

ACTION FOR LIVELIHOOD ENHANCEMENT IN NORTHERN UGANDA (ALENU)

TOMATO PRODUCTION MANUAL



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ACKNOWLEDGEMENTS AND DISCLAIMER

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

- Infonet Biovision website: <https://infonet-biovision.org/>
- Agrodok 17 - Cultivation of tomato: production, processing and marketing
Cultivation of tomato production, processing and

Pictures and text extract of these sources have been used in this manual.

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O. Training concept

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)

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? 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.

3. Introduction of the topic of the day and short brainstorming to identify what the participants know already about this topic. (10-20 minutes)

For each chapter, some guiding questions are proposed to stimulate the discussion.

4. 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.

5. 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.

Recommended training program

It is important that the training units are delivered at a time that is appropriate to the crop production schedule, so that participants are then able to apply the new knowledge gained directly at home.

Where appropriate, some training units may be combined (e.g., common varieties (Unit 1) and nursery establishment (Unit 3)). Other units may also be offered in two separate sessions to address or deepen different aspects (e.g., pest and disease management (Unit 6)).

Topic	Duration	Timing
1. Importance of tomato growing and common varieties in Uganda. What is agroecology?	2-3 h hours	4 weeks before planting time
2. Land selection and preparation for tomato growing (including soil fertility management)	2-3 hours	4 weeks before planting time
3. Nursery establishment and management	3 hours	4-6 weeks before planting
4. Transplanting	3 hours	Day of planting
5. Weeding, staking, pruning	3 hours	3-4 weeks after planting
6. Pests and diseases management in tomatoes	2 sessions of 3 hrs	5-10 weeks after planting
7. Tomato harvesting	3 hours	Week 11-20 after planting
8. Post harvesting and handling of tomato	4 hours	Week 11-20 after planting
9. Seed production	2 hours	Week 11-20 after planting
10. Record keeping and gross margin calculation	2 sessions of 2-3 hrs	Before/during the cropping season. End of cropping season

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 management¹.

Introduction to soil

Soil is what plants grow in and people cannot survive without soil. For that reason, knowledge of the soil is one of the most important requirements for farmers. It is the surface layer of the earth's crust which is capable of supporting life.

Soil Types

There are 3 main soil types in Uganda: Clay, Sand and Loam. If a soil is referred to as a "clay" soil then this usually indicates that clay is the major constituent in that soil. However, most soils contain a mixture of minerals. Soil mixtures are often referred to as loams. A soil made up of a mixture of sand, silt and clay with the properties of no one group dominating is called a loam. A "medium loam" would be made up of 50% clay and 50% silt. If the soil has a large amount of clay it may be called a "heavy loam" while a soil with a large amount of sand (50%+) may be called a "sandy loam"

The table showing the soil types and their characteristics

Soil type	characteristic
Sandy soils	<ul style="list-style-type: none">• Contain mostly sand• Do not hold water very well• Most sand is small pieces of stone
Clay soils	<ul style="list-style-type: none">• Holds water very well• Lacks pores, has few plant roots and is hard to dig
Loam	<ul style="list-style-type: none">• Made of gravel, sand, clay with good/high organic matter content• Loam has a dark colour• Has many roots and earthworm channels

Soil Composition

Fertile soil is generally composed of mineral matter, organic matter, water and air.

- Mineral Matter (45%) can be composed of; gravel (large pebbles and stones, sand, silt, clay particles and mineral salts (usually in solution).
- Water (25%) is found in the spaces between soil particles called pores.
- Air (25%) is also found in the spaces between soil particles called pores.
- Organic Matter (5%) can be composed of plant roots, dead leaves and twigs, humus (a product of the breakdown of organic matter), microorganisms (bacteria, fungi, yeast) and macro-organisms/small animals such as earthworms.

¹ and efficient irrigation, sustainable water use

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.

Soil fertility experiments

Experiment	Materials and method	Observation
Determine the soil water holding capacity.	<ul style="list-style-type: none">• Three soil samples; clay, loam and sand• Water• Paper filter• Empty water bottle Method: Three empty water bottles are cut A paper filter is placed on each bottle, holding a soil sample Water is poured through the soil sample and the rate of water infiltration determined	Water infiltrates fast through sand, then moderately through loam soil, then slowly through clay. Conclusion: loam soils have a good water infiltration rate therefore better to crop production
Determining the organic matter content of the soil.	<ul style="list-style-type: none">• Three soil samples; clay, loam and sand• Water• Used water bottle Method: Soil samples are put into three empty water bottles. Water is added, and the bottle shaken Allow to stand	Loam soil has a bigger layer of organic matter followed by sandy soil and then clay soil. Conclusion: The organic matter in loam soil is good for crop production
Determining soil acidity	<ul style="list-style-type: none">• Three soil samples; clay, loam and sand• Baking powder• Water Method: Three samples of soil are put into three containers A small quantity of water is added to wet the samples Baking powder is added The samples are put close to the ear to hear any sound made	The soil sample that gives the most hissing sound due to release of hydrogen gas is the most acidic
Determining soil alkalinity	<ul style="list-style-type: none">• Three soil samples; clay, loam and sand• Vinegar Method: Vinegar is added to the three samples of soil in three containers	The sample that gives the biggest hissing sound, was more alkaline

Section 2: soil and water conservation

What is soil conservation? It is the prevention and reduction of the amount of soil lost through erosion. It seeks to increase the amount of water seeping into the soil, reducing the speed and amount of water running off.

What is water conservation? This is a way of tapping as much water as possible and storing it in tanks or reservoirs. It allows water to sink into the soil increasing soil moisture levels. The aim is to slow down the flow of running water and spreads the water over a large area.

Benefits of soil and water conservation

- Conserving water makes it available for crops, livestock and domestic use over a longer period
- Controlling soil erosion improves crop yields.

Types of conservation measures

Agricultural conservation measures These are practices such as mixed cropping, contour cultivation, mulching, and manuring

- Crop management Good crop management reduces soil erosion by water and wind and improves soil fertility.
- Early planting. This ensures that the crop shoots from the ground within one or two weeks after the onset of the rains and protects the ground against raindrop impact.
- Crop rotation. Crop rotation ensures the addition of humus, soil fertility, control of erosion and
- Cover cropping this is the growing of crops to cover cultivated ground, reducing erosion by raindrop splash and overland flow.
- Contour strip cropping combined with crop rotation and minimum tillage is an effective method of soil and water conservation.

Soil management Inappropriate land use activities often cause changes in soil conditions, which in turn contribute to soil erosion.

- Use an appropriate tillage practice that does not make the surface soil too fine and powdery; and breaks up the hardpan if necessary.
- Applying organic manures and mineral fertilizers adding manure and fertilizers to the soil provides the required plant nutrients for vigorous crop growth.
- Mulching and the use of crop residues Dead plant materials such as dry grass, straw, dry leaves, banana leaves, sugar cane trash, and other crop residues are spread on the bare soil surface or placed around the stem of the plants to control soil erosion and conserve moisture.

Physical soil conservation measures Physical soil conservation structures are permanent features made of earth, stones or masonry, designed to protect the soil

from uncontrolled runoff and erosion and retain water where needed. Below are some of the physical conservation measures:

Cut – off drains. Cut-off drains are dug across a slope to intercept surface runoff and carry it safely to an outlet such as a canal or stream. They are used to protect cultivated land, compounds, and roads from uncontrolled runoff, and to divert water from gully heads.

Retention ditches These are dug along the contours to catch and retain incoming runoff and hold it until it seeps into the ground. They are an alternative to cut-off drains when there is no nearby waterway to discharge the runoff. They are often used to harvest water in semiarid areas.

Infiltration ditches This is a structure designed to harvest water from roads or other sources of runoff. They consist of a ditch 0.7-1.5m deep, dug along the contour, upslope from a crop field. Water is diverted from the roadside into the ditch, which is blocked at the other end. Water trapped in the ditch seeps into the soil.

Water-retaining pits Water-retaining pits trap runoff and allow it to seep into the soil. A series of pits are dug into the ground where runoff normally occurs. The soil from the pit is used to make banks around the pits.

Terraces - Fanya Juu, Fanya Chini, Bench terraces, Stone terraces

Fanya Juu Fanya juu terraces are made by digging a trench along the contour and throwing the soil uphill to form an embankment. The embankments are stabilized with fodder grasses and in between cultivated portions. Over time, the fanya juu develop into bench terraces.

ORGANIC PESTICIDES

1.Garlic/Onion + Hot Pepper Extract

Materials

- Hot pepper
- Garlic/ onion bulbs
- Warm water
- Strainer

Procedure

- Combine 0.5 kg of hot pepper with 1kg of garlic/onion bulbs, pound the two together to form a thick paste in a container.
- Add the vegetable paste to 4 liters of warm water and thoroughly mix the ingredients together.
- Pour the solution into a plastic container and allow it sit for 24hours in a relatively warm place.
- Strain the solution and put the filtrate in a clean container. And this is your pesticides.

