Baseline Study for Apples and Olives

In Lebanon

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General Introduction

Lebanon is approximately 10,452 km² as surface area with only 273,000 ha dedicated to agriculture, with a population of 4.4 millions, 9.2% of which is engaged in agriculture; it is well known for the diversification in its climatology that is, in turn, a direct effect of the diversification in topography, giving it the unique potential to produce a multitude of crops. The total irrigated area is about 118,000 ha, while the rain fed area about 138,500 ha. The total rainfall precipitations per year vary between 250 mm in areas such as northern Bekaa to 1,500 mm in mountainous areas in the northern of Lebanon. The mean monthly relative humidity ranges from 64% in November to reach 73% in August, on the coastal area, and from 76% in January to 44% in August in the inland areas. The Lebanese soil types differ greatly and range between the calcareous and the loamy with PH values, ranging between 6.4 in the volcanic-Basaltic type to 8.7 in the mixed type. It is hard to believe that such a country is capable of producing different types of crops ranging from tropical such as avocado, banana, kiwi, Cherimoya, etc... along its sea coast, East the Mediterranean, to subtropical like olives, pome-fruits, stone-fruits, etc…in its medium and high Western mountains, and open field like potatoes, wheat, legumes, etc…in its plains, mainly the Bekaa valley and Aakkar.

Until the 1980's, most of the Lebanese agricultural produce has found its way to the foreign markets in Europe, Soviet Union, and the Gulf countries. Unfortunately, this is not the case anymore for the inability to cost effectively produce a “safe” crop for both human consumption and the environment. The present situation is rather an awkward one, being the outcome result of many exacerbating flaws on the level of both, the official institutions and the producer. After more than 15 years since the Lebanese civil war has ended, the official institutions are still reluctant in issuing modernized laws, enforcing them, directing practical and beneficial research and studies, and disseminating results to growers through effective extension. The grower, traditional and uninformed in his turn, still conducts agriculture unprofessionally and wastes much of his inputs and resources, blaming the official bodies for not marketing his not-up-to-the-standards produce, when it is his prime responsibility. If the Lebanese agricultural produce is to regain its old rank and reputation for being of high quality to flow easily into the demanding markets, all the parties involved in its production, be it official or private,
ought to cooperate and each hold its responsibility to fulfill its "reason of being". Considering the farmers' part, what approach can be more effective than the integrated pest management in achieving a breakthrough on the level of improving production management, decreasing its cost, and increasing the yield and profit using environment friendly ways? There are many obstacles, hanging between the growers and their adoption of the integrated pest management, substantiated in how to find the right tool and the right environment to transfer not only a certain applied technology but also a way of systematic thinking to adults, many times illiterates, hanging tenaciously and dogmatically to erroneous beliefs. Well, it seems like there is an answer to this rhetorical question, residing in the so called "Farmers Field Schools" that have proven to be successful in giving the type of education the growers need in an informal participatory way of learning in several countries all over the world. The farmers' field school provides the right environment where the growers experiment what they know alongside with what is being facilitated to them to allow them to touch and believe, the same way "Thomas believed and put his finger".

Following is a baseline study on two traditional crops in Lebanon, apples and olives, which will serve as an assessment of the present situation, pertaining to the different inputs, problems, cultural practices, and activities achieved during the production of these two crops. This study will also be useful in assessing progress made as an outcome of establishing farmers' field schools in the areas of production of both apple and olive. Data gathered from publications, interviews with farmers, the writer's own experience while working with them, and questionnaires in the areas of intended FFS in the south and Mount Lebanon will be presented, pinpointing the problems with suggestions and recommendations when relevant.
I. Apple

A. Introduction

Over the years, the apple fruit has gained many attributes. To some religions, it is a symbol of sin and temptation. It was the reason why Adam was banished from paradise, for eating the forbidden fruit. To other religions, it is a symbol of redemption. According to some legends, Isaac Newton was inspired by the fall of an apple on his head to come up with the gravity theory. Another aspect of apples, that has to do with human health, is revealed through the old proverb "An apple a day keeps the doctor away", for it has been proven that apples play an important role in fighting many diseases among which is cancer. As to Lebanon's reputation, apples have been associated directly to its name, and many people worldwide used to recognize Lebanon out for its remarkable apples. In the seventies, Lebanon used to produce about 180,000 tons per year and used to export about 110,000 tons out of it to various markets worldwide, mainly to the Gulf countries, Europe, and the Soviet Union. Unfortunately, it is not the case anymore due to many reasons which will be discussed thoroughly later on in this study.

