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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPI
MINISTRY OF AGRICULTURI

TOMATO PRODUCTION

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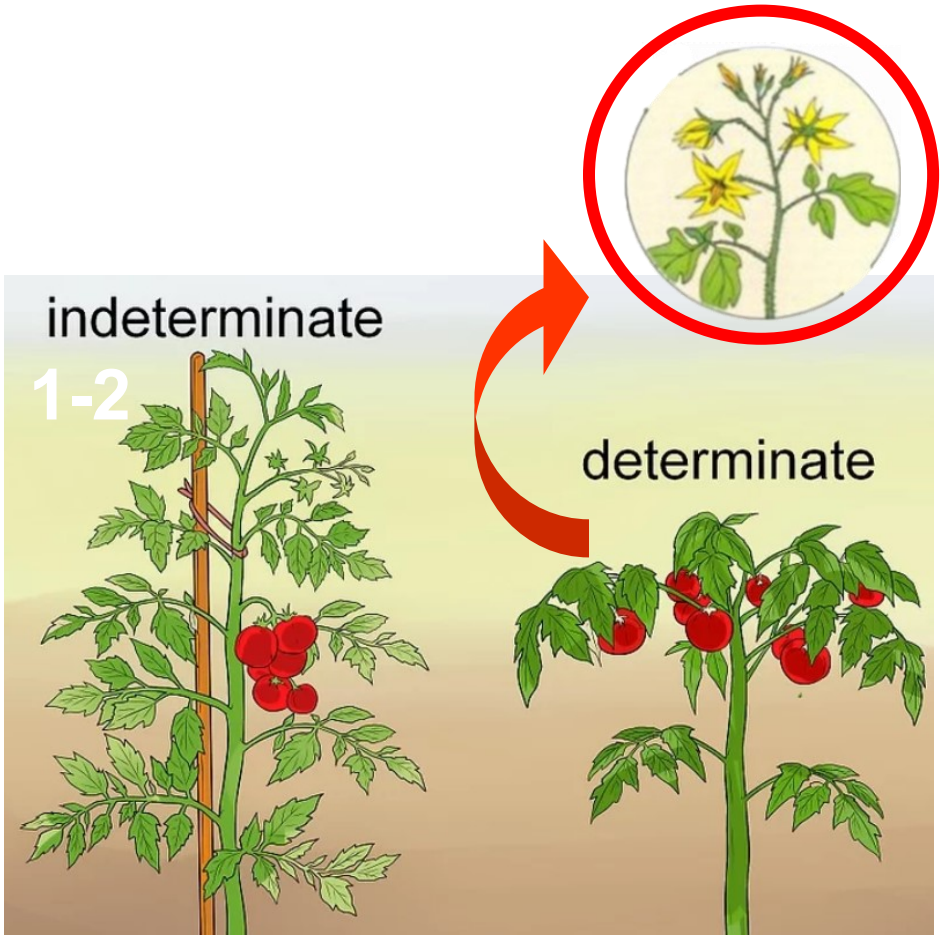
1. Introduction:
1.1 Background

Tomato

1. Introduction:
1.1 Background

- Tomato is a member of the ***Solanaceae* family** which includes crops such as **Irish Potato**, **Green Pepper**, **Chili, Eggplant and Tobacco**
- One of the most produced and consumed vegetables in Ethiopia
- Important cash crop for smallholder farmers
- Mainly grown in open fields
- Green house tomato production is still not common for smallholder producer in Ethiopia
- Rich in **Vitamin A and C**
- Used in preparing **salads**, processing **tomato paste**, **jam**, **sauce**, **catchup**, and **juice** etc.

1.2 Some Common Semi determinate Varieties



Two types of Tomato “indeterminate” & “determinate

1.2 Some Common Varieties

- There are two different habits of growth of tomatoes called “determinate” and “indeterminate”

“determinate” (dwarf)):

- The plants are bush-like (40-65cm tall), compact in growth, and mature their fruit within a relatively short period (within 2-3weeks)
- Do not require heavy pruning or sucker removal for good crop yield
- No need to do any pruning above the flower cluster. If you prune them, you are removing fruit-bearing branches
- Advantages: staking to support the plants is not a must (**minimal staking**) and it can harvest by mechanically

“indeterminate” (tall-growth)

- Indeterminate varieties grow like vines; therefore they need staking and branch control
- Labour intensive
- Longer harvesting period

1.2 Some Common Determinate Varieties

“Galilama” (Determinate)

“Roma VF” (Determinate)

1.2 Some Common Varieties Contd.

“Galilama”

- Determinate type
- Tolerant to **Tomato Yellow Leaf Curl Virus**, **early and late blight**
- Fruits: Firm and oval shape
- **Maturity Period: 80-92 days** after transplanting
- **Yield Potential: 500 qt/ha**

“Roma VF”

- **Determinate** variety
- Round to semi oval shape
- Short and bushy type, no need / minimal staking
- **To prevent disease** and **harvest high quality fruits**, stalking is recommended
- **Maturity Period: 95 – 100 days** after transplanting
- **Yields Potential: 400 qt/ha**

1.2 Some Common Semi determinate Varieties

“Galilea” (semi Determinate)

“Shanty” (semi Determinate)

1.2 Some Common Varieties

- The following are the common varieties grown in Rift valley and East showa introduced by Hazera seed company

“Galilea”:

- **Hybrid and semi determinate**
- Plant is slightly bushy and can be staked
- Skin color and firmness:- Brick red and firm
- Tolerant to **powdery mildew, early blight, late blight, bacterial spot and TYLCV**
- **Days to first harvest:- 60-90** days (after transplanting)
- **Yield Potential: 695 qt/ha**
- The fruits store and transport well

“Shanty”

- **Hybrid and semi determinate**
- Skin color:- Brick red and firm
- Tolerant to TYLCV, bacterial spot
- The fruits store and transport well
- **Days to first harvest:- 60-90 days** (after transplanting)
- **Yield Potential: 697 qt/ha**

1.2 Some Common DeterminateVarieties

“Melka shola”(Determinate)

“Melka Salsa”(Determinate)

1.2 Some Common Determinate Varieties

“**Melka Shola**” and “**Melka salsa**” both determinate varieties
- Suitable both for fresh and processing market
- Both short and no need of staking

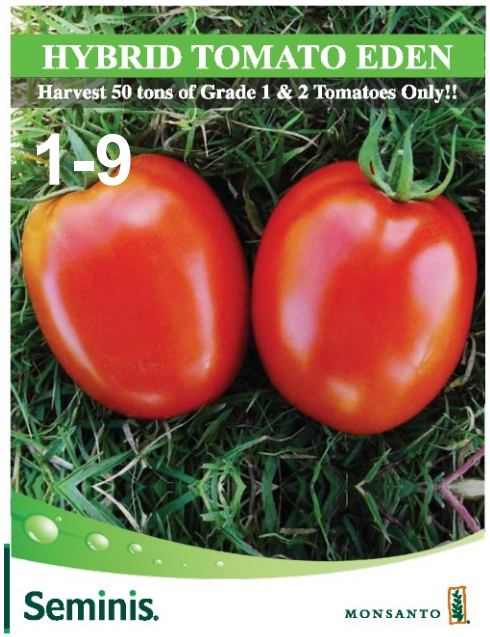
“Melka Shola”

- Fruit shape is **cylindrical**
- Average fruit weight is **60-70 g**
- Days to harvest: **100 – 110 days**
- Research productivity: **450 qt/ha**

“Melka Salsa”

- Fruit shape is **Pear**
- Average fruit weight is **40-50 g**
- Days to harvest: **100 – 120 days**
- Research productivity: **430 qt/ha**

1.2 Some Common Varieties Cont’



“Eden F1” (Determinate)

1.2 Some Common Varieties Cont’

“Eden F1”

- **Determinate** and vigorous growing variety
- Good tolerance to **Alternaria Canker**, **Verticillium Wilt**, **Fusarium Wilt**, **Nematodes** and **Bacterial Speck**
- Deep red blocky fruits have long shelf life
- **Maturity Period: 75 days** after transplanting
- **Yield Potential: 599 qt/ha**

1.2 Some Common Varieties Cont’

“Anna F1” (Indeterminate)

1.2 Some Common Varieties Cont’

“Anna F1”:

- **Hybrid** and **indeterminate fresh market variety** that produces blocky oval red fruits that have **a long shelf life**, **tolerance to Fusarium**, **Verticillium Wilt**, **Alternaria Stem Canker** and **Nematode**
- Ideal greenhouse Tomato
- Need support and pruning
- **Maturity Period: 75 days** after transplanting
- **Yield Potential: 543 qt/ha** (**18 kg** per plant for **8 months**)

Other varieties grown in Ethiopia:

kochoro, Eshete, Fetan, Bishola, money maker, Chali

1.3 Choice of Varieties

Tomato crop in the field

1.3 Choice of Varieties

Selection of variety need to be based on:

- **Growth Habit:** determinate (bush), indeterminate (climbing) and semi-determinate
- **Disease Resistance/Tolerance:** indicated by initials after variety name e.g.) **"V"** for **Verticillium Wilt**, **"F"** for **Fusarium Wilt**, **"N"** for **Nematodes etc.**
- **Fruit Type (shape, size & color):** Market requirement will determine fruit type.
  - Processing-intense red color & more solids
  - Fresh market- shape, color & size vary
- **Hybrid or Open Pollinated Varieties (OPV):** Hybrid seeds give higher yields but are more expensive

1.4 Optimal Ecological Requirements

Altitude	**700– 2,200 Meters Above Sea Level**
Rainfall	**Over 600-650 mm of rainfall annually or irrigation**
Growing Temperature	**Ave. daily temp. is 18-25℃** (Day:25-28 ℃ & night 10-15℃)
Soils	**•Well drained sandy, loam, and clay loam soils** **•pH range 5.5 – 7.5**

1.4 Optimal Ecological Requirements

- **Altitude:** Tomato can be cultivated up **to 700-2,200 m** above sea level
- **Rainfall:** Tomato performs well in areas that receive over **600-650 mm** of rainfall annually. It should be **well distributed** throughout the growing season. It is mainly cultivated by irrigation
- **Temperature:** Tomato performs well in **warm climatic conditions**. The optimal mean daily temperature for growth is 18-25℃ with night temperature 10-15℃
- **Soil:** Tomato requires **well drained sandy loam**, or **clay loam soils**. The optimal soil pH range is **5.5 – 7.5**.

2. Pre-Cultivation Preparation:
2.1 Market Survey

Carrying out a market survey on Tomato

2. Pre-Cultivation Preparation:
2.1 Market Survey (GHCP&PHHT20: Q1)

How to conduct a market survey

- Identify major dealers of the target crops
- Introduce yourself what the purpose of a market survey
- Find the potential market nearby your area (local market, big market in town, hospital, University, boarding school)
- It is important to consider seasonal or religious event, such as Christmas or fasting
- People consume more vegetables during fasting season
- Continuous surveys are important in order to find new market opportunities and also establish business relationships with the market players.

Note: It is recommended to conduct a market survey when you go to local market during your local market day

2. Pre-Cultivation Preparation:
2.2 Market Survey

Market Survey Questionnaire

Date : ____/____/_____

Region:_____ Zone:_____

Woreda:_____ Name of Group:_____

Name & Contact of the Produce Dealer	Produce & Variety	Produce Quality Market Requirements	Peak Demand (months)	Quantity (kg) & Frequency (daily/weekly etc.) of Supply	Place of Production	Purchasing Unit Price (ETB/kg)	Mode of Payment	Terms of Payment	Marketing Challenges	Dealer's Willingness to Purchase the Produce from the farmers
Mr. Abdela Qasim (0917-xxxxxx)	Tomato (Gelilea)	Medium to Large size	December to April	7 box/week (1box = 40 kg)		20 ETB/kg	Cash	Cash on Delivery	Poor quality (insect damage and diseased)	Willing to buy at shop
Mr. Kernal Husen (0911-xxxxxx)	Tomato (Roma VF)	Medium size	March to September	1 Isuzu truck/day (1 truck = 2,000kg	Megi	18 ETB/kg	Credit	Within a week	Poor quality (insect damage and rotten)	Willing to buy at farm gate

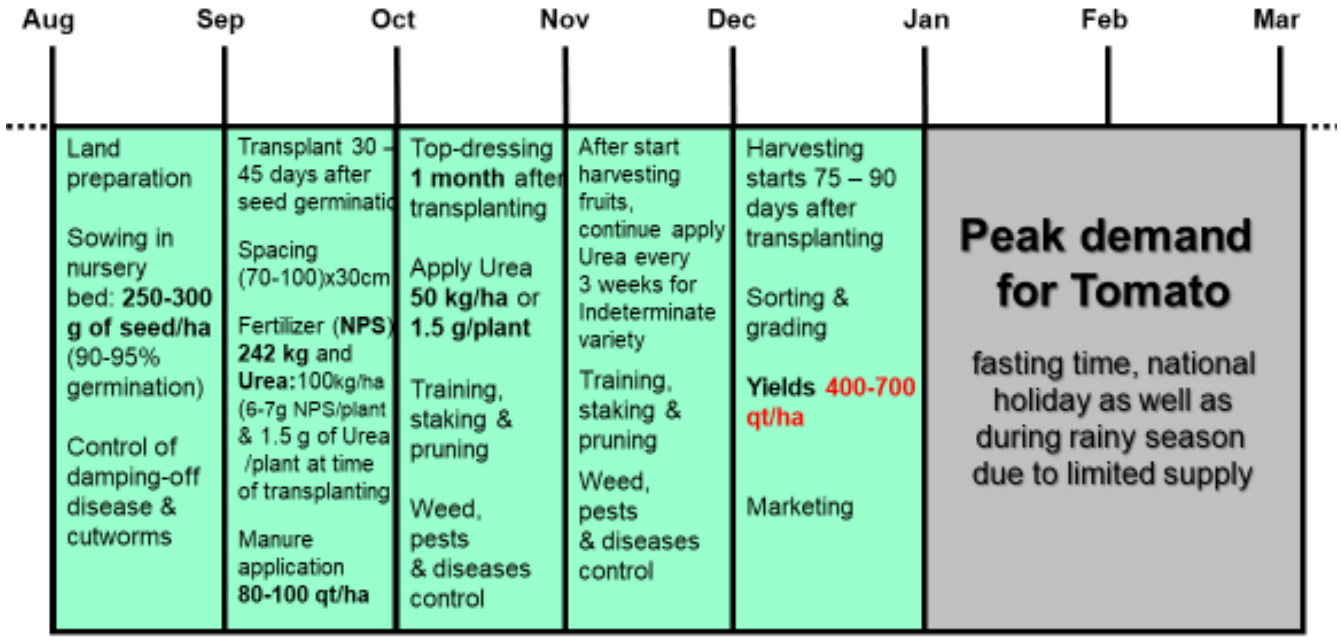
Market Survey Questionnaire

2. Pre-Cultivation Preparation:
2.2 Market Survey Questionnaire

Prepare sample questions to enable you gather the following information

- **When (month) is the peak demand for Tomato**
- The price of Tomato during the peak demand
- The Potato variety(s) that has the highest demand
- Supply requirements (quantities and frequency)
- Quality market requirements
- Potential buyers and terms of payment etc.

2.2 Cropping Calendar



A Sample of a Tomato Planting Calendar:

Targeting a peak market demand during fasting time, national holiday and rainy season

2.2 Cropping Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

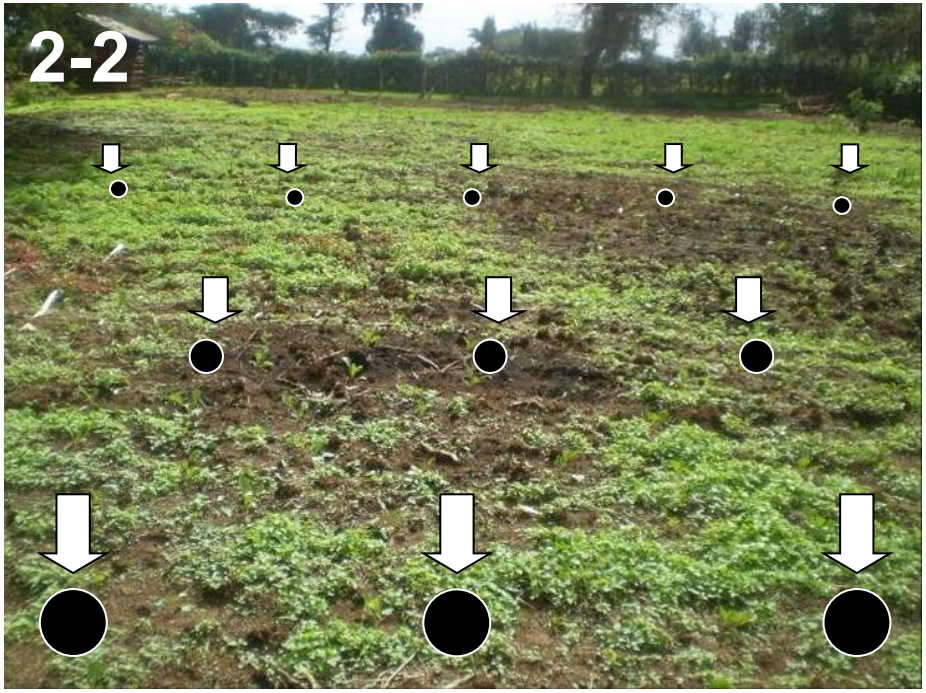
Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Tomato
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, irrigation is an absolute necessity.

