ADVANCING ACCESS TO INTEGRATED LIFE - SAVING ASSISTANCE AND PROTECTION SERVICES TO PROMOTE SELF - RELIANCE AND RESILIENCE FOR REFUGEES AND HOST COMMUNITIES.

BASIC AGRONOMY TRAINING MANUAL FOR ONION, TOMATO, AND CASSAVA PRODUCTION (PRM PROJECT)

MARCH 2024

TABLE OF CONTENTS

ACKNOWLEDGEMENT & DISCLAIMER

This manual is developed by the Agency for Accelerated Regional Development, for the implementation of ADVANCING ACCESS TO INTEGRATED LIFE - SAVING ASSISTANCE AND PROTECTION SERVICES TO PROMOTE SELF - RELIANCE AND RESILIENCE FOR REFUGEES AND HOST COMMUNITIES.

The manual formulation process included a review of a number of manuals for which we are indebted, namely:

- Youth Economic Empowerment supported by the European Union (EU).
- West Nile Development Initiative (WENDI) Program that was funded by Gorta, Ireland.

»

This publication was supported by IRC with funds provided by the United States Department of Bureau of population, refugees and migration (BPRM) and the contents, views, and statements of the publications produced under this Project are those of the Local Partner and must not comply with those of IRC and donors.

ABOUT **PRM PROJECT**

Uganda continues to be Africa's largest refugee-hosting nation. According to the United Nations High Commissioner for Refugees' (UNHCR) Uganda Population Dashboard as of January 2023, there was an influx of 122,780 refugees throughout 2022 fleeing war and persecution mainly from the Democratic Republic of Congo (DRC) and South Sudan. 94% of these refugees live in settlements alongside host communities in areas which are among the poorest and most underdeveloped in Uganda. The number of new refugee arrivals in Bidibidi and Palabek settlements have continued to rise, adding strain to the already overstretched services.

Between June and August 2022, 21% of the population (857,000 people) in refugee-hosting districts experienced high levels of acute food insecurity (Integrated Food Security Phase Classification (IPC) Phase 3 and above). All locations in which the IRC operates report that food insecurity is caused by a lack of income and income-generating activities, the reduction of food rations, a shortage of agricultural equipment, inadequate land, and the effects of climate change and environmental hazards. Thus, there was need to establish more farmer organizations and to strengthen the existing ones, so that more farmers can benefit from economies of scale, better prices for produce, and improved agricultural knowledge and practices.

Agency For Accelerated Regional Development (AFARD) in consortium with IRC, WORLD VISION, and UGANET, is implementing a three -year project entitled "Advancing access to integrated life-saving assistance and protection services to promote self-reliance and resilience for refugees and host communities in Uganda", with an overall goal of Advancing the safety, wellbeing, self-reliance and resiliency of refugees and host communities in Uganda through integrated and client -centered protection, health and livelihood services.

Programme Approach

The consortium delivers the program through four integrated objectives that aim to foster inclusiveness, self-reliance, resilience, and tangible pathways to durable solutions – aligning with the strategic objectives of the Uganda Country Refugee Response Plan (UCRRP) 2022-2025 and the Office of the Prime Minister's (OPM) 2021-2025 Comprehensive Refugee Response Framework (CRRF) strategic direction and expected outcomes.

AFARD implements objective 4, "Refugee and host community livelihoods and climate resilience are improved through coping initiatives to transition from aid to stability and self-reliance through food and income security" of the program, targeting refugees and host communities. AFARD supports communities

to transition from vulnerable subsistence farming methods to more resilient green farming approaches, promotes the sustainable practice of agroecology and climate smart agriculture (CSA) to increase food production and household incomes through mixed farming to feature livestock and annual systems which are capable of unlocking household capabilities to achieve food and income security.

The program's implementation strategy applies a hybrid approach of interventions that integrate actions to increase food production and availability by addressing the input and output constraints to enhance the production, processing, distribution, and consumption of food, while simultaneously addressing the root causes that prevent low-come people from effectively participating and accessing opportunities in the market. In both cases, the program focuses on the systemic constraints at the household level and market systems through value chain upgrading to stimulate inclusive market linkages with production and off-markets.

TRAINING **CONCEPT**

2.1 PEDAGOGICAL APPROACH

The training is based on elements of the FFS approach and adult learning theories. The following elements are important:

- The training should be conducted in a participatory and highly interactive way because involvement and learning are enhanced when participants contribute to the discussion. It is therefore essential that participants are encouraged to share their own experiences before the theoretical material is brought to them.
- Similarly, practical exercises, where participants apply what they learn directly in a demonstration field, will enhance learning.
- The demonstration field should be located on the farm of one of the participants (host farm). All training sessions will take place in this field. The host farmer must look after the field between training sessions.
- The training plan must follow the cropping calendar for the product concerned, so that the farmer can apply what he has learned directly at home (see the proposed training calendar below). Ideally, the participants should meet every week or second week on a learning cycle comprising 8-10 meetings.
- Where appropriate, encourage participants to try different things and make small "experiments", either at home or on the demonstration field (for example, applying different types of fertilizer) and observe the effect these treatments can have on the crop.
- If possible, the facilitator should visit farmers in their fields to give them feedback on how they implement their crop at home and help them find solutions to the problems they face.

The participatory method and learning-by-doing will create a direct link between the training and the challenges farmers face when implementing new techniques at home. This will enable them to develop their observation and innovation skills and to find solutions on their own to the problems they may face. It is recommended to start each training session with the practical part, before the facilitator gives technical advice at the end of the training sessions.

The training should promote as much as possible a ***production that includes the principles of agroecology.*** The general principles of agroecology are described in Chapter 0.2. These general principles can be explained and discussed during the first training session.

Specific aspects of agroecology, such as soil fertility management, crop rotation, pest and disease management, are discussed in more detail in the corresponding chapters and in a separate booklets.

They should be explained and discussed during training sessions devoted to these topics.

Recommended structure of a training session:

1. **Welcome**
2. **A look back at what has happened since the last meeting. (10-20 minutes)**
3. In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
4. In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown? What disease problems can be seen? Do they find insects, other organisms? How is the soil, the humidity, etc.? Facilitators can ask the participants to focus on aspects related to the topic of the day.
5. Introduction of the topic of the day and short brainstorming to identify what the participants know already about this topic. (10-20 minutes)
6. For each chapter, some guiding questions are proposed to stimulate the discussion.
7. Exercises in the field (2 hours). Practical aspects of the topic of the day are directly applied in the field by the participants, with the support of the facilitator. The participants shall then apply these techniques at home as well.
8. Summary (20-30 minutes): the facilitator summarizes important aspects of what has been learned during the sessions and give some more technical advice if necessary.

2.2 WHAT IS AGROECOLOGICAL FARMING?

Agroecology is farming that aims at feeding a growing population while conserving and nurturing the natural resource base. Agroecological farmers want to improve food yields for balanced nutrition, strengthen fair markets for their production, enhance healthy ecosystems, and build on traditional knowledge and customs. Their objective is to create stable food production systems that are resilient to environmental perturbations such as climate change and disease.

Agroecology views farmland as an ecosystem – a complex network in which every living and nonliving component of the system is important and affects every other component, either directly or indirectly. Since farmland provides many services to us humans (such as food production, clean water or biodiversity) we have to take care of it. Key principles of agroecological farming therefore include:

- Protect the environment and use natural resources efficiently and sustainably;
- Reduce the use of chemicals as far as possible;
- Make use of organic/biological measures and resources, and try to recycle what you can;
- Rather prevent problems (such as pests and diseases) than having to treat them;
- Let nature help you;
- Practice agriculture for the good of people and the environment.

Topics in which agroecological farming differs particularly from conventional farming are especially soil fertility management and pest and disease management .

Soil fertility management

Instead of simply using chemical fertilizers to boost crop growth, agroecological soil fertility management considers crop rotations or intercropping with legumes (that can fix nitrogen from the air), the use manure and compost, and beneficial organic matter management to keep soils healthy and fertile. Reducing tillage operations and protecting the soil with a permanent cover helps maintaining the soil fertile and healthy. Some practical guidelines on how to prepare and use soil fertility amendments are given in a separate leaflet.

Pest and disease management

To reduce the use of chemicals as far as possible, agroecological pest and disease management applies many practices to prevent pests and diseases from building up and creating losses:

- Cropping patterns such as crop rotations, intercropping, or trap/catch/push crops can break pest and disease cycles (and provide numerous other benefits), while anti-parasite crops may scare away (repel) or trap certain pests;
- Use resistant and tolerant varieties (quality seed, seed treatments, ...);
- Strong plants are less susceptible to pests and diseases (soil fertility, micro-climate, weeding, nurseries, effective micro-organisms and the like, ...);
- Introduce and nurture beneficial organisms (habitat, e.g. agroforestry, to enhance diversity);
- Adequate fertilization and irrigation (not too much N or humidity);
- Physical control: traps, enclosures/netting, by hand, scaring away, removing diseased plants, ...;
- Organic pesticides: produced by farmers, small businesses;
- Go regularly to the field and observe thoroughly.

Some recipes and guidelines to produce and use such measures are explained further-on or in a separate leaflet.

3.0 RECORD **KEEPING**

Activity 1: Introduction to record keeping

A. Learning Objectives

After this session participants will:

- Be aware of the importance of record keeping and be able to record costs and income of the target crop.
- Know how to calculate the gross margin in order to assess the profitability of a crop and find out ways of potential improvements.

B. Duration

2-3 hours

C. Learning aids

Flip charts, markers, calculator.

D. Activities and exercises

Introduction

The trainer will introduce the topic of the day. He will stimulate the discussion by asking the following questions:

- Do you know how much profit you generate with the target crop the last season?
- Do you know which expenditures are most important in the production?
- Do you know if your costs were higher or lower than your income?

Practical exercise

1. The facilitator asks the group to list all the expenses and costs (means of production and labour) they had for the target crop during the last crop year (or other crop). Producers are invited to mention them from memory. Do not forget the value of family labour and the costs of paid labour. The facilitator records the costs mentioned by the producers in the table below (on a flip chart).
2. Once the production costs are listed, the facilitator asks the group about the income: What have you done with the harvest product? Did you sell the entire production or only part of it? How much did you earn from the sales? Do you still have a remaining stock, how many bags/kg? The facilitator writes the cash income or the value of the production (in case of no cash value) in the table under part B. Income.

Table for the calculation of the costs and income for a crop

Name of farmer:		**Village/district:**	
Date of calculation:			
Time period (season from/to):			
Crop:			
Total field area (ha):			
Total yield (kg):			
	Quantity	**Unit cost (Ushs)**	**Total (Ushs)**
A. Production costs (input)			
Materials			
Seed	3 bags	600	1800
Organic fertilizers:			
- Manure			
- Compost			
Mineral fertilizers:			
- NPK			
-			
Pesticides:			
-			
-			
Packaging bags			
Labor (Person-days)			
Soil preparation			
Manure application			
Planting			
Weeding/ Hilling up 1			
Weeding/ Hilling up 2			
Dehaulming			
Harvesting			
Threshing			
Transport			
Total production costs (a)			
B. Income (output)			
Sales			
Home consumption*			
Remaining (storage)*			
Others*			
Total income (b)			
Gross margin (b - a)			
Profit per acre (Gross margin divided by field area)			

**Convert in monetary: kg multiplied by market price.*

3. The facilitator explains how to compute the gross margin, which is total income minus the total costs. Then he asks the group whether the production of this crop is profitable or not (see if the gross margin is positive or negative).

4. The facilitator asks who wants to try to keep a record for the target crop during this season. The facilitator distributes the above table to the participants. The latter should write down their expenses (materials and labor). At each session, the host farmer could present his data (or in turn). It could serve as starting point for a group discussion on the similarities and differences in the record keeping among the participants. And report on the difficulties faced in filling the table.

