german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

AFC
AGRICULTURE & FINANCE CONSULTANTS

A TRAINING GUIDE FOR COMMERCIAL PRODUCTION OF SELECTED VEGETABLES IN MALAWI

IMPRINT

Published by:

Supported by:
EMPOWERING YOUTH IN AGRIBUSINESS (EYA) TVET!
GIZ CLUSTER BUILDING
Area 43/498
Lilongwe 3
Malawi
Kristina.Spantig@giz.de
www.giz.de

February 2023

Authors
Chawanangwa Munthali & Dickson Banda (Corporate Institute of Horticulture)

Contributors:
James Muhowa (AFC)
&
Multi-stakeholder Panel from NGOs, Academia and private Sector

FOREWORD

This training guide was developed by the Corporate Institute of Horticulture (CIH) on behalf of and with financial and technical support from the Gesellschaft für Internationale Zusammenarbeit (GIZ) commissioned by Federal Ministry for Economic Cooperation and Development (BMZ) in the global project 'Employment in rural areas with focus on youth' (RYE). In Malawi, the project is implemented by Agriculture and Finance Consultants (AFC) called 'Empowering Youth in Agribusiness!' (EYA!).

This guide is a tool for extension workers to effectively train and advise farmers on Good Agricultural Practices (GAP), including Integrated Pest and Disease Management (IPM) for selected vegetables. The Corporate Institute of Horticulture (CIH) is grateful to GIZ and the EYA project for not only entrusting it with the responsibility but also investing the trust in the institution to develop the training guide.

The CIH is particularly grateful for the valuable support it received throughout the work on this document. Finally, the CIH thanks the HORTCUM staff in Lilongwe and the producer groups in Lilongwe and Dowa with whom the CIH has worked throughout the development of this guide.

LIST OF ACRONYMS

CIH	Corporate Institute of Horticulture
GIZ	Gesellschaft für Internationale Zusammenarbeit
AFC	Agriculture and Finance Consultants
HORTCUM	Horticulture Cooperative Union of Malawi
EYA	Empowering Youth in Agribusiness
GAP	Good Agriculture Practices
IPM	Integrated Pest Management
FC	Flip Chart
TSS	Total Soluble Solids

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

HOW TO USE THE MANUAL

This manual is divided into modules. If the modules are very extensive, they are sub-divided into topics. The topics each comprise training sessions of different duration.

Module or topic structure

a) A table that states:
   - Objectives/learning outcomes
   - Learning materials
   - Duration of the training session

   The contents of the table will be introduced at the beginning of each individual training session. Where applicable, a recapitulation of a previous training session and lessons learned in the meantime should be conducted.
   In addition, expectations of participants are collected at least at the beginning of each module.
b) One or several activities to get involved in the topic of the training session, to collect all the relevant facts already known by the participants and to share experiences.
   - The trainer will add any technical content that was not mentioned during the group presentations or plenary activities at the beginning of the session in a brief presentation based on the information sheet
c) An information sheet which provides information about the technical content of the training session:
   - The trainer uses the information sheet as reference
   - Participants may use the information sheet to review after the training or to prepare for the next training session
d) An activity to practice all the information collected and presented.
e) An activity to summarize what has been learned and practiced.
f) Outlook on the next training session and possibly a task to further practice the newly acquired technical content:
   - Trainers will need to set aside time at the beginning of the next session to review the results or observe the progress of the assignments

Role of trainer

In this training guide, the trainer takes on the role of a facilitator. The aim is to ensure that participants actively participate in the training and are supported by the facilitator to acquire new skills and knowledge. Each training session starts with a collection of all relevant facts already known by the participants and their experiences related to the topic of the session. The trainer then does not give a full presentation or lecture, but merely fills in missing technical content or corrects incorrect information.
This is a demanding task and requires that the trainer knows the training content of the session well. Consequently, the trainer needs to prepare the session in advance and ensure that he/she knows the entire content of the information sheet.
The trainer in the role of facilitator also ensures that all the materials needed for the practical activities, as well as the location and time, are set and communicated.
As new skills and knowledge are practiced during the training sessions, special attention must be paid to the choice of venue. Whenever possible, training should take place on participants' farms or demonstration fields.

ACTIVITIES TO GET INVOLVED INTO THE TOPIC OF THE TRAINING SESSION

a) Usual procedure:

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to brainstorm on the topic of training (encourage the participants to use as much personal experience as possible)
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Invite a representative from each group to present on behalf of the group what they had discussed during group work about the importance of growing vegetables
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants in plenary

Activity III: Plenary session (up to 40 minutes, depending on the extent of information to be added**)**

- After listening to the presentations of all groups, add facts that were not mentioned or correct misinformation. The information sheet is your reference
- Allow for further contributions and questions of participants
- Do not expand this part to more than 40 minutes

b) Alternative procedure:

Sometimes it may be more efficient to collect the participants' knowledge about the topic of the session in plenary:

- If a demonstration site or specialized farm is visited (see chapter **farm visits** below)
- A guest speaker or expert is invited
- The topic is unknown to more than half of the participants

Under these circumstances, the collection of prior knowledge on the topic of the session will be conducted as a plenary session

Activity I: Plenary session to collect prior knowledge on the topic of the session

- Ask participants to share any information and experiences they have gathered related to the topic of the session. Encourage all participants to actively contribute
- The trainer takes notes on flipchart if practicable
- After the collection is concluded, add facts that were not mentioned or correct misinformation. The information sheet is your reference
- Allow for further contributions and questions of participants
- Do not expand this part to more than 45 to 60 minutes

VARIATIONS AND ADDITIONAL INFORMATION FOR THE TRAINER

Farm visits

Visits to specialized farms or demonstration sites enrich the training sessions. After welcoming the owner or manager, they should first be given the opportunity to introduce themselves and the farm or demonstration site and to take a tour.

Then the session continues with the usual collection of all relevant facts already known to the participants and their experiences related to the topic of the session. This time it is done in plenary and in addition, the participants' observations on the farm or demonstration site are added. The trainer takes notes, if at all possible, on flipcharts.

Instead of adding to the collected knowledge himself, the trainer may ask the owner or manager to fill in missing information or explain the farming activities step by step. In the latter case, it is advisable to hold a preparatory meeting with the owner or manager and show or hand out a copy of the information sheet. The rest of the session, with practical activities, summarizing the skills and knowledge acquired, and giving assignments, proceeds as usual.

Instead of the trainer adding up on the collected knowledge, she or he could ask the owner or manager to present missing information or to explains farming activities step by step. In the latter case it is advisable to have a preparatory meeting with the owner or manager and to show or hand out a copy of the information sheet.

Practical training or practical exercises

All training should be as practical as possible. All newly acquired knowledge has to be applied in practice and the skills are to be practiced either during the training or between the trainings on the own farm or on a farm of a relative.

If practicable, the training should be carried out in the participants' farms, in specialized farms or at demonstration sites. However, this requires preparation:

- Is there enough space for the participants?
- Are all materials available?
- Are tools available or do the participants’ have to bring along their own?

Case studies

Sometimes case studies are helpful to get involved in a topic or to practice newly acquired skills.

If the case study is to be used to engage the participants with the topic of the session, then it will be analysed and worked on in - group setting at the beginning. The rest of the session proceeds as usual.

Case studies may also be used to apply newly acquired knowledge. Then the case study and related tasks are carried out instead of the practical activity.

At the beginning of a new series of training sessions

If the trainer starts a new training series with participants he has not yet trained, then she/he should follow these steps:

a) Climate setting (5 minutes)

- One of the trainers greets the participants and asks them how they feel about being participants of the training. Trainers should be relaxed and friendly. All trainers should be visible at this time
- Arrange seating plan into a “U” shape and remove the tables
- Set up the Flip Chart (FC) stand and all other materials that will be used
- Ask participants some introductory questions:

- For example: What is your interest in vegetable production?
- Also ask the participants what they expect to happen during training session
- Ask the participants if they personally know each other as well as the members of the training team

b) Trainer and participants introduction (20 – 30 minutes)

- First, trainers introduce themselves. The introduction should cover the first name, surname, family background, home and home district, duty station, official responsibilities and life goal. The introduction should be informal and friendly
- Let the participants pair up and arrange to introduce each other

c) Clarification of expectations (30 minutes)

Expectations of participants are collected at least at the beginning of each module.
Ask participants to write on one card or piece of paper provided what they expect to achieve at the end of the training course. These are called expectations. The participants should not list more than five expectations. The facilitators should not collect the cards.

- Ask one participant to write her/his expectations directly on a Flip Chart (FC). Afterwards ask the second participant to add what is not already on flip chart in writing and to make a check mark beside those expectations he/she has listed as well
  - This takes less time than one might expect since the expectations of the last participant will be included in those listed by the first part of the group
- Be frank with participants about expectations, all of them may not be met during the training program
- Give a brief overview of topics that will be covered
  - Keep the flipchart paper and check from time to time what has been covered and what could be integrated in the upcoming training sessions
  - Collecting expectations helps the trainer to find out what the participants had in mind when they came to the training
  - At this stage of the course, it is important to encourage participants to take part in order to establish the interactive mode that will continue throughout the course

Expectations may also be collected at the beginning of a new topic or session. In this case, the collection should take place in a short plenary session

d) Training rules and regulations - norms (10 minutes)

- Explain that norms are behaviors that participants agree upon to regulate their activities for the success of the training
  - The key to a successful norm is that it is agreed upon by the group and not imposed by the trainers. No norm should be “finalized” without discussion and agreement
- Examples of norms:
  - Putting phones on silent mode
  - Do not disturb others by making noises
  - Punctuality
  - Active participation
  - No side meetings
- Ask participants to propose norms for the training and let them discuss and agree to them by themselves
- Once agreed, write the norm on the flip chart
- Keep the flip chart paper and take it along to the other following sessions. If necessary, remind participants of the set norms

MODULE 1: INTRODUCTION TO GROWING OF VEGETABLES

Topic 1: Meaning, importance and challenges of vegetable growing in Malawi

ITEM	CONTENT
Objectives	By the end of this topic, farmers will be able to: - identify types of vegetables grown in Malawi - explain the challenges of vegetable production in Malawi
Training materials	Flip charts, markers, masking tapes, flip chart stand, ballpoint pens and note - books
Training duration	90 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to brainstorm on the meaning, importance and challenges of vegetables in Malawi (encourage the participants to use as much personal experience as possible)
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present on behalf of the group what they had discussed during group work on meaning, importance and the challenges of vegetable growing in Malawi
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to the presentations from all the groups, facilitate a plenary session on the importance of growing vegetables
- The trainer should build the session on the experience and knowledge shared by all the groups in their presentations
- Ensure that the session broadens the discussion to capture economic, social, nutritional, and environmental importance of vegetable growing and covers all details given in the information sheet

INFORMATION SHEET

Vegetables are an important source of fibres, mineral salts and vitamins, which are vital for good health.

Table 1: Examples of the crops that provide nutrients named in column 1

NUTRIENT	CROPS
Vit A	
Ascorbic acid (Vit C)	
Vit E	
Iron	
Calcium	
Iodine	

Vegetables

- Improve nutrition since they are rich in vitamins (A & C), minerals (iron and iodine) that prevent nutritional deficiencies
- Are good source of fibres, which can assist in prevention of constipation, gallstone, and cancer of the colon
- Have some medicinal values for example eating garlic lowers high blood pressure and assist in rheumatic conditions

- Generate better income to the household per unit area cultivated, since most vegetables are regarded as high value crops in comparison to other field crops
- Are sources of employment (e.g. Nali and other canning/processing factories and commercial farms)
- Source of foreign exchange; e.g. paprika is being exported

Despite being widely grown in the country, adequate supplies of vegetables are mostly during the rainy season, especially the indigenous vegetables. As a result, supplies are not adequate throughout the year.

Major issues being associated with vegetable production in Malawi are as follows:

- Seasonality in production due to high disease and pest occurrence during the rainy season and inadequate moisture during the dry season
- Scarcity or no improved vegetable seed
- Inadequate use of compost and other types of manure
- Inadequate availability of inputs such as fertilizers, seed\ and pesticides
- Unorganized marketing system

Therefore, efforts should be made to encourage year - round production of both exotic and indigenous vegetables. The exotic vegetables include: Cabbage, tomato, onion, lettuce, rape, leaf mustard and turnips while the indigenous and local vegetables include: Bonongwe (*Amaranthus spp*.), mnkhwani (*Cucurbita maxima*), khwanya (*Phaseolus vulguris*), mwamunaaligone (*Galinsoga parviflora*), chisoso (*Bidens pilosa*), kamganje (*Brassica juncea*), chitambe (*Vigna unguiculata*), denje (*Corchorus, trilocularis, Corchorus aestuans*) and many others.

Tips for facilitators

- When preparing for this session, prepare as much data and information as possible from a local agriculture office or any other relevant resource center
- If there is possibility of using a locally available vegetable grower, bring him/her during the training so that he/she motivates the participants of the training about the commercial viability of vegetable growing from his/her experience

Activity IV: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 2: Classification of vegetables

ITEM	CONTENT
Objective	By the end of this topic, farmers are able to: - identify various classes of vegetables - indicate different classification methods
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand
Training duration	90 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct them to brainstorm the various classes of vegetables they know or they may have come across
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for presentations of their discussion outcomes
- Invite representatives from each group in turns to present the outcomes of their discussion in the plenary session
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all the groups, facilitate a plenary session on classification of vegetables
- The trainer should build the session on the experience and knowledge shared by all the groups in their presentations
- The focus should be on how the classification affects productivity of vegetables in different agro - ecological zones, how classification affects customer preference and agronomic practices such as rotation

INFORMATION SHEET

Classification and types of vegetables

There are many methods of classifying vegetables but commonly they are grouped according to botany, climate and morphology.

Botanical classification

In this classification system, vegetables are named based on scientific grouping of binomina system where genus and species names are used. For example: Cabbage (Kabichi) –> Brassica oleracea var. capitata, Garden peas (Sawawa)–> Pisum sativum, Beans (Nyemba)–>Phaseolus vulgaris, Potato (mbatatesi) –> Solanum tuberousum. This classification helps farmers to develop good crop rotation plan.

Climatic requirement (for illustrations refer to temperature section below under the information sheet)

- Cool season or winter vegetables such as onion, garlic, peas, head cabbage, potato, asparagus, kohlrabi, head lettuce, broccoli, cauliflower, leaf mustard, rape, kale, etc.
- Warm season or summer vegetables such as tomato, corn, cucumber, watermelon, eggplant, beans, pumpkin, Jews marrow, *amaranthus*, cat whiskers, etc.
- Year round such as cabbage, tomato, carrot, pepper, Swiss chard, beet root, etc.

This classification system is very important for farmers because it helps in selecting suitable/adaptable vegetable species for given climatic conditions especially when temperature sensitive.

Morphological classification

This classification is based on the distinctive part/organ of plant that is consume or has economical value. On this basis, vegetables are classified as:

- Leafy vegetables: grown for their leaves e.g. leaf mustard, lettuce, kale rape, amaranthus, etc.

- Fruit vegetables: grown for its fresh fruits e.g. tomato, eggplant, watermelon, etc.

- Roots/bulbs/tuber vegetables: grown for underground parts or organs such as carrot, onion, garlic, potato, etc.



- Stem vegetables e.g. bamboo shoots and asparagus, etc.


- Flowers/curds such as cauliflower, cabbage, broccoli, etc.


- Seeds/pods such as peas, green maize, green beans



This classification helps farmers to know when different vegetables can be harvested and consumed. For example, snap beans are harvested when the pods are tender, while common beans are harvested when the pods are dry and filled with beans.

Activity IV: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 2: SITE SELECTION

ITEM	CONTENT
Objective	By the end of this topic, farmers should be able to select a suitable site for a nursery and for the production of various types of vegetables
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens notebooks
Training duration	120 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to brainstorm and share experiences on what should be key considerations when selecting a suitable site for vegetable production
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for presentations of their discussion outcomes
- Invite representatives from each group in turns to present the outcomes of their discussion in the plenary session
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (30 minutes)

- After listening to presentations from all the groups, facilitate a plenary session on major factors to consider when selecting a suitable site for vegetable nursery establishment and field production
- The trainer should build the session on the experience and knowledge shared by all the groups in their presentations
- The emphasis should be on the following factors: soils, water and accessibility

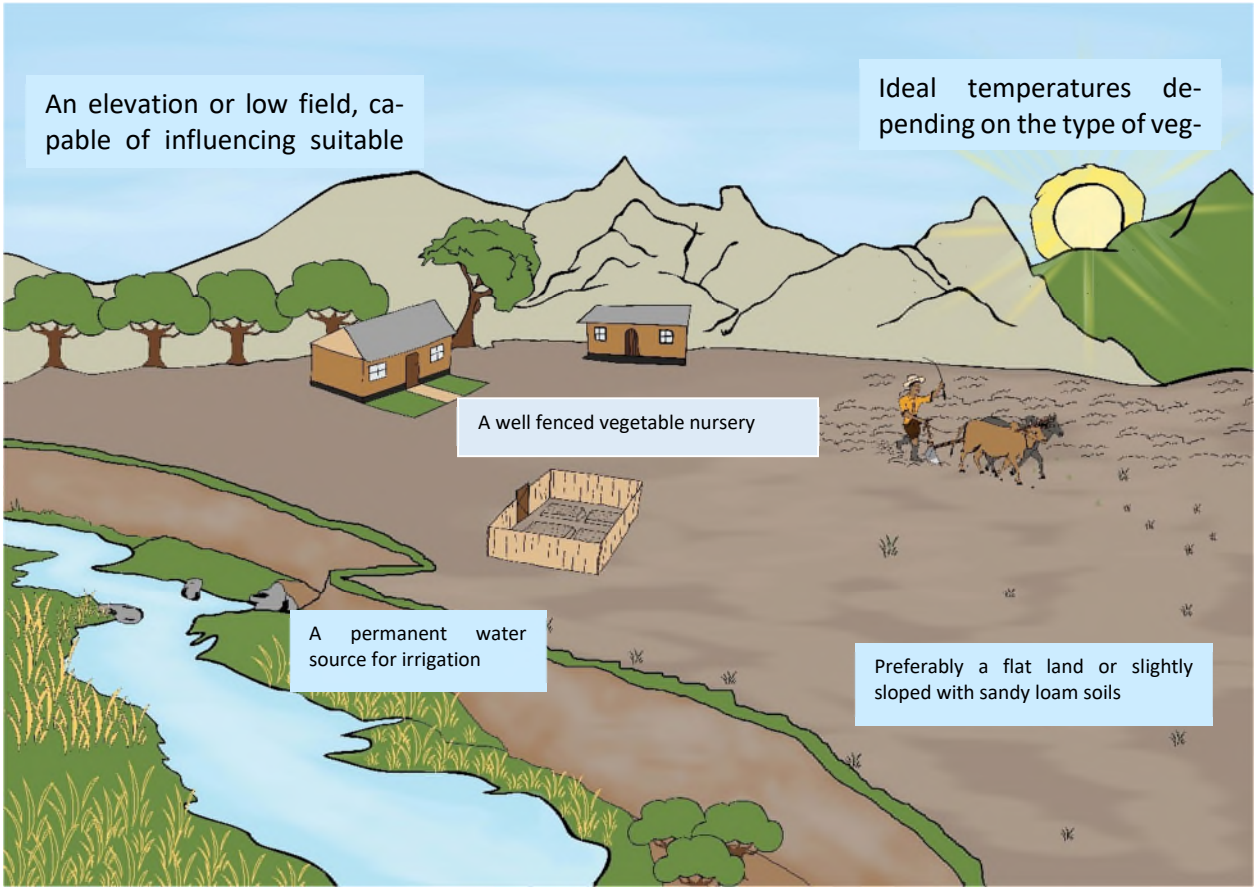

Figure 1: Important site selection factors for both nursery and field establishment of vegetables

INFORMATION SHEET

The success of vegetable production starts with the selection of a suitable site. Careful selection of the site before establishment is required.

The following factors must be considered when selecting a site: Water supply, temperature, topography, accessibility, sunlight, soils and fence.

Water supply

A vegetable garden must be sited near a permanent source of water such as a river, deep well, borehole etc. If rainfall is not adequate, supplement water by irrigation. Many vegetables do not withstand long dry spells.

Temperature

The type of vegetable to grow must be adapted to the prevailing temperature. Cool season crops tend to perform badly in warm or hot areas. The vegetable classification according to the temperature requirements below gives the details:

Warm season vegetables

Tomato	 **(Between 18^{O}C and 27^{O}C)**
Corn	
Cucumber	
Watermelon	
Egg plants	
Beans	
Pumpkin	
Jews marrow	
Amaranthas	
Cuts whisks	

Cold season vegetables

Onion	 **(Between 15^{O}C and 18^{O}C)**
Garlic	
Peas	
Cabbage	
Potato	
Broccoli	
Cauliflower	
Leaf mustard	
Kale	
Lettuce	

All year - round vegetable

Cabbage	  **(Between 15^{O}C and 18^{O}C) (Between 18^{O}C and 27^{O}C)**
Tomato	
Carrot	
Pepper	
Beet root	
Swiss chard	

Topography
The slope of the site must be fairly gentle; otherwise, terraces are necessary. There is always a lot of soil erosion where the slope is not gentle. Consider also the altitude of the area. Altitude can modify the temperature of the site. High altitude areas may be ideal for cool season vegetables such as lettuce, cabbage, broccoli and others.

Accessibility
The site must be accessible for easy transportation of produce to the market or home for storage. It should be easy to reach for supervision of activities. The real vegetable farmer should develop a skill of talking to his or her plants every day in checking their condition in terms of moisture, pests and diseases.

Sunlight
Almost all crops require sunlight at various stages or throughout the growing period. Vegetable plants manufacture food in the presence of sunlight (photosynthesis). Therefore, the site must receive plenty of sunlight.

Soils
The best soils are sandy loam but other soils can also be suitable provided there can be an improvement in texture and drainage. Raised beds are necessary during the rains for better drainage while sunken beds are for conserving soil moisture during the dry season. The soils must be rich in organic matter and that is why compost application is necessary in vegetable production after any crop, to improve the soil structure. Soil testing can be done in order to determine the nutritional status and soil pH. Generally, most vegetables perform well at pH ranging from 5.7 to 7.0. Soil testing can be done at institutions such as Chitedze and Bvumbwe Agriculture Research Stations, ARET and FES. Correct any deficiencies in the soil to boost production.

Fence
Consider fencing the vegetable garden in order to protect it from wind, both wild and domestic animals.

