegetable processing is intended to achieve the following;

- To preserve them by slowing down the natural processes of decay caused by microorganisms, enzymes in the fruit part of the vegetable, or other factors such as heat, moisture and sunlight.
- To change them into different products, that is based on the market demand. By doing this successfully, the vegetables can increase income for the processor.
- To reduce the bulkiness of the vegetables and thus reduce storage and transport cost.
- To enhance nutrient recycling where the by-products can be decomposed and put back on the farm (composting).

Figure 175: Vegetables kept fresh in a charcoal cooler

- To enable consumers access the vegetables even when it is out of season.
- Increasing the vegetable shelf life and avoid wastage.

Dried vegetables

- Drying is one of the oldest methods of food preservation.
- Drying preserves foods by removing enough moisture from the vegetables to prevent decay and spoilage. Vegetables are often traditionally dried in the direct sun, but many nutrients are lost from the vegetables in the process. Instead, using a solar dryer is recommended.

How to dry vegetables

- Wash the vegetables to remove dirt.
- Chop vegetables to the size required for cooking (2 - 4 cm).
- Spread thinly on coffee wire mesh.
- Dry in a solar dryer for about three days.
- When the vegetables are brittle and can be crushed, they are dry.
- Package the dried vegetables to sell or consume during the dry season. Dried vegetables can be stored in paper or sealable bags and kept for up to 1 year.
- Store in a dry and clean place, away from mice and other rodents.

Figure 176: Leafy vegetable drying process

Note:
If the colour turns darker, the vegetable may no longer be suitable for consumption.

Vegetable flour/powder (include vegetable seed flour)

- Once the vegetables have been dried using the solar drier, they are crushed into powder using a grinder (manual/electrical).
- The powder/flour is then weighed, packaged with a label. The powder/flour can be used to blend in other flours or used in curries.

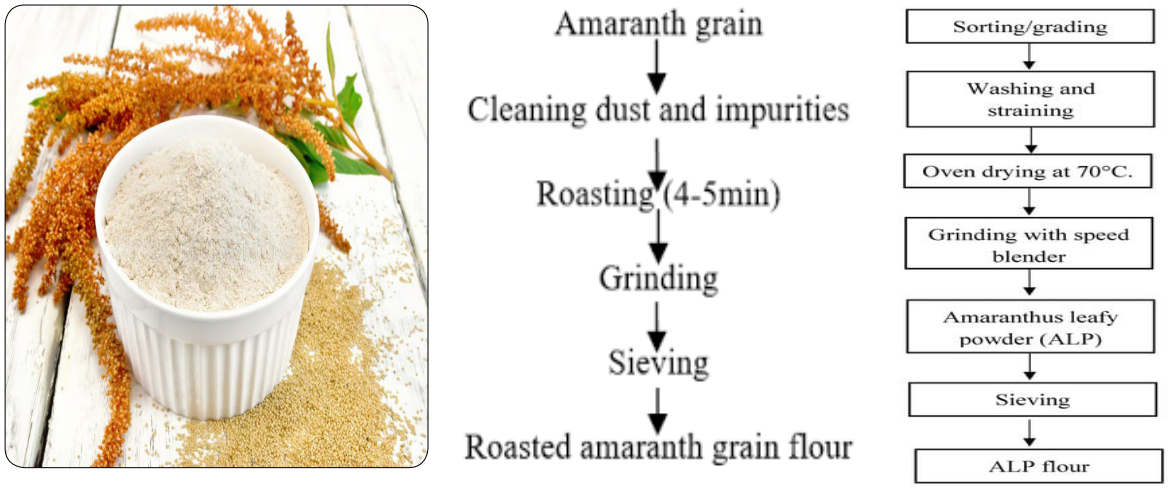

Figure 177: Processing of amaranth powder

Vegetable pickles/chutneys/sauces

- The vegetables are washed clean then salt-dried, placed in vinegar then other ingredients like sugar and spices are added. The product is then bottled in a glass jar.
- For chutney, the vegetable is put in vinegar with salt, sugar and spices (chillies).

Table 31: Sample recipe for creamed spinach sauce

Ingredients

- 140 g fresh spinach, trimmed and rinsed well
- 1 cup cream, plus more as needed
- 2 tablespoons unsalted butter
- Salt and black pepper
- Pinch freshly grated nutmeg (optional)
- Yield: 4 servings

Preparation

Step 1

- Bring a large pot of water to a boil, and salt it.
- Plunge the spinach into the boiling water, and cook for no more than a minute; transfer to an ice bath with a slotted spoon.
- Drain well, and squeeze with your hands to remove as much water as possible.

Step 2

- Put the cream and spinach in a blender or food processor, and purée.
- Transfer the mixture to a medium saucepan over medium heat.
- Add the butter, and sprinkle with salt, pepper and nutmeg if you're using it.
- Cook, stirring occasionally, until the mixture gently bubbles and thickens; add more cream for a thinner sauce.
- Taste, and adjust the seasoning and serve hot.

Table 32: Sample recipe for pickled kales

Ingredients

- 2 bunches of kale (black, purple or green)
- 4 cups of filtered water
- ¼ cup unpasteurised honey
- ¼ cup rice wine vinegar
- 1 teaspoon sea salt
- 1 tablespoon chopped garlic (optional)

Directions

1. Wash the kale well and remove the leaves from the stem. Tear into bite sized pieces. You can slice the stem into very thin pieces and use it as well!
2. In a large pot, bring the water to a boil on the stovetop.
3. Remove from the heat and add the honey, vinegar, salt and garlic if you are using it. Give a good stir to dissolve the honey and salt.
4. Add the kale to the pot and stir it until it has wilted into the hot liquid and is mostly covered.
5. You can serve immediately, but it is best to refrigerate and let it marinate for a day or two. When covered in the liquid, it will last for a couple weeks in the fridge, so make a big batch and use it often.

Variations

- Dissolve some spices in the hot liquid before adding the kale. Cumin, coriander, paprika, turmeric or chilli powder all work.
- You can also add other flavouring veggies such as jalapeño pepper, shallots and ginger. Peppers, thin sliced onions and carrots can also be added.