- Pour the pesticides in a squirt bottle that has been thoroughly well cleaned to get rid of other contaminants
- Mix the extract with water in a ratio of 1:4-5 liters and add 1 table spoon of liquid soap and apply.



2.Garlic brew

Materials:

- Garlic
- Cow Urine
- Bucket
- Gunny cloth
- Strainer

Procedure

- Crush or grind the garlic (1kg) into a paste and put into the bucket (10 liter) containing cattle urine (10 liter)
- Stir the materials for 5-10 min and cover with a gunny cloth or cotton cloth which can provide sufficient aeration
- Allow the material to ferment for 5-7 days
- After 7 days sieve the solution before spraying to avoid the nozzle of the sprayer
- The solution is diluted 10 times with water and sprayed on the foliage in the evening hours.
- Care should be taken that the concentrated solution should not be sprayed in the crop/ vegetables about to be harvested.



3. Marigold Extract Marigold (*Tagetes* sp.)

It is an excellent pest repellent for most of the pests. When these plants are planted along with the main crop especially in vegetables, due to the allelopathic effect, they help in managing soil borne insects, pathogens and nematodes.

Materials required

- Marigold flowers along with the entire plant
- soap

Method

- Take 5 kg of Marigold plants along with the flowers. Grind into fine paste.
- Add 100 litres of water and allow it for fermentation for 7 days.
- Add 100 grams of soap nut powder on the day of spraying which acts as emulsifier.
- Stir for 15 minutes and spray during evening hours.

4. Garlic Decoction

This spray can be prepared if there is a sudden incidence of pest and no sprays are available with the farmer to manage the pest.

Materials required

- Garlic- 1 kg
- Water – 10 litres

Method

- Boil 1 kg of garlic in 10 litres of water separately.
- Allow the solution to cool and sieve the solution with a muslin cloth.
- Dilute one part of the solution with 10 parts of water and spray on the crop during evening hours.

 <p>Garlic</p>	 <p>Garlic boiled in water</p>
 <p>Filtering cooled solution with a cloth</p>	 <p>The filtered garlic decoction</p>

5. Neem extract

Watery extracts from seeds and leaves are excellent against beetle larvae and caterpillars, and good against stalk borers and adult beetles

Procedure:

- Collect fallen neem fruits from underneath the trees.
- Remove the flesh from the seeds and wash away any remaining shreds.
- Dry the seeds in bags or baskets. Avoid mould formation.
- For the preparation of extract, shell the seeds.
- Grind 500 g of neem seed kernels in a mill or pound them in a mortar or grate them finely. Mix the crushed neem seed with 5 to 10 litres of water. Soak them overnight.
- Strain the liquid before use.
- Application of neem water extracts - Spray the neem water directly onto the plants using a sprayer or straw brush. - Neem works fastest during hot weather.
- Heavy rains may wash off the protective cover of neem on plants.
- Repeat the treatment if pest infestation is high. - Neem water will remain effective for 3 to 6 days if it is kept in the dark. All neem preparations lose their power rapidly when exposed to sunlight.

Precautions during preparation of neem extracts Leaf or seed

Although they are almost non-toxic to mammals, seeds or seed extracts are poisonous when consumed.

Take the following precautions:

- Place the neem extract out of reach of children and pets while preparing, using and storing it
- Avoid direct contact with the crude extract at any time
- Do not use utensils and containers for food preparation and for drinking for the preparation of neem extract.
- Clean all the utensils properly before and after use.
- Wash your hands after handling the plant extract.
- Always test the plant extract on a few infested plants first before going into large scale spraying.
- Use protective clothing when applying the solution.

MANURES

1.Liquid manure for pest management

A variety of plants (weeds) which have pesticidal value can be used. Plants which have strong disagreeable odour are ideal for making this preparation

Materials required

- Plants like Lantana, Artemesia, Stinging nettle, black jack - 3 kg
- Cattle dung - 3 kg
- 20 litre capacity plastic bucket
- Water – 20 litres

Procedure:

- Chop the plants into small pieces
- Mix with 3 kgs of cow dung
- Put in a gunny bag, tie the bag and hang in a bucket of 20 liters water for 5-7 days.
- Dilute 1 cup of solution to 10 cups of water



Cutting the plant material



Pouring water into the bucket



Removing the gunny bag after 5-7 days



The liquid manure solution

2.Dung Brew

It is a fermented solution of cow dung and provides nutrition to the crops.

Materials required

- Cattle dung - 5 kg
- Cattle urine – 15 litres
- Plastic bucket of 20 litres capacity

Method

- Add 5 kg of cattle dung and 15 litres of cattle urine in a bucket and mix it well.
- Cover the bucket with a gunny sack or any material that provides sufficient aeration.
- Stir the materials every alternate day for 15 days.
- The dung brew is ready for spray after 15 days and can be stored for 2 months.

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.

1

Importance of tomato growing and common varieties in Uganda

A. Learning objectives

At the end of this session, participants will:

- Understand the importance of tomato growing for income and nutrition
- Have reflected on the reasons why they would like to grow tomatoes
- Know the characteristics of different varieties of tomatoes 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

2-3 hours

C. Learning aids

- Flip charts
- Marker pens
- Masking tape
- Training manual
- Different varieties of tomatoes (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 tomatoes? How will tomato production fit within your farms? For which purpose do you want to grow tomatoes (self-consumption, as a source of income)?
- What could be the benefit to grow tomatoes?
- What could be the main problems for you to grow tomato? How to overcome

these problems?

- What do you know about agroecology? What does it mean in tomato production?

Exercise choosing the right variety (30 minutes)

The facilitator gathers on a table a sample of the tomato varieties available in Uganda (or pictures of them, if fresh tomatoes are not available). If possible, he also gathers different tomato plant types (tall, semi-bush, bush types) in pots, or pictures of them.

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. Which ones are more adapted to agroecological production?

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 tomatoes and presenting the information concerning the different varieties of tomatoes presented in the table 1. In table 2 a summary of the tomato varieties and their characteristics is presented.
- 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 Irish potatoes are more adapted to an agroecological production and why.

E. Content

1.1 Reasons for growing tomatoes

Tomatoes are grown for different reasons including:

- Household consumption: Tomatoes are an important ingredient in various dishes such as sauces and salads. In Uganda, three million households consume tomatoes at every meal.
- Tomatoes contribute to a healthy, well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. They

contains vitamin B and C, iron and phosphorus.

- As a source of income: Tomatoes are a high-income crop that is easy to sell. They have a short production cycle (90 days) and require small amounts of initial investment capital.
- Tomatoes can be processed into purées, juices and ketchup. Canned and dried tomatoes are economically important processed products.
- Tomatoes can be grown on small surfaces in backyards for self-consumption but also for medium-scale marketing because of the high demand for both fresh consumption and processing.
- However, if you want to grow tomatoes for sale, you must first find out if there is a market for your tomatoes and what varieties of tomatoes are in demand for that market.

1.2 Types of tomato plants

Tomato is an annual plant, which can reach a height of over two metres. Three different types of tomato plants can be distinguished:

- tall or indeterminate type
- semi-bush or semi-indeterminate type
- bush or determinate type

The tall varieties are the best choice for a long harvest period. They keep growing after flowering. This feature is called indeterminate. The plants generally have more foliage. This will keep the temperature lower within the crop and the fruits grow in the shade of the leaves. Because they are covered, the sun does not damage the fruits and they ripen more slowly. Slower ripening and a high leaf/fruit ratio improve the taste of the fruits and in particular the sweetness. The tall types have to be staked, caged or trellised.

Bush types usually support themselves and need no staking. Determinate types stop growing after flowering. They require less labour, so they are popular for commercial cultivation. They have a relatively concentrated fruit set which lasts only two or three weeks and the fruits ripen much faster than those from indeterminate types.



1.3. Selected varieties of Tomato 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 into dry tomato, tomato puree other products). Therefore, it is important to think about the intended use of the tomato you will cultivate, the market preferences, and to choose the varieties accordingly
- Local varieties (land-races) and improved (or commercial) varieties can be


distinguished. They are the result of a continuous process of selection of plants. Selection criteria are based on characteristics such as type of fruit, shape of plant, vitality and resistance to pests and diseases, yield, Duration of production cycle but also on factors related to climate and management. Farmers select varieties that perform best under the local conditions.

- Hybrid and non-hybrid varieties can be distinguished. Tomato breeding companies have produced F1-hybrids. These grow from seeds that have been produced by controlled hand pollination of male and female parent lines. These hybrids combine high yield, disease resistance and other plant and fruit characteristics. When using hybrids, new seeds should be purchased each season. This may cost more money, but the resistance against diseases of hybrids means the tomato plants need less spraying with pesticides. The yields are also higher, creating more opportunity to bring tomatoes to the market.

