Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

Smallholder Horticulture Empowerment & Promotion Project for Local and Up-Scaling (SHEP PLUS)

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

TOMATO PRODUCTION

Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **Tomato Production**

Objective: **To provide a guideline on production of Tomato**

Specific Objective:

- **To provide basic information on production, post-harvest handling, and marketing of Tomato**

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

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The cited agrochemicals are in accordance with “Pest Control Product Registered for Use in Kenya 11th Edition, 2018”. The registered agrochemicals are subject to change. Please refer to the latest registered agrochemicals by Pest Control Product Board.

1. Introduction:
1.1 Background

Tomato (Nyanya)

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1.1 Background

- Tomato is a member of the ***Solanaceae*** **family** which includes crops such as **Irish Potato**, **Sweet Pepper**, **Chili** and **Egg Plant**
- One of the most produced and consumed vegetables in Kenya
- Important cash crop for smallholder farmers
- Mainly grown in open fields, however green house tomato production is growing in popularity
- Rich in **Vitamin A, C** and **Lycopene**
- Eaten **fresh,** added to **salads**,cooked as a vegetable or processed into **tomato paste**, **jam**, **sauce**, **puree**, and **juice**

1.2 Common Varieties

1-2

Photo: Flora fields
http://www.florafields.com/index.php?route=product/product&product_id=189

“Rio Grande” (Determinate)

1-3

Photo: seminis,
https://seminis.co.za/product/assila/686

“Assila F1” (Determinate)

1.2 Common Varieties

1-2

Photo: Flora fields
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“Rio Grande” (Determinate)

1-3

Photo: seminis, https://seminis.co.za/product/assila/686

“Assila F1” (Determinate)

Determinate Varieties

“Rio Grande”:

- Fresh market and processing variety
- Plant is slightly bushy and can be staked or left unstaked
- Tolerant to verticillium and fusarium wilt
- **Maturity Period: 75 – 85 days** after transplanting
- **Yield: 18,000kg per acre**

“Assila F1”

- **Determinate** early maturing (**75 days)** variety
- Tolerant to **Tomato Yellow Leaf Curl Virus (TYLCV)** & **nematodes**
- It produces fruits with attractive **red colour** with **oval shape** & **heavy sweet fruits**
- Yield: **23,000kg per acre**
- Good keeping quality & transportability

1.2 Common Varieties Cont’

Photo: Syngenta Kenya, https://www.syngenta.co.ke/tomatoes

“Kilele F1” (Determinate)

Photo: Farm Fresh Seeds
http://www.farmfreshseeds.com/heirloom-tomato-seeds-cal-j.html

“Cal J” (Determinate)

1.2 Common Varieties Cont'

Photo: Syngenta Kenya, https://www.syngenta.co.ke/tomatoes

"Kilele F1" (Determinate)

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http://www.farmfreshseeds.com/heirloom-tomato-seeds-cal-j.html

"Cal J" (Determinate)

Determinate Varieties Cont'

"Kilele F1"

- Medium-early maturing, determinate type
- Suitable for drier or humid areas
- Disease tolerance: **Tomato Yellow Leaf Curl Virus**, **Tomato Mosaic Virus**, **Verticillium**, **Fusarium Wilt** & **Nematodes**
- Fruits: Firm and elongated and has shelf life of 21 days
- **Maturity Period: 75 days** after transplanting
- **Yield: 30,000 – 35,000 per acre**

"Cal J"

- Open pollinated **determinate** variety
- Tolerant to verticilium & fusarium wilts
- The plant produces red blocky shaped fruits
- The fruits store and transport well
- **Maturity Period: 75 - 85 days** after transplanting
- **Yield: 11,000 – 13,000kg per acre**

1.2 Common Varieties Cont’

Photo: seminis, https://seminis.co.za/product/eden/687

“Eden F1”

Photo: Kenya Highlands Seed Co. https://royalseed.biz/tomatoes

“Rambo F1”

1.2 Common Varieties Cont’

Photo: seminis, https://seminis.co.za/product/eden/687

“Eden F1” (Determinate)

Photo: Kenya Highlands Seed Co.
https://royalseed.biz/tomatoes

“Rambo F1”

1.2 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: 40,000-50,000kg per acre** (**9 – 10 kg** per plant)

“Rambo F1”

- Determinate, vigorous plant with uniformly set and firm fruits
- Tolerance: Bacterial wilt, Bacterial spot, Fusarium wilt, Verticilium wilt and Nematodes
- **Maturity 75 days** after transplanting
- **Yield: 30,000kg per acre**
- Good shelf life & transport quality

1.2 Common Varieties Cont’

“Anna F1” (Indeterminate)

1.2 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 **Nematodes**
- Ideal greenhouse Tomato
- **Maturity Period: 75 days** after transplanting
- **Yield: 64,000kg per acre** (**18 kg** per plant for **8 months**)

Other Determinate varieties grown in Kenya:

- **Fortune Maker F1**
- **Novel**
- **Nuru**
- **Valoria F1**
- **Zawadi F1**

Other Indeterminate varieties grown in Kenya:

- **Nemoneta**
- **Tylka F1**
- **Prostar F1**

1.3 Choice of Varieties

Photo: SHEP PLUS

Tomato crop in the field

1.3 Choice of Varieties

Photo: SHEP PLUS

Tomato crop in the field

1.3 Choice of Varieties

Selection of a variety needs to be based on:

- **Growth Habit:** determinate (bush), indeterminate (climbing) and semi-determinate
- **Disease Resistance/Tolerance:** indicated by initials after variety name e.g.) **"F"** for **fusarium wilt**, **"N"** for **nematodes**
- **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	**0 – 2,000 metres above sea level**
Rainfall	**Over 600 mm of rainfall annually**
Growing Temperature	**20 – 25 ^{0}C (day)** **15 – 17 ^{0}C (night)**
Soils	**•Well drained sandy, loam, and clay loam soils** **•pH range 6.0 – 7.5**

1.4 Optimal Ecological Requirements

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1.4 Optimal Ecological Requirements

- **Altitude:** Tomato can be cultivated up to **2,000 m** above sea level
- **Rainfall:** Tomato performs well in areas that receive over **600 mm** of rainfall annually. It should be **well distributed** throughout the growing season.
- **Temperature:** Tomato performs well in **warm climatic conditions**. The optimal day and night temperature range is **20 – 25 ^{0}C** and **15 – 17 ^{0}C**, respectively
- **Soil:** Tomato requires **well drained sandy loam**, or **clay loam soils**. The optimal soil pH range is **6.0 – 7.5**.

2. G20 technologies

1. Market survey
2. Crop planting calendar
3. Soil testing
4. Composting
5. Use of quality planting materials
6. Recommended land preparation practices
7. Incorporating crop residues
8. Basal application of compost/ manure
9. Recommended practices of seedling preparation/ seedlings from registered nursery

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[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

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10. Recommended spacing
11. Recommended fertilizer application rate
12. Supplementing water
13. Timely weeding
14. Top-dressing
15. IPM practices
16. Safe and effective use of pesticides
17. Use of harvesting indices
18. Appropriate post harvest handling containers
19. Value addition techniques
20. Keeping farm records

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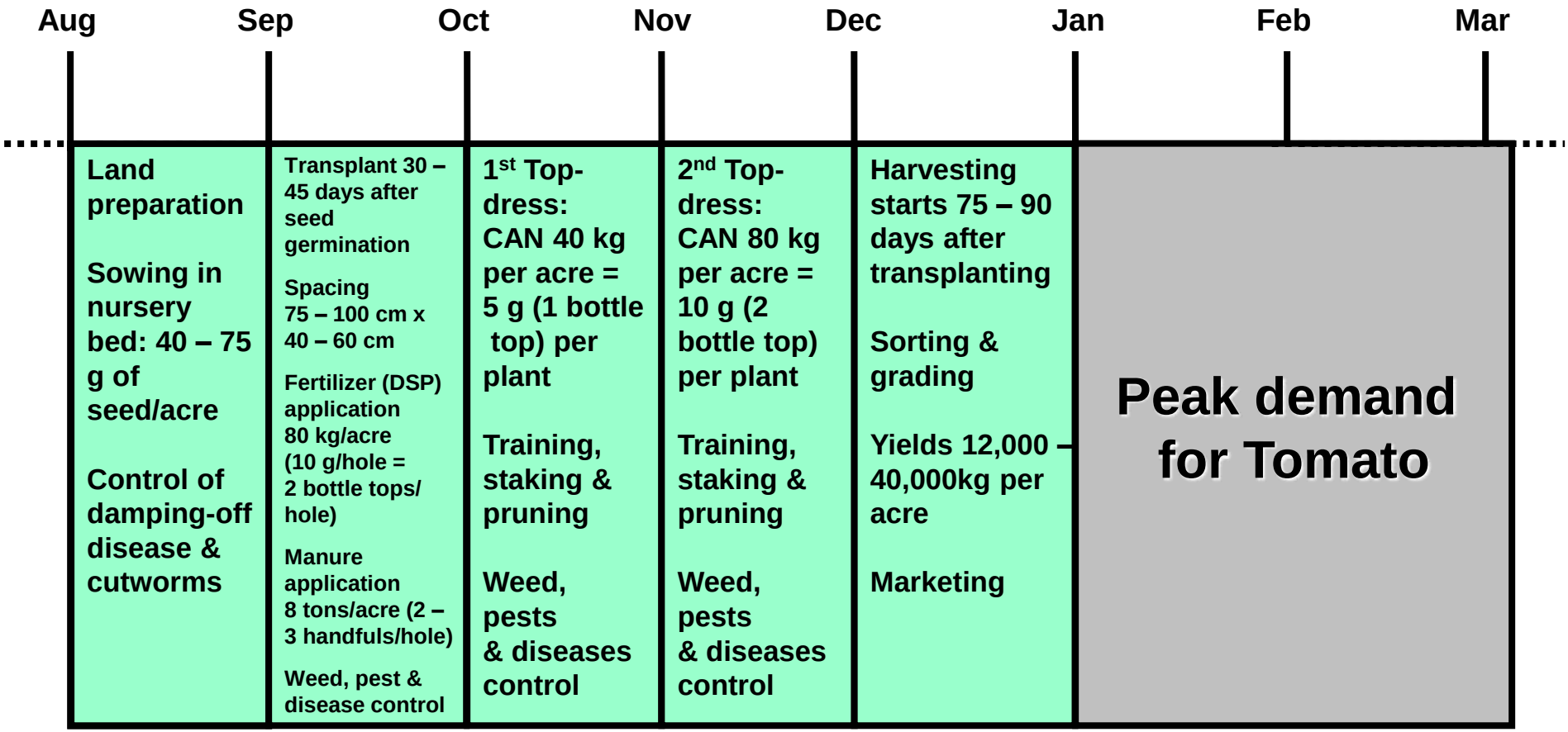
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

2.1 Crop Planting Calendar

A Sample of a Tomato Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Tomato Planting Calendar

A Sample of a Tomato Planting Calendar: Targeting a peak market demand beginning just after January

