Instituto de Hortofruticultura Subtropical y Mediterránea

SUSTAINABLE PRODUCTION OF AVOCADO

DECEMBER 2025

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FOREWORD

This manual is about sustainable production of avocado, taking into consideration both the supply and value chains.

Tanzania's avocado industry is steadily growing, with the *Hass* variety taking the market lead.

Despite this growth potential, several challenges affect yield and quality and hinder access to international markets.

These challenges can be addressed by following good agricultural practices to attain international standards.

Unfortunately, this knowledge is lacking among Tanzanian farmers.

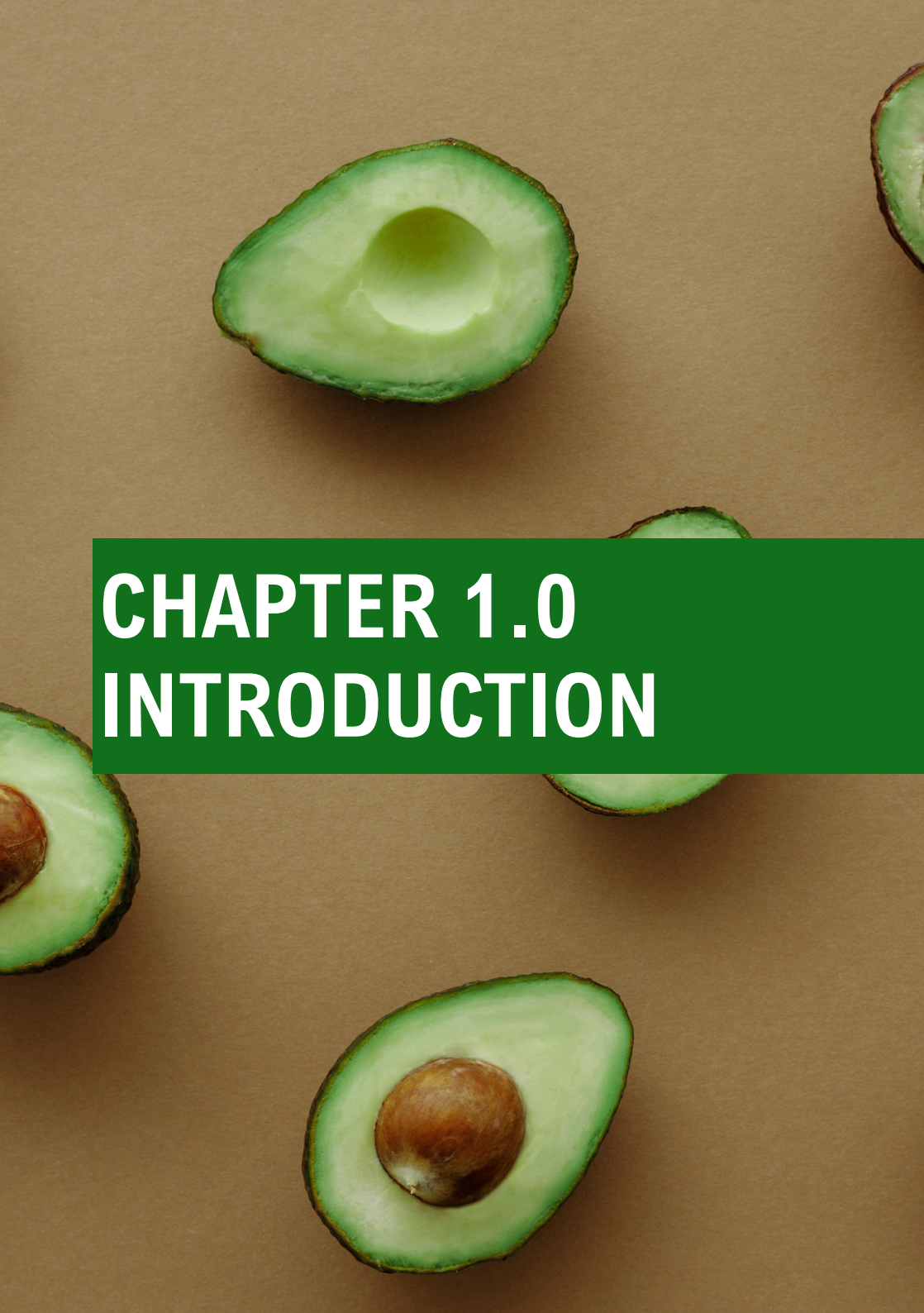
To address this gap, the partnership with different NGOs such as Assisting Small Farmers (ASF), Agronomos Sin Froteras (ASF) and MKULiMa LIFE organizations, in collaboration with the Sokoine University of Agriculture (SUA), developed this comprehensive guide for quality avocado production.

This guide covers a range of activities from seed selection to fruit grading.

The aim is to increase yield, to improve quality, and enhance access of Tanzanian avocados to international markets.

We hope that Tanzanian farmers will use this guide effectively for the sustainable production of quality avocado fruits.

The ultimate goal of the guide is to improve the livelihoods of farmers and to contribute to this sub-sector in the national economy.



CHAPTER 1.0
INTRODUCTION

Avocado is believed to have originated from a broad geographical region stretching from the eastern and central highlands of Mexico, through Guatemala, to the Pacific coast of Central America.

Tanzania ranks 21st worldwide in avocado exports, representing about 0.2% of the world's exports.

Tanzania's avocado export market by 78% between 2014 to 2018. For instance, in 2018, Tanzania exported about 7,551 tons of avocados valued at US$ 8.5 million.

The main export variety is *Hass*. Other varieties such as *Fuerte* and *Pinkerton* are also produced for international markets, although at a smaller scale.

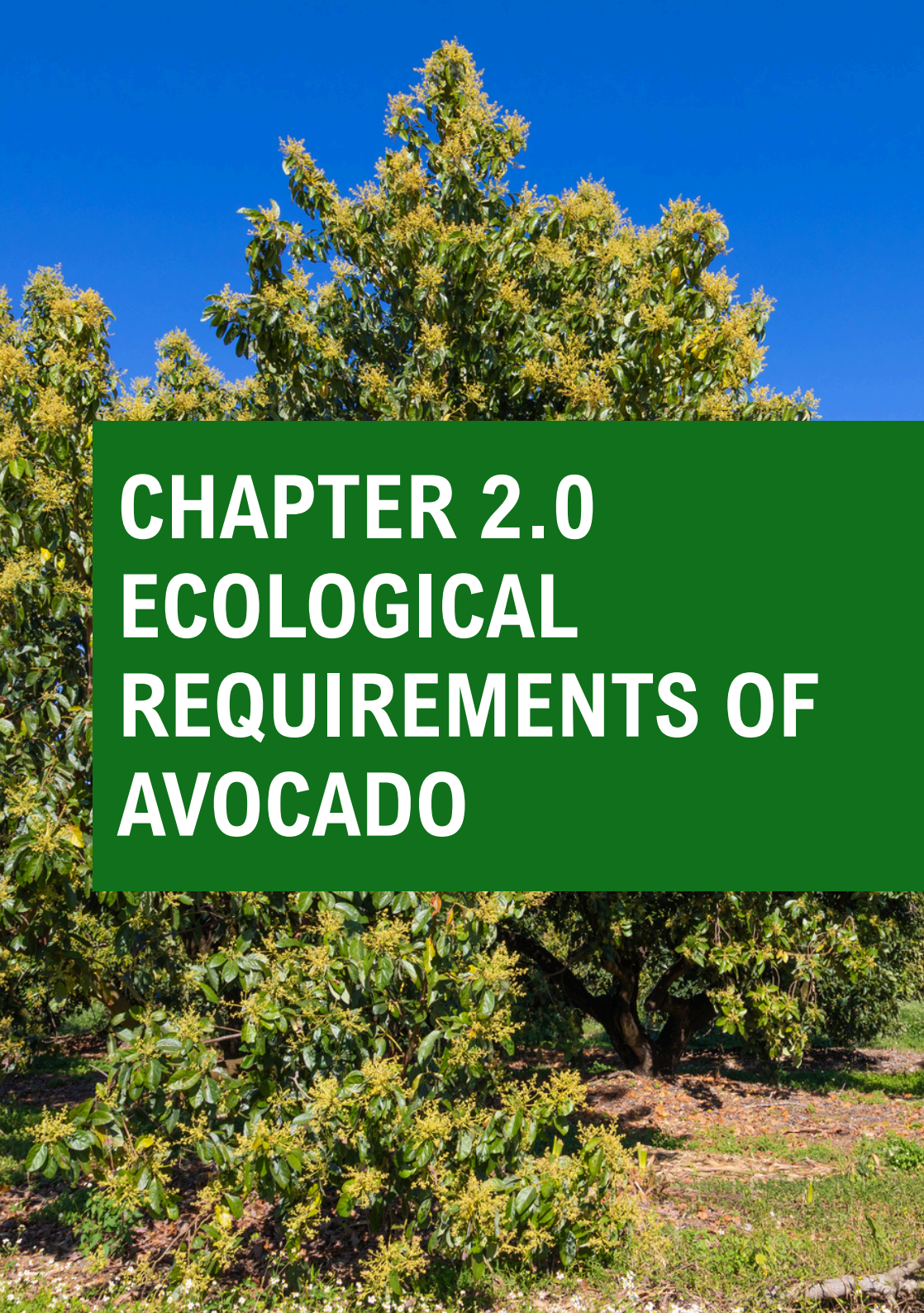
There are numerous varieties destined for local markets. The main producing regions are Kilimanjaro, Mbeya, Njombe, Kigoma, Songwe, Tanga and Morogoro.

Avocado is an important crop worldwide. The fruit is rich in healthy fats, vitamins, minerals and fiber.

Avocados can be eaten raw or, most commonly, as a topping for salads.

They are an important ingredient of processed foods such as guacamole, ice cream, or milkshakes.

Avocados are also used as raw materials in various products, such as cosmetics.



CHAPTER 2.0 ECOLOGICAL REQUIREMENTS OF AVOCADO

2.1 Temperature, Altitude and Rainfall

The optimal temperature range is 15 – 30 °C, at altitudes between 800 and 2500 meters above sea level, with adequate water provided by rainfall or irrigation.

2.2 Sunlight

Avocado trees needs sufficient sunlight for optimum growth and fruit quality. Full exposure to the sun may affect the stem, primary branches, and fruits, leading to sunscalds.

2.4 Wind

Avocado trees are susceptible to strong winds, both hot and cold. Winds may inhibit pollination, fruit formation, and it may cause severe physical damage to branches, flowers, and fruits.