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

Variety	Maturity	Yield	Attributes
<p>Rio grande</p>  <p>edenbrothers.com</p>	75 days from transplanting	15-17 tons/acre	<ul style="list-style-type: none"> ▪ Determinate open pollinated variety. ▪ Excellent keeping quality. ▪ Firm elongated fruits with excellent transport qualities. ▪ Tolerance to verticillium wilt and tomato leaf curl. ▪ Plant spacing: 60 by 45cm ▪ Well suited for processing into sauces, ketchups and for dry fruits
<p>Kilele F1</p>  <p>Syngenta.com</p>	80 days from transplanting	70-80 tons/acre under good practices.	<ul style="list-style-type: none"> ▪ Determinate hybrid variety ▪ Over 21 days shelf life. ▪ Tolerant to Bacterial wilt. ▪ Difference between the varieties regarding yield 10 – 80 tons per ha. ▪ However, does not do well in the W. Nile region. ▪ Plant spacing: 60cm by 60cm. ▪ Firm elongated oval fruit to suit market preference. ▪ Well suited for fresh consume.

<p>Improved Nouvelle F1</p> 	<p>80-85 days from transplanting</p>	<p>35 tons/acre</p>	<ul style="list-style-type: none"> ▪ Semi-determinate hybrid variety. ▪ Very good shelf life and transport quality. ▪ High bacterial wilt tolerance, verticillium wilt and fusarium wilt. ▪ Spacing: 60cm by 60cm. ▪ Well suited for fresh consume.
<p>New Fortune maker F1</p> 	<p>70-75 days from transplanting</p>	<p>30-35 tons/acre</p>	<ul style="list-style-type: none"> ▪ Determinate hybrid variety. ▪ Shelf life of over 21 days and good transportability. ▪ Tolerant to bacterial wilt, verticillium wilt and fusarium wilt. ▪ Spacing: 60cm by 60cm ▪ Well suited for fresh consume
<p>Money maker</p>  <p>Edebrothers.com</p>	<p>90 days from transplanting</p>	<p>25 tons/acre</p>	<ul style="list-style-type: none"> ▪ Undeterminate and open pollinated. ▪ Pinkish and hard skin. ▪ Requires staking. ▪ Delicate in transportation. ▪ No specific diseases tolerance. ▪ Spacing is 60cm by 60cm. ▪ Well suited for fresh consume.
<p>Cal J</p>  <p>Shambaza.com</p>	<p>75-85 days from planting</p>	<p>10-12 tons/acre</p>	<ul style="list-style-type: none"> ▪ Determinate and open pollinated. ▪ Does not require staking. ▪ Good yielder. ▪ Can be transported easily to far markets but it is delicate, losses should be considered. ▪ Sweet tasting deep red fruits. ▪ Tolerant to verticillium wilt and fusarium wilt ▪ Spacing: 60cm by 60cm ▪ Well suited for both fresh consume and processing.

<p>Maglobe</p>	<p>90-95 days after transplanting</p>	<p>20-25tons/acre</p>	<ul style="list-style-type: none"> ▪ Widely adapted, hardy tomato variety. Semi-determinate with long fruit bearing period. ▪ Does well in humid climates. Fruit weight 160-175gm and resistant to fusarium
<p>Roma VFN</p> 	<p>90-95 days after transplanting</p>	<p>20-25tons/acre</p>	<ul style="list-style-type: none"> ▪ Determinate, very productive variety. Widely marketable. ▪ Fruit weight 60-70gm with pear shape appearance with moderate firmness. Resistant to fusarium and verticillium
<p>Heinz 1370</p>	<p>Maturity 80-85 days after transplanting.</p>	<p>20tons/acre</p>	<ul style="list-style-type: none"> ▪ Determinate variety bearing medium-sized firm fruits. ▪ Very adaptable with fruit bearing period. Fruit is deep oblate, with average weight 120-140gm. Resistant to fusarium

2

Land selection and preparation for tomato growing

A. Learning objectives

After completing this module, participants will:

- Understand the factors to consider in selecting a suitable site for tomato production
- Understand how tomato plants interact with other plants and how to plan crop rotation considering spatial and temporal arrangement of tomato plants.
- Learn the best practices of land preparation for tomato production
- Know how to manage soil fertility
- How soil fertility should be managed 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 tomato 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 tomato plot (1 hour)

This activity should take place directly in the area where the tomato 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 tomato plot will be implemented:
 - How would you choose an appropriate site for growing your tomatoes?
 - 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 tomato 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 tomato plantation (1 hour)

The participants, together with the facilitator, will practically prepare the land for tomato 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 tomato production based on the aspects presented in the sub-chapter E. Content below.

E. Content

Land selection for tomato growing

The land selected should fulfill the growing requirements of tomato and shows the following characteristics:

Growth requirements of tomatoes

- Tomato grows well on most mineral soils that have proper water holding capacity and aeration, and are free of salt but prefer Sandy loam soils with good fertility and high organic matter content. Soil fertility can be assessed by looking at yields of other crops or by analyzing the vegetation type in the growing area. (The facilitator can ask the participants to mention different vegetation species indicating good soil fertility).
- Avoid soils with a very high content of clay.
- Tomato is moderately tolerant to a wide range of pH (level of acidity), but grows well in soils with a pH of 5.5 – 6.8 with adequate nutrient supply and availability.
- Sufficient moisture must be maintained on the land to establish the plant successfully and carry it through to fruit production. A simple rule of thumb

can be used to determine whether local water supplies are sufficient for growing tomato. If there are herbaceous plants (plants with many thin leaves) growing in the natural environment, it will be possible to grow tomato. You should be able to count on at least three months of rain. Water stress and long dry periods will cause buds and flowers to drop off, and the fruits to split.

- However, if rains are too heavy and humidity is too high, the growth of mould will increase and the fruit will rot. Cloudy skies will slow down the ripening of tomatoes. However, adapted cultivars are available. Seed companies have special tomato varieties for hot-humid climates.
- On a gentle slope to facilitate drainage and to avoid flooding. Soil depth should be 60 cm or more.
- Light and rainfall should be evenly distributed throughout the year. Very wet weather and little sunshine encourages excessive vegetative growth at the expense of fruit formation.
- Good air drainage (i.e. well ventilated, but not strong wind!) will reduce the risk of foliar disease.
- Few trees as they will lead to lot of shade in the field affecting proper tomato growth.
- Not recently used for production of tomatoes, egg plants, pepper, Irish potatoes, pumpkins, tobacco or watermelon in the last 3-6 years to minimize pests and diseases transmission risks.
- The climate of the site must be adapted: The optimum temperature for most varieties lies between 21 and 24 °C. The plants can survive a range of temperatures, but the plant tissues are damaged below 10 °C and above 38 °C (Table 1)
- In tropical lowlands, the minimum temperature at night is also important. Temperatures below 21 °C can cause fruit abortion

Table 1: Temperature requirements for different stages of tomato (source: Agrodok 17)

Stages	Temperature (° C)		
	Min	Optimum range	Max
Seed germination	11	16-29	34
Seed growth	18	21-24	32
Fruit set	18	20-24	30
Red colour development	10	20-24	30

Crop rotation

Crop rotation is the practice of growing a series of different types of crops in the same area in a sequence

Advantages or benefits of crop rotation include: It improves the soil structure and reduces depletion/erosion, It increases soil fertility, It helps control weeds, pests and diseases hence reduce reliance on chemicals

- Crop rotation is a major component of organic farming, affecting both soil conditions and pest cycles.
- A rotation with non-solanaceous crops for 3-6 years will avoid pest problems in tomatoes.
- Tomato followed by cereals and millet reduces the incidence of disease in tomatoes.
- Beans, marigold, cowpea and green leafy vegetables are common crops that are mixed to avoid the incidence of pests and diseases on tomatoes.

Land preparation for tomato growing

- The land must be prepared 4-6 weeks before transplanting and manure should be applied early enough to rest for at least one month for proper decomposition (see section on 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. It is also important to make it easy for tomato roots to grow by penetrating properly in the soil.
- A second tillage is then done to produce a fine bed. This will improve crop establishment and growth.
- Applying mulch can be positive to conserve soil and water and reduce evaporation.
- Sources of mulching material are: weeds or cover crops, crop residues, pruning material from trees, cuttings from hedges, waste from agricultural processing or from forestry

3

Nursery establishment and management

When: 4-6 weeks before transplanting

A. Learning objectives

At the end of the session, participants will:

- Understand the factors to consider during nursery site selection for tomato growing and the attributes of a good tomato nursery site.
- Be able to apply the different management practices for quality seedlings production in tomato growing.
- Find quality seed for planting.
- Understand the timing of seedling availability in tomato 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 tomato 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 tomatoes? Do you do a nursery? If yes, how do you do it (which steps, timing)?
- Why do you think it is important to have a tomato 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

- Tomatoes can be direct-seeded in the field, but this method is expensive as large amounts of seed are required (about 500 to 1000 g of seeds/ ha) and adds about four weeks of weeding labour to growing costs.
- In contrast, raising the young transplants in a special nursery enables growers to achieve great seedling uniformity, requires smaller quantity of seed and saves on weeding costs . Smaller quantities of seed are needed, the seedlings can be selected for growth and health before planting in the field, the plantlets can be well protected and the planting distance is more regular than after sowing directly in the field.
- A nursery is an area where young plants can grow with special care and protection. Tomato seedlings are first raised in nurseries because the seedlings are always needed in large numbers and seeds have more difficulties to germinate and survive when planted direct in the field.
- The seedlings are raised in beds until transplanting time when the seedlings are uprooted and planted in another prepared garden.