Table 33: Sample recipe for Amaranth leaves chutney

Ingredients

Amaranth leaves – Roughly chopped, 3 cups packed

Dried red chilly - 1

Sesame seeds - 1 tablespoon

Cumin seed - ½ teaspoon

Grated coconut – 2 tablespoons

Garlic – 3 to 4

Green chillies – 3 small

Tamarind – small cherry-sized ball

Salt to taste

Method

Step 1:

- Remove leaves, wash and roughly chop them and keep.
- Soak the tamarind in a little water and keep.

Step 2:

- Heat a little oil add red chilli, sesame seeds and cumin seeds.
- At the end, add the coconut, mix and remove.

Step 3:

- Heat a little oil, add green chili and garlic then roast.
- Thereafter, add the amaranth leaves and sauté for 3 to 4 minutes till the leaves wilt and no longer appear raw.

Step 4:

Remove and cool it.

- Next, grind all the roasted ingredients along with the tamarind and salt into a coarse paste then remove.

Vegetable puree

- Purée is cooked food, usually vegetables, fruits or legumes that has been ground, pressed, blended or sieved to the consistency of a creamy paste or liquid.
- Vegetable puree is a delicious way to serve vegetable. Spinach and other ALVs can be blended with potatoes resulting in a nutrient-dense and tasty puree. The puree can be served to babies and aged people.

Table 34: Sample Jute mallow puree

Mrenda puree recipe

Jute mallow plant *(mrenda)* is rich in iron, vitamin C and calcium, which is good for the bones.

What you need

- 3 bunches of *mrenda* (jute) leaves thoroughly cleaned
- Bicarbonate of soda
- Salt
- One tablespoon cooking oil
- Water
- Onions
- Two ripe tomatoes - washed and chopped.
- *Kunde* (cowpea leaves) - washed and chopped.
- Sour cream or fresh milk

Preparation

1. Put a cup of water in a pan, add salt and bicarbonate and boil.
2. Now add the vegetables and continue stirring to prevent them from sticking on to the pan.
3. In another pan, add oil and fry onions until tender.
4. Add the tomatoes and fry for a minute before adding the vegetables.
5. Stir for a few minutes to avoid sticking, and then add milk.
6. Keep on stirring as you simmer on low fire for about five minutes.

Serving tips

Best served with *Ugali* or rice dishes.

(Adapted from: Chef Lola's kitchen)

Vegetable juice

- Vegetables like spinach, kales and amaranth can be juiced. Freshly harvested vegetables are cleaned, blanched then put in a blender to produce juice. The juice is good for serving infants and the aged. The juice can also be cocktailed with other fruits.

Table 35: Sample recipe for spinach–based juice

Ingredients:

- 2 cups chopped spinach - tightly packed
- 1 apple or pear – cored and chopped
- 1 stalk of celery
- Juice from half a lemon or lime (to taste) – optional

Directions for making juice in a blender (without juicer):

- Wash and clean the spinach, apple and celery.
- Cut the apple and celery into large pieces.

- Pour ¾ cup of water into a blender jar.

- Add spinach and juice from lemon.

- Blend in a blender till smooth.

- Make sure there are no remnant chunks of vegetable or fruit.

• Place a fine mesh juice strainer (or cloth) over a large container and pour prepared juice mixture over it.	
• Press the pulp down with a spatula to get the maximum juice out of it. • Discard the pulp.	
• Pour the prepared juice into a serving glass and serve.	

(Adapted from: foodviva.com)

Blanched vegetables

- The vegetables can be placed in a cloth or basket made from wire, woven mesh or perforated metal (strainer). They are then dipped in boiling water or steamed by suspending above boiling water.

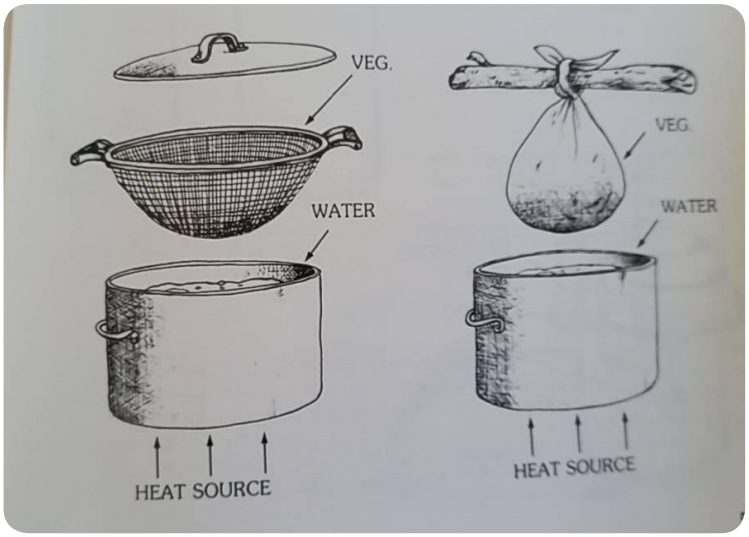

Figure 178: Vegetable blanching

Sample recipe for cooking ALVs

a) Cooking Spider plant

Ingredients

- Spider plant: 3 bunches
- Amaranth: 1 bunch
- Cooking oil
- Onions
- Groundnut paste or fresh milk or cream

Preparation and cooking (35-40 min.)

i) Wash vegetables 2-3 times and drain (5 min.)
ii) Pluck vegetables and place in a pan (15 – 20 min.)
iii) Add about ½ cup of water and cover with a lid
iv) Boil/steam (15 min.)
v) Fry onions in oil until brown
vi) Add tomatoes and fry until soft (5 min.)
vii) Add vegetables and mix well
viii) Add milk or cream
ix) Simmer (5 min.)
x) Serve

b) Cooking African nightshade

Ingredients

- African nightshade: 3 bunches
- Amaranth: 1 bunch
- Cooking oil
- Onions
- Groundnut paste or fresh milk or cream

Preparation and cooking (35-40 min.)

i) Wash vegetables 2-3 times and drain (5 min.)
ii) Pluck vegetables and place in a pan (15 – 20 min.)
iii) Add about ½ cup of water and cover with a lid
iv) Boil/steam (15 min.)
v) Fry onions in oil until brown
vi) Add tomatoes and fry until soft (5 min.)
vii) Add vegetables and mix well
viii) Add milk or cream
ix) Simmer (5 min.)
x) Serve

Vegetable seeds

This is particularly done for amaranth seeds.