It is recommended to establish windbreaks atleast one year before planting avocados (Figure 1).

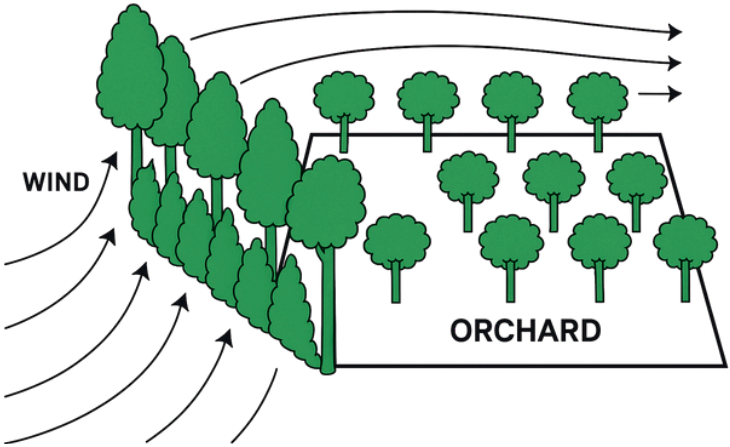
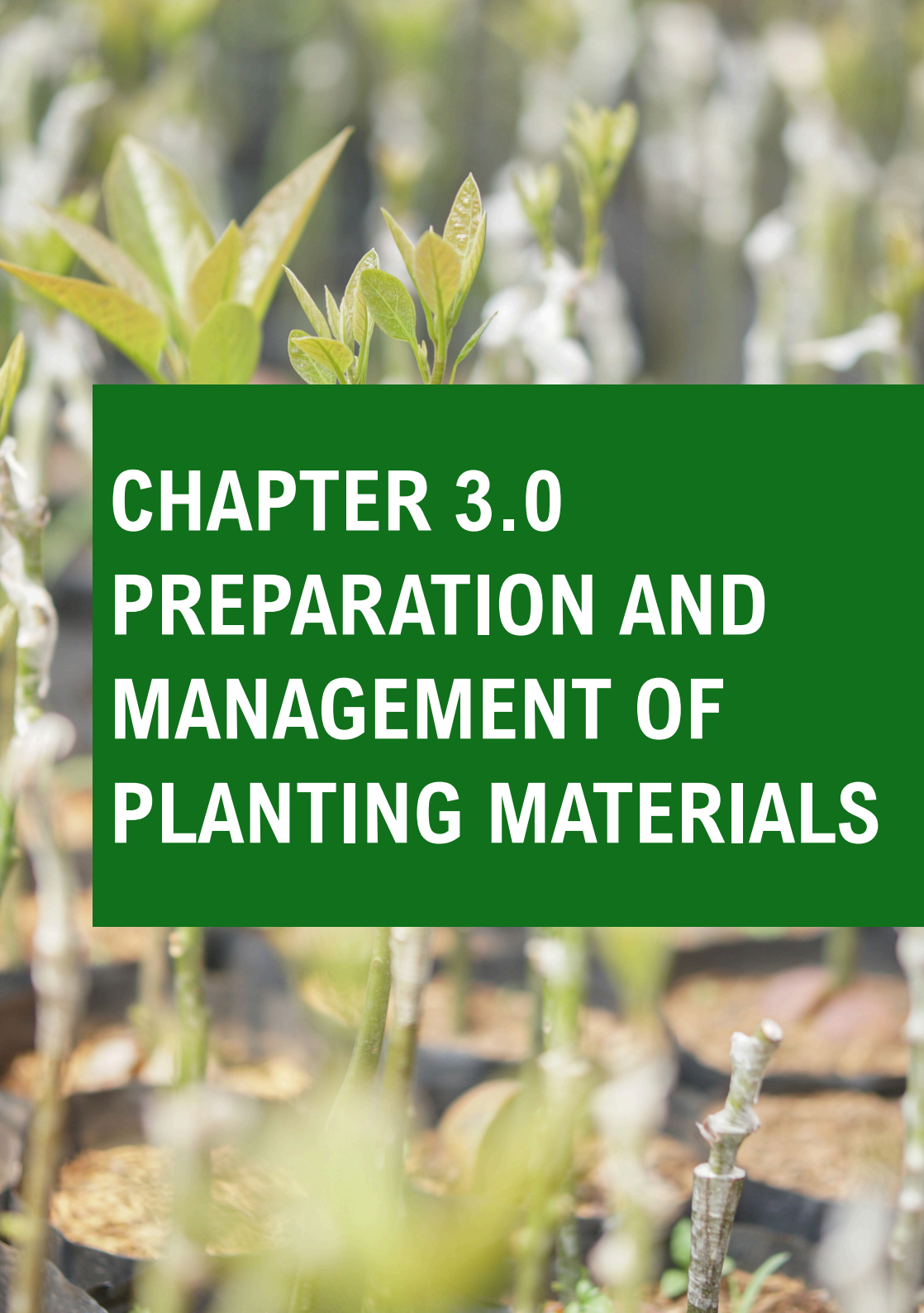


Figure 1: Trees planted around avocado orchard as windbreaks.

2.5 Soil Requirements

- Avocado grows well in soil characterized by features outlined in Table 1.
- A farmer is advised to use compost or manure to improve soil health.

Table 1: Ideal soils for growing avocados	
Texture	Loamy, sandy loam, clay sandy loamy
pH	5.5 - 7.0
Organic Matter (%)	2.5 – 5.0
Depth	0.8 – 1.5



CHAPTER 3.0 PREPARATION AND MANAGEMENT OF PLANTING MATERIALS

3.1 Field and Nursery Location

Select a site for an avocado nursery with the following characteristics:

- Access to a reliable source of water.
- Close to a reliable road.
- Free from key avocado pests and diseases,
- Good climatic and edaphic conditions to support optimal growth and development of avocado crops.
- Preferably close to markets/distribution channels.
- Avocado fields should be within reach of a pack-house facility, to ensure fruit quality and good storability.

Consider the following factors during the establishment of a new orchard:

- Avoid growing avocado in high saline, drought - prone, or waterlogged soils, as the crop is sensitive to such conditions.
- Select varieties or rootstocks with high tolerance to environmental conditions.

- Select varieties or rootstocks with high tolerance to environmental conditions.
- Grow Mexican or Guatemalan race varieties such as *Hass* and *Fuerte* in cold areas (1400 to 2700 m asl) and West Indian varieties in warm areas (100 to 500 m asl).
- Select varieties according to market demand. For the export market, consider fruit's resistance to transportation and extended storage.

3.2 Varieties and Characteristics of Good Planting Materials

Commercial avocado varieties grown in Tanzania include *Hass*, *Fuerte*, *Ettinger* and *X-Ikulu*.

The growth and reproductive characteristics of these varieties are explained in Table 2.

Table 2: Growth and development characteristics of commercial varieties of avocados grown in Tanzania		
Varieties	Plant and fruit characteristics	Appearance
Hass	Flower type: "A" Fruit: Medium – large (140g to 340g), pear-shaped (ovate), thick textured / rough or pebble skin turning dark green to dark purple when ripe. Flesh is creamy, nutty, Fat content 19% Fruit matures in 8 - 9 months Frost sensitive at < 0 °C. Height: up to 35m.	

Varieties	Plant and Fruit Characteristics	Appearance
Fuerte	Flower type: "B" Fruit: medium size (200 - 400g), slightly pebbled, pear-shaped, skin is thin, leathery, and easy-to-peel, remains green when ripe, oil content (18% to 26%) survive at low temperature (< - 2 °C). Mature in 6 - 8 months. Height: 6 to 10 meters, speading canopy of about 4m.	

Varieties	Plant and Fruit Characteristics	Appearance
Pinkerton	Flower type: "A" Fruit: Weighing 226 to 680g, oblong slender, pear-shaped, with moderately thick pebbled skin, easy to peel, and stays green as the fruit ripens. Can withstand temperature < - 2 °C Oil content not less than 20%. Height: Medium size but spreading canopy.	

Varieties	Plant and fruit characteristics	Appearance
Ettinger	Flower type: "B" Fruit: 225 to 453.5g. Fruit remains green when ripe, are oblong and larger than *Hass*. Can withstand temperature < - 2 °C Height: medium to large.	

50% of avocado varities produced in Tanzania are *Fuerte* followed by *Hass (30%).* Other varieties (20%) include: *Tano, X-Kubwa, Dulu, X-Ikulu, Tonnage, Mwaikokyesa, Gem, Bacon, Nabal, Pinkerton, Carmen, Ryan, Adranol, Reed, Puebla & Sharwil, Booth 7, Choquette, Weisal, Booth8, Duke, Duke6, Duke 7, lamb Hass, Zutano, Gem, Gem Hass, Muna, Dusa, Simmonds, Uyole 1* and *Uyole 2.*

3.3 Seedlings and Nursery Management

3.3.1 Production of Grafted Seedlings

- Commercial avocado production uses grafted seedlings to (i) shortening the time to bearing, (ii) enhancing adaptation of the seedlings to otherwise impossible-to-establish areas, e.g. due to soil-borne diseases/ pests or other soil stresses, and (iii) controlling the form of the plant for easy management.
- Use seedlings produced in a nursery certified by the official seed certification authority.

3.3.2 Media Preparation

- Prepare a potting medium by mixing forest soil, farmyard manure and rice husks in a 4:2:1, ratio.
- The ratios can vary depending on the soil fertility of a given area.
- Moisten the medium and fill it in polyethylene tubes of 15cm diameter and 20cm height.
- The size of the polyethylene tube may vary depending on the expected time that the seedlings will stay in the nursery.

