TOMATO PRODUCTION MANUAL

AUTHORS:

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# TABLE OF CONTENTS

## INTRODUCTION
- 4

## Origin and Distribution
- 7

## Climatic and Soil Requirements
- 8

## Selecting Variety (Cultivars)
- 9
  a) Resistance to Diseases
  - 12
  b) Fruit Type
  - 12
  c) Plant Habit
  - 13
  d) Hybrid or Inbred Lines
  - 13

## CROP MANAGEMENT
- 14
  a) Field Preparation
  - 14
  b) Seed rate Requirements
  - 14
  c) Nursery / Seedbed
  - 15
  d) Planting in the field (Transplanting)
  - 16
  e) Manure and Fertilizer
  - 17
  f) Mulching
  - 17
  g) Weeding
  - 18
  h) Other cultivation practices
  - 18
  i) Training/Staking
  - 18
  j) Pruning
  - 19
  k) Irrigation
  - 20

## CROP PROTECTION
- 21

## INSECT PESTS
- 21
  a) Cut worm
  - 21
  b) African bollworm
  - 22
  c) Whiteflies
  - 23
  d) Red spider mite
  - 25
  e) Leaf hoppers
  - 27
  f) Leaf miners
  - 28
  g) Tuta Absoluta
  - 29
  h) The tomato mirid bug
  - 30
  i) Aphids
  - 32
  j) Thrips
  - 34
  k) Root knot
  - 35

## MAJOR TOMATO DISEASES
- 37

## BACTERIAL DISEASES
- 37
  a) Bacterial canker
  - 37
  b) Bacterial Wilt
  - 38
  c) Bacterial spot
  - 39
  d) Bacterial speck
  - 40

## FUNGAL DISEASES
- 43
Alternaria spp. .................................................................43
Anthracnose .................................................................44
Early blight .................................................................45
Late blight .................................................................46
Fusarium wilt .................................................................48
Verticum wilt .................................................................49
Septoria leaf spot ....................................................50
Powdew meldew ....................................................52

VIRAL DISEASES .................................................................54
Tomato spotted wilt virus .......................................54
Tomato common mosaic virus ...............................57
Tomato Yellow Leaf Curl Virus ...............................58

NUTRITIONAL DISORDER .................................................................59
Nitrogen .................................................................59
Phosphorous .................................................................59
Potassium .................................................................59
Calcium .................................................................60
Magnesium .................................................................60
Iron ..............................................................................60

PHYSIOLOGICAL DISEASES OF TOMATO .................................61
Blossom end rot .................................................................61

POSTHARVEST HANDLING AND VALUE ADDITION OF TOMATO IN KENYA .................................................................64
Yields and Preference for Tomato .................................................................64
Harvesting .................................................................65
Field collection and packaging .................................................................68
Transportation of tomatoes from farm to market .................................................................70
Bulking and sorting at the market .................................................................71
Packaging at retail market .................................................................71

PROCESSING AND VALUE ADDITION OF TOMATOES .........74
Preparation of tomato jam .................................................................75
Tomato juice .................................................................76
Tomato puree .................................................................76
Tomato Ketchup .................................................................77

Appendix .................................................................80
Glossary .................................................................81
INTRODUCTION

Common Name: Tomato
Scientific name: *Lycopersicon esculentum* Mill.
Other name: Nyanya (Kiswahili)

Tomato belongs to the family Solanaceae. It is one of the most important vegetables grown in Kenya. Its fruits are used fresh in salads or cooked as a vegetable, processed into tomato paste (puree), tomato sauce, ketchup, juice and can also be sun dried. Tomato is rich in vitamins A and C and is gaining importance because of lycopene, a food component known to reduce the incidence of prostate cancer.

In 2014, vegetables contributed 31.8% to domestic horticulture and were planted on an area of 280,541 ha (9% increase from 2013); producing 3.6 million tons and valued at KES 64.1 billion (HCD, 2015). Tomato was ranked as the 3rd most important vegetable after kale and cabbage constituting between 18% to 20% of the vegetable value and area under production (HCD, 2015).

In 2010, 78 stakeholders ranked tomato as the most important exotic vegetable in Kenya during an agriculture product value chain national exercise (Ndegwa et al., 2012). Area under tomato in 2014 was 24,074 ha (15% increase from 20,985 ha in 2013) that yielded 400,204 tons (4% increase of 383,868 tons produced in 2013) and valued at KES 11.8 billion. The top counties growing tomato are Kirinyaga (12.1%), Bungoma (12.6%), Kajiado (11.6%), Makueni (5.3%) and Kiambu (4.5%) (Table1). Tomatoes are mainly produced through rain-fed agriculture except in Kirinyaga (Mwea), Loitoktok (Namelock), Machakos (Kabaa) were they are grown under irrigation. In the past decade tomatoes have been grown under covered agriculture (high tunnels, screenhouses or greenhouses). Under these systems major constraint is bacterial wilt causing over 50% losses and abandoned greenhouses.
Fig. 1. Priority vegetables (Source HCDA, 2012)
Table 1. Production of Tomato in Counties

<table>
<thead>
<tr>
<th>County</th>
<th>2012 Area</th>
<th>2012 Production (million)</th>
<th>2013 Area</th>
<th>2013 Production (million)</th>
<th>2014 Area</th>
<th>2014 Production (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kajiado</td>
<td>1,603</td>
<td>35,937</td>
<td>1,668</td>
<td>50,884</td>
<td>1,680</td>
<td>47,368</td>
</tr>
<tr>
<td>Bungoma</td>
<td>1,344</td>
<td>39,232</td>
<td>1,474</td>
<td>41,568</td>
<td>1,700</td>
<td>50,399</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>1,903</td>
<td>59,464</td>
<td>1,796</td>
<td>30,774</td>
<td>1,648</td>
<td>48,560</td>
</tr>
<tr>
<td>Makueni</td>
<td>431</td>
<td>17,582</td>
<td>486</td>
<td>22,560</td>
<td>558</td>
<td>21,096</td>
</tr>
<tr>
<td>Kiambu</td>
<td>964</td>
<td>18,029</td>
<td>691</td>
<td>9,169</td>
<td>964</td>
<td>18,029</td>
</tr>
<tr>
<td>Trans Nzoia</td>
<td>480</td>
<td>9,270</td>
<td>623</td>
<td>17,395</td>
<td>628</td>
<td>14,848</td>
</tr>
<tr>
<td>Machakos</td>
<td>547</td>
<td>10,335</td>
<td>724</td>
<td>11,548</td>
<td>447</td>
<td>6,189</td>
</tr>
<tr>
<td>Kisii</td>
<td>876</td>
<td>15,590</td>
<td>951</td>
<td>16,985</td>
<td>937</td>
<td>16,664</td>
</tr>
<tr>
<td>Nakuru</td>
<td>509</td>
<td>6,745</td>
<td>495</td>
<td>8,668</td>
<td>633</td>
<td>17,511</td>
</tr>
<tr>
<td>Kisumu</td>
<td>822</td>
<td>12,219</td>
<td>1,537</td>
<td>14,307</td>
<td>1,477</td>
<td>16,720</td>
</tr>
<tr>
<td>Total</td>
<td>19,185</td>
<td>364,105</td>
<td>20,985</td>
<td>383,868</td>
<td>24,074</td>
<td>400,204</td>
</tr>
</tbody>
</table>

Note that the total is for all tomato production in Kenya; Source HCD, 2015
Origin and Distribution

Tomato is indigenous to the Peru and Ecuador regions in South America and probably evolved from *Lycopersicon esculentum* var. cerasiforme, the cherry form. However, it was domesticated and first cultivated in Central America by early Indian civilizations of Mexico. The Spanish explorers introduced tomato in Spain and it was later taken to Morocco, Turkey and Italy. In Italy and France, it was termed “*love apple*”. It was widely believed that tomato was poisonous and its use as a food crop was only accepted in the 18th Century. Tomato is now one of the most popular and widely grown vegetables worldwide.

Table 2. Nutritive Value per 100 g of Edible Portion (*Source: Bioinfonet website*)

<table>
<thead>
<tr>
<th>Raw or Cooked Tomato</th>
<th>FoodEnergy (Calories / %DV)</th>
<th>Carbohydrates (g / %DV)</th>
<th>Fat (g / %DV)</th>
<th>Protein (g / %DV)</th>
<th>Calcium (g / %DV)</th>
<th>Phosphorus(mg / %DV)</th>
<th>Iron (mg / %DV)</th>
<th>Potassium (mg / %DV)</th>
<th>Vitamin A (IU)</th>
<th>Vitamin C (IU)</th>
<th>Vitamin B 6 (mg / %DV)</th>
<th>Vitamin B 12 (mg / %DV)</th>
<th>Thiamine (mg / %DV)</th>
<th>Riboflavin (mg / %DV)</th>
<th>Ash (g / %DV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red cooked tomato</td>
<td>18 / 1%</td>
<td>4 / 1%</td>
<td>0.1 / 5%</td>
<td>0.9 / 2%</td>
<td>11 / 1%</td>
<td>28 / 4%</td>
<td>0.7 / 4%</td>
<td>218.0 / 6%</td>
<td>489 IU / 10%</td>
<td>22.8 / 38%</td>
<td>0.1 / 4%</td>
<td>0 / 0%</td>
<td>0 / 0%</td>
<td>0 / 0%</td>
<td>0.6</td>
</tr>
<tr>
<td>Green raw tomato</td>
<td>23 / 1%</td>
<td>5.1 / 2%</td>
<td>0.2 / 0%</td>
<td>1.2 / 2%</td>
<td>13 / 1%</td>
<td>28 / 3%</td>
<td>0.5 / 3%</td>
<td>204 / 6%</td>
<td>642 IU / 13%</td>
<td>23.4 / 39%</td>
<td>0.1 / 4%</td>
<td>0 / 0%</td>
<td>0.1 / 0%</td>
<td>0 / 0%</td>
<td>0.5</td>
</tr>
<tr>
<td>Orange raw tomato</td>
<td>16 / 1%</td>
<td>3.2 / 1%</td>
<td>0.2 / 0%</td>
<td>1.2 / 2%</td>
<td>5 / 1%</td>
<td>29 / 3%</td>
<td>0.5 / 3%</td>
<td>212 / 6%</td>
<td>1496 IU / 30%</td>
<td>16 / 27%</td>
<td>0.1 / 3%</td>
<td>0 / 0%</td>
<td>0 / 3%</td>
<td>0 / 0%</td>
<td>0.7</td>
</tr>
<tr>
<td>Yellow raw tomato</td>
<td>15 / 1%</td>
<td>3 / 1%</td>
<td>0.3 / 0%</td>
<td>1 / 2%</td>
<td>11 / 1%</td>
<td>36 / 4%</td>
<td>0.5 / 3%</td>
<td>258.0 / 7%</td>
<td>0 IU / 0%</td>
<td>9 / 15%</td>
<td>0.1 / 3%</td>
<td>0 / 0%</td>
<td>0 / 3%</td>
<td>0 / 3%</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 2 *Percent Daily Values (DV) are based on a 2,000 calorie diet. Daily values may be higher or lower, depending on your calorie needs.
Climatic and Soil Requirements

Although tomato is fairly adaptable to different agro-ecologies, it prefers warm conditions with optimum temperatures ranging from 15°C to 25°C. whereas high humidity and temperatures reduce fruit set and yields, low temperatures delay color formation and ripening. Temperatures above 30°C inhibit fruit set, lycopene development and flavor. Tomato thrives best in low-medium rainfall with supplementary irrigation during periods of drought. Wet conditions increase disease incidence and affect fruit ripening. Tomato grows well in a wide range of soils, and prefers those that are high in organic matter, well-drained and a pH range of 5 - 7.5. Soil analysis should be done before fertilizer application. These services are available at KALRO-Kabete, KALRO-Muguga South, KALRO-Embu, Tea Research Institute, Kenya Plant Heath Inspectorate Service, and other laboratories in Kenya.

Selecting Variety (Cultivars)

The choice of cultivars is based on fruit quality, adaptability and reliability, resistance/tolerance to diseases and pests, quality (firmness), plant growth habit, availability and suitability to the growing conditions, the specific market (preference by customers), and the planting time.

The choice of the best variety to plant is critical for good yields. Since there are many varieties in Kenya, you need to choose those that will meet your needs and are suited to your climate. No single variety will combine all the best features.

Tomatoes are both indeterminate whereby new shoots form continuously, inflorescence occur on every third or fourth leaf, and fruits mature sequentially or are determinate whereby shoot development is arrested after four to six inflorescences (Madumadu et al., 2004).