Activity 2: Gross margin analysis

A. Learning Objectives

By the end of the training the participants are able to:

- analyze the record keeping and the gross margin, and identify how to improve the profitability of the target crop

B. Duration

2-3 hours

C. Learning aids

Flip charts, markers, calculator.

D. Activities and exercises

- The host farmer and each participant who recorded his costs and income present them to the group. Before the session, the facilitator can help the producers to copy the table on a flipchart to make it easier to read during the session.
- The facilitator initiates the discussion on the analysis of the results by asking the following questions. What are the reasons for the different figures/results between the producers? What does a positive or negative gross margin mean? What are the factors that influence expenditures and income? If the gross margin is low or negative, which expenditures could be reduced and how? Which price should you sell your products to make a profit?

IMPORTANCE OF ONION GROWING AND COMMON VARIETIES IN UGANDA 4.0

A. Learning objectives

At the end of this session, participants will:

» Understand the importance of onion growing for income and nutrition
» Have reflected on the reasons why they would like to grow onions
» Know the characteristics of different varieties of onions commonly grown in Uganda and be able to choose varieties adapted to the growing conditions of their farm and production objectives.
» Understand the principles of agroecology

B. Duration

1.5 hour

C. Learning aids

» Flip charts
» Marker pens
» Masking tape
» Training manual
» Different varieties of onions (if available) or pictures of these varieties

D. Activities

Introduction (20 minutes)

The trainer will introduce the topic of the day. He may discuss the following questions with the participants:

» Why is it important for you to grow onions? How will onion production fit within your farms? For which purpose do you want to grow onions (self-consumption, as a source of income)?
» What could be the benefit to grow onions?
» What could be the main problems for you to grow onions? How to overcome these problems?
» What do you know about agroecology? What does it mean in onion production?

Exercise choosing the right variety (30 minutes)

The facilitator gathers on a table a sample of the onion varieties available in Uganda (or pictures of them, if fresh onions are not available).

The facilitator asks the participants to discuss (either in groups first, or directly in plenum) the following questions:

» Which of these varieties / plant types do you know, how do you call them?

» Which one have you already grown, eaten? Which one do you prefer and why?
» What advantages and disadvantages do you know from these varieties / plant types?
» Which variety would you choose to grow for which purpose

The exercise can be closed by a degustation of the different varieties!

Summary by the facilitator (30-60 minutes)

» The facilitator summarizes the discussion by explaining the importance of growing onions and presenting the information concerning the different varieties of onions.
» He summarizes the main principles of agroecology and point out that these principles will be addressed in specific sessions during the whole production cycle
» He explains which varieties of tomatoes are more adapted to an agroecological production and why

.

E. Content

4.1 THE IMPORTANCE OF GROWING ONIONS.

Onion is a biennial vegetable grown in temperate regions as an annual crop. Onions are especially suitable for smallholder farming in many countries because they require a small amount of initial capital. Onions require a small piece of land and they take a relatively short time to mature. Onions can be grown year-round in the tropics where irrigation is possible. The crop also plays an important role in medicine.

Onion are mainly grown because of the following reasons.

» For food – they form an important ingredient of various dishes as sauce or salads
» For generating income- they are high income crops and easy to sell

4.2 QUALITIES OF A GOOD SEEDLING FOR TRANSPLANTING

The facilitator should emphasize that if seedlings is not properly managed in the nursery bed, they may not be very good for transplant, the trainer should emphasize the key qualities to consider when one is buying or selecting good seedlings for transplanting.

» Healthy and disease-free seedling
» Vigorous growth
» Have 4-6 true leaves
» Pencil thickness
» Free from physical deformities

It is recommended to purchase seed/seedling from a reputable supplier/stockist. Seedlings sourced from unreliable suppliers may affect production through the following:

» Varity not true to type

- Uneven bulb size
- Bulbs ripening at different time
- Reduced yields level
- High persistence of pests and diseases

4.3 SELECTED VARIETIES OF ONIONS COMMONLY GROWN IN UGANDA

Which variety to choose depends on local conditions and the purpose of growing and intended use (self-consumption, selling in the village, on supermarket, for hotels, processing). Therefore, it is important to think about the intended use of the onion you will cultivate, the market preferences, and to choose the varieties accordingly

The common onion varieties grown in Uganda are Bombay red and Red Creole. These varieties have only medium yield potentials, but they are very popular. Other onion varieties are the hybrids Jambar F1, Red Passion F1, Red Pinoy and Early Red Max.

Table 1: presents some characteristics of the main varieties that can be found in Uganda

Variety	Maturity	Yield	Attributes
Red Creole 	150 days after trans-planting	16,000 kg per acre	• A popular variety which produces red, flat-round, globular bulbs • It has very pungent taste • Excellent in storage
Bombay Red 	150 days from trans-planting	16,000 kg per acre	• Variety for dry and warm-er conditions • Produces small to me-dium sized bulbs, which are globe shaped, deep purple red color. • Good storage capability and transport
Jambar F1  *Figure 1 Source: Farming with Michael*	90 days from trans-planting	25'000 kg per acre	• Short day variety, re-quires 11-12 hours of day length to perform well • Suitable for both cool and warm areas • Early maturing variety • The bulbs are deep red and uniform (large -extra large) • Shelf life of 6 months after proper curing and harvesting

Red Passion F1  *https://www.smartfarmingug.com/product/red-passion-f1/*	120 days	25'000 kg per acre	• Deep red hybrid onion • Very good drying and keeping quality • Tolerant to pink rot disease • Produces good grade onions • Uniform maturity • Can store for up to 6 months • Plant spacing 30×10
Red Pinoy  *https://www.royalseed.biz/onions.php*	90 days from transplanting	25'000-30'000 kg per acre	• Well adapted to rainfed and irrigation • Strong pungency • Long shelf life of up to 6 months at room temperature • Deep red attractive bulbs with a high market demand.
Early Red Max  *Figure 2 Early Red Max (Source: East African Seed Company)*	75-90 days after transplanting	20'000-25'000 kg/acre	• early maturing • high yielding with medium sized globe shaped red bulbs at maturity stage • highly demanded in the market

4.4 LAND SELECTION AND LAND PREPARATION FOR ONION PLANTING

When: 4 weeks before transplanting (possibly together with chapter 1)

A. Learning objectives

After completing this module, participants will:

» Understand the factors to consider in selecting a suitable site for onion production

» Understand how onion plants interact with other plants and how to plan crop rotation considering spatial and temporal arrangement of onion plants.

» Learn the best practices of land preparation for onion production.

» Know how to manage soil fertility and how to prepare compost and manage manure (can be addressed in a separate session see separate leaflet for Activities and exercises and content)

B. Duration

3 hours

C. Learning aids

» Land where the onion plot will be implemented
» Tools for land preparation such as Hoes, Pangas, Slashers, Axes

D. Activities and exercises

Look back at what has happened since the last meeting.(10-20 minutes)

Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.

Introduction and practical selection of the land for the onion plot (1 hour)

This activity should take place directly in the area where the onion plot will be implemented

1. The trainer introduces the topic of the day. He then asks the participants and discuss with them the following questions with the participants, possibly directly in the area where the onion plot will be implemented:
   » How would you choose an appropriate site for growing your onions?
   » Which aspects would you look at or take into consideration?
2. Based on the discussion, the participants are asked to list the criteria on a flip chart.
3. The facilitator asks then the participants to choose the right location to implement the onion plot and justify their choice. Alternatively, they can assess the plot that has already been selected using the criteria that have been discussed.

Exercise: preparing the land for onion plantation (1 hour)

The participants, together with the facilitator, will practically prepare the land for onion plantation.

Optional: Exercise soil fertility management and compost and manure management

» see separate leaflet Soil fertility management

Facilitator's summary (30 minutes)

» The facilitator sum up important points of land selection and proper land for onion production based on the aspects presented in the sub-chapter E. Content below and on the separate leaflet Soil fertility management

E. Content

» Land selection for onion growing
» Onions grow well in sandy loam soils with good fertility. Fertility can be seen from the vegetation growing in the area.
» Soils with small gravels are suitable for onion production.
» The land should not be prone to flooding and it should have a gentle slope to facilitate drainage.
» There should not be many trees as they will lead to lots of shade in the field and yet shade affects the development of onions.
» The land should not have been used for production of onions or garlic in the last 1 year. This will help minimize pests and diseases build up.
» Crop rotation is essential to minimize pest and diseases!
» Crop rotation is a major component of organic farming, affecting both soil conditions and pest cycles.

» Wait 3-4 years before planting onions again at the same location
» A rotation with non-solanaceous crops for 3-6 years will avoid pest problems in onions.

Land preparation for onion growing

» The land must be dug and allowed to rest for at least one month. During this period, there is also decomposition of the trash/rubbish to manure for improved soil fertility.
» Deep ploughing by use of hand hoes or tractors is recommended to remove most of the weed roots and soften the soil for easy movement of water and air in the soil, but also make it easy for bulb formation and expansion.
» Second tillage is then done to produce a fine bed. This will improve crop establishment and growth.
» Apply mulch to conserve soil and water and reduce evaporation.
» If you are planning to plant in the second rains, open your land (1st digging) at the end of the 1st rains. This will enable you to have the land ready for planting by the time the second rains start.

4.5 NURSERY ESTABLISHMENT AND MANAGEMENT

When: 4-6 weeks before transplanting

A. Learning objective

At the end of the session, participants will:

» Understand the factors to consider during nursery site selection for onion growing and the attributes of a good onion nursery site.
» Be able to apply the different management practices for quality seedlings production in onion growing.
» Find quality seed for planting.
» Understand the timing of seedling availability in onion production

B. Duration

3 hours

C. Learning aids

» Seed
» Watering can
» Spray pump
» Panga
» Hoes, Poles
» Dry grass
» Tying materials

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

» In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
» In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants

grown?

Introduction (15 minutes)

The trainer will introduce the session of the day (nursery operations in onion growing). At this point the trainer should also make it clear to the participants that the session will involve practical work and will take some time. To stimulate the discussion, the trainer can ask the following questions:

» How do you plant onions? Do you do a nursery? If yes, how do you do it (which steps, timing)?
» Why do you think it is important to have an onion nursery?
» What are attributes of a good nursery site?
» Where do you procure you the seed? How can you recognize quality seeds?

Demonstration (2 hours 30 minutes)

This is to be done at the demonstration site and the trainees will practically participate in the different activities to establish a nursery that are described in the subchapter E. Content. During this session, the group nursery is established. The knowledge gained from the demonstration nursery will be used by the members in their fields at household level.

Facilitator's summary (15 minutes)

The facilitator will summarize what has been discussed and done to establish and manage a nursery. He will emphasize why it is very important to carry out all the recommended good practices in the nursery timely and safeguard the nursery site well against any form of destruction.

E. Content

» A nursery bed is a prepared plot of land for raising seedlings. It acts as a temporary home for young plants until they are eventually planted in a main garden.
» A poorly constructed and managed nursery bed will lead to poor germination or diseased seedlings, the seedlings may fail to grow when transplanted.

The purpose of the nursery is therefore to grow seedlings:

» Of the right variety and in sufficient quantities.
» Of the right size, health and strength at the beginning of the planting season.