3.3.3 Grafting

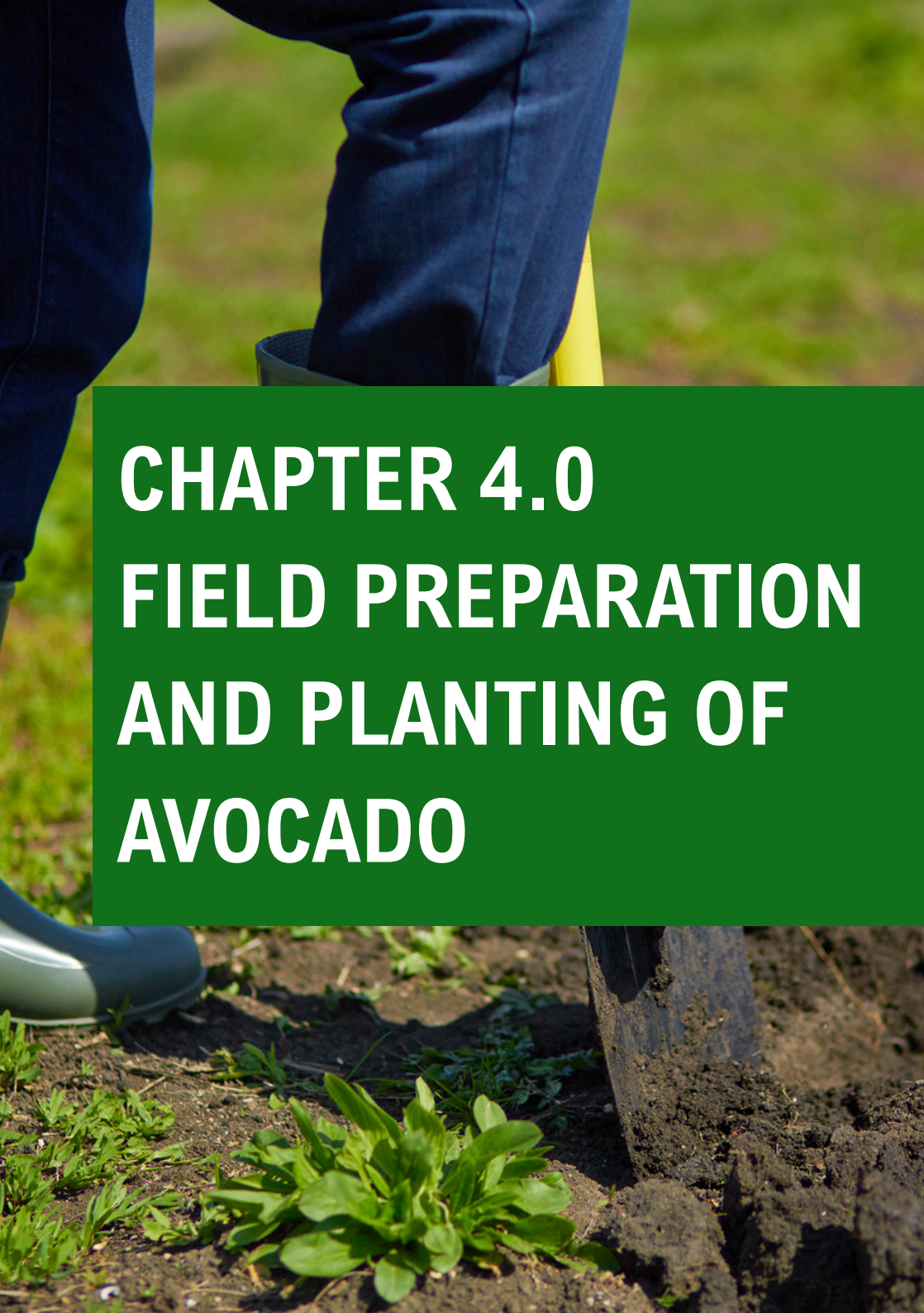
- Use suitable rootstocks, based on climatic and soil characteristics of the growing areas.
- Select seeds from well-mature fruits of a suitable variety for rootstocks.
- Plant seeds in the polytubes while maintaining polar and basal ends for easy germination.
  Irrigate seedlings
- Graft rootstocks after attaining a 0.6cm diameter and a height of 30cm from the soil.
- Select scion graft wood from a healthy mother plant (Figure 2) of the preferred variety at the dormant stage.
- Make a flat cut on the rootstock at 30cm from the ground, followed by a 2.5cm deep vertical cut at the top of the flat-cut rootstock (Figures 3(a) - 3(d)).

Figure 2: Selection of scion from mother plant.

- Make a wedge cut on both sides of a scion wood stick base and insert it while matching the hardwood and cambium/bark of the rootstock and scion (Figure 3c).
- Tie/seal the two pieces (rootstock and scion) using an elastic transparent plastic strip by wrapping from the bottom upward to prevent water entry and hold the parts together (Figure 3d).

Figure 3 (a – d): Stages of grafting avocado seedlings

- Keep grafted seedlings under shade and water them at least three times a week in the absence of rainfall.
- Scout and control any detected insect pests and disease pathogens.
- Spray foliar fertilizers when there are signs of macro and micronutrients deficiencies.
- Transplant seedlings at least a month after grafting.
- Arrange grafted seedlings in rows or groups of 1000 plants.
- Leave 1 m space between rows to facilitate nursery management and to allow the passage of light and air.



CHAPTER 4.0
FIELD PREPARATION AND PLANTING OF AVOCADO

4.1 LAND PREPARATION AND FIELD LAYOUT

4.1.1 Land Preparation

- Remove any tree stumps or large roots when establishing a new orchard to reduce the risk of spreading root rot disease.
- Avoid planting avocado trees in poorly drained areas.
- Plant avocado seedlings on ridges.
- Rip through any impervious soil layers or hardpans near the soil surface to ensure proper drainage.
- Install drains and grade soil surface to avoid waterlogging.
- Plant trees on raised soil berms or mounds (Figure 4).
- Prepare the subsurface layers before planting on raised soils to facilitate strong rooting and prevent waterlogging.

Figure 4: Planting trees on raised soil berms or mounds.

4.1.2 Soil Amendments before Planting

- Test the soil pH and adjust it to 5.5 to 6.5 using lime or dolomitic materials.
- Apply lime before the final cultivation to ensure that liming materials are well absorbed into the soil.
- Apply compost or manure to the soil during land preparation.

4.2 PLANTING

4.2.1 Timing

- In tropical regions, avocados can be planted at any time of the year, provided irrigation facilities are available.
- Plant avocado seedlings at the onset of the rainy season to minimize the need for frequent watering of the newly established plants.

4.2.2 Layout

- Plant trees in rows running from north to nouth to allow maximum sunlight exposure.
- Plant trees following the recommended spacing (see section 4.2.3).
- Adopt a rectangular layout where mechanization is anticipated (Figure 5).
- Leave sufficient space between rows (work rows) to allow movement of tractors and other agricultural machinery without damaging trees or roots.

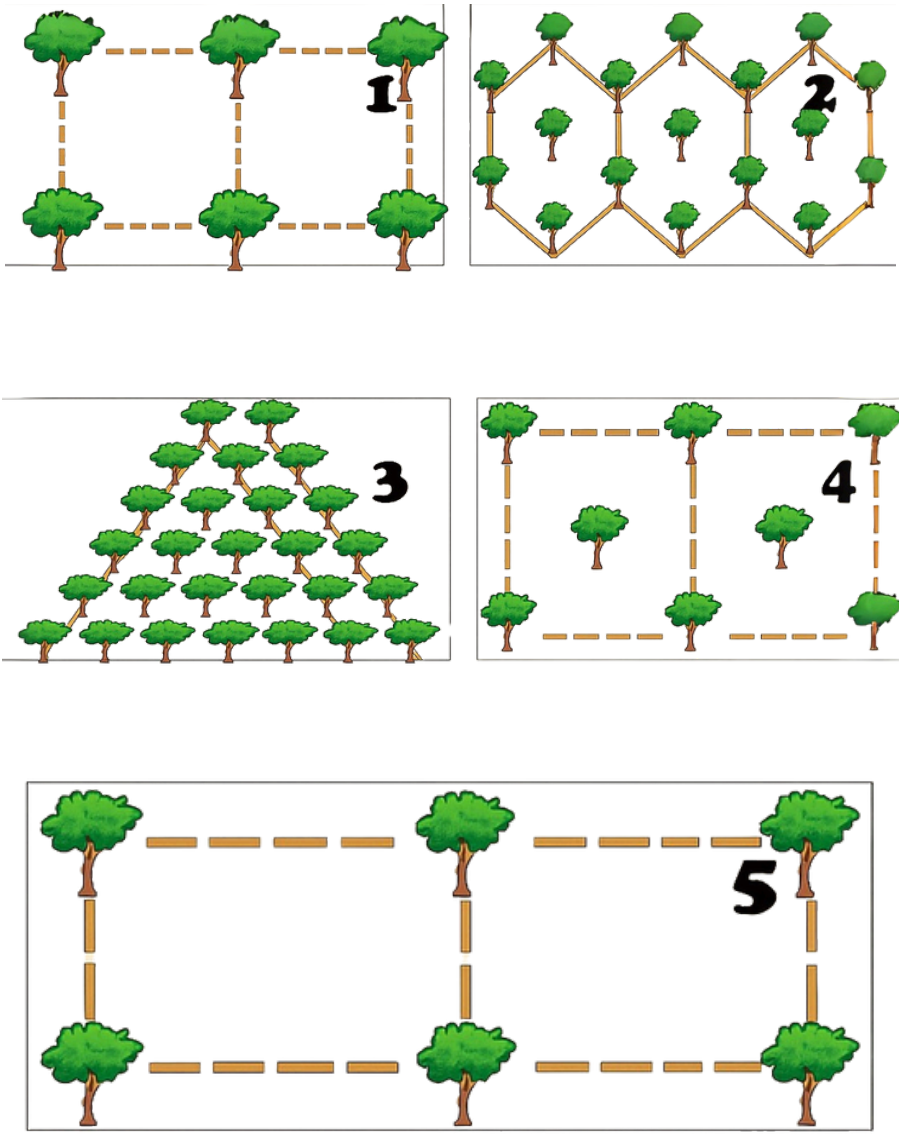
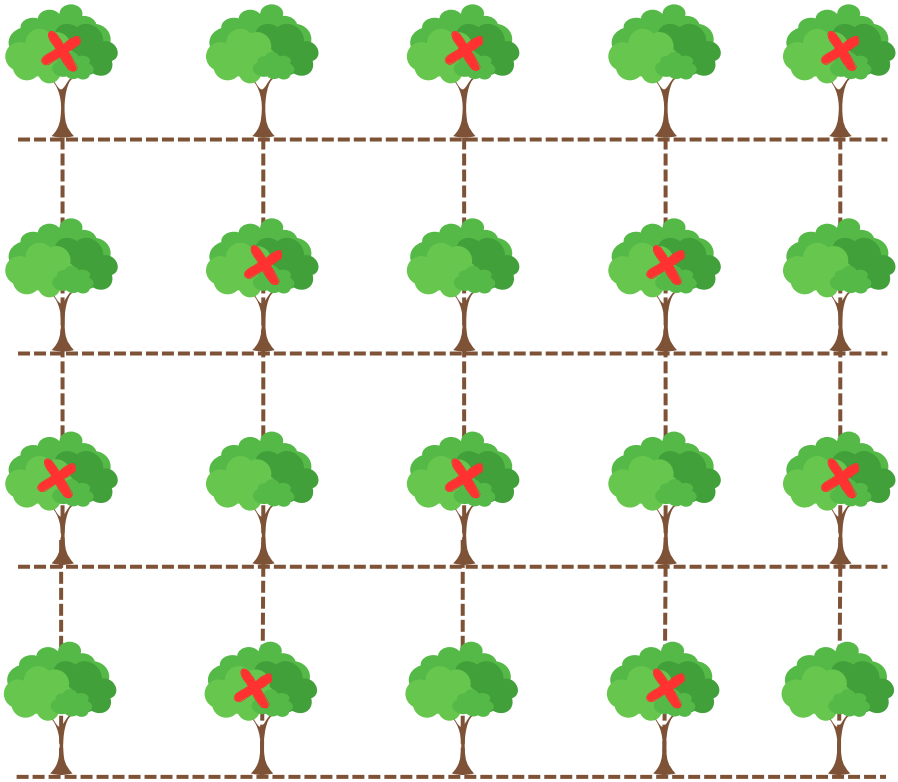