2.1 Crop Planting 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 demand as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Manure preparation through composting

2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching and volatilization 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 **5 – 8 tons/acre**

3.1 Basal Application

Manure incorporation as a basal application

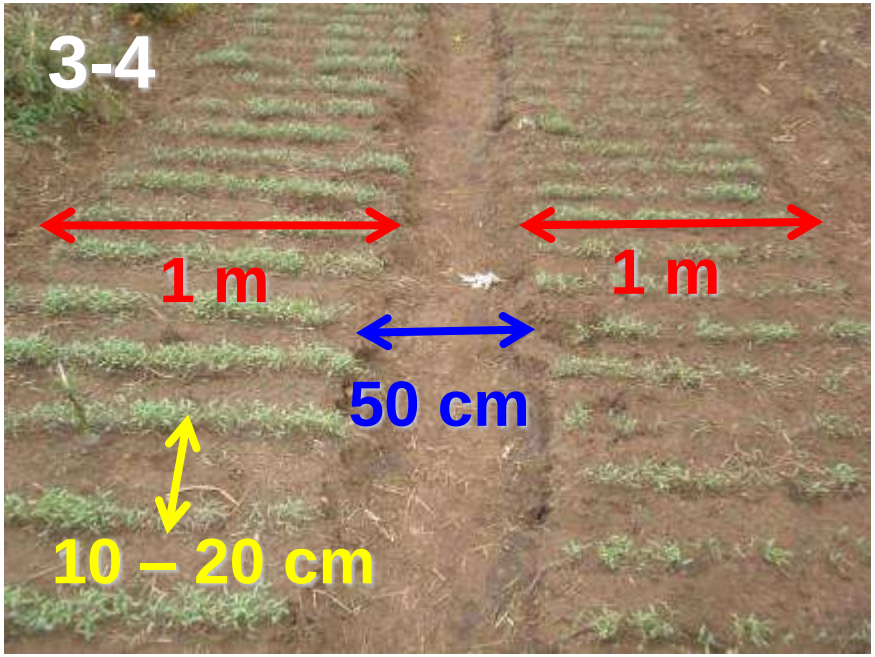
3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted (**5 – 8 tons/acre**) then worked into the soil (incorporated) preferably using a hoe
- Manure/compost should be applied **1 – 2 weeks** before transplanting the Tomato and incorporated into the soil

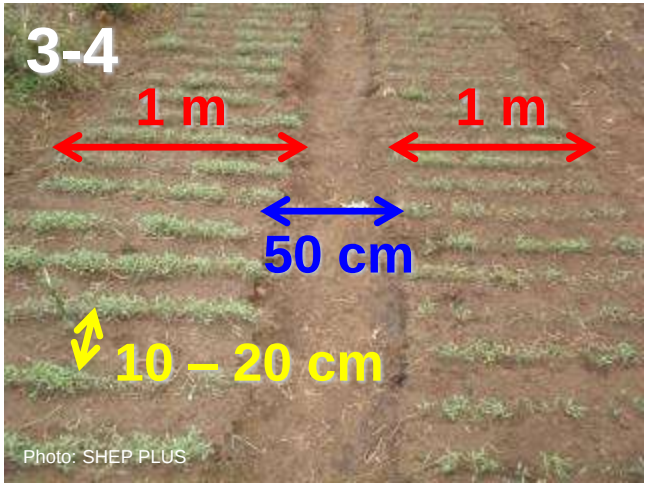
3.2 Raising Seedlings



Photos: SHEP PLUS

Tomato nursery

3.2 Raising Seedlings



Tomato nursery

3.2 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 **40 – 75 g/acre**
- **Seed trays** can also be used to raise seedlings

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**
- Choose the site with **good drainage**

Nursery Establishment:

- Prepare a seedbed of **1 m width** and of a convenient length
- Make drills on the seedbed at a spacing of **10 – 20 cm apart**
- Thinly sow the seeds in the drills and cover lightly with soil

Management of Nursery:

- Water the nursery regularly
- Harden the seedlings **1 – 2 weeks before transplanting** by reducing the frequency of watering and gradually exposing the seedlings to direct sunlight
- Insects such as whiteflies can transmit viruses to young tomato plants hence should be controlled using pesticides e.g. Amitraz (Mitac 20EC®), Buprofezin (Applaud 40%SC®), Azadirachtin (Nimbecidine®), Imidacloprid (Confidor 70 WG®)
- These insects can be blocked from reaching the seedlings by use of **an insect proof net** (agricultural type)

3.3 Transplanting

Recently transplanted Tomato seedlings

3.3 Transplanting

Recently transplanted Tomato seedlings

3.5 Transplanting

3.5.1 Appropriate Time

- Seedlings are transplanted **30 – 45 days** after seed sowing
- 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 **75 – 100 cm** (between rows) by **40 – 60 cm** (between seedlings) depending on the variety
- **Plant Population per Acre:** range from **6,666 to 13,333**
- 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 (**8 tons/acre**)
- **Apply 2 bottle tops** (**10 g**) of Triple Super Phosphate (TSP) per planting hole (**80 kg/acre**
- Apply Muriate of Potash (**MOP)** to enhance availability of potassium

3.4 Water Requirement

Drip Irrigation in a Tomato field

3.4 Water Requirement

Furrow Irrigation in a Tomato field

3.4 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:

- **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”

