



AGRICULTURE AND FOOD AUTHORITY

HORTICULTURAL CROPS DIRECTORATE

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MANGO (*Mangifera indica*) 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.

MANGO (*Mangifera indica*) GROWERS MANUAL

Common name-Embe (Swahili)



Introduction

Mango is an important cash crop for domestic and export markets in Kenya. The fruit is a source of vitamins, minerals and fibre. Varieties for lowland (0-700m a.s.l) are Dodo, Ngowe, Boribo and Apple. Varieties for medium altitude areas (1500m a.s.l) are Tommy Atkins, Kent, Haden, van Dyke Sensation and Alphonso.

In Kenya, the leading mango producing counties are: Makueni, Lamu, Kilifi, Meru, Kitui, Tana River, Kwale, Machakos, Elgeyo Marakwet, Siaya, Migori, Baringo, Bungoma, Embu, Tharaka Nithi, Kirinyaga, Muranga, Taita, Taveta, Garissa counties (HCD validated data 2020).

Ecological requirements

1. Temperature range – 15° C to 30° C
2. Rainfall - Annual 500mm-1500mm
3. Soils - Deep (3m) fertile, well drained and optimum pH 5.5-7.5
4. Altitude- 0-1500m 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 food 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 for all farm operations for ease of traceability.

Propagation materials

Certified mango seedlings are acquired from registered nurseries. Farmers can also plant seeds (local varieties) at farm and later graft using scions from registered mother blocks. The farmer can top-work the already existing mango trees to introduce recommended varieties.

Soil testing

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

Land preparation and planting

Dig planting holes 60cm × 60cm × 60cm during the dry season and separate top soil and sub soil. Depending on varieties and the area climatic conditions, spacing of 8 -12m × 8-12m is recommended giving a population of 36 – 70 trees per acre.

At planting, top soil is mixed with well decomposed manure 20kg and 125g TSP/DSP and returned in the planting hole. Excavate soil at center of the hole and place grafted seedling, firmly press soil at the base of the seedling and add more soil up to the level as the seedling was in the potting bag in the nursery but keep the graft union above soil surface.

Irrigation

Young plants require regular watering for proper establishment. Plants are tolerant to drought after establishment when the tap root reaches water table. Irrigate when 75% of flowers have set in a tree.

Fertilizer and manure application

Top dressing at the beginning of each rain season

Fertilizer	Year 1-3	Year4-5	Year6-7	Year 8 +
CAN (g/tree)	240	400	400	1000
NPK/TSP(g/tree)	150	500	1000	1200
Manure (kg/tree)	20	60	80	100

Foliar fertilizer with boron and potassium are used to induce flowering, promote good fruit set, size and continued growth at flowering and fruiting stage. However specific site nutrients requirements are guided by doing a soil and leaf tissue analysis.

Weeding and mulching

The method of weeding depends on the size of orchard and the age of the crop. Mulching of new plants during first establishment period is essential.

Pruning

Formative pruning should start early for shaping the tree. At 1m high, cut the main shoot back to 0.6-0.7 m below the ring buds with secateurs. After new growth select only 3-4 outward shoots to grow to branches to 1m length, then cut them back to 50-75cm length again. Repeat the same process twice. Ideal mango tree should have 3-4 main trunks open and be 4-5 meters high.

Pruning after harvesting and before flowering

Pruning established trees will involve removing all diseased or dead branches to keep infestation from spreading. Remove hanging branches to keep fruit from dragging on the ground. Removal of vertical shoots as opposed to horizontal ones for tree shaping and maintaining the right height. Trim horizontal branches to 50cm length. Open the tree center by removing cluttered branch to allow air and sunlight to reach all parts of the trees to stimulate growth and for ease of spray for any infections. Pruning should be done 2-4 weeks before flowering begins.

Major mango pests and diseases

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 pheromone traps, biological methods and others that will only give option of using pesticides as last option.