- The seeds are harvested when fully mature and dried under shade.
- Once fully dried, the grain is ground into flour for use in various meals like porridge, soups, ugali, pilau, whole amaranth meal, e.t.c.

Figure 179: Crotalaria seeds

Cowpea seed is also useful grain legume at home.

- The pods are harvested at maturity, dried, threshed and kept well for use as food or seed.

Figure 180: Amaranth vegetable seeds processing

(Source: netmeds.com)

5.2.4.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Knife • Spatula • Whisker • Wooden spoons • Masher • Measuring spoons • Scooping spoon • Tongs • Grater • Strainer	• Blender • Juicer • Dicer • Refrigerator • Coolers • Weighing scale • Mixer • Driers • Source of power	• Record book • Pen • Packaging material • Sealers • Products • Recipes • Sample ALVs, kales and spinach for processing

5.2.4.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Mention at least 3 products that can be processed from ALVs, kales and spinach.
2. Show step-by-step method of cooking one type of ALV.
3. Name any three items/tools/equipment used in ALV vegetable processing.

Notes:

5.2.4.5 References

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5.2.5 Learning Outcome 5:
Package Leafy Vegetable Products

5.2.5.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;-

- Identify and select packaging materials for leafy vegetables.
- Package and weigh vegetable products.
- Label and brand the packaged products.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify and select packaging materials for leafy vegetables.	• Guide a brainstorming session on the suitable packaging materials. • Facilitate a lecture to elaborate on types and properties of packaging materials used for vegetables. • Lead the trainees on a field visit/excursion to identify packaging materials.	• Various packaging materials. Notebook and pen. • Photo images of other packaging materials.
• Package and weigh vegetable products.	• Show the trainees videos on packaging and weighing of vegetables. • Organise a practical for trainees to package and weigh vegetables. • Give instructions to trainees/demonstrate as they package and weigh vegetables. • Simulate the packaging process.	• Various packaging materials • Video on packaging. • Notebook and pen. • LCD projector.
• Label and brand the packages.	• Demonstrate the packaging of products in various containers. • Practice packaging and weighing of fresh, dried, pickled and juice products.	• Various processed products. • Various packaging materials.
• **Duration: 6 hours**		

5.2.5.2 Information Sheet

Definition of terms

• **Packaging** - Wrapping or bottling of products to make them safe from damages during transportation and storage. It keeps a product safe and marketable and helps in identifying, describing, and promoting the product.

• **Labelling** - A label refers to any written or graphic communication on the packaging. It is part of branding and enables product identification. It is printed information that is bonded to the product for recognition and provides detailed information about the product. Customers make the decision easily at the point of purchase seeing the labelling of the product.

Figure 181: Packaged and labelled jute mallow leaves

Importance of packaging ALV products

In a competitive market place, packaging is so much more than just placing your product in a box. Packaging is important for various reasons;

- Protection from physical damage.
- Provides information about the products.
- To meet consumer needs.
- Protect them from contamination etc.

Selecting packaging material

To protect your customers and your brand, be sure to choose a packaging material that works best for the product. This can be done on the basis of;

- The commodity itself (fragility, safety etc.).
- The systems of production, storage, handling, and transportation.
- Cost factor involved in producing packaging material.

- Market requirement.
- Consumer attitude.
- Requirement of recycling, re-use disposal etc.

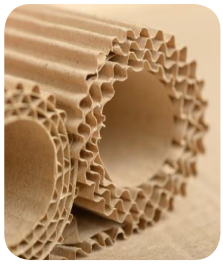
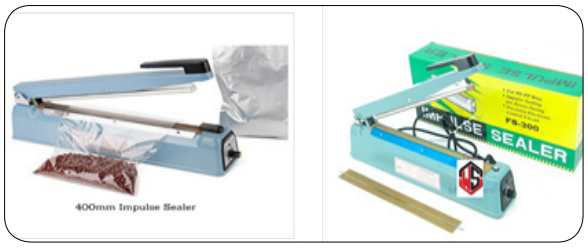
Important considerations in selecting packaging material for vegetables

There are a number of factors to put into consideration when selecting packaging material for your vegetables, these include;

- Easy to open and close.
- Easy to fill.
- Easy disposal.
- Easy to recycle.
- Pilfer-proof.
- Eye appeal.
- Should withstand rough handling.
- It must provide adequate ventilation to contents for rapid cooling during transport and storage.
- Readily available.
- Cost-effective in terms of the market value of the commodity for which it is used.
- Its dimensions and design suited to the available transport in order to load neatly, firmly with full capacity.
- It should be easily transported when empty and occupy less space than when full.
- Packages should be of a size, which can be easily handled.

Table 36: Recommended packaging materials

Type of packaging material/ accessory	Image	use
Cling film		• Seals food items, ensuring that they remain fresher for longer. • Banish vegetable flies.

Corrugated boxes	 	• Its rigidity can support heavy weight and pressure from stacked boxes in transportation, while its layers provide flexibility when wrapping individual items.
Khaki bags	 	• Package vegetables weighing 0.25kg to 12kg depending on size.
Wooden crates		• Transport and storage of vegetables
Nets		• Completely breathable, keeping vegetables fresh, protection from pests and attractive to customers.
Sealers		• Close openings of packaging materials such as khaki bags, corrugated boxes etc.

Ropes	  *Generic cotton twin and sisal ropes*	• Have s atrong grip in tieing packaging boxes, crates etc.
Packaging paper	 *Polybags with zip lock*  *Virgin plastic polythene bags*	• Transport, protect and store vegetables
Glue/wrapping tapes		• Dries clear and bonds paper, cardboard and small wooden objects.
Weighing scale	 *Digital kitchen scale* *Mechanical weighing scale*	• Measures the weight of fresh and processed/ packaged vegetable products.