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 flat, fertile, and well drained piece of land.
- Close to a water source (borehole or running stream are the best as stagnant water tends to have disease causing organisms).
- Located area not infested with weeds.
- The soil should be tilled deeply.
- Not bordering other tomato gardens, or gardens planted with Irish potatoes, egg plants or pepper to avoid diseases transmission.
- Not grown with these species during the last years

Nursery bed preparation, sowing and watering

The following steps should be implemented to implement a nursery:

1. Choose an high location with good drainage
2. Remove clods of earth, stubble and perennial weeds. The seedbed should be 1m wide and 20-25 cm high. The length depends on the number of seedlings wanted. To raise a sufficient amount of plants for one hectare, 150-200 g seeds should be sown on 250 m² of seedbed.
3. Sterilize the soil by burning the top of the bed for about 10 minutes using dried vegetation. The procedures for sterilizing the bed using the direct heat method are:
 - Sprinkle water on to the bed to make it moist.
 - Heap a lot of grass on top of the bed.
 - Set it on fire starting at the end away from the driving wind. This will slow down the speed of burning.
 - Keep on adding grass for about 10 minutes. This method sterilizes the first 5 cm of the soil.



Figure 1:
A seed box prepared with a mixture of one-part well-rotted manure (cow dung) and two-part sands

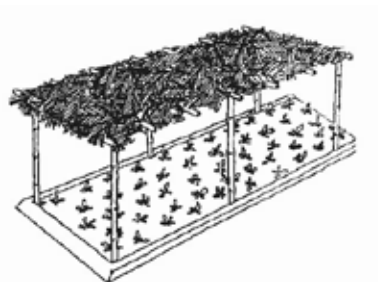


Figure 2:
Seed bed with shade

4. Allow the bed to rest for between 3 - 5 days.
5. Mix well decomposed manure and fine sand with the soil if is available and possible. Bring the seedbed to fine tilth.
6. Sow in drills 5-15 cm apart at 0.5 cm deep and cover lightly with soil. Than cover the whole bed with dry grass (mulch).
7. Shade the beds moderately with the shades slanting east at 1 meter height. This procedure is important to avoid sun and heat stress to tomato seedlings so that they grow well.
8. Water twice a day in the morning and evenings only.
9. Seeds germinate 5-8 days after sowing. Immediately seedlings start germinating remove the grass and put on top of the shade.
10. Start reducing the watering frequency after germination, control pests and diseases and keep seedlings free of weeds.
11. Stop watering completely one week before transplanting.
12. Hardening off the seedlings: after two weeks: exposure to sun light
13. After 3 weeks: seedling ready for 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 (Figure 3), which causes the stem to rot at the crown, leading to seedling death. Damping off is caused by different fungi that live in the soil (see also chapter on pest and diseases). It normally occurs in damp wet soils. Tomatoes seedlings are less susceptible to infection of damping off diseases caused by *Pythium* or *Rhizoctonia* when reach the 2- or 3-leaf stage. However, *Phytophthora* damping off disease infects tomato plants at any stage. An organic control to avoid tomato damping off in tomato nurseries, cinnamon (*Cinnamomum verum*), moringa (*Moringa oleifera*) and clove (*Syzygium aromaticum*) can be applied as extracts or powder.



Figure 3:
Tomato seedling affected from damping off disease.



Figure 4:
Tomato seedlings affected by damping off

4

Transplanting

When: at week 0

A. Learning objectives

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

- select good seedlings for tomato planting.
- plant tomatoes with the correct spacing.
- plant tomato according to the recommended practices.

B. Duration

3-4 hours

C. Learning aids

- Group demonstration field
- Hoes
- Tomato 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:

1. How would you transplant your tomato plants?
2. How would you select quality seedlings?

The transplanting will then be done practically and at the time of transplanting in the group demonstration field.

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

Transplanting, mulching, and gap filling

When properly managed in the nursery bed, seedlings are ready for transplanting 4-5 weeks after germination.

- The seedlings should not have been watered in the nursery for at least 7 days before transplanting to strengthen them.
- Water the bed heavily on the day of pulling (12-14 hours before seedlings are taken out of the seedbed) to ease lifting of seedlings and reduce injury to them. Prick out the seedlings and transplant into the main garden in the evening to avoid long day heat stress. When removing the seedlings, keep a large clump of soil attached to the roots to prevent them from being damaged.
- The seedlings are positioned in the holes. Make the holes for the plants deep enough so that the lowest leaves are at ground level. Press the soil firmly around the root, and water around the base of the plant to settle the soil.
- Spacing: 60cm x 45cm or 60cm x 60cm depending on the variety (1 plant per hole).
- Use vigorous seedlings for faster growth.
- Add water to the planting hole before planting. Water the plants immediately once they have been transplanted.
- 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 spoiled in case of rain.
- Care should be taken not to wet the lowest leaves, as this can stimulate the growth of mould.
- Eventually fill gaps (died seedlings) within 1 week of transplanting for even growth.
- The transplanted plants should be protected from heat during the first five days, e.g. by covering them with large leaves.

5

Weeding, pruning, mulching and staking

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 tomatoes.
- be able to apply the different methods of weed control in the tomatoes.

B. Duration

2-3 hours

C. Learning aids

- Demonstration field
- Staking poles/sticks
- Pruning knife

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 tomato plants?
- Do you stake your tomatoes? How and why?

- Do you prune your tomatoes? How and why?

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, pruning and staking of the tomato plants. 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 tomatoes since majority of the farmers tend to ignore this.

E. Content

Weeding

- The crop stand should be kept free of weeds at all time, because weeds compete for light, nutrients and water
- Weeds may be vectors for diseases and provide shelter for organisms that cause tomato diseases such as Tomato Yellow Leaf Curl Virus (TYLCV), and reduce the yield.
- Hand weeding is recommended.
- The following integrated practices are useful for controlling weeds effectively:
 - o Remove the previous crop residues and use sanitation practices to avoid introducing weed seeds.
 - o Deep cultivation and exposing soil to sunlight before transplanting help to destroy the weed seeds.
 - o It is important to keep the field weed free for 4-5 weeks after transplanting. It is during this period that weed competition must be suppressed to avoid reduction in yield.
 - o Weeds growing between crop rows are the easiest to control. Shallow ploughing (up to a depth of 15-20 cm) or using mulch usually removes them.

Pruning

- Pruning is important for tomatoes, especially for thick bush and indeterminate types. It improves the light penetration and air circulation. The need for pruning depends on the type of plant and the size and quality of the fruit. If plants are not pruned, they will grow at random and fruit will be smaller.
- Pruning the side-shoots is called nipping. Pruning the tops of the stem is called heading.
- **Nipping:** The lower side-shoots should be removed by pinching them out with the fingers and only one main stem should remain. If they are allowed to grow they will produce masses of foliage but few tomatoes. Nipping enhances quality and size of the fruits.



Figure 4: nipping of site-shoots should be done regularly

- Heading:** The tip of the main stem of the tall type is pinched off when 3 to 5 leaves are fully grown. The shoots that grow out of the top 2 to 4 buds are left to grow. In this way 2 to 4 side-shoots will grow as main stems, supported by sticks (see Figure 3). When these stems are 1 - 1.25 m long, the tops should also be pinched off. New side-shoots should be removed regularly by nipping them. Usually 3 to 4 fruit clusters grow along each stem. To avoid the spread of diseases from plant to plant, do not use knives for pruning 'Pinch out' the side-shoots instead using your thumb and forefinger.

