



# AGRICULTURE AND FOOD AUTHORITY

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## HORTICULTURAL CROPS DIRECTORATE

Nairobi Horticultural Centre next to JKIA; P.O. Box 42601 – 00100; Telephone: 020-2088469, 020-2131560  
Email: [directorhcd@afa.go.ke](mailto:directorhcd@afa.go.ke), [directorhcd@agricultureauthority.go.ke](mailto:directorhcd@agricultureauthority.go.ke) Website: [www.afa.go.ke](http://www.afa.go.ke)

## AVOCADO (*Persea americana*) 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.

## AVOCADO (*Persea americana*) GROWERS MANUAL

Common name-PARACHICHI (Swahili)



*Hass Avocado (Pic.1)*



*Fuerte Avocado (Pic.2)*



*Pinkerton Avocado (Pic.3)*



### Introduction

Avocado (*Persea americana*) is a fruit in the *Lauraceae* family that has gained a lot of nutritional importance in the world, over the years. It is high in protein, minerals (Zinc and selenium) and vitamins (A, C and E). It is eaten ripe and flavours soups, ice creams, milkshakes, smoothies, Guacamole and avocado oil which is easily digestible and largely unsaturated.

There are several varieties, but commercially Hass (Pic.1) and Fuerte (Pic.2) varieties are the most common. Avocado is mainly grown in West of Rift Valley (Narok, Bomet, Kericho, Kisii, Nyamira, Nandi, Uasin Gishu, Elgeyo Marakwet, Trans Nzoia, Bungoma, Kakamega) and East of Rift Valley (Nakuru, Murang'a, Kiambu, Nyeri, Meru, Embu, Machakos, Kajiado).

### Ecological requirements

**Altitude:** 1200 to 2200 meters above sea level

**Rainfall:** 1000 to 1600mm of well distributed rainfall annually

**Temperatures:** 16 to 30°C.

**Soils:** Soils should be deep (1.2M), well aerated, fertile, preferably Sandy loams with a pH range of 5 to 7.

### **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 for all farm operations for ease of traceability.

### **Propagation materials**

Certified avocado 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 avocado 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 7-10m × 7- × 10m ( Hass- 7mx7m, Fuerte 9mx9m, Pinkerton 6mx6m) giving a population of 50-81 plants per acre. Avocado plant population is defined by the variety of the avocado planted, attributed to their overall growth habit. Farm operations, soil type and climatic conditions are additional factors worth considering in determining the spacing.

At planting, top soil is mixed with well decomposed manure 20kg and 150gms 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.

Avocado is very sensitive to waterlogging, therefore if the orchard is flat and soil profile is less than 1m deep, then you dig the holes, mix top soil and manure and fill holes and raise the holes to 50cm or as a ridge. Ridging facilitates fast root growth and reduces chances of root rot caused by waterlogging especially in areas with high clay content.

### **Irrigation, fertilizer and manure application**

Young plants require regular watering for proper establishment and high productivity.

Avocados in Kenya are mainly grown under rain-fed conditions. In cases of insufficient rainfall, irrigation is recommended at the rate of 20-40 litres per tree per week in two splits. This is especially at flowering or fruit set and when it is generally dry.

Soil and tissue analysis is advised to determine the nutritional needs for the avocados.

Fertilizer requirement per avocado tree

Age of the tree	1-3 years	4-5 years	6-7 years	8-9 years	10-14 years	15 years and above
CAN(g)	125	225	450	650	900	1300
TSP(g)	225	450	650	650	1000	1200
Murate of Potash(g)	-	-	225	450	635	650
FYM(kg)	20	20	30	30	-	-

Source: Avocado Cultivation-KALRO, 2018

Fertilizer and manure should be applied around the canopy and incorporated well into soil, at 2 inches depth as the avocado feeder roots are at that level.

### **Weeding and mulching**

Manual control of weeds for young plants is adopted. Mechanical weeds control is recommended for older trees. Mulching is a recommended practice in avocado farming. It suppresses weeds growth, conserves soil by improving water holding capacity and prevents soil erosion from heavy rains or strong winds. Organic material should be used as it increases fertility when decomposed.