Important information to be included in a label:

Labelling products not only provides crucial information and instructions to consumers but can also help your product stand out. It goes without saying, that product labels must be entirely accurate and include important details such as;

i. Product name/content.
ii. Address/origin/producer details.
iii. Mark of certification.
iv. Nutritive value (food exchange table).
v. Batch number, quantity and shelf life.
vi. Instruction on usage and storage etc.

5.2.5.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Spoons • Scoop • Funnel • Jug	• Sealer • Kitchen scissors • PPEs • Printer • LCD • Laptop • Weighing scale • Measuring jug • Sterilising equipment	• Packaging materials (brown khaki papers, polythene bags, nets, woven baskets, wooden and plastic plates, corrugated cartons, glass jars and bottles) • Glue • Sisal/cotton twine • Labels • Processed ALV products, kales and spinach • Clean water • Heat • Video on packaging and labelling • Seal tape

5.2.5.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Select the most suitable packaging material for the following products:
   - ☐ A. Fresh Spider plant leaves.....
   - ☐ B. Dried Slender leaf vegetables.....
   - ☐ C. Dried Amaranthus seeds.....
   - ☐ D. Pickled African Leafy Vegetables.....

2. Indicate whether the following statements are **True** or **False**:
   A. Green and amber coloured glass containers do not protect the products from Ultra-Violet rays. (☐ True/ ☐ False)
   B. Windows should not be open to prevent air from entering the product store. (☐ True/ ☐ False)
   C. Market requirement does not influence selection of a packaging material for a product. (☐ True/ ☐ False)
   D. Packaging protects products when distributing, storing and marketing. (☐ True/ ☐ False)

3. Name any three aspects that must appear on a processed product label.
   A. _____
   B. _____
   C. _____

Notes:

5.2.5.5 References

Bhanu Malhotra, A. K. (2015). Natural Polymer Based Cling films for food packaging. *International Journal of Pharmacy and Pharmaceutical Science, vOL.7,* (Issue 4), 11-16.

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5.2.6 Learning Outcome 6:

Maintain Leafy Vegetable Product Quality

5.2.6.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify and observe vegetables product quality standards.
- Observe personal and general hygiene protocols.
- Conduct quality checks and apply recommendations.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify and observe vegetables product quality standards.	• Guide a brainstorming session for the trainees on vegetables product quality standards. • Facilitate a lecture to elaborate on maintenance of product quality standards. • Lead the trainees on a field visit/ excursion to a processing firm to identify vegetables quality standards maintenance. You can instead show them a video of the same.	• Meta plan cards • Flip chart • Marker pens • Means of transport
• Observe personal and general hygiene protocols.	• Organise a practical for trainees to practice observance of personal and general hygiene. • Give instructions to trainees or demonstrate as they observe personal and general hygiene.	• PPEs • Processing plant • Sample processed vegetable products.
• Conduct quality checks and apply recommendations.	• Give instructions to trainees/demonstrate how to conduct quality checks on vegetables. • Lead the trainees on a field visit/excursion to identify and observe quality checks procedures. • Give the trainees assignment on conducting quality checks at your institution's processing or kitchen/ catering facilities and develop a list of recommendations.	• Quality standards charts • Means of transport • Processing unit • Sample processed vegetable products.
• **Duration: 4 hours**		

5.2.6.2 Information Sheet

Vegetable quality standards - The quality standards of fresh and processed leafy vegetable products vary with their intended use.

For marketing purposes; size, attractiveness, maturity, organoleptic quality and freedom from defects are to be kept in mind.

Generally, maintenance of vegetables products quality ensures safety parameters of nutritional value, texture, flavour, crispiness, colour, acidity, aroma, microbial, food contamination and packaging.

Vegetable quality checks, tests and analyses

In maintaining quality, the following vegetable quality checks, tests and analyses can be conducted;

- Food allergen testing.
- Food chemical analysis.
- Food contact tests.
- Food contaminant testing.
- Nutritional analysis and testing.
- Pesticide residue testing.
- Packaging.

So as to:

- Preserve palatability.
- Reduce perishability.
- Avoid food poisoning.
- Preserve nutrients.

Figure 182: Simplified vegetable preservation method

You can achieve this through refrigeration, use of proper storage packages as well as keeping the store requirements in check by ensuring;

- The store area be kept as clean and hygienic as possible.
- All the surfaces be kept clean and completely washed down after each day's production.
- Windows are open for ventilation but covered with fly-proof mesh.
- Portable water and if possible, electricity made available.
- Animals are not allowed in the unit.
- Avoid smoking inside the facility.
- The floor is made of concrete and slopping to allow thorough wash-down.

Figure 183: Simple charcoal cooler

Hazard Analysis Critical Control Point (HACCP)

HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards. It is a proactive strategy where hazards are identified and assessed, and control measures are developed to prevent, reduce, or eliminate a hazard.

Potential hazards could be physical, chemical or biological and may include;

- Slivers of glass
- Human hair
- False nails
- Nail polish
- Pieces of jewellery
- Metal fragments from worn or chipped utensils and containers
- Dirt
- Pesticides/insecticides may leave residues on vegetables
- Germs, pathogenic micro-organisms
- Toxins
- Heat.

HACCP is conducted using seven steps as outlined in the following figure:

Figure 184: HACCP steps

Personal and general hygiene requirements

Good personal hygiene can prevent food poisoning. Bacteria that causes food poisoning can be on everyone, even on healthy people. You can spread bacteria from yourself to the food if you touch your nose, mouth, hair or your clothes, and then on food.

Good personal hygiene also makes good business sense. Customers like to see food-handling staff who take hygiene seriously and practice safe food-handling.