Qualities of a good nursery bed:

» A gentle slope fertile and well drained piece of land
» Close to water source for irrigation of the seedlings
» Should never be put in a water logged area
» Located in less weed infested area
» In areas with a lot of water, raise the nursery bed 10-15 cm above the ground
» The soil should be dug deeply
» Not neighboring onion or ginger gardens
» Should be near the main garden to avoid damage of seedlings at transplanting

Nursery bed preparation, sowing and watering

The following steps should be followed when implementing a nursery:

1. Choose a good location with a good drainage.

2. Clear the land.

» Measure 1.2 metre wide of any length, dig it well, ensuring that stones and roots lying underneath are dug out and thrown outside the nursery
» Construct the bed by heaping the soil to a height of 15 cm above the ground. The top of the constructed bed should be 1 metre wide with sliding sides.
» The soil should then be mixed thoroughly with farm yard manure where applicable
» Charcoal dust and ashes can also be mixed in the bed to correct the acidity of the soil and keep away worms

Sowing seeds in the nursery beds

Planting and planting depth

» The bed should be watered thoroughly on the evening before sowing.
» Spacing: 30cm x 10cm or at spacing of 15cm between rows (1 plant per hole).
» Cover the seeds lightly and mulch the bed with dry grass.
» Gaps fill within 1 week of transplanting for even growth.
» Onion should be transplanted at a depth of 2.5-3 cm deep when its already pencil size
» Add water to the planting hole before planting for better establishment

Maintenance of nursery bed

» Mulch the seed bed after sowing until germination
» Provide enough shade to the seedlings after germination, 1 metre above the bed
» Thin the seedlings properly, remove weak or disease seedlings and keep the bed weed-free
» Provide enough water to the seedings.

Figure 3 Well managed onion seedlings in the nursery bed ready for transplanting¬

Weeds, Pest and disease management in nursery bed

» Before watering, it is important to gently pull any weeds that are growing in the nursery bed. Such weeds compete with the seedlings for nutrients and water in the soil.
» One of the most common diseases of onions in the nursery is damping off, which causes the stem to rot at the crown, leading to seedling death.
» To avoid damping off, one week after germination, a spray with mancozeb or Dithane M45 is possible (but not recommended in agroecological production).
» Mix 1 tea spoon in 5 litres of water. On the day of spraying, ensure you water first and then spray after watering so that the chemical is not washed off the seedlings during watering. If there are signs of rain, do not spray. Spraying should be done at least 3 hours before or after any rain.

4.6 TRANSPLANTING

When: at week 0

A. Learning objectives

At the end of the session, participants will be able to:

» Select good seedlings for onion planting.
» Plant onions with the correct spacing.
» Plant onions according to the recommended practices.

B. Duration

3-4 hours

C. Learning aids

» Group demonstration field
» Hoes
» Onions seedlings
» Watering cans
» Strings
» Pegs
» Tape measure

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

» In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
» In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction of the topic of the day (20 minutes)

The facilitator will shortly introduce the topic of the day and the purpose of the activity. To stimulate the discussion, the following questions can be asked:

» How would you transplant your onion plants?
» How would you select quality seedlings?

Demonstration (3 hours)

The trainees, together with the facilitator will practically transplant the seedlings in the demonstration field of the group. The facilitator must explain all the different activities involved step by step. The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.

Summary (20 minutes)

The facilitator summarizes the main points of the topic of the day.

E. Content

Timing of seedling transplant

- Age of the seedling is important for establishment and higher bulb yield, this should be done when 3-4 true leaves emerge, before the bulb formation starts. Transplant seedling after 45-55days
- If seedlings overstay in nursery bed for 60 days after sowing bulb formation starts and potential for bulb size development reduced with consequent significant yield reduction.
- Harden the crop by removing shade a week before transplanting as this gives the seedling chances to get used to direct sun.
- Transplant at recommended spacing per crop early in the morning or late in the evening from (6:00am to 10:00am or 4:00 to 6:00pm)
- Plants should receive water as soon as transplanting is done.

Steps in Transplanting Seedlings

- **Step 1:** The day before transplanting gently water the seedbeds heavily, to loosen the soil for easy pulling and reduced root damage. Do not water on the day you transplant.
- **Step 2:** Use the correct in-row and between–row spacing and mark and dig all planting holes to be transplanted the same day.
- **Step 3:** Remove the seedlings from the seed bed with as much moist soil around its roots as possible. Hold the seedling very close to the root crown as you pull. This minimizes leaf damage during pulling.
- **Step 4:** Place the seedlings carefully in a bucket, basket or bowl and transport them immediately to the planting site
- **Step 5:** Quickly plant the seedling in its planting hole without bending its roots.
- **Step 6:** Hold the seedling in one hand and using two fingers of the other hand make a hole 3-5cm deep at a marked position. Carefully place the seedling in the planting hole with the roots pointing downwards.
- **Step 7:** Place the soil firmly around the root collar of the seedling with your fingers to keep it upright and to expel any trapped air.
- **Step 8:** Gently water the seedlings and then shade them with leaf twigs or arched dried grass to protect it from the heat of the sun
- **Step 9:** Continue transplanting, watering and shading until all the plating holes are filled.
- **Step 10:** Mulch the shaded seedlings.
- **Step 11:** Any excess seedlings may be sold except for a few which should remain to replace the ones that may die.
- **Step 12:** After a week remove the shading twigs or grass and water twice a week
- **Step 13:** Keep a diary to record all the activities you are doing each day and the dates as well.

4.7 WEEDING

When: first at 2-3 weeks and second at 7 weeks

A. Learning objectives

At the end of the session, participants will:

» know when and how to do weeding, pruning, and staking.
» understand the effects of weeds on the yields of onions.
» Be able to apply the different methods of weed control in the onions.

B. Duration

2-3 hours

C. Learning aids

» Demonstration field
» Tools for weeding

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

» In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
» In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction (20 minutes)

The trainer will introduce the topic of the day. He can stimulate discussion by asking the following questions:

» Do you weed at home. How and why?
» If not, why?
» What is the effect of too much weeds on the onion plants?
» Which weeds are the most problematic in your onion field?

Demonstration (1-2 hours)

This training should be practically done in the group demonstration field.

In a first step, the facilitator can walk through the plot with the participants and ask them to identify the weeds that can be found there.

In a second step, the participants, together with the facilitator, will do weeding. The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.

Facilitator's summary (20 minutes)

The facilitator should really remind the trainees about the important of pruning and staking in Onions since majority of the farmers tend to ignore this.

D. Content

Effects of weeds on onion plants

- Weeds directly compete with plants for growth factors like sunlight, water, nutrients, space, and this makes the crop weak and susceptible to attack by pathogens.
- Weeds greatly reduce crop yield as well as its general performance.
- Weeds harbor pests and diseases.
- Some weeds can damage the crop by producing toxic substances.
- Weeds cause harvesting problems, especially those that develop late in the crop season.

Weed Management

- Onions develop slower than other vegetable crops and are more susceptible to weed competition especially during the early growth stages. This can result in yield losses.
- Weeds can be controlled successfully if done at the right time, using the right methods.
- Care should be taken to avoid damage to the bulbs when mechanical weed control measures are used.
- Frequent weeding is encouraged as it does not only kill the weeds but also loosens the soil which helps in bulb expansion.
- Generally, 3 hand weeding are given at 1-month interval after transplanting.
- Weeding will greatly help curb pests and diseases.
- Apart from using a hoe, weeds in onions can also be controlled using the following:
  - Planting early maturing onion varieties
  - Using clean seeds that are free from weed seeds
  - Using irrigation water that is free from weed seeds
  - Mulching
  - Crop rotation
  - Hand pulling/uprooting the weeds

- There are also chemicals that will control weeds in onions but they also have a number of side effects on the environment if not used with great care. It is not recommended in agroecological production.

In addition, the following factors are important for a good onion production

- High temperature favors bulb formation and development, however if temperature exceeds that required for bulb formation, maturity is hastened and bulbs do not grow to maximum size. This lowers yield.
- Fertile well drained soil is also important for onion production
- Bulbs development stage needs substantial amount of moisture during the growing season
- Avoid application of fresh manure as the plants will develop thick necks and too much leaf at the expense of bulb formation.

A Well managed onion garden kept free from weeds

4.8 PEST AND DISEASE MANAGEMENT

When: during weeks 2-9

A. Learning objectives

At the end of this session, participants will be able to:

» Know the common pests and diseases affecting onions and their effects.
» Recognize the signs and symptoms of different pests and disease attack in onions.
» Apply the Integrated Pest and Disease management approaches in onion production.
» Understand the critical stages of growth of different pests to target control in onion production.

B. Duration

2 sessions of 4 hours

C. Learning aids

» Demonstration garden
» Insect bottle
» Stationery
» Knapsack sprayer
» Jerrycan
» Basin soap
» Pesticides
» Photo cards

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

» In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
» In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants

grown?

Introduction (20')

The trainer will introduce the topic of the day pointing out what is to be learnt, including the different pests and diseases affecting onions and their control. The trainer should inform trainees that training will be a practical one where the trainees will be taken to the group demonstration for different pest and diseases scouting and identification.

The following questions can be used to stimulate the discussion:

» What main pest and diseases affecting onions do you encounter in your field?
» What symptoms of pest attack and diseases have you seen on your onions?
» Which prevention measure do you know to avoid pest and disease attacks?
» Which organic treatment against pest and diseases do you know?

Practical exercise (2 hours)

How to observe the onion field and the onion plant to detect pest attack and diseases?
The facilitator discusses with the participant how the field should be visited to monitor pest and diseases. Then, he discusses with them how single plant should be observed, which aspects should be looked at. An observation format could be developed by the group.

Practical observation of the field in subgroups

Each subgroups of 4-5 participants will observe one or two plants taking into consideration the criteria identified in the previous exercise. Parts of sick plants and insects can be collected. Insects can be collected and placed in bottle. The groups summarize their observations on a flip chart and try to formulate recommendations.

Presentation by the subgroups in plenum and discussion

The findings of each subgroup are presented and discussed. At the end of the discussion, the mains pests and diseases found in the field should have been identified and possibilities for prevention or treatments discussed.

Summary

The facilitator summarizes the main findings of the group works and discussions. He presents other important pests and diseases that may affect onions.

In the next weeks, the groups may be doing scouting on their own and will be using the insect bottle to keep the insects and present to the Agricultural officers on the days they visit the groups. The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.
A diary on pests and diseases and control mechanisms can be written to share the experience with peers.

E. Content

General pest and disease management practices

Onions are not attacked by so many pests and diseases as other horticultural crops. This is because of their smell which repels some of the pests and disease vectors. It is however not completely immune to attack. It is recommended that control starts even before the pests or disease symptoms are seen.

Prevention measures should also be put in place. In principle, the following practices will greatly reduce pest and disease incidences in the field.

a. Crop rotation – this breaks the pest lifecycle.
b. Early planting – your crop escapes by the time pest/disease incidences rise, you are harvesting.
c. Use of resistant varieties – they resist damage even when the crop is attacked (see Table 1 to identify which variety is resistant to which diseases).
d. Weed control – weeds affect crop vigor which is related to damage. Weaker crops are more damaged (see previous chapter).
e. Scouting – To spot pests/diseases early and control them in time.
f. Correct identification of pest or disease to use the right control strategy.
g. When irrigating, do not wet the leaves. Otherwise, it will help fungal diseases to develop.
h. Mulching– reduces contact of soil and the plant parts.
i. Remove affected plant parts

Common onion pests and their control

Onion thrips, onion fly, onion crickets and cutworms are the most common pests that attack onion plants.

