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MINISTRY OF AGRICULTURE, LIVESTOCK, LANDS AND IRRIGATION

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Agriculture Sector Modernization Project

OPERATIONAL MANUAL

AVOCADO

AGRICULTURE SECTOR MODERNIZATION PROJECT

PARK
AGRICULTURE TECHNOLOGY DEMONSTRATION PARK

Prepared by -
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PROJECT DIRECTOR'S MESSAGE

Sri Lanka takes great pride in its rich heritage, with a written history that spans thousands of years. Its fertile soil, diverse landscapes, and strategic location have long made it an ideal hub for farming.

While agriculture evolved globally, Sri Lanka faced challenges. The industry became less profitable and labour-intensive, compounded by the introduction of an open economy. The fragmentation of cultivable land into small, inefficient plots further compounded the challenges as farming was no longer seen as a reliable career.

Sri Lanka allocates a significant portion of its foreign exchange on importing agricultural commodities. Recognizing the potential of its nutrient-rich soil, the government saw an opportunity to cultivate crops that meet international demand while reducing imports and boosting foreign exchange through exports. To capitalize on this, the government prioritized advanced agricultural technologies. In 2017, the "Agriculture Sector Modernization Project" (ASMP) was launched with the World Bank funding.

The project focused on areas where Sri Lanka had the most potential, such as export-oriented tropical fruits and vegetables . It started pilot project in year 2018 with World bank funding with seven districts in five provinces (Jaffna, Mulaithevu, Batticaloa, Anuradhapura, Polonnaruwa, Mathale and Monaragala) and expanded with the grant of the European Union, in another five districts (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) The project secured a loan of USD 64 million from the World Bank, along with a grant of USD 25 million from the European Union. To date, the project has generated USD 65 million in foreign exchange earnings, with potential savings of up to USD 3 million domestically.

The project focused to high-demand tropical fruits and vegetables. Small farms were consolidated into larger groups of 300 to 400 entrepreneurs into Agriculture Technology Demonstration Parks (ATDPs) and modern technologies were introduced.

Tropical Fruit varieties are the main crops selected for Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) by the International Service Provider (ISP) identified as Tropical Queens (Banana, Mango, Guava, Papaya and Pomegranate) which are among the most popular fruits in the world. ISP engaged in producing those competitive and marketable commodities for both local and export markets

The socio-economic problems and the COVID pandemic of the Country during year 2020-2022 affected the implementation of the ISP technology packages. Because of this, the ISP and the ASMP developed optional technology packages, designed to overcome the shortfalls of the crisis. Procurement of equipment and supplies already available in the Country was given priority to avoid import delays and constraints. Different irrigation systems were used when the preferred system was not available. Options are also being developed for inputs such as fertilizers and pesticides. Intercropping was implemented as the ideal weed control practice and staple food crops to provide much-needed food to the Country. More emphasis is given to IPM systems to control pests and diseases. Even existing crops were given pre- and post-harvest technology to start exports without waiting until newly planted crops are harvested. Therefore, most of ASMP crop clusters have both existing crops and new crops with complete ISP technology package. Therefore, the *Operational Manuals* of Dr Julian; the Agronomist of ISP are based on technology for both existing crops of farmers as well as new crops with entire technology package.

ASMP started with Pilots by introducing Department of Agriculture (DOA) technology. With the intervention of Dr. Julian, ASMP involved in Vertical upliftment of the existing DOA technology from land preparation to pre / post-harvest technology to end up with modern processing technology with reefer container protocol for export which have never been practised in Sri Lanka . High density double Row planting, Low pressure irrigation (mini sprinklers, Drip tapes), irrigation based on mini whether station data, soil test based fertigation, modern training and pruning of fruit trees (box and espalier), use of poly mulch, pre and post-harvest Technology (use of colour bagging, colour ribbons, fruit desk etc) are some of the promising technologies introduced by the ISP. ASMP has produced Operational Manuals for Banana (*Ambul, Kolikuttu, Cavendish*), Mango, Guava, Papaya, Soursop, Passion fruit, chilli, Vegetables, Jumbo peanut, potato, Red onion and Maize.

The project introduced innovative methods for increasing land productivity. Techniques like high-density double-row planting and the "espalier" method allowed agroprenuers to double or even triple their yields. Automated water-controlling systems based on weather station data ensured a effective use of water supply, enhancing productivity reducing use of fertilizer. Solar energy was harnessed to power these systems, reducing reliance on the main electricity supply.

Over the past seven years, the project had transformed the concept of "farming" in Sri Lanka. Once viewed as an unattractive profession, farming had become a thriving opportunity, attracting the new generation. This shift had marked a major change in societal attitudes and had empowered farmers as **agropreneurs**, driving innovation and growth in the agricultural sector.

A key initiative of the project was the transition from individual farming to the establishment of farmer companies. Farmers were organized into "Public Unlisted Companies (PUC)," raising the status of farming from a mere livelihood to an esteemed profession. This shift established a structured system, elevating agriculture to a professional level and instilling a sense of pride in the farming community.

Farmers of the Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) were organized into Farmer Producer groups and these groups were later registered as Farmer Companies under the Companies Act No 7 of 2007, in the Public Unlisted Company category. There are 59 Farmer Companies already functioning in the ASMP crop clusters.

The Farmer Company model facilitated direct business transactions between local farming organizations and international buyers, creating new global business opportunities

Specialized processing centres for each Farmer Company ensure that crops are processed, graded and packaged according to international standards. This system provides the buyers with access to high-quality products through a structured, well-organized, and accountable framework, ensuring benefits for both agropreneurs and buyers alike.

Dr. Rohan Wijekoon
Project Director
Agriculture Sector Modernization Project

Contents

1. INTRODUCTION

The avocado is a tree native to the tropical humid climate of Central America, Guatemala and Mexico and cultivated in South America and the Caribbean for centuries. Avocado has been described as the most nutritious among all the fruits. The avocado is also referred to as: Alligator pear (Brazil and Jamaica), Avocaat (Dutch), Abogado (Spain), Avocatier (France), Butter pear (Europe), Zaboca (Trinidad and Tobago) (Paul 2013).

2. AVOCADO TREE CLIMATE AND SOIL REQUIREMENTS

2.1 Soil and location

Avocado trees can grow well in a wide range of soils. The ideal soil for most varieties is loose, loamy, or sandy with a slightly acidic to neutral pH, between 5 and 7. However, farmers should generally avoid establishing an avocado orchard in fields with poor drainage and high salinity. West Indian varieties are generally the most salt-tolerant and are preferred for plantations in coastal regions. The cultivation is possible at elevations from sea level to 2,400m (7,874 ft). and areas protected from strong winds. Avocados have a high-water demand, and if the rainfalls are not sufficient (annual precipitation of 800–1700 mm) or well spread during the season, there might be a need for irrigation to support high yields.

2.2 Temperature and sunlight

The sudden temperature changes can stress the avocado tree. Frost is usually not an issue in our region, but the **low temperature** is one of the most limiting factors for growing this tropical species in other areas. As a tropical crop, avocado can survive temperatures between -4◦C and 40◦C. However, the level of the damage depends on the duration of these extreme temperatures and the variety. For example, Hass, like most varieties, thrives in an average temperature of 16 – 21 ℃ (60-70 ℉). While young trees (up to 3-5 years) are generally sensitive to low temperatures, mature trees can withstand temperatures as low as -2 ℃ (28 ℉). In order to produce flowers, avocado needs at least four weeks with cool temperatures. However, during blooming, the temperature should remain above 10℃.

On the other hand, high temperatures can also harm the trees and their production. Temperatures over 40℃ can cause severe damage to sensitive young trees and stress the older ones. During this period, avocado trees are in the most sensitive phase since they bloom or form fruits. Such conditions can lead to flower necrosis, fruit drop, and as a result, a significant yield loss.

Finally, most avocado varieties need 6-8 hours of ample sunlight daily. The sun will help maintain the bright green colour of the leaves and the fruits. In mature trees, sunburns are not very common. However, young avocado trees must be protected. For this, reason many farmers use shading net to protect the young avocado trees from sunburns.

3. PLANTING AN AVOCADO ORCHARD

3.1 Soil Selection and Preparation

It is important to note that perennial trees occupy the ground for a long time. Therefore, a proper plan for site selection, layout of field and access roads should be made. Avocados can be grown on a wide range of soil types with the primary requirement of good drainage. An understanding of the avocado's root system is important when selecting planting site. The root system is shallow and most of it is found on the upper layers of the soil. It is extremely sensitive to excessive soil moisture or even temporary water-logging. It is recommended that one avoids establishing plants in areas where the water table is above 0.9 m (3 ft.) from soil surface and areas with underlying hardpan.

Additionally, windbreaks are necessary for this crop and must be established as early as possible. Temporary and more frequent windbreaks may be needed until permanent windbreaks are large enough to be effective. Mangoes or timber trees may be used for permanent windbreaks, while bananas are more suitable for temporary windbreaks.

Land preparation should begin at least three months prior to establishment. The area should be cleared of all vegetation, tree stumps and rocks. It should then be ploughed and harrowed/rotavated prior to laying out beds or rows. The pH of the soil should be checked and adjusted to 5.5 to 7.0 with agricultural lime or dolomite if necessary. Liming materials should be applied before the land is rotavated to ensure that it is well incorporated.

3.2 Varieties and Propagation

Hass a variety in the Mexican – Guatemalan Group is preferred as it has many advantages. Some of its features are as follows

Type A flowering behaviour
Average weight of a fruit is 275-375g
High oil content (18-22%)
Thick and pimpled pericarp turning dark purple in colour when ripe
Less affected by fruit fly
Low post harvest losses
High demand in the international market

It is essential to plant a few plants (two plants per half an acre) of a Type B variety such as Fuerte in order to ensure satisfactory pollination and fruit set.

Avocados are propagated by seed in many parts of the world. While many important hybrids have originated from seed, vegetative propagation is essential to early fruiting, propagating true-to-type desirable cultivars and providing adequate supply of vegetative planting material.