Figure 5: Layout of orchard, 1 - Square, 2 - Diagonal, 3 - Contour, 4 - Hexagonal and 5 - Rectangular systems

4.2.3 Density

- Plant trees at a spacing of 5 × 4 meters or 6 × 4 meters, which is equivalent to approximately 204 trees per acre.
- Remove every other tree (skip one after each removal) after approximately 8 years to achieve a density of 102 trees per acre, if necessary (see the figure below).



4.2.4 Planting Hole

- Dig planting holes measuring 60 × 60 × 60 cm (length × width × depth) a month before planting. Separate top and sub-soils (Figure 6).
- Mix top soil with 20 kg of decomposed farm yard manure (FYM) and 55g of phosphorus by using Double Superphosphate (46% P_2O_5) fertilizer or Triple Super Phosphate.
- Fill the hole by starting with the top soil mixed with the fertilizer and finishing with the subsoil.

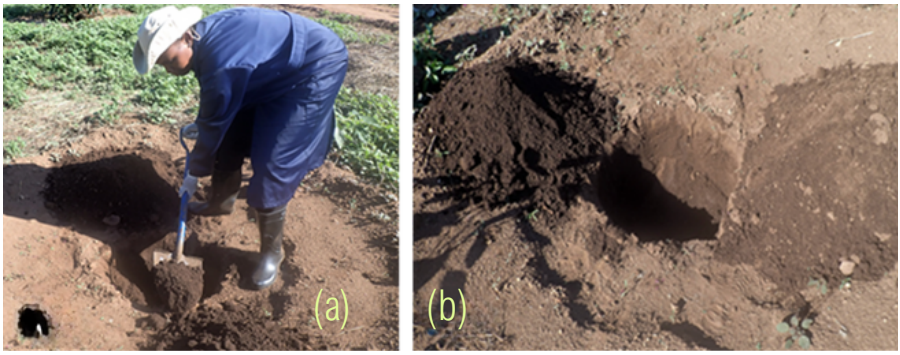


Figure 6: Digging holes for transplanting avocado seedlings

4.2.5 Planting

- Dig a hole at the center prepared pit to a depth of 20 - 25cm or equal to the height of the root ball. The width of the hole should be about 2 – 3 times the diameter of the pot or sleeve.
- Avoid lifting trees by their trunks to prevent damage to the scion.
- Carry one tree at a time, with one hand supporting the bottom of the seedling and the other hand holding the side of the root ball (Figure 7a).
- Place trees into the hole with the polythene sleeve intact to support the roots.
- Slit and remove the polythene sleeve once a seedling is positioned firmly on the ground (Figure 7b).
- Ensure that the trunk is slightly above the soil level (Figure 7c).
- Irrigate if it is not a rainy season.

Figure 7: Planting avocado seedlings.

4.3. Hedges / Wind-breaks

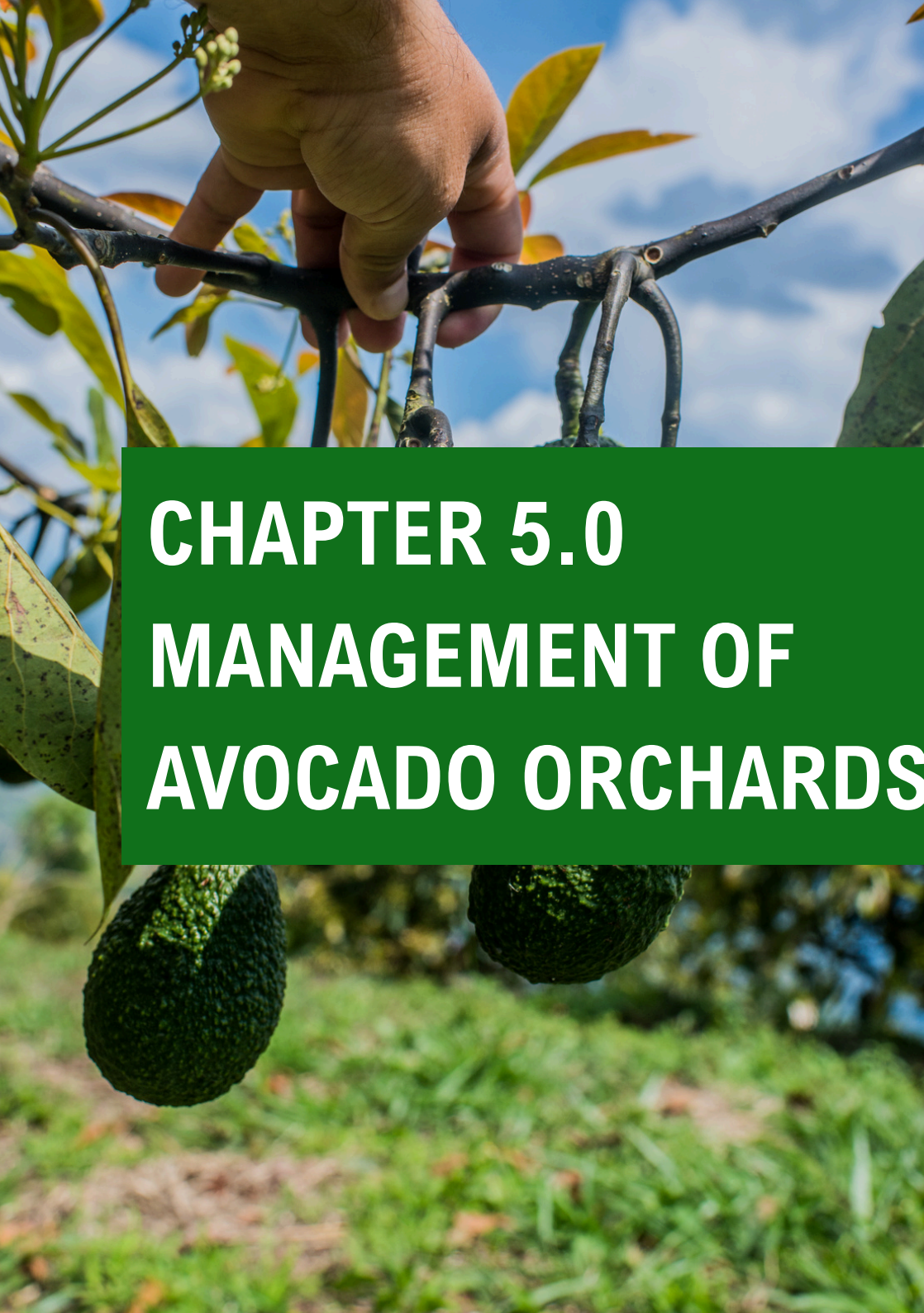
Prevent wind damage through the following:-

- Install the windbreaks to protect the orchard (refer to Figure 1).
- Choose natural windbreak species that pest and disease resistant, have non-invasive root systems, and are not hosts of pests and diseases.

- Avocado trees at the border/edge of the field should be planted closely to each other to serve as a windbreak and a source of pollen.

4.4 Early Care of the Trees

- Irrigate young trees Irrigate with water during the early growth stages for several weeks after transplanting to ensure survival and penetration of roots into the soil.
- Use stakes to support the young avocado plants in the orchard.
- Make stakes from wood, bamboo, or metal, depending on availability.
- Avoid tying young plants tightly to the stake.
- Tie the lowermost part of the trunk to the stakes, to avoid flopping over.



CHAPTER 5.0 MANAGEMENT OF AVOCADO ORCHARDS

5.1 Soil Fertility Management

- Avocado plants require adequate nutrients for proper growth and optimum performance.
- Deficiency of essential nutrients may lead to poor growth and reduced yields.
- Soil fertility can be maintained through the following:
  - Conduct soil analysis to determine nutrient requirements by consulting experts, for example TARI - Mlingano and Soil Science Laboratory at SUA.
  - Apply nutrients according to recommendations provided in Tables 3, 4 and 5.

Table 3: Nutritient requirements and recommended fertilizer amount after transplanting

Nitrogen (30 - 40 days after)	Phosphorus (30 - 40 days after	Nitrogen (180 days after)
15d of nitrogen per plant (45g /plant of Ammonium Nitrate	30g of P_2O_5 (65g / plant of Triple Superphosphate)	20g of nitrogen per plant (60g / plant of Ammonium Nitrate)

Table 4 : Nutrient requirements based on plants age				
Nutrients (Grams / Tree / Year)				
Cultivated Field Age (Year)	Ammonium Nitrate (33.5% N)	Triple Super Phosphate 46% (P_2O_5)	Potassium Chloride 60% (K_2O)	Calcium Ammonium Nitrate (CAN)
1 - 4	100 - 300	200 - 450	100 - 450	100 - 230
5 - 8	301 - 680	451 - 900	451 - 900	231 - 650
> 8	681-1400	901-1100	901-1400	651-1300

Table 5: Manure application plan	
Age of Tree (Year)	Manure or Compost (Kg/tree)
1 - 3	15
4 - 5	15
6 - 7	30
8 >	30

5.2 Macronutrient and Micronutrient Deficiencies

5.2.1 Nitrogen Deficiency

Deficiency symptoms include:

- Rapid yellowing of lower leaves, progressing upward to the top of the plant.
- Leaves become small, narrow, pale and slightly curved inward (Figure 8).
- Stunted growth with reduced fruit production.