5.2.6.3 Equipment, Supplies and Materials

Equipment	Supplies and materials
• Thermometer • Weighing machine • pH meter	• Personal Protective Equipment (PPEs) • Water • Processed vegetable products • Mops • Dust bins • Printed sanitation health and safety • rules and regulations • Sampling tools and reagent

5.2.6.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Which any four quality and food safety parameters are to be checked for in ALVs, kales and spinach products?
   A. _____
   B. _____
   C. _____
   D. _____

2. Why is it important to observe and maintain quality and food safety parameters?
3. How can the ALV products quality and food safety parameters be maintained?
4. Name any four general rules necessary to maintain the ALV product quality.

Notes:

5.2.6.5 References

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5.2.7 Learning Outcome 7:
Manage Processing Wastes

5.2.7.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify vegetable processing wastes.
- Apply vegetable processing waste management procedures.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify vegetable processing wastes.	• Guide a brainstorming session on the types of wastes from vegetables processing. • Give instructions/demonstrate to trainees as they identify waste from vegetables processing. • Facilitate a lecture/invite a guest speaker to elaborate on benefits of waste management.	• Stationery • Flip charts • Marker pens • Computer • LCD projector • Guest speaker
• Apply vegetable processing waste management procedures.	• Give instructions to trainees as they apply waste management procedures. • Facilitate a lecture/invite a guest speaker to elaborate on application of waste management procedures.	• Videos of waste management procedures • Flip charts • Marker pens
• **Duration: 4 hours**		

5.2.7.2 Information Sheet

Definition of terms

Wastes - These are by-products in processing emanating from raw material, intermediate products, finished products, by-products or waste products in the production cycle.

Recycling - Is the process of converting waste materials into new materials and objects. The recovery of energy from waste materials is often included in this concept.

The recyclability of a material depends on its ability to reacquire the properties it had in its original state.

Figure 185: Wastes from vegetable processing

Handling of wastes

- **Collection:** Waste collection is a part of the process of waste management. It is the transfer of solid waste from the point of use and disposal to the point of treatment or landfill.
- **Separation**: Waste separation is the process by which waste is separated into different elements. Waste separation can occur manually at the household and collected through curbside collection schemes, or automatically separated in materials recovery facilities or mechanical biological treatment systems.
- **Reducing:** Waste reduction is the practice of using less material and energy to minimise waste generation and preserve natural resources. Waste reduction is broader in scope than recycling and incorporates ways to prevent materials from ending up as waste before they reach the recycling stage. Waste reduction includes reusing products such as plastic and glass containers, purchasing more durable products, and using reusable products, such as dishrags instead of paper towels.
- **Recycling:** Waste recycling is the process of converting waste materials into new materials and objects. The recovery of energy from waste materials is often included in this concept. The recyclability of a material depends on its ability to reacquire the properties it had in its original state.
- **Reusing:** Waste reuse is the action or practice of using an item, whether for its original purpose or to fulfil a different function. It should be distinguished from recycling, which is the breaking down of used items to make raw materials for the manufacture of new products.
- **Safe disposal:** Is the process whereby spoilt foodstuff and condemned products may be disposed-off on the project site under supervision of a registered environmental health practitioner and/or the project site supervisor.

- Vegetables generates a lot of organic wastes that needs to be managed to produce useful products. The wastes come from processes such as rejected vegetables at the time of sorting, grading, processing, packaging and distribution.
- Increasing food waste generation, improper waste disposal and poor waste management strategies have adverse environmental issues hence the need to manage the wastes appropriately as elaborated below;

Biogas

Cost of energy consumption is rising at unexpected rates with each passing day. Biogas generation should therefore be considered as a renewable and sustaining energy source. Vegetable wastes can therefore be used to generate biogas instead of throwing them away and at the same time use wastes from bio-digestion as manure

Figure 186: A simple homemade biogas assembly

Compost manure

Composting the vegetable wastes is one way of achieving zero food wastage. There are several composting procedures like vermiculture (Vermiculture means artificial cultivation of worms and vermicomposting) is the excreta of earthworms which is rich in humus, composting basics, onsite composting, aerated window composting, aerated static pile composting, in-vessel composting.

Basic composting method flow

i. Start your compost pile on bare earth.
ii. Lay twigs/straw first a few inches deep.
iii. Add waste ALV in layers, alternating moist and dry.
iv. Add green manure or any nitrogen source.
v. Keep compost moist by sprinkling water.

Figure 187: Vermicomposting

(Source; Dreamstime.com)

Animal feed

Vegetable waste is important for its rich nutrients and phytochemical content. It is suitable for animal feed substitute;

- It lowers the cost of feed.
- It is eco-friendly.

Apply appropriate waste disposal mechanism

In general, the following steps can be used to manage ALV waste appropriately.

Steps in biodegradable waste disposal

i. Always separate biodegradable and non-biodegradable wastes.
ii. Place the segregated waste on wheelbarrow or buckets/sacks and transport to their designated pits.
iii. Cover the waste with a little soil to fasten degradation.
iv. Reuse the resultant manure in another farm or ornamental garden.

Steps in non-biodegradable waste disposal

i. Segregating reusable from non-reusable waste.
ii. Placing reusable and non-reusable wastes in separate bins.
iii. Transfer non-reusable waste to waste collection points.
iv. For reusable waste, reuse but do not use pesticide or food containers.
v. Pour waste water into a septic tank, not in rivers, lakes, dams or other water sources.

Benefits of waste management

Improving waste management can benefit business and the environment by:

- Reducing the cost of purchasing materials (e.g., through avoiding disposal of damaged products).
- Minimising waste treatment and disposal costs (and possibly generating alternative income streams by finding secondary markets for 'waste' products).
- Vegetable waste can also be channelled towards composting for soil nutrition enhancement.

5.2.7.3 Tools, Equipment, Supplies and Materials

Tools	Equipment	Supplies and materials
• Fork • Hoe • Rake • Slasher • Spade • Trowel/shovel	• Watering can • PPEs • Wheelbarrow • Compost boxes • Biogas-digester, hose, gas chamber, gas burner • Waste bin	• Waste collection bags • Waste collection bins • Composting site • Incinerator and incineration site • Water • ALV wastes • Nitrogen fertiliser • Gunny bags

5.2.7.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. Identify four various waste products from ALVs, kales and spinach processing.
2. Name three ways through which the waste can be disposed.
3. What three ways, can you manage wastes from processing ALVs, kales and spinach?