Vegetative propagation methods include **budding and grafting**. It has been reported that budding, which was a common practice, requires considerable skill and experience and is not successful with all cultivars. Grafting makes a stronger union than budding.

Vegetative propagation allows a grower to maintain consistent fruit production and quality by multiplying a known variety or cultivar of fruit.

Avocados, like many tropical fruit trees, are propagated by grafting.

3.3 Nursery Management:

Good Avocado nursery management involves many skills and attention to detail. The process starts with acquisition of high-quality rootstock seedlings of known origin and known genetic quality.

The following practices must be done in order to guarantee a healthy Avocado tree:

- **Seedlings**: The seedlings must be selected from a native avocado of good Vigor and health; the fruit used for this purpose must be at physiological maturity and come preferably from the smallest number of parent trees to avoid variation in the planting. Seedlings of tender, diseased fruit collected from the soil should never be used, as they may be infected by pathogens such as *Phytophthora cinnamomi*. The pulp is then removed, and the seed is extracted and washed with water, leaving it to airdry on a sack in a shaded and ventilated place.

  When the seeds are completely dry, it is advisable to treat them with a fungicide, which can **be Captan®, in doses of 3 g· L-1 of water,** The seeds are immersed for two hours, then dried and stored. The seed can be kept for up to 5 days in a cool place and one month in refrigeration (4°C). It is advisable not to let too much time pass between obtaining the seeds and sowing, as this decreases their viability.

- **Growing Media:** A mixture of 70% soil and 30% rice husk creates a good general mix for planting up the avocado seeds. If the soil is heavy, reduce soil content by around 10% and add some sharp sand, grit, or bulky organic matter to improve drainage.

  To minimize further development of fungal infection to the root (*Phytophthora cinnamomi*), the growing media must be disinfected with a fungicide:

  Drench the growing media with 2.5g of **Ridomil**(Laxy(8%Metalaxyl+64%Mancozeb) mixing in 1 Litre of water.

  After 2-3 weeks of **Ridomil** application, 1 ml or 1 g of **Carbendazim** mixing in 1 Litre of water should be drenched to the growing media

- **Nursery Plastic Bags:** Use deep bags, 15”(37.5 cm) or deeper, to allow root **growth.**Bags must be perforated to drain excess water and avoid water logging.

When the nursery bags are **too short,** Root binding, also known as root-circling, happens at the bottom of the bag, and the roots of a plant form into a dense, tangled mass. As a result, this inhibits the plant's growth by minimizing the space in the soil available for plant growth.

The stress or starvation of a plant are very common in cases of root binding. A root bound plant will receive less nutrition and hydration than plants that are not root-bound, in severe cases a plants roots can **suffocate and ultimately cause the plant to die.**

A plant suffering from root binding will often show the same symptoms as an under-watered plant. As a result, it will have fast wilting and brown or yellow leaves. As well as having stunted growth.

Root Binding (Root Circling)

- **Grafting:** . It usually takes 4–6 weeks for avocado seeds to germinate and can take 4–6 months to reach a g**raftable size which is 24”- 26**”. See Grafting section
- **Watering**: Irrigate carefully keeping the growing media wet, not too much water
- **Shade:** Keep the growing avocado trees in a shaded area.
- **Transport to field:** Transport the trees to the field stacked in wooden crates or plastic trays.

3.4 Grafting

3.4.1 Definition of grafting

In horticulture is, the joining together of plant parts by means of tissue regeneration. Grafting is the act of placing a portion of one plant (bud or scion) into or on a stem, root, or branch of another (stock) in such a way that a union will be formed and the partners will continue to grow. The part of the combination that provides the root is called the rootstock; the added piece is called the scion.

The principle in grafting are based on the matching of scion and rootstock cambiums (meristematic tissue, the cells of which are undifferentiated and capable of frequent cell division). Cambial tissue in most woody trees and shrubs is an inconspicuous single cell layer covering the central core of wood and lying directly beneath the bark.

3.4.2 Uses of grafting

In modern horticulture grafting is used for a variety of purposes: to repair injured trees, to produce dwarf trees and shrubs, to strengthen plants' resistance to certain diseases, to retain varietal characteristics, to adapt varieties to adverse soil or climatic conditions, to ensure pollination, to produce multi-fruited or multi-flowered plants, and to propagate certain species (such as hybrid roses) that can be propagated in no other way. The interaction of rootstocks may affect the performance of the stock through dwarfing or invigoration and, in some cases, may affect quality. Further, the use of more than one component can affect the disease resistance and hardiness of the combination.

Grafting as a means of growth control is used extensively with fruit trees and ornamental flowers. Fruit trees are normally composed of a scion grafted onto a rootstock. Sometimes an inter-stock is included between the scion and stock. The rootstock may be grown from seed (seedling rootstock) or asexually propagated (clonal rootstock.)

3.4.3 Grafting supplies (Fig.1)

- Pruning shears, sharp and clean
- Parafilm for sealing scion and graft union
- Grafting knife, sharp and clean
- Rubber bands or grafting tape for holding scion and rootstock together
- Rootstock plant
- Scion piece (from a known source)

3.4.4 Terminology

Rootstock

The rootstock is the base of the plant that provides the root system for the grafted tree. Use seeds of a known variety that you prefer for rootstock establishment, which have desirable traits such as resistance to soil-borne diseases and pests. Seeds are planted wide-side down in well-draining sterile media and in deep bag (**15" or deeper**) to allow root growth. It usually takes 4–6 weeks for avocado seeds to germinate and can take 4–5 months to reach a graftable **size which is 24"- 26**"(Figure 2).

Scion (Cutting)

The scion will become the fruit-bearing part of the grafted tree. Scion pieces should be selected from terminal branches of a desirable avocado tree variety or selection. The best scion material is from matured and hardened shoots, not ones that are young and overly succulent. Choose a shoot with plump, well-developed buds ready to flush on the selected branch terminals. Although only one bud is necessary, it is best to have at least three buds (Figure 3). Supplies needed to graft avocado. present, so cut scions 4–6 inches in length. Remove the leaves at the time of collection and store the scion wrapped in damp (not drenched) paper towels in a plastic bag in the refrigerator until time of grafting. When making the union, try to match the diameter of your rootstock and scion for optimal graft take.

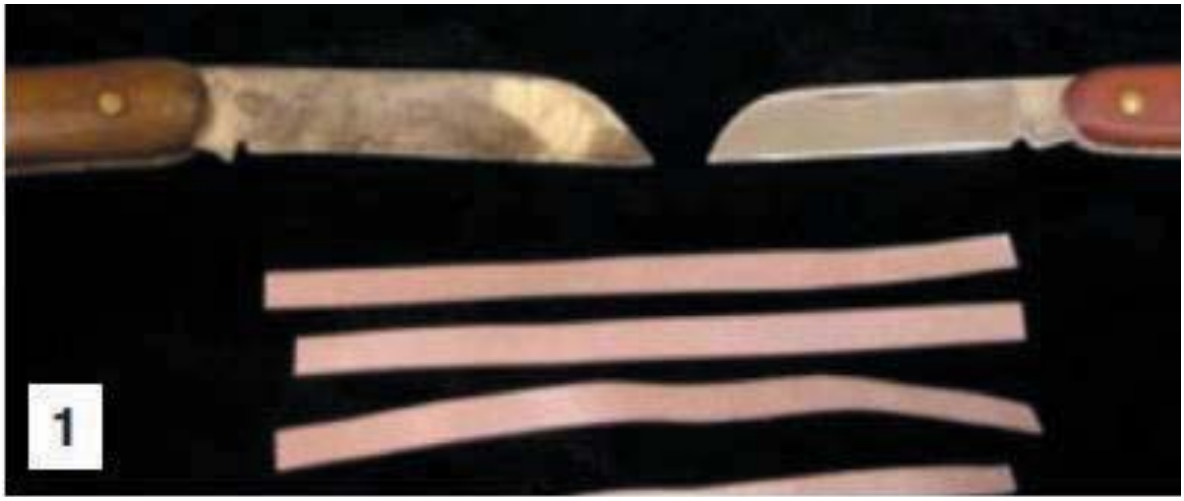


Figure 1. Supplies needed to graft avocado.

Figure 2. This is an example of an avocado rootstock. A rootstock is typically grown from a seed.

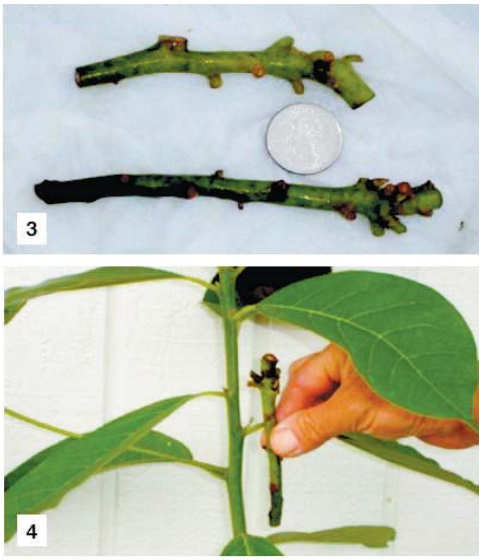


Figure 3 (top). Step 1: Selecting scion. Figure 4 (bottom). Step 2: Selecting rootstock.

3.4.5 Step-by-Step Guide to Grafting Avocado

Step 1: Select or grow your rootstock, as detailed above.

Step 2: Select your scion (Figure 3). When possible, use a scion that is of similar diameter to the rootstock (Figure 4). Try to harvest the scion and complete your grafts on the same day. Between cutting and grafting, be sure to keep the scion wrapped as detailed above to provide some moisture and prevent drying.

