



AGRICULTURE AND FOOD AUTHORITY

HORTICULTURAL CROPS DIRECTORATE

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TOMATO (*Lycopersicon esculentum*) GROWERS MANUAL

PREFACE

Kenya has been endowed with an enabling environment for production of horticultural crops that attracts high demand both in the domestic and international markets. Production is mainly by smallholder farmers, many of whom require skills and knowledge on good agricultural practices (GAP) to produce and handle the fresh produce. According to the Economic Survey 2022 published by the Kenya National Bureau of Statistics (KNBS), horticulture is among the leading sub sectors in agriculture. Therefore, enhancing the capacity of these producers could be of immense beneficial to the Kenyan economy.

Agriculture and Food Authority – Horticulture Crops Directorate (HCD) is a government agency mandated to Regulate, Promote and Develop the horticulture industry in Kenya. In carrying out its mandate, the Directorate through the Technical and Advisory Services department (TAS) has developed this grower’s manual for its stakeholders. The manual has been designed with a simple language and where necessary photos have been used to highlights all processes from plough to plate. HCD envisages that by using this grower’s manual, its stakeholders especially the smallholder farmers, extension staff and trainers would upgrade their knowledge and skills to enable them increase production of the crops thereby improving on food security, household health, as well as create employment and generate income.

The content has largely been developed from the TAS field staff experiences in the 26 stations spread across the country (*Collins & Dinah – Nairobi [NHC], Antonina – Nakuru, Miriam - Nandi, Grace – Homabay, Barnabas- Eldoret & Iten, Carol - Bungoma, Peter- Busia, Charles -Kisumu, Irene - Narok, Lal – Kisii, Victor – Mombasa, Crispin – Kibwezi, Esther Ngutho– Kitui, Esther Kabatha – Nyandarua, Susan – Taveta, Syphrosa – Machakos, Catherine – Yatta, James – Kitale, Julius – Kajiado, Amedeo & Brenda – Meru, Mary – Kericho, David & Delphina – Mwea, Fridah – Nyeri, Emma – Sagana, Sarah – Limuru*), some content were reviewed from literature and images used properly acknowledged. Technical editing and reviewing of the manuals were done by Mary Chacha, Syphrosa Wanyama, Barnabas Kiptum, Antonina Lutta, Carol Soita, Amedeo Muriungi, Peter Mwanja, Victor Omari, Emma Ndirangu, Esther Kabatha, David Makori, Dinah Karimi, Collins Otieno, Dr Jacqueline Oseko the acting Deputy Director, Technical and Advisory Services department and Director Benjamin Tito all of Horticulture Crops Directorate.

TOMATO (*Lycopersicon esculentum*) GROWERS MANUAL

Common name-Nyanya (Swahili)



Introduction

Tomato is one of the leading vegetable produced for income and consumption in Kenya. It is a member of the solanaceae family and an important cash crop for smallholder farmers. Mainly grown in open fields but greenhouse production has also gained popularity. Tomato is rich in Vitamin A and C and can be eaten fresh, added to salads, cooked as a vegetable or processed into tomato paste, jam, sauce, puree and juice.

Common varieties grown include open pollinated varieties (OPVs) such as Rio Grande and Cal J (Kamongo). The indeterminate hybrid tomato varieties include, Eva F1, Star 9082, Samantha F1, Mavuno F1, Bravo F1, ChontoF1, Monalisa F1, Maxim F1, Kilele F1, Eden F1, Ansal F1, Assila F1, Rambo F1, DRD F1, Nyota F1 and Nuru F1 and Ana F1. There is high preference for hybrid varieties due to their disease tolerance, high productivity and long shelf life.

In Kenya, the leading tomato producing counties are: Kirinyaga, Taita Taveta, Narok, Lamu, Siaya, Murang'a, Kajiado, Machakos, Trans Nzoia, Kitui, Meru, Makueni, Bungoma, Laikipia, Nakuru, Homabay, Kiambu and Bomet.