Activity IV: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Assignment/individual work (10 minutes)

- Inform the participants that each one of them has an assignment to do when they go back home:
    - They will be required to select a suitable site where they will grow their chosen vegetable(s) or set up a nursery using the knowledge gained from the training
- Explain to everyone that the chosen sites will be inspected before the day of the next training and before anyone begins to establish their nurseries or starts sowing

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date and time to follow up visits to check the selected sites for individual nursery and field establishments
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 3: VEGETABLE PRODUCTION PLAN

ITEM	CONTENT
Objective	By the end of this module, farmers are able to: - develop a production plan for their vegetable enterprise
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens note books, template and/or example of vegetable production plan.
Training duration	120 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to brainstorm and share experiences on the various components that constitute a vegetable production plan
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations: (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (30 minutes)

- After listening to presentations from all the groups present the major components of a good plan for vegetable growing
- The trainer should build the session on the knowledge shared by all the groups in their presentations
- The emphasis should be on the following factors: market availability, choice of crops, resources required, staggering production and seed rate

INFORMATION SHEET

Vegetable growers must plan garden activities properly in order to produce vegetables on a regular basis, preferably year - round. Planning requires good record keeping. If you do not keep records you cannot plan in detail. It is critical to consider the market - and/or the consumer demands in the plan because it is of no use to grow vegetables that will not be liked by the consumers or customers as being the market outlets.

Planning involves paper work and the following must be considered:

Table 2: Potato production plan

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall												
Site selection												
Land preparation												
Planting												
Weeding												
Fertilizer/compost												
Pest & disease control												
Harvest												
Packaging												
Marketing												

(a) Choice of crops to grow

Growers should plan in advance the types of vegetables to be grown in their areas and the quantities to be produced. Crops chosen must be adaptable to the prevailing climatic conditions in that area. For instance, in high areas, cool season vegetables will adapt well while in low areas it is important to grow warm season vegetables. Where farmers in low lands want to grow cool season vegetables then they must grow them during the cool month of the year.

(b) Resources required

In planning farmers must consider the resources required for the production of the chosen vegetables. Such resources include quantity of seed, manure/fertilizers, labour, etc. This helps farmers to reduce wastage. For example, many farmers waste seeds by sowing more than what they can transplant. Seed is very expensive and hence the need to reduce wastage. Farmers must calculate the quantity of seed required and its cost to buy the adequate quantity.

(c) Market availability

Many vegetables are perishable and cannot be stored for a long time, especially without cooling. It is therefore important to identify the market before production.

(d) Staggered production

Planning should also consider staggering of production in order to regulate supply of vegetables at the market. Staggering production will also enable a farmer to manage the crop easily. With staggered sowing for example, all year - round production is feasible and farmers have something to sell throughout the year. Many farmers have problems in selling all their produce because they do not stagger their production. Low market prices are as a result of over - production during certain periods. Farmers who stagger production are always compensated at certain periods when market prices for vegetable produce are high. The figure below illustrates an example of staggered production plan of cabbage with a two weeks staggering interval.

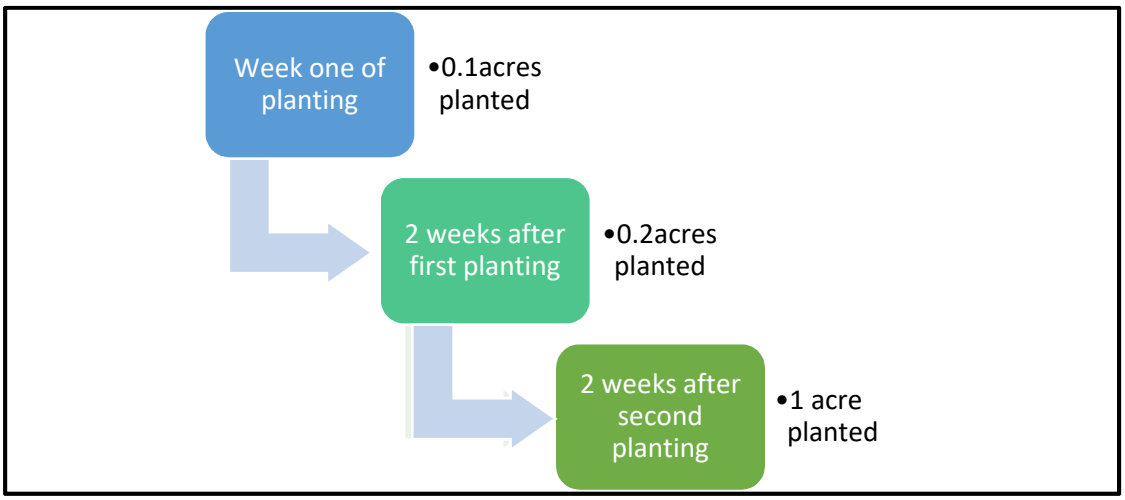

Figure 2: Staggering production of cabbage

(e) Seed rate

Many farmers waste seeds by sowing a lot but transplanting a few. Seed is expensive and hence the need to reduce wastage. It is important to know the seed rate. For example, a farmer needs about 80 to 120 g (gram) of French bean seed to plant a row of 10 meters. Therefore, growers should calculate properly the quantity of seed required and the cost to buy the adequate quantity of seed.

Table 3: Vegetable seed rates guide

CROP	SEED/G	SEED DEPTH (CM)	POPULATION PER HECTARE		GM/SEED ROW OF 10 M BED
			Gm	Kg	
Artichoke	8 - 10	2	500	-	2.5
Asparagus	50 - 60	1.5	1	-	9
Beans	4	5	-	56 - 90	80 - 120
Beet root	50 - 65	1.5 - 2	-	8 - 10	9
Broccoli	320 - 350	1 - 1.25	300	-	2.5
Cabbage	280 - 350	1 - 1.25	300	-	2.5
Carrot	800 - 1000	1 - 1.25	-	4.5 - 5	5
Cauliflower	280 - 350	1 - 1.25	300 - 450	-	2.5
Cucumber	30 - 40	2 - 2.5	-	2.5 - 3.5	5
Eggplant	200 - 500	1 - 1.25	350 - 500`	-	1.2
Garlic	(bulb)	4	-	500 - 700	6 - 10 bulbs
Leek	350 - 400	1 - 2	1500	5	5
Lettuce	600 - 1000	0.5	500	-	2.5
Muskmelon	30 - 40	2 - 2.5	-	1.5 - 2.5	5
Melon	10 - 18	2 - 3	-	1.5 - 3.5	9
Mustard	550				
Okra	14 - 18	2 - 2.5	-	6 - 9	18
Onion	280 - 350	1	-	3 - 3.5	9
Peas	3 - 5	3 - 3.5	-	100 - 180	150
Pepper	150 - 200	0.5 - 1	400 - 500	-	1.2
Pumpkin	5 - 7		-	3 - 4.5	9
Radish	100 - 140		-	1 - 12	9
Spinach	100 - 150	2	-	11 - 15	9
Squash	5 - 8	3	-	3 - 4.5	5
Sweet corn	5 - 6	2.5 - 3	-	10 - 15	75
Tomato	300 - 400		150 - 200	-	2.5

Activity IV: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Assignment/individual work (15 minutes)

- Inform the participants that each one has an assignment to do when they go back home
- They will be required to develop a plan for their commercial vegetable production following the factors highlighted in this session and any other important factors
- Explain to everyone that the plans will be checked during the next training

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 4: CROP ROTATION

ITEM	CONTENT
Objective	By the end of the module, farmers are able to design a successful crop rotation plan for their commercial vegetable production
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens note books, templates or examples of crop rotations plans
Training duration	120 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct them to brainstorm and share experiences on the knowledge, importance, principles, practices and activities governing crop rotation
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (25 minutes)

- After listening to presentations from all groups, facilitate a plenary session on the importance, principles, practices and activities in crop rotation
- Build your presentation on the points and experiences presented by the participants

INFORMATION SHEET

Crop rotation is planting different vegetable crops on the same field in a particular sequence to give the resources in the soil a chance to recover. Planting the same or related crops every season on the same piece of land (mono cropping), depletes the nutritive value of the soil and adversely affects the soil texture. Many diseases and pests are plant specific, and they attack specific plants. Therefore, if the same plant is grown in the same place every year, pests and diseases will be more of a problem therefore it is important that crops be rotated in the same piece of land.

Importance of crop rotation

Crop rotation has the following principles:

- Crops from the same family should not follow each other in rotation
- Deep – rooted crops should follow shallow rooted ones

Based on these principles crop rotation is practiced to:

- Control pests and diseases
- Improve soil fertility
- Reduce plant toxicity in the soil

Crop rotation reduces incidences of pests and diseases, depletion of plant nutrients from the same root zones and avoiding accumulation of toxic plant exudates. Crop rotation is known to eliminate *Pseudomonas,* bacterium causing late potato blight. It also controls the root - knot nematodes. Some of the plant families that farmers must know them when planning their crop rotation include:

Plant families/groups

Solanaceae – e.g. tomato, eggplant, white potato etc.

Brasicaceae – e.g. cabbage, broccoli, cauliflower etc.

Alliaceae – e.g. garlic, onion, shallot, leek etc.

Fabacease - e.g., green beans, pigeon peas, etc.

Crop rotation plan

Farmers should divide their piece of land into plots. The number of plots must be the same as the number of vegetable families to be planted in the season. On each plot, grow vegetables from the same group and change to a different family group next production season. A good example is shown below:

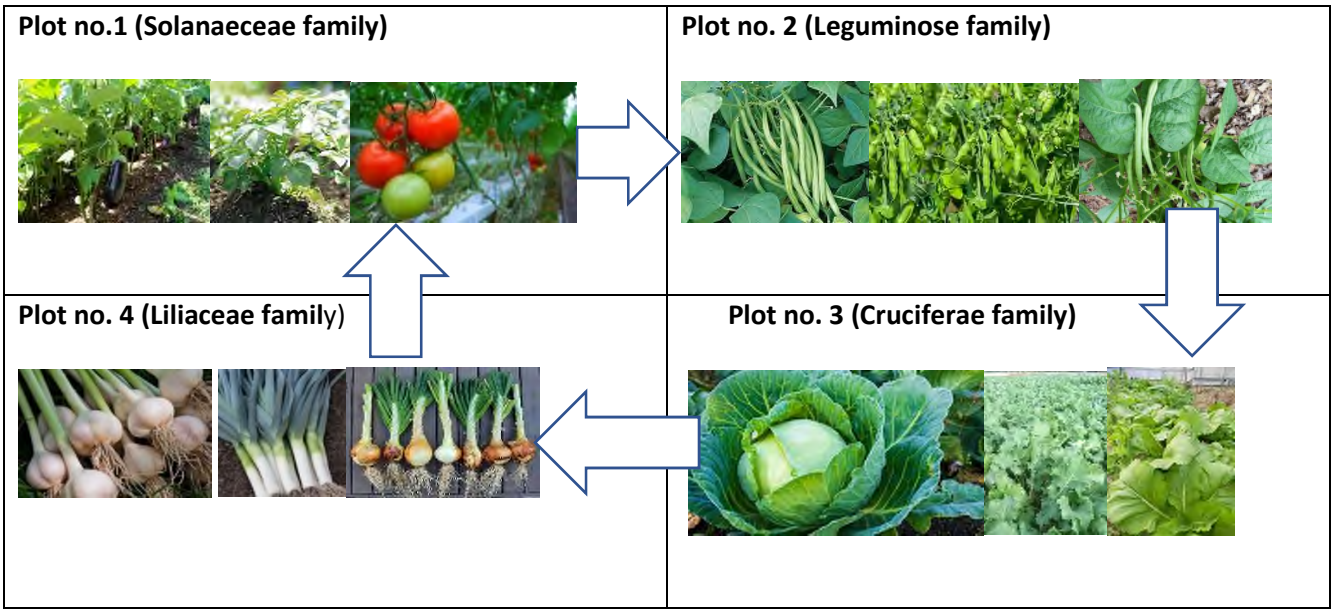

Figure 3: A sample rotation plan for vegetables based on the families

Legumes e.g. beans, peas and broad beans. Legumes can be used to improve the soil provided that succulent legumes are ploughed into the ground. If the legumes are harvested, there will be little improvement in the soil since they will have used up most of the nutrients. Legumes require little nourishment and rarely require extra nitrogen.

Leafy vegetables such as lettuce, cabbage, spinach, etc. These require a great deal of additional feeding since they absorb a lot of nutrients from the soil. Sufficient manure and compost should be applied.

Root vegetables such as carrots, onions, beetroot, turnip, etc. Do not use manure before planting these vegetables as it causes deformed and excessively branching roots with many side roots, giving the root an unattractive appearance. Manure contains a lot of nitrogen, which stimulates top growth to the detriment of the root growth.

Fruit vegetables such as tomatoes, peppers, marrows, sweet corn, watermelon, cucumber, etc. They do not need as much feeding as the leafy vegetables. If the ground is fertile, less manure and compost is necessary.

Fallow , it is beneficial to let the land rest (lie fallow) at the end of the rotation cycle, and allow weeds to grow. The soil can also be improved during the fallow period by planting a legume crop and then working the entire plant into the soil. The fallow period should last at least two months.

It is also better to plant leafy vegetables, which react well to higher nitrogen content, after legumes, because legumes have a beneficial effect on the nitrogen content of the soil. Since too much nitrogen adversely affects root crops, they should be sown at the end of the cycle. Leave two to three weeks between harvesting and the planting of the next crop. During this time the bed can be prepared for planting

Activity IV: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Assignment/individual work (10 minutes)

- Inform the participants that each one of them has an assignment to do when they go back home
- They will be required to develop a rotation plan for their vegetable production enterprise using the knowledge gained from this session
- Explain to everyone that the plans will be checked during the next training

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 5: COMPOST MAKING

ITEM	CONTENT
Objective	By the end of this topic farmers are able to: - identify the best method of making compost for their commercial production - prepare various types of compost
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand, sacks, organic matter (e.g. grasses, leaves, straw, garbage, farm manure), ash, water, hoe, weeds, rake, shovel, watering can.
Training duration	270 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct them to brainstorm and share experiences on the materials and procedures for making compost
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (30 minutes)

- Call the the participants back for the presentation of their discussion outcomes.
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (40 minutes)

- After listening to presentations from all groups, in present the materials and procedure for making compost
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET

Compost is well - decomposed organic matter capable of releasing nutrients to the plant and improving soil fertility and structure.

Figure 4: A well decomposed compost

Soil consists of two parts, animate (living) section called humus and inanimate (non - living) section comprising sand, and clay. Humus consists of millions of organisms, which are so small that they cannot be seen by the naked eye. They are called microorganisms, and they live on organic material such as manure, plant matter (grass, leaves, etc.), animal matter (bones), eggshells and sawdust. These microbes die when the organic material changes into compost. The dead microorganisms are good food for plants.

Compost requirements

The microorganisms function well if the following requirements are met:

a) Air

There must be enough air in the compost. Organic material must therefore not be squashed together too much or be full of water.

b) Water

The organic material must be kept moist and not be allowed to dry out.

c) Warmth

The organic material can either be kept warm by making it in a hole in the ground, or if it is above ground, by covering it with plastic sheets.

d) Food

Make sure that the organic material has enough carbon **C** and nitrogen **N**. Carbon is found in grass, hay, stems and branches. Nitrogen is found in manure, urine and chemical fertilizers.

1. Importance of compost

- Compost provides crops with plant nutrients
- Improve topsoil structure through supply of organic matter, hence: - improving root penetration, improving permeability, improving water retention, improving resistance to erosion, improving aeration in the soil
- Reduces leaching of the soil nutrients
- Improves soil microbial activity
- Supplies nutrients even in succeeding years after application

2. Problems associated with compost

- High labour demand
- The quality is variable, hence nutrient content in particular manure is not known
- Large volumes of water are needed to make manure
- Material is bulky and needs to be transported to the field if not made in the fields

3. Types of compost manure

- Pit compost
- Chinese compost (Changu method)
- Chimato compost
- Wooden frame compost
- Windrow compost
- Bokashi compost

4. Compost manure making

4.1 Pit method

It is made in a pit hence its name. Usually, it is not recommended during the rainy season unless an overhead protective roof is constructed to avoid excessive water entering into the pit that may stop the decomposition process.

Composting materials required

- Grass
- Crop residues
- Maize stover
- Leaves of various plants
- Booster with high Nitrogen content, e.g. Khola manure or previously made compost manure, decomposed matter from garbage pits. The booster provides microbes, which are required to speed up the decomposition process of the composting materials
- Green fresh matter and leguminous leaves
- Water

Equipment and tools

- Bucket or watering can
- Measuring stick
- Hoes
- Shovels
- Panga

Note

Chop the composting materials to at least less than 10 cm long to increase the surface area necessary for rapid decomposition.

Site selection

Preferably, the site should be:

- Near a garden where the manure will be used to ease transport problems. If it is made in the garden, it is better to site it on the edge of the garden in order not to disrupt cultivation operations in the middle of the garden
- The site should preferably be under ***shade*** in order to maintain moisture in the pit
- Select a fairly flat ground for even distribution of organic material and water
- The site should be convenient for collection of materials and water

Procedure

- Clear the surface of the ground in at least 2 m diameter for easy marking
- Measure out a square of 1.5 m by 1.5 m
- Dig a pit 1.5 meters square. The depth should be 1.0 m. Below 1.0 m there is a reduction in the number of microbes which are necessary in decomposing the composting materials. Separate topsoil from sub soil since topsoil may be re - used when piling the pit.

Figure 5: A standard pit for compost manure making at CIH in Salima

- Water the whole pit adequately. It is important because subsequent watering may not be required
- Spread the booster to a depth of 3 to 5 cm to provide N to microbes in the pit
- Water the manure adequately until it is completely saturated
- Pile the bulk of composting materials to a depth of about 30 cm

- Water adequately to induce the decomposition process.
- Put manure again to a depth of 3 to 5 cm to provide N
- Repeat the procedure of alternating the composting material and manure until the pit is full
- Cover the pit with topsoil of about 8 cm thick
- After three to five days check for warmth by inserting a stick to see if decomposition has started. Normally, the stick will feel warm

Note

If the pit is not under shade, cover the top with grass or leaves to conserve moisture.

Turning is not required

Signs of maturity

- The materials become dark or grey in color
- The pit sinks to almost half its original size
- The materials become unrecognizable

Duration to maturity

The manure will be ready in about two to three months' time depending on type of composting materials used.

4.2 Chinese type (Changu)

The organic materials decompose relatively fast hence the name 'Changu'. Site selection is the same as that for Pit compost but in addition the site should be away from dwelling houses and behind windbreaks. The composting materials are the same as in pit compost.

Procedure

1. Clear the ground for easy marking
2. Mark 1.5 to 2 m diameter circle by using a string and a peg
3. Heap 20 to 30 cm thick layer of composting materials. This will form the base of the compost heap
4. Water the heap adequately until water just oozes out when material is squeezed between the fingers
5. Add booster on top to a height of 3 to 5 cm thick
6. Water the booster layer adequately
7. Repeat steps 3 to 6 procedures process with the diameter of each subsequent layer reducing until the heap is 1.5 m high, thereby achieving a conical shape

- If the heap is not under shade cover it with grass to conserve moisture

Figure 6: Chinese (Changu) compost manure heaps at Corporate Institute of Horticulture in Salima

Procedure in turning

Where decomposition has started**:**

1. After two to three days the heap will have formed three distinct layers. The outer layer A, the middle layer B, and the inner layer C.
2. Turn the heap every five days to speed up decomposition.
3. During turning, remove the outer layer A from the heap and separate the middle layer B from the inner layer C.
4. Put layer A at the bottom as illustrated below:

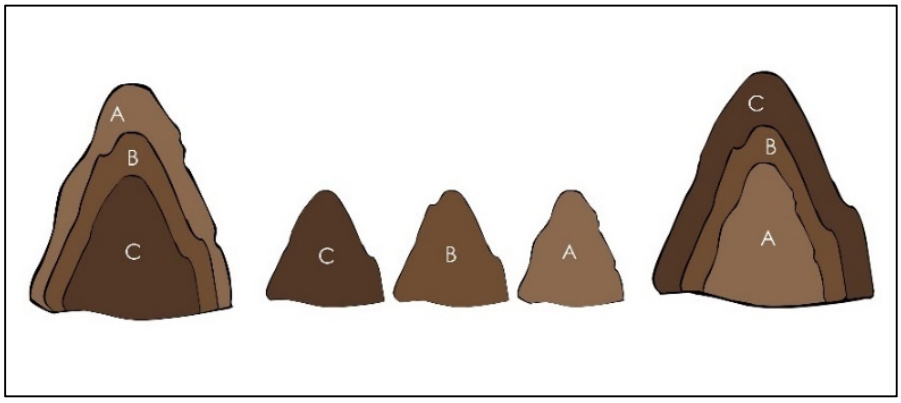

Figure 7: Procedure for turning compost

5. Water adequately.
6. Put layer C in the middle.
7. Water adequately.
8. Lastly put layer B on top/outside the heap.
9. Water and cover the heap with grass if necessary.

Note

The conditions are most suitable for decomposition at the middle of the heap. The heap will mature in about 30 to 40 days' time. The softer and greener the material the faster it will decompose.

Figure 8: A matured heap of Chinese compost

4.3 Chimato compost

Chimato is a form of compost that is made as a heap on the ground. When the heap is complete, it is smeared on the outside with mud and requires no turning and additional water.

Site selection and materials required are the same as for those already discussed in Pit and Chinese.

Procedure:

There are different ways by which Chimato compost can be made. The dimensions of the conical type of Chimato are the same as that of the Chinese compost. The major difference is that in the Chimato compost two cross poles are fixed when making the compost. The third pole is fixed at the centre. These three poles are later removed leaving holes that will act as air vents. The piling of the compost materials is exactly the same as in Chinese compost. Watering is done after heaping each layer. Smear the outside with mud leaving the vents open. Cover the heap with grass or plastic paper to maintain moisture.

1. Chimato compost has the following dimensions:
   Length: 1.5 m
   Width: 1.5 m
   Height: 1.5 m
2. Arrange the logs, bricks, stones in pairs at 10 cm apart creating a gap for air vents.
3. Set three air vents at 60 cm apart.
4. Lay down maize stover or twigs on logs to create a bed.
5. Fix a pole in the middle of the created bed. When the compost heap has been completed, the pole will be removed leaving a hole that will become an air vent for aeration in the compost heap.

6. Pile the chopped composting materials and manure in exactly the same way as in the Chinese compost.
7. Water every layer adequately, until it oozes when the composting materials are squeezed.
8. Add a booster on top to a height of 3 to 5 cm thick.
9. Water again on top of the booster till it is saturated.
10. Repeat the above process of 20 to 30 cm layer of watered composting materials topped by a 3 to 5 cm of booster material up to a height of 1.5 m.
11. As the heap grows, shake the pole to ensure that there is an open hole.
12. When the compost has attained the required height, smear the heap with mud leaving the air vents open.
13. Cover the heap with grass or plastic paper to maintain moisture.
14. After one day remove the ventilation pole fixed in the middle.
15. After two to three days close the top vent to retain warmth in the heap.