Step 3: Remove the top (apical growing point) of the rootstock with a sharp, clean pair of pruning shears. Make sure the remaining rootstock is about **6-8 inches high, so that the graft union is far enough off the soil surface but not so high that it might be prone to break in the wind (Figures 5A–B).**

Step 4: Using a sharp, clean grafting knife, carefully make a cut across the center of the cut surface of the rootstock. To do this, place the mid-point of the blade on the center of the cut surface. With a slight rocking motion of the grafting knife or mild tapping on the top of the knife, initiate the cut straight downward until the cut is about 1 inch deep. Carefully remove your grafting knife when the cut depth is obtained (Figures 6A–B)

Step 5: Now, holding the scion vertically with the buds (growing points) facing downwards, pull the grafting knife upward and diagonally through the base of the scion in one smooth motion. This will result in a slice that is approximately 30 degrees from the longitudinal axis. Turn the scion 180 degrees and repeat the same motion on the other side. Redo each slice as needed to achieve a wedge-shaped base on the scion (Figures 7A–B).

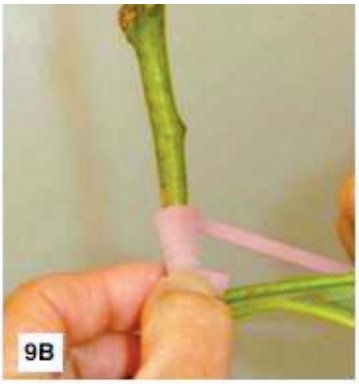
Step 6: Next, pair the rootstock and scion together. Gently push the scion into the cut on the top of the rootstock. Match the outer edges of the scion with the outer edges of the rootstock so that the scion is firmly wedged into the rootstock. Having the edges flush will help ensure optimal take by having the cambium layers of the scion and rootstock in close and direct contact (Figures 8A–C).

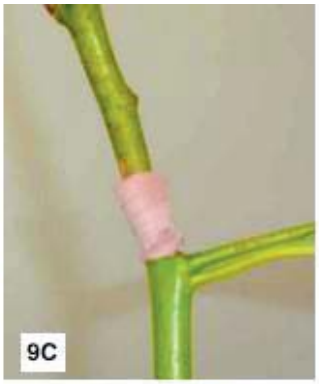
Step 7: Wrap the graft tightly with a cut rubber band or grafting tape to hold the graft in place. Avoid creating any airspaces where the scion and rootstock touch. Re-cut the scion or restart from step 4 if an airspace is present and cannot be closed with the pressure of the rubber band (Figures 9A–C).

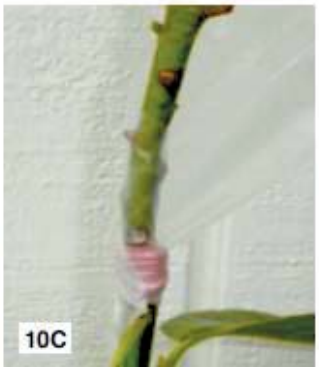
Step 8: Using a piece of parafilm, begin wrapping the scion from below the graft. Work your way upwards and then back down again. Wrap the graft union and the entire scion piece until they are completely covered to keep out potential pests and diseases from the cut surfaces. Wrapping will also help to retain moisture in the scion until the graft is successful. Once a union has formed, the rootstock will begin to provide water and nutrients to the scion (Figures 10A–D).

Step 9: After grafting, it is important to keep the grafted plant well-watered and in partial shade. It will typically take around 4–6 weeks for the graft union to heal successfully, at which time you will see new buds and growth pushing through the parafilm. You don't need to remove the parafilm, but you should remove the rubber band or grafting tape once the scion is growing successfully.

igures 7C–D (top). Step 5, continued: Making the cut in the scion. Figures 8A–C (bottom). Step 6: Placing the scion ıto the rootstock. Figures 9A–C (opposite top). Step 7: Wrapping the graft with a rubber band. Figures 10A–D (opposite ottom). Step 8: Wrapping the graft union and scion with parafilm.



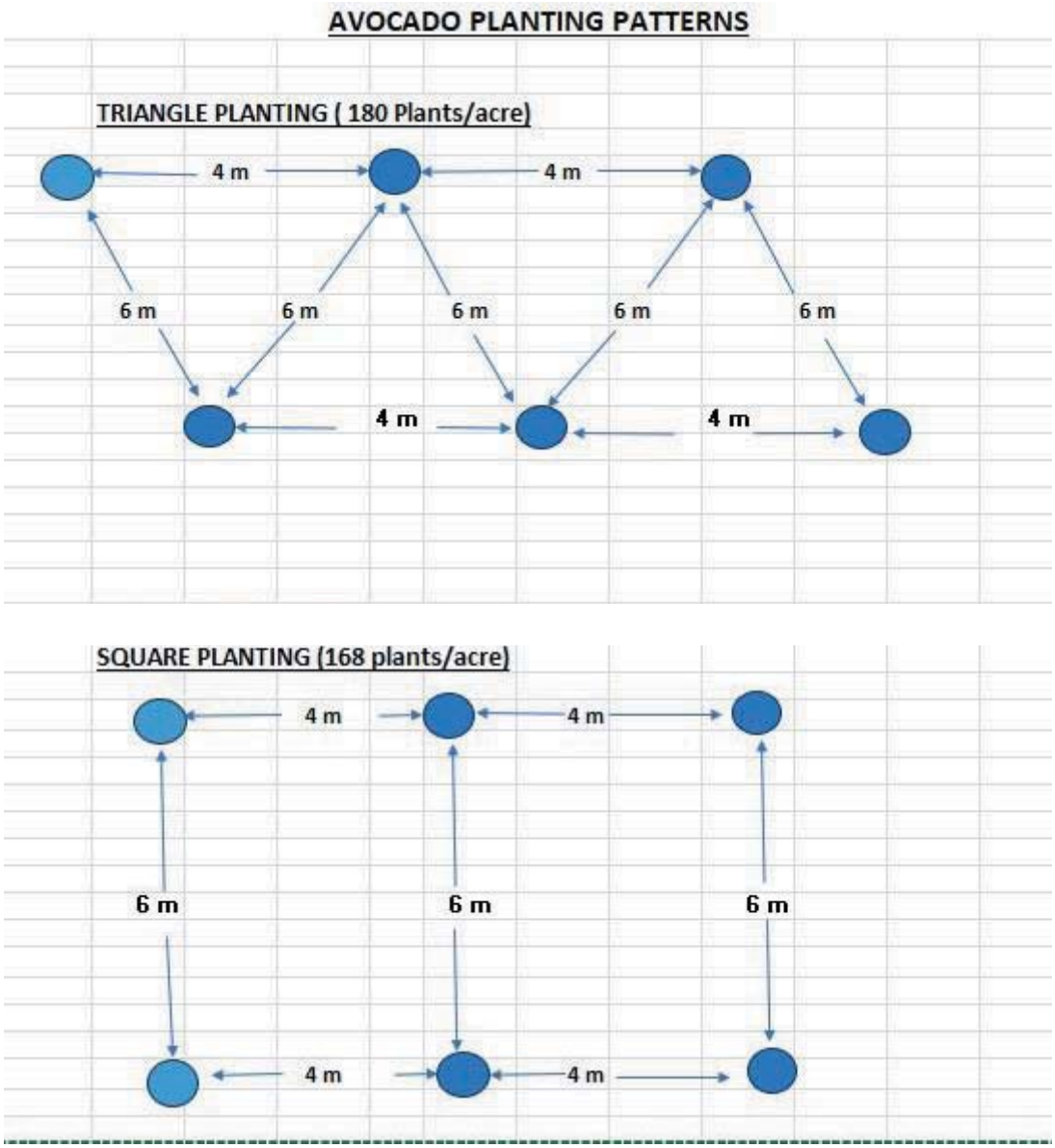


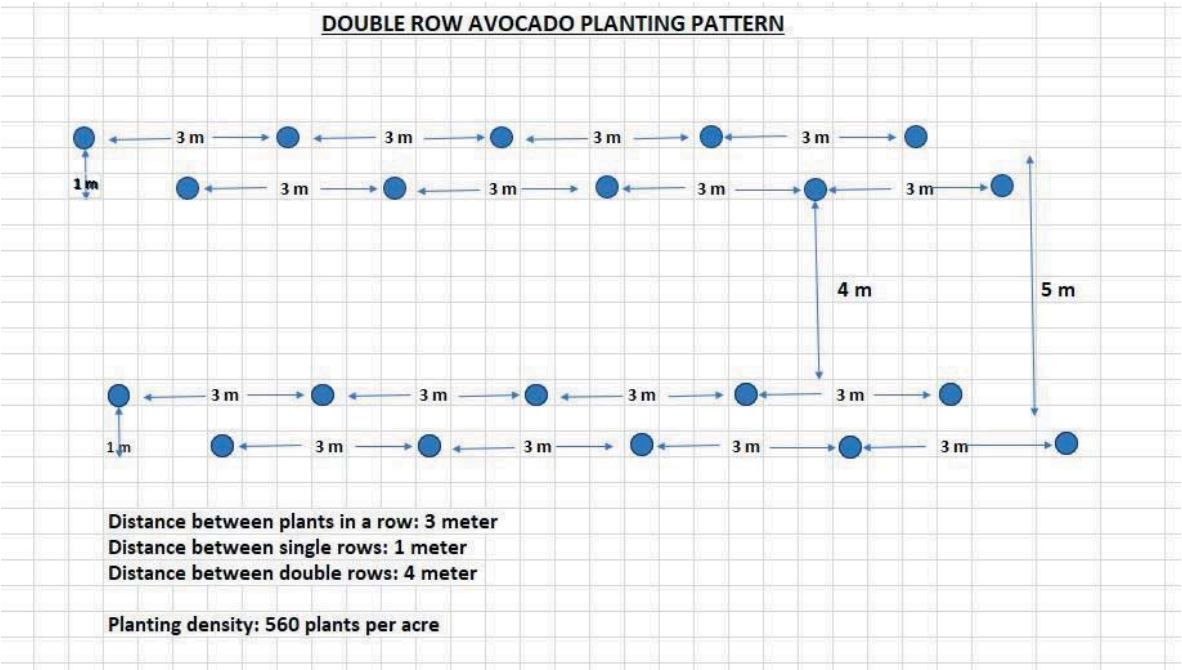


3.5 Planting

3.5.1 Planting patterns

- Select the planting distance and pattern planting. A planting distance of 4 meter between plants and 6 m between rows is recommended.