### **Pruning and Training**

Pruning determines the size, quality and quantity of fruits in avocado trees. Trimming of avocado branches is done for various reasons among them, encouraging lateral growth (central leader) and multiple framework branching. All sucker growth below the graft union should be removed to reinforce training of the tree.






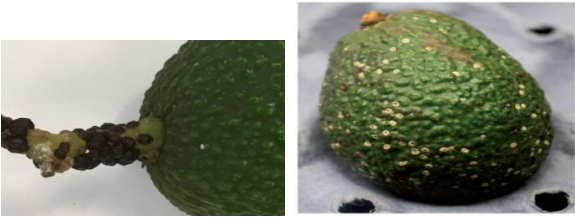


Young trees should not be pruned excessively as this interferes with the productive phase. Pruning is best done during the dormant phase and for declining trees it is important to bring them back to full productivity.




Horizontal branches hanging low should be pruned to allow access. Cutting windows in the canopy allows for light to enter. Dead wood should also be removed.

### Major avocado 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 attack symptoms and signs	Symptoms	Control
<p><b>1.False Codling Moth(FCM)</b> <b>( <i>Thaumatotibia leucotreta</i> )</b></p>   <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• After emerging from the egg, the young larva tunnels into the fruit</li> <li>• The larva feeds from inside the fruit with frass or excrement being produced at the entrance of larval tunnels</li> </ul>	<ul style="list-style-type: none"> <li>• Proper orchard sanitation</li> <li>• Infested fruits (both on the tree and fallen) should be removed regularly (twice a week) and buried 50 cm or dipped in a drum filled with water mixed with used oil for 1 week.</li> <li>• Use of pheromone traps.</li> <li>-Chemical control</li> <li>-Abamectin, Deltamethrin, Lambda cyhalothrin, Acetamiprid, Emamectin</li> <li>-Neem based extracts</li> </ul>
<p><b>2.Avocado Fruit fly ( <i>Batrocera invades</i> )</b></p>  <p>Source: SHEP PLUS</p>	<p>-Females lay eggs under the skin of the fruit that is just beginning to ripen, It also attacks young and old fruits</p> <ul style="list-style-type: none"> <li>• When the fruit reaches about the size of a golf ball a sting lesion appears as a slight puncture mark surrounded by a white exudate</li> <li>• As the fruit develops, the lesion becomes dry and turns into distinct star-shaped crack on the skin surface</li> </ul>	<ul style="list-style-type: none"> <li>• Orchard sanitation.</li> <li>• Scouting and monitoring.</li> <li>• Trap flies using commercial pheromone traps - Methyl Euginol (Bactrolure liquid) at 20 traps per acre.</li> <li>• Remove infested fruits (e.g. those with dimples and oozing sap) twice a week and destroy by burying 60cm deep</li> </ul>

<p><b>3.Scales</b> (<i>Coccus spp.</i>)</p>  <p>Source: SHEP PLUS</p>	<p>-Discoloration, malformation, leaf and fruit drop, and retarded growth</p> <ul style="list-style-type: none"> <li>• Damage is caused by toxic saliva, extraction of plant sap and honeydew in association with sooty mould.</li> <li>• A severe infestation forms a continuous crust over the underside of leaves</li> </ul>	<p>Conserve natural enemies such as parasitic wasps, ladybird beetles and lacewings, provided no broadspectrum pesticides are used and no ants are present</p>
<p><b>4. Thrips</b> (<i>Scirtothrips perseae</i>)</p>  <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• Affected parts become whitish or silvery and are usually covered with dark-coloured droppings</li> <li>• The infested plant tissues will turn brown and dry up, if the damage is too severe</li> <li>• On fruit, feeding begins near the calyx, gradually producing a scar that can cover the whole fruit</li> <li>• Attacked fruits develop a leathery brown skin</li> </ul>	<p>-Conserve natural enemies: Thrips are attacked by predatory Thrips, Lacewings and Predatory Bugs</p>
<p><b>Diseases infection symptoms and signs</b></p>		
<p><b>1. Root Rot –Die Back</b> (<i>Phytophthora cinnamomi</i>)</p>  <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• Trees affected lose vitality, become sparsely foliated and do not produce a good crop</li> <li>• Leaves are pale-green and wilted, branches usually become sunburned and die back in advanced stages</li> <li>• Feeder roots get darkened and decay and trees will eventually die prematurely</li> </ul>	<ul style="list-style-type: none"> <li>-Uprooting of affected trees</li> <li>-Hot water and fungicide treatment of seeds for propagation</li> <li>-Grafting on Phytophthora-tolerant and/or resistant rootstocks</li> <li>-Ridging or raised beds</li> </ul>