Farmers in Kenya grow wide a wide range of tomato varieties for processing e.g. Roma VF, Cal-J, and M-82 and fresh market e.g. Money Maker, Marglobe, Marmande, Elgon Ndume, Beauty and Riogrande. The popular tomato varieties grown in Kenya are Cal J, Rio Grande, Money maker, Roma, Anna F₁, Eden F₁, Kentom F₁, Kilele F₁, Safari F₁ Mavuno F₁ and Marglobe, (Table 2) (Madumadu et al., 2004; Owino, 2013; Ndegwa, 2015). Cal J and Rio Grande are sold by several seed companies (Table x).
Table 3. Tomato Varieties and Seed sources

<table>
<thead>
<tr>
<th>Seed company</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simlaw Kenya Ltd (Kenya Seed Co.)</td>
<td>Cal J, Prostar F₁, Libra F₁, Kentom F₁, Zawadi, New Fortune maker, Joy F₁, Money maker, Marglobe, M82, Simlaw Rio Grande, Monica F₁, Nouvelle F₁, Galaxy F₁,</td>
</tr>
<tr>
<td>Kenya Highland Seed Company (Royal Seeds)</td>
<td>Oxyl, Faulu, Onyx F₁, Rambo F₁, Sandokan F₁, Strike F₁, Chonto F₁, Bravo F₁, Harmony F₁, Mavuno F₁, Monalisa F₁, Samantha F₁</td>
</tr>
<tr>
<td>Syngenta Seeds</td>
<td>Kilele F₁, Tylka</td>
</tr>
<tr>
<td>Monsanto Africa (Seminis)</td>
<td>Anna F₁</td>
</tr>
<tr>
<td>East African Seed Company Ltd.</td>
<td>Faulu F₁, Nuru F₁</td>
</tr>
<tr>
<td>Seed Co.</td>
<td>Elite F₁, Rio Grande, Cal J</td>
</tr>
<tr>
<td>Amiran Kenya</td>
<td></td>
</tr>
<tr>
<td>Starke Ayres</td>
<td>Little Wonder, Star 9065 (hybrid)</td>
</tr>
<tr>
<td>Dryland Seed Ltd.</td>
<td>Padma 108 F₁, Kartik F₁</td>
</tr>
<tr>
<td>Rik Zwan</td>
<td></td>
</tr>
<tr>
<td>Freshco</td>
<td>Milele F₁ (hybrid)</td>
</tr>
<tr>
<td>Elgon Kenya</td>
<td>Napoli F₁, Rio Grande Super</td>
</tr>
<tr>
<td>Ultravetis Seed</td>
<td>Twiga F₁, Hybrid, Rio Grande, Nyati F₁ ??</td>
</tr>
</tbody>
</table>

Table 4. Select tomato varieties grown in Kenya

- Onyx
- Rio-grande
- Tomato F₁ Nours
- Cal J VF
- Mavuno F₁
- Oxyl Premium F₁
- Roma VF
- Faulu
Table 4. Tomato varieties grown in Kenya

<table>
<thead>
<tr>
<th>Field type</th>
<th>Greenhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Assila (TYLCV resistant - Seminis)</td>
<td>Anna $F_1$ – Seminis</td>
</tr>
<tr>
<td>2 Rwambo (Seminis)</td>
<td>Chonto $F_1$</td>
</tr>
<tr>
<td>3 Eden</td>
<td>Eva (Amiran)</td>
</tr>
<tr>
<td>4 Firenze (adapted to dry areas)</td>
<td>Nominneta $F_1$ (Amiran)</td>
</tr>
<tr>
<td>5 DRD 8551 (TYLCV and bacterial spot tolerance)</td>
<td>Corrazon (Amiran)</td>
</tr>
<tr>
<td>6 Bravo $F_1$ (Kenya Highland Seed Co)</td>
<td>Eden $F_1$</td>
</tr>
<tr>
<td>7 Rambo (Kenya Highland Seed Co)</td>
<td>Tylka $F_1$ (Syngenta)</td>
</tr>
<tr>
<td>8 Kilele $F_1$ (Syngenta)</td>
<td>Kilele $F_1$ (Syngenta)</td>
</tr>
<tr>
<td>9 Shanty (Amiran)</td>
<td>Little (Syngenta)</td>
</tr>
<tr>
<td>10 Tropicana</td>
<td>Eva</td>
</tr>
<tr>
<td>11 Monica $F_1$ (Simlaw)</td>
<td>Prosatar $F_1$ (Simlaw)</td>
</tr>
<tr>
<td>12 Nouvelle (Simlaw)</td>
<td>Top 11 $F_1$</td>
</tr>
<tr>
<td>13 Bigwa (E. A. Seed Co. Ltd)</td>
<td>Libra $F_1$</td>
</tr>
<tr>
<td>14 Nuru $F_1$ (E.A. Seed Co. Ltd)</td>
<td>Chonto $F_1$</td>
</tr>
<tr>
<td>15 Faulu $F_1$ (E.A. Seed Co. Ltd)</td>
<td>Bravo $F_1$</td>
</tr>
<tr>
<td>16 Mavuno $F_1$</td>
<td>Bingwa $F_1$</td>
</tr>
<tr>
<td>17 Monalisa $F_1$</td>
<td>Zawadi</td>
</tr>
<tr>
<td>18 Samantha $F_1$</td>
<td>Tanzanite $F_1$</td>
</tr>
<tr>
<td>19 Tengeru (Tanzania)</td>
<td></td>
</tr>
<tr>
<td>20 Tanya (Tanzania)</td>
<td></td>
</tr>
<tr>
<td>21 Zawadi $F_1$</td>
<td></td>
</tr>
<tr>
<td>22 Onyx $F_1$</td>
<td></td>
</tr>
<tr>
<td>23 Kenton $F_1$</td>
<td></td>
</tr>
<tr>
<td>24 Unique $F_1$</td>
<td></td>
</tr>
</tbody>
</table>
Table 5: Regional preference of tomato

<table>
<thead>
<tr>
<th>Region</th>
<th>Tomato varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mwea East</td>
<td>Kilele F1, Safari F1, Rio grande and Rambo (Source – Owino, 2013)</td>
</tr>
<tr>
<td>Mwea West</td>
<td>Rio tinto, Safari F1, Faloria, Kilele F1, Rio grande, Africa best (Source – Owino, 2013)</td>
</tr>
<tr>
<td>Subukia</td>
<td>Rio Grande, Asila F1, Cal J, Safari F1, African Best (Source – Owino, 2013)</td>
</tr>
<tr>
<td>Kitengela</td>
<td>Eva, Eden F1, Rio grande, Galtana, Money-maker, Asila F1, Cal J, Honex, Corrazone, Monetta and Anna F1 (Source – Owino, 2013)</td>
</tr>
<tr>
<td>Bungoma</td>
<td>Rio tinto, Safari F1, Faloria, Kilele F1, Rio grande, Africa best (Source – Owino, 2013)</td>
</tr>
<tr>
<td>Kajiado</td>
<td>Field – Assila F1, Rambo F1, Kilele F1, Tylka F1, Shanty F1, Monica F1</td>
</tr>
<tr>
<td></td>
<td>Greenhouse – Anna F1, Tylka F1 (Source - Kiulu, 2016)</td>
</tr>
<tr>
<td>Makueni</td>
<td>Field – Assila F1, Rambo F1, Kilele F1, Tylka F1, Shanty F1, Monica F1</td>
</tr>
<tr>
<td></td>
<td>Greenhouse – Anna F1, Tylka F1 (Source - Kiulu, 2016)</td>
</tr>
<tr>
<td>Machakos</td>
<td>Field - Cal J, Rio Grande, Roma</td>
</tr>
<tr>
<td></td>
<td>Greenhouse – Zawadi, Eden F1, Anna F1, Tanzanite F1 and Tanya (Source - Omari, 2016)</td>
</tr>
<tr>
<td>Kiambu</td>
<td>Greenhouse – Anna F1, Corazon, Chonto, Tylka, Prostar</td>
</tr>
<tr>
<td></td>
<td>Field – Cal J, Eden, Rionex,</td>
</tr>
<tr>
<td>Trans Nzoia</td>
<td>Greenhouse – Anna F1</td>
</tr>
<tr>
<td></td>
<td>Field – Rio grande, Cal J, Roma (Source - Kwambai, 2016)</td>
</tr>
</tbody>
</table>
Table 6. Recommended tomato varieties in Kenya

<table>
<thead>
<tr>
<th>Variety</th>
<th>Bearing Type</th>
<th>Fruit shape</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fresh market</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money Maker</td>
<td>Indeterminate</td>
<td>Round</td>
<td>67 days to maturity; yields 32 – 50 tons/ha</td>
</tr>
<tr>
<td>Rio Grande</td>
<td>Determinate</td>
<td>Square-round</td>
<td>128 days to maturity, yields 84 tons/ha</td>
</tr>
<tr>
<td>Marglobe</td>
<td>Indeterminate</td>
<td>Globe</td>
<td>70 days to maturity; yields 38 tons/ha</td>
</tr>
<tr>
<td>Marmande</td>
<td>Indeterminate</td>
<td>Round</td>
<td>72 days to maturity; yields 32 tons/ha</td>
</tr>
<tr>
<td>Elgon Ndume</td>
<td>Indeterminate</td>
<td>Globe</td>
<td>71 days to maturity; yields 28 tons/ha</td>
</tr>
<tr>
<td>Beauty</td>
<td>Indeterminate</td>
<td>Round</td>
<td>70 days to maturity; yields 20 tons/ha</td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal –J</td>
<td>Determinate</td>
<td>Pear</td>
<td>Very popular in the market and widely grown; 120 days to maturity; has a long shelf life; yields 73 tons/ha</td>
</tr>
<tr>
<td>M-82</td>
<td>Determinate</td>
<td>Pear</td>
<td>120 days to maturity; yields 57 tons/ha</td>
</tr>
<tr>
<td>Roma VF</td>
<td>Determinate</td>
<td>Pear</td>
<td>120 days to maturity; yields 83 tons/ha</td>
</tr>
</tbody>
</table>

**Source:** Madumadu et al., 2004

**a) Resistance to Diseases**

Disease control is one of the major factors affecting tomato quality and production. It is wise to avoid varieties that offer no resistance to serious disease prevalence in your area. Tolerance or resistance is usually indicated by initials after the variety name. Thus tolerance/resistance to Bacterial wilt, Verticillium, Fusarium, Nematodes, Tobacco Mosaic Virus and Alternaria.

**b) Fruit Type**

There are three market classes of tomatoes:
• **Fresh market** – Color shape or size may vary but the fruits are usually red.
• **Processing** – Fruits have intense red color and high solids content for making paste, sauce or ketchup, usually grown without staking.
• **Cherry** – Not very common in Kenya. It is a small fruit about (30g). They are a fresh market variety borne on long clusters.

c) **Plant Habit**

**Determinate** – These are short and bushy tomato varieties that are produce stems that end with flower clusters. These types of tomatoes ripen early, are easier to harvest and have a more concentrated fruit maturity.

**Indeterminate** – These varieties produce new leaves and flowers continuously and hence grow very tall (>2 m). Indeterminate varieties must be staked and continuously pruned. Most greenhouse types are indeterminate types.

**Semi-determinates** – They also produce stems that end with a flower cluster. These varieties grow slightly taller than the determinates.

d) **Hybrid or Inbred Lines**

Hybrids are intermediate plants resulting from the crossing of two or more different biotypes of the same or different species. Seeds of inbreeds can be harvested and saved for future planting while those for hybrids cannot. Hybrids often produce higher yields, uniform fruits or any other preferred quality attribute. Hybrids are usually more expensive than inbred.
CROP MANAGEMENT

Preceding Crop Recommendation
Avoid planting tomatoes in a field planted previously with tomatoes or plants of the same family like pepper, eggplant or other Solanaceous crop in the last 2 – 3 seasons. This is because they share similar insect and disease problems. Other crops not recommended include: - potato, okra, tobacco, onion, garlic, melon, cucumber and squash. Crops recommended include – green beans, cabbage, turnip, cassava, maize, sorghum, groundnut and broccoli.

Field Preparation
Hardpans or compacted soil should be thoroughly loosened by deep ploughing to enable the root system to spread to a depth of 40 – 60cm. Precise field leveling and instillation of drainage tiles should be done for sites with uneven topography, ditches and waterlogged sites.
The field should be near a reliable water source as tomatoes require frequent watering.
Low soil pH can be corrected by addition of Lime (CaCo3). High soil pH or Sodic soils remediation is done by application of Gypsum (CaSO4).
Soil borne Pathogens and Nematodes can be controlled by soil solarization after a deep plough. False sowing technique can be used to reduce the number of weed seeds present in the soil. This is done by watering the field after full preparation. The weeds are then eliminated by hoeing or by chemical weed killer. Regular ridges should be done about 30 - 35 cm high and 25 – 30 cm wide.

Seed rate Requirements
Tomato is usually raised in the nursery which can be purchased as certified seeds from the dealers and stockiest. These seeds are usually treated with spectrum fungicides such as, Captan, Lindane, Carbosulfan, Tebuconazole, Imidaclopid or Tolclofos methyl Triazoxide to control damping off. For a Hectare, you require about 250gms of seed which has approximately 70,000 seeds of indeterminate varieties or 125g of seeds for determinate varieties. For an acre use about 60 to 100gms for indeterminate varieties, and about 30 to 50gms for determinate ones. Sow seeds 0.5cm deep. Seed from a previous crop especially from hybrid varieties should not be used to avoid poor yields and seed borne disease.

Sowing Facility
In Kenya, tomato seeds are either sown into a nursery or sown on plastic seeding trays.
Seed Tray Method
In this method, the seed tray holes are filled with a media that drains well such as commercial potting soil, cocopeat, peat, moss or a mixture of sand and compost. Sow 2 seeds per hole and thin seedlings 2 - 3 days after the first true leaves. This method makes seeds healthier and more vigorous and suffers no root damage when transplanted.