3.5 Managing of Weeds

Tomato under good weed management

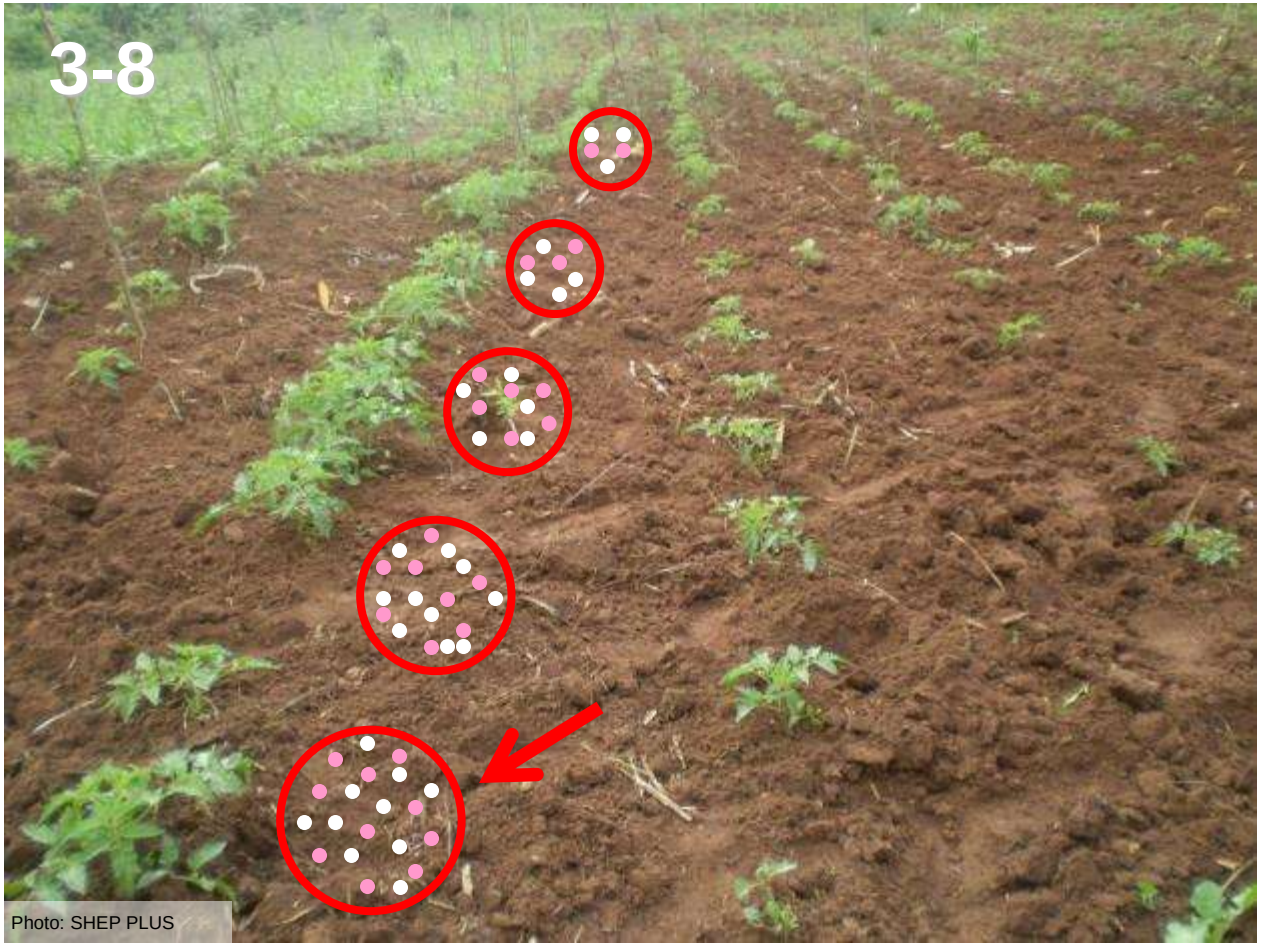
3.5 Managing of Weeds

Tomato under good weed management

3.5 Managing of Weeds (GHCP&PHHT20: Q13)

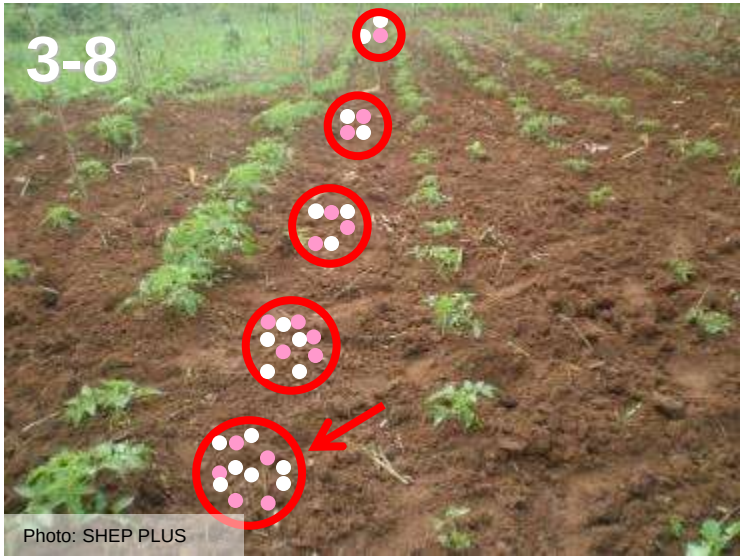
- Avoid bruising the roots during weeding
- This can be done through use of appropriate weeding tools
- Generally, keep the field weed free as much as possible to avoid competition for **nutrients**, **sunlight** and **moisture**
- Weeding Tomato field when the soil is wet can increase the spread of some **bacterial** (Bacterial Wilt) and **fungal** (Fusarium Wilt) **diseases**