Nevertheless, apple plantation is still considered a potential investment in Lebanon, but it still needs to be modernized at the level of orchard management and adoption of the new strategies of intensive or semi-intensive production mainly adoption of new varieties-rootstocks and integrated pest management approach. The taste of Lebanese apple is very good. Also, the Lebanese climate is very helpful in apples' production, sometimes 15 to 20 days earlier than many of the European apple producers, especially with early ripening cultivars. Of course, climate and taste aren't enough to retrieve our old rank in apples' export, when there was no or little competition. However, careful planning and studying of the export markets along with major improvements at the level of production will be enough to do the trick of pulling the apple sector out of its present situation and putting it back on the right track.

In Lebanon, apple cultivation is ranked third in terms of production area, amounting to about 9,391 ha out of a total planted area in Lebanon with fruit trees estimated about 78,000 ha and a total production of 113,289 tons distributed mainly on mountainous areas with elevation going from 900m to 1,800m (FAO Agricultural census, 2004).
<table>
<thead>
<tr>
<th>Region</th>
<th>Area (Ha)</th>
<th>Production (Tons)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Lebanon</td>
<td>3,615</td>
<td>40,087</td>
<td>35%</td>
</tr>
<tr>
<td>North</td>
<td>3,873</td>
<td>51,104</td>
<td>45%</td>
</tr>
<tr>
<td>South</td>
<td>395</td>
<td>7,100</td>
<td>6%</td>
</tr>
<tr>
<td>Nabatieh</td>
<td>72</td>
<td>938</td>
<td>1%</td>
</tr>
<tr>
<td>Bekaa</td>
<td>1,436</td>
<td>14,057</td>
<td>12%</td>
</tr>
<tr>
<td>total</td>
<td>9,391</td>
<td>113,286</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 1. Apple production and areas in different Mouhafazats
(FAO Agricultural census, 2004)

The largest region in apple production is the north of Lebanon (45%) mainly in the areas of: Fneideq, Michmich, Aakkar el Aatiqa, Ehden, Tannourine, Beharre, Bqarsouna, followed by Mount Lebanon, amounting to 35% mainly in the areas of Baskinta, Mtein, Kfarselouane, Tarchiche, Niha, Barouk, Mayrouba, Hrajel, Kfar Dibiane, Aakoura, followed by the Bekaa (12%), mainly in the areas of Bekaa el Gharbi, Anjar, Rouda, Nabi Osman, the rest of the area amounts to 7% scattered in the South of Lebanon and Nabatieh (area still named, the apple Ikleem (apple territory) mainly Jezzine, Jbaa, Kfarkila, Marjaayoun, Chebba. (See Map, FAO census, 1999)
A large portion of the produced apples, amounting to 40-50%, is destined for export towards traditional Arab market, mainly: Egypt (amounting to about half of the exported quantities about 30,000 tons), Saudi Arabia, Kuwait, Jordan, United Arab Emirates, and to a lesser amounts Qatar and others.
<table>
<thead>
<tr>
<th>Year</th>
<th>Production (tons)</th>
<th>Import (tons)</th>
<th>Export (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>150,305</td>
<td>772</td>
<td>18,805</td>
</tr>
<tr>
<td>2003</td>
<td>157,772</td>
<td>634</td>
<td>27,883</td>
</tr>
<tr>
<td>2004</td>
<td>113,286</td>
<td>1,338</td>
<td>55,337</td>
</tr>
<tr>
<td>2005</td>
<td>115,000</td>
<td>1,658</td>
<td>50,357</td>
</tr>
<tr>
<td>2006</td>
<td>n/a</td>
<td>939</td>
<td>45,787</td>
</tr>
</tbody>
</table>