	<ul style="list-style-type: none"> <li>• The fungus can be spread or introduced to new areas by infested planting material, soil and irrigation water</li> </ul>	<ul style="list-style-type: none"> <li>-Enhanced drainage in farms</li> <li>-Drench Mycorrhiza</li> </ul>
<p><b>2. Anthracnose</b> (<i>Colletotrichum lindemuthianum</i>)</p>  <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• Dry spots, dark brown in color, form on the skin, leading to abnormal development</li> <li>• In severe attacks, the young fruits drop</li> <li>• It is mostly a post-harvest disease as the fruits are more susceptible when mature</li> </ul>	<ul style="list-style-type: none"> <li>• Orchard sanitation</li> </ul>
<p><b>3. Scab</b> (<i>Cladosporium cucumerinum</i>)</p>  <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• Lesions appear as small dark spots slightly raised, oval to elongated</li> <li>• These coalesce, giving a corky appearance to the surface of the fruits-impairing the appearance but not the internal quality of the fruit</li> </ul>	<ul style="list-style-type: none"> <li>• Orchard sanitation: remove dead branches and twigs since they harbour the fungus</li> <li>• Also remove fallen rotten fruits from the field</li> </ul>
<p><b>4. Cercospora Fruit Spot</b> (<i>Cercospora purpurea</i>)</p>  <p>Source: SHEP PLUS</p>	<ul style="list-style-type: none"> <li>• Small, light-yellow spots later changing to reddish-brown appear on fruits and leaves which eventually become hard and crack, thus creating entry points for other decay organisms</li> <li>• Mature fruits are resistant</li> <li>• The disease development is favoured by humid conditions and high temperatures</li> <li>• The fungus is essentially spread by water splash and its spores are also wind-borne</li> </ul>	<ul style="list-style-type: none"> <li>Orchard sanitation</li> </ul>

### Nutrients deficiency

Essential micronutrients include Zinc, Boron, Manganese and Molybdenum

Element	Deficiency symptoms	Control
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<b>Potassium</b> – important for yield and fruit quality	It is characterized by necrosis of leaf margin which starts from the top downwards. Fruit quality is highly reduced.	Apply Potassium Sulphate/ Potassium Nitrate/ Potassium Chloride/ Muriate of Potash
<b>Boron</b> - essential for good flower formation, pollen viability and fruit set	It is characterized by apical and axillary growing points die off, leaves are distorted (crinkled with holes), the mid rib and main vein on the lower surface are frequently split and young twigs may swell	Apply Borax or Solubor Foliar of Solubor
<b>Zinc</b>	Chlorosis (yellowing) of young leaves and rounding of the fruits	Apply Zinc Sulphate on the soil

## Harvesting

Avocados mature 3 to 4 years after transplanting grafted plants. Determining the right harvesting stage is critical as it affects fruits quality, storage and shelf life. Avocados don't ripen on the tree but should be harvested when they are physiologically mature.

Avocado Maturity Indices:

1. Color change from green to black or purple (Hass) or Shiny to pale green (Fuerte)
2. Stalks change color from green to yellow
3. Size is also a factor of maturity but not accurate

## Determining maturity of avocados

1. Dry matter analysis

Dry matter is dependent on variety, region and season. This is a more accurate method of determining the maturity of avocados. 24% and 30% dry matter are the minimum specification for fresh fruits maturity and for oil processing respectively. Dry matter increases as the fruits mature.

Dry matter can be analyzed using several methods as follows:

- Microwave/Oven method-a Hofshi borer can be used to collect sample from fruits
- Near infrared spectroscopy-e.g. the Felix Instrument Dry Matter Reader
- Time-to-harvest predictive tool
- Penetrometer

## 2. Floating test

Avocados that are apparently mature are immersed in water, the mature ones should float while the immature ones sink or float below the water surface.

