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# *Integrated Production Manual for the Avocado Value Chain in Akkar*

## **GAP GUIDE**



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## I- INTRODUCTION TO GAP ANALYSIS

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The demand for avocados in Lebanese and middle-eastern markets has increased significantly in the last few years. Given the competitiveness of this value chain, farmers across Lebanon are showing a lot of interest in farming avocados. Through the ongoing “Private Sector Development Programme” implemented in partnership with Expertise France, the Rene Moawad Foundation (RMF) aimed to strengthen the entire infrastructure of the avocado value chain in the Akkar region.

Under this initiative, RMF developed this Integrated Production (IP) guideline to help farmers apply more sustainable agricultural practices which maximize natural control processes for pest and soil management and grow healthy avocados. The content is specialized to the Akkar region where different agricultural practices are applied due to the microclimate present there. The IP certification provided by CCBP Middle East is owned by Grow Smart s.a.r.l nursery.

Grow Smart will, in turn, disseminate it to 20 avocado farmers in Akkar who meet the requirements. A committee in charge of the IP monitoring and implementation and certification was established.

It consists of:

Quality Manager – Dr. Sandra Fahd

Technical Advisors – Eng. Hussein Abou Yehia and Eng. Ibrahim Kawtharani

Internal Inspectors – Eng. Baker Naiim and Eng. Mouhamed Abou Yehia

Members – Dr. Sandra Fahd, Mr. Mouhamed Hijazi and Eng. Georgette Lahoud



## II- AGROECOSYSTEM

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Many factors impact the sustainability of an agricultural system such as climate, soil, water and socio-economic influences.

The biological responses of an orchard normally are controlled by all these conditions especially climate. By applying comprehensive agro-ecosystem principles including a diversification in the ecological infrastructure of the orchard and ground floor management, farmers are able to maintain a high yield in production without destabilizing the agro ecosystem.

### 1. Natural Fauna and Flora

#### A. Diversification of Orchard

##### **Ecological Infrastructure:**

To maintain a balanced ecological infrastructure, orchards should not be cultivated evenly and grove margins should be created to build a buffer between existing plantation and new one. Diversifying production leads to a richer ecological system.

#### B. Management of the Ground Floor

To improve the agro ecosystem and to avoid soil erosion, zero tillage and mulches are highly recommended. Zero tillage releases plant residues at the soil surface and decreases the risk of topsoil depletion. Cover crop selection between rows also reduces soil erosion, diversifies the ecosystem, enhances pollination rate and traps natural enemies. It is worth noting that the selection of cover crop must coincide with the flowering season of avocados extending from January until end of April, in order to increase visitation of pollinators.

Studies show that the *trifolium subterraneum* and wild alfa alfa species help fix nitrogen and decrease the impact of erosion in the cultivated sloppy lands.



## 2. Local Climate

The climate in Akkar tends to be warm and temperate. The winters are mostly rainy and windy. In Akkar, avocados are generally cultivated at an altitude ranging between 50 and 800 m above sea level. The soil in the selected area is basic, nearly calcareous and has a pH higher than seven.

Avocado is an evergreen tree. It has low resistance to frost and shows variability according to varieties. Cold winters increase the risk of avocado damages. For this reason, the selection of the orchard site must start with the local climatic conditions. Adequate agricultural practices must be applied accordingly including the selection of cold tolerant varieties and the necessity of windbreaks creation.

The study of the climatic characteristics impacts

- Fruit phytosanitary
- Pollination correction
- Maturity time

The climatic factors taken into account are:

- A. Temperature
- B. Precipitation
- C. Wind velocity

### A. Temperature

Temperatures below zero that last over 24 hours can induce frost especially in the Akkar area. The optimal average daily temperatures for commercial avocado cultivars range between 20 and 25 °C. Light frost can be tolerated but not during spring when flowering and fruit occur. The temperature variance between day/night plays a critical role in the flowering cycle and fruit set of avocados. Average temperatures during flowering and fruit set should preferably be above 18 °C. The cultivars in increasing order of sensitivity to cold temperatures are the Hass and Pinkerton varieties. The Fuerte variety can withstand up to -5 °C in temperature. During the flowering phase of the Fuerte variety, temperatures should ideally be above 18 °C and not below 13 °C.

Spring season remains the most frost-prone and therefore the highest critical period.

#### ***Preventive measures to reduce frost damage***

- Selecting appropriate sites including geographical location and climate
- Selecting a suitable variety (late and early varieties that can overcome frost days during spring)
- Applying adequate agricultural practices
- Applying three urea sprays in early spring to maintain healthy trees and increase their freezing tolerance
- Keeping the orchard floor free of vegetation in winter
- Establishing raised beds
- Using heaters and wind fans
- Installing mini-sprinklers
- Using winter shade-cloth covers for young trees



#### ***Mitigation measures in case of frost***

- Harvesting all fruits within 10 days.
- Whitewashing defoliated trees with lime or acrylic-based paint
- Holding off for several weeks or months before pruning of dead wood
- Avoiding irrigation and fertilization until new shoots occur



## **B. Precipitation**

In Akkar, the rainfall period usually extends from October till end of April and the average precipitation rate is 700 mm/ year.

The yearly water requirement of an avocado tree is 1200 mm supplied by precipitation and/or irrigation.

In case of a dry spell, newly planted avocado trees should be watered. In case of high precipitation, the risk of waterlogging and root rot increases therefore establishing raised beds in an avocado orchard is recommended.

### C. Wind Velocity

During March, the high wind speed and varied air temperatures affects avocado flowers and consequently fruit set and production.