3.6 Top-dressing



Top-dressing using the placement method

3.6 Top-dressing



Top-dressing using the placement method

3.6 Top-dressing (GHCP&PHHT20: Q14)

- Tomato crop should be fertilized with organic and inorganic chemical fertilizers to produce high yields
- Top-dressing fertilizer such as CAN should be applied in **2 splits** at **40 kg & 80 kg/acre** at **4 and 8 weeks** after transplanting
- 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**

3.7 Crop Management
3.7.1 Training & Staking

3-9

Photo: SHEP PLUS

Well staked Tomato field

3.7 Crop Management
3.7.1 Training & Staking

3-9

Photo: SHEP PLUS

Well staked Tomato field

3.7 Crop Management
3.7.1 Training and Staking

- Indeterminate varieties need **staking/training** to facilitate pruning, harvesting and other cultural practices
- Determinate varieties may be **staked** in wet season or **mulched** 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

3.7.2 Pruning

Training of Tomato plants in the field
A side shoot has been pinched

3.7.2 Pruning

Training of Tomato plants in the field

(A side shoot has been pinched)

3.7.2 Pruning

- This practice is necessary for the **indeterminate** varieties
- It involves **removal of side shoots**, **extra flowers**, **fruits and diseased leaves**
- Leads to **early maturity** of fruits and encourages fruits to **increase in size and uniformity**
- **Sterilize** pruning blades by use of chlorine bleach and water at a ratio of 1:1. Use of unsterilized blades, and smoking can lead to spread of diseases e.g. **TMV, Bacterial Wilt**

3.8.1 Major Pests

Photo: SHEP PLUS

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?imgnum=5432149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid=22440495

3.8.1 Major Pests

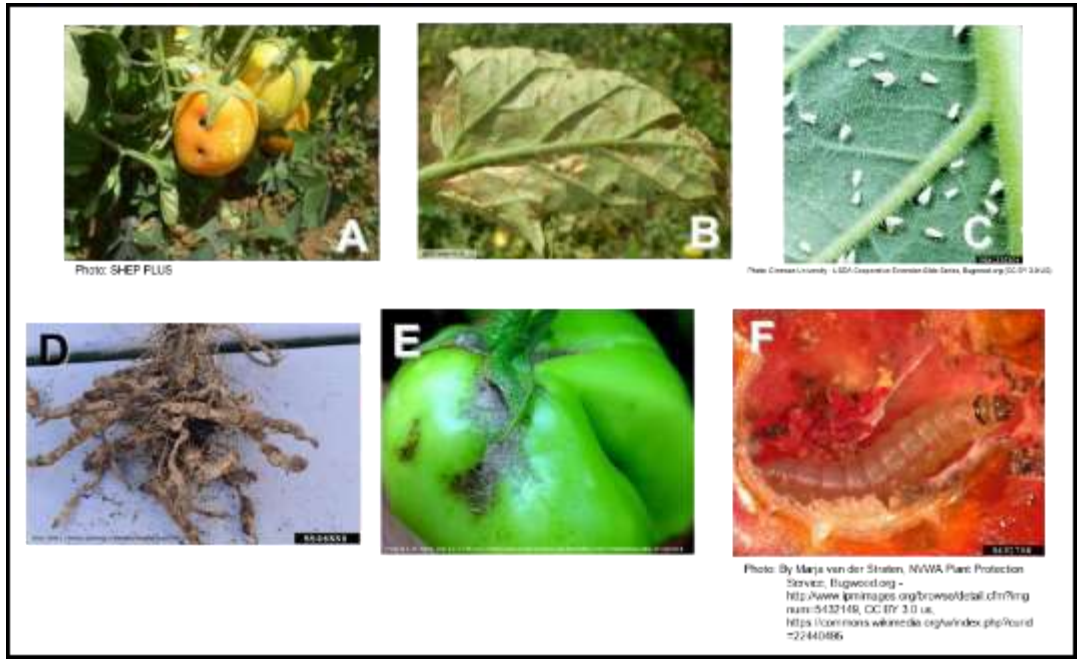


Photo: SHEP PLUS

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?img num=5432149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid =22440886

3.8.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Tomato in Kenya:

A. African Bollworm
B. Red Spider Mites
C. Tobacco Whitefly
D. Root-knot Nematode
E. Thrips
F. Tuta absoluta

3.8.1.A: African Bollworm

Symptom of fruit damaged by “African Bollworm”

3.8.1.A: African Bollworm

Symptom of fruit damaged by "African Bollworm"

3.8.1.A: African 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 & Africam Marigold**) 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:
  - Helocoverpa armigera SNPV Virus (**Helitec SC®)**
  - **Indoxacarb (Avaunt 150SL®)**
  - **Etofenprox 30%(TREBON 30 EC®)**

3.8.1.B: Red Spider Mites

Underside of Tomato leaf infested with “Red Spider Mites”

3.8.1.B: Red Spider Mites

Underside of Tomato leaf infested with "Red Spider Mites"

3.8.1.B: Red Spider Mites

Identification:

- Adult red spider mites are **oval in shape**, appear **reddish** or **greenish** with 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:

- Infested leaves 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:

- Use of pesticides (miticides) including:
  - Spiromesifen (**Oberon SC 240®)**
  - Hexythiazox (**Arsur 100 EC®**)
  - Abamectin (**Avirmec 1.8EC®**, **Almectin 1.8%EC®**, **Agrimec 18EC®**)
  - Amitraz (**Mitac 20EC®)**
  - ***Amblyseius californicus*** **(Amblytech®-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 modes of action and chemical composition/active ingredients- a.i**
  - Avoid **routine spraying**
  - Use the **recommended dosage**