Table 2. Import-Export and production in tons

Many reasons lie behind why the Lebanese apple sector is lagging behind. The first reason is the decreased productivity of old orchards that went down as low as 1 ton/duu, when the productivity in some of the younger orchards is averaged to 3.5 tons/duu and can go up to 4.5 tons/duu. This is attributed mainly to the fact that the old orchards are planted with full-sized trees and at distances farther apart than the trees of the modernized orchards that are planted on dwarfing rootstocks. The modernized orchards can be planted with about 190 plants/duu as compared to the old orchards that can't be planted with more than 40 plants in the same area. Another factor is the increased cost of production in the old orchards since all the cultural practices such as pruning, spraying, thinning, and harvest, are more difficult to achieve and time consuming, thus more costly. Third, increased competition for the outside markets contributes to the slow development of the apple sector since many of the traditionally importing countries turned out to be producers in the last few years. Fourth, the characteristics of most of the good old planted varieties are no more attractive to the outside market as compared to the new apple varieties. Though many people still have a taste for old varieties like the Golden Delicious and the Red Delicious, there are many benefits in planting improved cultivars compel the modern farmers to adopt them. Fifth, most of the Lebanese apples can't handle long period of refrigeration and can't store well for a long time. This is due mostly to malpractice of fertilization in addition to a bad criterion in most of the cultivars. Sixth, bad packaging that makes the commodities less attractive. Seventh, the produce which isn't checked for excessive pesticides residues above what is permitted in the importing countries leads sometimes to commodity rejection.
Following is a baseline study of apple production in Lebanon to set the standard according to which any improvement in any component of the production chain shall be measured. Recommendations for improvement shall be presented when available in the framework of the modernization of the existing orchards.

B. Varieties

Historically, apple plantation was brought to Lebanon by the Lebanese immigrants who came back after World War II. The first apple orchard founded on a commercial scale at the Mdeirij area, using mainly the Golden Delicious and the Red Delicious or Stark varieties, dated back to the late forties. Being a scarce commodity at that time, all the apple produce was sold at high prices, leading some people to compare that orchard to a gold mine. The apple-gold extraction continued during the fifties and the sixties, when most of the Lebanese orchards were founded in the areas of the Bekaa, Mount Lebanon, and other areas of Lebanon, at elevation going from 900m to 1,800m, using varieties that were demanded at that time. The main problem was that those orchards were started either from seeds leading to full size trees, or on uncertified vegetative materials for both rootstocks and varieties, practices that had bad implications.

Most of the commercial Lebanese orchards are old and, of course, were planted with more or less old varieties intended only for fresh consumption, and none of them could be processed into juice. Forty or fifty years ago, those varieties were demanded not only for local consumption but also in the outside markets. The problem resides in the fact that because of the war that extended for over than 15 years, farmers were unable to cope with the demand of the market taste to renew their varieties.

The majority of the Lebanese orchards are mostly planted with varieties such as: Golden delicious, Red Delicious or Stark, and to a lesser extent the locally called Mouwachah or (sans pareille), Renette de Canada, Amassia, Double Red Delicious, Mouftii or Golden Anjar or as its characteristics implies Early Gold, and to a very little extent the Starkrimson or as locally called (Ronson). One can count as many as 10 other varieties that are not different from the early mentioned ones, except for the local naming that quotes, for example, the time of harvest like the Tammouzi (meaning harvest in July) or Shatawi (meaning wintery), the taste like the Soukarri (meaning taste sugary), the smell like the Miskawi, and plenty of other local naming of imported varieties like
Malaket Loubanan, Mougheizly..... It is even worst when each region of Lebanon has adopted its own naming for the same variety. Unfortunately, the nurseries' owners and the state share the responsibility for this “salad”. On one hand, the nursery owners hid or camouflaged the original names of varieties and created their own naming in an effort to monopolize the market in creating a false exclusivity for the varieties. On the other hand, the state is reluctant in issuing a modern nursery law, in spite of many unsuccessful attempts, one of which was very recent.

Not later than fifteen years from now, many old fashioned, misinformed farmers realized the production decline in their orchards and started to renew them only to succumb to the same old error and use the same old uncertified varieties from the local nurseries. On the other hand, some other, more enlightened farmers started using new improved certified varieties along with what they had, mainly to satisfy the demand of the outside markets for the newly developed taste for apples. The new varieties that were introduced, though on a small scale, are mainly: Fuji, Gala, Ace, Top Red, Red Chief, Lysgolden, Smoothe, Early Red One, Top Spur, and Granny Smith (Assli, 1996).

