



Japan International Cooperation Agency



Agriculture and Food Authority
Horticultural Crops Directorate



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

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

“Changing Farmers’ Mindset from “Grow and Sell” to **“Grow to Sell”**”

AVOCADO PRODUCTION

Presented to the County & AFA (HCD) Staff in charge of the
SHEP PLUS Model Farmer Groups during the FT-FaDDE

Prepared by SHEP PLUS

1. Introduction:

1.1 Background



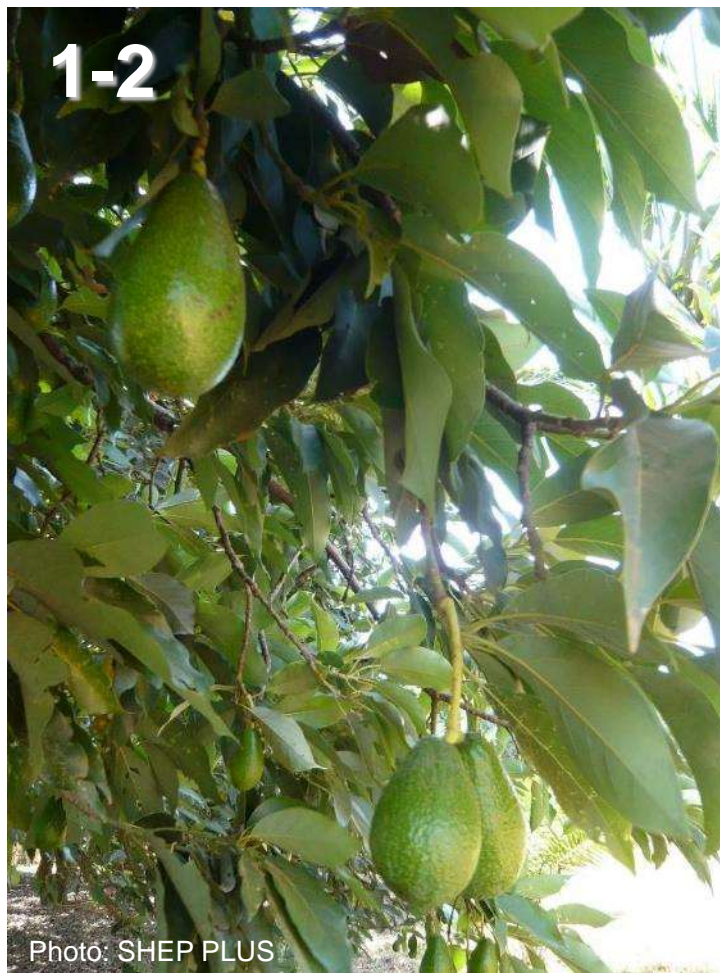
Avocado (Parachichi)

1. Introduction:

1.1 Background

- Avocado is a member of the ***Lauraceae*** family
- It is one of the most **important commercial fruits** in Kenya, for both local and export markets
- Mature fruits in Kenya are mostly available from **Mar. – Sep.** (small volumes **Oct. – Feb.**)
- It is eaten **raw (ripe)** and also flavors **soups, ice cream and milkshakes**
- It has **high protein, several minerals (Zinc & Selenium)** and **Vitamins (A, C & E)**
- Avocado oil is easily digestible, largely unsaturated and has low sugar content

1.2 Common Varieties



'Fuerte'

1.2 Common Varieties

“Fuerte”

- Fuerte is one of the major varieties in export markets
- The tree is **broad, very productive** and susceptible to both **Anthracnose** and **Scab**
- **Pear-shaped fruit with medium seed**
- **Weight: 140 – 395 g per fruit**
- **Smooth thin green skin**
- **Skin remains green** when fruits are mature
- **Creamy, pale green flesh**

1.2 Common Varieties Cont'



'Hass'

1.2 Common Varieties Cont'

'Hass'