2.3 Soil Sampling & Analysis



Depending on the farm, sample the soil using the most appropriate method or use ETHIOSIS soil test results

2.3 Soil Sampling & Analysis
(GHCP&PHHT20: Q3)

- It is recommended to have the soils analyzed for nutrient availability and other factors vital to crop production depending on soil type and their fertility status
- The results of the soil analysis can be used to determine fertilizer and manure requirement

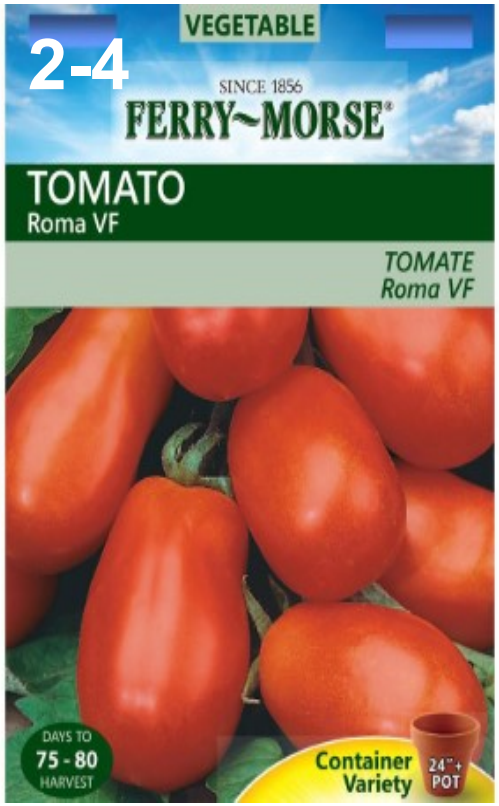
2.4 Composting

Compost preparation

2.4 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent volatilization and leaching of nutrients
- Tomato is a heavy feeder and does well in soils with high organic content (manure)
- Based on the results of the soil analysis, prepare adequate compost for application; the recommended rate of application ranges from **80-120 qt/ha**

2.5 Quality Seed/Planting Materials



Samples of certified seeds in package

2.5 Quality Seed/Planting Materials
(GHCP&PHHT20: Q5)

- Like any other planting material, Tomato seed should be of high quality and certified by Ethiopian Plant Protection and Seed Quality Control Directorate of MoA which is a government agency responsible for seed certification (check the lot number to confirm with EIAR through Seed certifying committee)
- Ensure you purchase **certified seed** from **authorized dealers** or seedlings from **registered** and **certified commercial nurseries**
- Farmers should pay attention to information on seed label, such as **expiry date**, **germination %, purity %, storage condition, and variety name.**

3. Cultural Practices:
3.1 Land Preparation

Well Prepared land ready for transplanting

3. Cultural Practices:

3.1 Land Preparation Practices (GHCP&PHHT20: Q6)

- Tomato roots go deep down into the soil; therefore need a deep soil
- Should be tilled fairly deep
- Prepare beds to depth of **25 – 30 cm**
- Soils should be ploughed **3-5 times to eliminate debris** and soil clods and ensure a **fine tilth**

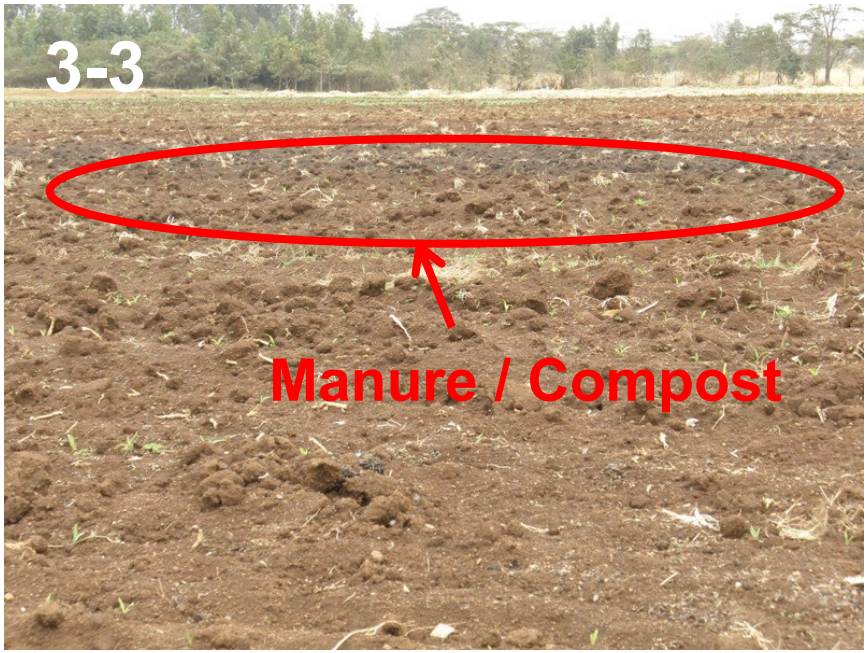
3.2 Incorporation of Crop Residues

Crop residues to be incorporated in a field

3.2 Incorporation of Crop Residues (GHCP&PHHT20: Q7)

- Incorporating crop residues in the farm land can significantly increase the soil organic matter content
- The crop residues should be incorporated at a depth of about **30 cm** at least **1 – 2 months** before transplanting the tomato. However, this can vary depending on the area and type of crop residues.
- **If the crop residues belong to the *solanaceae* family (pepper,egg plant, potato, tobbaco etc.), remove and burn it to avoid possible risk of disease build up**

3.3 Basal Application

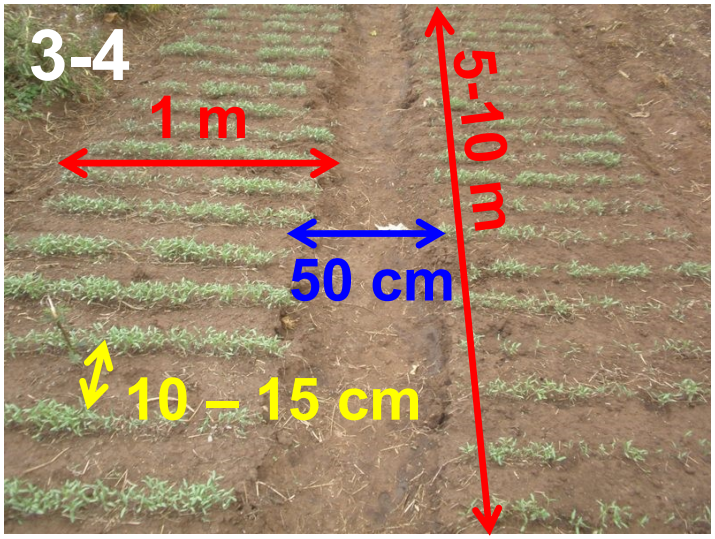


Compost / Manure incorporation as a basal application

3.3 Basal Application: (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted **(80-120 qt/ha)** then incorporated into the soil either by hoe or by oxen
- Manure/compost should be applied at least **1 – 2 weeks before transplanting** the tomato seedlings.
- Tomato respond very well to well decomposed organic manure

3.4 Raising Seedlings



Tomato nursery

3.4 Raising Seedlings (GHCP&PHHT20: Q9)

- Tomato can be established through the nursery or directly seeded
- Normally, it is raised in nursery before transplanting
- The seed rate is about **250-300 g/ha**

Nursery Site Selection:

- The nursery should be sited in a plot that has not been planted with a member of ***Solanaceae* family** for the last **3 years**

Nursery Establishment:

- Prepare a seedbed of **1 m width** and convenient length (**5-10m)**
- **Consecutive beds are 50cm apart**
- Make drills on the seedbed at a spacing of **10 – 15 cm apart**
- Thinly sow the seeds in the drills and cover lightly with soil, then covered with dried grass to keep moisture until germination.
- However, dried grass should be removed soon after germination.