## 3. Fruits can be stored in a warm place (about 20<sup>0</sup> temperatures) for a week.

If the fruits ripen without shriveling, that is an indication that the fruits are mature. Harvesting should be done early in the morning or late afternoon, when the weather is cool.

### **Harvesting Techniques**

It is advisable to train harvesters on harvesting techniques, hygiene and proper handling as well as occupational health and safety.

Avocado fruits should be clipped from the trees with secateurs, leaving a portion of the stalk attached on the fruit (about 0.5cm long). It is not advisable to pull fruits from the tree given this will damage the fruit and cause quality concerns.

Fruits should be harvested into soft bags or clean buckets and stored in clean crates. Harvesting records should be maintained by the farmer.

**Expected Yields:** With an average yield of between 250 to 300 kilograms (1000-1200 fruits per tree per year). The conversion is equivalent to 20 to 24 tonnes per acre per year.

### **Postharvest activities**

Packaging of harvested fruits should be done to maintain quality, preferably in crates and transported in closed trucks as per the Crops (Horticultural Crops) Regulations 2020.

#### Sorting and Grading

Sorting involves removing all field debris, diseased and pest damaged and bruised fruits. Grading into different sizes and ripening stage.

#### Pre-cooling

Harvested fruits in clean crates should be stored under shade to prevent sun-burn, loss of moisture, and dust accumulation.

The fruits should be precooled within 5 hours after harvest to a temperature of 5-7°C before cleaning, sorting and grading for final packaging.

## Packaging

Fruits are packaged in standard 4kg boxes. The small fruits sizes 26-30 are packaged in standard 10kg boxes. The fruits are packaged in respective sizes as below.

Fruit size	Grams/fruit	Fruit size	Grams/fruit
8	461-575	16	236-265
10	366-460	18	211-235
12	306-365	20	191-210
14	266-305	22	171-190

The fruits should be packaged in well ventilated cartons made of solid or corrugated fiberboard. They should be arranged in a single layer. The boxes should have holes to allow for effective cooling and air circulation. The boxes should be well labeled with the variety packed, size of fruits and a traceability number that's easy to trace the produce from market to the farms in case of a quality concern in the market.

## Dispatch

The packaged fruits should be palletized to allow for stacking of boxes to minimize on damage during transportation and movement of fruits within the boxes. The pallets should be hot water treated in a KEPHIS authorized facility.

## Gross margin analysis for 1 acre

1 acre (80trees, spacing 7m by 7m ) 5year tree yield of 300kg per year	Units	Quantity	Cost ksh/ unit	Year 1	Year 2	Year 3	Year 4	Year 5
Gross income	Kgs	24,000kg (5 <sup>th</sup> year)	80	-	-	320,000	640,000	1,920,000
<b>Variable costs</b>								
Land preparation		1	5,000	5,000	-	-	-	-
Soil analysis		1	2500	2500				
Seedlings		80	200	16,000	-	-	-	-
Holes		80	50	4,000	-	-	-	-
Manure		1	4,000	4,000	8,000	10,000	10,000	10,000
Planting		1	4,000	4,000	--	-	-	-
Fertilizer								
CAN	Kgs	25kg,	120	1500	2400	3000	4500	6000
TSP	kgs	50kg	120	1500	2400	3000	4500	6000
Farmyard manure	Kgs	20bags	100	2000	2000	2000	2000	2000
Foliar fertilizer (boron, potassium)	ml	500ml		500	1000	1500	2000	2500

Pheromone traps	No	10 traps	800	-	-	-	8000	4000
<b>Labour cost</b>								
-Pruning	Mds	2days	500	-	500	1000	1000	1000
-Spraying	Mds	10days	500	500	500	500	1000	2000
-Top dressing	Mds	2days	500	500	500	500	500	500
-Weeding	Mds	4days	500	6000	6000	6000	4000	4000
-Harvesting	Mds	10day	500	-	-	2500	5000	5000
<b>Total variable costs</b>				<b>48,000</b>	<b>23,300</b>	<b>30,000</b>	<b>42,500</b>	<b>43,000</b>
<b>Gross margin (gross income – total variable costs)</b>				<b>-43,000</b>	<b>-23,300</b>	<b>290000</b>	<b>597500</b>	<b>1,357,000</b>

**NB: Cost for irrigation not included**

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