Figure 9: Chimato compost heap at CIH in Salima

Duration to maturity

The manure will be ready in about 40 to 60 days time depending on type of composting materials used.

4.4 Windrow composting method

Windrow composting consists of placing the mixture of raw materials in long narrow piles called windrows that are agitated or turned - on regular basis (NRAES, 1992).

Windrow will help promote mass production of compost as preparation is done in large quantities.

Materials

- Dry stalks and leaves of maize (chopped)
- Soya or/and groundnuts residues
- Cattle/goat dung
- Virgin soils
- Wood ash

Procedure

Composting materials required

- Grass
- Crop residues
- Maize stover
- Leaves of various plants
- Booster with high nitrogen content, e.g. khola manure or previously made compost manure, decomposed matter from garbage pits. The booster provides microbes, which are required to speed up the decomposition process of the composting materials
- Green fresh matter and leguminous leaves
- Water

Equipment and tools

- Bucket or watering can
- Brushwood of about 2 m long
- Measuring stick/tape
- Hoe
- Shove
- Panga

Note

Chop the composting materials to at least less than 10 cm long to increase the surface area that is necessary for rapid decomposition.

Site selection

Site selection factors are same as pit compost.

Procedure

- Chop the crop residues/leaves preferably to 10 cm or less
- Clear the surface of the ground in at least 2 m wide for easy marking; the length of the cleared area should be dictated by the amount of composting material but should be in multiples of 1.5 m
- On the cleared surface, mark a rectangle of width 1.5 m and length of 8 m. The length could be extended in multiples of 8 m if one has adequate composting material
- Water the surface until the surface is just moist; Do not create a muddy condition
- Insert the brushwood along the perimeter of the windrow at 20 – 30 cm apart to a height of 1.5m
- Spread a layer of booster evenly to a thickness of 2 to 3 cm to provide a source N to microbes in the compost
- Pile a layer of about 30 cm of composting material on top of the booster
- Water adequately to induce the decomposition process
- Pile another layer 20 – 30 cm of composting material on top of the first layer followed by a layer of booster and water adequately
- Repeat the procedure of alternating the composting material and manure until the roll reaches a height of 1.5 meters
- Cover the compost roll with preferably black plastic paper to induce anaerobic decomposition
- Cover the roll with moist topsoil of about 8 cm thick
- After seven to fourteen days, check for warmth by inserting a stick to see if decomposition has started

Figure 10: Windrow ready for covering

Figure 11: A covered heap of windrow manure at CIH

4.5 Bokashi composting method

Bokashi is a product of fermented mixed organic fertilizer materials such as plant residues or compost that fully utilizes the ability of aerobic microorganisms. Ash is also added, hence the name Bokash. Bokashi manure is used for basal dressing and is of higher nutrient value than other types of manure

Composting materials required

- Crop residues such as maize stover or groundnuts straws/grass/leaves of various plants
- Booster with high nitrogen content, e.g. khola manure or previously made compost manure, decomposed matter from garbage pits. The booster provides microbes, which are required to speed up the decomposition process of the composting materials
- Wood ash
- Water

Equipment and tools

- Watering can or bucket
- Measuring stick
- Hoe
- Shovel
- Panga

Site selection

Same as factors for other types of compost explained above.

Procedure

- Clear the surface of the ground in at least two m (m) diameter
- Mark a circle of one m diameter
- Water the surface until the surface is just moist; Do not create a muddy condition
- Chop the crop residues/leaves preferably to 10 cm or less
- Mix five to eight wheel burrows chopped crop residues/grass/leaves with three to four wheelburrows chopped soya or groundnut haulms and 20 – 30 shovels cattle/goat/chicken dung, three to five shovels wood ash and half (1/2) shovels fermented gaga
- Apply water while turning the mixture thoroughly such that water is evenly distributed into the mixture. Water until the mixture is just moist
- Mark a circle of one m diameter
- At the center of the circle, insert a stick to a height of 1 m
- Pille the mixture around the stick to a height of half (1/2) m
- Cover the mixture with a plastic paper, preferably black
- Cover the heap with a thin layer of soil or stones so that the paper shall not be blown off by wind
- After five to seven days check for warmth by inserting a stick to see if decomposition has started

Table 4: Benefits, problems and application rate for the different types of manure

METHOD	BENEFITS	PROBLEMS	RATE
Pit	- No turning required - No subsequent watering - Pit can be reused	- More labour to dig the pit - More labour to lift the compost from the pit - Difficult to make during the rainy season	10 pits per 0.4ha
Chinese (Changu)	- Can be ready in 40 days at most - Possible to throughout the year	Labour - intensive during turning.	15 heaps per 0.4ha
Chimato	- No turning required - Possible to make through-out the year	- Requires shelter during the rainy season	10 heaps per 0.4ha

5. Method of application

Two handfuls per planting station for cereals is the most recommended. The two handfuls weigh about 250 g. At this rate, the amount of manure applied is 3.5 tons (t) per hectare. When farmers have adequate manure, they can apply manure in the furrows. The recommended amount is one 20 litre (l) tin/bucket spread along an 8 m of furrow. They can also apply using binding and broadcasting. Broadcasting is common in rice fields.

Generally, the soil colour becomes darker with subsequent application of manure due to increase in organic matter levels.

Activity IV: Practical on making compost (120 minutes)

- Give an opportunity to the participants to practice making of compost of your choice or their choice depending on the available materials
- For the selected type of compost, follow the procedures laid out above ensuring that all participants actively participate in the processes
- Ensure that participants are involved in every activity including collection of the materials

Tips for trainer

- For an effective delivery of the practical, ensure that you arrange for the practical area well in advance inspecting where the compost will be made
- Ensure that all the materials for making the compost are sourced and made available on the day of the training
- The procedure of the practical provided in the description is comprehensive. Trainers will select the steps from the procedure depending on their situation

Activity V: Quality assurance and course assessment (30 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the question

Processing questions

- ✳ What were the main steps/activities and/or considerations in making compost?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor quality compost?

Application questions

- ✳ Will you be comfortable to make compost on your own?
- ✳ What alternatives are there to achieve in making compost in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Inform the participants that they have the task of making their own compost
- The trainer should make it clear to all participants that they are being visited to check that they have made compost and followed the correct procedure
- In addition, farmers should check each other and see if they are all using the correct technique in compost making

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 6: NURSERY ESTABLSHMENT

Topic 1: Land preparation and vegetable bed construction

ITEM	CONTENT
Objective	By the end of the topic farmers are able to prepare beds for a vegetable nursery or vegetable fields
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, slashers, pangas, axes, hoes, shovels, tapes, pegs, hammer and manure
Training duration	210 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to brainstorm and share experiences on the best practices in land preparation for a vegetable nursery and vegetable fields
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, summarize the best practices in preparing land for nursery establishment and field production
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET - INCLUDING PRACTICAL EXERCISE

Land preparation involves clearing the land of stones, bushes and tree stumps. It is important to plough or till the soil deeply in order to remove roots of other plants. Clods must be broken to fine tilth before levelling and then rake the trash out of the area.

Activity IV: Group practical: Land clearing, ploughing and bed making (45 minutes)

Step 1: Land clearing and tilling

This practical will be done in one group as a demonstration with all the participants. Suggested below are some of the steps that a trainer must consider for an effective demonstration:

- Allow the participants to be in their small groups as divided earlier on
- Take them to the demonstration site
- Arrange them in such a manner that they have a clear view of the demonstration area
- State the objectives of the demonstration clearly explaining the skills that will be acquired
- The trainer should display and describe all the materials to be used during demonstration
- Participants should then be allowed to practice land clearing, tilling and breaking of clods to make fine tilth as explained above

Figure 12: Manual land preparation activities for a vegetable site- slashing and tilling

Step 2: Nursery bed construction and manure application demonstrations (60 minutes)

The trainer should explain to the participants that the aim of this practical is to make them understand the steps followed in making a nursery bed for raising vegetable seedlings and manure application. Participants should know that seedlings can either be raised from a seedbed, cellular or seed trays.

Figure 13: A cellular or seed tray

However, many farmers use seedbeds to raise their seedling since this is a cheap method. The seedbeds could either be sunken or raised. The sunken seedbeds are used in the dry season or in areas where rainfall is low. These beds conserve moisture.

The raised beds on the other hand are ideal in the rainy season in order to avoid waterlogging conditions on the seedbed. These beds are also widely used in areas of high rainfall areas. The beds are usually one metre (m) wide and of any desirable length.

Figure 14: Sunken seedbeds

Steps in nursery bed construction

- Together with the participants, mark out the dimensions of 1 m wide and 3 m long
- Let participants raise the loose soil to a 15 cm height to make a nursery bed.
- Flatten the top of the bed. It is important to have a well levelled bed because this type of bed:
  - Prevents water from running towards one side of the bed during watering
  - Prevents manure and fertilizer accumulate on one side
  - Results in uniform growth of seedlings
  - Prevents damping off of seedlings as water does not settle on the bed. Note that the fungus that causes damping off disease thrives well in wet conditions.

Steps in manure application

- ✓ Apply 10 to 15 kg(kg) of well decomposed manure per 1 m^2 on a bed
- ✓ Thoroughly mix manure with the top soil to a depth of 15 cm
- ✓ Prepare at least two seedbeds with the participants

Figure 15: Application of manure

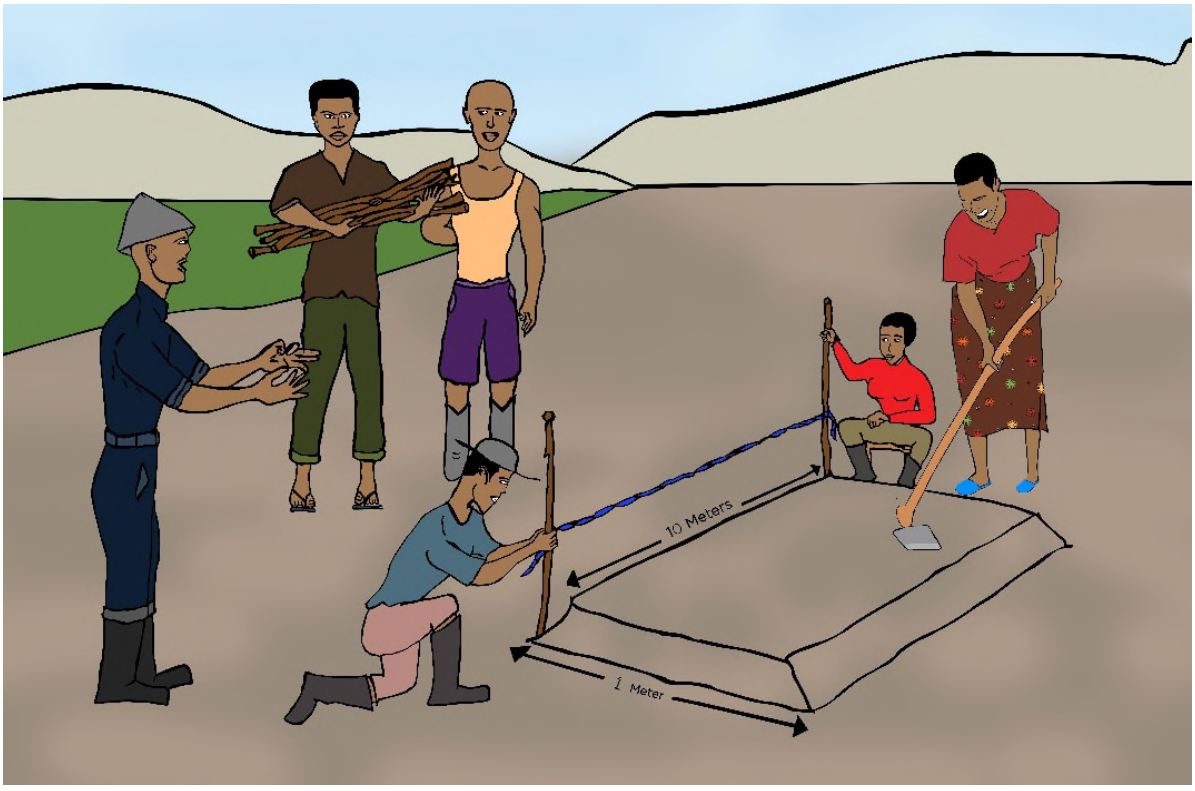

Figure 16: Demonstration on the construction of a vegetable nursery bed

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps in land preparation, making nursery beds and manuring?
- ✳ Which steps were the easiest and most difficult in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor vegetable seedling's growth?
- ✳ How can the skills gained here be applied to other crops?

Application questions

- ✳ Will you be comfortable making a nursery bed at your farm?
- ✳ What alternatives are there to achieve raising quality vegetable seedlings in the absence of other equipment or materials used in this demo?
- ✳ How can the knowledge gained in this session be applied to the production of other crops?

Activity VI: Assignment (10 minutes)

- Inform all the participants that each one of them has to prepare the land, make nursery beds and apply manure according to the knowledge and skills gained in this training session
- Explain also that this activity will be inspected before the next training as a means of verifying adherence to standards

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 2: Sterilizing nursery beds

ITEM	CONTENT
Objective	By the end this topic, farmers are able to sterilize nursery beds for vegetable seedlings production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, maize stalks or grass and matches
Training duration	180 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into groups of four to people depending on the number of participants
- Instruct them to brainstorm and share experiences on the procedure and reasons for sterilizing a vegetable nursery bed and vegetable fields
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, summarize procedure in sterilization of nursery beds and vegetable fields
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

Activity IV: Practical demonstration on sterilizing the beds (60 minutes)

Facilitate a practical on bed sterilization using the following steps:

- Beds should be watered to field capacity two days before sterilization to activate growth of weeds and resurgence of other harmful soil pests. Water also acts as a medium of heat. It reduces the loss of nitrogen and other nutrients from the soil in form of gas by avoiding direct heating
- Ask the participants to collect maize stalks or grass enough to sterilize the bed
- Instruct them to pile the maize stalks or grass on the bed to a height of 1 m
- Ensure that the participants completely cover the bed with maize stalks or grass for effective sterilization. After stacking the maize stalks or grass on the bed, the trainer should ask the participants to burn the maize stalks or grass as shown in figure 17a
- In addition, sterilize a second bed by solar energy as shown in figure 17b
- In this method, the bed is covered with a plastic sheet which attracts heat

Note

The trainer should emphasize that bed sterilization is done in order to kill pathogens that cause damping off disease, nematodes, other harmful insects, weeds and weed seeds.

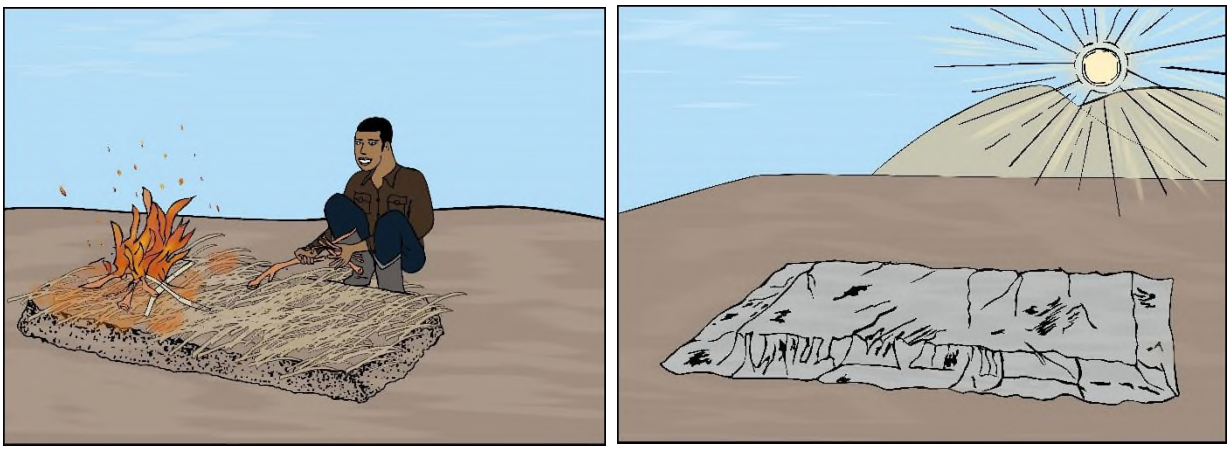

Figure 17: On the left hand side, sterilizing a nursery bed by burning maize stalks, on the right hand, sterilizing a vegetable bed by use of solar energy (solarisation)

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps in sterilizing the beds?
- ✳ Which steps were the easiest and the most difficult in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor growth of vegetable seedlings?
- ✳ How can the skills gained in this practical be applied to the production of other crops?

Application questions

- ✳ Will you be comfortable to sterilize nursery beds at your farm using the methods discussed in this lesson?
- ✳ What alternatives are there to achieve quality vegetable seedlings in the nursery in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Inform all the participants that each one of them will be required to sterilize their nursery beds according to the knowledge and skills gained in this training session
- Explain to all the participants that the sterilized beds will be inspected before the next training

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 3: Sowing vegetable seeds

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to sow the vegetable seeds for a commercial production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, ruler and seeds and 2 prepared seed beds
Training duration	210 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to discuss and share experiences on the procedure of sowing various vegetable seeds on a nursery
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group wor
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (15 minutes)

- After listening to presentations from all groups, summarize procedure in sowing of seeds in nursery and vegetable fields
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

Activity IV: Practical on sowing of vegetable seeds (120 minutes)

- Inform the participants that they have the task of sowing seeds on the beds they prepared and sterilized earlier on at least two days after beds have been sterilized in order to allow the beds to cool
- In sowing seeds, participants should follow the procedure laid out below

INFORMATION SHEET

Procedure for sowing vegetable seeds:

- Firstly, they must apply water to the seed beds in order to soften the soil for easy grooving
- They must make grooves of half a fingernail (0.5 cm for smaller seeds and a bit more for bigger seeds) deep and one full hand apart which is about 15 cm
- They must thinly and uniformly spread the seeds in the furrows
- Let the participants sow seeds as well on a second bed using the broadcasting technique. In this technique, the seeds are thinly and evenly spread on the bed without following any proper pattern. When small seeds are sown, the farmers should mix the seeds with sand to facilitate even distribution of the seeds on the bed.

After sowing seeds:

- They must cover the seeds lightly with sand to enhance germination
- They must immediately mulch the seed beds with grass to keep them moist and keep the beds cool on hot days. The participants must ensure that the grass they use for mulching is free from seeds, diseases and insects
- The mulch should be spread evenly and ensure that all bed shoulders are covered properly
- The participants should make sure that half of the mulch is removed as soon as most of the seedlings have germinated
- As grass mulch can attract white ants (termites), the participants must regularly check the mulch
- After mulching beds, they must irrigate the bed

Note

The trainer must emphasize to the participants that mulching and watering are crucial nursery management activities which start immediately after sowing. Duration: 60 minutes.

Figure 18: On the left, sowing vegetable seeds in broadcasting; on the right, watering a vegetable bed after sowing

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps and considerations in the sowing of seeds?
- ✳ Which were the easiest and the most difficult steps in the practical?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor chillies seedling growth?
- ✳ Which seeds are better sown in grooves and for which seeds should you use broadcasting?