Fig 1. Tomato seedlings on the planting trays (picture by Lusike Wasilwa)

Nursery / Seedbed Method
The nursery should be sited in a well-drained area preferably not previously planted with a Solanaceous crop. The seedbed or nursery site should be in a place protected from direct sunlight by erecting a shade structure. Seeds should be sown in rows 6 cm apart at a rate of 750 – 900 seeds / m2. The seedbed surface is spread with a thin layer of compost or straw mulch. Water the seedlings regularly so that the soil is moist but avoid water logging. Thin the seedlings 2-3 days after the first true leaves appear. A week before transplanting, reduce the watering frequency to harden the seedlings. Transplanting should take place one month after sowing (4-6 leaves stage) the seedlings are uprooted with a ball of soil when they attain from 4 to 6 leaves. This should be done on a cloudy day or late in the afternoon to reduce transplanting shock, before lifting seedlings from the bed, thoroughly water to avoid excessive damage to the roots.
Planting in the field (Transplanting)
Harden your seedlings prior to transplanting by reducing water application and directly exposing them to sunlight 6-9 days before. A good seedling ready for transplanting is in the fourth or sixth leaves stage (about 4 weeks old) and is vigorous and stocky. Thoroughly water the seedlings about 12 hours before transplanting to the field. This facilitates easy uprooting of seedlings. Transplant the seedlings in the late afternoon or early morning to minimize transplant shock. Insert the seedlings in a hole in such a way that the first real leaves are 5 – 10 cm above the surface. Plants can be planted on raised beds or flat land at a spacing of 0.6 – 1.2 m between rows and 0.45 – 0.9 m between plants giving a plant population of 37 000 ha$^{-1}$ – 9300 ha$^{-1}$ depending on the cultivar. Press the soil around the root and water around the base of the plant. Irrigate the field moderately as soon as possible after transplanting.
Manure and Fertilizer

In soils poor in organic matter use 20 tons ha\(^{-1}\) (two handfuls per planting hole) of manure and mix thoroughly with the soil. Triple superphosphate should be applied at 200 kg ha\(^{-1}\) (which is equivalent to 10g or one teaspoonful per planting hole) and mixed well with soil. Top dress with CAN at 100 kg/ha (5gms or ½ teaspoonful per plant), when plants are 25 cm high and 200 kg ha\(^{-1}\) (10g or one teaspoonful per plant) after 4 weeks. Inadequate nutrient levels may result in deficiency disorders that can be observed as patterns of leaf discoloration or fruit abnormality. The major nutritional disorder in tomato is blossom end rot caused by calcium deficiency. Other common nutrient disorder symptoms include chlorosis of older leaves due to nitrogen deficiency, stunted growth, purpling of leaves and late fruit maturation due to inadequate phosphorus and drying of leaf margins coupled with hollow fruit when potassium is limiting. Deficiency disorders can be corrected by application of foliar fertilizers (foliar feeds)

Mulching

Mulching conserves moisture and keeps down the soil temperature it is especially important for the determinate varieties to maintain the fruit quality.
Weeding
Weeding should be done regularly to reduce nutrient competition, and to destroy alternate hosts of pests and diseases.

Other cultivation practices
Training/Staking: Training of plants has a number of benefits, including improved spraying to control foliar diseases and pests, less sunburn, better air circulation around the plant and less fruit rotting. Cultivars that have an indeterminate growth habit require training on trellises or suspended on twine from overhead wires. The crop grown for the fresh market should also always be trellised. For the indeterminate varieties put a 2m stake firmly into the ground and loosely tie
seedling to the stake.

**Fig 6 Tomato Staking (Source Elizabeth Odoyo)**

**Pruning:** This is done for indeterminate varieties. The practice influences the flowering and fruiting of the tomato plant, leave one or 2 main stems and pinch out the laterals branches as they appear in the leaf axils. When 6-8 trusses are formed pinch out the growing tip to encourage growth of good size marketable fruits. Remove leaves close to the ground to help prevent the entry of blight. Smokers should wash their hands before handling plants as they may otherwise spread tobacco virus disease. It has been reported that pruning reduces early and total yield, detrimentally affects quality and increases the incidence of viral diseases and other disorders. This practice is not recommended for tomatoes grown in the open field.

**Fig 7 Pruning of the tomato plant using hand and pair of scissor (source Vincent Ochieng)**
Crop rotation
A three-to four year-rotation program with non-related crops is recommended to reduce build-up of pests and diseases.

Irrigation
In dry weather regular watering is essential. The ground should be given a good soaking 2-3 times each week. Irrigation for tomatoes should be regularly especially during critical periods like flower setting and growth of the fruits. Watering is reduced at the end of crop maturity. Regular watering reduces blossom end rot, ensures uniform fruit development, prevents fruit splitting, reduces the risk of sun scorch, enhances fruit growth and increases the size and number of fruits. Excess water increases water logging which leads to Magnesium, Phosphorous and Nitrogen deficiencies. Drought during fruiting period is the most critical for the final yield. In very hot weather, sprinkler irrigation should be done early in the morning to avoid heat shock, burned leaves, non-setting flowers and setting up of a microclimate favorable for diseases. Irrigation can only be performed by the end of the day so long as plants dry up by nightfall to avoid late blight disease. In practical terms, apply 3-4mm per day at planting, 6mm per day at first.

Fig 8 Drip irrigation (Source: Vincent Ochieng)
CROP PROTECTION

INSECT PESTS

Soil pests
Cutworm
The major soil pests attacking tomato seedlings are cut worms, *Agrotis* spp and chafer grubs, *Melolontha* spp. Cut worm larvae are grey to black caterpillars approximately 24 mm long often found hidden in the soil near the seedlings. They hide in the soil feeding on the underground parts of the plant during the day and come to the surface to feed on the aerial parts of the plant. Soil pest infestations are sporadic and are more common in weedy spots, fields with high organic matter and poor drainage.

![Image of cutworm](image)

**Fig 9 Cut worm, *Agrotis*,**

Damage
They cut the seedlings stem at the soil line, and eat holes into roots. The injured plant wilt, wither and die. Young caterpillars feed on the leaves leaving perforations on the leaves. The pests feed on the plants at the base causing serious damage to stems. Stalks of plants may be cut. Soil pest infestations are sporadic and often associated with sections of the field that are weedy, have high amounts of organic residue, or poor drainage. On digging up the soil, the pests are found in the roots region.

Control
• **Cultural control.** Fields need to be prepared and weeds eliminated at least two weeks prior to planting to reduce soil pest damage. Early detection and manual removal of observed soil pest. They can be found in the evening or scratch soil near plants to uncover them. Weed the field early also tilling and ploughing soil is necessary to kill soil pests. In fields with high infestations, put a 3 inch cardboard collar around young seedlings and push it 1 inch into the soil (OSU, 2002).

• **Bio-pesticides.** *Bacillus thuringiensis* (BT).

• **Chemical control-**
  1. 5% Malathion dust around the plant after transplanting preferably in the afternoon.
  2. Dipterex (Dylox) Trichorphon 5% dust similarly at 2 kg/ha and add baits e.g. Bran mixed with sugar.
  3. Spray with pyrethroid insecticides at transplanting (Brigade, Sevin, Fastac or Karate).

**Important notice:** Read the label on the pesticide container carefully and use the manufacturer’s recommended rate.

**African bollworm, *Helicoverpa armigera Hb.***
The caterpillars of the African bollworm are major pests of tomato. The pest is extremely polyphagous on a wide range of crops including (cotton, maize, sorghum, sunflower and beans). The caterpillars vary from dark green, reddish, brown, whitish and orange in color and have a characteristic undulating white band on each side of the body. They grow up to about 40 mm in length.

![Fig 10 African bollworm caterpillar (Source V. Ochieng)](image-url)
**Damage:**
The caterpillars cause damage to the floral buds, flowers and fruits. They bore into the fruit often with the hide part of the body exposed outside. They produce copious amounts of pellet-like grass. One caterpillar can cause damage to several plant parts such as flowers, flower buds and fruits which are characterized by presence of one or two rounded holes.
The caterpillars bore into fruit and feed on the inner part of the fruit releasing plenty of excreta (frass) which is noticeable on damaged fruits (Figure 2).

**Control**
- **Cultural control.** Scout the field for bollworm caterpillars to initiate control before actual damage is incurred. Practice deep cultivation to destroy pupae in the soil. Avoid planting susceptible crops in succession.
- **Natural enemies.** Parasitoids such as *Trichogramma, Trichogrammatoides* and predators (syrphid flies, ladybird beetles).
- **Bio-pesticides.** Use of microbial biocontrol agents is a potentially important compound of IPM for the African bollworm. The most commercially important include, strains of *Bacillus thuringiensis* (B.t.), nuclear polyhedrosis (NPV) *Metarhizium anisopliae* (M.a) neem products and insect growth regulators such as Match®.
- **Chemical control** should target young caterpillars before they can enter the fruit. The African bollworm is one pest that develops resistance to same chemicals over a short time. Registered effective chemicals products available against the African bollworm include: Deltamethrin, Carbaryl, *Bacillus thuringiensis*, Spinosad, Bifenthrin, Indoxacarb, Pyrethrin, Methomyl and Novaluron among others. Farmers MUST adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

*Chemical spraying should be done as soon as young caterpillars are noticed on the crop since control becomes increasingly difficult with older caterpillars.

**Whiteflies (Bemisia tabaci)**
Whiteflies are small mealy insects of about 1.5mm long with two pairs of white wings. They fly from foliage when plants are disturbed.
Damage
These small white scale like insects occur on the underside of leaves. The adults fly away from the leaf once the foliage is disturbed. The nymphs suck plant sap from the underside of the leaf. Their sap sucking activity may result in wilting and leaf malformation. After sucking the plant sap, the insect excretes a sticky sugary substance known as honey dew, which ants feed on. Sooty mould quickly establishes in the honey dew and may spread all over the leaves. Crop plants are weakened by the feeding of large numbers of whiteflies, whilst the sooty mould impairs leaf function. They also cause leaf distortion and stunting if the attack is very early. This can be a serious problem especially in hot areas. The insect is also a vector of cassava mosaic virus, cotton leaf curl, tobacco leaf curl and sweet potato virus B.

Control
- **Natural enemies.** *Encarsia formosa* is a tiny parasitic wasp of *B. tabaci*, in which case the parasitized larvae become transparent to brown in color. Another tiny wasp, *Eretomocerus* spp. parasitizes *B. tabaci*.
- **Bio-pesticides.** Neem products
- **Chemical control.** This pest is easily controlled using pesticides (Rogor), Diazinon or Brigade. It is important to completely cover the underside of the leaves with the pesticide being applied. High concentration of these chemicals may injure the crop.
Red spider mite, *Tetranychus spp.*

Red spider mites pose a major problem on tomato and other members of the Solanaceae family (eggplant, Chilies, Capsicums and Irish potato). The pest is extremely polyphagous attacking many cultivated and wild plants. Because of their great reproductive capacity, they are able to destroy plants within a short period of time. When left uncontrolled the farmer can lose his production within a week. Financial losses are greatly influenced by the initial population of the mites and the efficiency of the control measures. Infestation often starts on the outside (border rows) of a plot. Therefore, other adjacent (tomato) crops, wild plants and weeds can serve as a source of infestation (Keizer and Zuurbier). The mites can also be spread passively by irrigation water, dust storms, clothing and implements. The mites can also be spread by wind. All the different stages of insect development are usually found together on the leaves at the same time. The pest develops very rapidly in warm, dry weather.
**Damage**

The leaves are injured as a result of the mites sucking out valuable substances from the underside of leaves causing speckling and tarnishing and eventual leaf fall. Under severe attacks they will cause stunted growth and reduce yields. The problem is more acute during dry weather spells. The mites and its webbing, just visible to the eye, can be seen on the underside of the leaf. Spider mites may also cause spots on the fruits. Because of their small size (0.3-0.5mm), an infestation is often only noticed after the leaves have been discolored.

**Control**

- **Cultural practices.** Regular scouting of the crop to determine the presence of the pest and the level of infestation in an early stage is a substantial element of IPM (Integrated Pest management). Burning of infested plants can be successful during the early stages of infestation when the mites concentrate on a few plants. The separation of infected crops and newly planted crops or nursery areas and the burning or removal of infected crop residues and weeds, also helps to minimize the problem.

- Natural enemies such as predatory mites are effective in the control of Spider Mites. e.g. *Phytoseilus persimilis* has been very effective when used in the green house.

- Inter-planting tomatoes with garlic or onion, practicing field hygiene, use of resistant cultivars and planting host plants of predatory mites such as pigeon peas do help bring spider mites on check. Heavy rain or irrigation can reduce their numbers

- **Botanical pesticides.** Botanicals such as Neem (*Azadirachta indica*) and *Tephrosia* sp. are currently evaluated in Kenya for their effectiveness in the control of red spider mite

- **Chemical control.** Curative and preventive treatments especially during the vegetative phase are advisable. Effective insecticides include Abamectin, Amitraz, Dicofol, Clofentezine, Bifenthrin, Tetradifon and Azadirachtin among others. Care should be taken when considering chemical control. Thorough understanding of the different available chemical formulas and their cost-effectiveness is required (contact extension staff or KALRO). Some of the available systemic pesticides have shown to increase red spider mite reproduction. In addition, red spider mite species rapidly develop resistance against the most common used pesticides and acaricides. It is therefore recommended to rotate acaricides with different chemical compositions. Spraying should be done weekly and at an early stage of infestation to be effective.
Fig 14 Maize tomato intercrops to control pests and diseases (source Vincent Ochieng)

Leaf hoppers

Fig 15 Leaf hoppers (Empoasca spp) are green to yellowish green wedge shaped insects which jump off from foliage when disturbed.

Leaf hopper adult

Damage
They suck the juices from the plant and excrete excess fluids in the form of honeydew. As with aphids, this sugary substance may support the growth of sooty molds. Leaf Hoppers spread Curly Top Virus. Young plants are severely stunted and die, while older plants turn yellow, leaves roll upward, fruit production ceases, and plants slowly die. This is a minor pest in most cases but in dry weather numerous
hoppers feed on leaves, leaving a mosaic of white specks and stunting growth. These are possible vectors of virus diseases.

Control

- **Cultural control.** Remove any affected plants and destroy them. Sticky traps can be made using honey, molasses or another sticky substance on a piece of stiff cardboard. Wave the sticky traps over the plants and the insects will stick.
- **Natural enemies.** Predators e.g. lacewings or praying mantis.
- **Bio-pesticides.** Spray plants with soap and garlic spray
- **Chemical control.** Use effective chemicals in the market like Lebaycid, Karate

Leaf miners

Description
The adults are small black and yellow flies about 2mm long. They lay eggs which hatch into small larvae that feed by mining between the upper and lower epidermis of the leaves making a tunnel as they move along. Occasionally the larvae can be within the leaf mine as it feeds.

Damage
The act of laying eggs and feeding on leaves can kill seedlings and in older plants allows the fungal diseases to enter the leaves. Damage by “mining” causes whitish blotches inside the leaves, kills the leaves eventually making them fall prematurely. This reduces plant yield and exposes the fruits to sunburn.