Onion thrips (Thrips tabaci) 	• The onion thrips attack an extensive range of crops, including cereals and broadleaved crops. • They are tiny (1 mm in length), slender and very mobile insects. • Adult thrips: These are pale yellow to brown • Immature thrips: They are whitish to pale yellow.
Signs, symptoms and damages 	• Slower plants growth in severe infections • Distortion of leaves and bulbs • Pierce the upper surface of the leaves and suck on the plant sap on the development leaves, deep inside the plant resulting into white and silvery patches on the leaves • Reduction in yield.
Prevention and treatments	• Remove weeds. Thrips build up on them. • Remove heavily infested plants. • Crop rotation • Timely planting • Spray with organic pests or cypermethrin

Onion fly (Delia antiqua) 	• The most damaging stage of this pest is the larva, called the onion maggot. • Onion maggots are adapted to cool, wet weather, so usually they are less of a problem during hot dry periods. • They prefer soils heavy in organic matter. • The onion maggot attacks plants related to onion such as leeks, shallots and garlic.
Signs, symptoms and damages  *Figure 4 The maggots in the onion plants as a result of the onion flies.*	The onion maggot is white-cream in colour and it damages onions by: • Eating the lateral roots system and boring into the base of the stem. • Attacked leaves wilt and turn bluish, with the plants becoming shriveled and later wilting.
Prevention and treatments	• Where manure is used, it should have broken down properly before it is used to cut of attraction to the onion fly. • Avoid planting in soil with high undecomposed organic matter. This attracts adults to lay eggs in soil • Powdered hot pepper or powdered ginger placed around the stems helps when the onion fly population is moderate. • Practice rotation with crops not related to onions, do not plant in fields affected with crops in the same family • Neem-based products have a deterrent effect on the adult flies

Onion crickets  *Figure 5 Onion crickets on the plant*	
Signs, symptoms and damages  *Figure 4 The maggots in the onion plants as a result of the onion flies.*	• They cause serious damage to the crop particularly at the beginning of the season, both in the nursery bed and after transplanting in the main field. • They cut and feed on the seedlings killing them instantly.
Prevention and treatments	• Field hygiene by timely weeding especially immediately after transplanting

Cutworms (Agrotis ipsilon) 	• Cutworms are dangerous insects in onion farming. • They are caterpillars that live in the soil, and eat the stems of young seedlings and transplants of all garden crops. The seedlings or transplants may be entirely eaten, or may be felled like tiny trees at soil level, in most cases, overnight. A heavy or uncontrolled cutworm problem can kill entire crops.
Signs, symptoms and damages  *Figure 6 Cutworm damage on the plant.*	• Young larva feeds on tender foliage and grown up larva cuts the stem at collar region. • Moths appear after dusk, mate and lay eggs on ventral surface of leaves or moist soil. Freshly ploughed fields are preferred for oviposition. A female lays 300 to 450 eggs in 10 to 15 clusters. Eggs are globular in shape, ribbed and whitish in colour. Tiny caterpillars feed gregariously on foliage for a few days and then enter into soil. • Caterpillars are nocturnal in habit and hide during day in cracks and crevices in soil or under debris around plants. At night they come out, cut seedlings near ground level and eat tender parts. Damage is more pronounced in low-lying waterlogged areas. Full-grown caterpillars enter soil and pupate in earthen cocoons. Egg, caterpillar and pupal stages last for 2 to 13, 10 to 30 and 10 to 30 days, respectively. Total life cycle is 30 to 68 days.
Prevention and treatments	• Field hygiene as the cutworms tend to hide among debris in the field • Spray with organic pesticides • Proper timing of planting to avoid water stress in the early stages of crop growth as this leads to more extensive activity by the pest and damage to the crops. • Maintain weed-free plots

Helpful insects

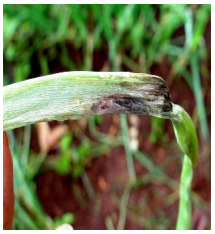
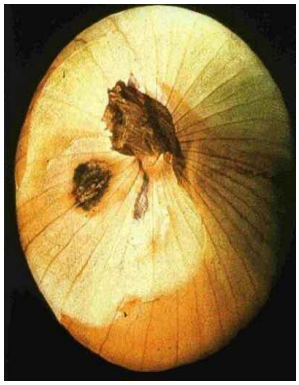
Some insects (and other organisms) can help to control harmful pests. Some examples of natural predators:

» Ladybird beetle controls whitefly.
» Green lacewings control aphids and whitefly.
» Hover flies (Syrphidae) control aphid eggs.
» Trichogramma wasps control codling moth.
» Bacillus thuringiensis against Army worm.

Common onion diseases and their control

A variety of diseases and disorders affect onions and related crops. Most of the diseases are caused by Fungi or Bacteria, while disorders are caused by environmental and nutritional imbalances.

Accurate disease diagnosis is an important step of an Integrated Pest and Disease Management (IPDM) program. Here below is a number of diseases that are common in onions in Uganda.

Purple blotch (caused by Alternaria porri) 	• Purple blotch attacks onion, garlic, leek and other Allium crops. • The fungus requires rain or persistent dew for reproduction. It can grow through a wide temperature range of 6 to 33.8°C. Optimum temperature of fungal growth is 25°C.
Signs, symptoms and damages   *Figure 7 Purple leave blotch infection in an onion plant*	• small white sunken spots developed on the leaves. These enlarge and under moist condition turn purple with a yellowish border and are covered with a sooty deposit of spores, after 3-4 weeks the leaves turn yellow and collapse. • Bulbs may be attacked, mainly at the neck. This can be seen as a yellow to reddish watery rot.
Prevention and treatments	• A good timing of sowing or transplanting can minimise purple blotch attack by A. porri, depending on the local environmental conditions. • Varieties with waxy foliage are generally more resistant than those with glossy leaves. • Increased ploughing between seasons may reduce the disease. • Crop rotation • Increased spacing between plants also may reduce disease development. • Other good practices include seed treatment, removal of crop debris and planting in well-drained soil. • sprays every seven days with a fungicide when signs of infection appear. Spray with Mancozeb or Dithane M45. (not recommended in agro-ecological production).

Downy mildew (caused by Peronospora destructor)	• The fungus survives in seeds, bulbs, sets, and on plant debris. • Spores are carried long distances by air currents. • The fungus can infect onion, Welsh onion, Egyptian onion, garlic, shallot, leek and possibly some other species of Allium.
Signs, symptoms and damages  *Figure 8 Downy mildew infection in onion plant*	• It attacks young plants, appearing as white specks, usually confined to the oldest leaves of young plants. • Lesions form near tips of old leaves (elongated yellowish patches) • Leaves die back and this extends to younger leaves • A greyish white mould develops rapidly in cool damp weather and progresses down the sheath, and plants eventually fall over and dry up. • Optimum temperatures for fungal growth are between 13 and 20°C. • Because of the temperature requirements of the fungus, the disease is more serious in higher cooler areas.
Prevention and treatments	• Use clean propagules • Use resistant varieties • Rotate at least 3-years free of onions or other Allium species (e.g. garlic). • Wider spacing of plants help reducing humidity and downy mildew. • Preventative treatments with rock powder can reduce the attack of this disease. • spray every seven days with a fungicide when signs of infection appear using mancozeb or Dithane M45 (not recommended in agroecological production).

Yellow dwarf (spread by Myzus persicae)	• Onion yellow dwarf virus is a potyvirus that has a narrow host range (onions, garlic, shallots and a few ornamental Alliums). • It survives in bulbs and sets, and therefore can be transmitted during vegetative reproduction. • The green peach aphid, Myzus persicae, as well as other aphids, spreads the virus from plant to plant in a nonpersistent manner. • The virus can also survive in volunteer onions. • Although the virus is not spread to the seed, seed from infected plants is of poor quality.
Signs, symptoms and damages  *Figure 9 Yellow dwarf infection in onion plants with crinkled leaves.*	• The first symptom of onion yellow dwarf in young onions is the appearance of yellow streaks at the bases of the first true leaves. • After this initial symptom, all developing leaves show symptoms ranging from yellow streaks to complete yellowing of the leaves. • Leaves are sometimes crinkled and flattened and tend to fall over; bulb size is reduced. • In combination with other viruses, this virus probably contributes to Garlic Mosaic symptoms.
Prevention and treatments	• Timely planting, improved field hygiene and sanitation • Use true onion seed (rather than sets) and use virus-free planting stock. In garlic, indexing for the virus and meristem tip culture eliminates the virus. • Remove infected plants. • No pesticides control this disease. Controlling aphids also does not prevent the disease because they retain the virus for a very short period of time and quickly transmit the virus as they move through the crop in search of preferred hosts.

Storage diseases of onion

When storing onion improperly, major diseases like neck rot, soft rot, Brown rot and Black mold can destroy the harvest.

Neck rot ***(caused by the fungus Botrytis allii)***	• Neck rot symptoms usually appear in storage; however, it may start immediately before harvest.
Signs, symptoms and damages  *Figure 10 Neck rot disease of onion.*	• When infected bulbs have been in store for several weeks, tissue becomes greyish and a grey mold may also develop
Prevention and treatments	• Use healthy seeds • Dry the onions properly • Leave at least 4 cm stem length at neck during topping

Soft rot disease ***(caused by Erwinia carotovora)***	• develops near the neck and these leaves can be easily pulled off the onion
Signs, symptoms and damages  *Figure 11 Soft rot in onion (Source: Omafra)*	• Symptoms can range from a spongy, water-soaked scales to complete bulb breakdown • Severe discoloration with soft rotting and water soaking of one or more of the inner fleshy scales. • Foul odour may ooze from the bulb when squeezed
Prevention and treatments	• Reduce, if applying, doses of nitrogenous fertilizers. • Proper drying: Onion tops should be allowed to mature well before harvesting. • Take care during harvesting and packing to avoid bruising. • Storage places should be well ventilated to avoid accumulation of moisture on the surfaces of bulbs. • Onions should be stored at 0°C and a relative humidity (RH) of 65-70%.

Brown rot (caused by Erwinia carotovora)	• develops near the neck and these leaves can be easily pulled off the onion
Signs, symptoms and damages  *Figure 11 Brown rot in onion*	• Dark brown discoloration on bulb scale • Rotting starts from inner scales and spreads to outer scales • Bulbs seems to be healthy, but when pressed, white ooze comes from the neck.
Prevention and treatments	• Proper drying and leave at least 4 cm stem length at neck during topping

4.9 ONION HARVESTING AND DRYING

When: 17-20 weeks

A. Learning objective

At the end of the training, the participant will:

» be able to identify signs of maturity and ripening in the onion crop
» know when to harvest onions
» know the different methods and practices of harvesting and drying onions

B. Duration

2-3 hours

C. Learning aids

» Tarpaulins
» Containers/wooden boxes
» Demonstration garden

D. Activities and exercise

Look back at what has happened since the last meeting. (10-20 minutes)

» In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
» In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction (20 minutes)

The trainer will introduce the topic and ask the following questions to stimulate the discussion:

» What are signs of maturity and ripening in the onion crop?
» What is the correct stage of harvesting? When do you harvest your onions?
» What are the common mistakes made by farmers during harvesting of onions?
» Do you dry your onions? How and why?

This can be directly in the field, so that participants can look at sign of maturities directly on the crop. The facilitator can show sign of maturities by cutting the onions.

Demonstration (2 hours)

The participants, together with the facilitator, will harvest the onions. This training should be done at the demonstration sites so that the farmers learn good harvesting practices and replicate in their fields at household levels.

E. Content

Signs of maturity and harvesting of onions

Onions take 165- 170 days (5 – 6 months) to mature including days in the nursery bed. Maturity signs include:

» Bulb necks become thin
» Leaves bend over/droop
» Leaf bending can be done by the farmer during the last month of maturity (to fasten ripening)
» The tops of the onions turn brown or yellow and fall over

Methods and practice of harvesting onion

Pull the onions early in the morning on a sunny dry day, Shake off excess soil.