Application questions

- ✳ Will you be comfortable to apply manure on the nursery bed at your farm?
- ✳ To how many beds will you apply the manure?
- ✳ What alternatives are there to achieve a good chillies nursery crop in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Inform the participants will need to go and sow seeds in their nursery beds according to the knowledge and skills gained during the training
- The trainer should make it clear to all the farmers that their sowing work will be inspected before the next training
- Emphasize on all the crucial steps in seed sowing discussed in the session (half finger deep grooves, grooves spaced at one full hand apart, thinly spreading seed, covering with sand after sowing, mulching and watering)

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 7: NURSERY MANAGEMENT

ITEM	CONTENT
Objective	By the end of this module, farmers will be able to: - manage a commercial vegetable nursery - tend to their vegetable seedlings in the nursery
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, panga, sticks and grass
Training duration	180 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to discuss and share experiences on the various management practices of a vegetable nursery
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (25 minutes)

- After listening to presentations from all groups, summarize the best practices on vegetable nursery management
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET

The following are key management practices done on a vegetable nursery:

I. Mulching and watering.

Figure 19: Mulching and watering

- When explaining the importance of erecting a raised mulch, the following points must be of emphasis:
    - To help conserve moisture for germination of seeds not germinated yet
    - To provide protection to the young seedlings during very hot weather. Young seedlings would easily wilt and die
    - To prevent breakage of seedling due to water force during irrigation
- This means that even in fairly cool weather, a raised mulch would save a purpose of protecting young seedlings
- Ensure that the raised mulch is very light and allows sunlight to penetrate. Your young seedlings need light as well
- Enlighten the participants that overwatering the plants on the nursery may cause damping off disease
- Too much watering will also cause tall weak seedlings while too little water will make seedlings grow slowly and get stunted
- Use watering cans with a fine shower rose and make sure that seedbeds are evenly watered
- The following watering schedule can be followed up the time of transplanting:
    - From seeding to complete germination (eight to fourteen days) lightly water the seedbeds three three times a day
    - In week 3 water the seedbeds once a day
    - In week 4 water the seedbed one time every three days
    - In week 5 to 6, water only when seedling show signs of wilting

II. Weeding

Figure 20: Hoe weeding in a vegetable garden

- Weeding is done to:
  - Eliminate competition for space, water, light and nutrients between plants and weeds
  - Weeding therefore promotes seedling growth
  - By making the bed and the surrounding clear, pests, rodents and diseases that could attack and destroy seedlings are also kept away
- Weeding on the nursery bed is done by pulling them out with hands
- Light hoeing can be done around the nursery area

III. Pest and disease management

- Building on the experience shared by the participants, identify the major pests as: aphids, cutworms, caterpillars and the major diseases as damping off:
  - During preparation for the training, prepare clear pictures of the pests and diseases so that participants can appreciate. This will enhance their skill of identification of the pests and diseases in the field
  - This skill of identification will be practiced during the demo practical
- Scheduled scouting is an effective way to monitor pest and disease attack on the nursery and determine an effective way of controlling them
- Scouting means systematic checking of pest and disease occurrence either on the nursery or in the field. It also involves careful study of the level and type of damage caused in order to determine when and how to control

Figure 21: Scouting for pest and diseases

- Chemical application should be the last resolution to control pests and diseases after the cultural controls have been exhausted. These include:
    - Nursery hygiene
    - Starting with clean and healthy seeds
    - Correct irrigation levels
    - Proper site selection
    - Use of predators
    - Crop rotation
- When chemicals are to be used, the correct type, concentration and application methods have to be employed
- Source the chemicals from a reputable agro - dealer

IV. Hardening off

- Building on the experience shared by the participants during their presentations, present the importance of hardening off of the seedlings as a means of:
    - Preparing the plants for field establishment by exposing the plants to harder conditions
- Importance of hardening is that it improves seedlings survival in the field because plants are strengthened to withstand rough field conditions
- The procedure for hardening for hardening off is as follows:
    - Gradually remove the raised mulching material from the nursery bed
    - Reducing the frequency of watering to once a day in week 3, once a day every three days in week 4 and water only when plants begin to wild in week 5 and 6

- Also reduce the amount of water applied on a seedbed. The figure illustrating hardening off is shwon below

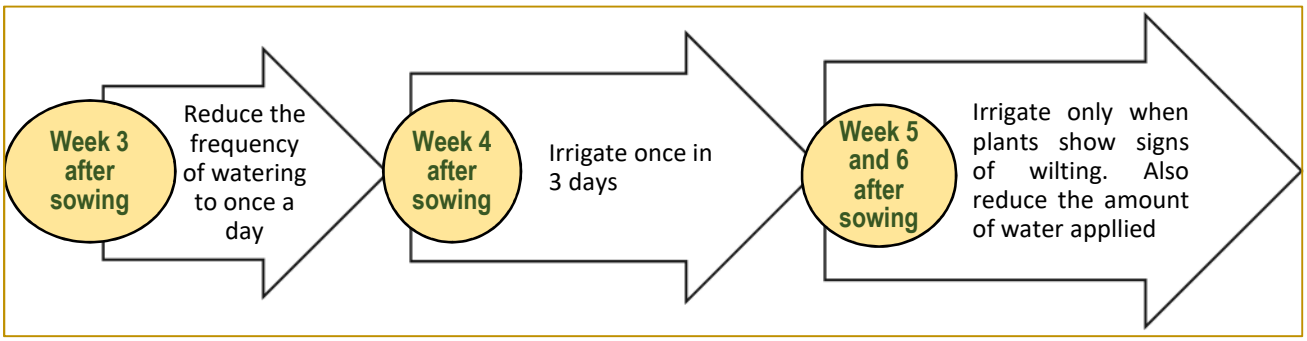

Figure 22: Illustrating hardening process off of the seedlings on the nursery bed

Activity IV: Practical on mulching and watering (60 minutes)

- Facilitate a demonstration on mounting a raised mulch, watering and any other possible practical on the manage ment practices. This can be done at the usual demo plot or at one of the participants' nurseries
- Let the participants practise on other nursery beds
- Ensure that during the practical, all participants are involved to ensure that they follow everything and acquire relevant skills

The trainer should facilitate a demonstration practical using the following procedure:

- Ask the participants to collect supporting sticks of between 25 – 40 mm diameter (the trainer can arrange to bring these in advance in order to save time)
- Fix these around the bed at between 30 – 45 cm high and put cross sticks which will support the mulch
- Thinly spread the mulch on top of the raised platform ensuring that some spaces are left for sunlight penetration. Remember these small seedlings will need light
- Use a watering container to apply water after checking the moisture content

Figure 23: Watering of the young plants on a raised mulch reduces seedling damage through breakage

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in the management of vegetables on a nursery?
- ✳ Which were the easiest and the most difficult steps in the practicals conducted in this session so far?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from the various practical on management of vegetables on a nursery?
- ✳ Which step if not followed would result in poor vegetable seedling growth?

Application questions

- ✳ Will you be comfortable implement the various management practices on your nursery and making informed decisions on the timing of implementation?
- ✳ What alternatives are there to achieve quality seedlings in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to implement the various management practices on their vegetable nursery according to the knowledge and skills gained during this training
- Explain to all the participants that the sterilized beds will be inspected before the next training
- Emphasize all the crucial reasons for implementing the various management practices including: constructing a raised mulch, decision making on watering frequency, pest and disease management and others

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 8: FIELD ESTABLISHMENT AND MANAGEMENT OF VEGETABLES

ITEM	CONTENT
Objectives	By the end of this topic, farmers will be able to: - carry out land preparation for commercial vegetable production - manage a vegetable production plots
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, hand forks or trowels, hoes, baskets and seedlings in the nursery
Training duration	180 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into groups of four to six people depending on the number of participants
- Instruct them to brainstorm and share experiences on the procedure for establishment and management of a vegetable field
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (30 minutes)

-

- After listening to presentations from all groups, summarize best practices on establishment and management practices of a vegetable field
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET

The key management practices after successful transplanting of the seedlings include the following: mulching, weeding, de - suckering, staking, fertilizer application, watering, pest and disease control and fruit thinning.

Transplanting

Figure 24: Transplanting of cabbage seedlings

Before seedlings are transplanted, reduce watering frequency to harden off the seedlings. Water the seedlings on seedbed to ease uprooting of seedlings and to avoid losing roots when transplanting. Also water the planting stations before transplanting. Seedlings should be transplanted when they are 10 – 15 cm or pencil size thick and have three to four true leaves. This must be done during the afternoon or on a cloudy day to avoid stressing the seedlings. Uproot seedlings with care using hand spade. Use a container to carry seedlings to avoid sun scorch or wilting. Transplant seedlings on the same day they are uprooted from the nursery. Cover seedlings with a wet sack to avoid drying and this will help good take - up. Seedlings must be watered immediately after transplanting. Basal dressing with 23:21:0 + 4S can be done immediately after the seedlings have established.

Plant population

The ideal spacing and plant population are those that maximize yield and quality without unduly increasing cost. As a general rule, all crops tend to increase yield per unit area as plant population increases, but only up to a certain limit. Beyond this limit, yield may not increase further and may even drop. Too many plants per planting station may lead to competition for space, sunlight and plant nutrients.

Figure 25: Spacing in cabbage at 30cm x 60cm at CIH farm in Dowa

Mulching

Mulching is needed to conserve moisture and to suppress weeds. The decomposed mulch material will turn into food for vegetables. Mulching the plants also controls soil erosion by reducing the raindrop impact. The mulch regulates heat by creating a shade.

Weeding

It is important to weed as soon as weeds appear to reduce competition for sunlight, space and plant nutrients.

De - suckering

De - suckering involves removal of sucker from the plants. This practice improves the quality of the produce. For example, de - suckering tomato plants results in good fruit size while those not de - suckered results into small fruit size. Fruits are consequently large where the plants are de - suckered because the nutrients are not diverted to the branches.

Figure 26: De - suckering in tomato at CIH in Salima

Staking is done to support the plant so that it grows in the right direction or upright position. It is done in vegetables which have weak stems that cannot stand erect on their own e.g. climbing beans etc. Stacking minimizes disease attack, improves sunlight penetration and creates good working space for other field operations such as weeding, irrigation, spraying and harvesting. Stacking can be done using strings or stakes

Figure 27: A well - staked tomato field at CIH in Salima

Figure 28: Fertilizer application in tomato

Basal dressing with 23:21:0 + 4S fertilizers be applied a week after transplanting followed by top dressing two weeks later when seedlings have fully established. Fertilizer should be applied 10 cm away from the plant. Nitrogen should be split applied. Apply 4g per plant on each side of the plant using dollop method.

Water application
Water the field when there is little moisture in the soil, it is important to apply adequate water. Different plants need different amount of water. For instance, cabbage needs more water than onion.

Pest/disease identification and control (refer to module 9 for more information)
Scout for pests and diseases. Once identified use the recommended control measures. It is important to control them at the right time and use the right chemical. Use protective clothes when spraying.

Fruit thinning
To control fruit size, some fruits must be removed from the plant before they enlarge. The plant nutrients are directed to only a reasonable number of fruits on the vegetable plant. Some plants such as cucurbits produce female flowers and set fruits so early that vegetative growth is still insufficient to support the normal growth of the fruit. This restricts vegetative growth and affects fruit setting and development. Remove the first one or two fruits on the vine. The number of fruits per vine is subsequently limited to one. This practice is widely used in melons.
Fruit thinning is mainly done in fruit vegetables like tomatoes, eggplants, watermelons and green peppers.

Activity IV: Practical on transplanting (60 minutes)

- Facilitate a practical on transplanting allowing the participants to apply the knowledge and skills gained from the session above
- Observe how the participants will prick out the seedlings, carry them to the transplanting field, select them and finally plant them
- Offer any guidance throughout the practical to ensure that the participants are doing the right thing

Facilitate the practical using the following procedure:

- Divide the participants into teams according to activities i.e. pricking out, watering, seedling sorting, planting station marking and planting
- Explain clearly the role of each team and what they will need to follow according to the guide provided during the plenary session
- Instruct the teams to start the operation beginning with the team that will do the watering of the nursery bed
- Throughout the practical, continue going around to spot check and ensure the participants are doing the right things

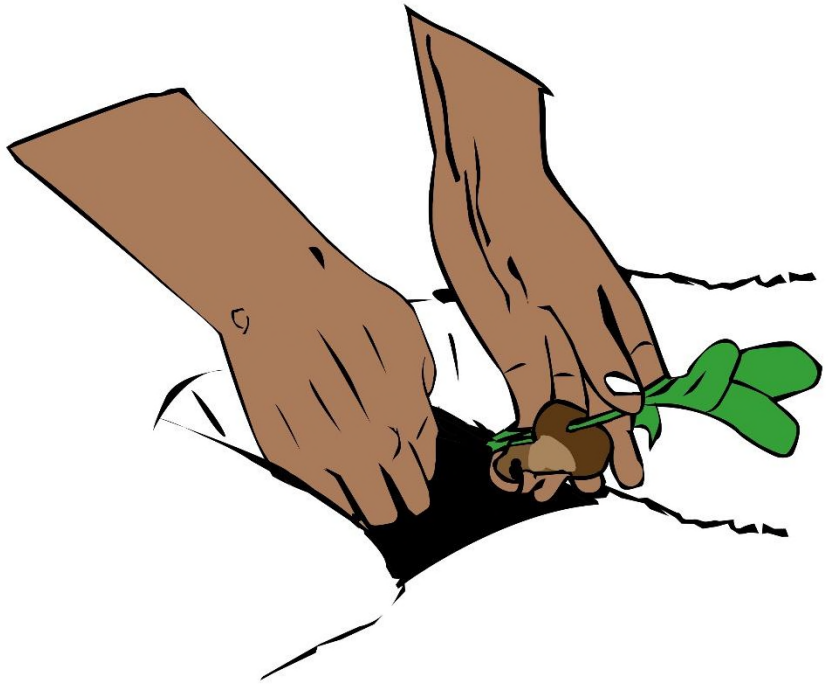

Figure 29: Transplanting vegetable seedlings

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in transplanting the chilli seedlings from the nursery?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor chilli seedling growth?

Application questions

- ✳ Will you be comfortable transplanting seedlings correctly at your farm?
- ✳ What alternatives are there to achieve a good chillies nursery crop in the absence of other equipment or materials used in this demo?
- ✳ How can the skills gained in this practical be applied in production of other crops?

Activity VI: Assignment (10 minutes)

- Ask participants to transplant their seedlings to their fields and utilize the knowledge and skills gained during this training
- Explain to all the participants that the sterilized beds will be inspected before the next training
- Emphasize the need to follow all the crucial steps in order to have successful transplanting

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 9: GENERAL MANAGEMENT OF PESTS AND DISEASES IN A VEGETABLE FIELD

Topic 1: Scouting of insect pests and diseases in vegetable field

ITEM	CONTENT
Objectives	By the end of this topic, farmers will be able to: - identify various methods of scouting for insect pests and diseases - carry out scouting for pests and diseases in their vegetable production
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens note books, data sheet, magnifying lens, PPE, Insect sticky traps, pheromones
Training duration	150 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of participants
- Instruct the participants to brainstorm on different methods of scouting for pests and diseases in vegetables fields (encourage the participants to use as much personal experience as possible
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (25 minutes)

- After listening to presentations from all groups, summarize most common pests and diseases and scouting activities
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET

Scouting for insect pest and diseases

Scouting is a physical check for the presence of insect pest and diseases in a vegetable nursery and field
Scouting helps a farmer to make appropriate decision on the best control measure for pest or diseases
It is an effective system of insect and disease identification in order to effectively monitor and control both insect pests and diseases

Procedure of scouting

Figure 30: Scouting in an okra field at CIH field in Salima District

Strategically divide the vegetable gardens using any of the following methods:

1. Scouting diagonally (X) assuming the field is square or rectangle.
2. Scouting following W.
3. Scouting following Y.
4. Zigzag scouting: one walks in a zigzag way going across the field while checking and taking note of the presence of pest and disease.
5. Random scouting: one selects beds randomly (20% of the shed) and check for the presence of pests or diseases and record on the checklist.

Then transfer the findings into the notebook.

General rules for scouting:

- Scouting pests is done weekly or every two days and all year round during the growing period
- Scouting pests must be conducted in the morning hours before pests have flown away and if possible, stick to one known person to do scouting
- Most insects are found on the flush, flowers and fruits rather than old shoots
- Focus the general inspection area on the new shoots, flower panicles or fruit
- Inspect the lower side of the tender leaves
- Use **magnifying lens** to check availability of insect eggs, tiny insects like *Thrips* and stings and holes on the fruits by ovipositioning insects i.e., fruit fly and mango seed weevil
- Record information as shown on a monitoring sheet below

Table 5: Pest and disease scouting sheet

NAME OF MONITOR/SCOUTER _____						
DATE	**BLOCK NUMBER**	**ROW NUMBER**	**TREE NUM-BER**	**PEST NAME**	**NUMBER OF THIS PEST OB-SERVED**	**GENERAL INFOR-MATION OR NOTES**
EXAMPLE 16/09/2022	2	1	15	Mealy bug	Too many to count	A lot of ants visible to the eye, but no mealy bug

Activity IV: Practical on scouting (60 minutes)

- Facilitate a practical on scouting allowing the participants to apply the knowledge and skills gained from the session above
- Observe how the participants carry out the activities and the recording
- Offer any guidance throughout the practical to ensure that the participants are doing the right thing

Activity V: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 2: Integrated pest and disease management (IPM)

ITEM	CONTENT
Objectives	By the end of this topic, farmers will be able to: - identify integrated pest and disease management practices and applications in vegetable production in Malawi - implement an effective integrated pest and disease management programme in their commercial vegetable production
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens notebooks
Training duration	135 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of participants
- Instruct the participants to brainstorm on integrated pest management as a way of controlling pests and diseases (encourage the participants to use as much personal experience as possible)
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary Session (25 minutes)

- After listening to the presentations from all the groups, facilitate a plenary session on IPM
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

INFORMATION SHEET

- Integrated Pest Management (IPM) is the use of all available pest control tactics in the design of a program to manage but not eradicate pest populations, so that economic damage and harmful side effects are avoided
- The cornerstone of an IPM program is the use of economic injury levels and pest monitoring as a basis for the judicious application of pesticides or other control tactics
- It is in contrast to the prophylactic or calendar spray approach where pesticides are applied routinely (or haphazardly), irrespective of pest levels
- IPM program does not eliminate the use of pesticides but reduces sole reliance on them
- It is a decision - making process to determine if, when, where and what strategy and mix of tactics should be used
- The basic requirements for developing IPM include an understanding of the biology and ecology of the key pests, economic information about the crop, pest damage and control measures, and the availability of environmentally acceptable control strategies
- This requires the inspection of each vegetable field on a regular basis (usually weekly) year in and year out

IPM programs combine management approaches for greater effectiveness. The most effective, long - term way to manage pests and diseases is by using a combination of methods that work better together than separately.

Approaches for managing pests and diseases in IPM program are often as follows:

Seed sources

Buy seeds from reputable source which are free from seed borne diseases.

Use resistant varieties

- Use varieties that are known to tolerant or resistant to insect pests and diseases. For example, sugar loaf cabbage variety is resistant to black rot
- Sterilize seed beds soil
- Sterilize the seed beds soil in which you are going to raise your seedlings
- Transplant only pest and disease - free seedlings
- Be sure that the seedling being transplanted are healthy and free from pests and diseases
- Do not overcrowd plants
- Close planting causes the air beneath the leaves to stay wet. This encourages fungal diseases, especially damping off
- Space the plants so that air can move between them
- Plant into soil that drains well
- Diseases such as damping off and root rot occur in soils that do not drain well. Plant your vegetables in deep, well - drained soil. Organic matter and mulch will help the soil to drain quickly
- Keep the plants healthy. Healthy plants normally withstand pests and diseases better than weak plants. Grow your vegetables in fertile soil, water them regularly and mulch them to keep the soil moist

Check plants for pests or diseases

Disease and pest surveillance should be a routine exercise. Control pests and diseases as soon as you notice them. Remove and bury all plants that show signs of viral infections that you cannot control. This stops vectors from carrying the disease to healthy plants.

Figure 31: Burying infected crops

Encourage the natural enemies of pests

There are many insects that eat plant - eating insects. These insect eating insects or natural enemies help to keep pest numbers down. You should encourage these natural enemies of pests by not spraying with chemical pesticides. Examples of insects that eat pest insects are ladybird beetles and larvae, preying mantises, spiders, wasps and some fly larvae. Some wasps lay their eggs into the larvae of pest insects.

Use clean tools

Figure 32: Predator for the control of whiteflies in cabbage

Figure 33: Disinfecting tools using methylated spirit (95%)

Tools can carry diseases from sick to healthy plants. If you handle tools such as knives used on diseased plants, clean them before using them on healthy plants. Dip the tools into a disinfectant (a liquid that kills microorganisms) such as household bleach (Jik or Javel), 95% methylated spirit, vinegar or jeyes fluid. You can keep a mixture of the disinfectant and water in a closed container for cleaning your tools.

Figure 34: Control of aphids which are vectors of viral diseases

Use pest control methods to control the vectors of viral diseases. Viral diseases cannot be cured. Dig up and burry any plants that have a viral disease to stop vectors from spreading the disease. Remove all alternative hosts from around the nursery and the field.

Mechanically or physically remove pests off the plants

Pick large pests such as grasshoppers, snails and beetles off plants and kill them. If there are large numbers of the pests, carry a bucket of water to drown them into.

Figure 35: Physical control of pests

Remove all debris from the field
Some plant diseases may over - winter in plant debris and these should be carefully disposed of.

Chemical control


Figure 36: Spraying against aphids in a bean field – try to avoid!

This is the use of pesticides and the last resort. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long - term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, non - target organisms, and the environment. With IPM you will use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality; use pesticides in bait stations rather than sprays; or spot - spray a few weeds instead of an entire area.
The above IPM principles and practices are combined to create *IPM programs*. While each situation is different, six major components are common to all IPM programs:

1. Pest identification (monitoring or scouting).
2. Monitoring and assessing pest numbers and damage (Use of thresholds).
3. Guidelines for when management action is needed.
4. Preventing pest problems.
5. Using a combination of biological, cultural, physical/mechanical and chemical management tools etc.
6. After action is taken, assessing the effect of pest management.

Advantages of IPM

- Decision making process (When, where, what)
- Does not eliminate use of pesticides
- Flexible and offers variety of options
- Saves on time, chemicals
- Reduced environmental pollution
- Reduced exposure of operators

Activity IV: Practical on IPM (45 minutes)

- Facilitate a practical on IPM by allowing the participants to be in groups
- Each group should select one of the IPM approaches mentioned above such as burying of infected crops, disinfecting of tools and mechanical or physical removal of pests
- Observe how the participants carry out the activities
- Offer any guidance throughout the practical to ensure that the participants are doing the right thing

Activity V: Quality assurance and course assessment (15minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 3: General guidelines for safe and effective use of pesticides

ITEM	CONTENT
Objectives	By the end of this topic, farmers will be able to: - use pesticides safely - apply pesticides efficiently in their commercial vegetable production
Training materials	Flip charts, markers, masking tapes, flip chart stand and ballpoint pens note-books, chemicals, knapsack sprayers, measuring cylinder, spare nozzles, and cleaning containers
Training duration	140 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to people depending on the number of participants
- Instruct the participants to brainstorm on how spraying of chemicals should be done in the vegetable field (encourage the participants to use as much personal experience as possible)
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (30 minutes)

- After listening to the presentations from all the groups, facilitate a plenary session on spraying of chemicals
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise
- The information below is a useful guide for the discussion. Use other sources to supplement on the information

INFORMATION SHEET

Important Note:

In order to promote sustainable and environmentally friendly agricultural practices, it is essential to minimize the use of chemical pesticides. Instead, farmers can adopt a variety of alternative strategies (e.g. IPM, biological control) to protect their crops and maintain soil health. These alternative strategies should always be the first option to look at and chemicals should only be used if unavoidable!
By reducing reliance on chemical pesticides, we can safeguard our ecosystems, protect human health, and support a more sustainable and resilient agricultural system for generations to come.

Pesticide is the general name used for the group of agricultural chemical products that principally includes insecticides, nematicides, bactericides, fungicides and herbicides. Pesticides contain hazardous chemicals; as such they must be mixed and sprayed safely. All workers who mix and spray pesticides must be properly trained to ensure their safety and that of other people and the environment.
Pesticides are formulated as liquids presented as Emulsifiable Concentrates (EC), Suspension Concentrates (SC) and Flowable Concentrates (FC); also, as powders presented as Wetable Powders (WP), Soluble Powders (SP), Water Dispersible Powders (WS) and Dusting Powders (DP); then as Granules (GR) and Water Dispersible Granules (WG) (Table 6). These pesticides according to WHO have colours to indicate their danger (Figure 36). Red indicates extremely toxic, red indicating toxic, yellow indicating moderately hazardous and blue indicating slightly hazardous and green indicating acute hazard unlikely in normal use.

Table 6: Characteristics of pesticides formulations

FORMULATION	CHARACTERISTICS
Liquids 	Pour easily; easily contaminate skin; fumes – inhaled and extremely toxic if swallowed
Powders 	Produce dust; inhalation poisoning and also dangerous on skin or swallowed
Granules 	Easier to work with; less risk of personal or environmental contamination and poisoning - inhalation, skin contact or swallowing

Protect biodiversity on the vegetable garden by reducing the use of WHO class I and II pesticides as shown in the figure below:

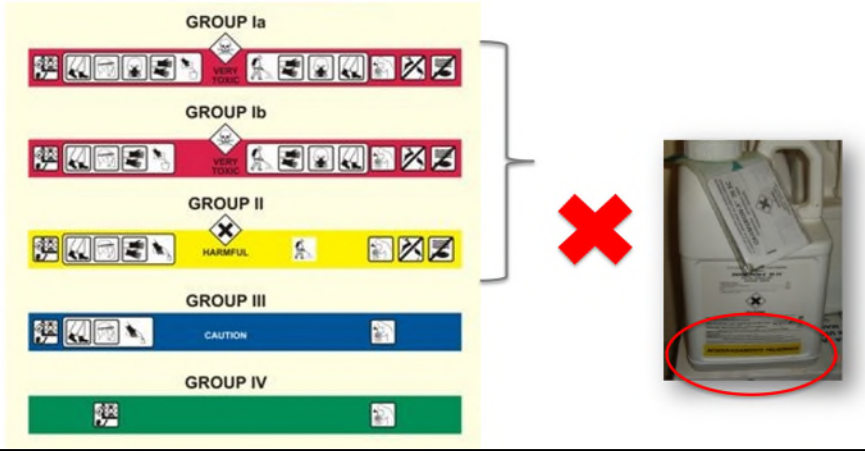

Figure 37: WHO classification of chemicals

While use of pesticides is increasing operational aspects that require respect should be given special consideration otherwise it may be hazardous to man or crop or ineffective and uneconomical. Various factors should be considered to attain both safety and effectiveness.