Figure 8: Nitrogen deficiency.

5.2.2 Phosphorus Deficiency

Deficiency symptoms include:

- Reduced growth rate, reddening of stems, small dark green-blue leaves and yellowing or withering of lower leaves.
- Irregular, interveinal, necrotic spots on older leaves (Figure 9).

Figure 9: Phosphorus deficiency.

5.2.3 Potassium Deficiency

Deficiency symptoms include:

- Necrotic spots on the lower leaves, reddening of stems and blackening of vascular bundles in the fruit (Figure 10).
- Large irregular necrotic spots on older leaves followed by interveinal chlorosis and reduced fruit size.

Figure 10: Potassium deficiency.

5.2.4 Calcium Deficiency

Deficiency symptoms include:

- Leaf deformation, especially in highly leached acidic soils (pH 4.5).
- Interveinal yellowing and narrow dark-green strips along the veins.

5.2.5 Boron Deficiency

Deficiency symptoms include:

- Abortion and death of new flowers.
- Emergence of lateral branches that restrict apical growth.
- Small holes form in the interveinal areas surrounded by pale halos.
- Necrotic lesions on branches and trunk.
  Fruits developing bumps, sickle-shaped curvature, and sunken corky lesions (Figure 11).

Figure 11: Boron deficiency.

5.2.6 Zinc Deficiency

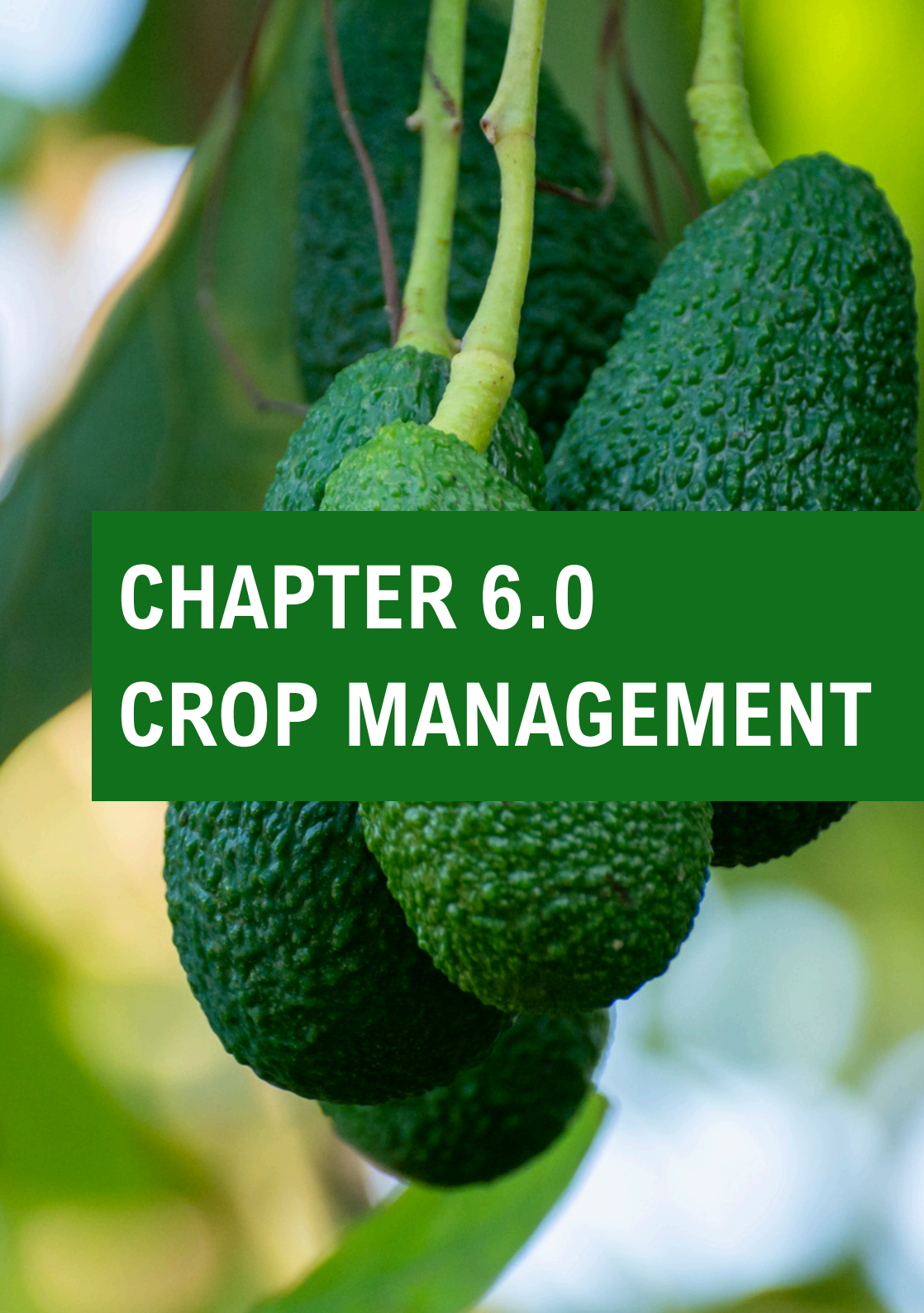
Deficiency symptoms include:

- Rounded fruits sometimes showing reddish discoloration.
- Small leaves, with shorterned internodes giving a "feather duster" appearance (Figure 12).

Figure 12: Zinc deficiency.

5.3 Soil Moisture Management

- Avocado trees have large, soft leaves that result in high evapotranspiration rates.
- Regular watering is therefore necessary to recover water loss.
- Ensure sufficient water availability through the following:
    - Irrigate young trees adequately especially during early growth stages.
    - Construct boreholes and dams to secure irrigation water.
    - Use drip irrigation or low-volume sprinklers for efficient water use.
    - Test irrigation water quality before use.
    - Apply mulch to reduce water loss and prevent soil erosion.



CHAPTER 6.0
CROP MANAGEMENT

6.1 Pruning

Avocados have large, soft leaves that cause higher evapotranspiration rates. Regular watering is therefore necessary to recover water loss. Ensure sufficient water availability through the following:

- Prune trees to expose flowers and fruits to air and light, improving yield and quality.
- Prune trees after harvest and before flowering.
- When pruning, maintain a single, clean trunk and allow branches to develop from approximately one meter above ground level to prevent interference with irrigation systems.
- Remove weaker vertical shoots.
- Cut back reduce the height if the tree exceeds the desired vertical limit.
- Prune old trees to a stump of about 1m high for effective management and to encourage regrowth.

6.2 Pollination

- Avocados have a specific flowering pattern that reduces the risk of self-pollination.
- There are two types of avocado varieties whose flowers are receptive at different times of the day (type A and and type B; Figure 13).
- For effective pollination, fertilization, and fruit set, plant type A and B varieties at a ratio of 1:9 as shown in Figure 13.