Proper harvesting of onions starts with a preparation phase called curing. Curing is a process intended to dry off the necks and outer leaves of bulbs. The main objective is to prolong shelf life by preventing moisture loss and attack by diseases

Field Curing - Curing can be done in the field if the maturity and harvesting coincides with dry months. It involves:

» Placing the harvested onions in rows with leaves partially covering the bulbs to prevent sunburn or greening
» The onions are then left in the field until the outer leaves and neck are completely dry and papery. This takes 2 – 3 weeks depending on the environmental condition

Protected Curing is where the drying of onions is done in in a protected environment, in a warm, dry and well-ventilated location protected from direct sunlight and rain

The process involves the following:

» Removal of excess soil
» Trimming of foliage leaving 2.5cm of section of stem at neck
» Placing onions in single layer in large flat tray

Onions can also be cured by tying tops of bulbs in bunches and hanging on a horizontal pole in well ventilated shade

Drying and storage of onion after harvest

- Dry in open sided bands or under tree shade on a raised platform that allows air circulation form the bottom of the heap, protected from sunshine to avoid scorching the bulbs
- Delayed drying after harvest can cause rotting
- Store in good houses, well ventilated for further curing.
- Tie bunches by the leaves and hang in an onion store well ventilated cool and dry
- Skin colour should be typical of the cultivar if it is to be stored
- Do not mixed varieties in the same package
- Remove all damaged, diseased and thick necked bulbs during sorting before storage

Weeks	Growth stage	Activities	Recommendation
8 Weeks before trans-planting	Nursery bed management Germination after 5-8days	• Prepare the nursery bed • Sowing (4 – 5 weeks before intended trans-planting date) • Watering • Raise the shade • Thinning • Pest and disease management and (Hardening)	• Soil sterilization • Fence the nursery bed after sowing • Water twice morning and evening) • Slant the shade west-east to a height of 1m by 1/2m im-mediately after germination • Reduce watering gradually • Remove the shade
1	Pencil thick	• Transplant and mulch immediately after transplanting. • Take care not to mulch with materials having viable seeds. These will become weeds	• Use clean material for carry-ing the seedling Sort seed-lings and plant uniform size seedlings • Transplant in the evening
2		• Gap fill	• Keep the field free of weeds all the time • Select more vigorous seed-lings for faster growth to catch up with those planted earlier. • Do it within a week after transplanting to avoid big differences in growth
3	The fourth and fifth leaves emerge	• First weeding • Monitoring for pests (cutworms and crick-ets)	• Remove the weeds from the field, taking care not to injure the plants

4	Vegetative growth	• Monitoring for pests and diseases (cut-worms, aphids, bacterial wilt)	• Spray with organic pesticides/ Pyrethroid and dimethoate derivatives • Fungicides (mancozeb, dithane M45) • Phyto sanitation
5	Vegetative growth continues	• Second weeding • Monitoring for pests and diseases (mole crickets, downy mildew, onion thrips)) • Do earthing-up	• Phyto sanitation • Reduce movement in the field
6	Bulbing starts	• Monitoring for pests and diseases (mole crickets, downy mildew, onion thrips) • Do earthing-up	• Spray with dimethoate • Phyto sanitation • Minimize movements in the garden • Start constructing a store for curing
7	Bulbing continues	• Weeding continues • Monitoring for pests and diseases (mole crickets, downy mildew, onion thrips)) • Earthing-up continues	• Minimize movements in the garden
8	Bulb expansions increase in size	• Field monitoring to check for exposed bulbs • Earthing-up exposed bulbs	• Reduce movement in the field Phytosanitation • Avoid foreigners from accessing the field
9	Bulb expansion continues	• Weeding continues • Monitoring for pests and diseases (mole crickets, downy mildew, onion thrips)) • Earthing-up for exposed tubers continues	• Guard against thieves • Avoid movements in the garden • Phyto sanitation
10	Physiological maturity signs appear (10% maturity)	• Field monitoring for exposed bulbs • Earthing-up for exposed tubers continues	• Guard against intruders (thieves) • Reduce movement in the field phyto sanitation • Organize the items used during harvesting and drying
11	Physiological maturity signs intensify (50% maturity)	• Field monitoring for theft	• Bend the leaves to fasten maturity
12	Maturity continues (70%)	• Start selective harvest incase bending wasn't done	• Guard against theft
13	Maturity continues (70%)	• Start selective harvest incase bending wasn't done	• Guard against theft

14	Harvesting	• Lifting the bulbs	• Take care to avoid bulb injury
15	Post-harvest handling	• Drying/ Curing • storage	• Cure under shade • Well ventilated stores

CASSAVA **PRODUCTION**

Introduction

Cassava is an important food crop in Sub Saharan Africa and the second most important crop in Uganda in terms of production and consumption. It produces acceptable yields under sub optimum conditions and practices. The practices include, land preparation, selection of healthy planting materials, timely planting and correct weed management among others

It is widely grown in Uganda and is now an important crop in both low and high rainfall areas. In addition to its importance as a food security crop, it is now an income earner to farmers. Cassava is one of the staple foods of the West Nile people

Important uses of cassava

» Food security; tubers and the leaves are eaten
» Nutritionally, cassava contains potassium, iron, calcium, vitamin A, folic acid, sodium, vitamin C, vitamin B-6, and protein.
» Industrially, cassava is applicable in many types of products such as food, confectionery, sweeteners, glues, plywood, textiles, paper, biodegradable products, monosodium glutamate, and drugs
» Cassava chips and pellets are used in animal feed and alcohol production

Growth requirements

» Cassava can grow on a wide range of soils
» For good growth and yields, cassava requires friable, light textured and well-drained soils containing sufficient moisture and balanced amount of nutrients

1. Site selection

- Field plots should be uniform in fertility, with light textured, deep, well-drained soil and as free as possible from noxious weeds.
- Avoid stony, clay or waterlogged soils.
- In sandy soils, apply minimum tillage to conserve soil, organic matter and moisture and reduce soil erosion.
- In shallow or hard soils, increase top-soil volume per plant for better establishment.
- In poorly drained soils, make ridges or mounds to reduce waterlogging.
- Allow an overlapping period in the field of at least six months between the 'old' and the newly planted field to ensure that materials that did not germinate can be replanted and provide a constant supply of planting material
- Secure and protect the field against theft, vandalism and damage by animals.

- Preferably virgin land, land with thick vegetation or under fallow for 2 years.
- Land should be flat or gently sloping. Avoid steep slopes
- Free from volunteer plants/ previous cassava cropping should be at least 2 years
- Free from swampy and shaded conditions
- Free from cassava residue and drainage from other cassava fields
- Easily accessible to beneficiaries
- Away from high pressure areas for cassava pests and diseases
- Fertile and well drained deep loamy soils which are rich in nutrients, easy to till, low in gravel and hold water well
- Away from other cassava fields; at least 200 meters for breeder stakes and 100 meters for basic and certified stake production
- Avoid land with known history of termite infestation because termites are difficult to control.

1. Agronomic practices

a. seed selection-qualities of good seeds and varieties,

Cassava varieties

NASE 14, NASE 19, NAROCAS -1

Selection of good quality planting material

» Cassava in West Nile is commonly grown from its stem cuttings
» Obtain stalks for planting from a healthy mature cassava plantation from plants of 10-18months old
» Healthy stems should be used. Avoid bruising stems, as bruises can be entry points for pathogens
» Diseased stems sprout poorly. It is important for the farmer to know the symptoms of most important diseases such as Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD) in order to select clean planting materials.
» Select disease tolerant varieties; especially to both CBSD and CMD
» Select stalks with good node distribution; stalks with normal internodes are preferred
» Cut off the woody bottom part and the immature upper part of the cassava stem to obtain cuttings for planting
» Over mature cuttings have dormant nodes, are lignified and have very little nutrients, while very young cuttings dehydrate easily and are susceptible to pathogens
» Avoid thin stems as they have less nutrients and moisture resulting in weak sprouts that can produce only a few tuberous roots; very big stems are bulky. However, when using thinner stems, cut at least

30cm long

- Each cassava cutting should be 25cm-30cm long. Cut materials to size using a sharp machete/panga
- Small cuttings lose viability and moisture very easily and that may affect spouting ability and establishment
- Each cutting should have at least 5-7 nodes to increase chances of sprouting

b) land preparation-nursery bed and seed bed preparation

Land clearing and first digging

- Removal of tree stumps, logs, slashing of tall grasses to ease way for first land opening by hand or tractor
- Done using axes, pangas, hoes slashers etc
- Initial opening of land that should be done early; preferably (6-8 weeks before second digging) for proper decomposition of debris into organic matter
- Cassava may be planted on fields prepared as mounds, ridges, flat tilled or zero tilled—using herbicides or slashing without loosening the soil
- If tilled; it should be deep enough; preferably 30 cm deep
- Ridges across the hill are recommended in areas with steep slopes
- Flat but deep tillage or zero till is recommended for flat areas

Second digging

- Breaking of large soil particles into smaller particles to make a fine seedbed for easy planting
- It also involves removal of the trashes, roots and crop debris
- Killing of early germinating weeds
- This is recommended where cassava is to be intercropped or where seedbed is extremely rough after the first digging. However, cassava can be planted on a fairly rough seedbed

c) Planting-spacing, seed rate, timing, methods and depth;

Seed rate and optimum plant population

- 5-6bags (sacks) of cuttings per Acre. A bag contains about 700-900 cassava cuttings
- The optimum plant population is 3640-4000 plants per acre
- Plant timely; at the onset of rains
- Plant clean and disease free cuttings
- Plant disease tolerant varieties
- Always plant when there is adequate moisture in the soil

Plant spacing and planting depths

- Plant in rows with a correct spacing of 1mx1m
- To plant; open a furrow/hole of about 32cm long and 5-15cm deep
- But recommended planting depths:

  At about 15cm in dry sandy soils and about 10cm for wet sandy soils

  For clay soils: plant at a depth of 10cm when dry and 5-7.5cm deep when wet
- Shallow planting at low moisture results in poor establishment and low yields, while deep planting at high moisture makes sprouting difficult
- Deep planting is advisable in areas prone to termite attack
- Drop horizontally one cassava cutting of 25cm-30cm long per hole along the row

- Cover with soil
- Dead plants must be replaced within the first month after planting. Plants replaced later than that may fail due to shading
- Some varieties are capable of producing many shoots per stool and must be thinned down to two or three only
- Do not plant on soils that remain water logged for most part of the year
- When intercropping; use one leguminous crops like beans, soybean, cow pea, simsim etc in spacing of 1-2 rows in between rows of cassava;

d) Weed and weeding- common weeds, time and interval, methods, control measures

- Weed 2-3times at a 2weeks interval, starting 3weeks after planting whether in a clean field or not to control and manage weeds
- Common weeds include spear grass, Congo signal grass, pig-weed, nut grasses etc

e) Soil fertility management-nutrient requirement, application

f) Field pest and disease management- types, damage, control

See sections of this manual on cassava pests and diseases discussed in depth

g) Harvesting-Maturity, expected yield, pre-harvesting, harvesting methods

- It is ready for harvesting in a period of 9-12 months
- Cassava can be harvested in two ways; bit by bit (for subsistence) or all at once (commercial use). In both instances, the tubers are dug out of the soil
- Cassava is harvested manually by loosening the soil around the plant and pulling the plant to lift the roots
- Harvesting is easier when the soil is moist, or if planted in ridges, beds or sandy soils
- Optimum yields of most improved varieties range from 2.5-5ton/acre of dry chips

3. Storage and Post harvest handling

- Cassava tubers cannot keep fresh for long due to high moisture content. It should be processed to extend its shelf live
- Peel and wash the tubers
- Cut tubers in to small pieces using sharp knives
- Dry the chips under the sun, solar driers may be used
- Pack the cassava chips in clean sacks
- Cassava chips can then be milled in to flour from which other products are derived
- Store dry chips/flour in a leak proof store or room on a raised platform or pallets
- Many specialized cassava processing machines do exist today

CASSAVA DISEASES AND MANAGEMENT

Cassava Brown Streak Disease (CBSD)

It is a devastating viral disease transmitted by the white fly and the most important cassava disease in Uganda that can lead to up to 100% yield loss. It is a quarantine disease and mainly spread by movement of infected planting materials (stems).