Choice of chemical:

- Use fungicides to control fungal diseases, insecticides to control insect pests and nematicides to control nematodes
- Buy the correct product
- The pest must be identified.
- Check for the recommended pesticide(s)
- Know the dose rate, dilutions, timing and frequency
- Identify the method of application
- Know precaution to be taken
- Know cost per unit area

Purchase and storage of pesticides

- Buy the correct product
- Do not buy damaged packs and without original labels
- Do not store pesticides with food or animal feed
- Never use food or drink containers for storage of pesticides
- Packages should be inspected for signs of damage and leaks regularly

Proper mixing of pesticides

- Before mixing, test the sprayer with water to see if it leaks and is working properly
- Read the label to determine the proper mixture
- Wear PPE while mixing pesticides
- Mix in a grassy area. Do not mix on concrete or hard surfaces
- Only use water unless directed by the label to use another liquid

- Fill the sprayer with two - thirds of the water needed. Then add the proper amount of pesticide. Then add the remaining one - third of water
- Mix only the amount necessary to do the job

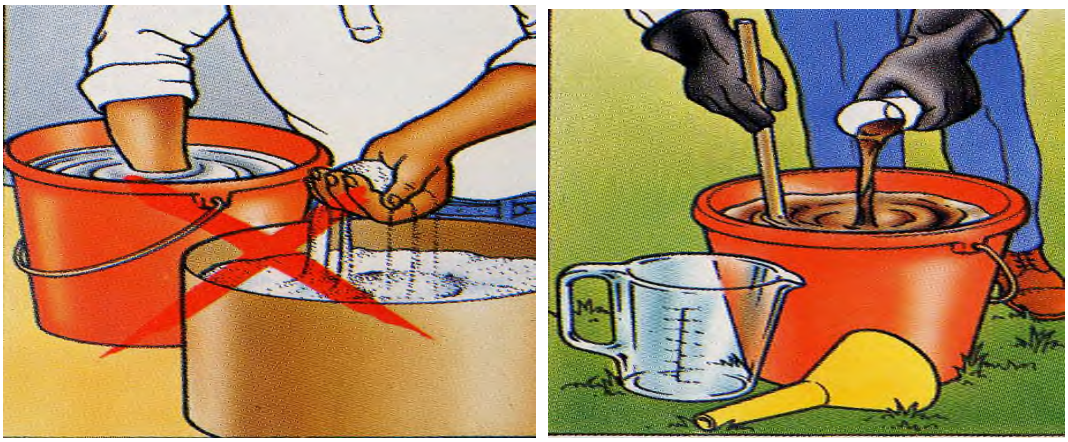

Figure 38: 35a: Incorrect way of mixing chemicals 35b: The right way of mixing chemicals

Figure 39: Wear PPE while mixing and spraying

Application equipment and pesticide use

- Check equipment before each day's operations. Residual pesticides may cause corrosion and clogging
- Do not use leaky or defective equipment
- Always read the product label and follow instructions
- Do not contaminate the environment by misuse of pesticides
- Always wear protective clothing to cover as much of the body as possible
- Wash all clothing and equipment after use
- Do not blow out clogged nozzles with the mouth - use water or a soft probe
- Never leave pesticides and dirty equipment unattended
- Wash hands and face before eating, drinking or smoking
- Clean and check equipment after use

Proper spraying of pesticides

- Spray so that other workers or persons are not exposed
- Other workers and persons must not enter the area where a pesticide is being sprayed
- Be aware of wind direction as it can cause the pesticide to drift to areas not chosen for spraying
- If possible, spray early in the morning or in late afternoon. High humidity will lessen the chance of drifting
- Wear PPE while spraying
- All workers must be notified in advance of where spraying is to occur
- All workers must have immediate access to water, soap, and towels for routine washing and emergency decontamination

Medical issues

- Anyone exposed to a pesticide must be taken to a medical facility. Tell medical personnel the type of pesticide being used
- All workers must be informed of pesticide label requirements. Central posting of recent applications is required

Clean up and proper disposal of pesticide containers

- Rinse all equipment with water in a grassy area. Never clean up on a hard surface
- Never flush pesticide residue into a storm drain or any type of drain
- Always wash with soap and water before you eat, drink, smoke, or go to the bathroom
- Clothing worn during spraying should be washed separately
- Before discarding an empty container
    - Fill it half full of water
    - Shake it to rinse
    - Empty the rinse water into the sprayer
    - Spray in a grassy area
    - Do this three times, this process will also clean the sprayer bottle and hose
    - Once the container has been completely rinsed punch a hole in the bottom
- Do not burn empty containers
- Do not recycle containers

The dangers of pesticides

Pesticides can get into water

Rain washes pesticides off plants and then moves into rivers and dams. The pesticides in the water kill fish and other water animals. Water birds that eat the poisoned fish can also be poisoned. Water for drinking and washing will contain pesticides.

Pests become resistant

Usually after a grower has sprayed pesticides a few times, the pests are no longer killed by the pesticide. This is because there are always a few survivors which are not killed by the pesticide. These survivors are stronger than the ones that were killed. This stronger type breeds so that fewer and fewer die after each spraying. We say the pests have become resistant to the pesticide and the grower must use a new stronger pesticide to kill the pests. With time, the pests will also become resistant to the new pesticide.

Dangers to man

Chemicals are poisons and can affect man directly or indirectly as he continues to use them. Some chemicals can affect man by direct poisoning while others may affect the genetic system. Allergies have also been associated with some chemicals.

Non - selectivity in action

Some chemicals are broad - spectrum and as such are capable of upsetting the natural balance that exists in the natural environment, such that beneficial organisms, which help to keep pest populations down are also killed.

Activity IV: Practical - identifying and familiarizing with various chemicals (45 minutes)

- Arrange a variety of common chemicals in a spacious place where all participants can see them clearly (this can be on a table or raised platform)
- Explain to the participants the names, uses and methods of application of the different chemicals in the display
- In their groups, participants should choose one of the chemicals and practise mixing and diluting it according to the procedure discussed in a plenary session or shown on the container. (If there is no need to spray any vegetables, use water and black tea instead of chemicals to practise mixing or diluting)
- Once mixed, participants should practise spraying in the field. (If there is no need to spray, use water and black tea instead of chemicals to practise mixing, diluting and spraying)
- Allow enough time for the participants to familiarise themselves with the chemicals so that they can easily identify them when they go to buy them in the shops

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 10: PROCESSING AND VALUE ADDITION OF VEGETABLES

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - indicate processing, value addition and preservation measures of vegetables - implement processing, value addition or preservation of various types of vegetables
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, baskets, processing equipment and vegetable
Training duration	180 minutes including practical

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of participants
- Instruct the participants to brainstorm and share experiences on processing, value addition and preservation of any type of vegetables
- Participants should as well discuss the economic value of processing, value addition and preserving of vegetables
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

-

- After listening to presentations from all groups, summarize best practices on processing, value addition or preservation of various types of vegetables
- Build your presentation on the points and experiences presented by the participants
- Inform the participants that all details will be addressed further during the practical exercise

Activity IV: Practical on vegetable processing, value addition and preservation (70 minutes)

- Facilitate practical on processing/value/preservation on a selected vegetable
- Ensure that as a trainer you are conversant with the methodology of processing/value addition/preservation of the selected vegetable
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Tips for trainer

- To make the practical relevant, you may try to involve someone who is a professional in the field of vegetable processing/value addition/preservation e.g. a nutritionist
- Ensure that the materials, tools and equipment for the practical for the selected vegetable are available for local sourcing and that they are affordable
- Working with a vegetable which the group produces would be ideal as far as tools, materials and equipment are available and the personnel to facilitate the practical is also conversant

INFORMATION SHEET

Processing of vegetables

Processing can transform vegetables from perishable produce into stable foods with long shelf lives and thereby aid in the transportation and distribution of many varieties of vegetables. The goal of processing is to deter microbial spoilage and natural physiological deterioration of the plant cells. Generally, the techniques include blanching, dehydrating, canning, freezing, fermenting and pickling, and irradiating.

Blanching

After vegetables have been washed clean, they must undergo blanching (heating) in hot water at 88 °C for two to five minutes or with steam in a conveyor at 100 °C for one - half to one minute. Blanching inactivates natural enzymes that would cause discoloration and off - flavours and aromas. It also serves to reduce the number of microorganisms and to render vegetables limp for easy packing into containers. For some vegetables, such snap beans, the blanching step also serves to remove harsh flavours. After blanching the vegetables must go through rapid cooling in either cold water or cold air for better quality retention. The vegetables are then ready for the various food - processing methods described below.

Figure 40: Blanching of vegetables

Dehydration

Drying is probably the oldest method of preserving foods. The removal of water from vegetables is accomplished primarily by applying heat, whether it be through the radiant energy of the sun or through air heated by electrical energy. A major advantage of removing water is a reduction in volume and weight, which aids in storage and transportation of the dried products. Modern drying techniques are very sophisticated. Many machines are available to perform tunnel drying, vacuum drying, drum drying, spray drying, and freeze - drying. Although freeze - drying produces a food of outstanding quality, the cost is high, and it has not been used widely in vegetable products.

Drying food at home

Dried foods are tasty, nutritious, lightweight, easy to prepare, easy to carry and easy to use. Low humidity, low heat and good air circulation are critical for successful drying. You can use a dehydrator, oven, and microwave or even air - dry some foods. Start with good quality foods. Blanch vegetables first and remember that successful drying takes time. Once dry, store foods in a dark, cool location in containers that keep out moisture and insects**.**

Drying or "dehydrating" food is a method of food preservation that removes enough moisture from the food so bacteria, yeast and molds cannot grow.

Figure 41: Dried tomatoes

Equipment and methods used in drying vegetables

Dehydrators

Produce the best quality product as compared to other methods of drying. Most food dehydrators have an electric element for heat and a fan and vents for air circulation. Efficient dehydrators are designed to dry foods uniformly and to retain food quality.

Oven drying

An oven takes two three times longer to dry food than a dehydrator. Drying in an oven is slower because ovens do not have built - in fans for the air movement. The oven uses a great deal more energy than a dehydrator.

To use your oven for drying:

Check the oven dial to see if it has a reading as low as 140 F or use the 'keep warm' setting. If the thermostat does not go this low, your food will cook instead of dry. An oven thermometer placed near the food gives an accurate reading of the drying temperature. Leave the oven door propped open 2 to 4 inches and place a fan near the outside of the oven door to improve air circulation.

Sun drying

Sun drying is not recommended in high humidity and cool night temperatures. Foods dried in the sun can take three to four days to dry; if the humidity is high, the food will mold before it dries. Sun drying requires constant exposure to direct sunlight during the day and a relative humidity of less than 20%.

Figure 42: A solar drier for vegetables and fruits

Air drying

Air drying differs from sun drying, since it takes place indoors in a well - ventilated attic, room or screened - in porch. Herbs, hot peppers and mushrooms are the most common air - dried items. Herbs and peppers are not pre - treated, but simply strung on a string or tied in bundles and suspended until dry. Enclose them in paper bags to protect them from dust or other pollutants.

Figure 43: Air-drying of vegetables

Microwave drying

Is a quick way to dry small quantities of herbs and some leaf vegetables, but it is not successful for most other foods. Food which has been microwave-dried often tastes overcooked rather than dried.

Drying herbs in the microwave

Place no more than four or five herb branches between two paper towels and microwave for two to three minutes. Remove the herbs. When cool, check to see if they are dry and brittle. If not, repeat drying for 30 second intervals until dry.

Fermentation and pickling

In both fermented and pickled vegetables, acid is used to preserve the products. Pickled vegetables include green tomatoes and cabbages. The variety of vegetables used for fermentation or pickling may not be the same as fresh market vegetables. Owing to the acid environment, fermented or pickled vegetables need less heat treatment before being placed in containers.

Irradiation

Ionising radiation, mostly gamma ray, has been used in several countries to preserve vegetables. The practice is quite common in preventing potatoes from sprouting during long - term storage. Despite studies showing that products treated with low - dose ionizing radiation are safe, consumers are still concerned about this processing technology and have not accepted it.

Importance of processing vegetables

The importance of vegetable processing has to keep pace with the needs of the population. There is always a shortage of food in developing countries like Malawi, storage results in wastage due to inadequate facilities available for storage and preservation. Vegetable processing is important because it helps in:

- Increasing the shelf life of food, thus increasing supply
- Making the seasonal food available throughout the year
- Saving time by reducing preparation time and energy
- Stabilizing prices throughout the year
- To meet food requirement during natural calamity, food wars, famines, etc.
- Reduces wastage and losses
- Generate employment
- Stabilizes farm prices and income
- Earn foreign exchange
- Preservation/processing increases the availability of foods, thus improving the nutrition of the people/population and checks nutritional deficiency
- Availability of seasonal foods through the year and thus adding variety to the diet (to meet mixed diet practice)
- Helps in storage of food by preventing microbial spoilage thus can be made available to public throughout the year

Examples of processed vegetables

Tomato soup

Tomato soup is a fairly popular product nowadays. It can be prepared either from pulp or tomato juice. Butter or cream, spices, starch etc. are used for preparation of soup.

Process

The juice is boiled in pans for concentration. Add spices in a cloth bag as in case of tomato ketchup, while it is being concentrated. In the meantime, arrowroot and butter with small amount of juice are mixed to form smooth paste and added to the whole lot. Boiling is continued to the desired consistency by stirring it continuously. At the end, sugar and salt are added and mixture is boiled for about two minutes to dissolve them. The soup is then filled into the cans and closed. The soup is filled hot (88^0C) into cans and is processed at 100 to 110^0C for 20 to 45 minutes depending on the size of cans and cooled quickly after processing.

Figure 44: Tomato soup

Tomato powder

Tomato first washed then seeds of the fruit is removed then let them dry in sun. Then the dried tomatoes are powdered. Products of tomato are standardized using powder of tomato.

Figure 45: Tomato powder

Process:

- Fresh potato free from any deformities are taken and peeled then washed
- Wash potatoes sliced in 1.5 to 2.0 mm into slices
- Remove the surface starch with water
- Blanch the slices in predicament at 60 to 80^{o}C for two to three minutes
- Dry the surfaces of the slices
- Fry the dried slices at 180^{o}C till they become golden

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations deciding processing/value addition/preservation of vegetables as described in the practical?
- ✳ What do you perceive to have been the easiest and the most difficult steps in the practical?
- ✳ What are the main skills that you have to master in the processing/value addition/preservation of vegetables?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical session?
- ✳ What do you perceive to be the most critical steps/considerations from the session/practical for successful vegetable processing/value addition/processing?
- ✳ What benefits would someone accrue from processing/value adding/preserving vegetables?

Application questions

- ✳ How comfortable will you be to follow/utilize the knowledge gained from this session at your home?
- ✳ Do you think there are alternative procedures in processing/value adding/preserving vegetables?
- ✳ How can the skills gained in this practical be applied in processing/value addition and preservation of other crops or any other fields?

Activity VI: Assignment (10 minutes)

- Ask participants to mention their prefered method of vegetable preservation or processing
- What would they need to kick - start the initiative
- As a trainer, make it clear to all the participants that there will be inspection programs to spot any initiatives on vegetable processing and preservation and the methodologies being adopted

Activity VII: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 11: MARKETING OF VEGETABLE

ITEM	CONTENT
Objective	By the end of this module, farmers will be able to market their vegetables
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, knives, vegetables, packaging materials and baskets
Training duration	120 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of participants
- Instruct the participants to discuss, brainstorm and share experiences related to the various marketing channels of vegetables and how they plan and prepare for marketing of their vegetables
- Participants should as well discuss the relevance of conducting a market - research for their commercial vegetables production
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (25 minutes)

- After listening to presentations from all groups, present information marketing as summarized in the information sheet below
- Use your prepared information on vegetable marketing to present supplementary information on what the groups might have discussed on marketing. Emphasis should be provided on market planning and customer identification

INFORMATION SHEET

- Marketing of vegetables refers to the performance of all business involved in the flow of vegetables from the farm to the final consumer at a given time, place and form the consumer desires at the price he is willing to pay
- Vegetable marketing has the following functions:
  - Buying and selling
  - Transportation
  - Storage
  - Grading
  - Price determination
  - Financing
  - Assumption of risks
- Marketing vegetables: Vegetables can be marketed in fresh or processed forms:
  - Fresh form such fresh garden peas, cabbage and fresh beans
  - Processed form
  - The vegetables are sold after value addition. These include canning, freezing, pickling, drying, converting them into juice, sauce or preserves
- Factors influencing vegetable marketing:
  - Perishability – vegetables are highly perishable hence they cannot be held for long periods of time to wait for better prices. Rapid and efficient marketing is vital for produce to maintain its farm fresh value
  - Price and quantity variations
  - Seasonality – most vegetables are seasonal. They grow best in certain seasons and places
  - Alternative product forms and markets – alternative products like tomato puree compete with the fresh form
  - Bulkiness of product – water makes them bulky and have low value per unit. Makes them expensive to ship. Sale fresh vegetables near production sites
- Methods of marketing vegetable

Individual marketing

This is where a farmer decides to market his own vegetables.

Advantages

- Maximum amount of freedom to make decisions
- Full control over how much, what, where and to whom to sell

Disadvantages

- Costly
- Competition among sellers

Methods of selling

- Open or direct marketing – directing selling to agents, traders (middlemen), processors, exporters, retailers, consumers, auction markets, commission agents and brokers and contract buyers
- Closed or contract marketing – selling crop by contract before it is harvested

Group marketing

Aims at enhancing the bargaining powers of farmers.

- Voluntary bargaining associations
- Compulsory bargaining associations
- Marketing associations

Activity IV: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Assignment (15 minutes)

- In their small groups, ask participants to brainstorm and come up with a strategy they will use to identify markets and customers for their products using the knowledge and/skills gained from this session
- Make it clear to the participants that their work will be presented in plenary in the next training session
- Enable participants to gather information from reliable sources in the region

Activity VI: Course feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

MODULE 12: MANAGEMENT OF SELECTED VEGETABLES

Topic 1: Commercial production of cabbage

Table 7: Production plan for cabbage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall												
Site selection												
Land preparation												
Nursery												
Planting												
Weeding												
Fertilizer/compost												
Pest & disease control												
Harvest												
Packaging												
Marketing												

Unit 1: General information and varieties of cabbage

ITEM	CONTENT
Objective	By the end of this topic, farmers are able to: - identify the various varieties of cabbage - select the most suitable cabbage variety for their commercial vegetable production - identify soil requirements for cabbage - implement field management practices in commercial cabbage production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, seed of different varieties of cabbage, cabbage heads of different varieties
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct them to discuss and share any general information/knowledge about cabbage including the common varieties on the market and their characteristics
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (25 minutes)

- After listening to presentations from all groups, present the general information about cabbage ad characteristics of the common varieties on the market
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful about cabbage, but use of other sources to generate more information is encouraged.

INFORMATION SHEET

Family

Cruciferae

Botanical

Brassica Oleracea var Capitata, `Kabichi'

Importance

Leaf vegetable for relish and salad, feed for livestock and income generation by selling.

Table 8: Some recommended cabbage varieties in Malawi and their characteristics

VARIETY	MATURITY (DAYS)	HEAD TYPE & WEIGHT	DISEASE(R&T)	REMARKS
Drum head	120 - 150 Late	Round - 3 - 5 kg	Susceptible to black rot	Oldest variety, lost flavour
Glory of Enkhuizen	75 Medium	Flat - round,1.5 – 2 kg	Fairy resistant to black rot	Old and reliable variety
Sugar loaf or cape spitz	75 - 80 Medium	Conical - 2– 4 kg	Resistant to black rot	Outstanding salad variety, cracks readily after maturity
Marcanta F1	70 - 75	Ball shaped, 2 - 2.5 kg	Tolerant to black rot disease	Outstanding variety, widely adapted and suitable for the rainy seasonal
Hercules (F1)	80 – 85 Medium	Round, 2 - 4 kg	Resistant to black rot	Outstanding variety
Big Cropper	90 – 95	Round, 2.5 – 5 kg	Resistant to black rot	Outstanding variety
Chogo (F1)	90 - 95 Late	Round, 2 – 4 kg	Susceptible to black rot	Good for cool season production
Copenhagen	75 – 90 Medium	Round, 1 – 2 kg	Susceptible to black rot	Old variety for normal seasons only.
Golden acre	65 – 75 Early	Round, 1.0 – 1.5 kg	Susceptible to black rot	Old variety, close spacing recommended
Stone head (F1)	60 - 75 Early	Compact, 0.5 – 1.5 kg	Resistant to black rot	Crack readily, not well for rainy season
Gloria osena (F1)	60 – 70 Early	Deeap round and compact 1.5 – 4 kg	Fairly resistant to black rot	Attractive on maturity, outer leaves unfold and expose head to cold

Climate requirements

- Cabbage performs satisfactorily in cool areas over 750 m above the sea level
- In low lying areas production should be restricted to cool months of the year (March to July) unless heat tolerant varieties are grown
- Optimum temperature is within the range of 16 to 18°C but the maximum is 24°C

Soil requirements

- Cabbage tolerates a wide range of soils. Fertile loam soil is the best
- Soil pH must be in the range from 6.0 to 7.0

Sowing

- In the cool highlands, sowing of cabbage is done throughout the year while in hot low - lying areas only the cool months are targeted for cabbage growing
- Sowing, in both production zones, should follow a production schedule or calendar to ensure availability of produce all the time. Grow varieties resistant to diseases
- Marcanta and Hercules are resistant to black rot
- Sowing is done in the nursery
- Seeds are sown in drills spaced at 15 cm apart
- Nursery duration is 25 to 30 days

Fertilizer application

- The types and amounts of fertilizer will vary depending on soil and climatic conditions
- Cabbage is a heavy feeder and so requires adequate levels of nutrients, therefore:

Basal dress

- Manure 20t/ha of manure
- Compound D fertilizer 660kg/ha i.e. N=53kg/ha; P_2O_5 = 119kg/ha and K_2O =99kg/ha
- Broadcast or band the fertilizer into the soil at or before planting. Dolloping is also recommended where fertilizer is limited and should be done within seven days of transplanting

Top or side dress - with 20g/m² of CAN or 10g/m² of urea:

- Apply all the P and K during basal application
- Nitrogen, which promotes vegetative growth in cabbage, should be split - applied; with some applied in the basal fertilizer whole the other half is applied twice at 21 day – intervals or once at the start of the head formation stage

Figure 46: A bag of NPK fertilizer

Special care

- Weed the field to minimize competition for nutrients, water, light and space
- Remove diseased plants to avoid spreading the diseases

Activity IV: Practical on sowing, planting, and fertilization of cabbage (60 minutes)

- Facilitate a practical on sowing, planting and fertilization of cabbage
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in applying fertilizer and manure in a cabbage field?
- ✳ What do you have to consider in sowing of cabbage seeds?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you? What would you need to practise?