3.8.1.C: Tobacco Whitefly

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

“Tobacco Whitefly” on the Tomato leaf

3.8.1.C: Tobacco Whitefly

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

"Tobacco Whitefly" on the Tomato leaf

3.8.1.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
- Cover tomato seedling nurseries with **nylon nets or insect proof nets** to protect seedlings from Whitefly infestations
- **Use of insecticides**, such as (**morning** & **ring spray**)
  - **Amitraz (Mitac 20EC®)**
  - **Buprofezin (Applaud 40%SC®)**
  - **Azadirachtin (Nimbecidine®)**
  - **Imidacloprid (Confidor 70 WG®)**
  - **Lambda Cyhalothrin (Karate 2.5WG®)**
  - **Lambda- cyhalothrin + Thiamethoxam (LEXUS 247 SC®)**

3.8.1.D: Root-knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

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

3.8.1.D: Root-knot Nematode

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

3.8.1.D: Root-knot Nematode

Description:

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

Damages:

- Plants are **stunted**, become **yellow** and tend to **wilt in hot weather**
- The roots of infested plants are severely **distorted**, **swollen** and **bear galls** or **knots**
- Heavy infestation 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**
- **Manuring** of soil to reduce nematode population
- Fields should be **ploughed deep** and **harrowed followed by dry fallow**
- **Use trap/ repellent crops** such as **Marigold**
- **Use of nematicides** such as
  - **Paecilomyces lilacinus (BIO-NEMATON 1.15% WP®) Azadirachtin (Nimbecidine®, Achook EC®)**
  - ***Paecilomyces lilacinus* (Mytech WP®)**
  - **Metham sodium (Metham sodium®)**
  - **Abamectin (Adventure 5G®)**
  - **Ethoprophos (MOCAP GR 10®)**

3.8.1.E: Thrips

Photo: © A. M. Varela, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Crops/Tomato#simple-table-of-contents-4

Photo: SHEP PLUS

Symptoms of Thrips Damage on Tomato (Left) and TOSPO Virus Symptom (Right)

3.8.1.E: Thrips

Symptoms of Thrips damage on Tomato

Tospovirus symptom

3.8.1.E: Thrips

Identification:

- Adult thrips are **small** (**0.5 – 2.0 mm**), **slender** and **winged**
- Wings are long, narrow and fringed with long hairs
- Nymphs are **white or yellow**
- Both adult and nymphs feed on lower leaf surface, buds, flowers and fruits
- It transmits the **Tomato Spotted Wilt Virus/ Tospovirus** (**"Kijeshi"**)

Damages:

- Attack on leaves causes **speckling** & **small necrotic patches**
- Heavy infestation causes **premature wilting**, **delay in leaf development** & **distortion of young shoots**
- Attack on buds and flowers leads to **abortion**

Control:

- **Ploughing and harrowing** before transplanting to kill **pupae** in the soil
- **Use of insecticides**, such as
  - **Lambda-Cyhalothrin (Karate 2.5 WG®)**
  - **Abamectin** + **Acetamiprid (Amazing Top 100WDG®)**
- Thrips are difficult to control with insecticides because their habits partially offer protection from insecticides (eggs are laid in plant tissue, adults shelter in flowers, and larvae pupate in soil)

3.8.1.F: *Tuta Absoluta*

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?imgnum=5362149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid=22430495

***Tuta Absoluta* adult (left) and larva (right)**

3.8.1.F: *Tuta Absoluta*

Tomato Leafminer adult

Tomato Leafminer larva

3.8.1.F: *Tuta Absoluta*

Identification:

- The moth is **grey-brown**, **same size** and **posture** as diamond back moth (DBM) and has long antenna and lays up to 260 eggs
- 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**
- **Distribution** is through **seedlings, containers, fruits, soil & Green houses**

3.10.3.F: *Tuta absoluta*

Photo: By N3v3rl4nd - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6598872

By Goldlocki - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=228832

Scouting on the leaves: Tomato Leafminer (left) *Tuta Absoluta* (right)

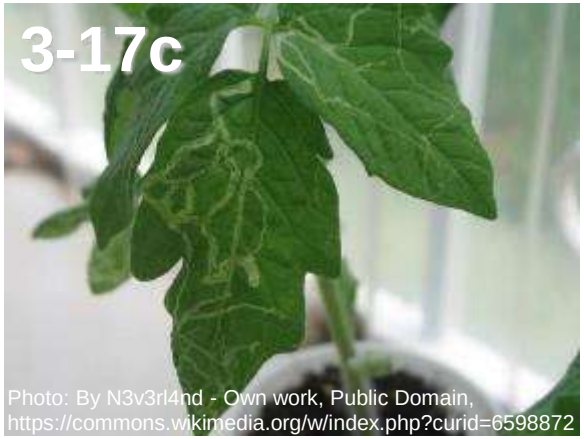
3.8.1.F: *Tuta Absoluta*

Damages:

- The caterpillar burrows (mines**) in the middle of the leaf tissue**
- **Unlike other Leafminers, it feeds indiscriminately** and from a distance, you see as if 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**
- **Can lead to 100% crop loss**

Control:

- **Early control** is important before the pest pressure builds up
- Carry out cultural practices like **field hygiene, crop rotation**
- 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
  - **Chlorantraniliprole (Coragen®)**
  - **Indoxacarb (Avaunt 150EC®, Merit 150SC®), Spirotetramat + Flubendiamide (Tihan OD®)**
  - **Thiocyclam 50% w/w; Thiocyclam-hydrogenoxalate (Evisect S®) and - Imidacloprid (Grizly 175/30 SC®)**
  - **Flubendiamide (Belt 480SC®)**
- The above pest control tactics should be combined in an **IPM strategy**