Following is a description of the planted varieties:

1. **Golden Delicious and its mutants**

**Origin:** Chance seedling, Mullins, USA, 1890.

**Tree:** Moderate vigor to vigorous

**Disease and pest status:**  
-Susceptible to powdery mildew, scab, wooly aphid, and virus  
-moderately resistant to fire blight

**Chilling requirement:** High

**Pollination:** Delicious, Granny Smith, Gala, Red Delicious and Mutant

**Fruit shape:** Medium to large (70-85 mm), conical and more elongated with altitude

**Skin:** Yellow-green to golden yellow with a pink cheek in young trees, lenticels obvious, bruises easily; can get russeted in cool conditions.

**Flesh:** Fine, creamy, crispy, sweet (refractometer index=13-15), slightly acid (g-equivalent of Malic acid/1 lit of juice=6-7), perfumed and juicy
**Harvest time in Lebanon:** September 2nd in Bekaa area

**Yield:** heavy

**Storage:** 120-150 days at 0- to 2 degrees Celsius

**Demerits:** russetting, alternate bearing

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**a. Smoothe**

**Origin:** Golden delicious mutant selection, USA, 1982

**Fruit:** Identical to Golden

**Harvest time in Lebanon:** September 2\textsuperscript{nd}

**Merits:** Resistant to russetting

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**b. Lysgolden**

**Origin:** Golden delicious mutant selection, INRA-france, 1977

**Fruit:** More elongated than golden

**Harvest time in Lebanon:** September 5th, later than golden delicious

**Merits:** Beautiful yellow skin, more resistant to russetting than Smoothe

**Demerits:** More alternating than Golden and Smoothe, higher susceptibility to powdery mildew

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**c. Golden Moufti or Golden Anjar or as its characteristics implies Early Gold**

**Origin:** USA, selection from a seed of Golden Delicious, 1971

**Tree:** Moderate vigor

**Disease and pest status:** Susceptible to powdery mildew

**Pollination:** Golden Delicious, Gala, Stark and red delicious mutants like (Top red, Top Spur, Ace, Starcrimson, Red Chief), Granny Smith, Fuji

**Fruit shape:** Medium to big (70-85 mm), regular, conical.

**Skin:** Golden like, green to green-yellow, clear, smooth, and russetting-free

**Flesh:** Fine textured, very juicy, moderately sweet (refractometer index=12-14, a bit acid (g-equivalent of Malic acid/1 lit of juice=6-8), and a very little perfume.

**Harvest time in Lebanon:** August 5th

**Yield:** Very good cropper

**Storage:** Around 60 days at 0 to 2 degrees Celsius
**Merits:** Early harvest can benefit exporters but for a very short period of time, before the harvest of the golden Delicious that has a better taste.

2. **Red delicious and its mutants**

**Origin:** Chance seedling, USA, selection from a seed, J.Hiatt, 1879. Most famous mutant, in Lebanon, is the Starking Delicious (striped Red), 1921, is used interchangeably with the Red Delicious.

**Tree:** Moderate to strong vigor in the standard tree and mutants, moderately to weak vigor in the spur type trees

**Disease and pest status:** Highly Susceptible to scab, mites, Nectria galligena, and woolly aphids. Some resistance to powdery mildew and fireblight

**Chilling requirement:** high

**Pollination:** Early gold, Lysgolden, Smoothe, and GrannySmith.

**Fruit shape:** Medium to big in size (70-85 mm), heart shaped, medium to tall, conical with crowns.

**Skin:** Medium to deep red, stripped or washed, area of red depends on the mutant

**Flesh:** Firm, crisp, and juicy, but with a high affinity to tarting in conservation, little aroma, moderately sweet (refractometer index=11-13%), (g-equivalent of Malic acid/1 lit of juice=4-5)