Windbreaks or shelterbelts can reduce damage caused by high winds.

Windbreaks are pre-requisite for orchard establishment located in frost and high wind prone areas. The selected companion crop can be a non-commercial avocado variety such as: Lola or Mexicola or a commercial one like Bacon.

## 3. Soil Characteristics

Avocados are adaptable to a wide range of soils but prefer soils with a pH 6.5 and with good organic matter content (2- 2.5%). Ideally, the best soils for avocados are of medium texture and drain quickly of excess moisture.

An avocado tree is sensitive to the presence of soluble salts in the soil and, particularly, to the presence of sodium chloride. The soils of Lebanon are typically Mediterranean, generally calcareous. Calcareous soil can induce Fe-deficiency “Chlorosis”, several applications of chelated iron is recommended to reduce chlorosis.

Thus, in relation to the requirements of the avocado, the soils used for growing this crop should meet the following criteria:

- (a) Good drainage and good physical properties; sandy loamy to loamy textures.
- (b) Avocados do best in soil with a clay content between 20 and 40%. If the clay content is below 20%, the soil has a limited water retention ability;
- (c) Sufficient soil depth from 0.8 to 1.0 m;
- (d) Absence of soluble salts
- (e) Max. Calcium content is 40%

Farmers can increase the organic matter content in the soil through shredding the pruning residues, applying farmyard manure, and growing cover crop in winter.

Before making a decision to plant avocados on a particular soil, an analysis should be carried out to determine the chemical and physical suitability of the soil. This helps indicate the required amendments prior to planting.





## III- AGRONOMIC MANAGEMENT

### 1. Establishment of Avocado Orchard

The geographic location, climatic conditions, soil quality and availability of water and labor should all be considered in selecting the appropriate site.

Orchard design and planting density are key factors that affect not only yield and fruit quality but also the future cultural practices. A good combination of orchard layout and planting density should result in optimum light interception and yet allow easy movement of required equipment throughout the orchard.

In order to set up an avocado orchard with sustainable agricultural practices that respect biodiversity and the environment, farmers are recommended to abide to the following steps:

#### 1- Carefully selecting the site with a soil depth between 1 to 1.5 m

#### 2- Planning the orchard layout

Planning the orchard is a complex procedure, below are key points to consider:

- Proper land clearing
- Shelterbelt installation
- Row direction and length – long rows are preferred
- Raised beds creation – raised beds are built with about 1 to 1.5 m width and 50 to 80 cm height. This can improve soil drainage immediately under and around the root ball and is highly recommended
- Surface drainage – uncontrolled water runoff removes valuable topsoil and exposes roots to desiccation. It may cause waterlogging and root rot problems. Surface drains are essential to carry out water safely through the orchard.
- Accessibility – it is important to have easy access to the orchard for spraying, harvesting and other operations.
- Access to clean water – avoid high salinity





### 3- Selection of varieties, rootstocks and tree spacing.

Farmers should only source true-to-type and virus free seedlings from nurseries. To achieve that, seedlings are grafted onto suitable seedling rootstock providing tolerance to Phytophthora, salinity and alkaline soil. The seeds are then extracted in winter, heat treated and planted into plastic bags. Once the young tree attains a suitable height and thickness, a fruiting commercial variety is grafted onto it. The grafts are taken from healthy trees selected from commercial varieties according to the market demand.

In terms of row and tree spacing, the Lambhass, Reed and Pinkerton varieties are adequate for high density at a 3x3 m spacing (approximately 110 trees per dunum) whereas the Fuerte variety can be planted at a 4 x4 m spacing (approx. 62 trees per dunum).

### 4- Allocation of varieties in orchard

Mixing A type and B type varieties increases cross-pollination and this will improve pollination and increase yield.

- A-type cultivars: Hass, Pinkerton, Reed and Lamb Hass
- B-type cultivars: Fuerte, Zutano, Bacon and Ettinger

#### - Pollination

A typical full-grown healthy avocado tree can produce up to a million flowers a year, but, on average, fewer flowers per tree will set fruit that will hold and develop to maturity and harvest (about 1.5 tons/ dunum or more). While there are many factors that contribute to poor yields, some of this failure to reach high yields is related to flowering, pollination and fruit set factors. Additionally, the avocado flower is considered a hermaphrodite whereby it has both staminate (male, pollen-producing) one day and carpellate (female, ovule-producing) the second day depending on the flower type (A or B type) as per table below:



	First Day		Second Day	
	Morning	Afternoon	Morning	Afternoon
A Type	Female (stigmata receptive)			Male (sheds pollen)
B Type		Female	Male	

To prevent early flowering, it is not recommended to spray any kind of growth regulators such as (GA or Auxins) before or after flowering.

- Planting an orchard with avocado trees with A type and B type flowers enhances cross pollination.
- It is recommended a pollinizer tree row be located at least every fourth row. Pollinizers can also be used as wind-breaks around the orchard.
- Beehives are also a good pollination promoter.