Symptoms

Symptoms of Cassava brown streak disease can be observed on leaves, stems and cassava roots as described below. However, some cassava plants or varieties do not show symptoms on leaves nor tubers; other varieties may only express symptoms on leaves and not on roots; while others do not show symptoms on leaves but on roots only. However, the typical response of cassava plants is the one in which plants reveal symptoms on leaves, stems, and roots. The symptoms may appear and disappear in young plants, but appear again in cassava plants at a later stage.

Leaves

Symptoms of Cassava brown streak disease appear as patches of yellow areas mixed with normal green colour. This phenomenon is commonly referred to as chlorosis

- It produces characteristic yellow or necrotic vein banding on leaves which may enlarge and join to form comparatively large yellow or necrotic patches
- The yellow patches are more prominent on mature (bottom) leaves than younger ones
- Chlorosis is often also associated with secondary veins; veinal chlorosis is on mature cassava leaves
- The infected leaves do not become distorted in shape as occurs with leaves infected by Cassava mosaic disease
- Advanced symptoms on the leaves become an irregular yellow blotchy chlorosis that is most pronounced in the periphery (margins or edge) of lower leaves

Stems

The disease appears as dark brown “streaks” and “spots” (see pictures below) on stems, with dead spots on leaf scars

- These streaks are most prominent on upper, green portions of the stem
- “Streaks” may appear as scratch-like wounds on stems
- The diseased plants may show shoot tip death, which may progress into cassava stem die-back
- In severe cases there may be leaf drying and shoot die-back

Roots

The disease may cause cracks and discoloration in the storage roots

- It often causes root constriction and malformation (see pictures below)
- The harvested roots have corky, yellow-brown necrotic spots
- Root rot becomes evident (roots start rotting)
- In the roots of a susceptible variety, the disease causes a dry, hard rot which is irregular yellow blotchy chlorosis
- Necrosis is most pronounced in the edges of the root when the root/tuber is cut across with a knife

How CBSD is spread

- The disease is spread through planting of stem cuttings from CBSD infected plants
- The virus also spreads from plant to plant by white flies (see picture below)
- Planting of susceptible varieties helps build up CBSD in the affected areas
- Cassava brown streak disease also spreads through multiplication centres if the original source of cassava materials were infested or if the planting materials being distributed are not checked for the presence of CBSD
- Farm implements such as knives used in cutting cassava sticks into cuttings can spread CBSD to healthy planting materials when the infested knife is used on them

CBSD Management

Field hygiene

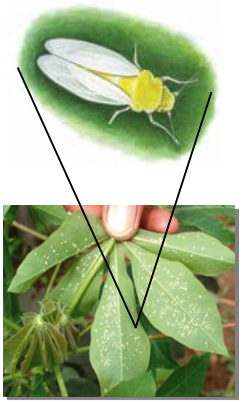
Field hygiene is one of the most important ways of managing CBSD and other diseases which are spread through cassava cuttings and insects. Field hygiene involves uprooting and destroying all cassava plants which are showing disease symptoms, and this helps in reducing the source of the disease. The following need to be done in order for field hygiene to be effective:

- Cassava plants in multiplication plots/blocks should be regularly checked for presence of CBSD
- Checking for CBSD should involve checking mature (lower) leaves, stems and storage roots for CBSD symptoms as shown below.
- All infected cassava plants should be uprooted and destroyed to avoid disease build up and spreading CBSD from the multiplication blocks
- All farm implements need to be sterilised over fire, especially when cutting cassava stems into planting materials (cuttings) in multiplication blocks

Use of disease free planting materials

Farmers should use clean planting materials

- Farmers should only plant cassava from reliable multiplication sources
- Farmers should plant resistant/tolerant varieties when available
- Farmers involved in community multiplication of cassava planting materials, and all those involved in such exercises should be trained in proper identification, how to reduce spread, how to manage and avoid spreading CBSD through cuttings

Disease	How it is transmitted	Symptoms
Cassava Brown Streak Disease (CBSD)	*White flies found on the underside of the leaves* 	

African Cassava Mosaic Disease (ACMD)

The typical symptom is reduced leaf size, malformed and twisted leaves, with yellow areas separated by areas of normal green colour. Severely affected plants are stunted.

Yield Loss

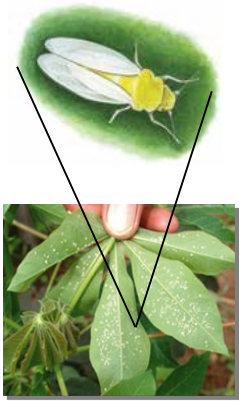
The magnitude of yield loss depends on the stage which the plant is infected and the degree of symptom severity. Plants infected as cuttings sustain highest (80-100%) yield loss. Plants infected after 5 months from planting may sustain very minimal or no yield loss. Similarly plants with very severe symptoms sustain highest yield loss and vice versa. Repeated planting of infected materials eventually results in no yield at all.

Transmission and Spread

The African cassava mosaic is transmitted by ineffective, whitefly (Bemisia tabaci). The whitefly acquires the virus from infected plants from within the field and outside sources. Once infected, it retains the virus for a long time and can transmit it to distant plants. Under favourable conditions all healthy plants of susceptible varieties become infected within five months from planting. The virus remains in infected stems indefinitely and planting such stems can disseminate the disease.

Control Measures

- Roguing of infected plants
- Planting 'clean' planting materials
- Use of resistant varieties
- Crop disposition and isolation
- Avoid planting cassava towards the end of the rains. This is the time when transmission of mosaic by the whitefly is rapid.
- Do not gather planting materials from cassava stems lying on the ground. You will not know the status of the stems or else you may transfer mosaic to your field.
- Never allow goats to break cassava during the dry season. This reduces the quality of planting materials and makes it difficult to select mosaic-free stems as the leaves would be absent.

Disease	How it is transmitted	Symptoms
Africa Cassava Mosaic Disease (ACMD)	*White flies found on the nderside of the leaves* 	

Cassava Bacterial Blight Disease

It is one of the most widespread and serious of the cassava diseases. It is common in Northern and Eastern Uganda and is transmitted mainly by infected planting material or infected farm tools. It can also be spread from one plant to another by rain splash, and by the movement of people, chewing insects like grasshoppers, machines or animals from infected fields to healthy fields. The bacterium infects first the leaves, which turn brown in large patches and eventually die, then the vascular tissues of the petioles and woody stems.

Bacterila blight destroys the leaves, which turn brown in large patches and eventually die.

Control measures

- Use Clean planting material
- Check visually for vascular browning
- Intercrop with maize or melon
- Crop rotation and fallowing
- Destroy all infected plants
- Disinfect tools regularly


Disease	Symptoms	
Brown leaf spot		Symptoms are restricted to older leaves. Brownish round spots appear on the upper leaf surface. Infected leaves later become yellow and eventually drop.
Anthracnose		Oval lesions (“sores”) on young stems. On older stems, raised fibrous lesions develop that eventually become sunken

CASSAVA PESTS AND MANAGEMENT

Cassava mealybug (Phenacoccus manihoti): serious pest during the dry season.

Identification

» Mealybugs occur on cassava leaves, shoot tips, petioles and stems.

» Mealybugs are covered with white waxy secretions.

» They survive on cassava stems and leaves and are easily carried to new fields in this way

» Their damage causes shortened internode lengths, compression of terminal leaves together into "bunchy tops," distortion of stem portions, defoliation, and "candlestick" appearance of shoot tip.

"Bunchy top" caused by cassava mealybug

Management

» Early planting in areas with heavy and long first rains results in minimal damage, enabling plants to establish and withstand attack during the dry spell.

» Planting resistant or tolerant varieties. High yielding varieties that are tolerant and recover quickly with first rains after pest attack include; Nase 1, Nase 3, Nase 14 and TMS4 (2) 1425.

» Weed control

Green spider mite (Mononychellus tanajoa): heavily infests susceptible varieties especially during the dry season in poor soils.

Identification

- Mites occur on the undersurface of young leaves, green stems, and axilliary buds.
- Mites appear as yellowish green specks to the naked eye.
- They survive on cassava stems and leaves and are easily carried to new fields in this way.
- Their damage causes yellow chlorotic leaf spots like pin pricks on the upper leaf surfaces, narrowed and smaller leaves, "candlestick" appearance of the shoot tip, and stunted cassava plants.

Cassava shoot tip with small and narrow leaves caused by cassava green mite

Management

» Use resistant or tolerant varieties such as Nase 1 and Nase 3, Nase 14, Nase 15, Nase 18 and Nase19

» Use clean planting material

Whitefly (Bemisia tabaci): very common during the dry season.

Identification

» Colonies of the whiteflies occur on the under surfaces of leaves.

» Damage cassava by sucking sap from the leaves and stems.

» Transmits ACMD and CBSD

Cassava scales (Aonidomytilus albus): common during the dry season

Scales cover the stem with conspicuous white secretions, and eventually the leaves turn pale, wilt and drop off. They suck sap from the stem and dehydrate it. Severely attacked plants are stunted and yield poorly.

Dead cassava plant covered with scales

Pest		Management
Grasshoppers		• Hand pick grasshoppers; feasible in small plots • Use pesticides
Rodents		• Fence farms and set traps in the fence. • Cover exposed roots with soil. • Weed your cassava farm to dis-courage rodents. • Harvest roots as soon as they are mature
Termites		• Plant early with the rains. • Avoid planting on very dry land or on termite mounds • Pesticides

TOMATO **PRODUCTION**

Session 4.21. Introduction to tomato production	Methods: Lecture, Brainstorming, Question and answer, Group work
Objectives: At the end of the session, participants are able to mention the importance of tomato growing, understand the weekly activity plan for, select and prepare land for tomato growing.	
Sub- topics: 1. Importance of tomato growing 2. Weekly activity plan for tomato production 3. Land selection and preparation for tomato growing	***Duration:*** 60 Minutes

Introduction

Introduce the session by telling the participants that in this session we are going to have an introduction to tomato growing.

Importance of tomato growing

Ask the participants to mention why tomatoes are grown. Record their responses on a flip chart. The following should be emphasized.

» For food – they form an important ingredient of various dishes as sauce or salads
» For money - they are high income crops and easy to sell
» They require small acreage (small piece of land)
» They take short time to mature (90 days)
» They require small initial capital.

Tomato growing weekly activity plan

Group work

Divide the participants into 4 groups. Ask each group to discuss and come up with 10 different activities that they expect to carry out in tomato production. Let them record these activities on a flip chart. The activities should be recorded in the order they occur in the season.

After each group presenting, brain storm on the correct timing for each activity so as to come up with a table as below.