![Fig. 15. leaf tracks cause by leaf minor (Source Lusike Wasilwa)](image)

Non-chemical control
- Use of parasitic wasps such as Diglyphus ssp has proved effective.
- Use of yellow sticky traps or yellow basins filled with water attracts the adult leaf miner. These are later killed.
- Destruction of hosts such as old crop debris as well as having a rotation with non-host crops can help reduce leafminer populations in the crop.
- **Chemical Control**—Leaf miners have an ability to develop resistance against pesticides very fast. Regular rotation of pesticides is therefore advised. Effective insecticides include Abamectin, and Spinosad among others. Farmers **MUST adhere to the recommended tank dose and observe the postharvest intervals PHI** as advised on the product label.

### *Tuta absoluta* (Tomato leaf miner)

*Tuta absoluta* is a devastating leaf miner on tomato crops. The pest can cause up to 50-100% yield reduction on tomato crops and its presence may also limit the export of the produce. It reproduces rapidly with a life cycle of 24-38 days, depending on the temperature, the minimum being 9 °C. The caterpillars are yellowish when newly hatched; later turn yellow green with a black band behind the head and the fully grown ones have a pinkish color on their back. Caterpillars mine inside the leaf, stem or fruit but exit to pupate. They can temporarily be temporarily found outside the leaf mines or fruits. Pupae are light brown and are found in the soil, on the leaf surfaces or in curled leaves or mines. Adults which are grey-brown are active at night and hide between leaves during the day.

### Signs and symptoms

Eggs are normally deposited on the underside of leaves
- Only green fruit is attacked by the larvae.
- Caterpillars prefer leaves and stems, may occur on fruit crowns or inside the fruit itself.
- Serious infection leads to the leaves dying off completely.
- Mining to the plant causes malformation and damage to fruit paves way for fungal infections, leading to fruit rot before or after harvesting.
- Rot due to secondary infective agents-

### Management

- Use of *Bacillus thuringiensis* have shown efficacy in controlling outbreaks as well as compounds of spinosad and imidacloprid.
- Use of sex pheromone traps is highly effective on the males, thus reducing the populations due to reduced fertilization of the females. Pheromone lures can be used for monitoring and mass trapping.
The tomato mirid bug (*Nesidiocoris tenuis*)
It is slender, greenish in colour with a dark brown tint on the forewings. Eggs are laid singly on the growing points, petioles and stems of the tomato plant. The young
bugs (nymphs) resemble the adults, but initially have no wings. Older nymphs have wing pads. The tomato bug feed on stems, leaves and flowers of tomatoes, but prefer young leaves and growing points. Sucking by nymphs and adults results in the formation of brownish rings on stems, petioles, growing points and leaf veins, which become brittle. Repeated feeding by the bugs cause crinkling (rolling, puckering and unevenness) of leaves.

**Damage**
Attacked stem bases become swollen with narrow brownish rings at the apices of the swollen areas. Shedding of flowers may be partly due to feeding by this bug. Other major crops attacked include eggplant, sesame and bottle gourds. The tomato bug also exhibits predatory habits, and has been reported preying on other insect pests, such as aphids, jassids (leafhoppers), caterpillars and whiteflies. It has been identified as an important predator of eggs and young caterpillars of the African bollworm and a potential control agent of whiteflies in Europe. This bug was found frequently and in large numbers on tomatoes, throughout NE and NW Somalia (Seif et al. 2003). It has also been reported as a tomato pest in Ghana (Youdeowei, 2002). In Kenya, large numbers of this bug have been observed in tomato fields under heavy and frequent spraying of synthetic pyrethroids.

**Control**
- Inspect crops for nymphs and adults feeding on buds, developing flowers and leaves, and for signs of bug feeding, including discoloured spots, necrosis, stunting, and early fall of flowers and fruits.
- Avoid volunteer crops weeds in the farm.
- Maintain Proper disposal of crop residues and pruning and harvest.
- Avoid indiscriminate use of broad-spectrum pesticides.

Fig 17 Tomato mirid bug adults (Source Vincent ochieng)
Aphids (*Aphis gossypii, Myzus persicae*)

Aphids green peach aphid (*Myzus persicae*) suck plant sap, which can reduce plant growth; they also secrete honeydew, on which sooty moulds growth. Sooty mould on fruits reduces their market value. They transmit virus diseases during feeding such as the cucumber mosaic virus. In Kenya, aphids are occasionally found on tomatoes, but they are not considered an important pest in the farm of tomatoes.

![Aphids feeding on a leaf](image)

**Fig 18** Aphids feeding on a leaf

**Control:**
- Conserve natural enemies. Aphids are usually kept under control by a wide range of natural enemies. In particular, avoid use of wide spectrum pesticides since they kill natural enemies.
- Use of sticky traps yellow in colour
- Use reflective mulch. Reflective aluminum mulches deter aphids from landing on plants. The effect is lost once plants are large enough to cover the mulch.

The tomato russet mite (*Aculops lycopersici*)

They are very tiny, approximately 0.2 mm long, and cannot be seen with the naked eye. They are yellowish, brown or pink. They have a ringed conical body with the head and two pairs of legs at the large end. They complete the lifecycle in 1 week; this explains the rapid increase of this mite in tomato fields. They prefer high temperatures and low humidity. They feed on all above-ground parts of the tomato plant, causing spotting, twisting or folding of leaves and fine cracks on the fruits. Attacked leaves and stems develop a greasy appearance and turn bronzed. The
plants can drop their leaves, especially in hot weather. Fruits are then exposed to sunburn. Damage to the plant typically begins near the ground and spreads upwards. Damage can develop very rapidly, and the mites can kill plants in a few days in dry hot weather. Since the mite cannot be seen, the symptoms are easily confused with diseases. The small size of the mites makes monitoring difficult. The first signs of mite presence are the curling and bronzing of the lower leaves of the stem.

**Control:**
- Conserve natural enemies. Few natural enemies of the tomato russet mite are known. Predatory mites are considered to be the most important natural enemies. However, the effect of these natural enemies is hampered by extensive use of pesticides.
- Spray neem extracts. Neem oil and aqueous neem kernel have been reported to give good control of this mite in Costa Rica. For more information on neem extracts click here.
- Ensure proper irrigation during early stages of the crop. This can help prevent mite build-up later in the growing season since tomato russet mite infestation is higher on tomato plants under water stress.
- No resistant varieties are available. In Kenya, tolerance to leaf damage was observed in two varieties, namely “Early Stone” and “Beauty”.

*Fig 19 Damage on tomato fruit and leaves caused by the Tomato russet mite (Source V. Ochieng 2016)*
Thrips (*Thrips tabaci*, *Frankliniella occidentalis*, *F. schultzeii* and *Ceratothripoides brunneus*)

Thrips may also be a problem in tomatoes in Kenya. Thrips are small (about 1 to 2 mm long). They usually feed on the lower surface of leaves puncturing them and suck the exuding sap. They also attack buds, flowers and fruits. Attacked leaves have a silvery sheen and show small black spots (thrips excrements). Under heavy infestation attacked buds, and flowers usually fall off. Attacked fruits show speckling and small necrotic patches on the surface affecting fruit quality. Fruits may become deformed.

Thrips feed on tomatoes at all stages, but their feeding on seedlings is particularly damaging. Heavy infestation can reduce stands of young seedlings in hot weather. Thrips of the genus *Thrips* and *Frankliniella* are vectors of viruses such as the Tomato Spotted Wilt Virus (the most economically important virus in tomato production) and the Tomato Chlorotic Spot Virus.

![Fig 20 Thrips adults and damaged fruits (Source V. Ochieng)](image)

**Control:**

- Conserve natural enemies. Predatory mites (eg. *Amblyseius* sp.), anthocorid bugs (eg. *Orius* spp.), and other predators such as ladybird beetles, lacewings and spiders, and the fungus *Entomophthora* are important in natural control of thrips.
- Monitor the crop regularly. Check plants daily in the nursery, and crop borders in the field. Be particularly vigilant at flowering. Pay careful attention to flowers and flower buds.
- Destroy thrips pupae in the soil. This helps reducing subsequent thrips populations. Plough and harrow before transplanting to expose pupae in the soil from previously infested crops to natural enemies and desiccation. Soil solarisation and flood irrigation (flooding previously infested fields prior to planting/transplanting) destroy a large proportion of thrips pupae present in the soil.
- If necessary spray bio pesticides. Neem and some other plant extracts are
reported to control thrips. Spinosad, a bacterial derivative is effective in thrips control. However, timing of biopesticide application is important. Thrips are difficult to control with insecticides due to their secretive habits (eggs are laid in plant tissue, the larvae and adult shelter in the flowers and larvae pupate in the soil). Spraying early in the morning or in the evening and mixing the spray with a sugar solution (which attracts the thrips out of the flowers) are reported to increase efficacy of sprays.

**Root knot**
This is caused by nematodes particularly *Meloidogyne incognita*, *Meloidogyne javanica* and *Meloidogyne hapla* which are the most widely distributed nematode pests of tomato. *Meloidogyne* has a wide host range among cultivated crops and in the off-season, if environmental conditions are favourable it survives in weeds particularly the broad leaf species. Females, eggs and juveniles (hatched from the eggs) survive in intact plant roots. Eggs and juveniles are releases into the soil as the plant debris disintegrates. Survival and completion of life cycle depend on the successful growth of the host plant, which offers shelter and nutrition.

![Fig 21](image)

**Symptoms**
Low populations of root knot nematodes may cause no damage (in early season they may even stimulate plant development) but severe infestations result in stunted plants and induce a high root-shoot ratio.
The normal transfer of substances from the roots to the plant top is restricted, often resulting in wilt and nutrient deficiencies. In the field, the galled roots may be invaded by pathogenic microorganisms (fungi, bacteria and viruses) causing more drastic damage than root knot alone.
Temperatures, moisture, soil type, age of the plant and other stress factors have profound influence on the damage caused by nematode infestations.
Control
Cultural
Crop rotation, leaving the land fallow, and burial of debris can reduce their populations.

Biological—Some common weeds (e.g. *Targetes minuta*) are antagonistic to nematodes and can be introduced to the furrow area to reduce the nematode populations.

Non-Chemical Control—Use resistant varieties as indicated by the numeral after the variety name. Practice crop rotation with crops that are resistant e.g Garlic. Flooding the soil a few weeks prior to planting and maintaining high levels of organic matter also reduces nematode numbers. Effectively carry out soil solarisation after a deep plough.

Chemical Control—There are registered chemicals on nematodes control. They are usually applied as a soil drench. However most of them are very dangerous and not cost effective for small scale farmers. Some of the registered chemicals include, Methane Sodium, *Paecilomyces lilacinus* and Azadirachtin among others. Nematicides can be applied at planting but not any other time in the crop season. Farmers MUST adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.
MAJOR TOMATO DISEASES

BACTERIAL DISEASES

Bacterial canker
This is caused by *Clavibacter michiganensis subsp. Michiganensis* (CMM). The bacterium can be introduced into fields on contaminated seed or on infected transplants. It may also survive in soil on infested plant material for at least one year. Symptoms do not appear until the disease is well established in the field. Splashing water and cultural practices such as pruning and tying (wounding) have led to epidemics. Like many other bacteria, canker development is favored by warm, wet conditions, especially when plants are wounded and inoculum is present. The disease can reduce yields by as much as 90%.

![Fig 22 A](image1)
![Fig 23 B](image2)

Note the discoloration of the pith (A) as a result of bacteria canker and desiccation of tomato leaves (B)

Symptoms
Bacterial canker is characterized by the symptomatic wilt of the whole plant. Symptoms in young seedlings are difficult to see, but often start as dark water soaked areas on leaves and stems. Systemic infections often start as wilting followed by discoloration of the vascular tissue. Stems may split vertically with dark brown necrotic cankers developing under certain conditions. The disease progresses as follows:

Lower leaves wilt and turn downwards. The whole leaf dries; curls upwards turns brown, wither but still remain attached to the stems. Stems may split open and the pith is often found to be discolored. Fruit symptoms are lesions with raised brown centers surrounded with a opaque halo. The most diagnostic feature of bacterial canker is the formation of fruit spots. These spots may be confused with those caused by bacterial speck or spot. However, fruit lesions caused by bacterial canker are bordered by a distinct white halo. These white halos may disappear as the fruit ripens.
Control

Cultural methods. The most important means of controlling bacterial canker is using certified seed and transplanting into disease-free soil. Remove and burn infected plant material.

Crop rotation. Practice crop rotation. Do not replant tomatoes in soil where bacterial canker occurred the previous year.

Crop management. When pruning in a field already attacked, disinfect the pruning knife after every 2 plants (use Jik or Dettol).

Resistant plant material. Resistant/tolerant varieties where available

Chemical control. No chemical control has been found effective for controlling bacterial canker. Applications of copper-containing fungicides will suppress but not kill the bacteria.

Bacterial Wilt (*Pseudomonas solanacearum*)

Bacterial wilt caused by *Pseudomonas solanacearum* is one of the most economic diseases of tomato. This disease causes wilt of tomatoes as well as potatoes. It is mainly seed borne in tomatoes.

![Fig 23 Lesions of bacterial wilt on stems and leaves of tomato(Source L.Wasilwa)](image)

**Symptoms**

Bacterial wilt infects the whole plant. Symptoms first appear on the youngest leaves and a rapid wilt of the whole plant occurs. Adventitious roots appear on infected stem. The vascular bundles will be yellowish brown in the initial stages of the disease. The pith of a completely wilted plant is brown. Bacterial wilt is distinguished from other wilts by suspending a part of infected stem in water whereby a slimy stream of bacterial cells from the xylem will be observed.