**5- Marking out the tree planting sites by digging holes with 60cm depth.**

**6- Installing the irrigation system: irrigation system (mini-sprinklers, drippers or inline drippers) can be selected depending on water availability, the plant need, type of the soil and the climate. In cold areas where frost can occur, mini-sprinklers 120 L/H are recommended.**

**7- Planting calendar: the time of avocados plantation is very critical and in Akkar, it extends from March till end of July.**

**8- Delivery of trees: as soon as the trees arrive, farmers are recommended to examine the colour of the root (dark brown discoloration is a sign of unhealthy trees).**

**9- The planting procedure consists of the below steps and is highly recommended while planting new orchards:**

- Digging the holes. Holes are dug after the tree spacing is marked out and the irrigation system has been installed. The holes should be dug about the same depth as the root ball. The width of the hole should be about 2-3 times the diameter of the pot or sleeve.
- Placing the tree in the hole by gently pulling the tree out from the pot without damaging the root ball. The root ball should remain compact and in one piece. It is recommended that the root ball is a little bit wet before plantation.
- Filling the hole with soil. After filling the entire hole with soil, farmers should add a 1000 grams mixture of chicken composted manure and 200 grams of NPK (12-12-17). The mixture must be spread on a radius of 30cm from the trunk of the tree. A shovel can be used to turn the soil to cover the mixture leaving a slight basin to contain water.
- To remove air pockets from the soil, the basin around the tree should be filled with water immediately. Each tree requires approximately 40- 50 liters of water by hose for three successive days after plantation. If a dripper is used for irrigation, it is important to have the dripper or mini-sprinkler placed on top of the ball so that water will run into the ball.

- **Mulching:** the young tree is then mulched with several inches of straw or wood chips or chopped tree leaves for moisture retention and cooling of the soil.
- **White paint:** to protect the trunk of the young trees from sunburn, it is highly recommended to paint the trunk with white wash using water soluble painting.
- **Stem support:** it is best to support the young tree with wooden stems.
- **Irrigation:** irrigation should be done by inline drippers (GR 4 liters/ H per dipper) next to the trunk, or by mini- sprinklers (120 liters /H).
- **Weed Control:** weed control is important because weeds steal water and fertilizer from the young tree. Weed control should be accomplished by mulching and hand weeding or by using trimmers. Herbicides are not recommended during the first two years of growth. Under this IP, only 50% of the weed in the orchard should be controlled.
- **Fertilizing:** after one month of plantation.





## 2. Rootstock Selection

There are three races of avocado rootstock: Guatemalan, Mexican and West Indian. The most suitable for Akkar is the West Indian. The characteristics of used rootstock in Lebanon are described in table 1 below:

**Table 1. Characteristics of Avocado Rootstocks Commercially Available to Growers in Lebanon.**

	Topa Topa	Mexicola	Zutano	Lula	Fuerte	Reed	Pinkerton
Propagation Type	Seed	Seed	Seed	Seed	Seed	Seed	Seed
Graft Potential	Good	Good	Excellent	Good	Good	Good	Good
Parentage Race	Mexican	Mexican	Mexican	Guatemalan	Mexican x Guatemalan (hybrid)	Guatemalan	Mexican x Guatemalan (hybrid)
Vigorousness	High	High	High	High	High	High	High
Yields	Medium	High	High	Medium - High	Medium	Medium	Medium
Tolerance to Phytophthora (PRR)	There is no rootstock that is tolerant for (PRR), even the cloned rootstock. According to studies, the Mexican cultivars such as Topa Topa, Mexicola are more tolerant to PRR than other rootstocks.						
Tolerance to Salinity	Medium	Medium	High	High	Weak	Weak	Weak
Tolerance to Frost	High	High	High	Low - Not recommended for cold areas	High	Medium	Medium



### 3. Selection of Varieties

The selection of avocado varieties is dependent on agroclimatic conditions and resistance to disease. There are currently eight commercial Avocados varieties grown in Akkar:

- Fuerte
- Pinkerton
- Hass
- Lambhass
- Reed
- Bacon
- Zutano
- Ettinger

#### Selection of Variety under Integrated Production

The selection of avocado varieties under IP in Akkar must take into consideration important factors like:

- Race
- Flower type
- Seasonality
- Consumer acceptancy
- Resistance to Phytophthora root rot, salinity frost and certain pests
- Local market and consumer demands

**Table 2: Selection of Avocado Varieties under Integrated Production in Akkar**

Avocado variety	Parentage	Flower Type	Plant size	Production	Ripening season	Fruit shape/ size/ Color/ Taste	Cold Tolerance	Susceptibility to insects and diseases	Commercial appreciation	Comments
Bacon	MxG	B	Tall, upright tree, leaves have an anise smell when crushed	High and consistent production	Precocious October - December	Fruit are ovate medium to large size, thin peel, green and glossy texture	High, frost tolerance is down to -3.3 °C	Extremely susceptible to Anthracnose	Fair	- Fruit has poor storage life, and is susceptible to internal flesh discoloration. - Successful pollinizer to Hass. Recommended for Akkar area
Zutano	MxG	B	Upright Growth	Consistent and heavy production	October - December	Fruit are ovate to pyriform, medium size, peel thin, light green, smooth, glossy with waxy bumps.	Predominantly grown in colder regions due to its high cold tolerance (down to -4,4 °C)	Susceptible to PRR	Poor to fair	Susceptible to peel cracking and anthracnose Used as rootstock recommended for Akkar