Tomato growing weekly activity plan

Weeks	Growth stage	Activities	Recommendation
8 Weeks before trans-planting	Nursery bed prepara-tion Germination after 5 - 8 days	• Prepare the nursery bed • Monitoring • Sowing (4 – 5 weeks before intended trans-planting date) • Watering • Raise the shade • Thinning • Pest and disease man-agement (Hardening)	• Soil sterilization • Fence the nursery bed after sowing • Water twice (morning and evening) • slant the shade west-east to a height of 1m by 1/2m im-mediately after germination • reduce watering • remove the shade
1	Pencil thick	• Transplant and mulch immediately after trans-planting. Take care not to mulch with materials having viable seeds. These will become weeds	• Use clean material for carry-ing the seedlings • Transplant in the evening
2		• Fill Gap	• Keep the field free of weeds all the time
3	The fourth and fifth leaves emerge	• First weeding • Monitoring for pests (cutworms and crickets)	• Remove the weeds from the field, taking care not to injure the plants
4	Vegetative growth	• Monitoring for pests and diseases (cutworms, aphids, bacterial wilt) • Staking starts	• Spray with organic con-coctions/Pyrethroid and dimethoate derivatives • Fungicides (mancozeb, dith-ane M45) • Phytosanitation
5	Flowering starts and production of suckers Explain what suckers are.	• Monitoring for pests and diseases (aphids, thrips, late blight, bacterial wilt) • Pruning should be done	• Phytosanitation • Reduce movement in the field
6	Flowering	• Monitoring for pests and diseases (Bacterial wilt, Late blight) • More pruning - with care to avoid flower damage)	• Spray with organic con-coctions/Pyrethroid and dimethoate derivatives • Phytosanitation • Avoid movements in the garden
7	Fruit formation starts	• Second weeding starts • During second weeding, • Monitoring for pests and diseases (Late blight,	• Move carefully in the garden • Fungicides (mancozeb, dith-ane M45)
8	Fruits increase in size	• Field monitoring to check for diseases/pests (Boll worms, fruit can-ker)	• Limit movements in the field, and where necessary, move carefully in the garden

9	Physiological maturity signs appear(10% maturity)	• Field monitoring for diseases/pests	• Guard against intruders (thieves) • Reduce movement in the field Phytosanitation • Organize the items used during drying
10	Start of harvesting	• Field monitoring for theft	• Guard against intruders (thieves)

Session 4.22. Land selection and preparation	**Methods:** Lecture, Brainstorming, Question and answer
Objectives: At the end of the session, participants are able to select and prepare suitable land for tomato growing.	
Sub- topics: 1. Land selection for tomato production 2. Preparation of land for tomato growing	***Duration:*** 60 Minutes

Introduction

Introduce the session to the participants that today we are going to learn about proper land selection and preparation for good tomato production.

Ask the participants how they would conclude that the land is suitable for tomato production

Land selection for tomato growing

» Land that is suitable for tomato growing has sandy loam soils with good fertility. Fertility can be seen from the vegetation growing in the area. (Ask the participants to mention the characteristics of vegetation indicating good soil fertility).

» The land should not be prone to flooding and it should have a gentle slope to facilitate drainage.

» There should not be many trees as they will lead to lots of shade in the field and yet shades affect the development of tomatoes.

» The land should not have been used for production of egg plants, pepper, irish potatoes, pumpkins or water melon in the last 6 months. This will help minimize pests and disease build up.

Land preparation for tomato growing

» The land must be dug and allowed to rest for at least one month. During this period, there is also decomposition of the trash/rubbish to manure for improved soil fertility

» Deep ploughing by use of hand hoes or tractors is recommended to remove most of the weed roots and soften the soil for easy movement of water and air in the soil, but also make it easy for roots to grow.

» Second tillage is then done to produce a fine bed. This will improve crop establishment and growth.

» Apply mulch to conserve soil and water and reduce evaporation.

» If you are planning to plant in the second rains, open your land (1st digging) at the end of the 1st rains. This will enable you to have the land ready for planting by the time the second rains start.

Session 4.23. Nursery operations	Methods: Lecture, Brainstorming, Question and answer, Practical exercise
Objectives: At the end of the session, participants understand the attributes of a good tomato nursery site and different steps in tomato nursery management.	
Sub- topics: 1. Qualities of a good nursery site 2. Nursery bed preparation, sowing and watering 3. Pest and disease management 4. Hardening	***Duration:*** 120 Minutes

Introduction

Introduce the session by telling the participants that in this session, we are going to learn about nursery operations in tomato production.

Qualities of a good nursery bed

» A flat, fertile and well drained piece of land
» Close to water source
» Located in less weed infested area
» In areas with a lot of water, raise the nursery bed 10-15cm above the ground
» The soil should be dug deeply
» Not neighbouring other tomato gardens, or gardens planted with irish potatoes, egg plants and pepper.

Nursery bed preparation, sowing and watering

The facilitator should guide the participants to discuss the following steps by asking them to mention the steps. Ensure all the steps below are explained. The steps are:

1. Sterilize the soil by burning the top of the bed for 20 minutes using dried vegetation. Chemicals can also be used but they are expensive
2. Allow the bed to rest for between 5-7 days
3. Mix manure with the soil
4. Sow in drills 5cm apart at 0.5cm deep and cover lightly. Seed rate is 1.2- 1.4kgs/acre. This seed is sown on a bed of 1 m width and 20 m length. A shorter bed will over congest the seedlings and they will

not develop well.

5. Shade the beds moderately with the shades slanting east
6. Water twice a day in the morning and evenings only
7. Seeds germinate 5-8 days after sowing.
8. Start reducing the watering frequency after germination.
9. Stop watering completely one week before transplanting

Weeding, pests and disease control in the tomato nursery

Before watering, it is important to gently pull any weeds that are growing in the nursery bed. Such weeds compete with the seedlings for nutrients and water in the soil. One of the most common diseases of tomatoes in the nursery is damping off, which causes the stem to rot at the crown, leading to seedling death. To avoid this, one week after germination, a spray with mancozeb or Dithane M45 is recommended. Mix 20 gm in 20 litres of water. On the day of spraying, ensure you water first and then spray after watering so that the chemical is not washed off the seedlings during watering. If there are signs of rain, do not spray. Spraying should be done at least 3 hours before or after any rain.

Practical Exercise

Introduce this exercise by explaining to the participants that in this session, we are going to practically carry out nursery operations from site selection, nursery bed preparation, sowing, shading and fencing. This training should be done on a small piece of land, not more than 1.5 m wide and 2.5 m long. The participants should physically do the work with the facilitator giving instructions. It is advisable that at each stage, explanations are given why things are done the way they are done. 9 skills to learn should include:

a. Indicators of good soils for a nursery bed
b. Deep cultivation of the field (1st digging)
c. Second cultivation, cleaning and beating up to produce a fine tilth
d. Laying 1 metre width of land for the bed
e. Soil sterilization
f. Sowing (sow half a metre of the bed)
g. Shade construction
h. Watering
i. Nursery bed fencing

Session 4.24. Tomato field management	Methods: Lecture, Brainstorming, Question and answer, Practical exercise
Objectives: At the end of the session, participants understand transplanting, weeding, mulching, pruning and staking of tomatoes.	
Sub- topics: 1. Transplanting and gap filling 2. Weeding and pruning 3. Tomato mulching and staking	***Duration:*** 120 Minutes

Transplanting and gap filling

- When properly managed in the nursery bed, seedlings are ready for transplanting 4 - 5 weeks after germination.
- The seedlings should have not been watered in the nursery for at least 7 days to strengthen them.
- Water the bed heavily on the day of pulling to ease lifting of seedlings and reduce injury to them.
- Prick out the seedlings and transplant into the main garden in the evening in order to avoid long day heat stress.
- Spacing: 45cm x 30cm or 60x60cm depending on the variety (1 plant per hole)
- Gap fill within 1 week of transplanting for even growth.
- Add water to the planting hole before planting.

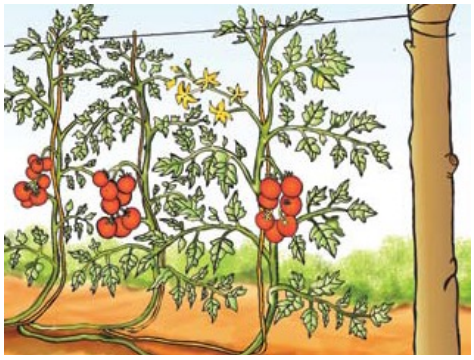
Weeding and pruning

Ask participants why weeds should be controlled. Ask them the common weeds of tomatoes (in local languages)

- The crop stand should be kept free of weeds at all time, because weeds compete for nutrients and are also vectors for disease.
- Hand weeding is recommended both for the greenhouse and outdoor tomatoes.
- To avoid the spread of diseases from plant to plant, do not use secateurs of knife.
- Pinch out' instead using your thumb and forefinger as shown in the picture.
- A weekly scouting is done for side shoots before they develop into big shoots.
- Remove side shoots, laterals, old leaves, diseased leaves & branches and overshadowed lower leaves by hand.
- After formation of the first fruit cluster of mature green tomatoes remove all the lower older leaves to allow for ventilation and disperse food to the fruits.
- Flowers should be pruned to 5-6 per cluster for medium- large sized fruits.

Mulching and staking

- Mulching should be done to conserve water in the soil; it should be done immediately after transplantation of the seedling.
- The mulch will also help to protect the fruits from being soiled in case of rain.
- Plant support is done by supporting the tomato plants on poles and wires. This is usually done early - three weeks after transplanting – to minimize plant damage.
- Tie a string lightly on the tomato and then gently twine the string around the plant to avoid snapping the stem as shown in the picture



Practical exercise

Introduce this exercise to the participants by telling them that that in this session, we are going to practically carry out transplanting and mulching of tomatoes.

This training should be done on a small piece of land, not more than 3 m wide and 5 m long. The participants should physically do the work with the facilitator giving instructions. It is advisable that at each stage, explanations are given why things are done the way they are done. 9 skills to learn should include:

a. Lining up
b. Lifting the seedlings (watering the seedlings before lifting) – use seedlings raised during the nursery operations practical exercise
c. Right size of seedlings
d. Depth of transplanting
e. Digging the correct size of planting holes
f. Correct spacing
g. Materials for mulching (avoid those with seeds) and the mulching process itself

Session 4.25. Tomato pests and disease management	**Methods:** Lecture, Brainstorming, Question and answer
Objectives: At the end of the session, participants understand the common tomato pests and diseases and their control.	
Sub- topics: 1. General pest and disease management practices 2. Pest and disease management	***Duration:*** 75 Minutes

General pest and disease management practices

Tomato is a crop that suffers a lot of pest and disease attack. It is recommended that control starts even before the pests or disease symptoms are seen. In principle, the following practices will greatly reduce pest and disease incidences in the field and you are encouraged to practice them.

1. Crop rotation – break the pest lifecycle
2. Early planting – your crop escapes by the time pest/disease incidences rise, you are harvesting
3. Use resistant varieties – they resist damage
4. Weed control – weeds affect crop vigor which is related to damage. Weaker crops are more damaged
5. Scouting – To spot pests/diseases early and control them in time

6. Mulching and staking – reduces contact of soil and the plant parts. Most tomato diseases are soil borne. Staking also improves crop coverage during spraying
7. Correct identification of pest or disease so as to use the right control strategy

Common tomato pests and their control

Aphids, thrips, whiteflies,
Cutworms, bollworms, leaf miners.
Spider mites and nematodes.

Control

Crop rotation, field hygiene, use of organic pesticides.

Common tomato diseases and their control

Late Blight

» The disease is very common particularly during the rainy season but also when there is excess moisture or humidity
» This disease can spread very fast wiping away plants within a short time and disease also affects fruits.