3-17c: common leaf miner infesting on leaves which normally does not affect the fruit

3-17d: Leaf-mining pattern of *Tuta Absoluta*

3.8.2 Major Diseases & Physiological Disorders

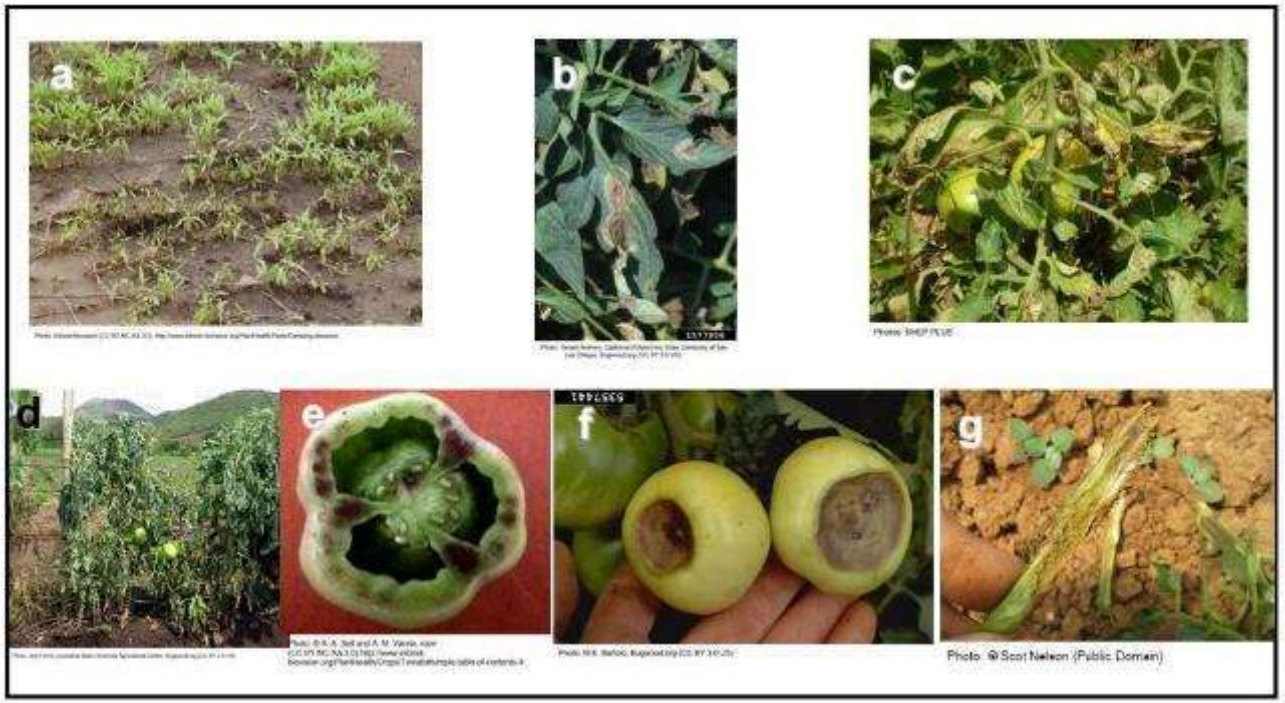
Photos: SHEP PLUS

Photo: © A. A. Self and A. M. Varela, icipe (CC BY NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Tomato/example-table-of-contents-4

Photo: M.E. Bartolo, Bugwood.org (CC BY 3.0 US)

Photo: © Scot Nelson (Public Domain)

3.8.2 Major Diseases & Physiological Disorders



28/37

3.8.2 Major Diseases & Physiological Disorders

- Disease infection 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 Mosaic
f. Blossom-end Rot
g. Fusarium Wilt

3.8.2.a: Damping-off

Photo: Infonet Biovision (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Pests/Damping-diseases

“Damping-off” symptoms on seedlings

3.8.2.a: Damping-off

“Damping-off” symptoms on seedlings

3.8.2.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
- Apply chemicals such as:
  - Metalaxyl + Mancozeb (Amidil 68WG)

3.8.2.b: Late Blight

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Edward Sikora, Auburn University, Bugwood.org (CC BY 3.0 US)

“Late Blight” on foliage and fruits

3.8.2.b: Late Blight

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Edward Sikora, Auburn University, Bugwood.org (CC BY 3.0 US)

"Late Blight" on foliage and fruits

3.8.2.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 with **foul smell**

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:
  - **Metalaxyl** + **Mancozeb (Ridomil Gold MZ68®)**
  - **Propineb** + **Cymoxanil (Milraz WP76®)**
  - **Mancozeb (Dithane M45®)**
  - **Dimethomorph** + **Mancozeb (Acrobat MZ®)**

3.8.2.c: Early Blight

Photo: SHEP PLUS

“Early Blight” on foliage

3.8.2.c: Early Blight

Photos: SHEP PLUS

“Early Blight” on foliage

3.8.2.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; warm wet weather
- The disease is favoured by warm rainy weather

Symptoms:

- **Premature loss** of **lower leaves** is the main symptom
- On leaves, brown circular spots with **dark concentric rings**
- Leaves turn yellow and dry when only a few spots appear
- On fruits, large sunken areas with dark concentric rings appearing velvet

Control:

- Use of certified seeds
- Appropriate spacing
- Avoid overhead irrigation, water in the morning and keep plants healthy/ stress-free
- **Use of fungicides**, such as
  - **Chlorothalonil (Odeon® 82.5WDG)**
  - **Manconzeb (Oshothane®)**
  - **Propineb (Antracol WP70®)**
  - **Mancozeb** + **Cymoxanil (Agromax®)**
  - **Propineb** + **Iprovalicarb (Melody Duo®)**

3.8.2.d: Bacterial Wilt

Photo: Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org (CC BY 3.0 US)

Symptom of “Bacterial Wilt” infection

3.8.2.d: Bacterial Wilt

Photo: Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org (CC BY 3.0 US)

Symptom of "Bacterial Wilt" infection

3.8.2.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
- **Solarize** planting beds
- Spot treatment with **Sodium Hypochlorite** at 10 % dilution (Jik) or with **lime/ ash**
- Sterilize pruning tools
- Use of Metam sodium (METHAM SODIUM 51 Liquid soluble®), Bronopol (ENRICH BM Wettable Powder®)

3.8.2.e: Tomato Mosaic Virus

3-24

Photo: University of Georgia Plant Pathology , University of Georgia, Bugwood.org (CC BY 3.0 US)

3-25

Photo: © A. A. Seif and A. M. Varela, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Tomato#simple-table-of-contents-4

Symptoms of “Tomato Mosaic Virus” infection on foliage and fruit

3.8.2.e: Tomato Mosaic Virus

Photo: University of Georgia Plant Pathology , University of Georgia, Bugwood.org (CC BY 3.0 US)

Photo: © A. A. Self and A. M. Varela, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealthyCrops/Tomato#simple-table-of-contents-4

Symptoms of "Tomato Mosaic Virus" infection on foliage and fruit

3.8.2.e: Tomato Mosaic Virus

General Descriptions:

- This is a **viral disease** which is easily transmitted by infected seed and plant debris in the soil
- Mechanically transmitted through transplanting seedlings and pruning tools

Symptoms:

- Mottling of leaves with raised dark green areas
- The shape of young leaves is distorted
- Internal browning of fruits, especially when fruits are affected **at mature green stage**

Control:

- Use certified disease-free seeds
- Remove crop debris and roots from the field
- Do not smoke or touch cigarettes as the virus is transmitted from tobacco leaves even if it is processed

3.8.2.f: Blossom-end Rot

Photo: M.E. Bartolo, Bugwood.org (CC BY 3.0 US)

Tomato fruits affected by “Blossom-end Rot”

3.8.2.f: Blossom-end Rot

Photo: M.E. Bartolo, Bugwood.org (CC BY 3.0 US)

Tomato fruits affected by "Blossom-end Rot"

3.8.2.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**
- **Soil liming** in calcium deficient soils, **reduce N** and **mulch** the field
- **Top-dress with CN, Mavuno Planting** and ensure adequate soil moisture
- **Spray the crop with calcium chloride**
- Foliar application of **EASY-GRO CALCIUM®**

3.8.2.g: Fusarium Wilt

Photo: © Scot Nelson (Public Domain Mark 1.0)

Symptoms of Fusarium Wilt

3.8.2.g: Fusarium Wilt

Photo: © Scot Nelson (Public Domain Mark 1.0)

Symptoms of Fusarium Wilt

3.8.2.g: Fusarium Wilt

General Descriptions:

- The fungus is both **seed- and soil-borne**.
- It causes most damage on **light, sandy soils**.
- It is most active at temperatures **between 25 and 32^{o}C**.
- The fungus can survive in the soil indefinitely **even when no tomatoes are grown.**
- **It can also survive in fibrous roots of weeds** (e.g. Amaranthus, Digitaria and Malva species).
- **Acidic soils (pH 5.0 to 5.6)** and excessive nitrogen fertilisation promote disease development.

Symptoms:

- **The lower leaves** of the plant usually turn yellow and die.
- Leaflets on one side may be affected while those on the other side are symptomless.
- Diseased leaves readily break away from the stem. When affected stems just above ground level and petioles are cut diagonally, **a reddish-brown discolouration of the water conducting tissues will be observed**.

Control:

- Use resistant tomato varieties (e.g. "Fortune Maker", "Rio Grande", "Tengeru 97", "Roma VFN“, “Eden F1”, “Rambo F1”, “Anna F1”).
- Use **certified disease-free seeds**.
- Do not locate seedbeds on land where Fusarium wilt is known to have occurred.
- Where soil is acidic, raise the pH by applying lime or farmyard manure.
- Avoid excessive nitrogen fertilisation and control root-knot nematodes.

4. Harvest

Photo: SHEP PLUS

Harvesting of Tomatoes

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
  - 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 fruits should be kept in a **cool**, **shaded** and **ventilated area** in order to minimize heat gain
- Where necessary, wipe fruits to remove dirt
- The yields vary from **12,000 – 40,000kg per acre** depending on the variety and crop husbandry

5. Post-Harvest Handling

Photo: SHEP PLUS

Graded tomatoes packed in crates

5. Post-Harvest Handling

Photo: SHEP PLUS

Graded tomatoes packed in crates

5. Post-Harvest Handling

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

- Tomatoes are normally packed in wooden & plastic crates

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

Sorting:

- Sorting is done to remove damaged or diseased fruits.

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’

5-2

Photo: SHEP PLUS

Tomatoes in crates ready to be transported to the market

5. Post-Harvest Handling Cont'

5-2

Photo: SHEP PLUS

Tomatoes in crates ready to be transported to the market

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

Processing:

- Processing Tomatoes into high value products such as **jam**, **sauce**, and **pickles** enables farmers to earn more income