Avocado variety	Parentage	Flower Type	Plant size	Production	Ripening season	Fruit shape/ size/ Color/ Taste	Cold Tolerance	Susceptibility to insects and diseases	Commercial appreciation	Comments
Ettinger	M	B	Upright with a strong central leader. leaves have a weak anise smell when crushed	Moderate to heavy production	Early maturing cultivar. December - First of February	Fruit is pyriform, medium to large, peel is bright green, very thin, with a slightly rough surface	High	Severe problems can occur with peel cracking, anthracnose and fruit spotting bug	Fair	This cultivar is more sensitive to chilling injury during storage than "Hass and Fuerte".  Recommended for Akkar area
Fuerte	MxG	B	Vigorous spreading tree. leaves have a strong anise smell when crushed	Alternate bearing Habit	November to April	Pear- shaped, small to medium, elongated. Green skin slightly rough. Good taste	Very High	The fruit is susceptible to Anthracnose, stem end-rot and insect attack which can cause a severe pre- and postharvest losses	Demanded by the Lebanese and Gulf consumers	The tree has tolerance to Persea mites. Due to it is sensitivity to low temperature during flowering and fruit set, yield is low. Recommended for Akkar area
Pinkerton	G	A	Semi - Dwarf, moderately spreading tree	Pinkerton is very precocious with consistent, heavy production	January to March	The fruit is pyriform but can excessively "Necky" in warm climates. Medium to large size. Peel has medium thickness, dark green, pebbly and tough. Good taste	Similar cold tolerance to Hass and Reed tolerating temperatures down to -2°C	Resistant to Anthracnose, but fruit can have a high percentage of internal disorders including uneven ripening	Demanded by the Lebanese and Gulf consumers	
Hass	GxM	A	Medium to large tree with semi-upright growth habit	Heavy bearing starts bearing from the third year.	Mid to late season February to June	Pear shaped to ovoid, bubbly skin and rough. Turn black when ripen. Peel medium to sick. High oil content	Low-Medium	The medium to thick peel provides tolerance to pests and diseases but leaves are susceptible to Persea mites and the fruit to avocado thrips	Most demanded in Europe and US. Good for export	Flowering and fruit set are less sensitive to cold temperatures in Hass than in Fuerte. But Hass leaves are more cold sensitive damaged below -1.1 °C. Biennial bearing
Lambhass	GxM	A	Growth Habit of the tree erect	Highly productive, Start production for the second year	March - July	The fruit is very similar to Hass but with wider shoulders and black skin at maturity. Larger fruit and matures later than Hass. Rough peel	Showed more tolerance to cold than Hass.	More tolerant to winds and to high temperatures. More tolerance to Persea Mites than Hass	Highly demanded	Used in Ultra- High density Can be stored postharvest for 1 month longer than Hass. Recommended for all areas and for high density cultivation

Avocado variety	Parentage	Flower Type	Plant size	Production	Ripening season	Fruit shape/ size/ Color/ Taste	Cold Tolerance	Susceptibility to insects and diseases	Commercial appreciation	Comments
Reed	G	A	Upright growth	Precocious, consistently producing heavy crops	March to June	Medium to large size fruit Round fruit with medium to coarse skin, green, corky, slightly grainy and easy to peel. Rich, nutty flavor, flesh does not blacken after cutting	Cold tolerance down to -1.1°C	Has some resistance to Persea mites	Good taste	Biennial bearing Used in Ultra- High density Can be stored postharvest for 1 month longer than Hass. Recommended in the coastal area

In Akkar, it is highly recommended to use the Fuerte variety as main crop (B type) and Lambhass to act as pollinator (A type). The percentage of cultivation of each variety can vary from (90% B – 10% A), (75% B – 25% A) or (50% B – 50% A).



**Bacon**



**Ettinger**



**Fuerte**



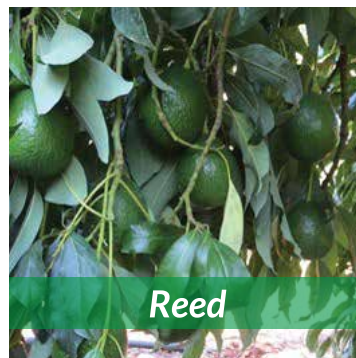
**Hass**



**Lambhass**



**Pinkerton**



**Reed**



**Zutano**



## 4. Tree Training or Tree Shaping

Pruning activities is not recommended for young avocado trees for the first 2 years.

General avocado pruning principles are:

- Pruning horizontal branches that are developing low to the ground (40 cm above ground level), as these interfere with tree access.
- Removing dead wood, as much as possible.
- Paying constant attention to pruning detail. Small cuts at the correct time minimizes the need for additional major pruning cuts.



## 5. Management of Soil Fertility

Soil fertility is defined as the ability of a given soil to improve plant health and sustain long-term biomass production and yield. Agronomic practices should be geared toward maintaining a balance between chemical, physical and biological properties of the soil.

Adequate management of soil fertility should meet the following objectives:

- Satisfy the nutritional requirement of the tree
- Improve the fertility of the soil
- Save the non-renewable resources
- Avoid soil contamination.

Soil fertility and plant nutrition can be managed in IP orchards through three different practices: manure, cover crop and fertilizers including foliar sprayers. Ideally, the green cover approach should be utilized first then manuring and the use of slow release fertilizers should be used last.

## A. Manure Use

Manuring is a common agricultural practice among Mediterranean growers to enhance soil fertility. Manure contains nitrogen, phosphorus, potassium and other nutrients. It also adds organic matter to the soil that may improve soil structure, aeration, soil moisture-holding capacity, and water infiltration. Farmyard manure is added to the orchard at a rate between 20 to 40 tons per hectare. Large quantities can be applied yearly in case of severe deficiency, however this can be costly. Well-decomposed manure contains only 8-10% of stable humus. Therefore, to raise the level of organic matter in deficient soil from 1 to 2 %, one needs around 400 tons of well-decomposed manure. When manure is applied yearly as a source of humus, macro and microelements, precautions should be taken to avoid losses during storage or after spreading on the floor. Up to 30 % of nitrogen may be lost if the manure is left uncovered and exposed to heat. Superficial spreading without adequate incorporation into the superficial layers (10-20 cm) of the soil layers result also in nitrate evaporation.