**Control**

Practice rigid crop rotation (long term), tomatoes should not follow Solanaceous crops like potatoes, chillies and others i.e. practice crop rotation with a non-
susceptible crop.
Produce transplants in pathogen free soil.
Remove and burn infected plants as soon as possible to check the spread of the diseases. Plant resistant tomato cultivars

**Bacterial spot (Xanthomonas campestris pv. vesicatoria (Didge) Dye)**
This disease is caused by a bacterium *Xanthomonas campestris* pv. *vesicatoria* (Didge) Dye. The bacterium is able to survive on tomato volunteers and diseased plant debris. Seed may also serve as a medium for the survival and dissemination of the bacterium. Disease development is favored by temperatures of 24-30 degrees centigrade and by high precipitation. The bacterium is disseminated within fields by wind driven rain droplets, the clipping of transplants, and aerosols. It penetrates through stomata and wounds created by wind driven sand, insect punctures, or mechanical means.

**Symptoms**
The bacterium affects all above ground parts. On the leaves, stems, and fruit spurs, the spots are generally brown and circular (Figure 12. A, B, C). The spots are water soaked during rainy periods or when dew is present. Lesions rarely to more than 3mm in diameter. On leaf lets the spots can easily be confused with early blight, gray leaf spot, or target spot. Bacterial spot lesions do not have concentric zones, as do target spots of early blight lesions, and they are generally darker in color and less uniformly distributed than gray spots lesions. Often a prominent halo surrounding pin point lesion is present with target spot and early blight but not with bacterial spot lesions. When conditions are optimal for disease development, spots on the leaves, petioles, and rachis coalesce to form long dark streaks. A general yellowing may occur on leaflets with lesions. Blighting of the foliage occurs with coalescing of the lesions, and the plants become huddled in appearance because of severe epinasty. Often the dead foliage remains on the plant, giving it a scorched appearance.

*Fig 25 Alternaria leaf spots.*
*Fig 25 Fruit lesions*  
(Source – Lusike Wasilwa).
Figure 12. Bacterial spot on tomatoes.
Fruit lesions begin as minute, slightly raised blisters. As a spot increases in size it becomes brown, scab like, and slightly raised. Lesions may also be raised around the margins and sunken in the middle.

Control
Rotate fields in an attempt to avoid carry over on volunteer and crop residue
- Produce disease free transplants by raising them in areas where tomato and pepper have not been grown.
- Use seed treatment (hot water at 50-55 degrees centigrade) to reduce possible transmission of the bacterium.
- Use copper fungicides as protectants to suppress bacteria.

Bacterial Speck (*Pseudomonas syringae* pv. *tomato*)
This is a bacterium that produces a number of compounds that help it infect and obtain nutrients from the tomato plant. One of these compounds is the plant-specific toxin coronatine, which is responsible for the yellow halo surrounding leaf lesions and the stunting of young seedlings. The major sources of infection for the bacteria are from seed and infected crop debris. Bacteria enter the plant through natural openings (Stomates and hydathodes) or wounds caused by wind-driven soil, insects or mechanical damage (handling, wind whipping, high pressure sprayers).

Symptoms
- Bacterial speck lesions may occur anywhere on the foliage, stems, or fruit.
- Only green fruit is susceptible to infection, not red fruit.
- Fruit lesions are small, black, slightly raised and often surrounded by a narrow green-to-yellow halo
- Speck lesions on the fruit are usually superficial and can be scraped off
- Severe infections may cause defoliation
- The major sources of infection for these bacteria are seed and infected crop debris.
- They may also be present on volunteer tomato plants and on contaminated equipment or surfaces (farm machinery, racks, greenhouse structures, tools).
- The bacteria are spread primarily by splashing water and wind-driven rain or mists produced during storms.
- In the field, spread by equipment or workers is probably of lesser importance than it is in the greenhouse, unless wounds are being opened up at the same time, as in pruning operation or when plants are injured by a cultivator.

Management/Control
- Tomato seeds should be disinfected, using acid or chlorine treatment.
- Do not plant diseased transplants.
- Keep transplants from different seed lots and different transplant growers separate to avoid cross-contamination. Keep tomato transplants separated from other host crops such as peppers. Areas of potential contact include in the transplant greenhouse, during shipping or holding plants, and in the field.
- Clean and sanitize plant trailer (any equipment used for shipping or holding) between loads.
- Clean and sanitize the transplanter (surfaces that contact plants and trays) between fields and varieties.
- Transplanting crew cleans and sanitizes their hands at every break or changes to new disposable gloves.
- Clean and sanitize equipment that touches the crop between blocks of plants or between fields.
- In processing and unstaked fresh market tomatoes, eliminate hoeing and inter-row cultivating beyond 3 or 4 weeks after transplanting.
- When working with staked plants (pruning, tying), clean and sanitize tools between each plant.
- Crop scouts and other visitors instructed to clean and sanitize hands or wear gloves prior to entering each field. Wearing plastic booties which are changed after each field will also limit the spread of soil borne pathogens from field to field.
- Visit KALRO-Centers for the most up-to-date research-based spray program recommendations for tomato bacterial disease.
FUNGAL DISEASES


*Alternaria* infection of seedlings can cause small stem lesions that can enlarge and eventually girdle the plant. *Pythium* and *Phytophthora* are water-molds. They are particularly destructive in wet and cool soil conditions. *Pythium* infection may result in pre- or post emergence damping-off, distinguished by dark-coloured, water-soaked lesions on roots or stem. Seed infected by *Pythium* becomes soft and water-soaked. *Rhizoctonia solani* persists in soil as a hard resting structure (sclerotia) and grows as microscopic threads through the soil. This damping off pathogen tends to prefer slightly warmer and dryer soil than the water molds. Often, *Rhizoctonia* will girdle the stems of susceptible crops slightly above and below the soil line. Lesions are tan to reddish-brown in colour.

**Symptoms**

- Seeds infected prior to emergence rot and typically fail to produce a seedling.
- The seedlings do emerge; they are usually weak and lack vigour.
- Post-emergence infections cause the seedlings to rot at soil line.
- This usually occurs within 2-4 weeks of emergence (or transplanting).
- Affected plants tend to curl downward or melt into the soil.
- The plants also moldy seeds and lesions or cankers on the roots, hypocotyl or lower stem.

**Control**

- Ensure seedlings are grown in sterile soil-less mixture in the greenhouse.
- Do not over water seedlings.
- Before planting into the field, ensure all seedlings are healthy, disease-free and vigorous.
Disinfect the seed beds before sowing seeds.

Fig 27: Damage of the seedling caused by Alternaria spp., Pythium spp., Anthracnose (Colletotrichum spp)

Anthracnose on tomatoes is caused by the fungus Colletotrichum coccoides, which is primarily a pathogen of the tomato fruit. As the fruit are ripening, the symptoms first become noticeable as small, circular indented areas, which later develop darkened centers. The diseased spots continue to grow larger with time as each infection site also spreads deeper into the fruit. With warm, moist and humid weather (from rainfall or over-head irrigation) the fungus produces salmon-colored spores that are exuded from the black fungal material in the center of the spots. These spores are spread by splashing water. Advanced infections occur on immature fruit and only later develop into visible lesions.

Fig 28 Anthracnose on tomato fruit (Source Vincent Ochieng)

Control

- Follow a minimum 3-year rotation with non-solanaceous crops.
• Control weeds that can act as hosts.
• Use disease-free or treated seed.
• Properly timed fungicide sprays are effective at reducing losses to this disease.
• Fungicide sprays can help reduce disease, products containing chlorothalonil can be sprayed weekly to reduce infection.
• Follow label directions. There is a one day waiting period between spraying and picking.

**Early blight**

*Fig 29 Early blight caused by Alternaria solani occurs wherever tomatoes are grown. In Kenya it is ranked amongst the diseases of economic importance.*

*Fig 30 Leaf and fruit symptoms of early blight of tomato (Source Lusike Wasilwa)*

**Symptoms**

This particular disease is more serious on tomatoes during the hot weather. It occurs on all above ground parts and is destructive at all stages of crop development. Early blight begins as small brownish/black lesions on leaves. The surrounding tissue becomes yellow covering the entire leaf resulting in partial defoliation. These spots typically develop first on the older leaves nearest the ground. Under favorable
conditions for disease development, these diseases can cause extensive defoliation, resulting in sun-scalding of fruit and reduction in the numbers of fruit produced. On stems, cankers form and occasionally fruits are infected causing premature fruit drop. Stem lesions on infected seedlings will continue to enlarge and subsequently girdle the seedlings.
The most important diagnostic feature of early blight is the formation of dark, concentric rings within the lesion, giving the spots a target-like appearance. Often, several lesions coalesce, causing the leaf to turn yellow, dry up, and fall off the plant. Defoliation weakens the plant and exposes the fruit to sunscald injury.

**Control**

- **Sanitation measures.** Field sanitation will reduce the amount of inoculum available for infection the following year. Deep-plough to bury tomato debris, or dead plants should be removed from the garden and destroyed.
- **Crop rotation.** Avoid planting tomatoes in the same area.
- **Use clean planting.** Clean seed and healthy transplants will help control the disease.
- **Chemical control** is the most effective method for control of late blight. This is due to the considerable distance over which the spores can travel. Spraying should start as soon as symptoms are observed, or preferably as soon as experience suggests that the conditions are right for disease development. During this time, protective fungicides e.g. Antracol (Propineb), Dithane M-45 (Mancozeb) can be sprayed every 7-10 days. These can be alternated with systemic curative and protective fungicides like Ridomil (Metalaxyl) and Milrax (Propineb+Mancozeb) at 14 day intervals.

**Late blight (Phytophthora infestans (Mont.) de Bary).**

This is one of the most destructive diseases of tomato. It is caused by a fungus *Phytophthora infestans* (Mont.) de Bary.

**Symptoms**

*P. infestans* attacks all above ground parts of tomato. Leaf lesions begin as water-soaked spots which rapidly enlarge to brown lesion engulfing the entire leaf which subsequently dries up. If the weather is cool, a gray/white moldy growth occurs on the underside of young lesions. Infected leaves shrivel, die and dry up. Infected areas on stems appear brown to black and entire vines may be killed in a short time when moist weather persists. Decaying stems emit a distinct foul rotting odor.

Late blight can also develop on green tomato fruit, resulting in large, firm, brown, leathery-appearing lesions, often concentrated on the sides or upper fruit surfaces. If conditions remain moist, abundant white mold growth will develop on the lesions.
and secondary soft-rot bacteria may follow, resulting in a slimy, wet rot of the entire fruit. Fruits also become infected in storage.

![Image of tomato leaves, fruit, and stem with symptoms of late blight](image)

**Figure 31. Symptoms of late blight on tomato leaves (A) and fruit (B) and stem (C – Source - Lusike Wasilwa)**

**Control**

- **Field sanitation** to reduce the source of primary inoculum for adjacent tomato fields or plants.
- Avoid planting tomatoes after potatoes.
- **Cultural methods** of control include adequately deposing all tomato culls.
- **Clean planting material.** Use tomato transplants from a disease free nursery.
- **Scout fields** regularly to look for late blight. Scouting should be concentrated in low-lying areas, field edges along rivers or ponds, near the center of center-pivot irrigation rigs, in areas near trees or any area that is protected from wind where the leaves tend to remain wet longer.
- **Chemical control** is the most effective method for control of late blight. This is due to the considerable distance over which the spores can travel.
Spraying should start as soon as symptoms are observed, or preferably as soon as experience suggests that the conditions are right for disease development. During this time, protective fungicides e.g. Antracol (Propineb), Dithane M-45 (Mancozeb) can be sprayed every 7-10 days. These can be alternated with systemic curative and protective fungicides like Ridomil (Metalaxyl) and Milrax (Propineb+Mancozeb) at 14 day intervals.

**Fusarium Wilt (Fusarium oxysporum f. sp. lycopersici.)**

*Fusarium* wilt is caused by *Fusarium oxysporum* f. sp. *lycopersici*. *Fusarium* is prevalent in fields where continuous cropping of tomato is practiced. *Fusarium* is disseminated by seed and soil. It survives of weeds e.g. *Amaranthus, Digitaria* and *Malva* as reservoirs (Varela et al., 2003). It is more prevalent in warm 25 – 32 ºC, acidic (pH 5.0-5.6) soils that are sandy and light in texture. This fungus can remain in the soil indefinitely and several strains co-exist.

![Figure 32. Typical symptoms of Fusarium wilt on tomato leaves and stem. Note the vascular discoloration of stem. (Source: Jones, 1993b; Varela et al., 2003).](image)

**Symptoms**

Seedlings infected by *Fusarium* wilt get stunted because the vascular system is affected. Typical symptoms include yellowing of leaflets on one side of the leaf while the other side remain healthy and green. Subsequently, the lower leaves turn yellow and this progresses to other parts of the plant. These leaves eventually die and drop off. If the stem is cut vascular discoloration will be observed. Also, infected plants show vascular discoloration within the fruit (Jones, 1993). The vascular system of roots succumbs to the disease and decays.

**Control**

- **Cultural methods.** Apply lime to increase the pH of the soil (pH 7.0). Avoid excessive fertilization and cultivation. Use nitrate nitrogen rather than ammonium nitrogen.
- **Crop rotation.** Practice a 5 to 7 year rotation between successive crops.
Avoid rotating with peppers, eggplant, potatoes, sunflower, alfalfa, sweet clover.

- **Field sanitation.** Remove all debris and crop refuse after harvest and control susceptible weeds. Do not use flood water for irrigation.
- **Chemical control.** There is no chemical control for *Fusarium* wilt.
- **Plant management.** Stake plants to improve aeration so that they dry out soon and also to avoid contact between plants
- **Resistant varieties.** Most commercial cultivars have resistance to *Fusarium* wilt. Graft tomatoes onto resistant rootstocks.