- The tree grows **tall** and requires **cutting back**
- Distinctive for its skin that turns from **green to purplish-black** when fruits are mature
- **Oval-shaped fruit** with **small to medium seed**
- Easy peeling
- **Great taste**
- Outstanding shelf-life and shipping characteristics
- One of the longest harvesting seasons

1.2 Common Varieties Cont'

Other varieties grown in Kenya are:

'Pinkerton'

- Long, pear-shaped fruit with small seed
- Large fruit that weighs 225 – 510 g per fruit
- Medium thick green skin with slight pebbling
- Green skin deepens in color as it ripens
- Excellent peeling
- Creamy, pale green flesh



Photo: © Farmanac
<https://www.flickr.com/photos/farmanac/5693686935>

“Pinkerton”

1.2 Common Varieties Cont'

'Reed'

- **Round fruit with medium seed**
- **Medium to large fruits with the weight of 225 – 510 g per fruit**
- **Thick green skin with slight pebbling**
- **Skin remains green** when fruits are mature
- Easy peeling
- **Creamy flesh with good taste**



Picture: sandid on Pixabay

“Reed”

1.2 Common Varieties Cont'

'Puebla'

- **Small compact fruits** resembling "Hass"
- Skin of ripe fruit is **black, thin** and **smooth**
- Fruit has a **velvety flesh** with **nutty aroma** and a **rich butter taste**

Other varieties:

Linda, Ettinger, Simmonds, Lyon, Tonnage, Zutano, Hardy, Teague etc.

Note: Cultivars used as **rootstocks** are **"Puebla"** or **"Local varieties"**

1.3 Optimal Ecological Requirements

Altitude	1,200 – 2,200 metres above sea level
Rainfall	1,000 – 1,200 mm of rainfall annually
Growing Temperature	25 – 30 °C
Soils	<ul style="list-style-type: none">• Deep, fertile well aerated, particularly sandy or alluvial loams• pH range 5 – 7

2. G20 technologies

➤ Make sure to support farmers carry out G20 techniques for any crop

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

2. G20 technologies

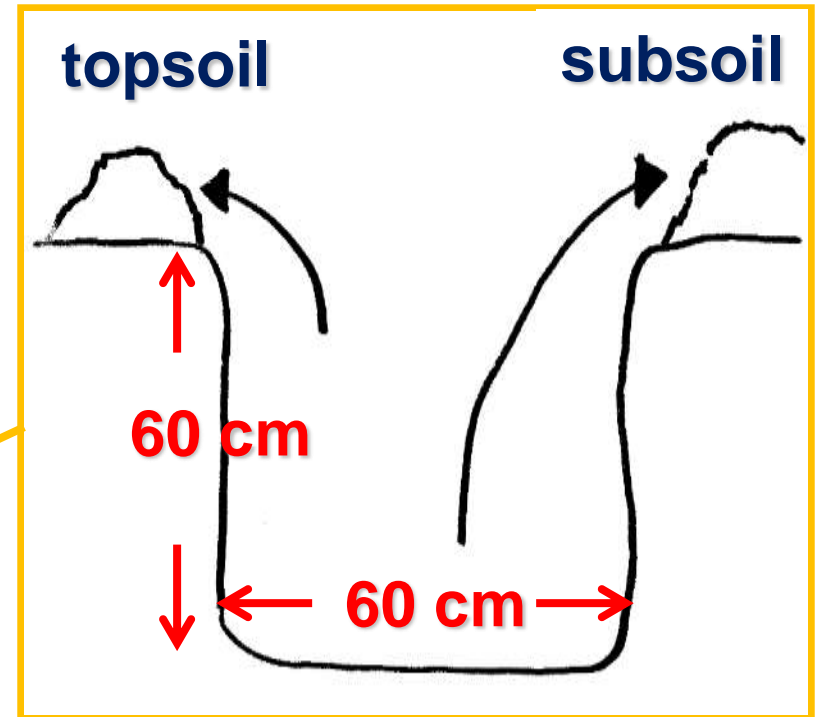
10. Recommended spacing
11. Recommended fertilizer application rate
12. Supplementing water
13. Timely weeding
14. Top-dressing
15. IPM practices
16. Safe and effective use of pesticides
17. Use of harvesting indices
18. Appropriate post harvest handling containers
19. Value addition techniques
20. Keeping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