The breakdown of organic matter (OM) depends on three main environmental factors: temperature, humidity and microflora. Over the years, very little of OM is accumulated in soil. Frequent manuring is therefore needed. Special attention should be given to the floor under canopy because leaf litters accumulate generally more in the row middles.

In order to take full advantage of the organic matter in the coastal area, the timing of applications is critical.

For avocado orchards, it is recommended that manure application be planned right before the first rain towards the end of Autumn in order to avoid triggering vegetative growth in the late season resulting in dysfunction of tree dormancy and physiological disorder.

During summer, drought may interfere with the rapid degradation of organic matter. It is strongly recommended to sow a cover crop using legumes or other suitable species to help catch the nitrate and reduce water table pollution.

## B. Cover Crop

The selection of specific cover crops under the IP system and their management varies with location, depending on factors such as seasonal rainfall, soil type, soil erosion potential, available equipment and seed cost. The most important species are trifolium subterraneum and wild alfalfa. A leguminous cover crop enhances the nitrogen content of the soil.





## C. Fertilization

Avocado trees have relatively few mineral deficiencies in commercial orchards.

The surface feeder roots seem to be very efficient at recycling nutrients from the decomposing leaf mulch generated from the trees.

Nitrogen should be applied yearly in order to maintain optimum production. Occasionally zinc, iron (mainly in alkaline soils), boron and possibly other minor elements should be applied.

A leaf analysis must be carried by avocado producers to identify the nutrient requirement for the orchard. This test of plant nutrient status is a diagnostic tool that allows producers to determine a nutritional program to maximize yield and fruit quality. Predictive sampling evaluates the effectiveness of fertilizer program for current year and the data is used to adjust for the subsequent year.

The type of fertilizers used can be determined according to the soil pH, the amount and quantities of the fertilizers varies according to the grown variety, age and size of the tree, yield, nutrient deficiencies, aim of the fertilization (production or growth).

Below is a table for standards of avocado leaf analysis to diagnose the nutrient status of mature trees.

Nutrient	Deficient (less than)	Commercial Range	Excess (more than)
N (%)	1.60	1.6-2.8	3.0
P (%)	0.14	0.14-0.25	0.3
K (%)	0.9	0.9-2.0	3.0
Ca (%)	0.50	1.0-3.0	4.0
Mg (%)	0.15	0.25-0.80	1.0
S (%)	0.05	0.20-0.60	1.0

Mn (mg Kg <sup>-1</sup> )	10-15	30-500	1000
Fe (mg Kg <sup>-1</sup> )	20-40	50-200	?
Zn (mg Kg <sup>-1</sup> )	10-20	40-80	100
B (mg Kg <sup>-1</sup> )	10-20	40-60	100
Cu (mg Kg <sup>-1</sup> )	2-3	5-15	25
Cl <sup>-</sup> (%)	?	-	0.25-0.50
Na (%)	?	-	0.25-0.50

### Nitrogen

Nitrogen can be applied using the following fertilizers; ammonium nitrate, calcium nitrate, ammonium sulfate, potassium nitrate (salinity symptoms), DAP, and other nitrogen fertilizers based on sulfur for soil with high pH.

During the first three years, 50kg of Nitrogen should be applied per hectare. The quantity should not exceed 200 kg/ha after year six.

The recommended application is once in autumn and once in February and 4-6 applications during summer for small trees. For older trees, the recommended application is 4 times during the year (once every 3 months). Some avocado varieties such as Hass and Pinkerton may require more amounts of nitrogen fertilizers than others. Over-fertilizing may burn the roots whereas under-fertilizing will result in poor growth.

## Phosphorus

Phosphorus deficiency is rare, but when it occurs it can be extremely debilitating to avocado trees. Some phosphorus applications to trees that do not exhibit deficiency symptoms may be beneficial in the long term. The quantity should not exceed 50 kg/ha. Using DAP during autumn is highly recommended.

## Potassium

Potassium deficiency is rare in avocado groves. Potassium application is recommended for avocado trees in small quantities 25 kg/ha for small trees and should not exceed 150 kg/ha for mature ones.

## Iron

When iron deficiency occurs, it is usually associated with alkaline soils high in calcium carbonate. Iron becomes increasingly insoluble and unavailable to the plant as the soil pH increases. It is preferable not to exceed 10 grams of iron/tree during the season.

Deficiency Symptoms:

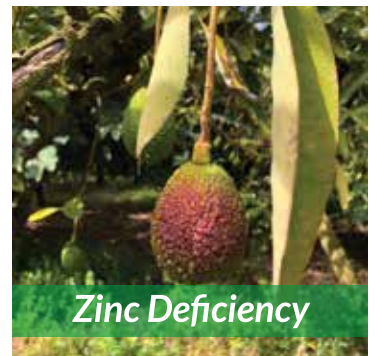
- Iron deficiency appears first on new leaves. In mild forms of deficiency, leaves show a network of green veins against a background of light green tissue between the veins.
- Interveinal tissue becomes yellow as the deficiency progresses and the veins eventually lose their green color.
- In severe cases, the leaves may show tip and marginal burn, leaves will drop and twigs will die.
- Iron chlorosis may occur on individual limbs or the entire tree.

## Zinc

Avocado has a small but essential requirement for zinc.