Generalization question

- ✳ Which step or steps if not followed would result in poor growth and significantly reduce the yield?

Application questions

- ✳ Will you be comfortable applying manure and/or fertilizer at your farm?
- ✳ What alternatives are there to achieve a good vegetable crop in the absence of other equipment and/or materials used in this demo?
- ✳ How can the skills gained in this practical be applied in production of other crops?

Activity VI: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Unit 2: Pest and disease management

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - identify most common pests and diseases that affect cabbage - control pests and diseases in their cabbage production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand, pest samples, pictures of diseases and cabbage heads
Training duration	210 minutes

Activity I: Group discussion and experience sharing (25 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any general information/knowledge about the various pests and diseases that attack cabbage and their control methods
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (40 minutes)

- After listening to presentations from all groups, present about the various pests and diseases that attack cabbage and their control methods
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Pests

Cabbage Aphid (Nsabwe)

These are tiny oval and soft - bodied insects that occur in different colours. Cabbage is mainly attacked by two main species namely *Brevicoryne brassicae* and *Myzus persicae*. *Brevicoryne* aphids are greyish mealy while *Myzus* aphids are green. The aphids usually attack undersides of leaves where they suck sap.

Brevicoryne brassicae *Myzus persicae*

Aphids deprive the crops of their nutrients, thus, causing stunting. They also curl the leaves which they have infested, in some cases preventing cabbage from cupping. They also transmit viral diseases which stunt the crops.

Figure 47: Aphids on the leaves of vegetables

Figure 48: A young developing cabbage head completely attacked by aphids

How do we recognize aphid infestation in a cabbage field?

- Distortion of leaves and young shoots
- Yellowing and premature death of leaves and young plants
- Honeydew on leaves, with black sooty mould in severe cases
- colonies of aphids clustered on young stems, leaves and buds

How can we manage aphids in a crucifer vegetable field?

- Keep the field and its surrounding free of weeds and alternative host plants
- Monitor the crop for signs of infestation
- Apply dimethoate 40 EC at a rate of 0.8ml/l of water or imidacloprid 70 WG at 0.3g/l of water or acetamiprid 225 EC at 1ml/l of water

Diamond back moth (Gulugufe)

Diamondback moths are small greyish brown moths which lay their eggs on leaves of cabbages. The larvae which hatch from these eggs are the ones which feed on the crops.

The larvae (caterpillars) are pale green and wriggle when disturbed, often dropping from the plant on a silk thread. Feeding by the larvae leaves irregular holes in the leaves, thus making the crop unattractive.

Adult and larva of the diamondback moth

Diamondback moths larvae make holes in cabbage leaves and these holes make the cabbage unsightly, unattractive and have less economic value.

Figure 49: Adult moth and larva of diamond back moth

Figure 50: Diamond back moth damage on the leaves of cabbage

Diamondback moth damage in cabbage

How do we recognize diamondback moth infestation in a crucifer vegetable field?

- Presence of erasure damages in leaves
- Presence of irregular holes in leaves
- Presence of small green larvae in leaves of the crop

How can we manage diamondback moths in a crucifer vegetable field?

- Avoid getting seedlings from nurseries which are infested with the pest
- Monitor the crop for signs of infestation
- Hand - pick and kill observed larvae if they are few
- Spray pesticides such as cypermethrin, confidor, dimethoate, thiamethoxam and decis forte. Read the label

Bagrada bug

Bagrada bugs are black shield - shaped insect with orange spots, which live by sucking sap from plants.

The Bagrada bugs deprive cabbage of their nutrients through sap sacking resulting into stunted growth of the crop and therefore reduced yield.

They also inject toxins into the plants as they suck sap. This toxin scorches leaves of the plants. Young seedlings die with this toxin.

Figure 51: The Bagrada bug

How do we recognize Bagrada bug infestation in crucifer vegetables?

- Leaves with edges having whitish scorched patches
- Presence of the bugs in the crop

Figure 52: Damage caused by Bagrada bug in cabbage

How can we manage Bagrada bugs in crucifer vegetable field?

- Monitor the crop for infestation every three days
- Hand - pick and kill all observed Bagrada bugs
- Spray insecticides such as cypermethrin, confidor, dimethoate, thiamethoxam and decis forte

Diseases

Damping - off (Kufa kwa mbande)

Damping off is a disease of seedlings, which is caused by various soil - borne fungi (*Pythium* spp. and *Fusarium* spp). It is recognized by rotting of seedling stems just above the soil surface and roots in the soil (in patches) and wilting and death of seedlings (in patches).

The disease derails farming programs because it can wipe out the whole nursery unexpectedly.

Figure 53: Signs of damping off in cabbage nursery

How can we manage damping - off?

- Choose sites with no history of damping off for raising nurseries
- Sterilize nursery beds before sowing
- Monitor the nursery and transplants regularly for signs of infection
- Apply fungicides such as ridomil gold and dithane M45 when infection is noted
- Remove and destroy all crucifer vegetable after harvesting
- Where possible, raise nurseries on new sites every time

Black rot (Kuola)

This disease is caused by seed - borne bacteria of the species *Xanthomonas campestris*. The bacteria enter the plant principally through the hydathodes water pores (hydathodes) at the leaf margins, stomates, and injuries on the leaves. In time, the bacterium spreads in the vascular system of the leaf and stem.

What are the signs of black rot infection?

Figure 54: Black rot infection in cabbage

- In seedlings, systemic infection makes the seedlings turn yellow, drop lower leaves, and die
- V - shaped dead patches in leaves which start from the leaf margins. They start by wilting and turning pale green, then yellow and finally turn brown and die
- The infected tissue is wilts and pale green initially, then becomes yellow, then turns brown and dies
- Veins in infected leaves, stems, and roots sometime turn black because the bacteria produce an extracellular polysaccharide that plugs normal water flow. The blackened veins can be seen in stems and leaf petioles by cutting crosswise.
- Black rot constrains cabbage production by causing death and rotting of plants in the field. Rotting can also occur after the heads have been harvested

How can we manage black rot in a crucifer vegetable field?

- Use seed or transplants certified to be free of *Xanthomonas campestris* or treat seeds with copper - oxychloride
- Avoid splashing water over crop leave during watering
- Control pests in order to prevent them from making injuries in crop leaves, since these injuries can allow infection
- Monitor the crop for signs of infection
- Treat the crop with copper - oxychloride if signs of infection are noted. This will not cure the diseased plants, but just prevent further spread of the disease
- Uproot and burry all infected plants (Figure 53 below)
- Strict rotation and ensure use of high fertility and resistant or tolerant varieties
- Grow cabbage only in the cool season

Bacteria soft rot *(Kuola)*

Figure 55: Black soft rot in cabbage

This is a disease caused by bacteria called *Erwinia carotovora*, whereby infected cabbage plants rot. The bacteria are seed - borne, soil - borne and also borne on other plant tissues. The bacterium is spread in the field by water splashes or contact with contaminated tools such as hoes or knives.

The main sign of bacterial soft rot is that the cabbage plant has mushy dark - coloured rotting areas which are smelly.

How does bacterial soft rot constrain cabbage production?

Bacterial soft rot reduces yield through rotting of the plants e.g. heads in cabbage. It can lead to significant loss of yield in the field and in storage.

How can we manage bacterial soft rot in crucifer vegetables?

- Plant resistant varieties e.g. Hercules
- Ensure effective control of insect pests since these help in spreading the disease
- Observe strict field hygiene e.g. uprooting and burning all infected plants
- Apply fungicides such as dithane M45
- Avoid injuring cabbage heads during harvesting and handling
- Store harvested cabbage in dry conditions
- Burn all crop residues since they may inhabit some spores of the pathogens

Figure 56: Burying infected plants

Club root (Kutupa kwa mitsitsi)

It is a root disease of cabbage, caused by a soil - borne fungus called *Plasmodiophora brassicae*. The fungus infects the plants through root hairs.

What are the signs of clubroot infection in a cabbage garden?

- Stunted growth of plants
- Wilting of plants especially during midday (despite the soil being moist) on sunny days, but recovering later in the afternoon
- Death of plants in patches
- Roots having galls or being swollen

Figure 57: Clubroot disease in cabbage

How does clubroot disease constrain cabbage production?
Clubroot is a serious disease in cabbage production because it stunts the crops and it also kills them, thus reduced yield. It can wipe out an entire field.

How can we manage clubroot disease in cabbage?

- Avoid bringing seedlings from infected nurseries or fields
- Avoid irrigating plants with water from areas known to have the disease
- Monitor the crop regularly for signs of infection
- Uproot and burry any diseased plant

Figure 58: Washing hands after handling infected plants

- Wash your hands after handling infected plants and sterilize any gardening tool that could have been used in infected soil
- Solarize infected fields using transparent plastic sheets for 60 days prior to planting of tomatoes
- Practice crop rotation with non - cruciferous crops (see Figure 3 on page 22)

Activity IV: Practical on pest and disease management (75 minutes)

- Facilitate a practical on pest and disease control that covers several aspects including scouting (checking), pests and diseases identification, decision on pest and disease treatment, chemical application and applying the chemicals to the field to control available pest and/or diseases
- For effectiveness of this practical, the trainer should inspect the fields of the farmers and choose where there are pests and diseases
- Allow enough time to ensure that participants are able to identify the various pests and diseases in the field
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (20 minutes)

- Use different different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in the pest and disease management program for a cabbage field?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor cabbage production in the field?

Application questions

- ✳ Will you be comfortable to implement a pest and disease control program at your farm?
- ✳ What alternatives are there to achieve a good chillies nursery crop in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to inspect their fields for any pests and diseases, identify the pests and diseases and implement a pest and disease management program utilizing the knowledge and skills gained during this session
- The trainer should make it clear to all participants that they will be inspected before the next training
- Emphasize on all the crucial reasons for which pest and disease management is done

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Unit 3: Harvesting, post - harvest handling and marketing of cabbage

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - describe maturity indicators of cabbage - carry out proper harvesting and post - harvest handling procedures - market cabbage
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand, baskets, mature cabbage
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share information/knowledge about harvesting procedure, post - harvest handling and marketing of cabbage
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (15 minutes)

- After listening to presentations from all groups, present the general information about harvesting procedure, post - harvest handling and marketing of cabbage
- Build your presentation on the points and experiences presented by the participants

INFORMATION SHEET

Harvest

Cut the base of the head when the heads are firm enough. Harvest early in the morning before the sun is hot for a nearby market. If taking to a distant market, harvest late in the afternoon and put the crop under a shed to minimize wilting. Leave enough wrapper leaves to preserve the quality of the head. Observe the safety period for all the chemicals mentioned above which is in the range of three to seven days. Stumps should not be allowed to sprout but be uprooted to avoid over wintering of some pests.

Figure 59: Harvested cabbage and cabbage still in the field

Post harvesting handling

Store cabbage in clean and cool dry airy conditions. Diseased cabbage must be separated from healthy ones. Avoid using plastic containers for they build up moisture, which speeds up cabbage rotting. Do not overfill the container to avoid heat build - up which damages on the way to the market. Wherever possible, pack independent heads into a pickup or lorry instead of putting them in bags first. Avoid exposure to direct sun heat at the market.

Market

Cabbage can be sold at district, urban and roadside markets. High quality cabbage can be sold at supermarkets such as Shoprite, Seven Eleven, etc.

Figure 60: Harvested cabbages loaded on a truck

Transportation

Transportation of cabbage to the market is by trucks. Farmers do not use refrigerated vehicles hence the need to advise them to cover the cabbage heads with grass to protect them from sunburn.

Activity IV: Practical on harvesting and post - harvest handling of cabbage (45 minutes)

- Facilitate a practical on harvesting of cabbage
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in harvesting cabbage?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor cabbage heads?

Application questions

- ✳ Will you be comfortable to harvest your cabbage at the farm?
- ✳ What alternatives are there to maintain the quality of cabbage in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to plan for harvesting of their cabbage in the field listing the materials they will need and how they will source them
- The trainer should make it clear to all the participants that the harvesting process will be inspected
- Of most interest at this time will be the materials used for handling the cabbage because these have the potential of compromising the post - harvest quality

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 2 Commercial production of garden peas

Figure 61: shelled and unshelled peas

Table 9: Production calendar for garden peas

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall												
Site selection												
Land preparation												
Planting												
Weeding												
Fertilizer/compost												
Pest & disease control												
Harvest												
Packaging												
Marketing												

Unit 1: General information, varieties and production requirements of garden peas

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - identify the various varieties of gardenpeas - indicate general production requirements of garden peas - prepare fields and plant garden peas
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes
Training duration	90 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to people depending on the number of available participants
- Instruct the participants to discuss and share any information/knowledge about peas including the common varieties on the market, their characteristics and production requirements
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, present the general information about garden peas, characteristics of the common varieties on the market and the production requirements
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Family

Leguminosae

Names

The botanical name is ***Pisum sativum***; there are different forms like the common garden peas of which only the seed is eaten or edible - podded peas with the names mangetout, sugar, snow peas or sugar snaps of which the seeds are eaten together with the pods.

Why is it cultivated

Garden peas, snow peas and sugar snaps belong to the most delicious vegetables and are used either as side vegetable dishes or mixed with other vegetables. The peas with edible pods are becoming more fashionable and are an excellent fresh export product.

Climatic requirements

Peas are essentially a cool season crop and do not grow well during the hot season.

Soil requirements

Peas perform satisfactorily on a wide range of soil but prefer deep soils rich in organic matter; optimum pH is 6.0 to 7.5. If the pH is acidic then apply lime about four weeks before sowing. The incorporation of fresh manure just before sowing is not recommended before peas are very susceptible to soil borne diseases.

Figure 62: Application of gypsum (lime) in the soil

Table 10: Varieties of garden peas and their characteristics

VARIETY	GROUP	CHARACTERISTIC	MA-TURITY (DAYS)	RESISTANCE/TOLER-ANCE
Novella 11 (S& G)	Garden pea	70 cm tall, dark green pod, pod 7 - 8 cm long blunt	110 - 120	Powdery Mildew, Fusarium Wild Race 1, Pea Leaf Roll Virus
Green - feast (Stark Ayres)	Garden pea	Standard cultivar, long growing and picking season, 70 cm tall	115 – 130	
Knight (Starke Ayres)	Garden pea	Early, high yield 40 - 50 cm tall vine	110 - 125	Powdery Mildew, Fusarium Wild Race1, Pea Enation Mosaic Virus
Oregon sugar pod 11* (S&G, Starke Ayres)	Snow Pea	50 - 60cm tall, edible flat podded pea, pod 8 cm long, medium to light green pods, standard variety	65 - 75	Powdery Mildew, Pea Enation Mosaic Virus
Snow flake (S&G, Starke Ayres)	Snow pea	50.60c m tall, edible flat podded pea, pod 10 cm long, slow seed development	70	Powdery Mildew, Common Wilt Race 1
Sugar Daddy (S&G, Starke Ayres)	Sugar snap pea	70 - 80 cm, string less round edible pod, pod 8cm long, pointed fleshly, standard variety	70 - 80	Powdery Mildew, Pea Leaf Roll Virus

Activity IV: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Activity V: Assignment (10 minutes)

- Ask participants to prepare a soil nutrition plan for their individual fields and implement it utilizing the knowledge and skills gained during this training
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that a proper soil nutrition program is crucial for both productivity and quality of the vegetable crop

Activity VI: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session.Close the session by thanking all participants for coming to the training.

Unit 2: Field management practices for garden peas

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - carry out various management practices for commercial garden pea production - identify most common pests and diseases that affect cabbage - control pests and diseases in their cabbage production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes
Training duration	180 minutes

Activity I: Group discussion and experience sharing (20 minutes**)**

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any good practices in the management of garden peas in the field
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (30 minutes)

- After listening to presentations from all groups, present the information about good practices in the management of garden peas in the field
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Crop husbandry

Staking

Peas are quite delicate and fragile vines. They appreciate support through staking or trellising. Dwarf varieties are staked with twigs on which the vines can climb up. Higher growing varieties need to be double staked on both sides on the row with strings fixed between the stakes along the needs. Drawing up the soil along the line also helps to give additional support.

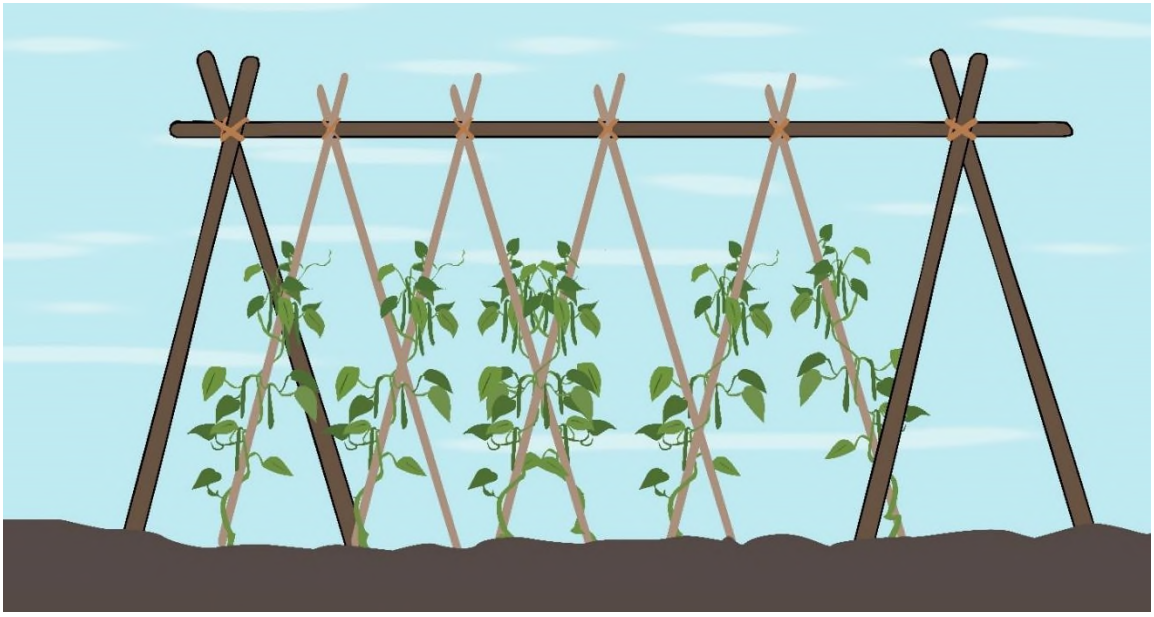

Figure 63: Trellising in climbing beans

Fertilizer

Peas do best when plenty of manure was given to the crop before. At the time of soil preparation give 60 g/m² (which is the same as three leopard match boxes or six teaspoons) of `D' compound fertilizer and give another light dressing of 20g/m² (which is the same as one leopard match boxes or two teaspoons) `D' compound or liquid fertilizer when flowers appear.

Over - fertilization with nitrogen will result in extensive growth of the vines with only little pod setting. Peas do collect atmospheric nitrogen in the root zone as do other leguminous crops.

Irrigation

At seed germination, watering has to be done with care in order not to encourage damage by fungal diseases and this especially during the cool season. Peas need plenty of water particularly when flowers just appear and then when pods start to swell. At petal fall no irrigation is required. Watering should always be done below the foliage and this is not difficult if the plants are well staked.

Figure 64: Watering of tomatoes below the foliage

Crop protection

Use best seed dressed with fungicides and of tolerant varieties in order to escape early infections of soil borne fungal diseases. Watch constantly out for powdery Mildew and spray weekly with Karathene 25WP 10g/10 litres water, Benomyl 50WP 10g/10litres water. Downy Mildew occurs occasionally during the cool season. Spray with dithane M45 20g/10 litres of water or Bayleton.

Insect pests

Aphids (Nsabwe)

Figure 65: Aphids that attack garden peas

Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in colour, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy, it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plant. Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver coloured plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

Root knot nematode (meloidogyne spp)

Symptoms

Galls on roots which can be up to 3.3 cm (1 inch) in diameter but are usually smaller; reduction in plant vigour; yellowing plants which wilt in hot weather. Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

Figure 66: Root knot nematodes in garden peas

Management

Plant resistant varieties if nematodes are known to be present in the soil check roots of plants mid - season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

Leaf miners (Lyriomyza spp)

Figure 67: Leaf miners on garden pea's leaf

Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause yield to be reduced; adult leaf miner is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior. Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as two weeks in warm weather; insect may go through seven to ten generations per year.

Management

Check transplants for signs of leaf minor damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leaf minor damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

Mexican bean beetle (Epilachna varivestis)

Figure 68: From left to right, Mexican bee beetle and eggs of Mexican bee beetle

Symptoms

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange - brown beetle with black spots; larvae are fat - bodied grubs which taper at the end and are in rows of conspicuous spine. Beetles can decimate bean crops; beetles overwinter as adults and undergo two to three generations per year.

Management

Some bean varieties may be less attractive hosts for the beetle, e.g. snap beans are preferred hosts over lima beans; early varieties may escape damage form beetles beetle populations can be reduced by remove overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy.

Figure 69: Hand picking of insect larva

Figure 70: Spraying of chemicals

Thrips (Frankliniella occidentalis)

Figure 71: Thrips

Symptoms
If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in colour. Transmit viruses such as tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life.

Management
Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up.

Diseases
Powdery mildew (Erysiphe pisi)
This is a fungal disease caused by *Erysiphe pisi*.

Figure 72: From left to right, powdery mildew attack on leaves and powderly mildew attack on pods

Symptoms
Yellow spots on upper surface of leaves; powdery grey - white areas which coalesce to cover entire plant; if plant is heavily infected it may appear light blue or grey in colour. Fungus overwinters on plant debris or alternate host; disease emergence is favoured by warm, dry weather with cool nights that result in dew formation.