Ecological requirements

1. Temperature range – 15 °C to 25 °C
2. Rainfall - Over 600 mm annually.
3. Soils - Well drained, high in organic matter with pH range of 5-7.5
4. Altitude- 0-2000m above sea level.

Good Agricultural Practices (GAP)

Horticulture industry in Kenya is guided by a code of practice (KS1758-2016 part II) which is a standard for vegetable, fruits, herbs and spices for both local and export market. The standard aims at ensuring food safety, environmental sustainability and social accountability by following good agricultural practices from production, processing, transportation and marketing of fresh produce. It is essential to maintain accurate records of all operations for ease of traceability.

Propagation materials

Certified tomato seedlings are acquired from registered nurseries /propagation units. In Kenya, tomato seeds are either sown directly into a nursery or sown on plastic seeding trays.

Land preparation

The field for planting tomatoes should be ploughed deep and levelled well. Drainage tiles done for the land with uneven topography and waterlogged sites.

Transplanting and Spacing

Transplanting is done when the seedlings are 4 weeks old. This is done early in the morning and late afternoon in order to minimise transplanting shock. Tomatoes are transplanted on raised bed or flat land with a spacing of 75-100 cm between rows and 40-60cm between plants depending on the variety. Seedlings are inserted in a hole in a way that first leaves are above the surface. The field is thereafter irrigated moderately as soon as possible after transplanting. Plant population per acre ranges between 6,000 to 13,000 plants.

Irrigation

Plants should be provided with adequate water since tomatoes are sensitive to water deficit especially immediately after transplanting and during flowering and fruit development. However, excess water leads to waterlogging which leads to Magnesium, Phosphorus and Nitrogen deficiencies.

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.

Soil testing

Soil testing is recommended before planting to guide on fertilizer and manure application.

Fertilizer application

During planting, NPK should be applied at the rate of 80kg/acre (equivalent to 10g/planting hole or one teaspoonful per hole), for root and shoot development.

Top dressing fertilizer application

Top dress with CAN at rate of 40kg/acre (equivalent to 5g/plant or 1/2 teaspoonful per plant) when the plants are 25 cm high and 80kg/acre (equivalent to 10g/plant or 1 teaspoonful per plant) 4 weeks later, for vegetative growth.

During flowering and fruit formation use of compound fertilizers (NPK) is recommended.

Application of foliar feeds as per the soil analysis results to foster better plant development.

Manure Application

During transplanting, apply 2 handfuls of well decomposed manure to the planting hole (8 tons/acre).

Mulching and weeding.

Mulching is done to conserve moisture and lowers soil temperatures. Depending on the type of weeds and growth stage of both the weeds and the crop, appropriate control measures can be adopted.

Training/Staking

Cultivars that have an indeterminate growth habit require training on trellises or suspended on twines from overhead wires. The benefits of training plants include better air circulation around the plant and less fruit rotting, improved spraying to control foliar diseases and pests and less sunburns.

Pruning




This is done for indeterminate varieties to reduce excess canopy and the practice influences the flowering and fruiting of tomato plant. It involves leaving one or two main stems and pinching out lateral branches as they appear on the leaf axils to encourage growth of good-sized marketable fruits. Leaves close to the ground are removed to prevent entry of blights due to high moisture accumulation.



Crop rotation

A three-to four-year rotation program with non-related crops is recommended to reduce build-up of pests and diseases.

Pests Management




Integrated Crop Management (ICM) is the best option for food safety. These methods include scouting of pests, field hygiene, proper spacing, physical methods like use of traps, pheromones, biological methods and others that will only give use of pesticides as a last option.