3.1 Composting

(GHCP&PHHT20: Q4)

- Based on the results of the soil analysis, prepare adequate compost for application
- The recommended rate of application is **4 tons per acre** for Avocado

3.2 Land Preparation



A Group Facilitator demonstrating how to prepare planting holes

Size of Planting Hole

3.2 Land Preparation

(GHCP&PHHT20: Q6)

3.2.1 Ploughing

- Soils should be ploughed sufficiently to eliminate **debris** and **clods**
- Plough to **a fine tilth**
- Avoid field operations when it is wet to avoid soil compaction and hard pans which affect proper root development.
- It is recommended to have the land ploughed at least **2 – 3 months** before transplanting

3.2 Land Preparation Cont'

3.2.2 Recommended Spacing (GHCP&PHHT20: Q10)

- **Spacing:** The usual spacing is **6-9m x 7-10m** depending on growth characteristic of the individual variety and the type of soil, fertility status, agro-ecological conditions and agronomic practices
- **Hole Size: 60 cm x 60 cm x 50 cm**
- **Plant population: 44-92 trees per acre**

3.2.3 Basal Application (GHCP&PHHT20: Q8)

- During the preparation of planting holes, **manure/compost** and **basal fertilizer** are applied to allow the soils to settle and establish

3.2 Land Preparation Cont'

Application Method:

- The **topsoil** and the **subsoil** are separated
- Topsoil is mixed with **one debe (20 kg per hole = 4 tons per acre)** of **well decomposed manure** and **250 g** of either **Triple Super Phosphate** or **rock phosphate** in the planting hole before refilling

3.3 Raising Seedlings



Make sure to buy seedlings from certified nurseries

3.3 Raising Seedlings

(GHCP&PHHT20: Q9)

3.3.1 Nursery Site Selection:

- Nearness to quality water source
- Good drainage
- Security (Animals, thieves etc.)
- Accessibility to the road
- Availability of wind breaks (Casuarina, Grevillea etc.)

3.3.2 Nursery Establishment:

- Prepare a seedbed of **width 1 m** and a desirable length by removing farm soil from the seedbed to a **depth of 30 cm** and refill the **30 cm depression** with sand

3.3 Raising Seedlings Cont'

3.3.3 Seed Preparation:

- Collect seed only from **healthy and vigorous mother trees** and from fruits which are **mature and healthy** rather than from off the ground
- Average to **large-sized seeds** generally produces vigorous seedlings
- Cultivars used as **rootstocks** are “**Puebla**” or “**Local varieties**”, **Fuerte** is not resistant to **Phytophthora** (Duvenhage & Köhne, 1997)

3.3 Raising Seedlings Cont'

3.3.3 Seed Preparation Cont':

- Extracted seeds should be treated in **hot water** (not exceeding 50 °C) **for 30 minutes** then coated or dipped in a broad spectrum fungicide (e.g. **Metalaxyl**) to prevent infection with **Phytophthora cinnamoni**

3.3.4 Sowing Seeds:

- Seeds are planted with the flat basal end pointing downwards either in **nursery beds** or directly into **eco-bags**, about **20 cm in diameter** and **30 cm deep**

3.3 Raising Seedlings Cont'

3.3.5 Transplanting

Appropriate Time:

- **After germination** (takes about **20 days**), when approximately **20 cm high** and having developed **two pairs of leaves**, the open-seeded seedlings (in nursery beds) are uprooted and transplanted into containers