Notes:

5.2.7.5 References

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5.2.8 Learning Outcome 8:
Market Leafy Vegetables Products

5.2.8.1 Introduction to the Learning Outcome

By the end of the training session(s) for this learning outcome, the trainee is expected to;

- Identify the target markets.
- Identify and select marketing strategies.
- Keep marketing and sales records.

Suggested Training Delivery Method

Training Activities	Training Delivery Methods and Description	Resources Required
• Identify the target markets.	• Guide a brainstorming session on factors to consider in identifying a target market. • Facilitate a question-and-answer session on how to identify target market. • Guide the trainees to discuss on how to identify target markets.	• Flip charts • Marker pens • Meta plan cards
• Identify and select marketing strategies.	• Facilitate a question-and-answer session on how to identify and select marketing strategies. • Invite a guest speaker to elaborate on identifying and selecting marketing strategies. • Provide a case study presentation on identification and selection of marketing strategies. • Guide the trainees to discuss on how to identify target markets. • Organise the trainees to do a role play on the various marketing strategies implementation.	• Flip charts • Marker pens • Videos/report on a case study on Identification and selection of marketing strategies • Sample processed vegetable products
• Keep marketing and sales records.	• Demonstrate to trainees how to generate marketing and sales records. • Organise a practical session for the trainees to generate and keep marketing and sales records samples. • Lead the trainees on a gaming session and award the best generated and kept marketing and sales record.	• Flip charts • Marker pens • Rewards • Video camera
• **Duration: 6 hours**		

5.2.8.2 Information Sheet

Definition of terms

Market - a means by which the exchange of goods and services takes place as a result of buyers and sellers being in contact with one another, either directly or through mediating agents or institutions. Markets in the most literal and immediate sense are places in which things are bought and sold.

Demand - is the number of goods that the customers are ready, able and willing to buy at several prices during a given time frame.

Supply - the quantity or amount (as of a commodity) needed or available to the consumer at a given time.

T**arget market** - a group of customers with shared demographics who have been identified as the most likely buyers of a company's product or service.

Market gap - refers to the difference between the supply and demand for a particular product. A gap in the market is an opportunity to make and sell a product or service.

Figure 188: Marketing simplified

(Source: Investopedia)

Answering the following questions will assist you in identifying and selecting your target market.

Identifying your target market

Consider the following information regarding your customers;

- Individuals or companies?
- Age, income, place of residence?
- Industries customers are in?
- Needs and wants my product will satisfy?
- Number of potential customers in my area?
- Demand for my product or service?
- Who is my competitor?

- Pricing of my product or service?
- What is unique about my product or service?

Tools for identifying target market

There are various tools that can be used in answering the above questions, these include;

- ***Questionnaire*** - a set of printed or written questions with a choice of answers, devised for the purposes of a survey.
- ***Interviews*** – oral questioning by meeting people face to face, over phone calls, especially for consultation.
- ***Observation checklist*** - is a set of questions that evaluate the behaviour of buyers and sellers in a market setting. Observation checklists assist an observer to identify market gaps and problem areas to further improve marketing strategies, market settings, and seller-buyer development.

Marketing strategy

Figure 189: Marketing

(Source: Investopedia)

Market plan - is a document that lays out the marketing efforts of a business in an upcoming period, which is usually a year. It outlines the marketing strategy, promotional, and advertising activities planned for the period.

A marketing plan will typically include the following elements;

- **Marketing objectives of the business** - The objectives should be **S**pecific, **M**easurable, **A**ttainable, **R**elevant, and **T**ime-bound (SMART).
- **Current business marketing positioning** - An analysis of the current state of the business concerning its marketing positioning.

- **Market research** - Detailed findings about current market trends, customer needs, industry sales volumes, and expected direction.
- **Outline of the business target market** – Business target market demographics.

Figure 190: Elements of a marketing strategy

(Source: YGL marketing)

- **Marketing activities** – a list of any actions concerning marketing goals that are scheduled for the period and the indicated timelines.
- **Product promotion and advertising techniques –** are plans and tactics one implements in their marketing plan to increase their product or service demand. These techniques include:
  - Social media advertising.
  - Print media advertising.
  - Word of mouth advertising.
  - Field day/public exhibitions.
  - Branding.
  - Marketing through groups or cooperatives.
  - Use of influencers.
  - Discounting.
  - Buy-one-get-one-free.
  - Free samples.
  - Commissions to sales agents.
  - After-sale service.
  - Guerrilla - is an advertisement strategy in which a company uses surprise and/ or unconventional interactions to promote a product or service.
  - Broadcast - The commercials aired on radio and televisions are an essential part of broadcast advertising.

Figure 191: Branded Jute mallow leaves

Marketing and sales records

Marketing records – the information on promotional data and materials, advertising and marketing materials, pricing lists, market research, customer lists, supplier lists, business plans, competitive analyses and catalogues relating to the products.

Sales records – the information a business has on your customers, including but not limited to their contact information, how often they make purchases from the business, what they purchase and their mode of payments.

Table 37: Sample sales record template

DAILY SALES LOG BOOK							
Date			**Month**				
Location (Store, Online, etc.)							
Item Name	**Item No.**	**Quantity**	**Category**	**Price**	**Cost**	**Tax**	**Total**

Filing – is the process of classifying, arranging, sorting, and storing records so they may be easily located and retrieved when needed. The classification and control of records involves consideration of the basic file groups, material collection procedures, file preparation, sorting, indexing, maintenance, and cross referencing.