- Marking the Planting sites: Paint marks every 4 m on a wire which is long enough to be extended across the plot that is to be planted.
- Extend the wire across the terrain and fix it at both ends to wooden sticks.
- Put wooden sticks into the ground in the wire marks.
- Dig 45x45 cm. planting holes.
- Follow the planting instructions outlined in the following PLANTING PROTOCOL.

3.5.2 Avocado Planting Protocol

List of Tools, materials and Inputs For 100 Transplanting

1. Tools and materials

- Hole-digger
- Shovel
- 200Lt plastic drum
- Wooden piece for pressing the soil
- Rubber gloves
- Sharp cutting knife
- Watering can
- GI plant protector (4ft height)

2.Agriculture Inputs

- Cruiser /Actara (Thiamethoxan) insecticide :100ml
- Carbendazim Fungicide :150ml
- Growth Regulator (Atonic /Vikonic) :300ml
- Rooting hormone :500ml
- Agriculture Lime :35.0kg
- DAP : 7.5 kg
- Mycorrhiza fungus : 10.0kg
- Soco super Absorbent polymer
- Stress-Nil (Immunity Enhancer) 10gm/ plant: 1.0kg

15 -20 days before transplanting

1. Keep spacing -6mtr x 4 m
2. Dig holes 45cm (wide) x 45cm (depth)
3. Apply 35gm Agriculture Lime + 6kg compost to the dug soil and mix them thoroughly
4. This mixture should be used for transplanting

On the day of transplanting

1. Prepare the following mixture in a plastic drum
    - Water : 200lt
    - Thiamethoxan insecticide : 100ml
    - Carbendazim fungicide : 150ml
    - Growth regulator (Vikonic/Atonic) : 300ml
    - Rooting hormone : 500ml

1. Immerse the avocado plan in the prepared to soak soil in the bag (15-20 seconds) and carefully remove it.
2. Put a 10cm layer of the dug soil in the bottom of the hole.
3. Put a 10cm layer of the soil mixture on to the dug soil layer.
4. Place the avocado plant in the centre of the hole and cut the bag with a sharp knife and carefully remove it.
5. Apply 25gm of DAP+100gm of mycorrhiza fungus to the soil around the plant.
6. Put a 10cm layer of the soil mixture and press it using a wooden piece.
7. Repeat steps 5 and 6 until filling up the hole.
8. Pour 1.5 l of the prepared mixture into the soil around the plant.

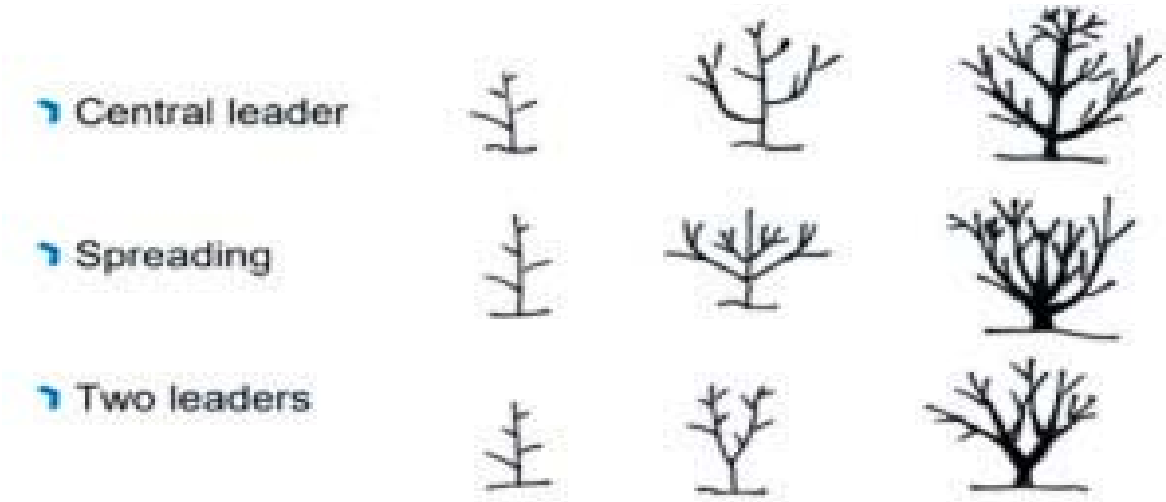
4. TRAINING AND PRUNING

Like many other fruit-bearing trees, avocados need to be trained to obtain a desirable shape/structure and size that will maximize production, balance yield and quality, and facilitate its cultivation. Before any action is taken, as a farmer myself, I would recommend that you take one step back and consider the needs and peculiarities of your field. Factors like the position of the field, the direction of the planting rows (wind exposure), the soil depth and fertility, the irrigation system, as well as the variety cultivated, the plant spacing, and the available means for harvesting should be taken into account when forming the permanent structure of the limbs.

Training should start already from the first years of the orchard establishment. This is especially important when training for the central-leader system. If the trees are grown in a field with a slope, it is best to keep them shorter. This should also be done when the field has shallow soil or a very high-water horizon.

4.1 Pruning systems

There are three main growing systems for avocado:



Usually, avocado growers choose the “spreading” system. In this case, one of the training priorities is to create one strong tree trunk that can withstand the future weight of a mature tree and a high yield. The main branches should start about 70 cm from the ground.

Branches that have more than half the thickness of the central shoot (future trunk) must be removed. Around four strong branches are also selected to be the primary limbs.

To facilitate harvesting from the ground, avocado farmers want to promote lateral growth of the trees. The farmer should take all necessary actions to encourage lateral growth and multiple framework branching.

Terminal shoots should be pinched at the beginning of the second growing season. These should be repeated until the trees have obtained the desired structure and height.

You may avoid pruning young avocado trees very strictly (excessively) since this will delay the production phase even more. Finally, after the first three years of training, the farmer should not neglect its trees and perform pruning annually. Generally, avocado trees do not need too much pruning after the 4th year of growth in the field.

4.2 Pruning techniques

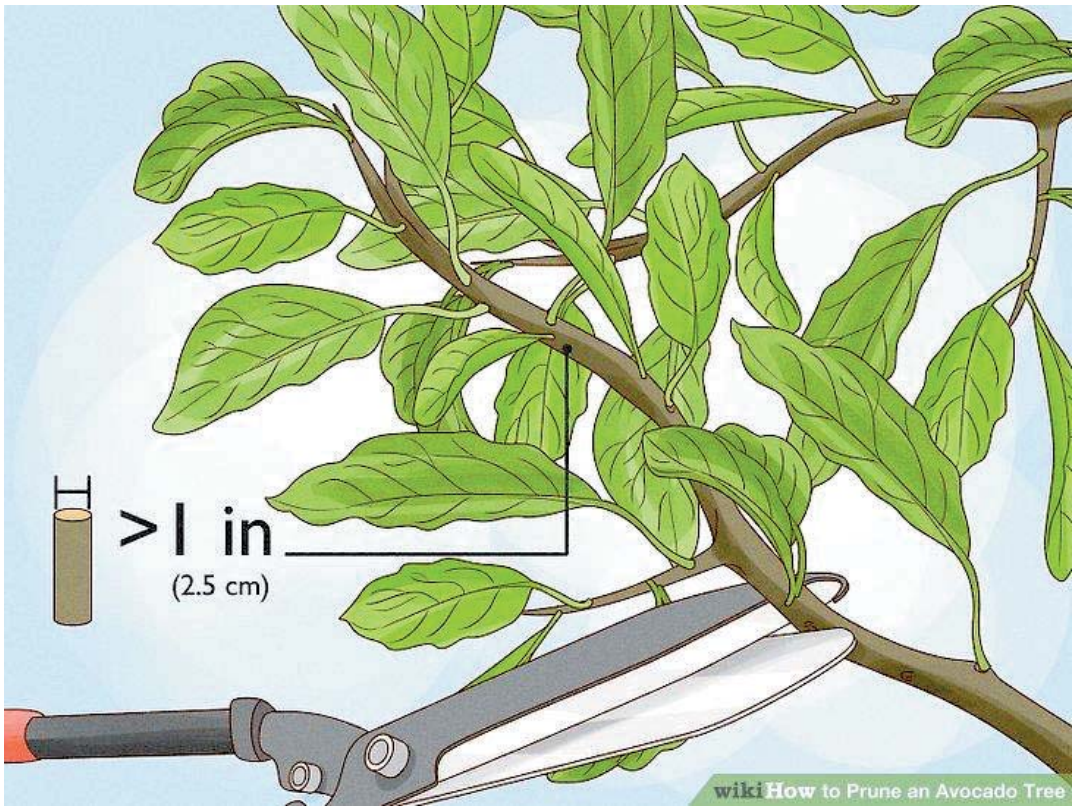
The principles to keep in mind when pruning an avocado tree are the following:

- Remove all suckers that grow from the tree's base and rootstock.
- Prune dead and infected wood to reduce the spread of the infection to healthy plant parts during the following season.
- Try to keep a more open formation with branches of lateral growth. Remove any branches that go downwards, inwards, or pinch out the terminal buds or the branches that grow straight up. Trim the branches by 1/3 or 1/4 of their size.
- If a vigorous secondary limb is shading or leads a primary lateral down, it should be (partially) removed.
- Avoid pruning the tree too heavily because it will lead to excessive leaf loss and favour vegetative growth against fruit formation.
- You can open "windows" to improve aeration and sun penetration that will help flowering and fruit set. In regions with very high solar radiation and heatwaves, it is better to leave enough vegetation to offer shade and protect the branches, the trunk, and the fruits from sunburns.
- It is better to thin the number of branches in order to maintain a 30-38 cm (12-15 in) distance between them. This will allow enough light to enter the tree canopy and simultaneously reduce the friction and bumps between branches when strong winds prevail.
- Rejuvenate the branches to keep them productive (new fruit-bearing wood). Depending on the variety, you may need to remove one major limb per year.
- Except for the training (formation pruning) and the annual pruning, there might be a need to perform regenerative pruning in very old trees where productivity has declined.
- Additionally, in high-density orchards, growers often choose to remove trees after seven years, to allow the growth of the remaining.