Pests, symptoms and management		
Pests	Symptoms	Control
<p>1. Mango weevil (<i>Sternochetus mangiferae</i>)</p>  <p>http://www.infonetbiovision.org/PlantHealth/Crops/Mango © A.M. Varela, icipe</p>	<p>-Females lay eggs on young fruit which hatch to the larva that enters the fruit by burrowing through the flesh into the seeds, where it feeds until pupation, destroying the seed, leading to premature fruit fall.</p> <p>- Attack remains undetected in the field, and is seen when cutting the fruit.</p>	<ul style="list-style-type: none">• Cultural control<ul style="list-style-type: none">-Collect fallen fruits and destroy by burying or burning-Paint the tree trunk with agriculture lime at flowering to prevent the pest from climbing-Applying sticky bands at the upper end of tree trunks when the trees start flowering to reduce migration of weevils to branches for egg laying.• Chemical control<ul style="list-style-type: none">-Spray insecticides before flowering and fruit set and repeat every 14 days interval use; Abamectin, Deltamethrin, Lambda cyhalothrin, Acetamiprid Emamectin

<p>2. Mango Fruit fly (<i>Ceratitis cosyra</i>)</p>  <p>https://www.bighaat.com/blogs/kb/effective-management-of-fruit-flies-in-mango</p>	<ul style="list-style-type: none"> -Female fruit flies puncture the skin of mature ripe fruit and lay eggs that hatch into maggots (larvae) that feed on flesh destroying the fruit. -The affected fruit fall prematurely. 	<ul style="list-style-type: none"> -Collection of fallen fruits and destroy by burying 50 cm deep. -Harvest mangoes before they are ripe. -Use of pheromone traps. -Use of parasitic wasps. -Post harvest hot water treatment (dip fruit for 3- 5minutes in 50°c water).
<p>3.Scales (<i>Aulacaspis tubercularis</i>)</p>  <p>https://plantvillage.psu.edu/topics/mango/infos</p>	<ul style="list-style-type: none"> -These insects suck sap from the leaves, branches, flowers and fruit. -They excrete honeydew that develops into black sooty moulds, reducing photosynthesis and may cause leaf and fruit fall -Poor growth and blemished fruits. 	<ul style="list-style-type: none"> -Cut and burn infested tree parts -Use natural enemies e.g., parasitic wasp, lady bird beetle, lace wings, -Use White oil plus appropriate insecticides.
<p>4. Mealy bugs (<i>Drosicha mangiferae</i>)</p>  <p>https://plantvillage.psu.edu/topics/mango/infos</p>	<ul style="list-style-type: none"> -These insects suck sap from the leaves, branches, flowers and fruit. -They excrete honeydew that develops into black sooty moulds, reducing photosynthesis and may cause leaf and fruit fall -Poor growth and blemished fruits 	<ul style="list-style-type: none"> -Cut and burn infested tree part -Use natural enemies e.g., parasitic wasp, lady bird beetle, lace wings. -Mineral oils, neem products and soapy solutions (1 to 2%)
<p>5.Mango gall midge (<i>Procontarinia pustulata</i>)</p>  <p>https://images.app.goo.gl/8TVSzcAUkAgJht7SA</p>	<ul style="list-style-type: none"> - abnormal plant growth called galls that can cause damage to mango leaves, flowers, fruit and shoots -Adult fly lays eggs on the young leaf tissues. Once the eggs hatch, larva burrows in the leaf and gall formation begins in 7 days. -Severe infestation can result to total defoliation 	<ul style="list-style-type: none"> -Orchard sanitation - clear all weedy areas, pruning crowded branches. -Mineral oil mixed with deltamethrin