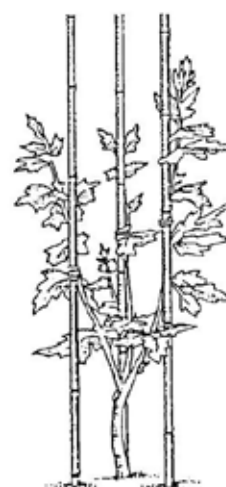


Figure 6: A tomato plant of which the top three side-shoots are supported (source: Agrodok 17)

- Trimming leaves:** old, yellow or sick leaves should be removed from tomato plants. This controls the development and spread of diseases. Be careful when pruning the plants. It is very easy to spread disease via your hands or any tools that are used, so avoid sick plants. Clean tools regularly. It is best to prune in the morning on a sunny day so that the wounds can dry quickly. It is advisable to burn or bury the infected leaves to avoid disease infections.
- Bush varieties require no pruning for most of the season. Remove any yellow or decaying foliage as soon as possible to avoid the spread of disease. If plants become too large to support themselves, either trim out a few major branches or add more support canes. The side branches can be tied on to the additional support canes.
- 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.
- When the plant has developed 6-7 branches with tomatoes, stop the plant from growing further by breaking off the growing tip. If more than seven branches of tomatoes begin to develop, pinch extra branches out to encourage the plant to produce good quality tomatoes rather than an

abundance of low-quality late-maturing fruits.

- Flowers should be pruned to 5-6 per cluster for medium- large sized fruits.
- When the plant has developed 6-7 branches with tomatoes, stop the plant from growing further by breaking off the growing tip. If more than seven branches of tomatoes begin to develop, pinch extra branches out to encourage the plant to produce good quality tomatoes rather than an abundance of low-quality late-maturing fruits.
- Flowers should be pruned to 5-6 per cluster for medium- large sized fruits.

Mulching

Should be done to reduce soil temperature, conserve soil moisture, and prevent soil erosion. Different materials like dry grass/non seeded weeds can be used to cover the soil. This is especially important where no staking is done. Tomatoes are very sensitive and once not mulched and staked, soil bacteria can cause diseases to the fruits. It is advisable to mulch after first weeding.



Figure 7: staking in tomatoes

- Staking or trellising tomato plants with bamboo poles, wood stakes, or other sturdy material provides support and keeps the fruit and foliage off the ground. Staking will increase fruit yield and size, reduce fruit rot, and make spraying and harvesting easier.
- Staking is usually done early – three weeks after transplanting – to minimize plant damage
- Indeterminate varieties should be staked to facilitate pruning, pinching, harvesting and other cultivation practices.
- Determinate varieties should be staked in the wet season to prevent fruit contact with the soil.
- Rice straw, plastic strips, horticultural fixing tape or other materials can be used for fixing. Fixing should be done to support fruit clusters. Tie a string lightly on the tomato and then gently twine the string around the plant to avoid snapping the stem.

6

Pests and diseases management in tomatoes

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 tomatoes and their effects.
- Recognize the signs and symptoms of different pests and disease attack in tomatoes.
- Apply the Integrated Pest and Disease management approaches in tomato production.
- Understand the critical stages of growth of different pests to target control in tomato production.

B. Duration

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 minutes)

The trainer will introduce the topic of the day pointing out what is to be learnt, including the different pests and diseases affecting tomatoes 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 tomatoes do you encounter in your field
- What symptoms of pest attack and diseases have you seen on your tomatoes?
- 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 tomato field and the tomato 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 main 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 pest and diseases that may affect tomato.

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.

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. 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 and staking** – reduces contact of soil and the plant parts. Most tomato diseases are soil borne. Staking also improves crop coverage during spraying.
- i) **Remove affected plant parts**

Common tomato pests and and their control

Aphids (Figure 4), thrips, whiteflies, Cutworms, bollworms, leaf miners, Spider mites and nematodes are the most common pests that attack tomatoes.

Nematodes



- Nematodes are very small worms living in the soil that feed on plant roots. Due to their small size (only a few mm long), it is not possible to see them with the naked eye.
- Nematode infestation and transmission can occur in many ways: via infected plant material, tools, rainwater and irrigation water, strong winds (which carry infested soil particles), and contaminated soil carried on shoes, or animal feet. Nematodes will survive in soil as long as it stays moist.

Signs, symptoms and damages

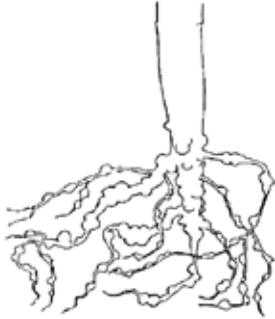






Figure 8: roots of tomatoes with gale caused by nematodes

- Some nematodes feed from the outside of plants, others enter the plant. All feed on the plant's sap, which can reduce the plant's productive capacity.
- Even greater damage can occur if viruses or fungi enter the plant as a result of the injuries caused by the nematodes, and then proceed to make the plant sick, and eventually die.
- Root-knot nematodes are of major importance in tomato cultivation. They cause galls (infected swellings) on plant roots (see Figure 11). Three common types of root-knot nematodes are: *Meloidogyne incognita*, *M. javanica* and *M. arenaria*.
- Affected plants remain small. Nematodes cause yield losses of about 30% in tomato in the tropics.
- If you discover an area in the cultivated field where part of the crop is clearly lagging behind in growth, the plants are lighter in colour, and their leaves are abnormally shaped but do not show signs of a mosaic pattern, then you may well have a nematode infestation. It usually begins in a small, limited part of the cultivated area, and spreads slowly throughout the plantation.

Prevention and treatments



- Rotate tomato with other crops such as cereals, cabbage, onion, ground nut, cassava, sesame, etc. Do not rotate with Solanaceae. It is not advisable to rotate with crops of the Cucurbitaceae family (e.g. cucumber or pumpkin) or papaya either, as these can also cause the transmission of diseases.
- Remove weeds and plant remains (rotten leaves and fruit).
- Interplant with plants that emit substances via their roots which nematodes do not like or which kill them, such as sesame or African marigold (*Tagetes erecta* and other related varieties).
- Expose the soil to sun and wind. Plough the soil several times. The nematodes will be ploughed up to the surface of the soil and will be exposed to the sun and high temperatures, which kill them.
- Chemical pesticides (nematicides) and soil sterilants (including steamtreatment) are effective but costly control methods. They should only be used at last resort.

<p>Aphids</p>   <p>Figure 9: Aphids in the under side of a leaf</p>	<ul style="list-style-type: none"> ▪ Aphids are soft, oblong insects about 2.5 mm in length (Figure 13). ▪ There are aphids with and without wings.
<p>Signs, symptoms and damages</p>	<ul style="list-style-type: none"> ▪ Direct damage occurs when they attack the crop in large numbers, especially the youngest leaves and stems. ▪ Aphids also transmit several viruses.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Remove old crop debris before sowing new crop. ▪ Intercrop with other crops. ▪ Use nitrogen fertiliser in moderate amounts; apply organic fertilisers. ▪ Spray a solution of soap, cow urine or extract (<i>Azadirachta indica</i>). ▪ Cover the ground with grey plastic sheeting, which repels the aphids by reflecting sunlight.
<p><i>Thrips</i></p>   <p>Figure 10: thrips feeding on a tomato leaf</p>	<p>Thrips are very small insects, only 0.5 to 2 mm long . You have to look carefully to spot them. They usually have wings.</p>

Signs, symptoms and damages



Figure 11 Thrips damage on a flower bud



Figure 12 Thrips damage to a tomato






Figure 13 Thrips damage to a tomato leaf

- Thrips lay their eggs on the leaf. The larvae appear after about 10 days. The larvae and adult thrips suck the leaf sap, causing silvery spots on the leaf surface.
- The adult thrips also leaves its excreta on the leaf as small black dots.
- A few thrips species are vectors of Tomato Spotted Wilt Virus (TSWV).

Prevention and treatments

- Cover the ground with plastic sheeting to prevent the thrips from passing into the soil for their cocoon stage.
- Plough well, so that cocoons are brought to the surface where they will dry up and die.
- Remove crop debris.
- Spray plants with a solution of soap or neem extract (*Azadirachta indica*). This will not affect the cocoons in the soil so repeat spraying regularly to kill the aboveground adults.

<p>White fly</p> 	<ul style="list-style-type: none"> ▪ The adult fly is white in colour and 1-2 mm long. It feeds, just like the larvae, on the leaf sap.
<p>Signs, symptoms and damages</p> 	<ul style="list-style-type: none"> ▪ When plant leaves are turned over, a whole swarm of whitefly may fly up. They lay eggs on the underside of the leaves. ▪ Whitefly are especially a problem in the dry season. Once the wet season starts they disappear.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Encourage the presence of natural predators of whitefly, by planting shrubs or other plants between the crop rows (interplanting) or along pathways between borders. ▪ Use resistant cultivars (hairy leaves make it difficult for the whitefly to lay its eggs). ▪ Spray a solution of kerosene and soap to control whitefly
<p>Butterflies and moths (Lepidoptera)</p> 	<ul style="list-style-type: none"> ▪ Butterflies and moths are common pests in tomato crops. ▪ They lay green or brown eggs on young leaves, flowers and fruit. ▪ The hatched larvae (caterpillars, Figure 15) feed on leaves, flowers, fruit and even the roots. ▪ While feeding, the caterpillars grow in size, passing through a number of larval stages. Eventually they form cocoons in the soil. A few weeks later these hatch and the adult butterflies fly out and disperse.