4.3 Pruning tools

Use hand pruners for branches less than 1 inch (2.5 cm) in diameter. These tools are smaller and can typically handle smaller growths. Hand pruners are perfect for removing smaller branches in the tree's canopy to let the sun shine through.

Choose loppers to cut any branches thicker than 1 inch (2.5 cm). Loppers are perfect for removing large branches, particularly at the base of the tree.[2] These tools often go dull easily, so sharpen your loppers often and make sure they're sharp before you start pruning.



Spray your tools with a disinfectant to keep from spreading insects or disease. Pruning tools like pruners and loppers can carry insects, fungus, and bacteria between trees, so it's essential to clean them between each pruning.[4] Fill a spray bottle with a disinfectant spray, like diluted bleach or rubbing alcohol, and keep it with you to spray down and disinfect the tools before moving on to the next tree.

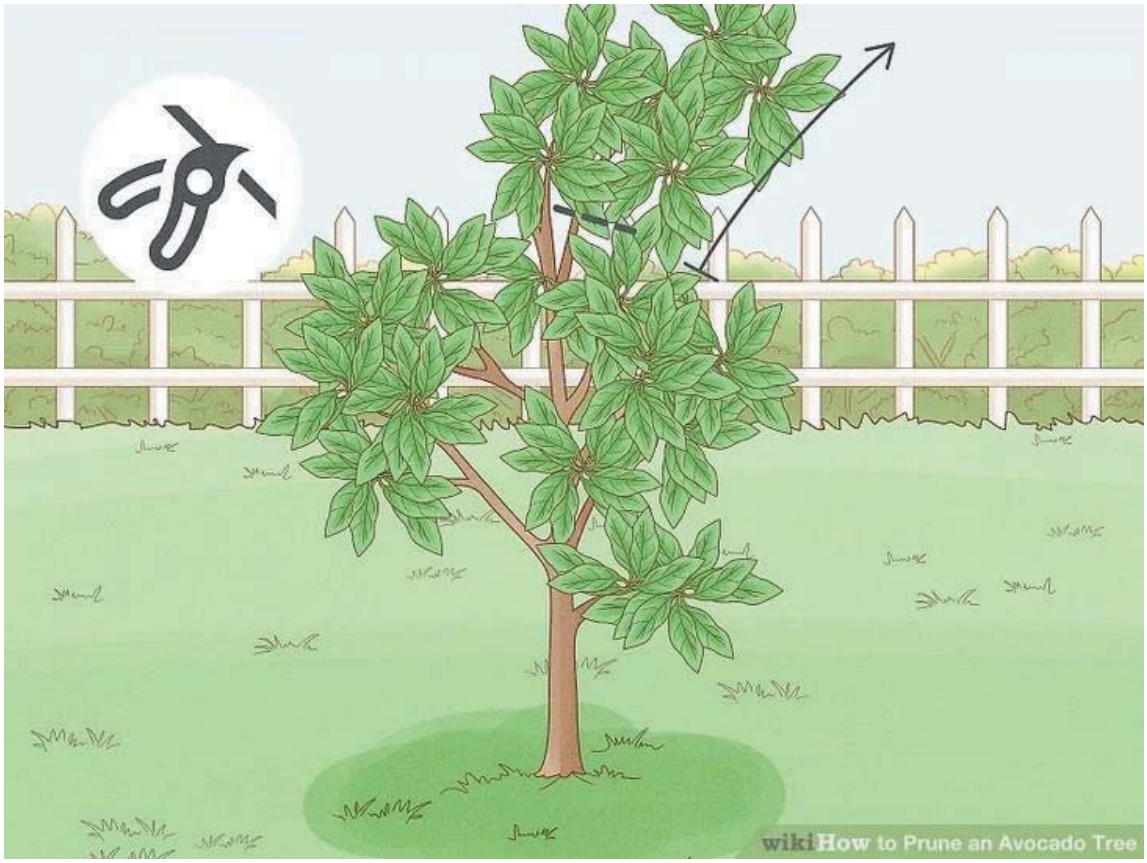
4.4 Pruning basic principles

Aim for balance and symmetry when you're pruning. Keep track of how many branches you remove from each side and mirror your cuts on the other side of the tree as well. It's important to prune the sides of the tree symmetrically, making identical cuts to either side, to balance the tree's weight.[14]

For example, if you prune several branches on one side of the tree, it may stunt fruit growth on that side. When the fruit grows, the tree's weight will be unevenly balanced and make it more susceptible to strong wind and harsh weather.

Remove branches at the top of the tree to control its height. Use your loppers to trim back the top slowly, removing only 1 major branch per summer, starting with the tallest. This is especially important for newly planted trees, which don't have a strong enough root system to support extra height.

- Be extra vigilant with trees purchased from nurseries, which will likely have a good deal of the roots removed.
- This process may take 3-4 years to complete, but the slow and steady approach will help reduce stress on the tree.



Cut away any dead branches at their base. Use your pruners or loppers to cut away dead branches just above their connection to the trunk, or the branch collar. This will direct the tree's nutrients to the healthy limbs and promote new growth.

4.5 First Pruning

The first pruning of a young avocado tree is done when the tree is 1.20-1.50 meters high (8-12 months after planting). As most of Sri Lanka is, the spreading pruning method is recommended for slopy fields.

The following practices are done in the first pruning to start training the avocado tree in the spreading method:

- Cut 4" of the apical branch, measured from the top, to promote the growth of the lateral branches.
- Remove all branches coming from the rootstock.
- If the tree has two main branches, remove the weakest, leaving the stronger as the main branch.
- Leave without branches 8" (20 cm) from the ground to the first branch by cutting the sprouts in this part of the tree.

4.6 Preventive pruning year around

Use preventive pruning often to reduce the need for major pruning. Use your hand pruners to cut away any growing tips in areas where you don't want new branches. Since heavy pruning tends to lower the fruit yield and make the tree just grow back faster, frequent thinning cuts are a much better way to keep the avocado tree's growth in check.

Remove water shoots to prevent imbalances. Before the tree flowers in the spring, use your hand pruners to trim away any water shoots at their base. These vigorous, leafy shoots grow vertically in the bark and pruning them helps keep the tree's growth lateral and controlled, rather than wild and untamed.

Fix small limb breakages by cutting away the branch at its base. If your branches have been broken by the weight of their fruit or a strong wind, you should remove them completely. Use your loppers or hand pruners to cut away any small broken branches at their base. This will help redirect nutrients to the rest of the tree and encourage branch regrowth.

Control wild growth by using thinning cuts. In any areas of the tree that tend to grow quickly and get out of hand, prune smaller branches back to their main subtending branches. These “thinning cuts” will help keep the tree’s growth in check and prevent wild growth in the future.

Nip minor issues in the bud so they don't become major problems. If you spot any wild branches starting to form, such as at the top or low to the ground on the sides, it's much easier to cut them with loppers or pruners while they're still small. Waiting until they've grown will make the pruning process more difficult and can potentially cause the tree more stress.

For example, watch for horizontal branches forming close to the ground. These branches will grow to block your access at the base of the tree, so cut these back at their base as soon as possible.

5. WEED MANAGEMENT

- Integrated weed management uses multiple strategies to manage weed numbers in an economically and environmentally sound manner. Strategies usually include various combinations of cultural, mechanical, chemical, and biological methods.

- Weeds compete with trees for water and nutrients, primarily during the grove's early years of growth. Weeds are usually a minor concern in healthy, mature groves that have thick mulch and a dense canopy that shades the ground.

- Weed competition may be a problem in nurseries and in older groves where trees have been heavily pruned or are unhealthy and have a sparse canopy, allowing more light to reach the soil surface.

- A dense canopy that shades the soil reduces the amount of sunlight that weeds need to grow to be competitive with the trees. Competition is strongest from perennial and summer annual weeds. If tall or dense weeds are allowed to excessively compete with young trees, the trees may start producing fruit much later than those with minimal competition.

- Weeds within groves, along orchard borders, and on roadsides may host or harbor pests that attack fruits or trees. Weeds on field margins can also serve as a reservoir for future weed problems, because seeds can enter the orchard with the wind or on equipment. Additionally, weedy vegetation along field margins can spread wildland fires into groves.

5.1 Mulching

After planting, maintain a thick layer of organic mulch beneath the canopy to just beyond edge of the tree canopy (i.e. the drip line). However, to avoid crown disease problems, keep mulch thin near the tree trunks. Mulching and hand-weeding provide the best and safest weed control around young trees in most situations.

5.2 Mechanical weed control

1. Cultivate using a hoe.
2. Cut down weeds with a cutlass or a motorized brush cutter.
3. Irrigate to germinate seeds near the surface.
4. Cultivate shallowly to destroy seedlings.
5. Repeat at least once to be effective.

5.3 Chemical weed control

It is possible to apply preemergence herbicides before planting to the entire grove or to strips 4 to 6 feet wide where trees will be planted. If weeds have emerged, use methods such as cultivation or contact herbicides before planting trees.

After trees are planted, a preemergence herbicide can be applied additionally. Be aware that some preemergence herbicides should not be applied before planting or near young trees because they can injure avocado trees. Be sure to follow the instructions of the current herbicide label.