Management of Nursery:

- Water the nursery regularly
- Harden the seedlings **1 – 2 weeks before transplanting** by reducing the amount and frequency of watering and gradually exposing the seedlings to direct sunlight
- Insects such as whiteflies can transmit viruses to young tomato plants
- These insects can be blocked from reaching the seedlings by use of **an insect proof net or application of insecticide**

3.5 Transplanting

Recently transplanted Tomato seedlings

3.5 Transplanting

3.5.1 Appropriate Time

- Seedlings are transplanted **about 35 days** after seed sowing or 3-4 true leaves or 12-15cm height
- It is recommended that transplanting should be done either **early in the morning** or **late in the evening**

3.5.2 Recommended Spacing (GHCP&PHHT20: Q10)

- Spacing: range from **70-100 cm** (**between rows**) **by 30cm (between seedlings**) depending on the variety
- Plant Population per hectare: range from **33,333-47,619**
- Appropriate spacing produces short, stocky plants with good root system

3.5.3 Fertilizer Application Rates (GHCP&PHHT20: Q11)

- Apply **2-3 handfuls** of manure per planting hole (**80-120 qt/ha**) or **242 kg/ha NPS and 100kg/ha urea in split form**

3.6 Water Requirement

Furrow Irrigation in a Tomato field

3.6 Water Requirement (GHCP&PHHT20: Q12)

- Tomato is sensitive to water deficit:
  - Immediately after transplanting
  - During flowering and fruit development
- Plants should be provided with adequate water
- Tomato plants are sensitive to water logging and flooded fields should be drained within **1 – 3 days**

Irrigation Methods:

- Irrigate newly planted seedlings immediately after transplanting and water regularly until the seedlings are established
- Water every 4-5days for the first 4 weeks
- Later on, apply every 7-10 days interval
- **Furrow** and **drip irrigation** are the most effective methods
- **Furrow irrigation minimizes** spread of fungal diseases, such as “Early Blight”
- **Drip irrigation** on the other hand is **efficient on water utilization**
- **Overhead irrigation encourages** spread of diseases such as “Early Blight”
- DO NOT pour water by watering can on the leaves and fruits after start flowering to reduce blight disease

3.7 Managing of Weeds

Weeding of Tomato using appropriate tool

3.7 Managing of Weeds (GHCP&PHHT20: Q13)

- **Planting field should be weed free**
- The crop needs to be cultivated and weeded at least 2-3 times

Cultivation and weeding:

1st : 3-4 weeks after transplanting
2nd: 6 weeks after transplanting
3rd: 8 weeks after transplanting

- If no weed control is done, yield loss will be **nearly 70%**
- Avoid bruising the roots during weeding
- This can be done through use of appropriate weeding tools, including "**Jembe**" **"Small Finger Hoe"**, **"Finger Hoe"**, **"Split Hoe"** and **"Flat Hoe"**
- Generally, keep the field weed free as much as possible to avoid competition for **nutrients**, **sunlight** and **moisture**
- Weeding Tomato field when the soil is wet can increase the spread of some **bacterial** (Bacterial Wilt) and **fungal** (Fusarium Wilt) **diseases**

3.7 Managing of Weeds

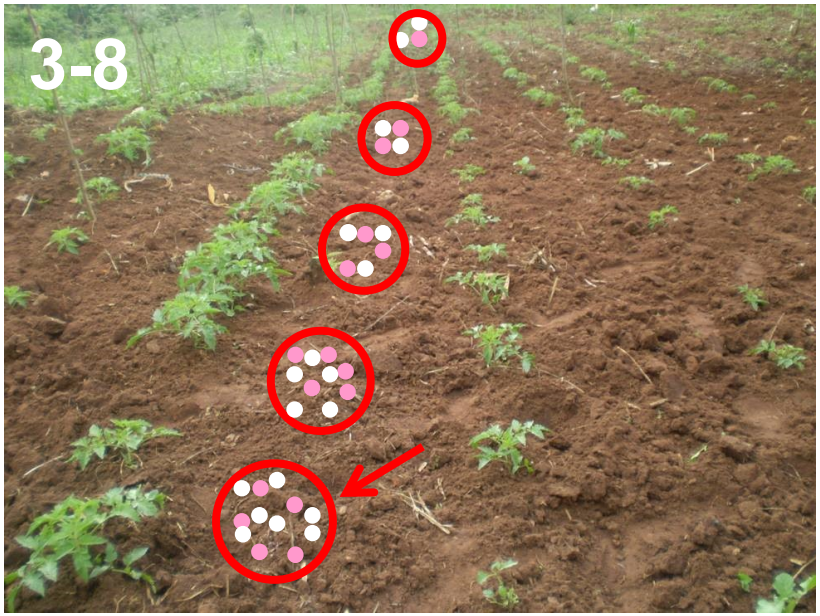
Orobanche ramosa

Orobanche cernua

3.7 Managing of Weeds (GHCP&PHHT20: Q13)

- Common name: nodding broomrape
- Local name in Ethiopia: delantuba; yebeg eras; yemeder kitenge
- There were no sustainable and consistent control methods for this weeds.
- ***Orobanche. ramosa*** and ***Orobanche. cernua*** become increasing problems in some area, especially Central Rift Valley of Ethiopia.
- The single broomrape plant can release more than 500,000 seeds, which are remain viable for 10 years in the soil. Therefore, minimizing the reproduction of new seeds is crucial. It causes the yield loss of more than 75%
- Grazing animals should be forbidden to enter un-infested fields after grazing infested areas.
- Farmers should use fermented manure which kills the weed seeds
- Crop rotation with bean, oat, maize or wheat could reduce the viable seed in the soil. Intercrop with maize or snap bean can reduce soil seed bank on average 65%
- **Soil solarization is effective to kill the weed seeds** in the soil. Soil solarization is the heating of soil by sunlight trapped under a clear polye-thylene film, which increase soil temperature of 48-57℃.
- Seeds of *O.ramose* can survive 35 days at 50℃ in dry condition, but are quickly killed by temperatures of 40℃ when wet conditions.
- Applying 20 tons/ha of chicken/goat manure is effective in reducing weeds and enhancing growth of tomato since this weeds like less fertile soil conditions

3.8 Top-dressing



Top-dressing using the placement method

3.8 Top-dressing (GHCP&PHHT20: Q14)

- Tomato crop should be fertilized with organic and inorganic chemical fertilizers to produce high yields
- Top-dressing fertilizer Urea (or CAN) **100kg/ha** in 2 splits at **50kg each time** at **4 and 8 weeks** after transplanting
- But it depends on the variety (determinate or indeterminate); therefore it is always important to **check seed package**
- If Calcium Ammonium Nitrate (CAN: 26% of N and 8% of Calcium) is available, use **CAN** instead of Urea. It would prevent **blossom-end rot**. CAN is also good for acidic soil because this does not acidify the soil since it contains limestone
- Application method: circular band around the stem
- **Inadequate top-dressing can result into physiological disorders:**
  - Hollow cavities and poor taste in fruits due to potassium deficiency
  - Blossom-end rot due to an imbalance between **Nitrogen**, **Calcium** and **soil moisture**