Fig 33 Tomatoes affected by *Fusarium wilt* (source Vincent Ochieng)

*Verticillium Wilt*

*Verticillium* wilt is caused by a soil borne fungus *Verticillium albo-astrum* Reinke & Berhold. It is a pathogen of many hosts including cucurbits (cucumber, watermelon, muskmelon), pepper, potato, eggplant etc. *Verticillium* is prevalent in cool temperatures (21-25 ºC) and occurs in all tomato-growing regions.
Symptoms

Verticillium wilt of tomato can sometimes be confused with Fusarium wilt (Pohronezny, 1993). The difference is that plants show wilt symptoms during the warmest period of the day. Mature leaves (usually on the lower part of the plant) become yellow (interveinal chlorosis) and defoliation occurs. These symptoms are more pronounced during periods of drought or when the plant is heavy with fruit. If the stem is cut lengthwise brown discoloration is evident.

Control

- **Crop rotation.** Practice a 3 to 4 year rotation between successive crops. Avoid rotating with peppers, eggplant, potatoes, sunflower, alfalfa, sweet clover.
- **Field sanitation.** Remove all debris and crop refuse after harvest and control susceptible weeds
- **Chemical control.** There is no chemical control for Verticillium wilt.
- **Resistance.** Most commercial cultivars have resistance to Verticillium wilt.

Septoria leaf spot

Septoria leaf spot is a common disease of tomato. It is caused by a fungal pathogen (*Septoria lycopersici*) that infects mainly the foliage of the tomato plant. The fungus rests in plant debris, on seed, or on weeds such as nightshade. Spores of these fungi may be splashed or blown to tomato leaves. Disease development is favored by relatively warm temperatures, abundant rainfall and high relative humidity. Small, uniform, brown spots caused by *Septoria lycopersici* on tomato leaves. Chlorosis is often associated with the spotting.
It occurs on the older (lower) leaves after first fruit set and spreads upwards to the younger leaves as the disease progresses. It is characterized by presence of having tiny brown/black angular spots on leaves and can be confused with early blight. Eventually the center portion of the Septoria lesion turns light tan or gray while the margin remains dark. The leaves turn yellow to brown and subsequently wither and die. The pathogen also infects stems, petioles and the calyx.

![Symptoms of Septoria leaf spot of tomato](image)

**Fig 35 Symptoms of Septoria leaf spot of tomato (Source John Wadenje)**

**Control**

- **Cultural methods.** Practice a 1 – 2 year crop rotation
- **Field sanitation.** Remove all debris and crop refuse after harvest and control susceptible weeds
- **Crop rotation.** Rotate tomatoes with cereals, corn, or legumes. A 4-year rotation is recommended where disease has been severe.
- **Plant management.** Stake plants to improve aeration so that they dry out soon and also to avoid contact between plants
- **Chemical control.** Use protective fungicides at regular intervals following manufacturers’ recommendations. Apply fungicides on a preventative schedule before the disease first appears on the lower leaves. Begin sprays when the first fruits of the first cluster are visible after blossom drop. Apply fungicides every 7 to 10 days or more often when the weather is warm and wet.

**Powdery Mildew-Leveillula taurica**

The disease is characterised by white talcum-like coatings on the leaves. Older plants are more susceptible to infection. It is not known to be seed borne. Infection occurs when temperatures are high and at a high humidity.
Damage
Leaf surface develops yellow patches which die. Disease starts on the upper side and spreads to lower leaf surface. Leaves die resulting in sunburn in fruits and weak plants.

Control
Non-Chemical Control Remove and destroy crop debris after harvest. Keep the field free of weeds and practice crop rotation. Irrigating regularly avoids drought stress in old crops.
Chemical Control- Use of products such Azoxystrobin, Myclobutanil, Thiophanate, Tebuconazole, Kresoxim-methyl and Sulfur based fungicides among others have given satisfactory control.

Fig 36 Powdery Mildew on Tomato plant (Source V. Ochieng)
VIRAL DISEASES

Tomato spotted wilt virus (TSWV) (‘Kijeshi’)
Tomato spotted wilt virus (TSW) is a virus disease that occurs commonly in the tropics. Thrips (*Frankinella occidentalis*) are the vectors for TSWV.

TSWV symptoms on tomato fruit

![Tomato spotted wilt virus on fruit](Source: Lusike Wasilwa)

Symptoms of TSWV vary depending on the environmental conditions and viral load. Necrotic spots, streaking, ring spots, stunting and wilting are some of the symptoms exhibited by this virus. Symptoms may resemble fungal and bacterial diseases or environmental stresses. Diagnosis often is misleading, if based on symptoms alone but the most conspicuous symptom is the rings on the mature fruits which become red and white or yellow and red hence the name Kijeshi (like the army color). Infected plants may remain asymptomatic. An easy, relatively inexpensive means to detect TSWV is using ELISA (enzyme-linked immunosorbent assay) test which uses an antigen/antibody reaction to detect certain virus particles in plant tissue.

Control
To manage TSWV, it is important to manage thrips. Thrips spend a large part of their lives off the plant. Thrips completes its life cycle in about 10 days. Eggs are laid in the leaf and larvae hatch in about three days and immediately begin to feed.
thereby picking up the virus. After four days, they pupate in the soil, and in a little over three days, the pupae become adults. Adults feed and transmit the virus. Thus the larvae pick up the virus and adults transmit it. Adults can transmit the virus within 30 minutes of feeding. Both virus and vector need to be targeted in control programs. If larval stages can be controlled, virus transmission can be prevented, even if adult thrips are present.

\[\text{1 = egg; 2 = larva (picks up virus); 3 = pupa (non-feeding); 4 = pupa (non-feeding); 5 = adult (transmits virus).}\]

**Fig 38** Thrips life cycle

**Control**

- **Early warning** of virus presence also can be noted by using indicator plants or plants such as petunia cultivar Calypso and Gloxinias that show TSWV symptoms earlier than tomato. Both plants are extremely susceptible to both viruses and will show symptoms within a week after infection. Non-sticky blue or yellow cards placed near indicator plants can attract thrips and increase the likelihood that plants will become infested.
- **Inspect** all incoming plants for virus symptoms and thrips.
- **Isolate** all incoming plants until certain they are virus and thrips-free (usually seven days is enough). If virus symptoms appear on the plants within four or five days of receipt, it is likely the disease was present when plants were shipped.
- Remove (sanitation) and destroy all infected (symptomatic) plants as they
cannot be cured. Destroy all weeds in and around the greenhouse; they can harbor virus and thrips. Do not vegetative propagate infected plants. To break the disease cycle, avoid continuous cropping.

- **Monitor** adult populations with yellow or blue sticky cards. Place one to three cards per 1,000 sq. ft. Check, count thrips and change sticky cards every week. Thrip control using insecticides is initiated when 10 to 20 thrips occur per card per week.

**Tomato Yellow Leaf Curl Virus (TYLCV)**

TYLCV is not seed-borne, but is transmitted by whiteflies. This disease is extremely damaging to fruit yield in both tomato and pepper crops. Whiteflies may transmit the disease into the field from infected weeds nearby, such as various nightshades and jimsonweed. After infection, tomato plants may be symptomless for as long as 2 - 3 weeks.

![Figure 39: Tomato plant infested by Tomato Yellow Leaf Curl Virus. Source: Zachary Boone Snipes, ©2015 Clemson Extension](image)

**Symptoms**

Tomato plants leaves are curled, yellow (chlorotic) leaf margins, smaller leaves than normal, plant stunting, and flower drop.

If tomato plants are infected early in their growth, there may be no fruit formed. Infected plants may appear randomly throughout the garden.

**Control**

- Removal of plants with initial symptoms may slow the spread of the disease.
- Rogued (pulled out) infected plants should be immediately bagged to prevent the spread of the whiteflies feeding on those plants.
- Practice intercrop with other plants like onions, chives and garlic
- Plant trap and repellant crops around your farm.
- Use sticky traps to control the victors population
Keep weeds controlled within and around the garden site, as these may be alternate hosts for whiteflies. Reflective mulches (aluminum or silver-colored) can be used in the rows to reduce whitefly feeding.

• Spray low concentration sprays of a horticultural oil or canola oil will act as a whitefly repellent, reduce feeding and possibly transmission of the virus.
• Spray chemicals that are effective in the market
• At the end of the season, remove all susceptible plants and burn or dispose of them.

**Tomato Common Mosaic Virus**
The disease is seed borne and can survive in the soil to reinfect new planted crops. It can be mechanically transmitted through transplanting seedlings and pruning.

**Damage**
Affected plants show dark and light green mottling effect and some distortion of young leaves, as well as disturbed or elongated leaves with a fern leaf characteristic. Under high temperatures and high light intensity, mottling is severe while under low temperatures stunting and leaf distortion is severe. Fruits are discoloured as well as show brown streaks inside.

![Fig 40](image-url)

**Control**

**Cultural Control-**
• Use resistant varieties and certified disease free seeds.
• Remove crop debris and roots from the field.
• Avoid smoking while in the farm as it is believed the virus is transmitted from tobacco.
• Field hygiene should be well practiced.

**Chemical Control -no chemicals to manage the disease.**

**Tomato Yellow Leaf Curl Virus.**
The disease is neither seed-borne nor mechanically transmitted but is spread by Whiteflies. It is also favoured by high temperatures and low rainfall which favor whitefly populations. Weeds such as Datura stramonium can be hosts.

**Damage**
Infected tomato plants become stunted and branched. Attacked leaves are chlorotic and curl upwards. Plants have very few flowers hence few fruits or no fruits at all. There are no signs of infection on fruits however.

![Infected tomato plants](image)

Fig 41

**Control**

**Cultural –**

- Rogue diseased plants and destroy by burning.
- White flies should be controlled to discourage spread of the virus; for instance, by use of oil sprays. Practice a good crop rotation programme.
- Maize crop can also be planted around the tomato field to reduce the ability of white flies to reach the crop.

**Chemical Control** - No chemicals to manage the disease but one can control the host transmitter of the diseases (whiteflies)

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**NUTRITIONAL DISORDERS**

Symptoms of nutritional disorder in tomatoes may occur on leaves, stems, or fruit. They result from inadequate or excessive nutrient supply resulting from characteristics of the soil, climate or from poor fertilizer application. Furthermore, availability of nutrients is influenced by soil pH, moisture, and temperature and balance micro and macro nutrients. Although an experienced observer may diagnose diseases with some accuracy in the field, leaf analysis is necessary to confirm nutrition deficiencies.

**Nitrogen**

An immediate response to nitrogen deficiency occurs with a restriction in growth rate and uniform chlorosis on the oldest leaves.

With continued nitrogen shortage, chlorosis appears on progressively younger leaves, and the oldest leaves become yellow and finally drop.

Excessive nitrogen may encourage vegetative growth, often at the expense of fruit production. Fruit may be poorly colored, puffy, and of generally poor quality. High
rates of ammonium nitrogen fertilizers applied to tomatoes growing in acid soils or under conditions of restricted nitrification cause stem lesions.

**Phosphorous**
The onset of phosphorous deficiency is less dramatic than in most other deficiency diseases. An often unnoticed restriction in growth is followed by a dull or light green coloration. Thereafter, a purple coloration appears on the leaf undersides, beginning at the veins and proceeding to inter-venial areas. Finally, the plant is dwarfed with stiff, often upright leaves that are light green to yellow in the upper side and purple on the underside. Since phosphorous is readily translocated within the plant, symptoms of deficiency occur first on the oldest leaves. The symptoms proceed to younger leaves with continued phosphorous shortage, and leaf drop of the oldest leaves occurs.

**Potassium**
Marginal necrosis of older leaves is a universal indication of potassium deficiency. The necrosis is preceded by scattered small, chlorotic areas near the leaf margin, which enlarge, coalesce, and finally become necrotic. With continued potassium deficiency stress, marginal necrosis progressively appears on the younger leaves. Mild deficiency symptoms may occur late in the growth cycle as a result of translocation of the nutrient to developing fruit. This is a natural occurrence and associated with maturation. However, if symptoms appear early or are unusually severe, yields and fruit quality are impaired. Defects in fruit quality associated with potassium stress include puffiness, ripening diseases, softness, irregular shape, and low acidity.

**Calcium**
Calcium deficiency symptoms first appear at the terminal growing point, if the plant is not pruned, axillary growing points are affected later. Undeveloped leaves at the growing point develop interveinal chlorosis and marginal necrosis, and the growing point dies. Because the transport of calcium is dependent on active transpiration flow, its movement is mostly to fully developed leaves with a large surface area available for transpiration. Once deposited, most of it is incorporated into the insoluble organic compounds, thus translocation to younger leaves is negligible. Fruit, like undeveloped leaves, has low transpiration rates, accordingly, it is subject to calcium deficiency, which manifests itself as blossom-end rot. (See blossom-end rot).

**Magnesium**
Deficiency of magnesium is characterized by an interveinal chlorosis of the oldest leaves that gradually progresses to younger leaves. The main veins are green, even
though interveinal areas may become necrotic and collapse. With a heavy fruit load, some cultivars show deficiency symptoms on lower leaf areas as a result of the translocation of magnesium to developing fruits.

**Iron**

Interveinal chlorosis of young leaves, beginning at the leaf base and progressing to the tip, is the characteristic symptom of iron deficiency. Eventually the youngest leaves become yellow or even white as the deficiency progresses. Because plants tolerate a rather wide range of iron concentration, iron toxicity is rare.

**Plate 16. Nutrient deficiency**

**Physiological Diseases of Tomato**

**Blossom end rot**

This is a physiological disorder caused by a localized deficiency of calcium in the distal end of the fruit (see nutritional disorders). This occurs with a fluctuation in water supply even for a short period of time. Thus moisture extremes promote incidence of the disease. Other conditions that reduce calcium intake by the plant, such as high salts, the use of ammonium nitrogen, and high relative humidity, can
intensify the problem. Rapidly growing plants are more subject to the disease.