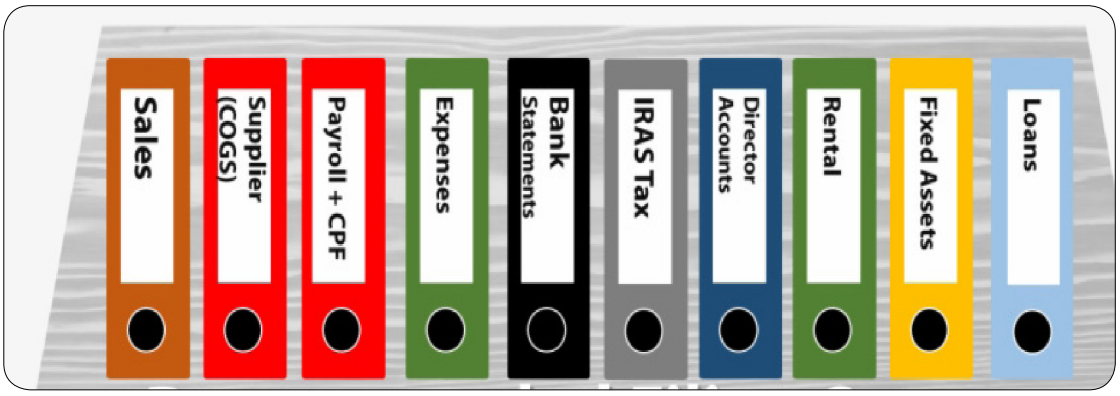

Figure 192: Records filing

5.2.8.3 Tools, Equipment, Supplies and Materials

Equipment	Supplies and materials
• Means of transport • LCD projector • Marketing tools (fliers, brochures, booklets) • Communication mechanism (phone, internet).	• Processed vegetable products • Labels/stickers/marker pens • Packaging material (strings, tapes) • Holding material (crates, cartons) • Audio-visual material for adverts • Marketing and sales record.

5.2.8.4 Self-Assessment Questions

Use the following questions to assess your knowledge on the learning outcome:

1. What **five** processed ALVs, kales and spinach products can we market?
2. What **three** ways you can market ALVs, kales and spinach products?
3. Name any **three** markets for ALVs, kales and spinach products?
4. Name **three** uses of a marketing record?

Notes:

5.2.8.5 References

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5.3 Model Responses to the Self-Assessment Questions

5.2.1 Learning Outcome 1:

Prepare Leafy Vegetable Processing Unit

1. Which of the following is not among ALVs, kales and spinach products?

   B) Syrup, E) Nectar and F) Jelly

2. How do you select a suitable ALV to process?
   - **Through assessing and analysing market demand.**
   - **Through analysis of meeting your business objectives**

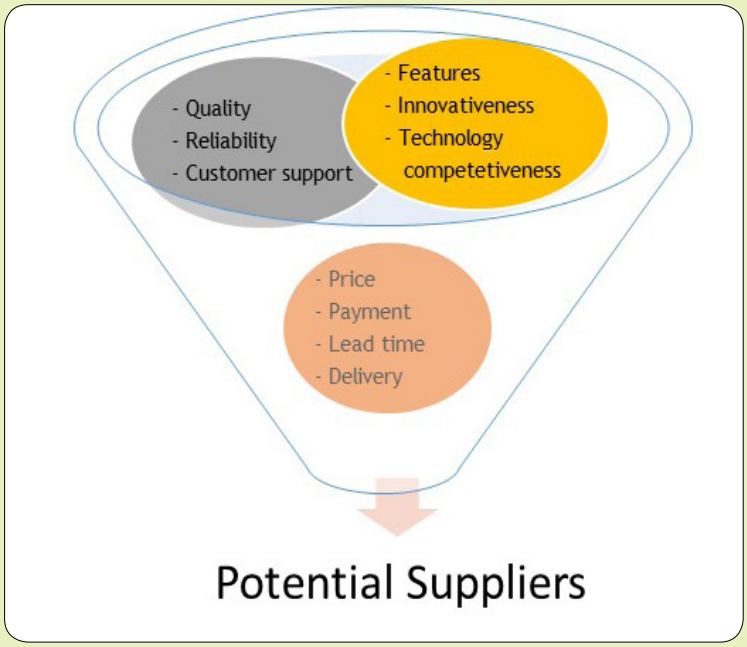
3. What is the importance of processing ALVs, kales and spinach?
   - **Preserve the color, flavour, texture, and nutritional value.**
   - **Prolong the shelf life of perishable vegetables.**
   - **Ease marketing and distribution of vegetables.**
   - **Eliminate microorganisms and toxins that may cause disease.**

4. What factors should you consider when setting up a vegetable processing unit?
   - **Maintenance of hygiene standards.**
   - **Enough lighting and ventilation.**
   - **Personal safety for personnel.**
   - **Proper waste disposal.**
   - **Adequate working space for all processing activities.**
   - **Space for amenity rooms. These include;**
     - **Changing room where clothing and shoes that are not worn for work can be stored,**
     - **Separate hand-washing facilities for staff, with soap, clean water, nail brushes and clean towels,**
     - **Toilets, which should be separated from the processing room by two doors or located outside the building.**
   - **Office work space.**
   - **Fully-equipped first aid kits.**
   - **Security against entry of contaminants.**
   - **Storage of chemicals in a facility separate from the processing room.**

5.2.2 Learning Outcome 2:

Source Leafy Vegetables

1. What are the factors to consider when selecting a potential supplier?



2. What is the importance of supplier contracting?
   - **Service performance**
   - **Contract trust**
   - **Cost reduction**

3. What quality checks would you perform while collecting/receiving vegetables?
   - **Fresh, desired colour and texture.**
   - **Crispiness, size and uniformity.**
   - **Aroma and flavour.**
   - **Clean from any dirt, blemishes and mechanical injury.**
   - **Free from insect damage and debris.**
   - **Variety of choice.**
   - **Free from pest infestation.**
   - **Free from chemical residue.**

4. Which are the bulking strategies for ALVs, kales and spinach?
   - **Supplier contracting**
   - **Cooperatives**
   - **Farmer groups.**

5.2.3 Learning Outcome 3:

Prepare Leafy Vegetables for Processing

1. What steps are followed in sorting vegetables for processing?
   - **Assemble the sorting materials, tools and equipment.**
   - **Set up the sorting table.**
   - **Spread the vegetables on the table.**
   - **Remove rotten, shrivelled, damaged and moulded vegetables.**
   - **Weigh the sorted vegetables.**
   - **Record the weighed vegetables.**
   - **Dispose-off safely the waste generated.**

2. Grading is the _____?

   Classifying of vegetables according to the size, shape, colour, dry matter, freshness, flavour, aroma, weight and volume.