Preparation:

- **Potting media:** medium texture, sterilized if possible and with good drainage properties

3.3 Raising Seedlings Cont'

Nursery Management

- Nurseries should be sited away from Pineapple fields as this is a source of ***Phytophthora cinnamoni*** infection
- Avoid formation of hard pans on the potted plant by regularly pricking the soil with a sharp stick
- Scout regularly for pests and diseases
 - **Common Pests:** Aphids, White Flies, Cut worms and leaf miners
 - **Common Diseases:** Powdery Mildew and Damping-off in case of excess watering

3.3 Raising Seedlings Cont'



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

Grafting an avocado seedlings

3.3 Raising Seedlings Cont'

3.3.6 Grafting

- The rootstocks is ready for grafting **6 months after transplanting into biodegradable containers (6 X 9 Inches)**
- The rootstocks are grafted using scions of **desired variety**
- **4 to 6 months later**, the seedlings are ready for transplanting into the field and should be well healed and free from pests and diseased

Notes: All commercial nurseries **MUST** be registered and licensed by HCD & KEPHIS

3.4 Transplanting

3.4.1 Appropriate Time:

- Trees should be planted **at the beginning of the seasonal rainfall** and as soon as the rain has deeply penetrated the ground
- Trees planted at this time of the year have a full growing period ahead to establish themselves before the next dry season

3.4.2 Transplanting:

- The potted plants are **carefully removed from their eco-bags** in such a way that the soil around the roots is not disturbed

3.4 Transplanting Cont'

3.4.2 Transplanting Cont':

- The plant is placed into the planting hole
- **Topsoil mixtures filled** into the hole **first**, followed by the **subsoil** and firming down
- Never plant an Avocado tree **deeper than the soil level** it was in while in the eco-bag
- After transplanting, the leftover soil is used to build **a basin around each tree** in order to collect water from rain or irrigation
- Transplants **must be watered regularly** until they are established

3.5 Water Requirement

(GHCP&PHHT20: Q12)

- Avocadoes have large soft leaves and evaporate a lot of water in warm weather, so they **need regular watering**
- Irrigation is required incase of insufficient rainfall, especially during **flowering** and **fruit setting**
- In Kenya, most established Avocado trees are rain-fed and receive their water needs without additional irrigation
- The most crucial period when additional irrigation water may be required is **around mid-January until April** (the beginning of the long rains)

3.6 Top-dressing

(GHCP&PHHT20: Q14)

Fertilizer requirement per avocado tree

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

Application Methods:

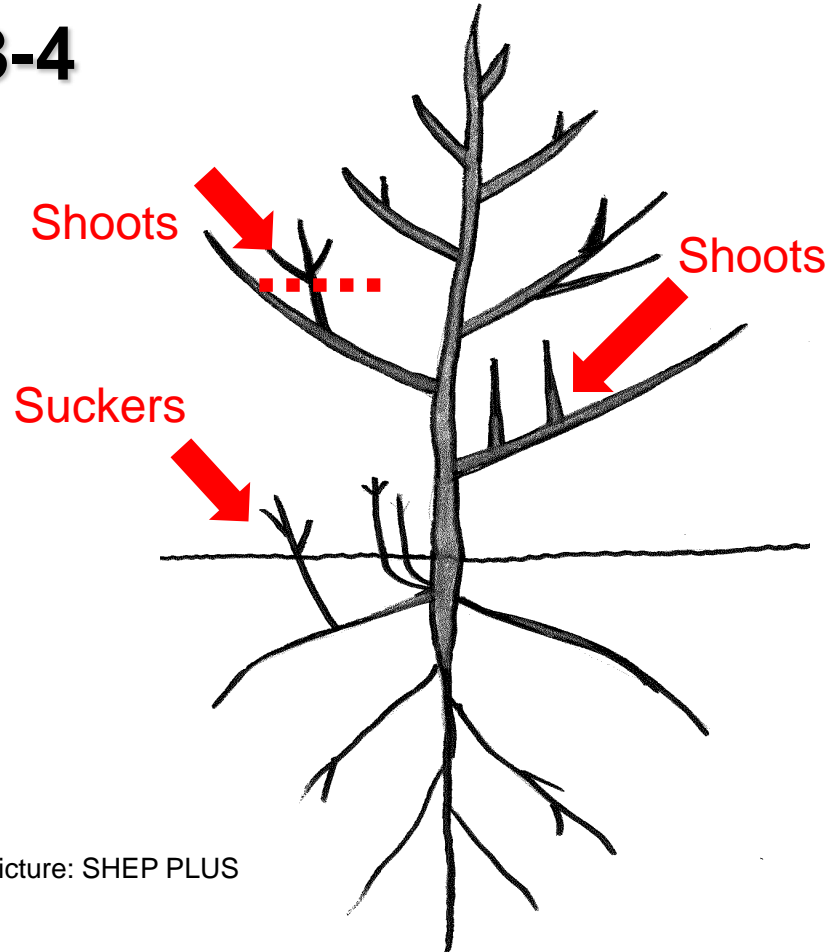
source: Avocado Cultivation, 2018 KALRO

- Apply fertilizer and manure **around the tree canopy** at the beginning of the rains
- Incorporate well in the soil

3.7 Crop Management:

3.7.1 Pruning & Training

3-4



Picture: SHEP PLUS

Prune off suckers & terminal shoots

3.7 Crop Management:

3.7.1 Pruning & Training

- Formative pruning is important to encourage **lateral growth** and **multiple framework branching**
- In order to reinforce this shaping of the tree, remove **all sucker growth** originating from below the graft union
- Cut back **shoots** or pinch out **the terminal buds of shoots** growing straight up
- Training involves **creating a strong central shoot** from which extend spaced side branches at the desired height and **the creation of a bare main trunk about 70cm in height**

3.7 Crop Management:

3.7.1 Pruning & Training Cont'

Notes:

- **Excessive pruning of a young tree** will delay the productive phase
- In later years, pruning is mainly undertaken to influence the **size, quality** and **quantity of the fruits**
- The best time to prune is **during the dormant season**
- This is also the best moment for the frequently required rejuvenation pruning aimed at bringing declining/neglected trees back to full productivity

3.8 Pests & Diseases Control:

(GHCP&PHHT20: Q15 & 16)

3.8.1 Major Pests

- The following are the major pests of Avocado in Kenya:
 - A. False codling moth**
 - B. Thrips**
 - C. Scales**
 - D. Fruit flies**

3.8.1.A: False Codling Moth



Caterpillar (left) & adult (right) of the False Codling Moth

3.8.1.A: False Codling Moth

Identification:

- Adult is a **small brownish, night-flying moth**
- Females lay eggs singly, **mostly on fruit**
- Larvae are **white to pinkish in color** with **brown to black head**

Symptoms:

- After emerging from the egg, the young larva **tunnels into the fruit**
- The larva feeds from inside the fruit with **frass** or **excrement** being produced at the entrance of larval tunnels

3.8.1.A: False Codling Moth Cont'

Control:

- Proper **orchard sanitation**
- **Infested fruits** (both on the tree and fallen) **should be removed regularly** (at least twice a week) and buried at least **50 cm** or dump in a drum filled with water mixed with a little used oil for **1 week**
- Use of **pheromone traps (FCM PRO CAPS)**

3.8.1.B: Thrips



Photo: Jack Clark, University of California - Davis, Bugwood.org (CC BY 3.0 US)



Photo: Mark S. Hoddle, University of California - Riverside, Bugwood.org (CC BY 3.0 US)

Avocado thrips

Damage of Thrips on a fruit

3.8.1.B: Thrips

Identification:

- Small slender insects **1 – 2 mm long** with two pairs of fringed wings
- Adult Thrips attacking Avocado are **dark brown** or **black**, and the immature stages are **yellow** in colour
- The **Red-banded Thrips** can be distinguished by a **bright red band** across the abdomen of immature Thrips
- Feeding is most common **on young fruit**
- **Older fruit with thicker skin** is less susceptible to attack

3.8.1.B: Thrips Cont'

Symptoms:

- Affected parts become **whitish** or **silvery** and are usually covered with **dark-coloured droppings**
- The infested plant tissues will turn **brown** and **dry up**, if the damage is too severe
- On fruit, feeding begins **near the calyx**, gradually producing **a scar** that can cover the whole fruit
- Attacked fruits develop **a leathery brown skin**

3.8.1.B: Thrips Cont'

Control:

- Conserve natural enemies: Thrips are attacked by **predatory Thrips, Lacewings** and **Predatory Bugs**
- If chemical control is considered, use products such as Lambda Cyhalothrin (eg. **Karate 2.5 WG®** PHI 3days)

3.8.1.C: Scales



Armoured Scales on a leaf (left) and fruit (right)

3.8.1.C: Scales

Identification:

- Scales are **small, stationary brown greenish insects** occasionally found sucking sap from Avocado leaves
- There are 2 types of scales: **soft** and **armoured scales** and both are protected by a shell

Symptoms:

- **Discoloration, malformation, leaf and fruit drop, and retarded growth**

3.8.1.C: Scales Cont'

Symptoms Cont':

- Damage is caused by **toxic saliva**, **extraction of plant sap** and **honeydew** in association with **sooty mould**
- A severe infestation forms a **continuous crust** over the underside of leaves

Control:

- **Chemical control:** Use of insecticide such as **Malathion** ((Dera Malathion DC®) PHI 14days)
- Conserve natural enemies such as parasitic wasps, ladybird beetles and lacewings, provided no broad-spectrum pesticides are used and no ants are present

3.8.1.D: Fruit Flies

Symptoms:

- Some fruit flies lay eggs under the skin of the fruit that is just beginning to ripen, but others attack young and old fruit
- 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**
- As the fruit develops, the lesion becomes dry and turns into distinct **star-shaped crack** on the skin surface



Photo: (c) R. C. Copeland, icipe
<https://www.infonet-biovision.org/PlantHealth/Crops/Avocados>

A fruit fly adult

3.8.1.D: Fruit Flies

Control:

- Practise orchard sanitation.
- Practise monitoring.
- Trap flies using commercial pheromone traps - Methyl Euginol (Bactrolure liquid) at 20 traps per acre.
- Remove infested fruits (e.g. those with dimples and oozing sap) twice a week and destroy by burying about 60cm deep

3.8.2 Major Diseases

- The following are the major diseases of Avocado in Kenya:
 - a. **Root Rot (Die Back)**
 - b. **Anthracnose**
 - c. **Cercospora Fruit Spot**
 - d. **Scab**

3.8.2.a: Root rot (Die back)



Symptom of die back on an avocado tree

3.8.2.a: Root Rot (Die back)

General Information:

- This is a **fungal disease**; *Phytophthora cinammomi*
- It is **the most serious disease** in nearly all Avocado producing areas of the world and in Kenya
- In areas subject to **flooding** and **in poorly drained soils**, trees of any age or size are likely to be infected by the fungus

Symptoms:

- Trees affected **lose vitality**, **become sparsely foliated** and do not produce a good crop

3.8.2.a: Root Rot (Die back)Cont'

Symptoms Cont':

- Leaves are **pale-green** and **wilted**, branches usually become **sunburned** and **die** back in advanced stages
- Feeder roots get **darkened** and **decay** and trees will eventually die prematurely
- The fungus can be spread or introduced to new areas by **infested planting material, soil** and **irrigation water**