Management
Plant resistant varieties, particularly if sowing late; **use overhead irrigation** as it washes fungus from leaves and reduces viability; plant crop as early as possible; frequent applications of Sulphur 80%WP may be required to control heavy infestations.

Figure 73: Overhead irrigation in onions

Septoria blotch (Septiria pisi)

Figure 74: Appearance of Septoria blotch on leaves as well as pod

Symptoms

Fungal disease with irregular yellow lesions on leaves and pods with no definitive margin that coalesce to form large yellow patches; large patches may dry out and become covered in black fungal fruiting bodies. Disease emergence favours high humidity and moderate temperatures; disease is common but rarely causes economic damage as it occurs mainly on old leaves and pods.

Management

Rotating crops regularly prevents disease build - up in soil.

Activity IV: Practical on pest and disease identification and management (60 minutes)

- Facilitate a practical on pest and disease control that covers several aspects including scouting (checking), pests and diseases identification, decision on pest and disease treatment, chemical application and applying the chemicals to the field to control available pest and/or diseases
- For effectiveness of this practical, the trainer should inspect the fields of the farmers and choose where there are pests and diseases
- Allow enough time to ensure that participants are able to identify the various pests and diseases in the field
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Tip or trainer

- Observe how the participants are able to apply skills learnt in the module of handling and application of chemicals to ensure safety
- Keep on reminding the participants about the safety measures to take when handling and applying chemicals throughout the practical

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in staking and/or applying fertilizer and manure in the field during the demonstration/practical?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor performance of garden peas and significantly reduce the yield?

Application questions

- ✳ Will you be comfortable to stake and/or apply manure and/or fertilizer at your farm?
- ✳ What alternatives are there to achieve a good garden peas production in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to prepare materials for staking and/or a soil nutrition plan for their individual fields and implement it utilizing the knowledge and skills gained during this training
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that a proper soil nutrition program is crucial for both productivity and quality of the garden peas crop

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Unit 3: Harvesting, post - harvest handling and marketing of garden peas

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - describe maturity indicators of garden peas - implement harvesting, post - harvest handling procedures and marketing of garden peas
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand, sacks, packaging materials, mature garden peas
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share information/knowledge about maturity indices, harvesting procedure, post - harvest handling and marketing of garden peas
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Duration: Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, present the information about maturity indices, harvesting procedure, post - harvest handling and marketing of garden peas
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Harvest

Pick the pods of garden pea's sugar snaps when still young and full. Early picking encourages further production and avoids that peas become starchy. Since the vines are fragile, use both hands when picking. Hold with one hand the plant and pick with the other. Snow peas are supposed to be flat podded and should be picked at the right length but before the seeds develop.

Post - harvest handling

It is important to harvest peas in the morning during the cool hours and when the pods are fully turgescent. They should be kept as cool as possible during storage and transport. Garden peas when shelled do keep quite long. They are normally presented as shelled peas in the market. Snow peas and sugar snaps are best - packed 200 g in a foam covered with cling foil.

Markets

Garden peas presented unshelled and shelled are usually found in both rural and urban markets and are bought by all kinds of customers. Usually they are harvested too late, so that the pea contains starch. Foreign customers prefer fresh peas without starch. Snow peas and sugar peas are usually sold in urban supermarkets and green grocers where foreign customers are buyers. Because of their special packaging the price per kg can be quite high.

Economy

Since peas are a rather delicate crop, the success depends on the carefulness when tending the plants and the harvested pods. Crucial for the success is to keep them as long as possible free from diseases. The yield can then be as high as 4 t/ha for shelled garden peas.

Activity IV: Practical on harvesting and post - harvest handling of garden peas (45 minutes)

- Facilitate a practical on harvesting and post - harvest handling including packaging of garden peas
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in harvesting, post - harvest handling and packaging of garden peas?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor quality peas to be offered on the market?

Application questions

- ✳ Will you be comfortable to harvest, carryout post - harvest activities and package your garden peas at your farm?
- ✳ What alternatives are there to maintain a good quality of garden peas in the absence of other equipment or materials used in this demo?
- ✳ How can the skills gained in this practical be applied in production of other crops?

Activity VI: Assignment (10 minutes)

- Ask participants to plan for harvesting, post - harvest handling and packaging of their garden peas in the field, listing the materials they will need and how they will source them
- The trainer should make it clear to all the participants that the harvesting process will be inspected before the next training
- Of most interest at this time will be the materials used for handling the garden peas because these have the potential of compromising the quality of garden peas

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training

Topic 3: Commercial production of beans

Figure 75: runner beans

Table 11: Cropping calendar for beans

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall												
Site selection												
Land preparation												
Planting												
Weeding												
Fertilizer/compost												
Pest & disease control												
Harvest												
Packaging												
Marketing												

Unit 1: General information, varieties and production requirements and practices for common beans

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - identify various varieties of beans - indicate production requirements for common beans - carry out land preparation practices for commercial production of beans
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes, seeds of various varieties of common beans
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any information/knowledge about beans including the common varieties on the market, their characteristics and production requirements of beans
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (15 minutes)

- After listening to presentations from all groups, present the general information about beans, characteristics of the common varieties on the market and the production requirements
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Family

Leguminoaceae

Names

Botanical: *Phaseolus vulgaris* (Nyemba)

Importance

Beans are a good source of proteins and cash income. Due to easy storage, beans can be made available throughout the year. They are grown throughout the country mostly in cool areas but they can also be grown in low altitude areas during winter.

Most farmers inter plant beans with maize crop although it is possible to produce beans in pure stand. In districts like thyolo beans are grown as relay crop.

Figure 76: From left to right; Intercropping of beans and maize, and Beans intercropped with cabbage

Varieties and their characteristics

It is important to grow improved varieties that produce high yields. Some of the improved varieties that are recommended include Nasaka, Bwensilaana, Sapelekedwa, Kamtsilo, Napilira, Maluwa, Nagaga, Mkhalira, Kambidzi, Kalima, Sapatsika and Chimbamba. All these are determinate (dwarf) varieties. The indeterminate (climbing varieties) varieties such as Kanzama. Bunda 93 and Namajengo are also available for production.

Field preparation

The field should be prepared in advance before the onset of rains for early planting. For relay crop, ensure that the field is ready in February or early March. Beans are grown on ridges spaced at 75 cm and 25 – 35 cm between plants.

Figure 77: Ridges spaced at 75 cm for bean production

Planting

Planting of beans is done soon after planting the main crop where intercropping is done. Pure stands can be planted in mid rain season. In relay cropping, planting should be done when the main crop has matured. Where irrigation is possible, farmers should be advised to plant soon after the summer crop has been harvested while the *dimba* crop can be planted when the climate is favourable.

In pure stands and relay crop, plant dwarf beans in two rows spaced at 30 cm on the ridge. One seed should be planted per station spaced at 10 cm apart along each row. Climbing beans on the other hand should be planted on one row and one seed per planting station spaced at 15 cm. In *dimba* crop, beans should be planted on flat beds as this assist in moisture conservation. Plant dwarf varieties in rows, 45 cm apart, one seed per planting station spaced at 20 cm. Climbing beans should be planted in rows, 45 cm apart, 1 seed per planting station spaced at 30 cm and they should be staked.

Activity IV: Practical on land preparation for bean planting (60 minutes)

- Facilitate a practical on land preparation and planting of beans in the field
- Offer guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in land preparation and planting of beans in the field?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor growth of beans and significantly reduce the yield?

Application questions

- ✳ Will you be comfortable to prepare land for bean production at your farm?
- ✳ What alternatives are there to achieve high yield and quality beans production in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to prepare land for bean planting in their respective individual fields utilizing the knowledge and skills gained during this training
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that a proper land preparation is crucial for both productivity and quality of the beans

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

Unit 2: Field management practices for beans

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - carry out field management practices in commercial bean production - identify most common pests and diseases that affect beans - control pests and diseases in their bean production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes
Training duration	210 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any good practices in the management of beans in the field
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (40 minutes)

- After listening to presentations from all groups, present the information about good practices in the management of beans the field
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET
Crop husbandry
Staking
Climbing beans have delicate and fragile stem. They appreciate support through staking or trellising. Dwarf varieties are staked with twigs on which the vines can climb up. Higher growing varieties need to be double staked on both sides on the row with strings fixed between the stakes along the needs. Drawing up the soil along the line also helps to give additional support.

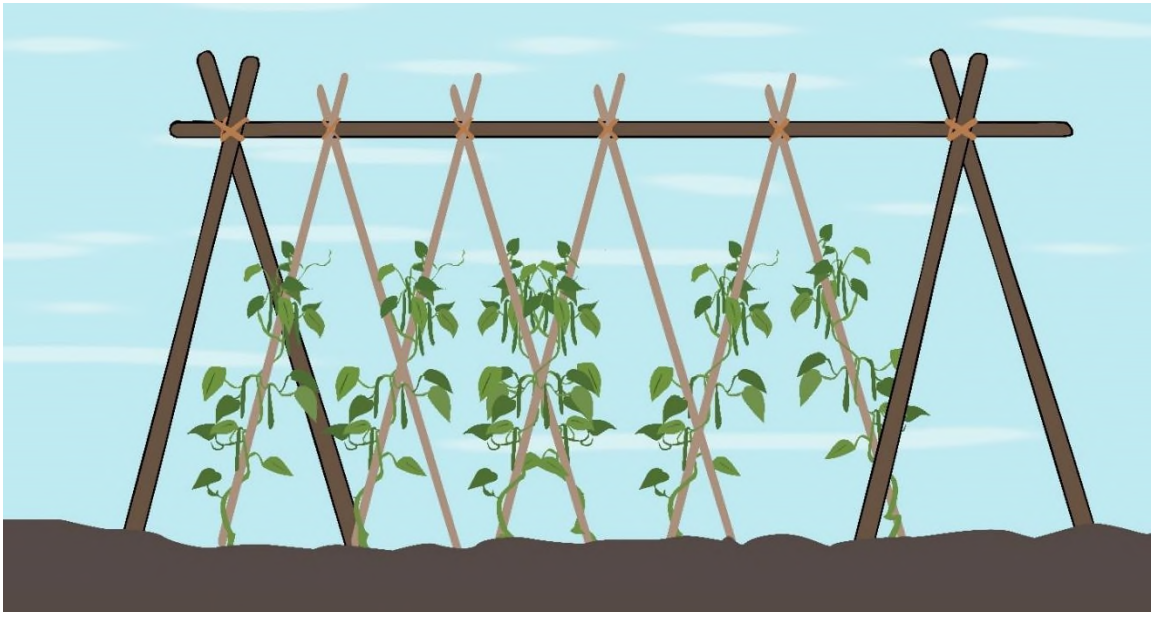

Figure 78:: Staking/trellising, a common practice in climbing beans

Insect pests and their control
Aphids (Cowpea aphid, pea aphid)

Figure 79: 79a: Aphids on bean plant

79b: Close look of aphid

Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in colour, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants. Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

Management

If aphid population is limited to just a few leaves or shoots then the infested part can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver coloured plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

Figure 80: Spraying against aphids

Mexican bean beetle (Epilachna varivestis)

Figure 81: On the left, bean beetle eggs on the right hand side, bean beetle leaf damage

Symptoms
Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange - brown beetle with black spots; larvae are fat - bodied grubs which taper at the end and are in rows of conspicuous spines. Beetles can decimate bean crops; beetles overwinter as adults and undergo to to three generations per year.

Management
Some beans varieties may be less attractive hosts for the beetle, e.g. snap beans are preferred hosts over lima beans; early varieties may escape damage from beetles. Beetle populations can be reduced by removing overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy.

Cutworms (Agrotis spp.)

Figure 82: A cutworm destroying a bean stem

Symptoms
Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5 to 5.0 cm (1 to 2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C - shape when disturbed. Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

Management
Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; hand - pick larvae after dark and apply appropriate insecticides to infested areas of garden or field if not growing organically.

Diseases and their control
Alternaria leaf spot (Alternaria alternate)

Symptoms
Small irregular brown lesions on leaves which expand and turn grey - brown or dark brown with concentric zones; older areas of lesions may dry out and drop from leaves causing shot hole; lesions coalesce to form large necrotic patches

Management
Disease emergence favoured by high humidity and warm temperatures; plants grown in nitrogen and potassium deficient soils are more susceptible.
Plant beans in fertile soil; foliar fungicide application may be required.

Figure 83: Beans destroyed with altenaria disease

Anthracnose
Symptoms
Small, dark brown to black lesions on cotyledons; oval or eye - shaped lesions on stems which turn sunken and brown with purple to red margins; stems may break if cankers weaken stem; pods drying and shrinking above areas of visible symptoms; reddish brown spots on pods which become circular and sunken with rust coloured margin.

Figure 84: Plants being watered at the base

Management
Plant resistant varieties; use certified disease - free seed; avoid sprinkler irrigation, water plants at base; plough bean crop debris into soil.

Figure 85: On the left hand side: Anthracnose on bean pods on the right hand side; anthracnose on bean canopy

Black root rot (Thielaviopsis basicola)

Symptoms
Elongated red - purple lesions on root tissue which turns dark grey to black; lesions coalesce to form large dark areas on roots and stems; deep lesions can cause stunted growth, wilting leaves, defoliation and plant death.

Management
Rotate crops with non - susceptible grasses; avoid excess irrigation or drought stress.

Figure 86: Black rot disease on bean roots

Fusarium root rot (Fusarium solani)

Symptoms
Young plants stunted with chlorotic leaves; older plants with chlorotic leaves and some leaf drop; severely decayed roots which are hollow and dry. Fungus can survive in soil for several years.

Figure 87: Fusarium wilt on bean roots

Management
Practice long - term crop rotation; avoid over or under watering plants; some bean varieties exhibit some tolerance.

White mold (Sclerotinia timber rot)

Figure 88: On the left hand side, white mold on stems and pods; on the right hand side; white mold on dry pods

Symptoms
Flowers covered in white, cottony fungal growth; small, circular, dark green, water - soaked lesions on pods leaves and branches which enlarge and become slimy; cottony white growth may be visible on lesions during periods of high humidity; death of branches and/or entire plant. Fungus can survive in soil for in excess of five years; disease can be spread by wind, contaminated irrigation water and by infected seeds.

Management
There is no true immunity to white mold in any bean varieties; rotate crops with non - hosts like cereals and corn; plant rows parallel to direction of prevailing winds to prevent spread of disease from secondary hosts nearby; avoid excessive nitrogen fertilizer; use a wide row spacing.

Bacterial blight (Xanthomonas campestris)


Figure 89: Bacterial blight signs in beans

Symptoms
Water - soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red - brown lesion may be present on pods; pod lesions may ooze during humid conditions. Disease can be introduced by contaminated seed; bacteria over - winters in crop debris; disease emergence favoured by warm temperatures; spread is greatest during humid, wet weather conditions.

Management

Plant only certified seed; plant resistant varieties; **treat seeds with an appropriate antibiotic** prior to planting to kill off bacteria; spray plants with an appropriate protective copper - based fungicide before appearance of symptoms.

Bacterial brown spot (Pseudomonas syringae)

Figure 90: Signs of bacterial brown spot in beans

Symptoms
Small, dark brown necrotic spots on leaves which may be surrounded by a zone of yellow tissue; water - soaked spots on pods which turn brown and necrotic; pods may twist and distort in area of infection. Bacterium overwinters in crop residue; disease more severe when foliage is wet for extended periods.

Management
Plant only certified seed; rotate crops regularly; remove crop debris from field after harvest.

Mosaic (Bean common mosaic virus BCMV: Bean common mosaic necrosis virus BCMNV)

Figure 91: Bean common mosaic virus disease

Symptoms
Mottled dark and light green patterns on leaves; leaves may be distorted; yellow dots may be present on leaves; growth of plant may be reduced. BCMV can be transmitted by seed and has a world-wide distribution; BCMNV also transmitted through infected seed but geographic range more restricted.

Management
Plant only virus - free seed or resistant varieties

Irrigation
At seed germination, watering has to be done with care in order not to encourage damage by fungal diseases and this especially during the cool season. Beans need plenty of water particularly when flowers just appear and then when pods start to swell. At petal fall, no irrigation is required. Watering should always be done below the foliage and this is not difficult if the plants are well staked.

Figure 92: Watering at the base of the plant foliage

Crop protection

Use best seed dressed with fungicides and of tolerant varieties in order to escape early infections of soil borne fungal diseases. Watch constantly out for powdery Mildew and spray weekly with Karathene 25WP 10 g/10 litres water, benomyl 50WP 10g/10litres water. Downy Mildew occurs occasionally during the cool season. Spray with dithane M45 20 g/10 litres of water or bayleton.

Activity IV: Practical on staking and/or pest and disease control (45 minutes)

- Facilitate a practical on staking, manure application and pest and disease control allowing participants to apply knowledge gained from the group and plenary discussions above
- For effectiveness of this practical, the trainer should inspect the fields of the farmers and choose where there are pests and diseases
- Allow enough time to ensure that participants are able to identify the various pests and diseases in the field
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in staking, fertilization and/or pest and disease control in the field during the demonstration/practical?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor performance of garden peas and significantly reduce the yield?

Application questions

- ✳ Will you be comfortable to stake beans apply manure or fertilizer and perform pest and disease control at your farm?
- ✳ What alternatives are there to achieve a good garden peas production in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to prepare materials for staking and/or pest and disease control including identifying pests and diseases, sourcing the right chemical and diluting them for application in the field utilizing the knowledge and skills gained during this training
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that proper staking and an effective pest and disease control program is crucial for both productivity and quality of the garden peas crop

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

Unit 3: Harvesting, post - harvest handling and marketing of beans

ITEM	CONTENT
Objective	By the end of the topic, farmers will be able to: - describe maturity indicators of beans - implement harvesting, post - harvest handling procedures and marketing of common beans
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand, weaved baskets, plot of mature beans, threshing and packaging materials
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any information/knowledge about maturity indices, harvesting procedure, post - harvest handling and marketing of beans
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, present the information about maturity indices, harvesting procedure, post - harvest handling and marketing of beans
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Harvesting

Beans are harvested when most of the pods on the plant have started drying. Harvesting should be done in the morning when dew has evaporated. Do not harvest late when pods are too dry to avoid loss of beans through shattering. Bean should be sun dried before threshing. .

Figure 93: Sun drying of harvested beans

Threshing and sorting

Beans are threshed either by hand or beating using a stick when the pods have thoroughly dried. However, beans for seed should be threshed by hand to avoid damage. After threshing, beans should be carefully sorted discarding shrivelled and diseased beans.

Figure 94: Threshing of beans on the left hand side, and a woman sorting threshed beans on the right handside

Storage

Beans are packaged in clean sacks for storage or any other clean local materials. Store well dried beans in cool dry place. Apply either 25 g of actellic super to 50 kg grain or 25 of super grain dust to prevent bruchid which can be mistaken for weevils.

Activity IV: Practical on harvesting and post - harvest handling of beans (60 minutes)

- Facilitate a practical on harvesting, threshing and post - harvest handling including packaging of beans
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (15 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing question

- ✳ What were the main steps/activities and considerations in harvesting, post - harvest handling and packaging of beans?

Generalization questions

- ✳ Which step if not followed would result in poor quality beans to be offered on the market?

Application questions

- ✳ Will you be comfortable to harvest, carry out post - harvest activities and package your beans at your farm?
- ✳ What alternatives are there to maintain a good quality of beans in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to plan for harvesting, post - harvest handling and packaging of their beans in the field listing the materials they will need and how they will source them
- The trainer should make it clear to all the participants that the harvesting process will be inspected before the next training
- Of most interest at this time will be the materials used for handling the beans because these have the potential of compromising the quality of garden peas

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
  - Date, venue, time, topic of next session and activities to take place before the next meeting
  - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

Topic 4: Commercial potato production

Figure 95: potatoes

Table 12: Cropping calendar for potato

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall												
Site selection												
Land preparation												
Planting												
Weeding												
Fertilizer/compost												
Pest & disease control												
Harvest												
Packaging												
Marketing												

Unit 1: General information, varieties and production requirements of potato

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - identify various varieties of potatoes - indicate production requirements for potatoes - carry out land preparation and plant potatoes
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes
Training duration	150 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any information/knowledge about including the common varieties on the market, their characteristics and production requirements of potatoes
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (20 minutes)

- After listening to presentations from all groups, present the general information about potato, characteristics of the common varieties on the market and the production requirements
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET
Family:
Solanaceae

Names
Botanical: *Solanum tuberousum*, `Mbatata ya chizungu or kachewere', ` mbatatesi'.

Importance
- Potatoes are used as food after being boiled or made into chips when fried
- They are also used as a cash crop

Table 13: Varieties of potatoes and their characteristics

VARIETY	CHARACTERISTICS
Cardinal	Red skin
Desiree	Red skin
Mirka	Yellow white skin
Kennebec	Yellow white skin
Roslin Bvumbwe	Yellow white skin
Rosita	Red skin

Climate requirements
Grow best under cool conditions with temperatures in the range of 16 to 18°C. Tuber formation is promoted by short days (sunlight hours of less than thirteen). Long day periods prolong growth cycle. The temperature range during growth preferably should be 15 to 20°C. Temperatures above this range decrease the rate of tuber formation and usually ceases at 29°C. From flowering to harvesting the weather should be dry as to reduce rotting of the tubers.

Soil requirements
Best soil is sandy loam and must be deep and well drained with pH of 5.0 to 5.5. The sandy loam soil enables easy expansion of the tubers. Clears the land and plough deeply (30 cm depth) to improve soil porosity and aeration.

Sowing
Plant well - sprouted tubers and ensure that sprouts are pointing upwards. Potatoes are grown from tubers and are better planted in ridge furrows. The tuber needs to have at least one `eye' or sprout. Leave the tubers in a shady spot for a week or two before planting to harden shoots. Space potatoes at 90 cm between rows (ridge furrows) and 30cm between plants in a row (only healthy tubers should be planted). The crop is best grown in a pure stand.

Figure 96: Potato plants in the field

Activity IV: Practical on land preparation and planting of potato (60 minutes)

- Facilitate a practical on land preparation and planting of potato in the field
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and/or considerations in land preparation and planting of the potatoes in the field?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor growth and reduced yield of the potatoes?

Application questions

- ✳ Will you be comfortable to prepare land and plant potatoes at your farm?
- ✳ What alternatives are there to achieve high yield and quality potato production in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to prepare and plant potatoes in their respective individual fields utilizing the knowledge and skills gained during this training
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that a proper land preparation and planting procedure is crucial for both productivity and quality of the potato crop

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

Unit 2: Field management practices for potatoes

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - apply field management practices for potato - identify most common pests and diseases that affect potatoes - control pests and diseases in potato production
Training materials & tools	Flip charts, markers, masking tapes, flip chart stand and hoes
Training duration	240 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share any good practices in the management of a potato field
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (25 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (40 minutes)

- After listening to presentations from all groups, present the information about good practices in the management of a potato field
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET
Crop husbandry
Fertilizer
During planting sprinkle first Calcium Ammonium Nitrate (CAN), single super phosphate and potassium sulphate and mix the fertilizer thoroughly with the soil. The rates must be as follows: 100 kh/ha, 200 kg/ha and 15 kg/ha respectively. After three weeks from emergence, top - dress the crop with CAN at the rate of 100 kg/ha.