Deficiency Symptoms:

- Leaf mottling usually starts in the terminal leaves and progresses to the older leaves.
- New leaves remain smaller than normal.
- The distance between the leaves on the stem is shortened, giving a crowded “feather duster” appearance.
- Fruit may develop to be small and rounded. In advanced stages a marginal burn develops on the new shoots.
- Stunted leaves and twig dieback occurs.



## Boron

Boron in high pH soils application is recommended in small quantities and should not to exceed 1 gram for small tree and 2 grams for mature tree (3times /year).

Deficiency Symptoms:

- Marginal necrosis of younger leaves
- Shot holes in leaves
- Loss of apical dominance, often resulting in multiple shoot production
- Downward growth of branches
- Swelling of stem nodal regions (chronic symptoms)
- Fruit distorted with a crooked neck and malformed on the shortened side



**Table 6: Mineral Deficiency Symptoms of Avocado**

Symptoms on Leaves						
Age of Leaf	Colour	Size and Necrosis	Shedding	Symptoms on Branches	Symptoms on Fruit	Deficient Element
All ages	Pale green	Small	Yes	Short internodes + dieback		N
	Dark green	Necrotic				Cu
Young Leaves	Interveinal yellow-white	Necrotic tip and margins	Yes	Dieback	Light green	Fe
	Interveinal chlorosis	Small leaves with necrosis in margins	Yes	Rosetting, short internodes	Round	Zn
	Pale green to yellow	Small leaves, shot-holes with Pale green to yellow halos	Yes	Horizontal growth, dieback, nodal swelling, loss of apical dominance	Bumpy surface, sickle-shaped with lesions	B
Old Leaves	Brownish-green	Small and rounded	Yes	Dieback		P
	Interveinal chlorosis, brownish-red spots	Small and Narrow		Thin branches, dieback		K
		Water-stress symptoms		Dieback		Ca
	Interveinal chlorosis					Mg

## 6. Water Management

Water supply is a major factor influencing tree growth, productivity and fruit quality.

Proper irrigation scheduling, with good quality water supplied to the trees through an efficient irrigation system, is a requirement for all avocado groves.

Avocado is a challenge to irrigate properly because it has a shallow feeder root system (80 –90% of the feeder root length is located in the upper 30-60 cm of root zone soil). The feeder roots are rather inefficient at water absorption because they have very few root hairs. Due to the location of the feeder roots, soil moisture is consumed rapidly in the upper layer of rootzone soil. Water sensor devices (for example a tensiometer) are recommended to monitor the supply and need to avoid over irrigating.

The normal irrigation frequency for avocado in Akkar is 2–7 days for mini-sprinklers and 1–3 days for drip irrigation. Generally, scheduling is determined through the combination of evaporation rate with specific crop factors, soil texture and plant indicators.



## 7. Plant Protection

### A. Biocenosis

Avocados growers should aim to promote the natural balance between beneficial predators and pests. There are 4 categories of living organism in the agroecosystem where avocados are grown:

1.1 Insects: Avocados are characterized by high complexity of the agroecosystem.

Some pests can be dangerous for the yield; others can be dangerous in the grace period.

In the coastal area, thrips and mites are the most common pests and avocado farmers must pay attention to the control of these insects.

1.2 Natural Enemy: Good agricultural practices must be applied to enhance the presence of predators as they can substitutes the chemical pest control.

1.3 Alternative prey: The population of this prey can be easily increased in spontaneous vegetation and shrub trees.

1.4 Beneficial crop: It is important to study the flora in the environment that can influence the productivity of avocados. Flora includes cultivated plants, steppe, weeds and trees. A rich biodiversity can enhance the presence of insects that increase natural pollination.

## B. Common Pests and Diseases

Avocado can attract many dangerous pests that affect the yield negatively. Farmers should be aware of the common diseases and the key pests in order to adapt the appropriate agricultural practice and strategy.

### ***Ambrosia Beetle Xyleborus Glabratus***

The Ambrosia beetles (>34,000 species world-wide) are characterized by boring into trees and forming galleries in the sapwood. The adult and larvae feed on the mycelium and spore clusters of the fungus and typically attack trees under stress. The beetles carry the fungus which digests the wood disrupting the flow of water and nutrients. This causes the laurel wilt (LW) disease.

**Chemical Control:** Chlorpyrifos



### ***Avocado Thrips***

Thrips are an injurious pest that affect avocados. The pest attacks young avocado foliage and fruit causing the fruit to drop, lowering the grading, and/or rendering the fruit unmarketable. Thrips damage to mature fruit causes unsightly brown scarring which leads to downgrading of the fruit and economic loss.

**Monitoring:** Growers monitor the groves during bloom time to determine the amount of fruit set and the intensity of the avocado thrips infestation. If the thrips population is at a significant level, typically when there are two to five thrips per leaf, chemical treatments are indicated and typically continued until the fruit diameter is larger than 20 mm.



**Cultural Control:** Vigorous growth and the accompanying healthy foliage and growing fruit can be attractive to avocado thrips and should be monitored accordingly.

**Biological:** Biological control agents have not been observed to reduce avocado thrips populations below damaging levels. Predaceous thrips, franklinothrips vespiformis, banded wing, and black hunter thrips occur naturally as a response to the presence of avocado thrips population.

**Chemical Control:** Once a spray program is initiated, treatments to reoccurring populations are continued until the fruit has reached the size that it will no longer host the pest. Ideal timing is from January to beginning of July.