3.8.2.a: Root Rot Cont'

Control:

- Uprooting of **affected trees**
- **Hot water** and **fungicide treatment of seeds** for propagation
- Grafting on **Phytophthora-tolerant** and/or **resistant rootstocks**

3.8.2.b: Anthracnose

3-12



Photo: © A.A. Seif, icipe
<http://www.infonet-biovision.org/PlantHealth/Crops/Avocados>

Anthracnose on Avocado fruit

3.8.2.b: Anthracnose

General Information:

- This is a **fungal disease**
- It is important **only in fruits**, where it is the most serious disease affecting the Avocado

Symptoms:

- **Dry spots, dark brown in color**, form on the skin, leading to **abnormal development**
- In severe attacks, **the young fruits drop**
- It is mostly a **post-harvest disease** as the fruits are more susceptible when mature

3.8.2.b: Anthracnose Cont'

Control:

- **Orchard sanitation**
- **Fungicides** are normally used to control the disease besides other chemicals such as: Mancozeb (Dithane M-45 WP®) and Propineb (MILRAZ WP 76®) among others

3.8.2.c: Cercospora Fruit Spot

3-13



Photo: © A.A. Seif, icipe
<http://www.infonet-biovision.org/PlantHealth/Crops/Avocados>

**Avocado fruit showing a lesion caused
by Cercospora**

3.8.2.c: Cercospora Fruit Spot

General Information:

- This is a **fungal disease**
- It is **another important fruit disease** impairing the quality of the Avocado
- The severity of infection varies from season to season and can cause **losses of up to 60 %**

Symptoms:

- **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**
- **Mature fruits are resistant**

3.8.2.c: Cercospora Fruit Spot Cont'

Symptoms Cont':

- The disease development is favoured by **humid conditions** and **high temperatures**
- The fungus is essentially spread by **water splash** and its spores are also **wind-borne**

Control:

- **Orchard sanitation**
- **Fungicides** are normally used to control the disease besides other chemicals such as: Propineb (**MILRAZ WP 76®**)

3.8.2.d: Scab



Scab on a Avocado fruit

3.8.2.d: Scab

General Information:

- Scab is a **fungal disease**
- It is **common in humid areas**
- The fungus readily infects **young, succulent tissues of the leaves, twigs and fruits**

Symptoms:

- Lesions appear as **small dark spots** slightly raised, oval to elongated
- These coalesce, giving a corky appearance to the surface of the fruits-impairing the appearance **but not the internal quality of the fruit**

3.8.2.d: Scab Cont'

Control:

- **Orchard sanitation:** remove dead branches and twigs since they harbour the fungus
- Also remove **fallen rotten fruits** from the field
- **Fungicides** are normally used to control the disease besides other chemicals such as Mancozeb (DITHANE M-45®) at **pre-flowering, fruit formation, and after harvest**

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Maturity Period: 3 – 4 years** after transplanting into the field (grafted plants)

Maturity:

- Since Avocados do not soften on the trees, it is not easy to identify the right harvesting period. Some indicators of maturity include:
 - **Dark varieties:** a change in colour from **green to black or purple**
 - **Green varieties:** the fruit stems turn **yellow**, the skin may appear **less shiny**, or the end develops **rust-like spots**
 - Some varieties develop a **whitish appearance**

4. Harvest Cont'

Methods of Determining Fruits Maturity:

- **Floating Test:**

- Fruits that float on the surface when immersed into water are usually mature
- Immature Avocados **sink** or **float below the surface.**

- **Another Method:**

- Pick a few fruits when they are apparently mature
- Leave them to ripen in a warm place
- If these soften without shriveling within a week at room temperature (about 20 °C), then the crop is ready for picking

4. Harvest Cont'

Harvesting:

- The main harvesting season of Avocados in Kenya is from **March to September**
- Assessment of the correct harvesting time is important because it directly affects **fruit quality, storage and shelf life**
- Harvesting should be done **early in the morning** or **late in the afternoon** when it is cool