<p>1. Powdery mildew (<i>Oidium mangiferae</i>)</p>  <p>https://krishiseba91.blogspot.com/2018/08/mangodiseasemanagement.html</p>	<p>-Infected plant show patches of white powdery fungal growth on leaves, flowers and young fruits, old leaves and fruit display purple-brown cast.</p> <p>-This fungus appears mostly in warm, humid weather.</p> <p>-In severe attacks, the entire blossom panicle may be involved and fruit fail to set (affecting yields).</p>	<p>-Cultural control An open, well-ventilated and faster drying orchard that is regularly pruned hinders the mildew infestation</p> <p>-Triadimephon -70% neem oil</p>
<p>2. Anthracnose (<i>Colletotrichum gloeosporioides</i>)</p> 	<p>-It affects leaves, stems and floral panicle, but the fruit receive the most damage.</p> <p>-The fungus causes brown necrotic spots on leaves and black spots on fruits and flowers, on young shoots it causes die back. Wet humid warm weather condition favor infection.</p>	<p>-Remove dead material (branches, leaves and infested fruit) from the orchard.</p> <p>-Hot water treatment of fruits at 50°C for 3 to 5 minutes.</p> <p>-Wide spacing of the trees.</p> <p>-Copper-based sprays 14 days before and after flowering.</p>
<p>Bacterial black spot (Bacterial canker) <i>Xanthomonas campestris</i></p>  <p>https://plantvillage.psu.edu/topics/mango/infos</p>	<p>-Leaf lesions</p> <p>-Black raised angular areas surrounded by a yellow halo.</p> <p>-Cankers on stems leads to terminal die back</p> <p>-Affected fruits form black oval to irregular raised spots.</p> <p>-Ooze sap full of bacteria.</p>	<p>-Source disease free seedlings.</p> <p>-Remove and destroy infected parts.</p> <p>-Apply copper-based fungicides.</p>

Nutrients deficiency

Element	Deficiency symptoms	Control
<p>1.Potassium</p>  <p>https://hort.ifas.ufl.edu/database/nutdef/pic53.shtml</p>	<ul style="list-style-type: none"> -It is characterized by necrosis of leaf margin which starts from the tip downwards. -Fruit quality is highly reduced. -Disease and pest attack as secondary infections. 	<p>Manage by applying muriate of potash, urea and super phosphate fertilizer.</p>
<p>2.Boron</p>  <p>https://www.complesal.com/en/key-crops/mango-1</p>	<ul style="list-style-type: none"> -It is characterized by flower abortion, and also cracking of fruits. -Brown areas can also be seen in yellow fruit pulp 	<ul style="list-style-type: none"> -Apply 250gm boron per tree (10-15-year-old). -
<p>3.Copper</p>  <p>https://vikaspedia.in/agriculture</p>	<p>Common in young tree due to heavy nitrogenous fertilizer, the terminal shoot is weak, defoliation and die back of branches, drooping shaped branches</p>	<p>-spray copper or copper oxychloride (0.3%) at monthly interval</p>
<p>3.Calcium Deficiency</p>  <p>http://postharvest.ucdavis.edu</p>	<p>-It's a physiological disorder that causes Jelly seed in mango fruit due to Calcium deficiency. Symptoms:</p> <ul style="list-style-type: none"> -Degeneration of fruit pulp after harvesting fruit characterized by premature and uneven ripening of the mesocarp 	<p>Application of dolomitic lime ($\text{CaCO}_3 \cdot \text{MgCO}_3$) at the rate of 3.2 tons per acre per year applied once at the onset of long rains (March – April).</p>

	-Other symptoms include internal breakdown, soft nose, stem-end cavity or spongy tissue	
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Mango harvesting

Harvesting starts 3-4 years after transplanting. Fruits are ready 3-5 months from flowering depending on the variety. Fruit should be clipped from the tree leaving 3 to 4cm stalk attached to the fruit which is later reduced to 1cm.

Hand harvesting can be done for fruits that are near the ground. Use harvesting tools to help protect fruits at harvesting. Use a basket on a long pole with a cutting tool attached, any blades used for harvesting should be sharpened regularly to minimize damage to the fruit and tree. Proper training before harvesting is key to using harvesting tool correctly. Harvest fruits early in the day to keep them cool and reduce water loss.

Transport fruits to a cool shaded place, avoid dropping or throwing fruits to the ground during harvesting to prevent mechanical damages.

Harvesting hygiene

Use plastic crates which are easy to clean and are smooth inside to protect fruit from damage. Harvesting environment, tools and field containers must be clean to avoid contamination. Personal hygiene for harvesters is important and facilities such as hand wash and clean accessible toilets should be available as a measure of ensuring food safety is maintained.