**Harvest time in Lebanon:** September 2nd

**Yield:** Medium to high with a risk of alternate bearing

**Storage:** 120-150 days at 0-1 degree Celsius

**Demerits:** Very bad coloration at elevation less than 1,200m, isn't fit for hot weather, sometimes shows russetting

   a. **Top Red Delicious**

**Origin:** USA, 1961, red delicious mutant selection of Shotwell, standard vigorous

**Fruit:** Perfumed, distinctive taste, crispy, redder than the stark.

**Harvest time in Lebanon:** August 28th

**Merits:** Early harvest, good coloration even in the Bekaa

   b. **Early Red One**

**Origin:** USA, 1966, selection mutant of RedKing, standard type, weak vigor
**Fruit shape:** Medium to large size (70-85 mm), uniform fruits

**Skin:** Red to deep red, striated and washed, crispy, firm, and very juicy with a mild taste.

**Harvest time in Lebanon:** September 8th

**Merits:** Early bearing similar to the spur type, and tree is smaller in size of all the trees of its type

c. **Starkrimson**

**Origin:** Mutant of Starking, USA, 1961, **spur** type, medium vigor

**Fruit:** Elongated medium size, deep crimson red almost black in color, sometimes with a stripe, firm greenish white flesh

**Harvest time in Lebanon:** September 10th

**Merits:** Very good production, early coloration than Stark

**Demerits:** Its red washed color isn't quite attractive to the international and national consumer; in addition, the Starkrimson can't store well in the fridge and is prone to texture change that affects its taste.

-Susceptible to russeting in some seasons

d. **Red Chief**

**Origin:** Mutant of Starkrimson with a smaller tree than Starkrimson, USA, 1977, **spur** type, medium vigor

**Fruit:** Solid red color not as black as Starkrimson but with a slight stripe

**Harvest time in Lebanon:** September 2nd

**Merits:** More precocious than Starkrimson, better coloration and more elongation than Starkrimson

**Demerits:** susceptible to russetting

e. **Ace**

**Origin:** Mutant selection of Trumdor, USA, 1990, **spurs** type, moderate to weak vigor

**Fruit:** Medium to Large size,

**Harvest time in Lebanon:** September 10th

**Merits:** Early bearing about 2 years after planting, suitable for the Bekaa
f. **Top Spur**

**Origin:** Mutant of Red Delicious, USA, 1990, *spur* type, medium vigor  
**Fruit:** Striped red, elongated, crispy,  
**Harvest time in Lebanon:** September 10th  
**Merits:** Store very well and for a long time

3. **Gala**

**Origin:** Selection from cross of Kidd's orange x Golden Delicious, New Zealand, 1939  
**Tree:** Moderately to strong vigor  
**Disease and pest status:** Moderately susceptible to scab, powdery mildew, and mites. Susceptible to fireblight, woolly aphids, and to *Nectria galligena*.  
**Chilling requirement:** Medium about 600 hours.  
**Pollination:** Red Delicious, Fuji, Golden Delicious, Granny Smith  
**Fruit shape:** Conical, regular, medium caliber (65-80 mm)  
**Skin and Flesh:** Striped red-orange over 50% of the area over a yellow background. Creamy-white flesh, firm, crispy, sweet (refractometer index=12-14%), a bit acid (g-equivalent of malic acid/ 1 lit of juice=3-5), and perfumed.  
**Harvest time in Lebanon:** August 22nd  
**Yield:** High and early production  
**Storage:** can be stored for 90 days at temperature between 0-2 degrees Celsius.  
**Demerits:** fruit size is medium whereas the taste of the region, contrary to Europe markets, demands big-sized fruits. Therefore, special care to thinning should be observed at a proper time if the commodity should be directed to local and gulf markets.

4. **Fuji**

**Origin:** Selection from cross of Rall's Janet x Delicious, Japan, 1939. it was introduced to Lebanon in 1992, mainly its mutants of Nagafu 1 and Nagafu 6.  
**Tree:** Medium to strong vigor with long weeping branch
**Disease and pest status:** moderately resistant to powdery mildew, fire blight, and scab. Susceptible to mites, woolly aphids, and *Nectria galligena*

**Chilling requirement:** Medium 575 hours.

**Pollination:** Red Delicious, Golden Delicious, Gala, and Granny Smith.

**Fruit shape:** Flat round to conical and a bit cylindrical. Moderate to large caliber (70-85 mm in diameter).

**Skin and Flesh:** Pinkish red over a green-yellow to yellow background over 3/4 of the fruit area. The Flesh is white creamy, firm, crispy, juicy, perfumed, very sweet (Refractometer index=14-18%), and very little acidity (g-equivalent of malic acid/ 1 lit of juice= 3-4).