## *Persea Mite* *Oligonychus Perseae*

Persea mite is most damaging to Hass and a few other varieties. Pinkerton, and Reed are of intermediate susceptibility. The Bacon, Fuerte, Lamb Hass, and Zutano varieties are much less affected.

High persea mite numbers cause premature leaf drop and defoliation. Defoliation leads to sunburned bark and fruit, aborted or dropped fruit, and severely stressed trees, which later reduces yields.

Numerous predators feed on persea mite. Predaceous mites include *Amblyseius*. Most predators are not highly effective because of the persea mites protective webbed nests. However, it is recommended to conserve natural enemies because they can reduce persea mite numbers, and predators often provide good biological control of avocado brown mite and sixspotted mite.

**Cultural Control:** Eliminate or reduce persea mite alternate host plants growing near avocado, including mite-susceptible ornamentals, non-commercial fruit trees, and weeds. Provide trees with appropriate irrigation and other good cultural care to maintain the flush of new growth and compensate for mite-induced leaf drop. However, be careful not to overfertilize. Excess fertilization, especially with quick-release formulations, may increase persea mite numbers and damage during late spring and summer due to increased foliar nitrogen. Spraying the underside of leaves with a forceful stream of water can reduce mite presence on a few small trees where this is feasible. Whitewash trunks and major limbs to protect bark and wood from sunburn after premature leaf drop.

**Chemical Control:** Abamectin combined with mineral oil.

## *Anthracnose* Genus *Colletotrichum*

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. External symptoms are difficult to see on ripe 'Hass' fruit because of its dark skin color. Unhealthy or dead leaves are the most obvious symptom in groves. Spots form on leaves, beginning as yellow, then brown discolorations that coalesce into large dead areas. Necrosis occurs across or between leaf veins, on leaf margins, and most

often at leaf tips. If disease is severe, trees drop many leaves prematurely. New shoots can develop brown or purplish lesions, and shoots may dieback. Infected flower heads can turn dark and die without producing fruit, or young fruit may form and then drop.



In Lebanon Anthracnose attacks mainly the avocado fruit and appears as lesions of various sizes. The lesions are dark in color and expand rapidly in size, affecting the skin and pulp and they usually appear after the ripening of the fruit.

**Management:** Control anthracnose primarily with good agricultural practices in the grove and proper pre-harvest and postharvest fruit handling.

Prune out dead limbs and twigs where fungi sporulates. If many dead leaves are entwined in the canopy, knock them out of the tree.

Prune low limbs to at least 60 cm off the ground to reduce humidity within canopies by improving air circulation.

Prune and harvest only during dry conditions and minimize fruit contamination and injury.

Dispose of dead wood and old fruit away from avocado trees before bloom.

**Chemical Control:** Copper or other fungicides thoroughly sprayed on healthy tissue can prevent infection.

### ***Phytophthora Root Rot***

**Pathogen:** *Phytophthora Cinnamomi*

Foliar symptoms of *Phytophthora* root rot include small, pale green or yellowish leaves. Leaves often wilt and have brown, necrotic tips. Foliage is scarce and new growth is rare. There may be little leaf litter under infected trees. Small branches die back in the tree top, exposing other branches and fruit to sunburn because of the lack of shading foliage. Fruit production declines, but diseased trees frequently set a heavy crop of small fruit.

Small, fibrous feeder roots are scarce at advanced stages of this disease. Where present, small roots are black, brittle, and dead from infection. Foliage is wilted even when soil under diseased trees is wet. Affected trees will decline and often die either rapidly or slowly.

**Management:** Purchase certified disease-free nursery stock and root rot-resistant cultivars.

Inspect roots before planting

Employ stringent sanitation measures, good cultural practices, and appropriate chemical controls. The most important control of this disease is good irrigation management and planting on raised beds.

**Chemical Control:** Certain phosphonate fungistats (phosphorous acid and phosphonate compounds).







## 8. Harvesting

Mature fruit does not ripen and soften on the tree. Farmers learn to notice when hard, green fruit is mature and ready for harvest. If an avocado is picked prematurely, it will not ripen to an acceptable eating quality. Picking over-mature fruit results in poor flavor and an increased incidence of disease and flesh disorders, and reduces the yield of the next crop.

### ***Deciding when to harvest***

It is recommended to check the maturity before starting to pick by doing a dry matter test. There are currently no dry matter standards in Lebanon. Below is an example of the dry matter standards in California across the main varieties:

### **Current California Minimum Maturity Standards**

<b>Variety</b>	<b>Dry Matter %</b>
Bacon	17.7
Zutano, Reed	18.7
Fuerte	19
Hass	20.8
Pinkerton	21.6
Lambhass	22.8

Dark-colored varieties (such as Hass and Lambhass) are usually mature when they start to turn from green to dark color.

Green-colored varieties (such as Fuerte) become smoother, and develop a yellow tint to skin and stem.

Mature avocados can be recognized by a dull appearance of the skin or yellowing of the fruit stalk.

### ***Harvesting Method:***

- Avocados should be picked by hand or small shears using ladders.
- Several picks may be required. Farmers should start by removing bigger and mature fruits first, allowing remaining small fruit to increase in size.
- The use of proper picking equipment such as ladders, shears and picking bags is recommended.
- Farmers should avoid picking during wet weather, as the fruit are more susceptible to skin damage and fungal infection.
- Farmers should avoid picking during extremely hot weather.
- Farmers should not pull fruit from the stem instead they should cut the stem at 1 cm without injuring the fruit.
- Farmers should not drop fruit to the ground without any protection.
- To avoid damage, farmers should handle each fruit very carefully. The fruit should be carefully and gently placed into picking bags and/or crates. Extra caution must be taken not to puncture fruit with fingernails.
- It is recommended not to overfill crates as top fruit will be bruised.
- Avocados are hand graded for quality therefore each variety should be packed in separate crates.
- Infected avocados on the ground should not be mixed with harvested ones
- Fruit should be packed in clean crates. Avocados can be packed in one layer or two layers inside the crates.