Signs, symptoms and damages



Figure 14: Bollworm feeding on tomato fruit



Figure 15: Cutworm destroying tomato plant

- Depending on the species, different parts of the plants (fruit, leave, root) may be affected.

Prevention and treatments

- Remove weeds regularly.
- Plough one month before sowing or transplanting.
- Remove and destroy the infected fruits.
- Use crop rotation.
- Check regularly for the presence of eggs and then take measures to
- control the young larvae.
- Use light traps that attract moths at night, preventing them from laying their eggs on the plants.
- Apply wood ash, wood chips or shavings and/or calcium on the seedbeds.
- Intercrop with cabbage.
- Spray *Bacillus thuringiensis*, a biological insecticide, which you can buy from your pesticide supplier.
- Spray with a neem solution (*Azadirachta indica*) or other locally used natural pesticides.

Helpful insects


Some insects 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 tomato diseases and their control

Tomato plants are susceptible to several fungi, bacteria and viruses. Fungi and bacteria cause foliar (leaf), fruit, stem or root diseases. A virus infection often leads to dwarfed growth and decreased production. Damage caused by diseases can result considerable yield losses for a farmer.




Bacterial diseases


Bacterial wilt (caused by <i>Ralstonia solanacearum</i>)	<ul style="list-style-type: none">▪ Soil born disease▪ 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.▪ The bacteria survive in the soil and enter roots of young plants through wounds made by transplanting, cultivation, insects or certain nematodes. The bacteria are spread through irrigation water, soil movement, or moving infected plants (e.g. when transplanting).
Signs, symptoms and damages  Figure 16: Stem of tomato plant affected by bacterial wilt	<ul style="list-style-type: none">▪ Rapid wilting of the youngest leaves at the ends of the branches without yellowing or spotting leaves 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.▪ Brown colorations are evident inside the stems of bacterial wilt infected tomato plants.






Prevention and treatments



- Use of resistant varieties.
- Crop rotation.
- Avoid infested fields. Once the soil has been infected, do not grow Solanaceae for at least 7 years. Rotate with cereal crops.
- Do not injure roots or leaves, so be careful during transplantation and prune as little as possible.
- Make sure the field is well drained.
- If necessary, sterilise the soil (see Agrodok 9: Vegetable gardening in the tropics).


<p>Bacterial canker (caused by <i>Clavibacter michiganensis</i>)</p>	<ul style="list-style-type: none"> ▪ Economically important tomato disease that occurs worldwide. ▪ Spread via seed or the soil or infected via injured stems or roots. ▪ The bacteria can survive in plant debris.
<p>Signs, symptoms and damages</p>   	<ul style="list-style-type: none"> ▪ Damage may be severe when root-knot nematodes are present. ▪ Symptoms may be noted on leaves, stems, and inside fruits. ▪ Areas of leaves above the second or third cluster may show dull green, yellow and water-soaked areas. ▪ Wilting progresses until the plant dies. ▪ Long, brown stripes, which can split open, appear on the stem. Adventitious roots may develop on the stems. ▪ Stems may also display cankers under some conditions. Internally, the vascular tissues of the stems display light yellow to brown streaks. ▪ 'Bird's eyes', round slightly raised spots with a red dot surrounded by a white ring, appear on fruits. These do not always occur, but are a helpful diagnostic aid when present.

<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Use diseases-free seeds or transplants. ▪ Soak seeds for 30 minutes in water at 56°C, or 5 hours in a 5% solution of hydrochloric acid to ensure disinfection. ▪ Plant into a clean field. ▪ Disinfect pruning tools before each use and clean them well after use. ▪ Remove and burn crop debris. ▪ Rotate tomatoes with a non-host crop.
<p>Early blight (caused by <i>Alternaria solani</i>)</p>	<ul style="list-style-type: none"> ▪ Early blight is a fungus caused tomato disease. ▪ spread via seed, wind, rain and infected plant remains. Plants that have been damaged are more susceptible to this fungus.
<p>Signs, symptoms and damages</p> 	<ul style="list-style-type: none"> ▪ Lower leaves show brown or black spots with dark edges, almost like a target. ▪ Stem ends of fruits may be attacked, showing large, sunken black areas with concentric rings. ▪ This fungus strikes after plants set fruits. ▪ Flowers and small fruit fall off.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Crop rotation: Avoid to grow tomato on the same location as egg plants, potato and pepper for 4-6 years. ▪ Do not plant young plants near older plants. ▪ Make sure the plants have enough water but avoid excessively moisture or humidity on the tomato field. ▪ Use tolerant varieties. ▪ Remove and burn damaged plant parts. ▪ Weed regularly and thoroughly. ▪ Use pathogen-free seeds. ▪ Apply effective fungicides, if available


<p>Late blight</p>	<ul style="list-style-type: none"> ▪ The disease is very common particularly during the rainy season but also when there is excess of moisture or humidity.
<p>Signs, symptoms and damages</p>  <p><i>Figure 17: Signs of late blight on fruits</i></p>  <p><i>Figure 18: Signs of late blight on leaves and stem</i></p>	<ul style="list-style-type: none"> ▪ It can spread very fast wiping away plants within a short time and it also affects fruits. ▪ 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. ▪ Rapid death of the entire plant.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Remove and destroy the infected leaves (be sure to wash your hands afterwards to avoid other plants contamination). ▪ The best control measure for late blight is prevention avoiding excessively moisture and humidity on the field.
<p>Fusarium and verticillium wilt (caused by <i>F. oxysporum</i>)</p>	<ul style="list-style-type: none"> ▪ These wilt diseases are caused by fungi in the soil that enter through young plants, then begin to plug the vessels that move water to the roots and stems of the plants.

Signs, symptoms and damages	<ul style="list-style-type: none"> ▪ Without enough water, the plants begin wilting on sunny days, although they will appear to recover at night. ▪ Tomato wilt may first appear in the top or lower leaves of the plant, causing them to lose color and turn yellow, then die back from the tips. ▪ The plant may wilt on only one side or on a leaf, while the other half or rest of the ▪ plant remains healthy for a long time. ▪ The process continues until the entire plant is affected. ▪ A brown stain can be seen if the stem or roots are cut. ▪ Pink fungus fluff is found on dead plant parts. 
Prevention and treatments	<ul style="list-style-type: none"> ▪ Use resistant tomato varieties ▪ Minimise the watering schedule. To prevent the soil drying out ▪ apply mulch on the seedbed. ▪ Remove and destroy all affected plants. ▪ Avoid using location for tomato, egg plants, potato and pepper for 4-6 years, because the fungi that cause the wilt can remain in the soil that long without a host to infect. ▪ Decrease the acidity of the soil by applying calcium or marl.
Anthraxnose (caused by Colletotrichum coccodes)	<ul style="list-style-type: none"> ▪ The disease spreads quickly in humid weather, and when it is hot and humid.

 <p>Signs, symptoms and damages</p>	<ul style="list-style-type: none"> Signs of infection by this disease are grey-brown spots (dents) on the fruit and, in humid weather, salmon-pink spores.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> Transmission is most common via infected plant material (especially the fruit). Therefore, measures relating to crop hygiene are very important. Choose resistant plant varieties. Do not compost infected fruits, leaves or stems and clean up the garden after harvest, to reduce over wintering of fungal spores. Use of organic fungicide like Neem oil spray
<p>Septoria leaf spot</p>	
<p>Signs, symptoms and damages</p> 	<ul style="list-style-type: none"> Small black spots may show up in the center. The affected leaves turn yellow, wither, and fall off.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> Correct spacing between tomato plants. When watering tomatoes, water at the base of the plants.
<p>Damping off</p>	<ul style="list-style-type: none"> Damping off is a fungal disease that causes sudden collapse of seedlings or failure to germinate.



 <p>Signs, symptoms and damages</p>	<ul style="list-style-type: none"> ▪ Seedlings fail to emerge from the soil resulting in patches that appear to have germinated poorly. Alternatively, seedlings may emerge but fall over and die some time afterwards. ▪ First leaves appear water soaked and mushy. ▪ Very thin stems that become wet and brown ▪ Damping-off can occur when seedlings die before they have pushed through the soil, resulting in patches that appear to have germinated poorly. Alternatively, seedlings may emerge but fall over and die some time afterwards. The base of stem of affected seedlings become wet and brown. These disease-causing fungi are common in moist soils. They can also be transmitted on seeds.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Do not site seedbed on a field previously planted with eggplants, pepper, potatoes or tomatoes. ▪ Use clean land, if reusing the old plots, it is important to sterilize them. ▪ Use certified disease-free seeds. If it is farmer-saved seed, it can be given hot water treatment. ▪ Plant seeds when soil is at optimum temperature. ▪ Presoak seeds to speed germination. ▪ Remove all infected seedlings immediately. ▪ Solarisation of seedbed should be done where feasible. ▪ Avoid excessive watering. Allow the soil to dry between watering.