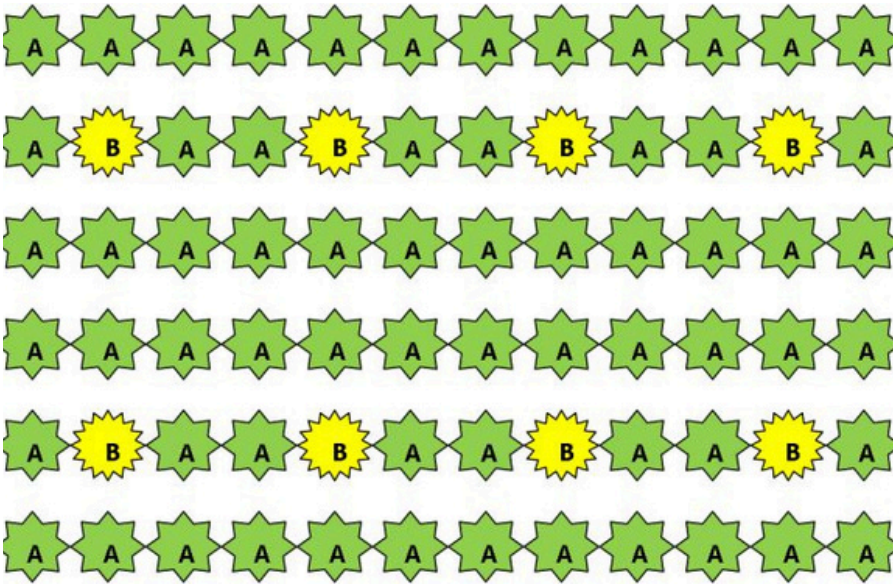


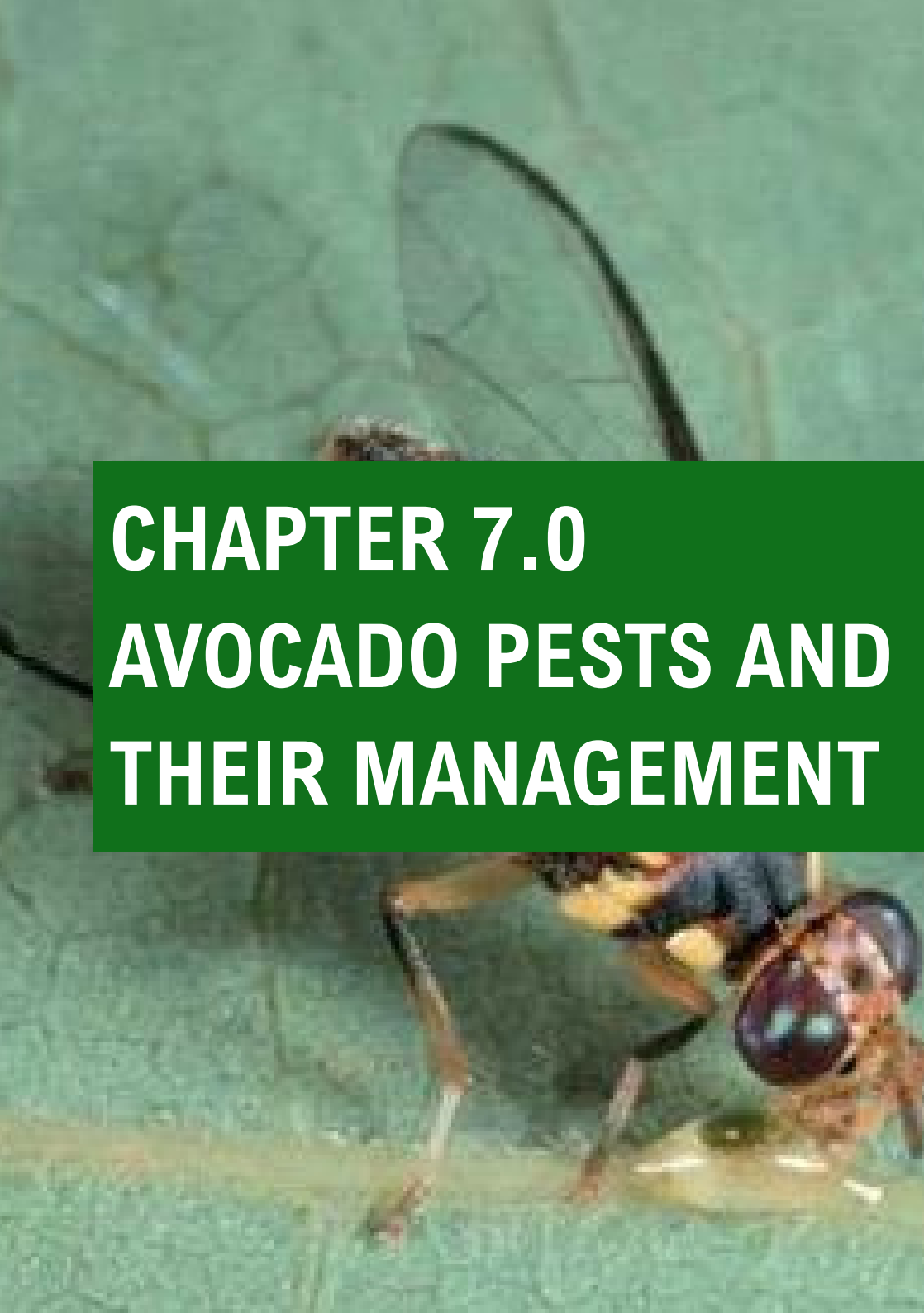
Figure 13: Style of planting trees to enhance pollination.

Note

- If types A and B are not planted, encourage pollinating insects, such as bees and flies by maintaining flowering plants around the orchard.
- Introduce beehives if natural pollinators are few.
- Certain cultivars such as Hass have two or more flowering periods per year, depending on
- climatic conditions.
  The period from pollination to harvest is usually 6 to 14 months.
- Thus, fruits from two or more flowerings can be present simultaneously.

6.3 Floral induction

- Maintain adequate moisture levels during warm seasons to improve vegetative flushing, flowering intensity and fruit set.



CHAPTER 7.0
AVOCADO PESTS AND THEIR MANAGEMENT

7.1 Insect Pests

7.1.1 Fruit Flies

True fruit flies (Figure 14) are small, colorful, picture-winged insects. Important species include:

- The **Oriental fruit fly** - *Bactrocera dorsalis*:
  - Adults range from dark brown to black, with bright yellow longitudinal stripes on the thorax.
- The **Natal fruit fly** - *Ceratitis rosa*:
  - Adults are brown coloured, with a dark thorax and brownish-yellow abdomen with black bands.
  - Its wings have dark brown bands.
- The **Mediterranean fruit** fly - *Ceratitis capitata*:
  - Adults are yellow to brown with dark spots on the thorax.
- Damage by fruit fly species is similar.
- Female flies lay eggs inside the fruit using a sharp-pointed ovipositor.
- Larvae develop inside the fruit, feeding on the flesh and causing both qualitative and quantitative losses.

- The presence of cream-colored larvae in fruits could lead to rejection of the entire consignment.
- Infested fruits normally rot and fall to the ground.
- The major means of dispersal is movement of fruits.

Oriental Fruit Fly ©RS Copeland

Natal Fruit Fly ©RS Copeland

Mediterranean Fruit Fly ©RS Copeland

Fruit Fly eggs and Pupae

Figure 14: Fruit fly species (A - C) attacking avocado and fruit fly eggs and pupae (D).

Fruit Fly Management

- Monitor populations using parapheromones and food bait traps. Use methyl eugenol for the Oriental fruit fly and terpinyl acetate for the Natal fruit fly and the Mediterranean fruit fly (Figure 15).
- Hang traps on trees about 1.5m from the ground at a density of two traps per hectare.
- Replace attractants every four weeks.

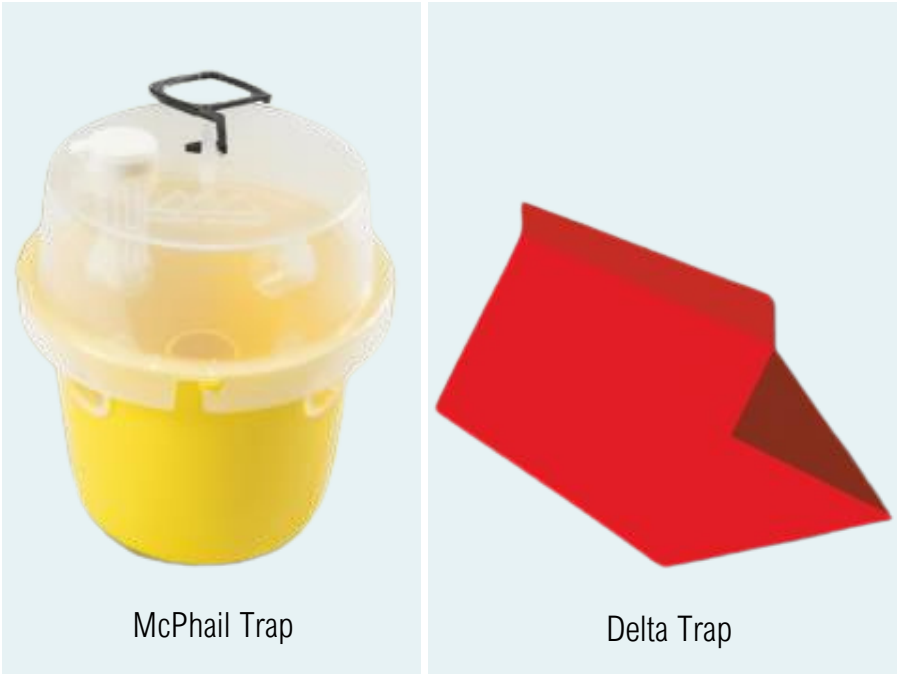


Figure 15: Fruit fly traps.

- Apply baits like GF 120 (0.02% spinosad).
- Mix 1 litre of GF 120 in 6 litres of water and apply the mixture to 1Ha of the farm.
- Apply a one-square-meter spot on one side of the canopy. Spray alternative rows weekly.
- Collect all fallen fruits and either bury them, make compost, or use them to feed animals.
- Dispose fruits in an augmentorium in areas where parasitoids have been released (Figure 16).
- Apply the Male Annihilation Technique (MAT) by placing parapheromone traps at a 4 – 5 traps per acre to target male flies.
- Harvest fruits when they mature but in a pre-ripe stage to minimize exposure to high pest populations.
- Apply pesticides judiciously only when populations reach high damaging levels.
- Apply pyrethroids like deltamethrin.
- Conserve beneficial insects, such as weaver ants, by using pesticides judiciously.

Figure 16: Augmentorium for disposing fruits which are damaged by insects.

7.1.2 The False Codling Moth - *Thaumatobobia Leucotreta*

- The moths are slender, brownish and mottled.
- Newly hatched larvae, are creamy white with a dark brown or black head.
- As they age, larvae darken and finally have a pink body color.
- Pupae are dark brown, wrapped in silken cocoons (Figure 17).
- Damage begins when the female moth inserts eggs the fruit skin.
- Emerging larvae develop and feed on the flesh of fruit causing qualitative and quantitative losses.
- Other symptoms include brown spots on fruit and dark brown frass which are visible signs of an infestation.
- When larvae exit the fruit to pupate, the skin around the point of infestation turn yellowish-brown as the tissue decays and collapses.
- Other symptoms include spots, mold growth on infested fruit, premature ripening and fruit drop.

- The major means of control is removing and destroying infested fruits.

Figure 17: Adult False Codling Moth.

Management

- Disrupt mating by trapping adult males with pheromones.
- Apply insecticides like lambda cyhalothrin, deltamethrin, emamectin benzoate.
- Apply Entomopathogenic Fungi (EPNs) like *Metarhizium anisopliae*.
- Bag the fruits, if possible.

7.1.3 Stink bugs - *Nezara viridula*

- They are called stink bugs because, when disturbed they can excrete fluid with an unpleasant odor.
- The adult is shield-shaped with an overall dull green color.
- It has small black dots that can be found along the sides of the abdomen.
- The wings completely cover the abdomen.
- The males' average length is 12.1 mm and the females' average length is 13.15 mm.
- Nymphs are similar to adults, but wingless (Figure 18).
- Stink bugs damage plants by piercing and sucking plant sap from leaves, buds, blossoms and fruits.
- Damage causes death of seedlings, stunted plant growth, wilting of leaves, and superficial spots and pits.
- Fruit may drop, become deformed, or fail to form at all.
- They spread through human activities, especially trade.

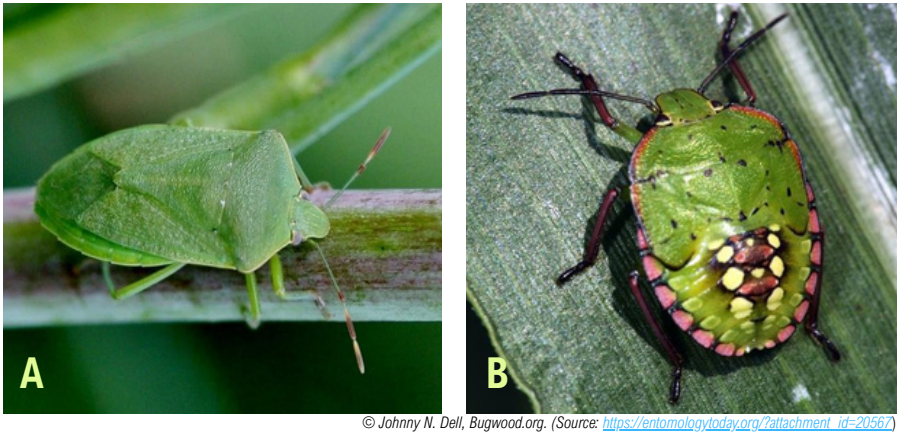


Photo 18: Stink bug adult (A) and nymph (B).