The chosen control methods depend on the extent of canopy shading and mulching, irrigation frequency and method, need for erosion and runoff control, soil type and rockiness, spectrum of weeds present, terrain, tree spacing, and considerations such as economics and grower preferences. Combine several methods and take action at the appropriate time to obtain good control.

6. FERTILIZING

The avocado tree is known for its superficial root system, a fact to be considered in agricultural practices such as irrigation, cultivation and fertilization. The use of inorganic sources of fertilizer materials is practiced through-out most of the avocado-growing countries. Since soils in Kandy and Badulla are Red Yellow Podzolic lateritic, **which have a low fertility, it is very important to have a complete soil analysis to design a proper fertilizing program.**

Soil analysis should be done for formulate a fertilizing program. This soil analysis includes:

6.1 Physical properties of the soil:

- Texture
- pH: It is important to note that an ideal pH for avocado production is between 5.5 and 6.5.

6.2 Nutrient content in the soil

Macronutrients:

- NITROGEN
- PHOSPHORUS
- POTASSIUM

Secondary nutrients

- CALCIUM
- MAGNESIUM
- SULFUR

Micro-nutrients

- BORON
- CHLORINE
- COPPER
- IRON
- MANGANESE
- MOLYNDENUM
- ZINC

Foliar analysis remains a useful auxiliary tool for fertilizer recommendations. These analyses enables to uncover any extreme deficiency or excess which demands special fertilizer treatment.

6.3 The role of nutrients in avocado cultivation

Nitrogen

This element is considered to have a great influence on the growth of the avocado tree and is therefore commonly used. Nitrogen 'deficiency symptoms are expressed by restricted growth, pale, small-sized leaves, and early leaf shedding. In cases of acute lack of N, the veins turn yellow. Yields were markedly decreased when trees were not fertilized for several years.

Phosphorus

Symptoms of P deficiency is expressed by decreased vegetative growth, small round leaves, early leaf shedding, and branch dieback. Leaves are brownish-green in color and burnt.

Avocado plantations have not shown any definite P deficiency symptoms. In cases of low P level in the leaves and its successful raising by fertilization, the effect on yield was nil. Still, the practice continues of supplying P fertilizer to avocado plantations growing on poor soil. It has been shown that excess amounts of P are likely to cause Zn deficiency symptoms.

Potassium

Deficiency of Potassium: The leaves were small and narrow, brownish-red necrotic spots began to appear on older leaves, subsequently, the spots spread over the whole leaf blade between the large veins.

On severely deficient trees, the twigs were very thin and some dieback occurred. However, in another research work, deficiency symptoms began to appear on the leaf base and petiole and advanced through the central and secondary veins towards the tip. It is of interest to note that interveinal necrosis was also a symptom of K excess. As with P, there have been no reports of K deficiency in avocado plantations

Boron (B)

Avocado trees probably use more boron than any other crop, mainly for good flower formation and fruit-set. Boron is essential for Ca transport within the tree, and for normal development of growing shoot tips (apical meristems), especially during pollination, as it enhances pollen-tube growth, which directly increases fruit-set rate.

B is also essential for normal branching, normal formation of flowers, fruits and roots, synthesis of nucleic acids, and metabolism of carbohydrates. Its weak negative charge makes it very sensitive to leaching, hence- to low use efficiency. Higher use efficiency is obtained if the soil is rich in organic matter, or if the boron is applied complexed with humic acid. Sugar-borate complex is mobile in the tree's xylem, but its phloem mobility is limited.

Zinc

Zinc is a key structural and catalytic component of a large number of proteins, as cofactor for over 100 specific enzymes, transcription factors and protein interaction domains, and nucleic acids synthesis. Zinc is essential for the transformation of carbohydrates and regulation of sugar consumption in the plant. It is indispensable for producing the auxin IAA and Gibberellic acid. Therefore, Zn deficiency causes growth retardation, and 'little-leaf' and rosette growth pattern. Zn- root availability is highest at soil pH of 5-7.5, and much lower on both sides of this range. Its availability is negatively related soil to phosphorus availability. Zn deficiency symptoms: Leaves' mottled interveinal chlorosis, they are smaller than normal, and have a rosette growth pattern. Also, small rounded fruits.

Copper

In most of the Cu functions as a plant nutrient, it is bound to enzymes, which catalyse redox reactions in photosynthesis, respiration, C- and N- metabolism, and protection against oxidative stress. It forms highly stable complexes, and participates in electron transfer reactions, in which it continuously changes its valence between +2 and +1. Cu-

enzymes react in living cells directly with molecular oxygen. More than 98% of the Cu in plants is present in complexed forms in cells' cytoplasm. Cu- root availability is highest at soil pH of 5-7.5, and much lower on both sides of this range. Its availability is also positively related to soil organic matter. Cu deficiency symptoms: older leaves have a dull appearance. Shoot tips have multiple bud formation. New leaves abort and dry up.

Iron (Fe)

Iron is a constituent of two major protein groups, namely, the Heme, and the Fe-S-proteins. These macromolecules are involved in respiratory and photosynthetic activity, essential for numerous plant functions. A central one is, of course, chlorophyll production and functioning, but other important functions are redox reactions, dealing with respiration, energy transfer and metabolic processes, within the plant. Several Heme proteins act as cofactors of the cytochromes, involved in respiratory reactions. Other Hemi proteins include catalase, and peroxidase, converting hydrogen peroxide into water and O_2. Fe-S proteins have a strong involvement with the light dependent reactions of photosynthesis. Ferredoxin, that contains iron atoms, is the end product of photosystem I, and it transfers electrons to a number of acceptors. Fe- root availability is highest at soil pH of 4–7, and much lower above 7. Most prevalent avocado Fe deficiency symptom is interveinal chlorosis of young, fully expanded leaves.

Manganese (Mn)

Mn functions mostly in activating many enzymatic systems, and is also a constituent of certain enzymes. It participates in a variety of redox processes, such as enzymes, involved in breakdown of carbohydrates, and as a cofactor of enzymes reducing nitrate to nitrite. It also plays important roles in photosynthesis, pollen germination, and growth of the pollen tube. Mn is rather immobile within the active transport phloem system. So, its deficiency symptoms will firstly appear on younger leaves. Manganese root availability is highest at soil pH of 5-7.3, and much lower on both sides of this range.
Most prevalent avocado Mn deficiency symptom is interveinal chlorosis of young, fully expanded leaf.

Molybdenum (Mo)

Molybdenum is vital in the avocado tree for the reduction of nitrates, on their way to protein synthesis. Mo- root availability is highest at soil pH above 6.5, and much lower-below 6.5.

The following table is a suggested fertilizing program:

FERTILIZING RECOMMENDATION FOR AVOCADO MANUAL(EDAFIC) APPLICATION							
Amount (gr) per tree per cycle (4-month cycles)	AT PLANTING	4	8-12	16-20-24	28-32-36	40-44-48	52 ONWARDS
DAP	75	100					
UREA			100	500	850	850	1000
TSP			180	180	180	180	180
KCL (MOP)				450	750	750	1000

FOLIAR APPLICATIONS: Apply BORON+ZINC+MICRONUTRIENTS foliar fertilizer from pre-flowering, during flowering and the filling of the ftuit. Apply every 30 days.

6.4 Nutrient deficiencies symptoms

Nitrogen (N): Small narrow pale leaves that become stiff and slightly inwardly rolled. Growth is stunted with reduced fruit production.

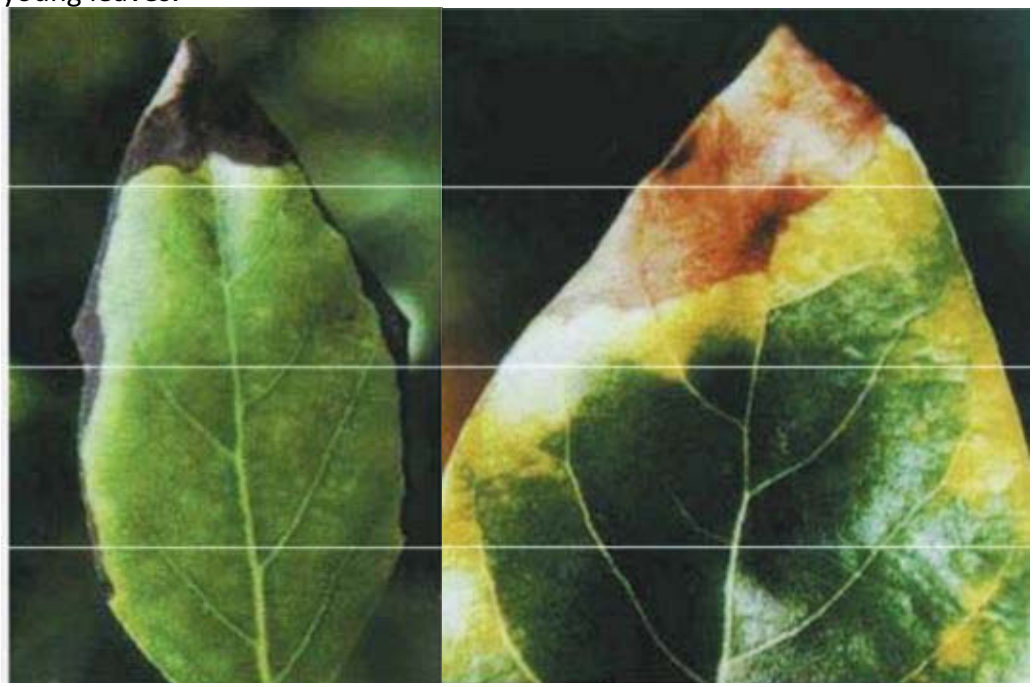
Phosphorus (P): Irregular, interveinal, necrotic spots on older leaves.

Potassium (K): Blackening of vascular bundles of the fruit. Large irregular necrotic spots on old leaves, followed by interveinal chlorosis and smaller fruit size.

The potassium (K) is known to Help regulate avocado fruit acidity, while increasing the oil content in the fruit.