Maturity indices

Maturity indices are indication of readiness of fruit for harvest. These includes

1. Fruit shape- mature fruit have flat shoulders at the stem end and full cheeks (Ngowe).
2. Fruit Peel appearance-peel has white powdery substance, peel color change from dark green to pale green
3. Fruit pulp - pulp color change from white to light creamy yellow.
4. Built shoulders- slight depression near the stalk in mature fruit (Apple).
5. Maturity period - it takes 95 to 115 day from flowering to fruits maturity.
6. At harvesting stage mango are recommended to have a minimum of 7-9% brix level.
7. Latex exudate reduces as the fruit matures. The colour changes from milky to clear as the fruit matures.

Yields

In an acre mango trees yield is from 12,000kgs to 18,000kg (500 to 800 fruits per tree per year) in a year for a 5-year orchard.

Post- harvest handling techniques

1. Desapping/delatexing

Is the removal of fresh latex from the fruit by either inverting freshly de-stemmed fruits on plastic or steel mesh racks, allowing the latex to drip for 30 minutes under shade.

2. Trimming

At harvesting fruit is clipped from the tree to leave 3 to 4cm stalk attached to the fruit which is later reduced (trimming) to 1cm during final packing.

3. Sorting

Fruits are sorted to remove diseased, misshaped, immature fruits, bruised fruits and any foreign material

4. Grading

Grade mangoes based on the standard criteria accepted by the industry. Three standard mass grades can be set as: large (over 300 g), medium (150–300 g) and small (below 150 g). Minimal defects such as wind scar and latex stain may be accepted. Fruits are graded according to size, colour and texture (class I and II).

4. Transporting

Use covered vehicles to avoid direct sunlight heat which cause damage to the fruits. Minimize fruits contact with soil to avoid contamination that causes decay and safety concerns. Use clean plastic crates for fruit transportation. Refrigeration is encouraged.

5. Storage

Use clean crates during storage. Mango can be stored under refrigeration at 12°C. Separate ripe from unripe mangoes and other ripe fruits to slow down ripening by reducing exposure to ethylene.

6. Hot water treatment

Mango hot water treatment involve immersing mango fruit in water bath at temperature of 46.1 0C for 68, 75 and 84 min depending on variety. Hot water treatment is used to minimize fruit fly damage by killing the egg and also for control of anthracnose and stem end rot on harvested fruits.

Gross margin analysis for 1 acre

1-acre (50 trees, spacing 9m by 9m) 5year tree yield of 240kg per year	Units	Quantity	Cost ksh/unit	Year 1	Year 2	Year 3	Year 4	Year 5
Gross income	Kgs	12,000kg (5 th year)	30	-	-	30,000	90000	360,000
Variable costs								
Land preparation		1	5000	5000	-	-	-	-
Soil analysis		1	2500	2500				
Seedlings		50	200	10000	-	-	-	-
Holes		50	50	2500	-	-	-	-
Manure		1	4000	4000	6000	8000	10000	12000
Planting		1	2500	2500	-	-	-	-
Fertilizer CAN	Kgs	25kg,	120	1500	2400	3000	4500	6000
NPK		50kg	120	1500	2400	3000	4500	6000
Foliar fertilizer (boron, potassium)	ml	500ml		500	1000	1500	2000	2500
Insecticides	ml	500ml	500 x 3	500	500	500	1000	1500
Fungicides	ml	500ml	400 x 5	500	750	1000	1500	2,000
Pheromone traps	No	10 traps	800	-	-	-	8000	4000
Labour cost								
-Pruning	Man days	2days	500	-	500	1000	1000	1000
-Spraying	Man days	10days	500	500	500	500	1000	2000
-Top dressing	Man days	2days	500	500	500	500	500	500
-Weeding	Man days	4days	500	6000	6000	6000	4000	4000
-Harvesting	Man days	10day	500	-	-	2500	5000	5000
Total variable costs				38,000	20,550	27500	43,000	46,500
Gross margin (gross income – total variable costs)				-38000	-20,550	2,500	47,000	360,000-46,500=313,500

- ◆ **NB:** Cost for irrigation not included.
- ◆ An intercrop in the first three years will reduce the cost of weeding. After the 4th year, the canopy will have reduced the weed incidences.
- ◆ Plant matures well hardened seedlings

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