Pest (Insects)	Symptom/Damage	Control
<p>Tomato leaf miner (<i>Phthorimaea absoluta</i>, formerly <i>Tuta absoluta</i>)</p>  <p>Photo: By N3v3r14nd - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=65988</p> 	<ul style="list-style-type: none"> -The caterpillars' burrows (mines) in the middle of the leaf tissue and from a distance it seems the leaves are 'burning' -Most distinctive symptom is blotch-shaped mines in the leaves -On the fruits, it leaves symptomatic tiny holes. -Is a serious pest and can cause 100% loss if not controlled in time. 	<ul style="list-style-type: none"> -Field hygiene, crop rotation and regular scouting to monitor pest population. -Use of pheromone traps for surveillance and pest control -Use of chemicals e.g. chlorantranilipole, indoxacarb, spirotetramat + flubendiamide, imidacloprid.
<p>Red spider mites (<i>Tetranychus</i> spp.)</p>  <p>Photo: Fauna Press/FLPA Images of Natur Copyright: Flora Press/FLPA</p>	<ul style="list-style-type: none"> -Infested leaves turn silvery and brownish in colour -The leaves have cobwebs on the lower leaf surface -The pest develops rapidly during warm dry weather -High population causes drying and defoliation of leaves which leads to smaller and lighter fruits. 	<ul style="list-style-type: none"> -Weed control to remove alternate hosts -In severe infestation, burn the plants. -Intercrop tomatoes with onions or garlic, practicing field hygiene, planting host plants for predatory mites such as pigeon peas -The natural enemy <i>Phytoseilus pepersimilis</i> (predatory mite) has been very effective when used in greenhouses -Foliar sprays with recommended chemicals



		e.g. amitraz, abamectin and spiromesifen
<p>White flies (<i>Bemisia tabaci</i>)</p>  <p>Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)</p>	<ul style="list-style-type: none"> -These are white mealy flies that fly from foliage when plants are disturbed. -They suck sap and infested plants are low in vigour, may wilt, turn yellow in colour and eventually die. -The larvae secrete honeydew which support growth of black sooty mould and the whiteflies transmit the Tomato Yellow Leaf Curl Virus (TYLCV). 	<ul style="list-style-type: none"> -Keep tomato field weed-free through regular weeding. -Mount yellow sticky traps to monitor population. They can also be used for mass trapping of adult flies. -Use of neem products (azadirachtin) is effective for control. Other biological products include the parasitic wasp <i>Encarsia formosa</i> that is commercially available as Encartech. -When populations builds up, spray using recommended chemicals: e.g. Lambda cyhalothrin, thiamethoxam , deltamethrin and alpha cypermethrin
<p>African bollworm (<i>Helicoverpa armigera</i>)</p>  <p>Photo: http://www.infonet-biovision.org/PlantHealth/Crops/Beans#27680 © A.M. Varela, icipe</p>	<ul style="list-style-type: none"> -The caterpillar feeds on the floral buds, flowers and fruits. -It bores into fruit and feed on the inner part of the fruit releasing plenty of excreta (frass) which is noticeable on damaged fruits 	<ul style="list-style-type: none"> -Deep cultivation destroys pupae in the soil. -Avoid planting susceptible crops in succession. -Use of biopesticides are effective such as <i>Bacillus thuringiensis</i> var. kurstakii (Btk). Others include <i>Metarhizium anisopliae</i> (M.a), Helitec (<i>Helicoverpa armigera</i> nucleopolyhedrovirus-HearNPV) and neem products -Chemical sprays with abamectin, deltamethrin, spinosad, indoxacarb and methomyl. Sprays should be started as soon as young caterpillars are noticed on the crop since control becomes increasingly

		difficult with older caterpillars which have entered the fruits
<p>Cutworms (<i>Agrotis</i> spp)</p>  <p>Photo courtesy of: MB Agriculture, Soils & Crops Branch</p>	<p>-Early in the season, cutworms may cause stand loss by cutting off seedlings or recently planted tomato plants at the soil line</p> <p>-Later in the season, the pests can also injure tomatoes by eating irregular holes in the surface of the fruits</p> <p>-Infestation are sporadic and more common in weedy spots, soils high in organic matter and poor drainage</p>	<p>-Early land preparation and elimination of weeds at least 2 weeks before planting.</p> <p>-Use of the bio-pesticide <i>Bacillus thuringiensis</i> (B.t.)</p> <p>-Soil solarization</p> <p>-Chemical sprays with recommended chemicals e.g. alpha cypermethrin, deltamethrin, azadirachtin or imidacloprid.</p>