- Harvested fruit should be kept under shade.
- Crates should be covered to minimize heating of fruit to prevent sunburn.
- Farmers should avoid excessive delays between picking and delivery to market.

### Harvesting Schedule in Lebanon

Varieties	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Non-Commercial												
Zutano												
Fuerte												
Ettinger												
Pinkerton												
Hass												
Lambhass												
Reed												

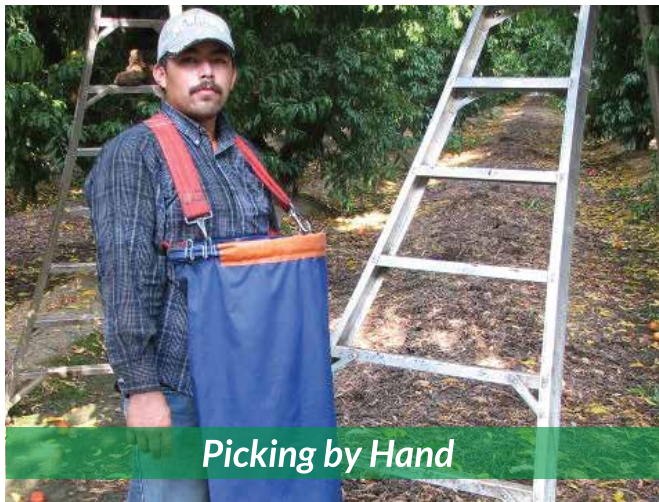


Avocado Picker



Picking Baskets





Picking by Hand



Minimizing Fruit Injury



Pulling is Not Recommended



Cutting the Stem at 1 cm



Fruit Packing



Keeping Harvested Fruit Under Shade

*Annexes*

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Region & Altitude

**MONITORING OF BUD EMERGENCE**

<200m       <200-400m       <400m

Avocado Varieties	Date of Occurrence of the Phase			
	Bud Emergence	First Bloom Stage	Flowering	Fruit Set

The registration of the date of occurrence of each phenological phase is important :  
 To set the exact monitoring date of pest and disease  
 To build a practical control strategy



# TRAINING RECORD

Trainer Name	Trainee Name	Number of Hours	Type of Training	Date

The training is important for the farmer to able him to access the Integrated Production system (the number of training hours depend on the cultivated area)

Area (du)	Hours of Training/per year
<4	2
4- 25	6
> 25 (for further training)	12





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PRIME SECTOR DEVELOPMENT PROGRAMME



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## RAW MATERIAL RECORD

Invoice No	Source	Quantities	Commercial Name	Type

The raw materials involve the materials that are intended to be used directly or to be stocked (invoice is a must)

- Amendments and Fertilizers
- Pesticides and Insecticides in addition to the pheromones and traps
- Avocado seedling for new plantation
- Organic products











## PEST & DISEASE MONITORING RECORD

No of Natural Enemies	Threshold	Kind and No of Monitored Parts	Monitoring Method	Date	Plot No	Disease Name

Direct observation (10 trees 2 leaves from each) branch checking Pheromone traps

Monitoring pest & diseases is important in order to plan an integrated management. 12 hrs are required as minimum per season distributed mainly before and after fruit set.













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# AVOCADO MATURITY TEST

Result	20-30% Dry Matter	Variety	Date

Maturity test is important to be done on filed in order to determine the right time of harvesting. From 10 trees, 10 fruit will be tested for dry matter.









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*This manual was prepared by  
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CCPB Middle East is a certification body recognized by the European Commission (according to Reg CE 834/07) in 39 countries all over the world. It operates in compliance with the most important international standards in order to offer an agrifood product certification able to guarantee integration between natural inputs and a reduction of chemical inputs: Globalgap, Integrated Pest Management, Traceability system in agrifood sector, Vegan products, GMO-free Products, protected geographical indications for typical wine and food and the Conosci il tuo pasto (Know your meal) standard for food service and tourism.

For more information, please contact: 01 874 851

Grow Smart s.ar.l is a Lebanese local nursery established in 2015. Grow Smart's main aim is to produce high quality seedlings. It has now developed an extension service center to establish and cultivate new orchards as well as provide farmers with technical assistance and extension services. Grow Smart works with over 300 farmers across the coastal area of Lebanon and especially in the South. In 2019, Grow Smart received Integrated Production certification from CCPB Middle East and will assist local farmers improve their production quality (IP, GAP or Organic Certified) whilst continuing to develop the sub-tropical fruit production in Lebanon.

For more information, please contact: 71 495 410



The René Moawad Foundation is a Lebanese Non-Profit, Non-Governmental Organization that works to empower the human being both intellectually and financially through education, health and economic development to guarantee their dignity and basic rights, and to build their capacities as responsible citizens through various fixed operation centers, and donor supported projects. RMF collaborates extensively both nationally and internationally with different organizations and institutions in order to achieve our goals and mission. RMF has been working for over 28 years to improve lives in Lebanon and is dedicated to making your life better through our work.

For more information, please contact: 06 666 093 [www.rmfmf.org.lb](http://www.rmfmf.org.lb)    



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