Harvesting Methods:

- **Clip fruits** from trees with secateurs leaving a short stem portion of **about 0.5 cm** on the fruit
- Fruits should not be pulled off the tree as this may **damage the skin** and **allow decay diseases to enter**

4. Harvest Cont'

Harvesting Methods Cont':

- For picking fruits growing high on a tree, use **ladders** or a specially designed **picking tool**

Notes:

- Recommend to use **cotton gloves** during picking, grading and packing
- The fruits should not be dropped but placed carefully in **collection bags** or **field boxes**
- Collection bags must be emptied carefully, with each fruit being removed individually

Yields:

- **3.2 – 4.0 tons per acre per year (250 – 300 kg per tree per year)** from the 5th year

5. Post-Harvest Handling



Avocados in a packhouse

5. Post-Harvest Handling

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

- The **plastic** or **wooden containers** must be padded to prevent **damaging the skin of fruits** as this can result into infections
- Store the field boxes in the shade in order to minimize **sunburn**, **loss of moisture** and **dust accumulation**

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

- **Sorting:** Remove **all the field debris** including **misshaped**, **diseased** and **bruised fruit**
- **Cleaning:** Use **cold, clean water** to remove any dirt found on the fruits

5. Post-Harvest Handling Cont'

- **Pre-cooling:** Fruits must be cooled **as quickly as possible**. “**Fuerte**” and “**Hass**” must be cooled to **5 °C – 7 °C** within five hours of harvesting
- **Grading:** Fruits are graded according to **size** and **stage of ripening**. For the export market, the size grades are coded as shown in the next slide.

5. Post-Harvest Handling

Cont'

Size Code*	g/fruit	Size Code*	g/fruit
4	781 – 1,222	14	266 – 305
6	576 – 780	16	236 – 265
8	461 – 575	18	211 – 235
10	366 – 460	20	191 – 210
12	306 – 365	22	171 – 190

* No. of fruits per 4 kg carton

5. Post-Harvest Handling Cont'



**Avocados packed into a box for the
export market**

5. Post-Harvest Handling Cont'

5.3 Storage

- Avocado fruits can be stored at **temperatures of 5 °C – 7 °C** and a **relative humidity of 85 % – 95 %** for three to four weeks

5.4 Packaging

- Fresh Avocado fruits are packed in cartons made of **solid** or **corrugated fiberboard**
- They should be packed **in a single layer**
- The boxes must have adequate ventilation, holes, for **effective cooling** and **air circulation**

5. Post-Harvest Handling Cont'

5.5 Transportation

- Avocado fruits **must be packed firmly in place** and should not roll around or rub against one another in transport vehicle
- Boxes must not be shaken during loading and offloading and must be **securely stacked in the container**, preferably on pallets, **throughout transportation**
- Covered vehicles should be used: **insulated** or **refrigerated trucks** are recommended

5. Post-Harvest Handling Cont'

5.6 Processing

- Generally, Avocado is served raw (ripe), though it can be processed into **juices, shakes, ice creams, dips, pastes and purees**
- **Avocado oil** is also famous as a cooking oil



5-3

Photo:
<https://www.flickr.com/photos/avlyz/36401909675> (CC BY-NC 2.0)



5-4

Photo: By Suzette - www.suzette.nu from Arnhem, Netherlands - salade-avocado-ui, CC BY 2.0,
<https://commons.wikimedia.org/w/index.php?curid=35714778>



5-5

Photo:
<https://www.flickr.com/photos/48076930@N02/12326875374/>
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Reference

- The proposed agrochemicals are in accordance with “Products Registered for Use on Crops Version 1_2018” by Pest Control Products Board. The registered agrochemicals are subject to change. Please refer to the latest registered agrochemicals by Pest Control Product Board.
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THANK YOU

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