3.9 Crop Management
3.9.1 Training & Staking

Well staked Tomato field

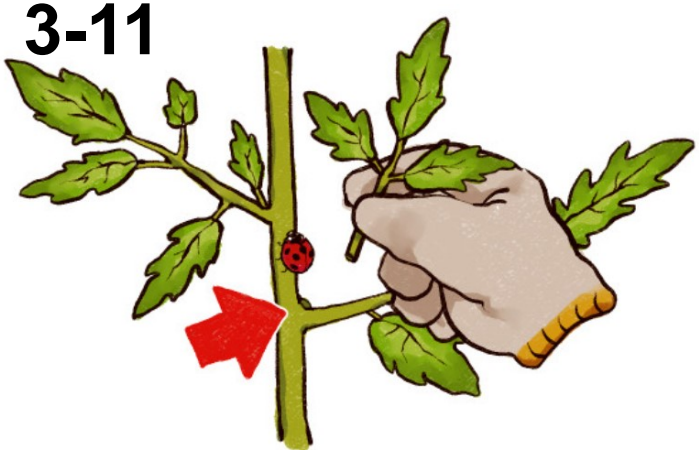
3.9 Crop Management
3.9.1 Training and Staking

- Indeterminate varieties need **staking/training** to facilitate pruning, harvesting and other cultural practices
- Determinate varieties may be staked in wet season to prevent fruit contact with the soil
- Staking materials: **wooden stakes**, **bamboo** or any **sturdy material**
- **Strings**, **plastic strips** or other material can be used to train the plant to the stake
- If plants were trained by plastic strips, it is important to **remove all the plastic** materials from the field after harvesting tomato; otherwise livestock would suffer by eating plastics; it may die due to a **hardware disease**

3.9.2 Pruning

Staking of Tomato plants

3-11



Pruning of Tomato plants

3.9.2 Pruning

- This practice is necessary for the **indeterminate** varieties
- Timing: two weeks after transplanting
- **Frequency:** once a week
- It involves **removal of side shoots**, **extra flowers** and **fruits**
- Leads to **earlier maturity** of fruits and encourages fruits to **increase in size and uniformity**
- **Sterilize** pruning blades by use of chlorine bleach at a ratio of 1:1 to water
- Pruning by use of unsterilized blades should be avoided since it can lead to spread of viral diseases e.g.) **Tomato Mosaic Virus**

3.10 Pests & Diseases Control
3.10.1 Control/Management Strategies

1.	Cultural Control
2.	Mechanical Control
3.	Biological Control
4.	Chemical Control
5.	Integrated Pest Management (IPM)

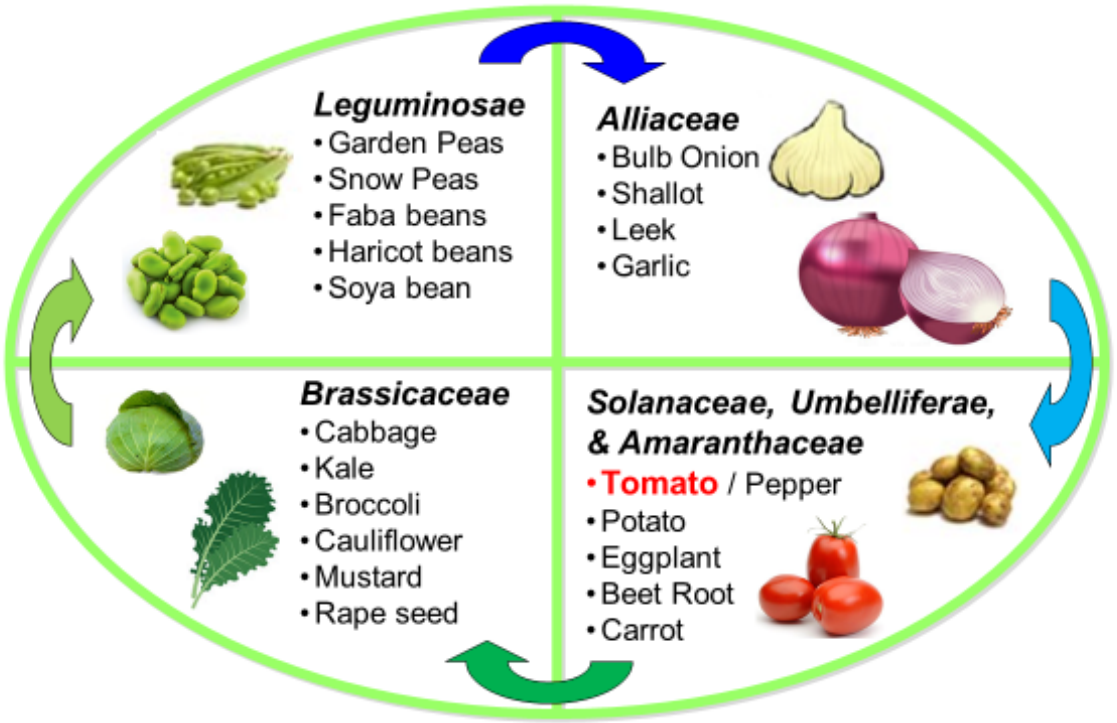
3.10 Pests & Diseases Control

3.10.1 Control/Management Strategies (GHCP&PHHT20: Q15)

- Pests and diseases can be managed through either single control strategies or an integration of two (2) or more methods. The single control strategies are: cultural; physical; biological; and chemical.

1. **Cultural Control:** This involves managing the environment in which the crop is growing/grows with a view of maintaining pest and disease below the harmful level. The cultural methods include: field sanitation/hygiene, intercropping, crop rotation, furrowing, flooding, solarization etc.
2. **Mechanical Control:** This involves use of insect traps, hand picking, screening house, weeding etc.
3. **Biological Control:** This involves use of natural enemies (predators and parasitoids), resistant/tolerant varieties, trap plants, push and pull system, and repellant plants
4. **Chemical Control (GHCP&PHHT20: Q16):** This involves use of pesticides. Pesticides are preferred because of the quick knock down effect; they have high efficacy. Pesticide usage has been linked to environmental degradation and should be used as last resort
5. **Integrated Pest Management (IPM):** Due to limitation of a single control strategy, use of IPM is a more recommended strategy. IPM integrates cultural, mechanical, biological and as a last resort, chemical control to minimize the crop loss caused by pests and diseases.

3.10.2 Crop Rotation

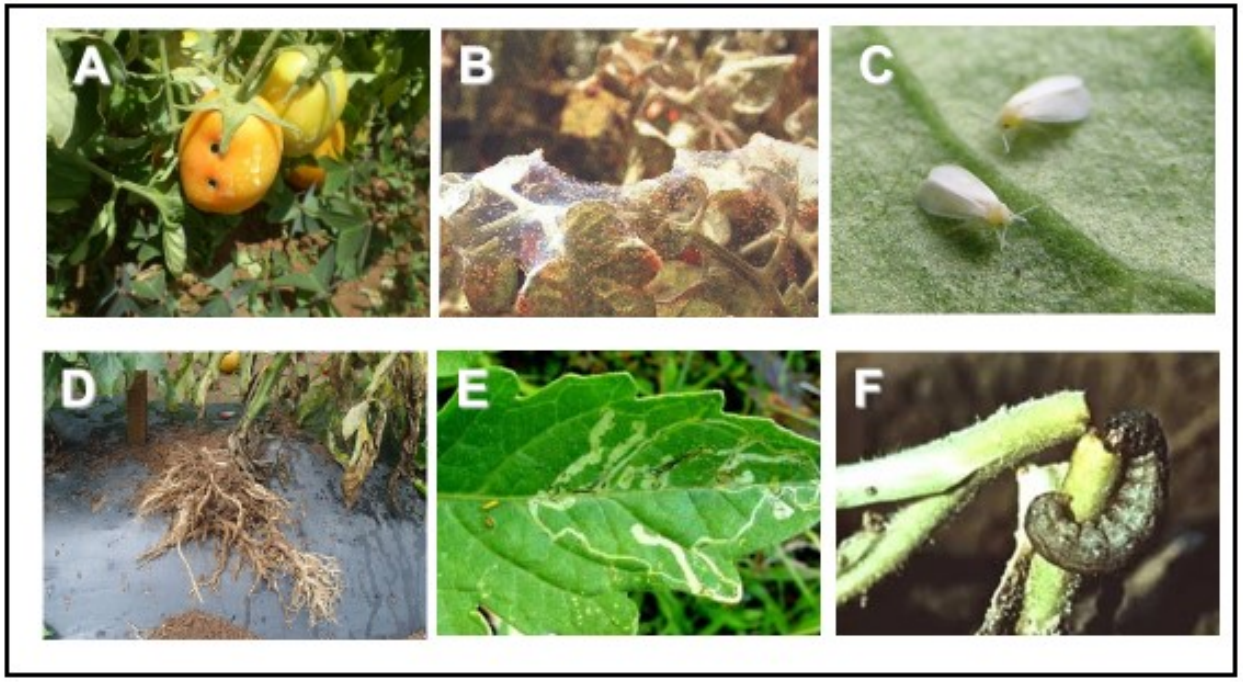


An example of a Crop Rotation

3.10.2 Crop Rotation

- One of the most important strategies of IPM is crop rotation
- Crop rotation prevents pest and disease build-up and in addition, it replenishes soil nutritional status
- It is recommended to rotate crops with those from different families; an effective rotation program should last for 3 – 4 years