Calcium (Ca): leaves Deformation of the leaf, this symptom is common in **highly leached acid soils (pH 4.5).**

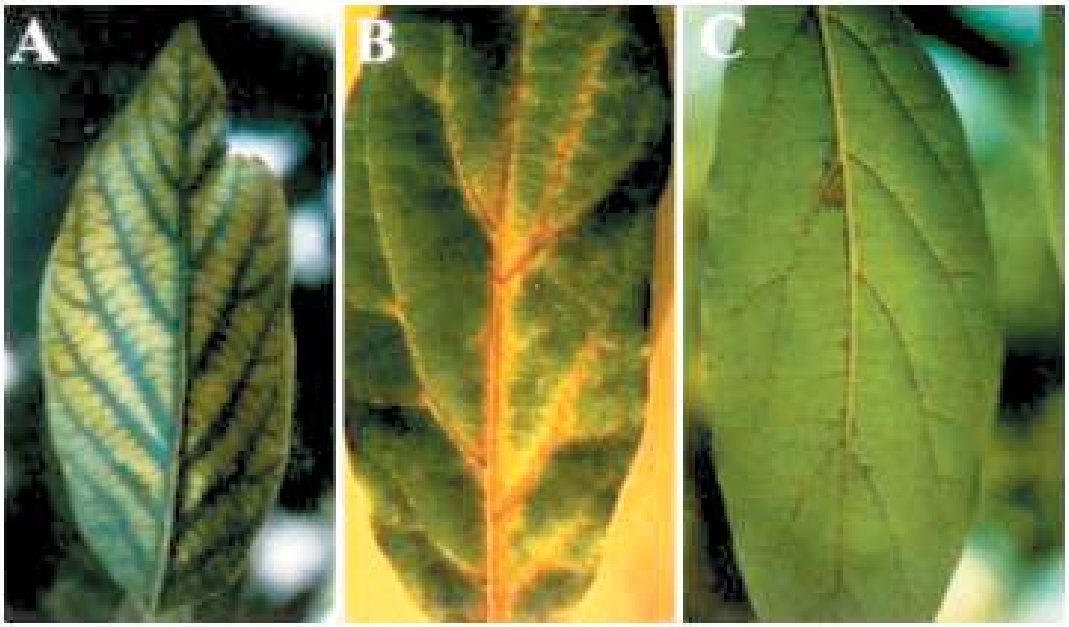
Interveinal yellowing and narrow dark- green strips along the veins. Symptoms show on young leaves.



Mg (magnesium): Interveinal chlorosis progresses inward from leaf margins and from the tip towards the base of the leaf. Develops first in older leaves.

Iron (Fe): Interveinal yellowing and narrow dark- green strips along the veins. Symptoms show on young leaves.

Manganese (Mn): Interveinal chlorosis, with small reddish- brown spots, mainly appear on young leaves.



Zinc (Zn): Fruit becomes rounded and can acquire a reddish discolouration. Smaller leaves, with shorter internodes which produces a "feather duster" appearance.

Boron (Bo): Small holes form in the interveinal areas with a narrow pale halo around each hole. In severe cases, necrotic lesions develop on branches and trunk.
Fruit shows a wide range of abnormal symptoms like bumps, sickle-shaped growth and sunken corky lesions.

Copper (Cu): The terminal and young leaves are the most affected and are usually smaller than normal leaves. Shortening of internodes and death of growth tips.

7. DISEASE AND PEST MANAGEMENT

7.1 Major Avocado Diseases: Symptoms and Management

Phytophthora

Symptoms: Foliar symptoms of Phytophthora root rot include small, pale green or yellowish leaves. Leaves often wilt and have brown, necrotic tips. Foliage is sparse and new growth is rare.

Small, fibrous feeder roots are scarce at advanced stages of this disease. Where present, small roots are black, brittle, and dead from infection.

Disease Management:

Since no definitive measures have yet been found to control the disease, an integrated approach to managing the disease has been found to be most effective. This approach includes the following preventative measures, cultural practices and chemical treatments:

1. Cultural Practices

- Provide favourable soil conditions.
- Use certified disease-free nursery stock.
- Prevent soil or water movement from infested areas.
- Irrigate carefully, not too much water
- Provide appropriate nutrition
- Avoid water retention in the basin of the trees by making hand-dug drainage trenches.

2. Chemical Control:

- Metalaxyl (Ridomil®) can be applied as granular, drench or with irrigation water.
- Drench the root system with 2.5g of Ridomil/Laxy(8%Metalaxyl+64%Mancozeb) mixing in 1 Ltr of water (one Ltr of fungicide solution is required for a plant)

- After 2-3 weeks of Ridomil applicaton 1 ml or 1 g of Carbendazim mixing in 1 Ltr of water should be drenched to the root zone of the plant .(one Ltr of fungicide solution is required for a plant).

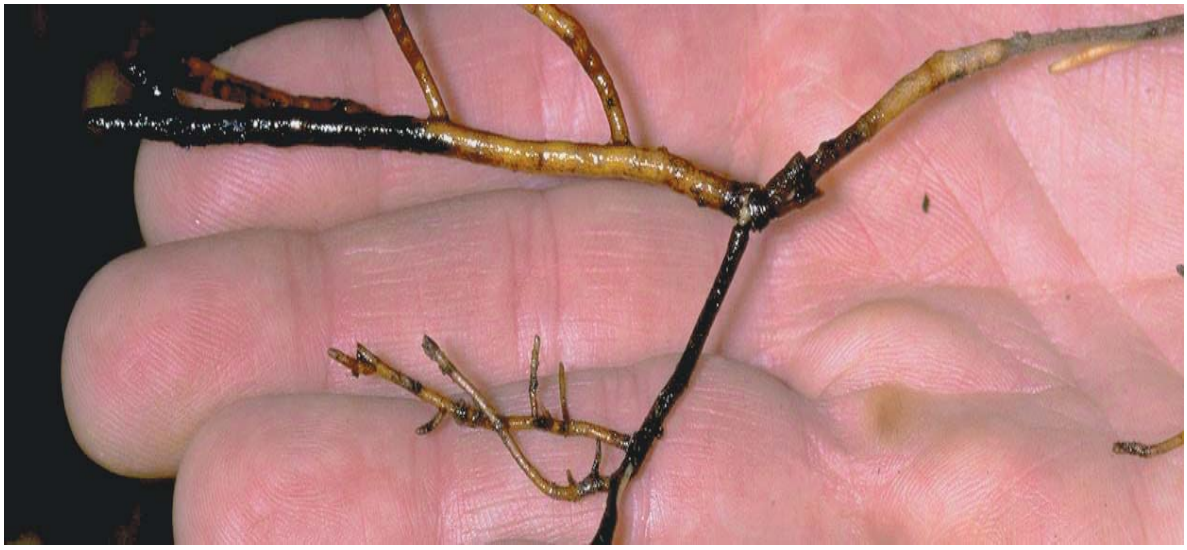
If the attack is very intense and advanced, it is advisable to uproot the tree with all its roots, remove it from the plot without dragging it, and burn it. Afterward, remove the soil in the hole and discard it outside the plot, then the hole and its surroundings should be disinfected with one of the following soil fumigants:

Granulated basamid: Spread by hand (use gloves), at a rate of 200 gr./m2. Then give a light dig and water thoroughly, so that the product goes deep and reaches the roots.

Vapam: Products of 410 gr./liter

Solasán 510 and Fumathane: at a rate of 200 c.c./m2.

After 2 months of disinfection a new avocado tree can be planted at the site.



Fusarium

Internal Symptoms: The fungi interrupt the transport of water and nutrients in branches of affected trees. Infected wood is discoloured brown to black. Scrape away bark around beetle entry and exit holes to easily see discoloured wood. Cross-sections of cut branches show the extent of infection

Management: Early detection of infestations and removal of infested branches will help reduce vector beetle numbers and the extend of disease spread.

Chemical Control: Apply the same treatment described above for controlling Phytophthora

Powdery Mildew

Avocado powdery mildew is caused by a type of fungus called Oidium. The disease only affects the leaves. In general, powdery mildew is not considered a serious disease impacting avocado trees.

Signs that you may have powdery mildew will show on the leaves of your avocado tree. On younger leaves, look for darker green spots that are covered in a powdery substance.

Management: Spray with Thiophanate-methyl, Chlorothalonil.

Anthracnose

Symptoms: Anthracnose symptoms can develop on flowers, fruit, leaves, or twigs. Infected fruit is the most serious concern, but most fruit damage does not develop until after harvest.

After harvest, lesions become blacker, larger, and increasingly sunken.

Management:

- Prune out dead limbs and twigs where fungi sporulate. If many dead leaves are entwined in the canopy, knock them out of the tree.
- Prune low limbs to at least 2 feet off the ground to reduce humidity within canopies by improving air circulation.

Copper, Tebuconazole, Hexaconazole fungicides thoroughly sprayed on healthy tissue can prevent infection.

Scab Disease

Symptoms: The symptoms on the fruit are the scabs that the disease is named for. They appear as raised bumps with irregular borders and can be brown or purple in color. The lesions are generally 3mm in diameter but have been measured up to 10mm.

Management: Some fungicides, including **Carbendazim**, Tebuconazole, dicopper chloride trihydroxide, copper sulfate and copper hydroxide may be used as flower buds begin to appear on the avocado tree.

Stem end Rot

Symptoms: A dark rot develops from the stem end as fruit ripen after harvest. A dark brown to black rot begins at the stem end as a dark brown ring and the rot proceeds towards the other end. The rot produces dark streaking of the water-conducting tissues (this symptom distinguishes stem end rot from anthracnose).

Management: As water stress during fruit development may predispose fruit to infection, manage irrigation and root rot control carefully. Pre-harvest sprays of fungicides to control bacterial black spot or anthracnose may reduce the incidence of stem-end rot in fruit. Prune trees to improve ventilation and spray penetration. Remove dead branches from trees.