Management

- Apply insecticides containing lambda cyhalothrin, acetamiprid + pyriproxifen.
- Manually remove bugs from trees where feasible

7.1.4 Thrips

Black tea thrips - *Heliothrips haemorrhoidalis*

- The adults are dark brown with the apex of the abdomen paler.
- Females are longer than males.
- The legs are entirely white or yellow.
- Full-grown larvae are yellow, with the ninth and tenth abdominal segments brown (Figure 19).

- The thorax and abdomen have many thin longitudinal plaques.

© Whitney Cranshaw, Colorado State University, Bugwood.org

Figure 19: Black tea thrips.

Red-banded Thrips - *Selenothrips Rubrocinctus*

- The female adult is about 1.2 mm in length and has a dark brown or black body.
- The male is similar to the female, but it is smaller.
- The nymphal stages are light yellow with two bright red bands around the abdomen, i.e. “red-banded” (Figure 20).
- Nymphs resemble adults but are wingless.
- The legs are entirely white or yellow.

Figure 20: Red-banded thrip

Damage Symptoms

Thrips scrap the skin of the fruit and feed on the oozing sap, leading to various symptoms of damage that include:

- Premature fruit drops.
- Scarring of the fruit.
- Browning of the surface, giving an “alligator skin” appearance (Figure 21).

© Mark S. Hoddle, University of California - Riverside, Bugwood.org

Figure 21: Thrips damage symptoms

Dispersal and Spread

Flight is the major means of dispersal and spread

Management

- Apply baits like GF 120 (0.02% spinosad).
- Apply natural insecticides like azadirachtin (neem).
- Spray insecticides like abamectin and deltamethrin.

7.2 Avocado Diseases

7.2.1 Avocado Root Rot

Description

Avocado root rot is caused by a fungus called *Phytophthora cinnamomic*. The fungus is soil-borne, and the disease is commonly triggered by excessive moisture in the soil. It is usually fatal to the tree.

Damage

In a favorable environment, the fungus releases spores that are small enough to enter a root through the root tip. Once they enter the root, they start absorbing nutrients and carbohydrates, breaking down the root structure and preventing the plant from absorbing water and nutrients (Figure 22).

Symptoms

- Black, brittle, and decayed small feeder roots when present.
- Stem cankers.
- Collar rot.
- Darkened patches of bark and gumming.

- Death of shoots, and eventually, the tree is reduced to a bare framework of dying branches.
- Small yellow leaves with tip burn.
- Sunburn fruits from the reduced canopy.
- Dieback of the young shoot.

Disease Management

- Select a site with well-drained soil and avoid overwatering.
- Avoid planting avocado in areas infested with root rot.
- Monitor trees regularly by inspecting for signs of disease and take prompt action if symptoms appear.
- Plant avocado varieties that are resistant to root rot disease.
- Maintain good tree health through proper pruning and fertilization.
- Replant new seedlings to replace dead trees.
- Remove diseased roots and dispose them by burning.
- Avoid replanting in the same hole where a diseased tree was removed.

- Select a site with well-drained soil and avoid overwatering.
- Avoid planting avocado in areas infested with root rot.
- Monitor trees regularly by inspecting for signs of disease and take prompt action if symptoms appear.
- Plant avocado varieties that are resistant to root rot disease.
- Dispose dead branches and infected fruits away from the trees and the ground.
- Disinfect tools, machinery, especially tires, and footwear regularly.
- Use fungicides which have active ingredients of metalaxyl, e.g. Ridomil for young plants and potassium phosphonate for older trees to control the spread of the disease.
- Potassium phosphonate is effective to be used as a preventative measure, rather than a cure.
- Use gypsum at a rate of 0.5 - 1kg/m^2.
- Apply gypsum to promote root growth and disease resistance.

© California Avocado Commission

Avocado trunk canker and collar rot symptom

© University of California

Small, yellow, tip-burned leaves

The black, brittle, and decayed feeder roots

© California Avocado Commission

A tree is reduced to a bare framework

© The daily garden

Darkened patches of bark

Thin canopy

Figure 22: Effects of avocado root rot.

7.2.2 Anthracnose

Description

Anthracnose is caused by the fungus Colletotrichum gloeosporioides. The disease is most common in humid and warm regions, especially during periods of rain.

The infection of avocado fruit by the anthracnose pathogen can occur at any time after fruit set, with spores spread during rain, humidity, dew, and overhead irrigation.

Symptoms

- Circular brown spots on the leaves. These spots can merge, causing the leaves to turn brown and fall.
- Sunken, brown lesions on the tree's bark, which may eventually kill the affected portion of the stem.
- Twig dieback, leading to stunted growth and decreased fruit production.
- Spots with a sunken gray center, where the fungus is growing (Figure 23).

- Defoliation due to severe infections to the tree that can cause leaves to drop prematurely, reducing the plant's ability to photosynthesize and produce fruit.
- Small, black spots on the fruit that may grow in size and eventually lead to rotting of the entire fruit.

Small black spot

Sunken grey spot

Figure 23: Effects of anthracnose.

Disease Management

- Farm sanitation.
- Regularly inspect trees for early signs of infection.
- Early detection can prevent the spread of the disease.

- Maintain the tree's health by weeding, proper fertilization and irrigation.
- Regularly inspect trees for signs of anthracnose, including leaf spots, twig blight, and fruit rot. Early detection can help prevent spread of the disease.
- Prune and dispose the infected plant parts far away from the farms.
- Use fungicides with active ingredients such as copper oxychloride, mancozeb, metiram, propineb and thiabendazole. Use fungicides in conjunction with other management practices.
- Keep harvested fruit dry and cool.

7.3 Avocado Sunblotch

7.3.1 Description

The disease is caused by viroid known as Avocado sunblotch viroid (ASBVd). It is transmitted by propagating rootstocks, in scion material used for grafting, such as pruning blades and harvesting clippers. Also, the disease is transmitted by pollen to the developing fruit.

7.3.2 Symptoms

- Depressed streaks on the young stems.
- Cracking/grooves on the bark of older branches and trunks.
- Bark lesion and crocodile skin pattern.
- Foliar discoloration.
- Sunken white, yellow, or pink blotches or streaks on the fruit and leaves (Figure 24).

7.3.3 Disease Management

- Use clean/virus-free plant materials from accredited suppliers, whose materials are certified.
- Monitor the orchard regularly and inspect for the presence of new pests.
- Remove infected trees to reduce spread of the virus.
- Disinfect tools used for pruning.
- There are currently no chemical treatment for the disease.

Multiple yellowish sunken streaks on fruits
Source: Plant Health Australia

Discoloured and deformed leaves.
Source: Plant Health Australia

Avocado sunblotch
© Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Lesions, yellow streaks, and blotches occur on fruit and leaves. *Source Judy A. Szychowski and Plant Health Australia*

A bark lesion and crocodile skin pattern.
Source: Judy A. Szychowski

Figure 24: Effects of avocado sunblotch.

CHAPTER 8.0 HARVESTING AND POSTHARVEST

Fruits quality, nutrient content and shelf life depend on the maturity level at harvest.

8.1 Maturity Indices

Harvest avocados using maturity indices outlined in Table 6.

Table 6: Maturity indices for avocado fruits	
Dry matter (DM)	⩾ 20/23%
Oil content (OC)	⩾ 8%
Days after flower setting	*Hass* : 8 to 9 months *Fuerte*: 6 to 8 months *Ettinger*: 6 to 8 months
Weight of the fruit	*Hass*: 140 to 340g *Fuerte*: 170 to 400g *Ettinger*: 255 to 453.5g
Days to ripening (at 20 - 25^{o}C storage temperature)	4 to 7 days for all varieties
Stalk weakness at the attachment point	The stalk gets weaker as the fruit matures

8.2 Harvesting Materials and Methods

- Harvest avocado fruits when they mature but not yet ripe.
- Harvested fruits should exhibit a smooth texture and acceptable organoleptic qualities.
- Avoid harvesting on rainy days.
- Avoid harvesting damaged fruits or those affected by pests and diseases.
- Harvest fruits selectively by hand (Figure 25) or using special picking poles with baskets to prevent physical damage (Figure 26).
- In large farms, harvest avocados using special hydraulic ladders (cherry pickers).
- If fruits vary in size and maturity within a tree or orchard, begin by harvesting the larger, more mature fruits.
- Avoid picking or harvesting fruits by shaking the trees.
- Trim the fruit stem close to the surface, leaving about 0.5cm, to prevent fruit injury and delay ripening (Figure 27).

Figure 25: Avocado harvesting by hand.

Figure 26: Avocado harvesting using special picking poles with baskets.

Figure 27: Trimming of fruits stem after harvesting.

8.3 Postharvest Handling

8.3.1 Sorting and Grading

- Sort and grade avocado fruits based on varietal characteristics (size, colour, shape, internal and external defects, texture, dry matter and oil content), maturity, and safety characteristics (Figure 28, Tables 7 and 8).
- Ensure that fruits are free from chemical and biological contaminants.

Figure 28: Avocado grading based on quality.

- Pack avocado fruits in four-kilogram cartons, typically holding 12, 14, 16, 18,20, or 22 fruits (Figure 29).
- Pack avocados in cartons made of solid/corrugated fiberboard.

Size Code	4	6	8	10	12	14	16
Weight Range (g)							
	781 to 1220	576 to 780	456 to 576	364 to 462	300 to 371	258 to 313	227 to 274

Size Code	18	20	22	24	26	28	30	*S
Weight Range (g)								
	203 to 243	184 to 217	165 to 196	151 to 175	144 to 157	134 to 147	123 to 137	Less than 123

Source: MARKUP, 2021

Figure 29: Avocado quality grades according to size / weight as per the United Nations Economic Commission for Europe (UNECE).

Table 7: Quality characteristics of first grade avocado fruits

Type	Size Code	Dry Matter Content	Weight
Hass	16 - 20	21%	> 80g
Fuerte	14 - 16	20%	> 123g

8.3.2 Grades/ Classes

Table 8. United Nations Economic Commission for Europe (UNECE) Avocado classes

Class	Defect
Extra Class	Free from all defects except slight superficial defects that do not affect quality, keeping quality and presentation in the package. If such a defect is present, the stalk must be intact.
Class I	These defects are allowed provided they do not affect the fruit flesh and do not affect quality, keeping quality and presentation in the package. • Slight defects in in shape and color. • Skin defects (corkiness, healed lenticels) and sunburn, provided they are not progressive; t total affected area must not exceed 4 cm^2 • The stalk, if present, may be slightly damaged.