3.10.3 Major Pests



3.10.3 Major Pests

- Pests damage causes a reduction in quality and quantity of produce
- The following are the major pests of Tomato in Ethiopia:
  - **A. African Bollworm (Cotton bollworm)**
  - B. Red Spider Mites
  - **C. Whitefly**
  - D. Root-knot Nematode
  - E. Tomato Leafminer (*Tuta absoluta*)
  - F. Cutworm

3.10.3.A: African Bollworm

Symptom of fruit damaged by “African Bollworm”

3.10.3.A: African Bollworm (Cotton bollworm)

Identification:

- Adult moth is **dull yellow** to **brown**
- The female moth lays **tiny round & brownish eggs** near or on flowers or small fruits
- Larvae have alternating **light and dark colored stripes** on either side of the body
- The pupa is **shiny brown**

Damages:

- Caterpillars feed on flowers and green fruits causing **flower abortion** and **sunken necrotic spots**, respectively
- Feeding holes made by the caterpillar serve as entry point for bacteria and fungi which may lead to rotting of fruits

Control:

- **Tilling** & **ploughing** of old tomato field exposes pupa to desiccation and natural enemies
- **Planting of trap crops** (**Cucumber** & **Maize** etc.) which attract the pest before it attacks tomatoes (Need to synchronize planting of both maize and tomatoes so that they flower at same time)
- **Use of selective pesticides**, such as microbial control agents like **Thuricide WP®** (a.i. ***Bacillus thuringiensis*-Bt**)
- **Chemical control**
  - Spraying with 2l/ha of **endosulfan 35%E.C**
  - **Carbaryl 85% W.P**
  - 50-70 g/ha of **cypermetrin 10% E.C** mixing with 500 l of water
  - **Agrothoate 40%** (Dimethoate 40%), **karate**
  - **Hondize 60% EC** (Diazinon) or **Rider 5%EC** (Lamdacyhlothrin)

3.10.3.B: Red Spider Mites

Tomato leaf infested with "Red Spider Mites"

3.10.3.B: Red Spider Mites

Identification:

- Adult red spider mites are **oval in shape** and appear **reddish** or **greenish** and have eight (8) legs
- Eggs are very **tiny**, **spherical** and **whitish**; and are laid singly on underside of leaves
- Red spider mites **spin silk threads** which anchor the pest and their eggs to the plant

Damages:

- Leaves when infected show **white to yellow speckling**, **later turn pale** or **bronzed**
- **High population causes serious drying** and dropping of leaves (defoliation) which leads to smaller and lighter fruits

Control:

- Pesticides (miticides) include: Apollo®, Omite®, petroleum oil sprays, and neem oil formulations
- Use of pesticides (miticides) include:
  - **Arsur 100 EC®** (a.i. Hexythiazox)
  - **DYNAMEC EC®, Avirmec EC®**, **Almectin EC®**
  - **Agrimec EC®** (a.i. Abamectin)
  - **Mitac EC®** (a.i. Amitraz)
  - **Amblytech®** (**Amblyseius californiws – predatory mite**)
- **Spider mites rapidly develop resistance to pesticides**, especially when they are used continuously for several seasons
- To avoid development of resistance, farmers need to:
  - Use miticides **with different chemical composition**
  - Avoid **routine spraying**
  - Use the **recommended dosage**

3.10.3.C: Tobacco Whitefly

"Tobacco Whitefly" on the Tomato leaf

3.10.3.C: Tobacco Whitefly

Identification:

- Adult whitefly resembles **small white moth –** like insect which cluster on the underside of upper leaves from which they suck sap
- Eggs are laid in arc or circle on the underside of young leaves
- When eggs hatch they produce **greenish white nymphs** which resemble scales

Damages:

- Suck plant sap and remove nutrients which cause **yellowing of infested leaves**
- The larvae secrete honey dew which supports growth of **black sooty mould**
- Transmit viral diseases, especially **Tomato Yellow Leaf Curl Virus (TYLCV)**

Control:

- Keep tomato fields **weed free**
- Use of **yellow sticky traps** to monitor their population levels
- Covering tomato seedling nurseries with **nylon nets** to protect seedlings from Whitefly infestations
- **Use of insecticides**, such as
  - **Mitac®** (a.i. **Amitraz**)
  - **Applaud®** (a.i. **Buprofezin**)
  - **Nimbecidine®** (a.i. **Azadirachtin**)
  - **Confidor®** (a.i. **Imidacloprid**)
  - **Canon EC®** (a.i. **Permethrin**)

3.10.3.D: Root-knot Nematode

Root galls: characteristic of "Root-knot Nematode" infection

3.10.3.D: Root-knot Nematode

How to describe damages of Nematode attack:

- Nematodes are **soil inhabitants** which are easily spread by **infested seedlings**, **soil washed down the slopes** or by farm **implements**
- Root–knot nematodes are most serious on **light sandy soils**

Damages:

- Heavy infection results in severe loss in yield
- Plants are **stunted**, become **yellow** and tend to **wilt in hot weather**
- The roots of infected plants are severely **distorted**, **swollen** and **bear galls** or **knots**
- Heavy infection results in severe loss in yield

Control:

- **Burn the top soil** using waste plant material after seedbed preparation
- **Solarize seedbeds** if possible by covering soil with clear polythene sheet for **2 – 3 months**
- Fields should be **ploughed deep** and **harrowed followed by dry fallow**
- **Use trap/repellant crops**, such as **Marigold**
- **Use of nematicides**, such as
  - **Achook EC®**
  - **Nimbecidine®** (a.i. **Azadirachtin**)
  - **Bio-nematon®** (a.i. ***Paecilomyces lilacinus***)
  - **Adventure 5G®** (a.i. **Abamectin**)

3.10.3.E: Tomato Leafminer

Tomato fruit and leaf damaged by leaf miner (*Tuta absoluta*)

3.10.3.E: Tomato Leaf miner

Identification:

- The moth is **grey-brown**, **same size** and **posture** as diamondback moth (DBM) and has long antenna
- Newly hatched caterpillars are **small** (0.5 mm) and **yellowish**
- Mature caterpillars (9 mm: fully grown) are **yellow-green**, have **pinkish color** on the back and **a black band** behind the head
- Pupae is **light brown** and size is 6 mm
- The larva (caterpillar) is the **damaging stage**

Damages:

- The caterpillar **burrows** (**mines**) in the middle of the leaf tissue
- Unlike other Leaf miners, it feeds indiscriminately and from a distance, you see leaves are **"burning"**
- Most distinctive symptoms are the **blotch-shaped mines** in the leaves
- It bores on fruits, leaving **symptomatic tiny holes**
- It also burrows on stems causing **breakages**

Control:

- **Early control** is important before the pest pressure builds up
- Carry out **regular scouting/monitoring** of pest population
- Use of pheromone traps to attract male insects for both monitoring/surveillance and pest control e.g.) mating disruption, mass trapping 'lure & kill' method, such as **Tutrak traps**
- **Use of biological control agents**, such as
  - **Coragon**
  - ***Bacillus thuringensis* (Bt)**
  - **Use of low impact insecticides**, such as **Tracer** (a.i. **Spinosad**)
- The above pest control tactics should be combined in an **IPM strategy**

3.10.3.F: Cut worm

Symptoms of cutworm damage on Tomato

3.10.3.F: Cutworm

Identification:

- Cutworm larvae come in various colors and patterns, but always appear smooth skinned to the naked eye.
- Most species of cutworms reach 2.54 to 5.08 cm when fully grown.
- They usually curl up when disturbed.
- Cutworms are mainly active at night.
- During the day, cutworms hide in soil, under clods, or in debris at the base of plants.