Fig 42. Blossom end rot in tomato (Source – Owino, 2013)

**Symptoms**
Blossom-end rot begins with a light tan, water soaked lesions, which then enlarge, turn black and leathery, and often become overrun with secondary black mold. The disease generally occurs at the blossom end of the fruit. Affected fruits ripen more rapidly than normal (Plate 17. A and B).

Fig 43 Blossom end rot on immature fruit in greenhouse (A – Source: Lusike Wasilwa); on mature fruit in Bungoma (B)

(A) Young fruits. (B) Mature fruits

Plate 17. Blossom-end rot on Tomato fruits.
Control

- Proper fertilization and water control
- Soil testing to determine the level of calcium in the soil
- Foliar feed with calcium based fertilizers if calcium deficiency or high salts occur during the growing season.
POSTHARVEST HANDLING AND VALUE ADDITION OF TOMATO IN KENYA

Yields and Preference for Tomato

Tomato yields between 5 tons under field conditions to 20 tons per acre under greenhouse conditions were reported by Owino, 2013 from Mwea, Kitengela and Subukia (Fig. x). Tomato buyers consider colour, freshness and blemish free fruit as important quality parameters when procuring fruit from farmers (Fig. x ). Size, shape and packaging also influence purchase preference (Owino, 2013). The main cause of spoilage for tomato is disease, harvesting, sorting and poor handling during transport (Owino, 2013) other causes are pests, maturity level, high/low temperatures.

Fig 44. Yield per acre of tomato in four regions of Kenya (Source - Owino, 2013)
Harvesting

Harvest maturity
The end-use of the produce and the distance to the market will determine when to start harvesting. Tomatoes for processing are harvested when they are fully mature. Fruit to be shipped long distance is harvested at a less mature stage, while the crop for local markets is picked at a more mature stage.

Maturity Signs and Harvesting of Tomato
- Harvesting tomato depends on the intended use and the preferred stage of harvesting is determined by the market.
- Four maturity stages are recognized for tomato (Table x).

Table x: Harvest indices for tomatoes in Kenya

<table>
<thead>
<tr>
<th>Harvest index</th>
<th>Characteristics</th>
<th>Use</th>
</tr>
</thead>
</table>

Fig 45. Traits of importance to tomato buyers (Source Owino, 2013)

Postharvest Handling
<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity Color</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaker</td>
<td>Break of color from green pink or red</td>
<td>Fruits are harvested and transported to distant markets</td>
</tr>
<tr>
<td>Light red</td>
<td>60-90% of pink or red color</td>
<td>Fruits are picked for the local market</td>
</tr>
<tr>
<td>Turning</td>
<td>10-30% of pink or red color</td>
<td>Fruits are consumed or used for canning and processing</td>
</tr>
<tr>
<td>Pink</td>
<td>30-60% of pink or red color</td>
<td></td>
</tr>
</tbody>
</table>

Source: Muchui et al. (2016) ; www.mypyproductivitybackyard.wordpress.com

Fig 46 Different varieties have different maturity colors (Fig. 7)

Fig. 46 Mature tomato fruits ready for harvesting (Source:www.alamy.com)
1.2 Harvesting tomato

- Harvesting commences about 50 days after transplanting but varies with variety

- Harvesting is done by hand by twisting and turning until the fruits snap off the vine (Fig. 48)

Fig. 48. Harvesting tomatoes in Kenya (Waiganjo et al., 2016)

- It is recommended to harvest early in the morning when temperatures are cool.
It is recommended to place harvested fruit into holding containers (plastic buckets) (Fig. 49)

**Fig. 49.** Putting harvested tomatoes in plastic buckets (Source:www.businessdailyafrica.com)

- The harvested fruits are emptied into holding containers (plastic or wooden crates) placed under shade in the farm.

### 1.3 Collection, sorting and grading

- This is done at the field and market
- Sorting is done to remove the bruised and fruits damaged by pests and diseases as well as debris (Fig. 50)
1.4 Field collection and packaging

Tomatoes are placed into plastic/wooden crates or baskets in the open fields under shade until they are transported to the market (Fig. 52)
Fig. 53. Tomatoes placed in plastic crates in the field ready for transport to the market (Source A –www.farmerstred.co.ke; Source - Lusike Wasilwa)

1.5 Transportation of tomatoes from farm to market

- Transport of tomatoes from farm to the market should be done early in the morning when temperatures are cool
- The markets are fresh produce wholesale markets or retail markets.

Fig. 55. Transportation of tomatoes using motorbikes, pick-up and bicycle
1.6 Bulking and sorting at the market
Tomatoes should be sorted to remove damaged and decayed fruits from the crates.

![Fig. 56. Sorting of tomatoes at the market](image)

1.7 Packaging at retail market
Tomatoes are packed in plastic polythene bags (1.2 to 1.5kg)

![Fig. 57. Tomatoes packed in plastic polythene bags at retail market](image)

- Retail units also include plastic containers (2-5kg) and heaps (3-5 fruits) (Fig. 9)
Display at supermarkets

- For the retail supermarket, tomatoes are placed either in heaps on shelves or packaged in 1.5-3 kg labelled plastic bags and displayed on shelves (Fig. 59)

Fig. 60. Display shelves for tomatoes at different ripening stages (Muchui et al., 2016)

The recommended practices for postharvest handling are summarized in Table 2.

Table x: Recommended practices for postharvest handling of tomatoes in Kenya

<table>
<thead>
<tr>
<th>Postharvest procedure</th>
<th>Recommended practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting maturity for retail market</td>
<td>• Breakers to turning;</td>
</tr>
<tr>
<td></td>
<td>• Pink to light red</td>
</tr>
<tr>
<td>Harvesting container (times of filling)</td>
<td>Plastic crate (once)</td>
</tr>
<tr>
<td>Weight of container in the field</td>
<td>20 kg</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Cooling</td>
<td>Cooling in cool area, e.g. under shade</td>
</tr>
<tr>
<td>Sorting</td>
<td>Weight, color</td>
</tr>
</tbody>
</table>
| Grading                        | Size (6 levels)  
|                               | Grade (3 grades) |
| Packaging materials            | • Cardboard (rigid)  
|                               | • Plastic film |
| Weight of packaging            | • 1.5 to 10 kg for retail  
|                               | • 10 to 15 kg for processing |
| Storage temperature            | Temporary storage at 15 to 18°C |
| Transportation                 | Temperature control |

Table 8 Source: Wayua et al. (2016)

PROCESSING AND VALUE ADDITION OF TOMATOES

The seasonality of tomatoes has led to high price elasticity’s and spoilage (which leads to wastage) during their peak seasons (Mutegi, 2004). The need to introduce farm level processing and packaging is necessary. The transfer of affordable technologies to farmers on how to process their fresh produce is inevitably very important. The following are a few products and ways of processing them, which can be easily adopted.

There are many methods of processing tomato including:
- Canning
- Tomato juice e.g. V8 juice
- Tomato Ketchup
- Tomato sauce
- Tomato jam
- Dried tomato solar drying or freeze drying

At industrial level, factories processing tomato products include Premier Foods (which processes Peptang tomato sauce), True Foods Ltd, Heinz Company, etc.
2.1 Preparation of tomato jam
(Source: PELUM, 2011)

**Ingredients**
- 3 cups of finely chopped tomatoes
- 2.3 cups of sugar
- 3 lemons

**Processing method**
- Wash the tomatoes and put in warm water for a few minutes to loosen the cover skin
- Remove the skin and cut the tomatoes into small pieces
- Wash the lemons, grate and squeeze off the juice
- Add the lemon mixture to the tomatoes, grind and cook for 10 minutes in gentle heat
- Add 2.3 cups of sugar while stirring the solution to dissolve
- Increase the cooking heat for the mixture to boil
- Remove from fire and let the mixture cool for some time
- Remove the scum layer and pour the jam in clean containers (glass jars)

2.2 Recipes for tomato sauce and tomato ketchup

Adding Value (Source Charity Mutegi)
Tomato juice

Ingredients
1. Fresh, well ripened tomatoes with uniform red color
2. Salt
3. Glucose

Procedure
1. Thoroughly wash tomatoes in clean water
2. Sort them and trim calyx, green part, discolored spot and cracks
3. Crush the tomatoes by a chopper (Fig. xx 1)
4. Heat the crushed tomatoes to 80°C within 1-2 minutes
5. This process aims at:
   a. Inactivating pectase, pectinase, ascorbic acid oxidase, etc.
   b. Increasing viscosity by dissolving pectin
   c. Increasing the yield of the product
   d. Removing the grassy smell.
6. Extract the tomato juice by using a pulper-finisher through a coarse and a fine screen (residues from the extraction should be kept for tomato puree production)
7. Add 0.5-0.6% of salt against the total juice
8. Add glucose to adjust the soluble solid content to be 6.5-7.3° Bx. This process should be completed within 10 minutes
9. Fill the juice into cans while hot, leaving no head space
10. Seam the cans by a vacuum steamer (figure 2)
11. Sterilize the can at 100°C for 15-20 minutes
12. Cool the can rapidly to 380°C after sterilization

NB: Amongst the important data that should be noted includes: Soluble solid content in the raw tomatoes (this is done using a hand refractometer), total weight of raw tomatoes, total weight of final product, yield of product and soluble solid content in the product, by use of a hand refractometer.

Tomato’s puree (tomato pulp)

Ingredients
1. Fresh, well ripened tomatoes with uniform red color

Procedure
1. Follow the same procedure as above until the point of juice extraction
2. No salt and glucose should however be added
3. Concentrate the juice, of which total solid content reaches 8.4-12%
4. Concentration can be carried out either by a vacuum evaporator (for large scale production) or by an open pan (for small scale or cottage industry)
5. Total solid may be determined by a hand refractometer, using a conversion table
6. Tomato puree obtained here will be used for tomato ketchup production

Tomato Ketchup

Ingredients
1. Tomato puree containing 10% tomato solid – 20kg
2. Sugar – 3kg
3. Salt – 450g
4. Vinegar (as 10% acetic acid) – 2l
5. Onion – 1kg
6. Garlic – 100g
7. Thyme – 20g
8. Sage – 20g
9. White pepper powder – 16g
10. Red pepper (chilly) powder – 12g
11. Cloves – 16g

Procedure
1. Chop onion and garlic
2. Put chopped vegetables and spices in a cotton cloth bag
3. Boil the spice bag for 2 hours in 3l of water
4. Put tomato puree into a steam kettle and boil it
5. Add sugar and salt into the puree
6. After dissolving sugar and salt, add the spice extract to the puree
7. Add vinegar just before the end of boiling
8. Stop boiling when total solid content reaches above 25%
9. Fill the product into either cans or plastic bottles while the temperature of product is above 85°C
10. After sealing, sterilize at 85°C for 20 minutes
Table 9 Note: Quantities can be altered depending on the amount that one requires.

<table>
<thead>
<tr>
<th>TOMATOES GROSS MARGIN (KES)</th>
<th>units</th>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable yield</td>
<td>Kg</td>
<td>45000</td>
<td>45 Ton/Ha</td>
</tr>
<tr>
<td>Returns</td>
<td>KES</td>
<td>45000</td>
<td>20</td>
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<tr>
<td></td>
<td></td>
<td><strong>Sub-total</strong></td>
<td><strong>900,000</strong></td>
</tr>
<tr>
<td>Variable costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td>grams</td>
<td>200</td>
<td>75</td>
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<tr>
<td>Nursery Management</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>approximately 12 M²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyethylene Sheet</td>
<td>M</td>
<td>16</td>
<td>250</td>
</tr>
<tr>
<td>Manure</td>
<td>kg</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyethylene Sheet</td>
<td>kg</td>
<td>0.12</td>
<td>30</td>
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<tr>
<td>Pesticide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicide</td>
<td>Litres</td>
<td>0.04</td>
<td>1800</td>
</tr>
<tr>
<td>Labor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land/bed preparation</td>
<td>Man-days</td>
<td>1</td>
<td>350</td>
</tr>
<tr>
<td>Irrigation/Spraying</td>
<td>Man-days</td>
<td>5</td>
<td>350</td>
</tr>
<tr>
<td>Sub-total</td>
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<td><strong>19,344</strong></td>
<td></td>
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<tr>
<td>Field Mgmt.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td>Tons</td>
<td>20</td>
<td>2000</td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSP</td>
<td>kg</td>
<td>250</td>
<td>30</td>
</tr>
<tr>
<td>CAN</td>
<td>Kg</td>
<td>300</td>
<td>26</td>
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<tr>
<td>Fungicide e.g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil</td>
<td>kg</td>
<td>2</td>
<td>1500</td>
</tr>
<tr>
<td>Dithane M45</td>
<td>kg</td>
<td>2.5</td>
<td>620</td>
</tr>
<tr>
<td>Insecticide e.g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brigade</td>
<td>Litres</td>
<td>1</td>
<td>1800</td>
</tr>
</tbody>
</table>

Pg 74
<table>
<thead>
<tr>
<th>Activity</th>
<th>Units</th>
<th>Hours</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>A chook</td>
<td>Litres</td>
<td>1</td>
<td>1700</td>
<td>1700</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td></td>
<td></td>
<td>63,350</td>
</tr>
<tr>
<td><strong>Labor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land preparation (Mechanized)</td>
<td>1</td>
<td>2</td>
<td>2500</td>
<td>5000</td>
</tr>
<tr>
<td>Hole preparation and Manure application</td>
<td>Man-days</td>
<td>10</td>
<td>200</td>
<td>1500</td>
</tr>
<tr>
<td>Transplanting and fertilizer application</td>
<td>Man-days</td>
<td>5</td>
<td>200</td>
<td>750</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Man-days</td>
<td>25</td>
<td>200</td>
<td>4500</td>
</tr>
<tr>
<td>Weeding</td>
<td>Man-days</td>
<td>30</td>
<td>200</td>
<td>6750</td>
</tr>
<tr>
<td>Spraying and Topdressing</td>
<td>Man-days</td>
<td>10</td>
<td>200</td>
<td>8000</td>
</tr>
<tr>
<td>Harvesting and Handling</td>
<td>Man-days</td>
<td>6</td>
<td>200</td>
<td>4500</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td>31,000</td>
</tr>
<tr>
<td><strong>Total Variable Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td>128,694</td>
</tr>
<tr>
<td><strong>Gross margin per Hectare</strong></td>
<td></td>
<td></td>
<td></td>
<td>771,306</td>
</tr>
<tr>
<td><strong>Gross margin per Acre</strong></td>
<td></td>
<td></td>
<td></td>
<td>308,522</td>
</tr>
</tbody>
</table>

**Note**

**Marketable yield**: refers to, 10% less of actual yield to cater for both pre- and post-harvest losses.

**Price**: Produce price - farm-gate.
Input prices - market prices in September 2016.

**Record keeping is recommended**

**Production schedules**

**Utilization**: Tomatoes are used in a variety of ways. Ripe tomatoes are consumed fresh or processed into puree, paste, powder, ketchup (tomato sauce), sauce and soup or canned as whole fruits. The unripe ones are pickled or used for preserves. Medicinal uses of tomatoes have been documented. Tomato extract has been used to treat various diseases in traditional medicine in Japan, Greece, Peru and Guatemala. Hot water extract of dried fruit has been used to treat ulcers, wounds, hemorrhoids and burn while tomato poultice has been used to treat edema during pregnancy. Fresh fruit apparently aid in digestion and to treat kidney and liver problems. The fruit is also rich in lycopene and vitamin C.
Appendix I – Basamid (Dazomet) Soil Sterilant  
(Adapted from Kenya Seed Co., 2001)

Basamid is used to control nematodes, fungi, insects and weeds in the soil. It is however harmless to beneficial soil organisms. Basamid is non-hazardous, easy to use and inexpensive.