Weeding
Keep the crop free from weeds. The rows must be carefully weeded and earthen - up as soon as shoots appear. The last earthling - up must be done before the plants meet in each row. Earthling up the plants reduces potato tuber moth incidences.

Crop protection
Insect pests
Regular field scouting is one of the most important aspects of effective insect control.

Aphids (Aphidedae spp)
Green peach, melon or potato aphid may occur in potato. These aphids colonize the potato fields from mid June through July. Potato aphid is the largest aphid of the three aphids, 3 to 4 mm long, and may be pink or green. Cornicles are the same as the body colour with dark tips (Figure 15). Plants of the rose family serve as alternate hosts to potato aphid in autumn and spring. A wide range of weeds, field crops and vegetable crops are hosts in summer. In potato they feed first in young, growing tips, spreading downward into older leaves. Damage includes leaf deformity and dieback.


Figure 97: Adult wingless and winged aphids

Aphids are the main vectors of viral diseases like potato leaf loll, PVX and PVY which can reduce yields and quality.
They should be controlled by spraying with malathion 25WP at the rate of 14g in 14 litres of water or dimethoate 20 WP at 34 g in 14 litres of water. Fields should be scouted for aphids starting in early June. Examine aphids per leaf on 50 fully - grown compound leaves (five leaves at ten locations in the field) from top, middle and bottom of the canopy.

In fresh market and processing potato, the threshold for insecticide application is when an average of five aphids per leaf is present, or ten per leaf within two weeks of vine kill. The economic threshold for table stock and processing fields is when aphids are found on 50% of the plants or one winged aphid is found within the field.

Potato tuber moth (Phthorimaea operculella)

The damage to potatoes by potato tuber moth is due to the larvae tunnel on the tubers thus predisposing them to decay or rotting. They also damage the eyes and reduce sprouting potential of the potato. The tunnelling of tubers (Figure 90) detracts from market quality and value as potatoes become unsaleable. The adult moth (Figure 89) only lays eggs on the stems and tubers of potatoes. The pest occurs both in the field and in storage. The pest causes most severe damage on the late dry season crop.

Control

Potato tuber moth is controlled by earthing or hilling - up the ridges to cover the tubers. Reducing ground-keepers and alternate hosts are good field hygiene practices which help control prevalence of the tuber moth. In storage, the potatoes should be regularly dusted with 40 g of actellic dust or related insecticide for every 90 kg tubers. Other preventing measures include the use of clean seed and irrigating soil well to minimize soil cracks.

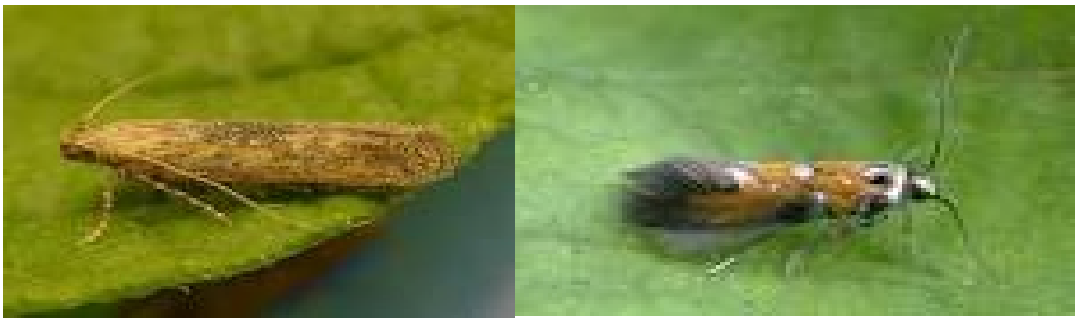

Figure 98: White and multicoloured adult potato tuber moth

Figure 99: Potatoes damaged by potato moth larvae

White grubs

These are white bodied beetle larvae with brown heads that eat out shallow holes on tubers (Figure 18). They disfigure the tubers and lead to loss of tuber market quality. The grubs cause serious problems in lands that are excessively high in organic matter.

Control

General integrated control measures include:

- Practicing rotation where potatoes should follow legumes
- Avoiding planting in excessively fertile lands or old pasture lands where the beetle lays a lot of eggs
- Deep ploughing of soil to expose the grubs to birds and sunshine
- Soil sterilization or fumigation and fallowing the production field

Figure 100: White grubs

Potato leafhopper

Low levels of leafhopper feeding can severely damage plants and cause symptoms known as hopper burn. Leaves turn yellow or brown and die. Adults are light green, and wedge - shaped, while nymphs are bright green, flatter and fatter than adults, and move sideways in a crab - like fashion (Figure 19).

Control

Sample with sweep net and treat if more than one adult per sweep is found. Nymphs can be monitored by visually inspecting lower leaf surfaces on the lower leaves. Treat with cypermenthrin if more than 15 nymphs are found per 50 leaves.

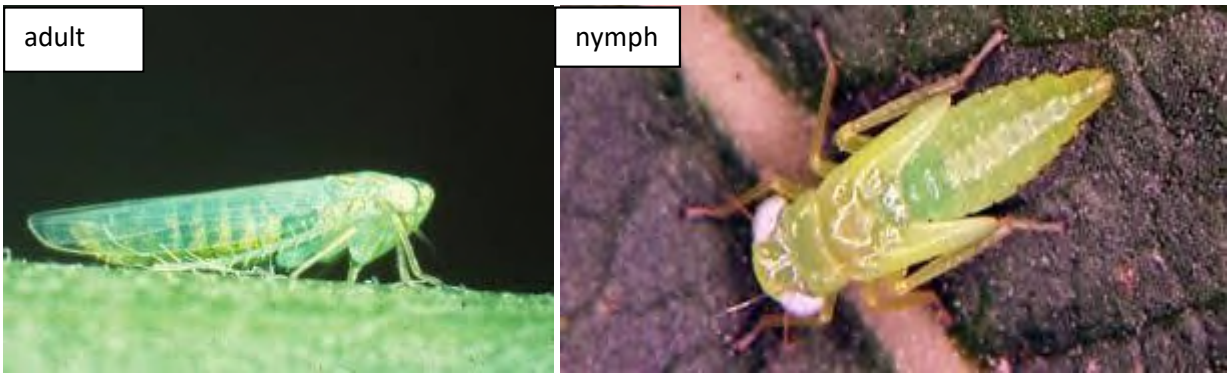

Figure 101: Potato leafhopper

Wireworms

Wireworms are the larvae of slender black beetles known as click beetles. The wireworm is slender, jointed, and usually hard shelled, with three pairs of legs and tan brown (Figure 20). Adult beetles emerge in the spring from the soil where they wintered. Shortly after mating, the female beetles lay up to 300 eggs in the soil, usually around grass roots. Eggs hatch within a few weeks and the larvae begin feeding on root hairs and fungi. At this stage, they are usually overlooked as they are small and the damage, they cause is negligible. Because of the long lifespan of wireworms, damage may continue in the same field for several years, although severity will depend on weather and crop rotation.

Control

'Thimet' is one of the commonly used insecticides for control of wireworm. Alternative fields should be considered if populations of wireworms are high.

Figure 102: An adult Wireworm

Diseases

Bacterial wilt (Pseudomonas solanacearum)

Bacterial wilt also called brown rot is a soil - borne disease of potatoes. This disease is caused by a bacterium known as *Ralstonia solanacearum.*

Symptoms

First symptoms of wilting occur at the plant tips where only a leaf or branch show signs followed by sudden wilting and death of the whole plant. If the infected plant has already formed tubers, these tubers will probably also show symptoms. A brown vascular ring will be observed when the tuber is cut through. When an infected tuber is cut through and squeezed, slimy drops of bacteria will ooze from the vascular ring (Figure 21). In addition, when an infected stem is cut and placed in a glass of water, a milky bacterial suspension will flow out of the stem. It is spread by infected seed tubers as well as soil water, especially where drainage is poor. Warm, moist soil conditions are very favourable for the development of bacterial wilt. No bactericide has been registered against the disease.

Control

a. Plant only clean or certified seed potatoes.
b. Do not plant on fields with a history of bacterial wilt infection. Research has shown that the pathogen can survive in soil for many years.
c. Limit the spread of disease by removing infected or suspect plants and destroying them.
d. If the infestation is severe, stop irrigation to prevent spread by runoff and ground - water.
e. Do not use irrigation water which may possibly be contaminated. e.g. where the runoff of an infected field may contaminate an irrigation dam.
f. Sanitise all implements after use on an infested land using 0,5% jeyes fluid.
g. Avoid movement of vehicles, animals and humans through an infected field.

Where a potato field has already been infected, the following measures may limit survival of the bacteria in the soil:

a. Drying of the land by regular tillage.
b. Removal of volunteer potato plants and weeds (some weeds may serve as hosts).
c. Applying crop rotation with non - host crops such as maize, grains and grass varieties.

d. Cultivating table potatoes in the cooler season. There is always the risk that the bacteria may be latently present in the tubers. If such symptomless tubers are used as seed, the disease may still develop under favourable conditions.

Figure 103: Bacterial wilt in potatoes

Late blight (Phytophthora infestans)

This is a disease caused by the fungus *Phytophthora infestans* which attacks leaves, stems and tubers of the potato.

Symptoms

Leaf symptoms of **late blight** are small, light green, circular to irregularly shaped water - soaked spots (Figure 22). The lesions usually first appear on the older leaves and often begin to develop near the tips or edges of leaves, where dew drops form. During cool moist weather, these lesions expand rapidly into large, black lesions. Stem symptoms have become prevalent in Malawi and are characterised by brown lesions on the stems, leaves and petioles. Tuber infections are not common in Malawi. Tuber infections are more predominant in wet, cool soils. The soaked lesions on leaves and other parts that quickly turn brown when dry. The disease is very destructive in a highly humid environment and at temperatures between 15 and 20^{o}C. If no control measures are implemented, entire fields can be destroyed within a short period of time.

Control

Control is achieved by a combination of methods such as use of resistant varieties and good seed; removal of volunteer plants and good agronomic practices like wide ridge spaces. The above control measures should be complemented by chemical control. Spraying the crop with fungicides like dithane M45 80 WP at the rate of 20 g in 10 litres of water and daconil 2787 WP – 75 WP at the rate of 30 g in 10 litres of water. Ensure that the crop is well ridged at the end of the growing season, to prevent infection of the tubers if late blight was present. Irrigate judiciously, particularly when the conditions are favourable for infection. This is even more important if late blight is present. Avoid wet spots in the field. Do not harvest during wet weather, especially if late blight has occurred on the foliage. Fields should be inspected at least twice a week for the presence of late blight.

Figure 104: Late blight disease attack on the potato foliage

Potato virus Y (PVY)

The causal agent of potato virus Y is a filamentous virus of the genus Potyvirus and family Potyviridae. Infected seed potatoes, volunteer plants and some weeds can all be sources of this virus. Transmission is mainly by aphid vector, although some mechanical transmission may also occur.

Symptoms

Potato virus Y causes a range of symptoms from mild defoliation to die off, depending on the virus strain, potato cultivar and environmental conditions. It ranges from virtually none (latent), to noticeable stunting and mosaic symptoms to severe foliar damage and even the die off of the entire plant.

PVY is spread by aphids in a non - persistent manner. The stylets of the aphids carry PVY particles after feeding on an infected plant and when they subsequently feed on a healthy plant they infect with their contaminated stylets. In the case of non - persistently transmitted viruses, aphids are virus free again after one to two hours. The aphids thus acquire the virus from infected plants and lose it quickly when they probe healthy plants. The green peach aphid, Myzus persicae, is the most effective vector. Potato virus Y (PVY) infects a range of solanaceous crops including potato, capsicum, tomato and tobacco. Carryover is mainly via potato tubers (seed tubers or volunteers).

Control

The use of insecticides is largely ineffective in the control of PVY, because they do not act fast enough to kill aphids quickly and thereby prevent virus spread. Methods of control include:

a. Planting of certified disease - free seed potatoes.
b. Spatial isolation of seed potato production from ware potato production.
c. Planting of border crops in order for aphids to lose their virus inoculums before moving into potato.
d. The eradication of aphid weed hosts, especially other solanaceous plants.

Figure 105: Examples of Solanaceae family egg plants and chillies

e. Growing crops in regions where aphid pressure is low.
f. Refraining from growing new crops in the proximity to established crops that might act as an infection source.
g. The destruction of volunteer potatoes as they may habor the virus.
h. The destruction of haulms of seed potato crops before maturity, to prevent late infections spreading to tubers that are developing.
i. The application of non - toxic mineral oils has shown to reduce PVY transmission.
j. Roguing: the immediate removal and destruction of infected plants as well as adjacent plants

Nematodes (Meloidogyne spp)

The Meloidogyne spp are the most damaging on potatoes in Malawi. Plants are stunted and with galls on roots and tubers (Figure 11). Application of nematicides to the soil, treating soil with fumigants, practicing crop rotation and using healthy seed all help to control the problem.

Figure 106: Nematodes attack on potato tuber

Potato disorders

The physiological disorders in potatoes include the misshapen, little potatoes and greening.

Misshapen tubers

Poor soil conditions or adverse weather conditions like droughts lead to misshapen tubers. The tubers may be kinked, bulging on one side or even forked. These affect potato quality and reduce the saleable volume. They arise from growing potatoes in heavy soils or poorly prepared land that has clods or many stones. Production of potatoes on suitable soil, good land preparation and regular irrigation will minimize occurrence of misshapen tubers.

Greening

Greening occurs due to exposure of tubers to direct sunlight. Tubers get exposed due to poor cultivation practices and also cracks created by the development of potato. The exposed sites develop a green colour due to the accumulation of solanine which is poison to humans (Figure 12). Greening can be prevented by growing potatoes on suitable soil, hilling ridges to close all cracks and engaging good general cultivation techniques such as deep ploughing.

Figure 107: Potato greening

Activity IV: Practical on pest and disease control (90 minutes)

- Facilitate a demo practical on pest and disease control including scouting of pests and diseases allowing participants to practice knowledge gained from the group and plenary discussions above
- Calculate the size of the plot used during the practical and calculate fertilization needs
- Observe how the participants will select the chemicals to use, dilute and apply them in the field to control specific pests and/or diseases
- For effectiveness of this practical, the trainer should inspect the fields of the farmers and choose where there are pests and diseases
- Allow enough time to ensure that participants are able to identify the various pests and diseases in the field
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Tip for trainers

- Conduct this practical either in the demo plot or at one of the farmer's fields where pests and diseases have been identified

Activity V: Quality assurance and course assessment (20 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing questions

- ✳ What were the main steps/activities and considerations in potato pest and disease control during the demonstration/practical?
- ✳ Which were the easiest and the most difficult steps in the practical?
- ✳ What skill stands out for you?

Generalization questions

- ✳ What conclusion would you draw from this practical?
- ✳ Which step if not followed would result in poor performance of potato and significantly reduce the yield?

Application questions

- ✳ Will you be comfortable to control pests and diseases at your farm?
- ✳ What alternatives are there to achieve high yield and quality potato production in the absence of other equipment and/or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to identify the diseases, use the right control method including sourcing the right chemicals and apply them in the field following the correct procedure
- The trainer should make it clear to all the participants that their fields will be inspected before the next training
- Emphasize that an effective and proper pest and disease control program is crucial for both productivity and quality of the potato

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

Unit 3: Harvesting, post - harvest handling and marketing of potatoes

ITEM	CONTENT
Objective	By the end of this topic, farmers will be able to: - describe maturity indicators of potatoes - implement harvesting, post - harvest handling procedures and marketing of potatoes
Training materials & tools	Flip charts, markers, masking tapes and flip chart stand, sacks and mature tubers
Training duration	120 minutes

Activity I: Group discussion and experience sharing (20 minutes)

- Organize participants into smaller groups of four to six people depending on the number of available participants
- Instruct the participants to discuss and share information/knowledge about maturity indices, harvesting procedure, post - harvest handling and marketing of potatoes
- Advise the participants to clearly write down their points on the provided flip charts, which they will present afterwards. At the beginning of their group work they shall assign a presenter

Activity II: Group presentations (20 minutes)

- Call the participants back for the presentation of their discussion outcomes
- Invite a representative from each group to present what they had discussed during group work
- Allow members from other groups to ask questions or seek clarification from the points raised by the presenting group (members of the group and not necessarily the presenter should respond and/or provide clarification on the questions asked by the participants)

Activity III: Plenary session (15 minutes)

- After listening to presentations from all groups, present the information about maturity indices, harvesting procedure, post - harvest handling and marketing of potatoes
- Build your presentation on the points and experiences presented by the participants
- The information sheet below may be helpful, but use of other sources to generate more information is encouraged

INFORMATION SHEET

Harvest

Varieties in Malawi vary in days to maturity from 75 to 120 days. Harvest mature tubers having hard skins. These are not easily bruised when rubber by hand when harvesting and collecting from the field. Harvest when the crop foliage and haulm have dried out naturally. Harvest potatoes by uplifting the plants. Implements such as hoes, forks and pangas may be just to dig out the tubers but care must be taken to avoid cutting them. Dry weather at harvest is a must of minimizing rotting. The yield is around 15 t/ha.

Figure 108: Mature, harvested potatoes

Post harvesting handling

Heavy losses occur due to rotting and hence white or Irish potatoes should not be washed. The soil on the tubers should only be rubbed off.

Storage

Keep the tubers in a container, which allows free air circulation and out in a cool place, which is well ventilated. Cover with a sack to avoid greening of potatoes. Best results in storage are always obtained with potatoes free from disease and insect damage.

Market

Potatoes are sold at supermarkets like Shoprite, PTC as well as on the roadside markets. Factories like Universal Industries also do buy from farmers to process into crisps.

Activity IV: Practical on harvesting and post - harvest handling of potatoes (45 minutes)

- Facilitate a practical on harvesting and post - harvest handling including packaging of potatoes
- Offer any guidance throughout the practical to ensure that the participants are following the right procedures
- Make sure that the participants closely watch and actively participate in the entire activity
- Allow each participant to practice

Activity V: Quality assurance and course assessment (10 minutes)

- Use different techniques to assess how the participants understood the lesson. Ensure that this is as participatory as possible. Techniques could be:
    - Allow participants to state their key take away points and lessons from the session
    - Provide an opportunity for pairs or individuals to facilitate a recap of the lesson
    - Ask specific questions from the content of the lesson allowing all participants to take part in responding to the questions

Processing question

- ✳ What were the main steps/activities and considerations in harvesting, post - harvest handling and packaging of potatoes?
- ✳ Which step if not followed would result in poor quality potatoes to be offered on the market?

Application questions

- ✳ Will you be comfortable to harvest, carryout post - harvest activities and package your potatoes at your farm?
- ✳ What alternatives are there to maintain a good quality of potatoes in the absence of other equipment or materials used in this demo?

Activity VI: Assignment (10 minutes)

- Ask participants to plan for harvesting, post - harvest handling and packaging of their potatoes in the field listing the materials they will need and how they will source them
- The trainer should make it clear to all the participants that the harvesting process will be inspected before the next training
- Of most interest at this time will be the materials used for handling the potatoes because these have the potential of compromising the quality of garden peas

Activity VII: Feedback and planning for the next session (10 minutes)

- Discuss the way forward/upcoming activities with participants:
    - Date, venue, time, topic of next session and activities to take place before the next meeting
    - Encourage all participants to prepare, arrive on time and be present for the entire session
- Obtain feedback from participants on the concluded training session
- Close the session by thanking all participants for coming to the training way forward

References

1. Chagomoka, Takemore, Victor Afari - Sefa and Raul Pitoro (2014): Value Chain Analysis of Traditional Vegetables from Malawi and Mozambique; International Food and Agribusiness Management Association; 17(4):57 - 83

2. Department of Agriculture, Forestry and Fisheries (**2013**), Potato: *Production Guidelines,* Directorate of Plant Production, Division of Vegetable, Pretoria , South Africa; Available at: www.daff.gov.za
3. Gabor, B., Kao, J. and Krause, D. (**2013**): Crucifer Disease Guide: A Practical Guide for Seedsmen, Growers and Agricultural Advisors, available at: https:// www.seminis.com/global/us/grower resources/Documents/SEM12093 _Crucifer_Disease_Guide_072313.pdf.

4. Hartley, S; Saskatchewan, Ministry of Agriculture and Gavloski, J Manitoba Agriculture, Food and Rural Initiatives (**2013**): Insect Management in Pulse Crops and Special Crops.

5. Joosten Frank (**2013**): Development of a Horticultural Fresh Produce Supply Chain in Malawi; Report on a Scoping Mission.

6. Kachigamba,D. L., Soko,M. M. and Kumwenda, R. (**2019**): Recommended Production Practices and Integrated Pest and Disease Management for Selected Horticultural Crops in Malawi Trainer's Manual (2nd Edition); Department of Agricultural Research Services.

7. Kachitsa, Saulosi, Ndapile Bwanausi and Alfred Maluwa (**2014**): Guide to Potato Production in Malawi; Consortium for the Advancement of Research for Development, Lilongwe, Malawi.

8. Kuhar, T. (**2012**): Brown Marmorated Stink Bug Injury on Vegetable Crops, Department of Entomology, Virginia Tech, Blacksburg, VA.IPM Thresholds for Vegetables, University of Maryland.

9. Madelyn Ostendorf (**2021**): Manure Provides Farmers an Alternative Nutrient Source amid Volatile Fertilizer Market; available at, https:// www.agriculture.com/news/livestock/net - zero - initiative - enters - next - phase
10. Ministry of Agriculture & Food Security (**2012**): Guide to Agricultural Production and Natural Resources Management in Malawi.

11. National Tested Seeds, Insecticides, Vegetable Production - Quick Reference GUIDE, available at: http// www.natseeds.co.zw.

12. Sami Rokayya, Chun - Juan Li, Yan Zhao, Ying Li, Chang - Hao Sun. (**2013)**: Cabbage (Brassica oleracea L. var. capitata) Phytochemicals with Antioxidant and Anti - Inflammatory Potential; Asian Pac J Cancer Prev. 14 (11), 6657 - 6662.

Additional resources

The *Access Agriculture* website provides access to locally produced videos on various agricultural topics in English and local languages such as Chichewa. These can be used to supplement training. https://www.accessagriculture.org/