DISEASES

Disease	Symptom	Control
<p>Late blight (<i>Phytophthora infestans</i>)</p>  <p>Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo. Buawood.org</p>  	<p>-Is a fungal disease that affects foliage and fruits</p> <p>-Irregular greenish-black water soaked patches appear on leaves and later turn brown. The leaves wither but remain attached to the stem</p> <p>-Water soaked streaks appear on stems</p> <p>-Grey water-soaked spots appear on fruits</p>	<p>-Use of crop rotation</p> <p>-Remove volunteer crops that are more susceptible to the disease</p> <p>-Carry out pruning and staking to improve air circulation and reduce humidity</p> <p>-Spray fungicides such as mancozeb, propineb, metalaxyl+ mancozeb, propineb+ cymoxanil</p>

<p>Early blight (<i>Alternaria solani</i>)</p>  <p>Source: Lusike Wasilwa</p>	<ul style="list-style-type: none"> -Begins as brownish/black lesion on leaves and the surrounding tissue becomes yellow covering the entire leaf and leads to partial defoliation -There is formation of dark concentric rings within the lesion giving the spots a target-like appearance -The spots develop first on older leaves nearest the ground -Is prevalent during hot weather and occurs on all above ground parts 	<ul style="list-style-type: none"> -Field sanitation reduces the amount of inoculum available for infection the following year -Crop rotation -Use of clean seed and healthy transplants -Use of protective and curative fungicides e.g. propineb, mancozeb (protective) and metalaxyl, propineb+ mancozeb (curative)
<p>Fusarium wilt (<i>Fusarium oxysporum</i>)</p>  <p>Source: Varela <i>et al.</i>, 2003</p>	<ul style="list-style-type: none"> -Fusarium is prevalent in fields where continuous cropping of tomato is practiced -Characterized by yellowing of leaflets on one side of the leaf while the other side remains healthy and green -Subsequently lower leaves turn yellow and this progresses to other parts of the plant. -Leaves eventually die and drop off -If the stem is cut, vascular discoloration is observed -Seedlings infected by Fusarium wilt get stunted 	<ul style="list-style-type: none"> -Crop rotation of 5 years between successive crops -Remove all debris and crop refuse after harvest -Stake plants to improve aeration -Use of resistant or tolerant varieties
<p>Bacterial wilt (<i>Pseudomonas solanacearum</i>)</p>	<ul style="list-style-type: none"> -Is a seed borne disease of tomato -Wilt symptoms first appear on the youngest leaves and a rapid wilt of the whole plant occurs -The vascular bundles will be yellowish-brown in the initial stages of the disease but as it progresses, the pith of a 	<ul style="list-style-type: none"> -Produce transplants in pathogen-free soils -Remove and burn infected plants as soon as possible to check the spread of the disease -Practice rigid crop rotation

 <p>Source: Lusike Wasilwa</p>	<p>completely wilted plant is brown</p> <p>-Bacterial wilt is distinguished from other wilts by suspending a part of the infected stem in water whereby a slimy stream of bacterial cells from the xylem will be observed.</p>	
<p>Blossom end rot (Physiological disorder)</p>  <p>Stages of blossom end rot</p>	<p>-It is caused by calcium deficiency and irregular watering.</p> <p>-The disease occurs at the blossom-end of the fruit. It starts as a water-soaked spot that enlarges to become dark brown and sunken.</p> <p>-The surface of the spot becomes dark and leathery. The rot is dry.</p>	<p>-Avoid water stress during early stages of fruit development</p> <p>-Apply lime in calcium deficient soils</p> <p>-Apply foliar sprays of 0.5% calcium chloride at fruit development stage.</p>

Viruses reported on tomato crop include:

Tobacco mosaic virus or tomato mosaic virus (TMV or ToMV), Cucumber mosaic virus (CMV), Tobacco etch virus (TEV), Potato Virus-Y (PVY), Potato leaf roll virus.