Method of Application
1. Broadcast the granules on the soil surface and incorporate into the soil by hand or by mechanical means
2. Submerge soil surface with water for a few days and then use.
3. For small heaps of seedlings or potting compost, wet sacks may be placed on top to prevent escape of chemical into air
4. In case it is being used to sterilize compost, turn over compost to get air for a few days and then use.

Note: Basamid cannot be used on a crop that is growing or in drip irrigation.
Glossary

- Absorption: The process by which a chemical product and/or microorganisms passes through an organism’s natural barriers.
- Active Ingredient: The biologically active portion of a pesticide present in a formulation.
- Alternate Host: Different type of plant which a pest or a disease can survive on.
- Bactericide: Pesticide which kills bacteria.
- Beneficial insects: Insects which are helpful to farmers by killing pests or pollinating plants.
- Biological Control: Use of natural enemies from the animal or plant kingdom to control pests.
- Biological Product: An organism, a substance or a preparation used to control pests, whose active ingredient consists of living organisms or products of their metabolism.
- Botanical: A product made from plant extract.
- Broad spectrum: A description of pesticides which kill many different types of pests. They are likely to kill beneficial insects too.
- Canker: A dead or discoloured area on a plant caused by disease.
- Caterpillar: A wingless larval stage of a moth or butterfly.
- Compost Manure: Plant material which has been piled up and left to rot to break down, release nutrients and kill the pests and pathogens which may be present. This manure is then added to the soil to improve soil structure and fertility.
- Concentration: The quantity of active ingredient per litre of pesticide.
- Control: Successfully killing or reducing pests and pathogens to economically acceptable levels.
- Crop variety: The particular type of a crop being grown, with its own characteristics such as yield potential, disease resistance and time to maturity.
- Crop Hygiene: Taking care not to spread pests and diseases on to new crops by removing residues from previous diseased crops.
- Defoliation: Causing leaves to fall off.
- Determinate: Word that describes tomato varieties which are short and bushy and do not usually need staking / trellising or pruning.
- Disease: Plant sickness caused by a pathogen or physical and chemical factors such as low temperatures or shortage of particular nutrients.
- Soil Drench: Use of high volumes of dilute pesticide solution applied directly to the soil with sprayer or bucket to control pests and diseases in the soil.
- Drip Irrigation: Type of irrigation where water is supplied directly to plants through small holes in pipes laid on or in the soil next to crop rows.
Dose: The amount or portion of an active ingredient or preparation applied per unit of treated material.

Emulsifiable Concentrate (EC): A liquid pesticide formulation which is mixed with water before spraying.

Formulation: The mixture of ingredients, including the active ingredient, which makes up a commercial pesticide.

Fresh Market: Refers to tomato types which are suitable for eating fresh usually thin skinned and quite juicy.

Fungicide: An active ingredient or formulated product that kills moulds and fungus.

Growth Regulators: Product that affects physiological mechanisms, particularly cell growth and differentiation, after penetrating and circulating inside the plant without destroying it. This action usually triggers a change in the plant’s morphology and structure (the term “growth regulator” is inaccurate because it implies regularity).

Herbicide: An active ingredient or formulated product that kills vegetation.

Honeydew: Sticky sugary substance excreted by pests which suck plant sap such as whitefly and aphids.

Host: Organism on which a pest, disease or natural enemy feeds.

Indeterminate: Type of tomato variety which usually needs pruning and cannot support itself so needs staking or trellising.

Inoculation: Introduction of an antigen substance into the plant to produce immunity to specific pests and diseases.

Intercropping: Cultivation of two or more crops simultaneously on the same field, with the aim of controlling pests and diseases and conserving soil.

Insecticide: An active ingredient or formulated product that kills insects.

Integrated Pest Management (IPM): A pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilises all suitable techniques and methods in as compatible a manner as possible to maintain the pest populations at levels below those causing economically unacceptable damage or loss.

Label: The written, printed or graphic matter on, or attached to, the pesticide or the immediate container thereof and also to the outside container or wrapper of the retail package of the pesticide.

Maximum Residue Limit (MRL): The limit or parts per million, which is set by regulatory authorities as the amount of pesticide allowable in agricultural produce. These MRLs vary from one pesticide to another, from country to country and from crop to crop.

Mixed cropping: The practice of planting more than one type of crops in a...
field.

- **Mottling**: Patchy discolouration of leaves or fruit.
- **Mulching**: Covering the surface of the soil with material such as crop residues, compost or plastic sheeting to reduce water loss, splashing and break some pest life cycles.
- **Nutrients**: Chemicals in the soil made available either from breakdown of organic matter or added by farmers as artificial fertilizer which plants use for growth.
- **Overhead irrigation**: Type of irrigation where water is sprayed from sprinklers like rain over the crop.
- **Organic Farming**: Farming without using most synthetic pesticides or fertilizers.
- **Pathogen**: Infectious micro-organism which can cause disease.
- **Persistence**: The capacity of a pesticide to remain active for a long time after spraying.
- **Pesticide**: Any substance or mixture of substances intended for preventing, destroying or controlling any pest. It may be synthetic (man-made), biological (containing a living organism) or botanical (made from plant extracts).
- **Physiological Disease**: Plant damage caused by factors other than pathogens or pests.
- **Pollination**: Transfer of pollen from the male sexual parts of a plant to the female sexual parts in order to achieve fertilization which is required to set some fruits and crops.
- **Pre-Harvest Interval (PHI)**: The minimum number of days that must pass between the last application of a pesticide and the start of harvesting.
- **Product**: A pesticide in the form in which it is packaged and sold; it usually contains an active ingredient plus adjuvant and must be diluted before use.
- **Pruning**: Cutting off parts of a plant to control size or improve its growth or shape.
- **Repellent**: Describes something which is able to make organisms stay away. e.g. the smell of onion plants repels some pests.
- **Residue**: Any specified substances remaining on or in food, agricultural commodities, or animal feed. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance. The term “pesticide residue” includes residues from unknown or unavoidable sources (e.g. environmental) as well as known uses of the chemical.
- **Resistant**: Able to withstand something.
- **Roguing**: This is destroying plants which are affected/infested by pests or
diseases in order to prevent infestation/ infection spreading to other plants in the field.

- **Rotation**: The practice of changing the crop type in a field at each new planting to prevent the build up of pests and diseases.
- **Sap**: Plant juices containing water and nutrients.
- **Scouting**: Examining crop plants in a systematic way to assess pest, disease and natural enemy situation in order to decide whether any crop protection intervention is necessary.
- **Seed dressing**: A treatment which coats the seed with pesticide to prevent early season attack by diseases.
- **Selective**: A word relating to pesticides/specific which only kill organisms in a narrow range.
- **Solanaceae**: The plant family containing tomatoes and other crops such as egg plant, Irish potato and peppers.
- **Solarization**: Covering the soil with plastic (preferably clear) so that hot sunshine will heat the soil and kill pests and diseases in it.
- **Spray**: A solution or suspension, usually in water, to be applied by spraying, watering or dipping, containing formulated products and sometimes adjuvants.
- **Staking**: Using a pole to support plants so that they can grow upwards without falling on to the soil.
- **Stippling**: Damage showing as small white dots on leaves as a result of leaf sucking pests or leaf miner adults laying eggs or probing to find good egg-laying sites.
- **Stunted**: Plants which are small and poorly developed.
- **Succulent**: Very soft soapy or juicy plants which are quick growing.
- **Sunscald**: Physiological condition of tomato fruits caused by exposure to hot sunshine.
- **Susceptible**: Capacity to be affected by something.
- **Systemic**: A substance or preparation that acts after being absorbed and translocated from one organ to another in the treated plant.
- **Tolerance**: A plant’s capacity to withstand attack from pests, so that damage does not cause economic injury.
- **Trap crop**: Crop which is planted to attract a pest and is then destroyed together with the pest.
- **Treatment**: The application or introduction of one or more physical, chemical or biological agents to protect or improve agricultural production.
- **Trellising**: Supporting tomato plants with wire strung between posts. The plants are tied to the wire.
- **Weed**: Any plant growing where it is not wanted.
Wettable Powder: Powder pesticide formulation which is mixed with water before spraying.

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KILIMO VETCARE
PLANT CLINIC

Our products include:
- Professional Seeds
- Plant Pests and Diseases Clinic
- Green House Farming Advisories.
- Customized Farm Visits (Plant & Animal Clinics)
- Stockist for Syngenta, Bayer, Seminis, Murphy, Osho, Stake Aries, MEA, Norbrook, Coopers E.T.C.
- Agrochemicals, Fertilizers & Animal Breeding Services

Location: Kikuyu Town Opposite Law Courts and Adjacent to Kenya Commercial Bank (K.C.B)
Branches: Kabete & Redhill Rd (Gachie)
Phone / WhatsApp: 0720 78 18 72
E-mail: kilimo.agrivetcare@gmail.com

A one stop agricultural knowledge centre.
KOPIA Kenya Centre was established in August 2009 based on the MOU between the Rural Development Administration (RDA) and Kenya Agricultural and Livestock Research Organization (KALRO). The Centre is located in Nairobi and the main subjects of cooperative projects are improvement of production system of poultry, maize, potato, sweet potato and vegetables.

**Projects activities are to**:

- Promote model villages for increased income for small scale farmers through indigenous poultry and quality potato seeds.
- Develop new feed formulations with locally accessible materials for small holder poultry farmers.
- Develop MLNV (maize lethal necrosis virus) resistant-varieties for stable food production and self-sufficiency.
- Enhance potato and sweet potato production through development and promotion of improved agronomic technologies and strengthening of market linkages.
- Train school pupils on basic crop production practices to help them appreciate agriculture as a profession.

**Other activities are to**:

- Assist small holder farmers with innovative crop production systems through demonstration of modern agricultural technologies in experimental farms.
- Elevate research capacity through exchanging programs for scientists and experts in agriculture.
- Host KOPIA Field-day and support international events with Korean Embassy and Support agro-industries.
Climate Smart Agriculture- Tomato farming as an income generation activity

Introduction: Climate change poses a significant threat to farmers and to the sustainability of their output. According to optimistic lower-end projections of temperature rise, a changing climate may reduce crop yields globally by as much as 10 to 20 percent by the 2050s in the absence of adaptation. Climate-smart agriculture offers real hope. Climate smart agriculture is about increasing farm productivity in an environmentally and socially sustainable way. It is about strengthening farmers’ resilience to climate change, and reducing agriculture’s climate imprint by curbing greenhouse gas emissions and increasing carbon storage, including in the soil. Climate-smart agriculture relies on the limitless ingenuity of farmers, and includes proven techniques such as mulching, and developing drought or flood tolerant crops to meet the demands of a changing climate.

Horticulture industry is one of the most vibrant sub-sectors of agriculture in the Kenyan economy contributing 8% of the country’s GDP and 36% of the agricultural GDP. One of the main horticultural crops grown is tomato (Lycopersiconesculentum mill) which is amongst the promising commodities in horticultural expansion and development in Kenya. It accounts for 14% of the total vegetable produce and 6.72% of the total horticultural crops. Tomato is grown either on open field or under greenhouse technology. Open field production account for 95% while greenhouse technology accounts for 5% of the total tomato production Kenya. The best tomato variety will increase tomato farming as an alternative source of livelihoods in smallholder farmers. Tomato fruits are one of the most common vegetables in Kenyan meals, and are ever in high demand.

Contributions to the 3 pillars of climate smart agriculture (Tomato as an alternative source of livelihood).

- Mulching-Will improve soil cover thus reducing soil and moisture loss. It will add nutrients and beneficial bacteria to the soil which reduces erosion and increases soil quality.
- Water-harvesting- Better soil and water conservation will be achieved through using drip irrigation
- Less chemical fertilizers-Composting and organic mulching
- Improved varieties and diversification of crops-Will help to stabilize and even increase production and incomes.
- Adoption of Insect Pest Disease Management (IPDM) strategies, e.g. use of biological control options, traps, bio-pesticides
- Growing tomatoes under soil-less media (hydroponics technologies)