Common tomato virus diseases and their control

<p><u>Mosaic virus</u></p>	<ul style="list-style-type: none"> ▪ Mosaic virus attacks many kinds of plants and is common in tomatoes. While mosaic disease does not kill the plant, it diminishes the number and quality of fruits. ▪ Seeds transmit the virus.
 <p>Signs, symptoms and damages</p>	<ul style="list-style-type: none"> ▪ yellow-green spotted leaves, rolled-up leaves, stunted growth and discolouration of fruits and internal browning under the skin
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ The virus enters through cuts in leaves and stems, so avoid handling the plant as much as possible. ▪ The virus also attacks tobacco and can be transmitted from it, so if you have handled cigarettes or other tobacco products recently, wash hands thoroughly with soap first entering the field. never smoke tobacco near the plants - even cigarette ash can transmit infection. ▪ Planting resistant varieties. ▪ Crop rotation. Do not grow other Solanaceae near the field. ▪ Use pathogen-free seed and destroy infected plants.

Other problems

<p>Blossom-End Rot</p>	<ul style="list-style-type: none"> ▪ This disease is caused by a lack of calcium, most often brought on by fluctuating water or a result of too much salt in the soil, which is caused by the use of saline water, or irrigating with too little water during the dry season.
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<p>Signs, symptoms and damages</p> 	<ul style="list-style-type: none"> ▪ It appears as a sunken, dead area opposite the stem (the blossom-end of the fruit). ▪ The area will expand as the fruit matures.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ Water plants regularly to maintain moist, but not waterlogged soil. ▪ Spread a 2-inch thick layer of mulch around plants to conserve soil moisture. ▪ Prevent calcium deficiency in the soil. ▪ The amount of salt in the soil can be lowered by flushing it out with one or more abundant applications of salt-free irrigation water (normally during the rainy season), making sure that there is good drainage.
<p>Sunscald</p>	<ul style="list-style-type: none"> ▪ essentially a sunburn on a tomato fruit.
<p>Signs, symptoms and damages</p> 	<ul style="list-style-type: none"> ▪ Sunscald cause a section of the fruit to become soft, light in color and dry.
<p>Prevention and treatments</p>	<ul style="list-style-type: none"> ▪ It is important to maintain enough foliage to shade fruits from strong sunlight.

7

Tomato harvesting

When: 11-20 weeks

A. Learning objectives

At the end of the training, the participant will:

- be able to identify signs of maturity and ripening in the tomato crop
- know when to harvest tomatoes
- know the different methods and practices of harvesting of tomatoes

B. Duration

2-3 hours

C. Learning aids

- Tarpaulins
- Containers/wooden boxes
- Demonstration garden

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 and ask the following questions to stimulate the discussion:

- What are signs of maturity and ripening in the tomato crop?
- What is the correct stage of harvesting? When do you harvest your tomatoes?

- What are the common mistakes made by farmers during harvesting of tomatoes?

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 tomatoes.

Demonstration (2 hours)

The participants, together with the facilitator, will harvest the tomatoes. 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

Harvest management practices

- Tomatoes take around 90 days to mature (including days in the nursery bed).
- It will be necessary to harvest several times as the fruit of tomato plants do not all ripen at the same time » the harvesting continues for up to 2 months.
- Important considerations during harvest practices are the proper stage of fruits maturity, the way the fruit is detached from the tree and the time of harvesting.
- Harvest maturity
- Quality tomatoes are firm and are uniform in colour.
- Tomatoes are ready for harvest as soon as they are mature but still green.
- If the tomatoes are to be used for the production of, for example, ketchup, chutney, purée or juice, the fruit must be picked when it is red and completely ripe.
- If the tomatoes are to be sold as vegetables on the market, they can be harvested while still green. Green tomatoes can be ripened after picking, until they are red. A few red, ripe tomatoes will speed up the ripening process. One disadvantage of early picking is that the nutritional value of the tomatoes is lower. One advantage is that green tomatoes are less likely to get damaged or to rot.
- Tomatoes can be classified in four stages of maturity:
 - **Stage 1:** Seed are white in colour (immature) and can be cut when the tomato is sliced. There is no juice inside the tomato.
 - **Stage 2:** Seeds have a tan colour (mature) and some juice present.
 - **Stage 3:** Seeds are pushed aside when cut. The colour inside is still green.
 - **Stage 4:** Juice becomes red in colour.
- Tomatoes that are harvested at the first stage of maturity will ripen into poor-quality tomatoes. Tomatoes harvested at third and fourth stages of maturity will ripen into good-quality tomatoes.
- Representative samples of green mature fruits are cut crosswise and if the seeds slide without being cut, then the tomatoes of the same variety can be considered mature.
- Immature fruits when picked, fail to develop full color and flavor and deteriorate easily



Figure 14: Tomato should be picked when they are mature but still greenish

Time of harvesting

- Pick tomatoes during the cooler part of the day.
- It is recommended to harvest up to noontime and to keep the harvested fruits in a shaded area soon after picking. A rise in fruit temperature occurs when the fruits are left exposed to the sun. Heating up will result in accelerated ripening of fruits.
- Harvesting method
- Harvesters should observe good personal hygiene during harvesting.
- Harvest tomato carefully by hand picking. Mature fruit is best removed by a “lift, twist and pull” technique.
- Harvested tomatoes should be placed in clean collecting containers such as plastic pails with smooth inside finish and then transferred to field containers like the wooden boxes with smooth lining.
- While harvesting, avoid throwing tomatoes into the container, dropping, and dragging of containers during hauling causing fruits to bump against each other must be prevented. These poor handling practices will result in both visible and non-visible damages like internal bruising. Visible injuries can be in the form of cuts, punctures or abrasion. Internal damage will appear later as brown or black discoloration in the seed area or manifested as faster ripening and increased susceptibility to decay.
- Picking containers should never be too full.

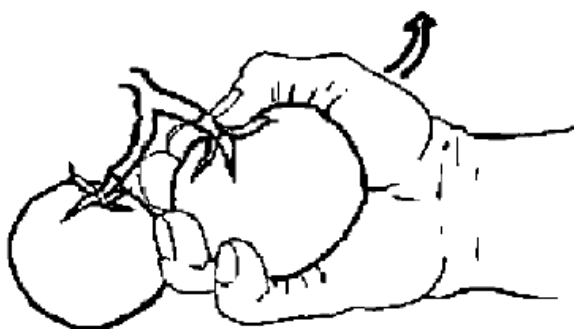


Figure 15: proper way of harvesting tomatoes (Agrodok 17)

8

Post harvesting and handling of tomato

When: 11-22 weeks

A. Learning objectives

At the end of the training, the trainees will:

- know the different stages of post-harvest handling in tomatoes
- be able to identify common mistakes during post harvesting and handling that affect quality and quantity in tomato production
- be able to apply basic technologies of post-harvest handling for tomatoes

B. Duration

4 hours

C. Learning aids

- Stationery
- Packaging boxes
- Tomato fruits

D. Activities and exercises

Introduction (20 minutes)

The trainer will start the topic of the day. The following questions can be used to stimulate the discussion:

- How do you handle tomatoes after harvesting
- to which aspects should you pay attention?

Demonstration (2 hours)

This training should be at the time the farmers are harvesting so that the knowledge the farmers will get they will use at their household level. Participants, together with the facilitators, will apply post-harvest operations.

Summary (30 minutes)

The facilitator will summarize important aspects of post-harvest handling of tomatoes.

E. Content

Post-harvest handling of tomatoes

Proper post-harvest handling is important in maintaining the quality and ensuring safety of tomatoes at all handling stages. In many cases farmers pay keen attention on good agronomic practices of tomato production but pay less attention to post-harvest handling and end up with a lot of post-harvest losses in terms of quality and quantity.

Post-harvest handling operations

Post-harvest operations refer to activities done to the fresh produce in preparation for marketing. These operations can be done in the field, in collection centers or in a packing house. The packing area should provide adequate protection from sun and rain, kept always clean, and pet animals should be kept away from the packing area. After harvesting ripe tomatoes, they should be stored in a cool place if they are not sold immediately. It is essentially to avoid to let the ripen tomatoes under sunshine to avoid the bursting of the fruits.

Cleaning/washing

In places where tomatoes are not staked and grown during the rainy season, soil particles may adhere on the fruit. Soil-borne decay-causing microorganisms can cause fruit rots thus the need to clean them prior to marketing. Fruits should be dried properly prior to packaging.

Tomatoes can also be cleaned by wiping them with moist cloth. Ensure however, that the water and the cloth used in wiping the fruit are clean to prevent contaminating the fruit.