Damages:

- Early in the season cutworms may cause stand loss by cutting off seedling or recently transplanted tomato plants at the soil line.
- Later in the season these pests can also injure tomatoes by eating irregular holes in the surface of fruits; tomato fruit touching the ground are generally the most seriously injured.

Monitoring and Treatment Decisions

Treat only when the presence of cutworms is detected. Cutworms are usually localized within a field, so consider marking the areas where damage is observed and treating only those areas.

Organically Acceptable Methods

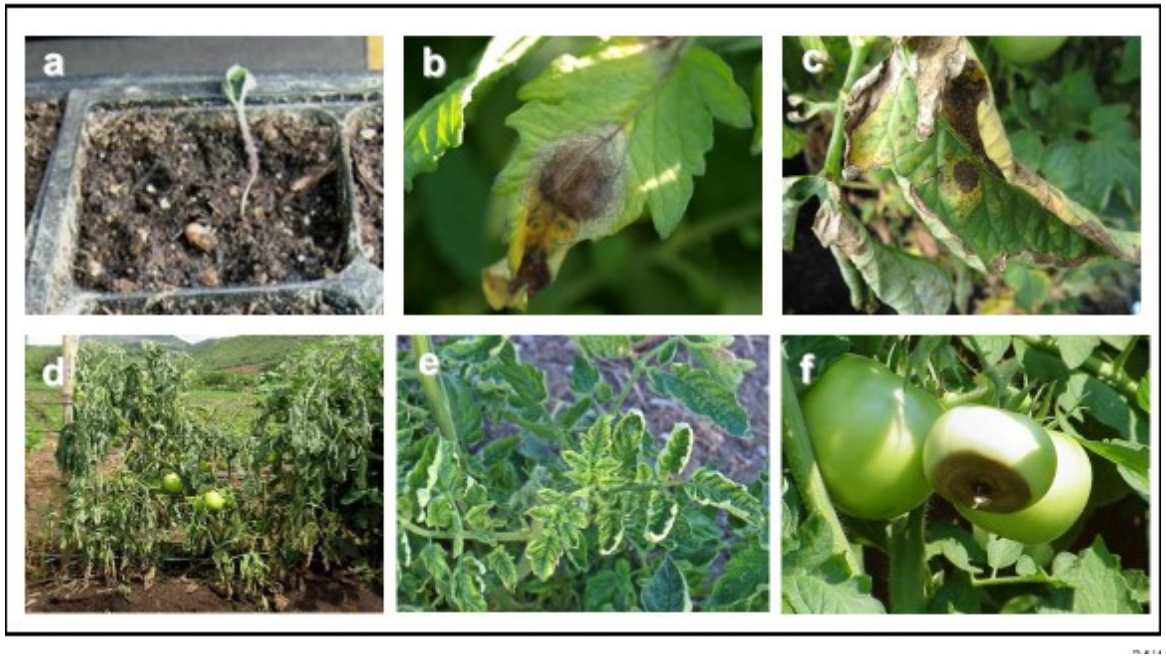
- Cultural control, *Bacillus thuringiensis,* and the Entrust formulation of Spinosad are organically acceptable management tools.

Control:

- Field Sanitation
- Manage weeds surrounding the field before planting.
- If pupae are overwintering, only getting rid of host plants may not prevent damage.
- Cutworm incidence is often associated with residue of host plants remaining in the field before planting and surrounding weedy plant matter.
- As most cutworm species have a wide host range, tillage at least 2 weeks before planting will help destroy plant residue that could harbor larvae and pupae.
- Use of appropriate insecticides such as dimethoate, malathion, or trichlorophon

source: http://ipm.ucanr.edu/PMG/r783301511.html

3.10.4 Major Diseases & Physiological Disorders



3.10.4 Major Diseases & Physiological Disorders

- Disease infestation leads to reduction in quality and quantity of produce
- The following are the major diseases and physiological disorders of Tomato in Kenya:

  a. **Damping-off**
  b. **Late Blight**
  c. **Early Blight**
  d. **Bacterial Wilt**
  e. **Tomato yellow leaf curl virus (TYLCV)**
  f. **Blossom-end Rot**

3.10.4.a: Damping-off

“Damping-off” symptoms on seedlings

3.10.4.a: Damping-off

General Description:

- This disease is **soil borne**

Symptoms:

- **Decay** of germinating seed
- **Girdling** of stem of young seedling at ground level

Control:

- Use of certified seed
- Avoid locating the seedbed on infested field
- **Avoid excessive fertilizer** application and **watering** to young seedlings while still at nursery bed

3.10.4.b: Late Blight

“Late Blight” on foliage and fruits

3.10.4.b: Late Blight

General Descriptions:

- This is a **fungal disease** which affects foliage and fruits
- The development of the disease is favoured by **cool** and **wet conditions**

Symptoms:

- Irregular **greenish-black water** soaked patches on leaves
- The spots on the leaves later turn **brown** and the attacked leaves wither but remain attached to the stem
- Water soaked **brown streaks** on stem
- Grey water soaked spots on fruits – usually the upper half of the fruit

Control:

- Crop rotation
- Removal of all volunteer crops that are more susceptible to this disease
- **Pruning and staking** in order to improve air circulation and reduce humidity
- **Use of fungicides**, such as:
  - **Ridomil Gold WG®** (a.i. **Metalaxyl** + **Mancozeb**)
  - **Milraz WP ®** (a.i. **Propineb** + **Cymoxanil**)
  - **Dithane M45 ®** (a.i. **Mancozeb**)
  - **Acrobat MZ ®** (a.i. **Dimethomorph** + **Mancozeb**)

3.10.4.c: Early Blight

“Early Blight” on foliage and fruit

3.10.4.c: Early Blight

General Descriptions:

- This is a **fungal disease** which affects foliage and fruits
- The fungus is seed borne
- It is well adapted to semi-arid areas
- The disease is favoured by warm rainy weather
- The disease appears on older leaves and progresses upwards

Symptoms:

- On leaves, brown circular spots which have dark concentric rings
- On fruits brown circular spots with dark concentric rings

Control:

- Use of certified seeds
- **Use of fungicides**, such as
  - **Daconil®** (a.i. **Chlorothalonil**)
  - **Oshothane®** (a.i. **Manconzeb**)
  - **Antracol®** (a.i. **Propineb**)
  - **Agromax®** (a.i. **Mancozeb** + **Cymoxanil**)
  - **Melody Duo®** (a.i. **Propineb** + **Iprovalicarb**)

3.10.4.d: Bacterial Wilt

Symptom of "Bacterial Wilt" infection

3.10.4.d: Bacterial Wilt

General Descriptions:

- This is a **bacterial disease** which is **soil-borne**
- It is easily spread by run off water and infested soil

Symptoms:

- **Rapid wilting** and **death** of entire plant **without yellowing or spotting of leaves**
- When the stem of a wilted plant is cut across, the pith has **a darkened water** – soaked appearance
- When stem of wilted plant is squeezed, a **greyish slimy ooze** is produced
- To distinguish this wilt from others when a thin slice is taken from the brown stem tissue and placed inside a glass of water, **a milky ooze** is produced from the cut surface

Control:

- Practice crop rotation with crops such as cereals
- Remove wilted plants, with the soil around roots, from the field and destroy
- **Solarization** of planting beds
- Spot treatment with **Sodium Hypochlorite** at 10 % dilution (Jik) or with **lime**

3.10.4.e: Tomato Yellow Leaf Curl Virus (TYLCV)

Strongly crumpled, curl upward, and turn yellow at the edges and between veins

3.10.4.e: Tomato Yellow Leaf Curl Virus (TYLCV)

General Descriptions:

- This is a **viral disease** which is easily transmitted by infected seed and plant debris in the soil
- One of the most damaging pathogens of tomato
- Heavily infected plants produce no fruits.