Pre-harvest sprays of **Carbendazim, Tebuconazole, Copper** fungicides to control bacterial black spot or anthracnose may reduce the incidence of stem-end rot in fruit. Prune trees to improve ventilation and spray penetration. Remove dead branches from trees. Avoid harvesting immature fruit.

Erwinia (Soft Rot)

Symptoms: In avocado, the fruit has a darkened metallic sheen externally. Internally, the flesh is grey to black and soft with a putrid smell.

Bacteria survive in crop debris and infect by water splash through damaged tissues.

Worse in hot wet weather. The bacteria spread in contaminated water.

Infection is through injuries to the fruit, storage root or stem (for example through grub holes or fruit fly stings).

Management: There is no treatment for the affected crop. In future crops, use certified seed and clean and disinfect seed cutting and handling equipment. Develop a long-term crop rotation program.

Do not recycle washing water. Provide good aeration to dry storage fruits.

7.2 Major Avocado Pests: Symptoms and Management

Fruit Fly

The avocado is not considered a suitable host for fruit fly development. De Villiers & Van den Berg (1987) state that under normal orchard practices no larval development takes place in the avocado fruit. There are however, isolated instances where larvae can be dissected from over-ripe fruit rotting on the ground underneath the avocado tree.

Male Fruit Fly

Female Fruit Fly

Aphids

Symptoms: Fruit aphids sucking sap from leaves, stems and sometimes the fruits of trees. Although this can affect the plants appearance the plant's vigour and yield are in many cases not greatly reduced.

Many aphids have substances in their saliva that cause a variety of symptoms, such as stunted growth, leaf curling, distorted fruits and discoloration of the foliage.

Management: Apply contact-action insecticides, **Imidocloprid,**

Thrips

Symptoms: Thrips damage causes discoloration, distortion, premature drying, and shedding of leaves, flowers, and buds. Feeding can also impact a plant's ability to grow, causing stunting or dwarfing.
Infested fruits are discolored, deformed, and scabby.

Management:

- Apply organic mulch around the plant.
- Spray thrips **with Imidacloprid, Thiamethoxan, Pymetrozine, Abamectin.** Use of pyrethrins is recommended to avoid severe mortality of natural enemies

Mites

Symptoms: Persea mites (Oligonychus perseae) are found feeding in colonies along midribs and veins on the undersides of avocado leaves. Their increased feeding produces the most damage and involves defoliation of the trees.
This increased defoliation increases the risk of sunburn to new fruit, which results in premature fruit drop. The defoliation also promotes new growth, which fosters thrips populations.
Colonies of perseamite occur on undersides of avocado leaves.

Management: Spraying the underside of leaves with a forceful stream of water can reduce mite populations on a few small trees where this is feasible. If mites become too abundant, horticultural (narrow-range) oil or **Fenpyroximate,**

Abamectin can be sprayed on foliage. Be sure to thoroughly cover the underside of leaves where persea mites occur.

Caterpillar

Young amorbia larvae chew the leaf surface, leaving a thin brown membrane or skeleton of leaf veins. Mature caterpillars consume the whole leaf, starting in the centre or at the leaf edge. Young larvae often web terminal leaves together and feed within them. This damage becomes apparent when terminals grow and unfold. Mature avocado trees can tolerate considerable larval chewing without severe effects on tree growth or fruit yield.

Management: Several insecticides (**Novaluron, Spinosad**) are labelled for use against avocado caterpillars. *Bacillus thuringiensis* (Bt) is an alternative that has effect on certain types of caterpillars and is sold under several trade names.

Stem Borer

When present, borers cause a recognizable hole in branches. This entrance to a larval feeding tunnel often exudes sugary sap that turns white and flaky. Infested branches with tunnels can be easily broken by wind.

Management

- Protect trees from sunburn and injuries, such as by whitewashing exposed bark.
- Provide appropriate irrigation to keep trees healthy.
- Remove badly diseased or borer-infested trees and branches from the orchard. Promptly destroy brush piles. Branch and twig borers can emerge from cut limbs and attack nearby trees.
- Spraying insecticides does not kill borer larvae because they are protected inside the branch. Consequently, pesticides are not recommended for this insect.

Pit Borer

Avocado pit borer (Stenoma catenifer): Feeds on the fruit by drilling holes in the pit that damage its quality.

Management

- Pheromone traps are a pest control technique that uses the sexual attraction of insects to trap them. The traps release pheromones that attract male borers, which prevents them from mating with females, thus reducing the borer population in the crop.
- Chemical control by fipronil (1ml / 1l of water)

- Application of Folicur 10ml

8. HARVESTING AND PROCESSING AVOCADOS

By German A. Cadavid

8.1 When to harvest

Harvesting avocados at the right stage ensures that the avocado has full flavor and nutritional value. It is best to harvest the avocado when it is mature but unripe, and this is achieved through observation. A mature avocado usually has a dark green skin and a firm texture when gently squeezed. The skin may also have small bumps or a pebbled texture. These are positive indicators of maturity.

If you think your fruit might be ready, check it with ripening and dry matter tests. Fruit should pass both tests before you start picking.

Ripening test

- Pick 5–10 representative fruit and allow them to ripen at room temperature.
- Mature fruit will:
    - ripen within 7–12 days without shriveling
    - have good flavour
    - not be watery.

Dry matter test

Percent of Dry Matter the easiest and accurate maturity test for avocados. The % DM at which you harvest will depend on the variety and the intended market. The export market standard for Hass is now set at a minimum of 23% and a maximum of 28%.

This is based on an average DM over a sample of at least 10 fruits.

A sample of the flesh of a fresh fruit is taken. The sample is weighed to obtain the “wet weight”. Fruit is then dried in either an oven or microwave until all moisture has evaporated. It is then weighed again to obtain the dry weight. Dry matter content is calculated using the following relationship:

DM=(dry weight / wet weight) x 100 = % Dry Matter

Dry matter electronic testers are now available (see photo below)

8.2 How to harvest

- Avoid picking fruit when wet or fully turgid as this increases the risk of postharvest rots, sensitivity to mechanical abrasion and lenticel damage.
- Harvested avocados should not drop to the ground as this will result in mechanical damage of the fruit. The Hass variety should be 'snip' picked (cut from the tree with a pair of special harvesting tool).
- Avoid picking fruit during hot weather. This will shorten the shelf life of the fruit unless the field heat can be removed within a few hours of harvest using forced air-cooling.

Telescopic fruit picker with collecting bag

8.3 Transport to Processing Facility

The harvested avocados are collected in20-kg plastic trays and transported to the processing facility the same day. Avocados should be protected from dust and sunburn during transportation.

- Keep harvested fruit cool and shaded
- cover bins with a cover or green branches
- place bins in the shade.

8.4 Grading and packing

- **Sorting**: There is an initial hand sorting step to separate out the defective fruit, including issues such as decay or sunburn, which is followed by an optical sorting step to remove any fruit that does not meet product specifications.

- **Wash Step**: The avocados receive a single-pass wash with sanitizer as they pass through different coloured brushes, where each brush serves a specific purpose: the green brushes are for agitation and application, the red brushes are for water removal and the black brushes are for polishing

- **Fungicide application:** Registered postharvest fungicides should be applied to fruit within a few hours of harvest. Follow the label instructions for exposure time for effective coverage and timing after harvest.

- **Grading and packing: Packing** lines should be short and padded to prevent fruit damage and also cleaned regularly. when packed; avocados are sized into categories based on the weight of an individual fruit. These sizes are named according to the number of fruits from each size category needed to fill a 25-pound carton.

For example, a “size 48” avocado refers to the size category where 48 avocados placed in carton have a net weight of 25 pounds. Using this method, the larger the size designation, the smaller the fruit. As with maturity standards, the Avocado Inspection Service has the responsibility of monitoring the size of the individual fruit in each carton and, in addition,

Grading

Size	Total Weight
28	13.75 – 15.70 oz.
32	11.75 – 14.00 oz.
36	10.50 – 12.50 oz.
40	9.50 – 11.50 oz.
48	7.50 – 9.50 oz.
60	6.25 – 7.50 oz.
70	4.75 – 6.25 oz.
84	3.75 – 4.75 oz.

8.5 Food Safety Considerations

For an avocado harvesting and packing operation, some of the leading food safety concerns are:

- Sanitation of the harvesting tools – Tools should be cleaned and sanitized, including having a clean place to store them while the workers are on break, and the company needs to have a program in place to store the knives overnight instead of having the workers take them home with them.

- Sanitation of the harvesting bags and bins – Cleaning and sanitizing of the bags and bins needs to occur on a regular and frequent basis. In this case, they are using bags that need to be laundered (differently from how you would clean a bin or harvesting bucket).

- Testing and changing of the wash water – The avocados are exposed to water during the hydrocooling and packing process. The water needs to be frequently tested and changed when needed, based on the policy in place.

- Worker hygiene – Since the harvesters touch every avocado they harvest and the workers at the packing house hand sort and pack them individually, there is a lot of handling taking place. Whether they are using their bare hands or gloves, there needs to be a hygiene policy in place to ensure that hand washing occurs every time before they return to work, and if they are using gloves, that they are clean and/or switched out regularly. This is even more so a topic with avocados now that it is recommended that the consumer washes the exterior portion of the avocado prior to cutting into it.

8.6 Temperature ranges

Always aim to pack and cool fruit within 24 hours of harvest, especially if the fruit is destined for export or expected to remain in the supply chains for more than 2 weeks.

Avocados need to be cooled as soon as possible after picking and packing to maintain quality.

The temperature for cooling hard, green mature fruit depends on the variety:

- 4°C to 5°C for Hass with a maximum storage time of 4 weeks
- 6°C to 8°C for other varieties with a maximum storage time of 2 weeks.

Use forced air-cooling if warm fruit needs to be cooled before packing. This is a more effective way of removing heat from fruit than room cooling (up to 10 times faster) and preventing condensation from developing.