Sorting/grading



Figure 21 sorting and grading tomatoes

Good quality tomatoes are generally preferred by buyers; thus sorting/grading of fruits is a necessary operation. Sorting is the grouping of tomatoes based on the criteria of the one classifying and there is no definite set of standards followed.

Good quality and safe tomato fruits are mature, clean, well-formed, free from insect and disease damage, free from mechanical damage such as cuts, abrasion, and punctures, free from microbial, chemical, and physical contamination.

Because the harvesting time of tomatoes continues at intervals for up to two months it is important to pick fruits as they ripe and according to your market demand.

Tomato fruits with the following defects, on the other hand, are most likely to be rejected:

- Insect-and disease-damaged.
- Mechanically-damaged such as cuts, punctures, abrasion, compression.
- With preharvest defects such as deformation and cracks. physical contamination.

Packaging

Proper packaging is essential in maintaining product quality during transport and subsequent handling.

Packaging materials

Rigid containers such as plastic crates and wooden boxes with smooth linings are highly recommended for tomatoes since they provide adequate protection against compression damage. They have smooth inside finish and can be easily cleaned. They are also stackable and reusable/returnable.



Figure 22: Wooden boxes for tomatoes transportation



Figure 23 Packaging of tomatoes in crates

Considerations in the use of wooden boxes

- **Hygiene** – should be thoroughly cleaned with soap/detergent after use.
- **Handling** – handle with care during loading, stacking, and unloading; do not drop.
- Do not use the boxes as seats when sorting.
- **Storage** – store them in a clean area free of insects and rodents.
- Store separately from chemicals and farm machinery to prevent contamination.
- Do not use as storage container for chemicals (fertilizers and pesticides) if used for fresh produce.

Transport

The main objective in transport is to ensure that tomatoes will arrive in top quality condition to the final market. This includes movement from the garden to the homestead and later to the market.

In all the post-harvest and handling stages, it is important to follow proper transport practices:

- Handle containers/boxes gently; they should not be dropped or thrown on to each other.
- Do not sit on top of packed tomatoes during field transport.
- Do not expose tomatoes to the sun during transport.
- Allow air to circulate in the stacks or piles of produce by providing space in between stacks

9

Tomato seed production

A. Learning objectives

After completing this module, participants will:

- Know the right ripe stage to produce tomato seeds
- be able to extract and store tomato seeds for the next crop generation

B. Duration

2 hours

C. Learning aids

- Ripe tomatoes or a tomato fields with the right ripening stage of fruits
- Containers
- Knives
- Teaspoons

D. Activities and exercises

Introduction (20 minutes)

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

- Where do you procure your seeds?
- Do you produce your own seeds?
- If yes, how? If not, why not?
- What is the right tomato ripening stage to extract seeds?

Exercise tomato seeds extraction (1 hour)

The trainer asks some questions to the trainees

- Has someone already extracted tomato seeds?
- What is the right tomato ripening stage to extract seeds?
- The trainer together with the trainees look for tomatoes to extract seeds in

the field and start the extraction procedure step by step. Because after the extraction the seeds need a fermentation time of 2-3 days the trainer can prepare in advance fermented seeds for this exercise for the steps 4 and 5. Otherwise the exercise is split up in two sessions and the trainees work on their own fermented seeds after 3 days.

Summary (10 minutes)



At the end of the exercise the trainer will summarize again all the steps for the seeds extraction.

E. Content

For own seed production, it is not recommended to use hybrid (F1) varieties. Hybrids are plants that are a result of artificial cross-pollination. The first crop from hybrid seeds will produce well, but it is not advisable to use second-generation seed for planting. The chance that you will get plants with inferior characteristics is high. New seed must be bought and used for each crop.

If you want to produce your own seeds, you need to work with non-hybrid varieties!

Table 2: steps to produce seeds from tomato

<p>Step 1</p> 	<ul style="list-style-type: none"> ▪ The plot where to choose the tomato to extract seeds should not previously have had tomatoes planted recently. ▪ Choose ripe fruits only from robust and disease and pest-free plants. ▪ Wash the tomato fruit. ▪ Cut the tomato in two pieces. The best is if the cut is done halfway between the top and bottom of the tomato to expose the maximum number of seeds.
<p>Step 2</p> 	<ul style="list-style-type: none"> ▪ Extract the seeds may using a teaspoon. Put the seeds into a container including the liquid surrounding the seeds. A small amount of the harder tomato flesh may also be included but do not worry about it. ▪ You can also simply squeeze the tomato halves to extract the seeds but at this stage they are very soft and easily damaged, so pay attention! ▪ We do not recommend to add water at this point

Step 3



- Cover the top of the container with cling film cutting a couple of slits in it or cover it with cloth or paper. This is useful to keep away dirt and other possible contaminants.
- Place the container in a warm, dry and shaded position. Let the seeds stand for 2 to 3 days.
- Stir the seeds daily to ensure uniform fermentation and to prevent seed discoloration

Step 4



- Wash the fermented seeds with clean water well until the liquid is clean.
- Any seeds that float during washing should be discarded because they are either not fully ripened or filled properly.
- Dry the seeds in indirect light and in well-ventilated places. The seeds could be spread out over a clean manila sack to dry

Step 5



- In case the tomato seeds cannot be sown immediately, they should be stored well. A waterproof container (transparent plastic bag, non-colored glass bottle) are good storing possibilities.
- Store the seeds in a cool place, as dry as possible.
- Check the seeds regularly once a week, if mould develops dry the seeds again

10

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

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	2 man days	2000	4000
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.

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. (See Page 64)

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

Introduction

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

- 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?

Summary of tomato growing weekly activity plan

Week	Growth stage	Critical activities	Recommendations
4-6 weeks before trans-planting	Nursery bed preparation Germination after 5-8 days	<ul style="list-style-type: none"> • Prepare the nursery bed • Monitoring • Sowing (4 – 5 weeks before intended transplanting date) • Watering • Raise the shade • Thinning • Pest and disease management • Hardening 	<ul style="list-style-type: none"> • 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 immediately after germination • Reduce watering gradually • Remove the shade gradually
0	Pencil thick	<ul style="list-style-type: none"> • Transplant and mulch • immediately after transplanting. 	<ul style="list-style-type: none"> • Use clean material for carrying the seedlings • Transplant in the evening • Take care not to mulch with materials having viable seeds as these will become weeds
1		<ul style="list-style-type: none"> • Gap fill 	<ul style="list-style-type: none"> • Keep the field free of weeds all the time • Use vigorous seedlings for faster growth
2 and 3	The fourth and fifth leaves emerge	<ul style="list-style-type: none"> • First weeding • Monitoring for pests (cutworms and crickets) 	<ul style="list-style-type: none"> • Remove the weeds from the field, taking care not to injure the plants
4	Vegetative growth	<ul style="list-style-type: none"> • Monitoring for pests and diseases cutworms, aphids, bacterial wilt) • Staking starts 	<ul style="list-style-type: none"> • Spray with organic concoctions/ • Pyrethroid and dimethoate derivatives • Fungicides (mancozeb, dithane M45) • Phytosanitation

5	Flowering starts and production of suckers (Explain what suckers Are)	<ul style="list-style-type: none"> • Monitoring for pests and diseases (aphids, thrips, late blight, bacterial wilt) • Pruning should start 	<ul style="list-style-type: none"> • Phytosanitation • Reduce movement in the field
6	Flowering	<ul style="list-style-type: none"> • Monitoring for pests and diseases (Bacterial wilt, Late blight) • More pruning - with care to avoid flower damage) 	<ul style="list-style-type: none"> • Spray with organic concoctions/Pyrethroid and dimethoate derivatives • Phytosanitation • Avoid movements in the garden
7	Fruit formation starts	<ul style="list-style-type: none"> • Second weeding starts • During second weeding, • Monitoring for pests and diseases (Late blight) 	<ul style="list-style-type: none"> • Move carefully in the garden • Fungicides (mancozeb, dithane M45)
8	Fruits increase in size	<ul style="list-style-type: none"> • Field monitoring to check for diseases/pests (Boll worms, fruit canker) 	<ul style="list-style-type: none"> • Limit movements in the field, and where necessary, move carefully in the garden
9	Physiological maturity signs appear (10% maturity)	<ul style="list-style-type: none"> • Field monitoring for diseases/pests 	<ul style="list-style-type: none"> • Guard against intruders (thieves) • Reduce movement in the field • Phytosanitation • Organize the items used during harvesting
11-20	Harvesting	<ul style="list-style-type: none"> • Field monitoring for theft 	<ul style="list-style-type: none"> • Guard against intruders (thieves)
11-22	Post-harvest handling	<ul style="list-style-type: none"> • Follow the recommended PHH practices 	<ul style="list-style-type: none"> • Guard against intruders (thieves)