3. Cleaning vegetables is removal of external dirt materials and contamination from the vegetables.

   True

5.2.4 Learning Outcome 4:

Produce Leafy Vegetable Products

1. Mention at least 3 products that can be processed from ALVs, kales and spinach

   a) **Puree**
   b) **Dry vegetables**
   c) **Flour/powder**
   d) **Seeds**
   e) **Salads**
   f) **Sauces/chutneys**

2. Show step-by-step method of cooking one type of ALV

   a) **Pluck vegetables**
   b) **Wash vegetables three to four times and drain**
   c) **Boil/steam for 15 min.**
   d) **Fry onions until brown**
   e) **Add tomatoes and fry until soft**
   f) **Add vegetables and mix well**
   g) **Add milk of cream**
   h) **Simmer for five minutes**
   i) **Serve**

3. Name three items/tools/equipment used in ALV processing.

   a) **Trays**
   b) **Strainer**
   c) **Knife**
   d) **Ingredients**
   e) **Energy source**
   f) **Water**

5.2.5 Learning Outcome 5:

Package Leafy Vegetable Products

1. Select the most suitable packaging material for the following products:-
   a) Fresh Spider plant leaves - **Net, woven basket**
   b) Dried Slender leaf vegetables - **Brown Khaki paper, glass, polythene bags**
   c) Dried amaranthus seeds - **Brown Khaki paper, glass**
   d) Pickled ALVs - **Glass**

2. Indicate whether the following statements are true or false:
   i. Green and amber coloured glass containers do not protect the products from Ultra-Violet rays. **(False)**
   ii. Windows should not be open to prevent air from entering the product store. **(False)**
   iii. Market requirement does not influence selection of a packaging material for a product. **(False)**
   iv. Packaging protects products when distributing, storing and marketing. **(True)**

3. Match the following packaging materials and corresponding characteristics:-

No.	Packaging Material	Characteristics
	Glass	***Doesn't allow entry of moisture or air when tightly sealed***
	Wooden crates	***Relatively resistant to environmental conditions***
	Woven basket	***Prone to weather conditions and moisture***
	Cling film	***Improves shelf life***
	Brown Khaki papers	***Useful in brand promotion and marketing***
	Corrugated fibre board boxes	***Cushioning effect due to relatively soft walls***

4. Name any three aspects that must appear on a processed product label
   - **Product name/content.**
   - **Address/origin/producer details.**
   - **Mark of certification.**
   - **Nutritive value (food exchange table).**
   - **Batch number, quantity and shelf life.**
   - **Instruction on usage and storage etc.**

5.2.6 Learning Outcome 6:

Maintain Leafy Vegetable Product Quality

1. Which any four quality and food safety parameters to be checked for in ALVs, kales and spinach products.
   - **Texture**
   - **Flavour**
   - **Crispness**
   - **Colour**
   - **Acidity**
   - **Aroma**
   - **Soluble sugar**

2.

a) Why is it important to observe and maintain quality and food safety parameters?
   - **Preserve palatability;**
   - **Reduce perishability;**
   - **Avoid food poisoning; and**
   - **Preserve nutrients.**

b) How ALV products quality and food safety parameters can be maintained.

- **Through refrigeration,**
- **Use of proper storage packages, and**
- **Keeping the store requirements in check.**

3. Name any four general rules necessary to maintain the ALV product quality.
   - **The store area should be kept as clean and hygienic as possible.**
   - **All the surfaces should be kept clean and completely washed-down after each day's production.**
   - **Windows should be open for ventilation but covered with fly-proof mesh.**
   - **Portable water and if possible, electricity should be available.**
   - **Animal and smoking should not be allowed in the unit.**
   - **The floor should be made of concrete and slopping to allow thorough wash-down.**

4. Indicate whether the following statements are **True** or **False**:
   i. To conduct quality checks of the storage, the stores should be inspected regularly. **(True)**
   ii. *Windows should not be open to prevent air from entering the product store.* **(False)**

5.2.7 Learning Outcome 7:

Managing Processing Wastes

1. Identify four various waste products from ALV processing.
   a) **ALV stalks**
   b) **Soil and other debris**
   c) **Waste water**
   d) **Damaged ALV leaves.**

2. What three ways can you manage wastes from processing ALVs, kales and spinach?
   a) **Biogas fuel**
   b) **Compost manure**
   c) **Animal feed.**

5.2.8 Learning Outcome 8:

Market Leafy Vegetable Products

1. What five processed ALV, kales and spinach products can we market?

- **Fresh**
- **Seedlings**
- **Seeds**
- **Powder**
- **Pickles/chutneys**
- **Cooked**
- **Sauces**
- **Purees**
- **Salads**

2. What **three** ways you can market ALVs, kales and spinach products?

- **Social media advertising**
- **Print media advertising**
- **Word of mouth advertising**
- **Field day/public exhibitions**
- **Branding**
- **Marketing through groups or cooperatives**
- **Use of influencers**
- **Discounting**
- **Buy-one-get-one-free**
- **Free samples**
- **Commissions to sales agents**
- **After-sale service**
- **Radio adverts**
- **Tv adverts**
- **Guerrilla - is an advertisement strategy in which a company uses surprise and/or unconventional interactions to promote a product or service.**
- **Broadcast - The commercials aired on radio and televisions are an essential part of broadcast advertising.**

3. Name any **three** markets for ALVs, kales and spinach products?

a) **Hotels**
b) **Schools**
c) **Supermarkets**
d) **Open-air markets**
e) **Wholesalers/general stores**
f) **Hospitals**

4. Name **three** uses of a marketing record?

a) **Asses/calculate profitability**
b) **Plan production quantities**
c) **Plan sourcing**
d) **Credit rating**
e) **Buyer database**
f) **Market links or network channels.**

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and Development