Effects of the disease

» The disease forms irregular greenish or water soaked lesions on the leaves, stems and fruits.
» Leaves develop bluish-grey patches, turn brown, wither but stay attached to the plant.
» Fruits develop watery spots which develop on upper half of fruit.
» The disease leads to rapid death of the entire plant.

b) Bacterial wilt

Bacterial wilt is one of the major diseases of tomato. The pathogen can also cause the bacterial wilt in several major crops such as eggplant, pepper and potato

Symptoms

» Non-yellowing
» Wilting of the youngest leaves at the ends of the branches during the hottest part of the day
» During its early stages, only one or half a leaflet may wilt and plants may appear to recover at night, when the temperatures are cooler
» The entire plant may wilt quickly and desiccate although dried leaves remain green leading to general wilting and yellowing of foliage and eventually the plant dies as shown in the picture.

c) Bacterial Canker

- Symptoms may be noted on leaves, stems, and inside fruits.
- Areas of leaves above the second or third cluster may show dull green and water soaked areas.
- Wilting progresses until the plant dies.
- Symptoms may be as seen in the picture

Session 4.26. Tomato harvesting, post-harvest handling and marketing	**Methods:** Lecture, Brainstorming, Question and answer
Objectives: At the end of the session, participants are able to harvest tomatoes at the right stage, minimize post-harvest losses and prepare for marketing,	
Sub- topics: 1. Signs of maturity and harvesting of tomatoes 2. Post-harvest handling of tomatoes 3. Quality considerations and marketing of tomatoes	***Duration:*** 90 Minutes

Signs of maturity and harvesting of tomatoes

- Tomatoes take 90 days to mature including days in the nursery bed.
- The fruits turn from light green to yellowish-reddish color
- Usually the very first cluster bears the first ready fruits.
- Pick fruits at intervals as they ripen depending on your market demand.
- The very first harvest is usually less compared to the later harvests.
- Hand pick and place fruits in buckets /trays when the weather is cool
- Harvesting continues for up to 2 months

Post-harvest handling of tomatoes

- After harvesting ripe tomatoes, the fruits should be washed and stored in a cool place if not sold immediately.
- When transporting to the market, design wooden boxes to avoid being crushed.
- Sell immediately after picking the fruits.
- Keep away from domestic birds.
- Do not leave already harvested tomatoes in the sunshine to avoid bursting of fruits.

Quality considerations and marketing of tomatoes

- The fruits are accepted in the local market, supermarkets, and other institutions because of their quality.
- When targeting specific markets, grade before selling by sorting out according to sizes, colour or weight.
- Potential markets are within the community where they are grown, urban centres in the region, and as volumes increase, Arua town, Lira, Gulu, DR Congo, Moyo, Koboko, Adjumani
- Always have contacts of customers and share information with them e.g. expected quantity to sell, quality, time of harvest, variety planted, price and packaging

KEY FACTS ABOUT POST-HARVEST HANDLING

Harvest: a single and deliberate action intended to separate food stuff from its growth medium

» P.H Technology - includes procedures and measures taken to ensure that the produce maintains its life/shelf life

» Damage- is the superficial evidence of deterioration from which losses may occur.

» Loss - Refers to changes in wholesomeness of food stuff. This maybe in form of quality or quantity

» Shelf life - A period within which produce remains wholesome and safe under specified conditions of storage or handling.

» The post-harvest system describes the various stages through which crop products pass, from the time of physiological maturity in the field to the time of consumption and the different operations and activities they are subjected to during the different stages in the system

The processes in the Post-harvest system

» Pre-processing: This describes on-farm primary processing activities in readiness for storage and processing. This may include threshing, shelling, winnowing, and initial drying etc

» Transportation: This describes both on-farm and off farm transportation

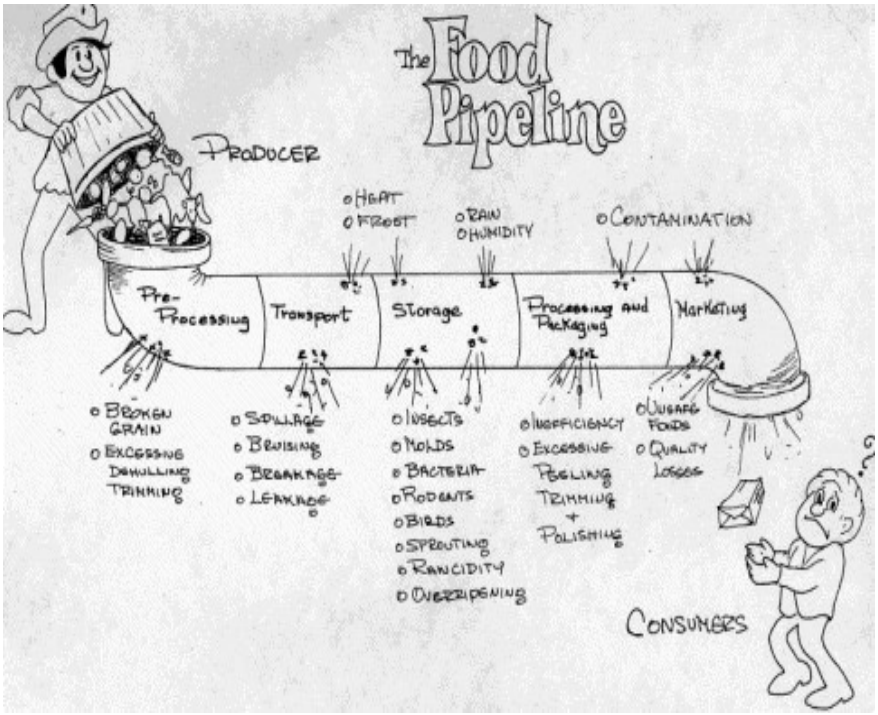
» Storage: This describes both on-farm and off-farm storage

» Processing and Packaging: This describes secondary processing and advances processing activities which may include shelling, milling, product development etc. Most are off-farm activities and may relate to industrial or commercial enterprises.

» Marketing: This describes marketing of both the produce or products for varying quantities

One important point to note is that losses occurring in the pipeline are finite, and unlike losses to growing crops, they cannot be compensated for by further plant growth or development.

The Food Pipeline



Why store crop produce

	To minimize reduction in quantity through physical losses
	To give security against pests, diseases, theft and physical losses
	To give easy accessibility when needed and in the right quantity.
	To effect a uniform supply of food throughout the months of the year, either for domestic use or for export.
	To provide a reserve for contingencies such as droughts, floods, and war
	To speculate on high prices either in domestic or in the export market

Factors that may influence storage level losses

Stage	Practices	Factors
Pre-storage	Harvesting	Time and method of harvest
	Drying	Method and level of drying
	Threshing or shelling	Method and level threshing or shelling
	Winnowing	Method and level of winnowing
Storage	Hygiene	Storage hygiene
	Structure	Nature and condition of the structure
	Management	Reception, inspection, grading, pest control, arrangement of produce, packaging, handling, dispatch etc.
	Condition of produce	Moisture content, infestation level, quality, Packaging etc.
Post-storage	Grading	Methods and level
	Processing	Methods and levels

Storage Systems:

In Uganda the main agricultural produce which are stored for a long time include grains, mainly beans, maize, sorghum, millet, rice, and wheat, and dried root tubers, particularly cassava and sweet potatoes.

To be able to achieve these objectives, the store must satisfy the following parameters as far as possible.

- The produce must be kept dry. It should be able to prevent moisture re-entering the produce after drying
- The produce should be kept at a uniform temperature
- The produce should be protected from insect attack
- Rodents and birds should be excluded.

Storage methods

There are a number of ways in which dried agricultural produce can be stored. Some may be more appropriate than others for particular circumstances.

Bag storage	Bulk storage
Partly mechanizable	Mechanizable
Flexibility of storage	Inflexible storage
Slow handling	Rapid handling
Considerable spillage	Little spillage
Low capital costs	High capital costs
High operating costs	Low operating costs
Inspection more difficult	Easy inspection

Food Losses and their Causes

Food loss refers to a measurable decrease of the commodity, produce or product from its original amount.

The major causes of and respective factors responsible for grain losses are:

» Physical: These include effect of temperature, moisture content and relative humidity
» Biological: These include microflora (mould, bacteria), vertebrates (rodents, birds), arthropods (insects, mites), and man (due to his inaction or action).
» Technical: These include storage (conditions, methods, duration etc.), state of grain (whether broken, with impurities, with residues etc).

Losses may be in terms of quality or quantity.

» Quantitative loss : Weight reduction may or may not constitute a loss. Where weight reduction is attributed to reduced moisture content the weight reduction does not mean a loss, but referred to as shrinkage
» Qualitative loss : Generally quality is assessed and products graded on the basis of appearance, shape, size, etc, but smell and flavour are often used. Presence of foreign matter, such as insect fragments, frass, rodent hairs and excreta, weed seeds, plant parts, soil, stones, animal products etc. often lead to quality downgrading.
» Nutritional loss :This may be a product of either qualitative or quantitative loss. This refers to loss in nutrition value to the human or animal population concerned, which is also dependent on the population's nutritional need.
» Loss of seed viability :This relates to reduced seed viability, which has an effect on future food production. Method and length of storage may reduce seed viability, and so will insect, rodent and fungal attack.
» Commercial loss : All the above factors do cause commercial losses. Commercial losses can be kept to a minimum through knowledge, experience and good management. Economic losses may be sub-divided as follows:
  * Wet Heating, is the type of loss which results from storage of grains with high moisture content, or by storage in unsatisfactory non-weather proof stores, or as will be discussed later by metabolic activities of insects and micro- organisms. It can be in form of;
  * Presence of hot spots in grain masses. The temperature of these spots is higher than that of the general grain bulk. It may be as high as 63.0oC.
  * Caking and fermentation of the grains or their products.

* Germination of grains.
* Rotting
* Infestation by fungi and bacteria.

Physical Factors that affect storage

» Temperatures of both the air surrounding the grain and within the grain are important in grain storage. Low temperatures are best for grain storage. In most tropical countries however, higher temperatures prevail which favour fast multiplication of fungi and pests.

Moisture content (M.C)

» Grain water exists both at intra-cellular and extra cellular levels. Grain M.C is very important in determining storability of produce because;
» The dryer the grain the lower the respiration rate, thus longer storage
» Weight changes due to loss or gain in grain M.C.
» Insects develop faster at higher M.C and temperatures
» Relative Humidity (R.H): The amount of water in air is expressed as relative humidity (RH). The RH is a percentage measurement of the actual amount of moisture in the air as compared to the maximum amount of moisture the same quantity of the air could hold at the same temperature

Moisture determination

» Salt test: Dry common salt (non-ionised) is mixed with grain in a glass jar and shaken.
» If salt in the grain sticks to glass wall, it has absorbed moisture from air, which must have therefore have been at a RH greater than 75%. This means that grain had a MC greater than 15%, thus unsuitable for storage
» Hardness test :This involves placing the grain between the teeth and biting it.Ifit is difficult cracking the grain, it is assumed to be sufficiently dried for storage. If grain is very soft the MC is too high for safe storage. Experience will perfect this technique.
» Feeling test : The hand is pushed in bulk grain; if little resistance, grain assumed to be sufficiently dry for storage, if too much resistance grain is assumed to be too wet for storage.

Losses in quality

Losses in quality occurs in various forms which include:

» Changes in colour of the stored produce.
» Changes in smell.
» Changes in taste.
» Loss in nutritional value (degradation of proteins and vitamins)
» Loss in cooking, milling or baking quality
» Contamination of stored produce with pathogenic agents.
» Loss of seed viability

The Agency for Accelerated Regional Development (AFARD) is a local, not-for-profit, non-denominational, non-governmental organization (NGO) formed in July 2000

CONTACT US

Afard

Plot 3-5 Butime Rd.
P.O. Box 80, Nebbi
Nebbi Town Council
Uganda

Phone

+256 (772) 437 175
+256 (782) 400 856

Website: www.afard.net
E-mail: afard@afard.net
Twitter: @AFARD_UG
Facebook: @AFARDuganda