Symptoms:

- Leaves of infected plants are small and curl upward
- Show strong crumpling and interveinal and marginal yellowing
- Infected plants become shortened and , together with the stunted growth]
- Plants often take on a bushy apprearance

Control:

- Use virus- and whitefly-free transplants
- Transmit by the vector , *Bemisia* whitefly species, so it is important to manage whiteflies
- Rogue diseased plants when incidence of virus infection is low
- Remove crop debris and roots from the field

3.10.4.f: Blossom-end Rot

Tomato fruits affected by "Blossom-end Rot"

3.10.4.f: Blossom-end Rot

General Descriptions:

- This is a **physiological condition** caused by **calcium nitrogen imbalance in the soil**, especially when moisture level in the soil is low

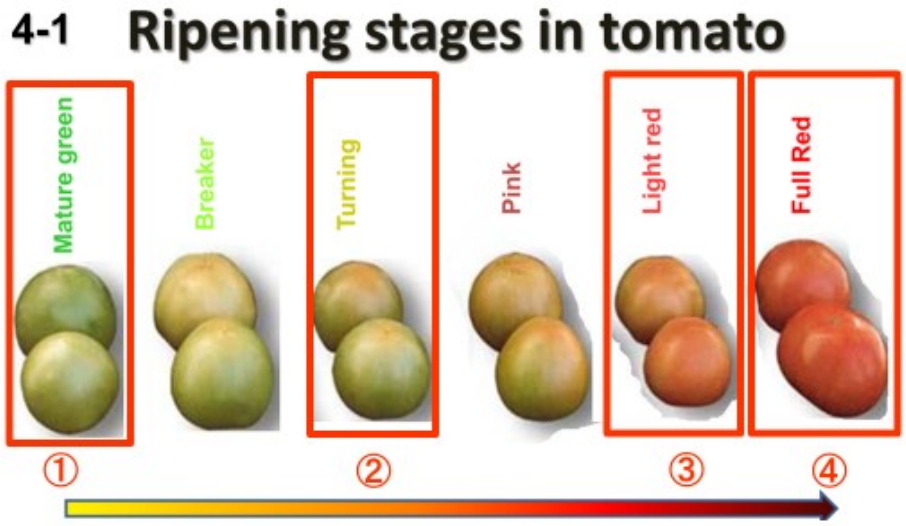
Symptoms:

- A rot at the **blossom-end of the fruit**
- The surface becomes **dark brown** and **sunken**

Control:

- **Maintain adequate soil moisture**, especially **at fruit development stages**
- **Carry out soil liming** in calcium deficient soils
- **Top-dress with CAN** and ensure adequate soil moisture
- **Spray the crop with calcium chloride**

4. Harvest



Harvesting of Tomatoes

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Maturity period range between **3 – 4 months** after transplanting depending on the variety and environmental conditions
- Tomato can be harvested at different stages depending on the market requirement and distance to the market
- There are **four (4) main harvesting stages:**
  - **Mature-Green Stage**: where the fruit is green but internal gel is well developed
  - **Breaker/turning Stage**: up to **30 %** of fruit surface has definite color break from **green to yellow**
  - **Pink/Light Red Stage**: **30 – 90 %** fruit surface has **pink/red color**
  - **Red/Ripe Stage**: over **90 %** fruit surface has changed to **red color**
- Fruits should be harvested **early in the morning** when it is cool since the fruit temperature is low
- Harvested fruit should be kept in a **cool**, **shaded** and **ventilated area** in order to minimize heat gain
- The yields vary from **400-700 qt/ha** depending on the variety and crop husbandry

5. Post-Harvest Handling

Sorting & grading of Tomatoes: Tomatoes packaged in cardboard (wooden containers are preferable)

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Pack Tomatoes in clean well ventilated containers to transport
- Tomatoes are normally packed in wooden crates

5.2 Value Addition Techniques: Cleaning, Sorting, Grading, & Processing (GHCP&PHHT20: Q19)

Sorting:

- Damaged, diseased and fruits with chemical residues should be cleaned and sorted out

Grading:

- Tomatoes are graded depending on the uniformity of ripening and fruit size
- There are **tree (3) main tomato grades:**
  - **Grade 1**: big size fruits of uniform color and shape
  - **Grade 2**: medium size fruits of uniform color and shape
  - **Grade 3**: small size fruits with slight variation in color and shape

5. Post-Harvest Handling Cont'

Zero energy cooling chamber

5. Post-Harvest Handling Cont'

5.2 Storing (GHCP&PHHT20: Q17)

Low cost cooling storage

- A Low cost zero energy cooling chamber (ZECC) was introduced from India
- It is a double walled storage structure made of bricks and a roof made of wood and grass
- The 15m cavity between the walls was filled with wet riverbed sand and watered daily
- The storage structure was targeted to vegetable growers and traders who can store large quantities of vegetables and fruits, but it has no been popularized due to its cost and luck of appropriate information
- Maintain inside temperature by as much as17-18 ℃ & keeps RH above 80% during peak summer.

6. Cost & Income Analysis

Item	Quantity	Unit Price	Total (ETB)
Marketable Yield	30 qt	500 ETB/qt	1,500 ETB
Variable Costs			
Land Preparation	2 days	150ETB/day	300 ETB
Manure/Compost	20 qt	50 ETB/qt	1,000 ETB
Seeds	5qt	1500 ETB/qt	7,500 ETB/qt
Fertilizers	NPS 50kg, Urea 30 kg	1,000 ETB/qt 600 ETB/qt	1,600 ETB/qt
Fungicides	1 bottle	350 ETB	350 ETB
Insecticides	2 bottles	450 ETB	900 ETB
Others e.g.) selective Herbicides			
Labour			
Planting	5 people	150 ETB/person	750 ETB
Spraying/Weeding/Harvesting/Grading	6 people	120 ETB/person	720 ETB/person
Transportation/Packaging	1 isuzu truck	1,000 ETB	1,000 ETB

A sample sheet of items and activities to be considered for determining an enterprise's gross margin

7. Cost & Income Analysis

- Farmers are encouraged to keep accurate records of all enterprise activities **(GHCP&PHHT20: Q20)**
- This is vital in determining the enterprise profitability
- Record keeping is very important for farmers practicing commercial agriculture

There are 2 types of records:

- **Individual Records:**
  - Kept by individual farmers and include the cost of production and sales
  - Useful in analyzing whether the farmer is making profit or losses in his farming enterprise
  - Records are very important for traceability of produce
- **Group Records:**
  - Include activities such as group purchase of inputs, selling of produce etc.

7. Post-Training Evaluation Exercise

QUESTION	YES	NO
1. Tomato is one of the most produced and consumed vegetables in Ethiopia.		
2. “Roma V.F” and “Galilama” are some of the varieties grown in Ethiopia .		
3. Market survey enable buyers to understand the price of Tomato during the peak demand.		
4. Tomato planting calendar need to be prepared before the market survey.		
5. Transplanting of Tomato seedlings is 6-7 leaves stage or 25cm tall.		
6. Training/staking of Tomato plants is an important crop practice to prevent fruit contact with the soil which reduce diseases-infected fruits especially in wet season.		
7. Leaves attacked by “Red Spider Mites” curl and role inside.		
8. “Blossom-end Rot” is caused by the deficiency of Magnesium (Ma) in the soil.		
9. Maturity period of Tomato is 5 – 6 months after transplanting.		
10. Grading is one of the value addition techniques which farmers can do right after the harvest.		

7. Post-Training Evaluation Exercise

*** Please ask the farmers to appropriately indicate answers to each of the following questions.**

PAGE NUMBER	QUESTION	YES	NO
1/45	**1.** Tomato is one of the most produced and consumed vegetables in Ethiopia	✔	
2/45	**2.** “Roma V.F” and “Galilama” are some of the varieties grown in Ethiopia .	✔	
10/45	**3.** Market survey enable buyers to understand the price of Tomato during the peak demand.		✔
11/45	**4.** Tomato planting calendar need to be prepared before the market survey.		✔
19/45	**5.** Transplanting of Tomato seedlings is 6-7 leaves stage or 25cm tall.		✔
23/45	**6.** Training/staking of Tomato plants is an important crop practice to prevent fruit contact with the soil which reduce diseases-infected fruits especially in wet season.	✔	
29/45	**7.** Leaves attacked by “Red Spider Mites” curl and role inside.	✔	
40/45	**8.** “Blossom-end Rot” is caused by the deficiency of Magnesium (Ma) in the soil.		✔
41/45	**9.** Maturity period of Tomato is 5 – 6 months after transplanting.		✔
42/45	**10.** Grading is one of the value addition techniques which farmers can do right after the harvest.	✔	

[Note]

- If there is any question which half of the participants gave the wrong answer, you need to repeat the specific area regarding to question