Class	Defect
Class II	These defects are allowed as long as the avocados retain their essential characteristics in regards to quality, keeping quality and presentation. • Slight defects in shape and color. • Skin defects (corkiness, healed lenticels) and sunburn, provided they are not progressive; t total affected area must not exceed 6 cm^2 . • The stalk, if present, may be slightly damaged. The defects must not affect the fruit flesh.

Source: Markup (2021)

8.3.3 Packaging

- Pack avocados in 4kg box cartons in one or two rows of the same size fruits.
- Packages should be perforated on the sides and top to allow ventilation.

- Place boxes on pallets (Figure 30) to prevent damage to the fruits.
- Individual fruits may be wrapped in paper to prevent friction damage.

Figure 30: Cartons arrangement on the pallets.

8.4 Pre-cooling and Storage

- Keep harvested fruits in the shade.
- Ship fruits to a pack house without unnecessary delays (within 48 hours).
- Pre-cool avocado fruits using forced air at 7 - 12 °C, maintaining air circulation rate of 80 - 100%.
- Store fruits in a cold storage facility at 4.5 °C for *Fuerte* and *Hass* varieties and 7 °C for other varieties (Table 9).
- Very low temperature may cause abnormal ripening and poor eating quality. Higher storage temperatures may reduce storage life. Maintain RH at 85 - 90%.

Table 9: General storage temperature for different races of avocado varieties

Variety	Mature - Unripe	Possible storage period
Guatemalan varieties (eg. *Hass*, *Fuerte*)	5.6 - 8 °C , 80 - 90% RH	4 weeks with only 10% loss
Mexican varieties	8 - 10 °C, 85 - 90% RH	14 – 28 days
West Indian varieties	12.8 - 15 °C and 85 - 90% RH	2 weeks with 6.3% loss

8.5 Shipping of Avocado Fruits

- Avoid shipping avocado fruits with other crops that produce ethylene.
- Load palletized cartons onto pre-cooled trucks and set the shipping temperature at 4 - 7 °C for *Hass* and *Fuerte,* and 13 °C for all West-Indian varieties.

8.6 Standards

8.6.1. Mandatory Standards

- Exporters must comply with mandatory phytosanitary regulations before exporting avocado fruits.
- The mandatory standards aim to protect consumers' health and safety in an importing country.
- Exporters must comply with World Trade Organization (WTO) Agreement on Sanitary and Phytosanitary (SPS) measures.
- The convention sets basic sanitary rules (human and animal health) and plant health measures and standards.

8.6 Standards

8.6.1. Mandatory Standards

- Exporters must show evidence that the produce comes from disease - free areas, have been inspected, have low Maximum Residue Levels (MRL).
- Do not have restricted food additives.

The following are the guidelines to follow for exporting avocado to the European Union:

- General Food Law of the European Union - Regulations and Rules of European Commission (EC) No 178/2002, 852/200, 396/2005, 2073/2005,1333/2008 178/2002 and section 18.
- International Avocado Standards eg. ISO 2295:1974: Avocado Guide for storage and transport.
- All consignments must be certified free from diseases and insect pests that may harm animals or plants.

- Diseases and pests can be reduced by using good agricultural practices, good environmental hygiene practices, appropriate use of approved pesticides, and good fruit storage and transportation practices.
- It is therefore important to obtain a Phytosanitary certificate, a certificate that ensures that the consignment is free from pathogens, insects and weeds and that it meets the phytosanitary requirements of the European Union market.
- In addition to international standards, the marketing of avocados in the country and within the East African Community need to meet the following regulatory requirements:
  EAS 19:2017 - Fresh avocado – Specification, and TZS 1704: 2015(E) Fresh avocado – Specification.

8.6.2. Voluntary Standards

- Farmers should also comply with voluntary standards to access lucrative markets.

- Voluntary standards are the requirements that must be met before a product can enter a
- targeted, specific market segment (niche markets), for example, organic farming, and Fair-Trade standards (Table 10).

Table 10: Examples of voluntary avocado quality standards according to markets

Voluntary Standards	Details
GlobalGAP	It is a required certification for avocados sold in supermarkets. It promotes Good Agricultural Practices (GAP) for agricultural products worldwide to ensure food safety, sustainability, environmental protection, traceability, and worker safety and well-being.
Fair Trade	Fair Trade certification ensures that producers are paid at least the Fairtrade minimum price (if not more) and receive an additional Fair Trade Premium that can be invested in their communities and improve ecosystems through reforestation and water pollution prevention.

Voluntary standards	Details
Organic Certification	It is a certificate for exporting organic avocados to European countries. Producers are required to be certified by a regulatory agency recognized by the European Union. To be certified as an organic producer, the farmer must change production methods to fully comply with organic principles. Organic farms are inspected annually to check whether they meet the criteria.
British Retail Consortium Global Standards (BRCGS)	BRCGS for food hygiene and safety is required by all buyers of fruits and vegetables in the North -West European markets.

Voluntary Standards	Details
	It covers food safety standards, packing and packaging of produce, storage and distribution, consumer products, agents and brokers, retail customers, gluten-free products, plant-based ingredients, and marketing ethics to assure consumers of the safety, legality, and quality of the products.
Sedex Members Ethical Trade Audit (SMETA)	It is a certificate that helps manufacturers to comply with ethical business requirements through social audits to assess the working environment on the part of the service provider. It assesses manufacturers' compliance with worker health and safety and meeting international human rights standards, such as zero tolerance for child labor.

CHAPTER 9.0 MARKETS AND MARKETING OF AVOCADO FRUITS

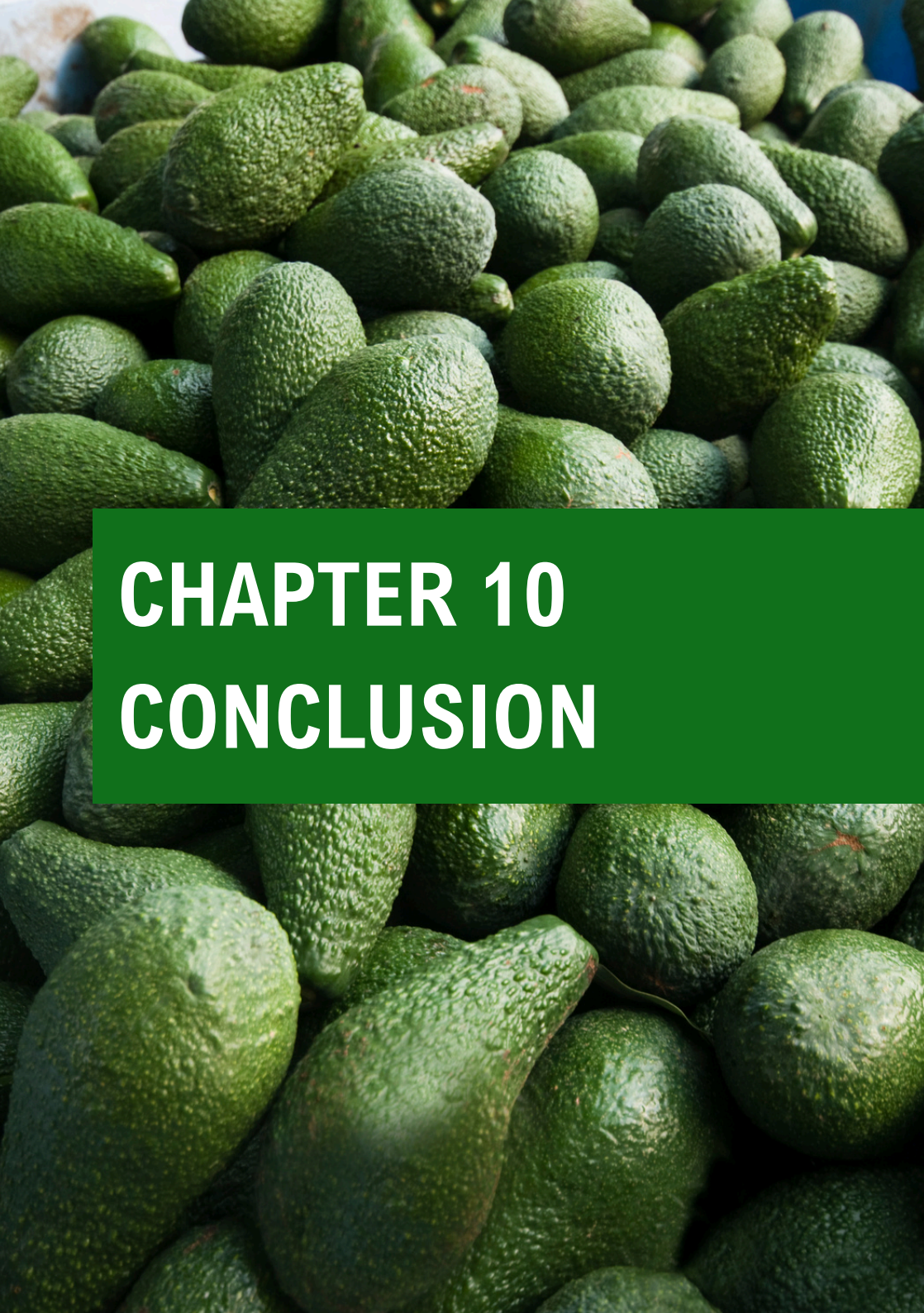
The top destinations for avocado from Tanzania are France and the Netherlands.

The two markets accounted for more than three-quarters of this product's exports between 2014 and 2018.

The United Kingdom came third with 14% of exports.

Other markets with large untapped export potential include:

- Japan
- Switzerland
- Spain
- Germany
- The United Arab Emirates
- China
- India
- South Africa



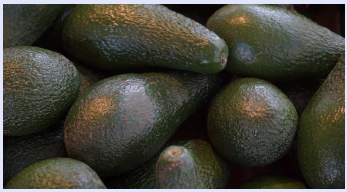
CHAPTER 10
CONCLUSION

This manual has described the sustainable production of avocados using recommended agricultural principles, from the seedling production stage to harvesting, shipping, and marketing.

It is expected that this manual will help avocado growers to understand and apply the outlined principles and practices of avocado production. The methods and principles recommended in this book are easy to follow and cost-effective.

ASF and its partners expect both members and non-members to implement these principles so that avocados of the highest quality are produced in the country. This will, in turn, increase production and eventually expand both domestic and foreign avocado markets.

Most importantly, if these guidelines are followed, they will reduce losses incurred by farmers and protect the interests of traders and avocado consumers.



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