Common control measures include:

Use tolerant varieties and certified disease-free seeds, protect seedlings with a net in the nursery, Control the insect vector, eliminate weeds and ornamental plants that harbour the virus, Remove and destroy infected plants, avoid an overlap of tomato crops, remove crop refuse and roots from fields, smoking or snuffing should be avoided while working in tomato fields since the virus can be transmitted from tobacco.

Harvesting and harvesting techniques

Maturity period varies from 55 to 105 days. Harvest fruits that are fully ripened but still firm. Most varieties are dark red. Harvested tomatoes should be put under shade with temperatures less than 25°C and a relative humidity of 80-90%. Some green tomatoes can be picked for a distant market.

Maturity indices: There are 4 main harvesting stages;

- Mature-green stage: the fruit is green but the internal gel is well developed

- Breaker/turning stage: up to 30% of the fruit surface has definite colour break from green to yellow
- Pink/light red stage: 30-90% of fruit surface has pink/red color
- Red ripe stage: over 90% fruit surface has changed to red color

Postharvest activities;

Cooling: postharvest cooling to remove excessive field-heat aids greatly in maintaining quality and substantially lengthens the shelf-life of tomatoes.

Sorting and Grading: During sorting damaged, rotten and cracked fruits should be removed. The grades are mostly based on the condition and the quality of the fruits and not specifically on their size.

Packaging: For local markets, the fruits are packed in wooden or plastic crates. The packing should be rigid enough to protect the fruit from being crushed.

Transport:

Tomatoes should be transported from farms to markets when it is cool.

Expected Yields and Gross margin

Tomato yields between 5 tons under field conditions to 20 tons per acre under greenhouse conditions.

Gross Margins

Gross margins vary depending on costs and production system used (open-field or protected). Below is a template for calculating gross margin under open field conditions.

GROSS MARGIN ANALYSIS PER ACRE (2023)

TOMATOES {F1 VARIETY}

1 acre - expected yield 15 tons

	Unit	Quantity	Cost/unit	Total cost
Gross income (GI)	Kshs	15000	25	375,000
Variable cost				
<u>Inputs</u>				
Ploughing	Acre	-	-	3,500
seedlings	Nos.	5000	3.50/-	17,500
Manure	Tons	8	2000	16,000
Soil testing				2,500
Fertilizers CAN	Kgs	80	80	6,400
NPK	kgs	80	120	9,600
Foliar fertilizers	Lts	2	1500	3,000
Fungicide	kgs	2	2500	5,000
Insecticide	Lts	3	2000	6,000
Irrigation water	Weeks	24	1,000	24,000
Stakes	No.	5000	2/-	10,000
Pheromone traps	No.	7	500	3,500
<u>Labor costs</u>				
Land clearing	Mds	7	500	3,500
Furrowing	Mds	20	500	10,000
Planting	Mds	10	500	5,000
Irrigation	Mds	12	500	6,000
Weeding	Mds	15	500	7,500
Topdressing	Mds	5	500	2,500
Staking/pruning	Mds	5	500	2,500
Spraying	Mds	15	500	7,500
Harvesting, grading & packaging	Mds	20	500	10,000
Total variable costs (TVC)				161,500
Gross margin (GM)= Gross income (GI)- total variable costs (TVC)				375,000 - 161,500= 213,500

Key; mds= man day

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