**Harvest time in Lebanon:** October 10th

**Yield:** Early and high cropper, susceptible to alternate bearing

**Storage:** can store very well to 210-240 days at temperature of 0-1 degrees Celsius

**Demerits:** Susceptible to russetting and discoloration at high temperature, in addition to sunscald, and cracking when exposed to elongated sun exposure. Disadvantages that should be taken into account in the Bekaa and in the areas of elevation above 1300m.

5. **Granny Smith**

**Origin:** Selection from a chance seedling of French Crab apples, Australia, 1850.

**Tree:** Strong vigor

**Disease and pest status:** Moderately susceptible to fire blight, scab, and woolly aphids. Susceptible to Powdery mildew.

**Chilling requirement:** medium to high

**Pollination:** Red delicious, Golden Delicious, Fuji, and Gala.

**Fruit shape:** Round to conical

**Skin and Flesh:** Green, turns a bit yellow at end of harvest. Its texture is white-green, very firm, crispy, very juicy, little sweet (refractometer index= 11-12%), acidic (g-equivalent of Malic acid/ 1 lit of juice= 9-10)

**Harvest time in Lebanon:** October 15th till 25th

**Yield:** Early and high yield

**Storage:** Stores well for 90-120 days at 0-2 degrees Celsius
Demerits: it requires a long growth season, making it unsuitable for elevation of more than 1100m; for if picked immature, it is susceptible to scald and skin browning.

6. **Mouwashah or sans pareille**

**Origin:** France  
**Tree:** Very vigorous  
**Disease and pest status:** Susceptible to fire blight and Powdery mildew nevertheless tolerant to Scab and russetting  
**Chilling requirement:** high  
**Fruit shape:** Flattened, large.  
**Skin:** Mostly green sometimes with a red cheek.  
**Flesh:** Whitish with an acid taste.  
**Harvest time in Lebanon:** Very early. It matures the 1st of August in the Bekaa  
**Yield:** Good  
**Storage:** can't be stored for long period  
**Demerits:** Very short marketing period

7. **Reinette de Canada**

**Origin:** Canada  
**Tree:** Large up to 3-3.5 m  
**Disease and pest status:** Tolerant to scab but susceptible to powdery mildew and russetting  
**Chilling requirement:** High  
**Fruit shape:** Flattened and irregular. Large size.  
**Skin:** green to yellow at maturity  
**Flesh:** Creamy, granular, and sugary with an acid taste.  
**Harvest time in Lebanon:** Mid September  
**Yield:** High  
**Storage:** Doesn't store very well

8. **Amassia**

**Origin:** Very old, Asia minor - Turkey
Tree: Moderately vigorous and a slow grower

**Disease and pest status:** Susceptible to scab, fire blight and powdery mildew

**Fruit shape:** Round to conical, medium to big (65-80 mm in diameter)

**Skin and Flesh:** Pale yellow to green with a deep red blush, rough texture, sweet

**Harvest time in Lebanon:** Starting mid September

**Yield:** Good

**Storage:** Doesn't store very well.

**Demerits:** It can't be transported easily in addition to the fact the outside markets don't have a taste for it anymore.

Nurseries around the world are in continuous selection of improved cultivars of fruit trees and everyday provide the market with mutants that are better in one characteristic or another. Anyhow, when selecting varieties to start an apple orchard, several important criteria should be taken into account like fruit size, taste, color, bloom period, ripening season, disease resistance, and pollen compatibility.

When it comes to Lebanese apple growers, they should, whenever they are modernizing their old orchards or starting new ones conforming to the intensive or semi-intensive production approach, keeping in mind several matters pertaining to varieties, mainly:

1. Since the market demand for the old varieties such as the red and the golden delicious varieties has decreased over the years for the benefit of new varieties because taste has changed, it is only logical for the Lebanese growers to adopt these new demanded varieties at a wider range, especially those that have been introduced before and tested such as: Fuji, Gala, Granny Smith etc... Of course, care for climate compatibility (towards chilling requirements, temperature, humidity, etc...) with these varieties should be taken into consideration. In the case of Lebanon, alternatives can be easily found due to the wide distribution of the areas of production that extend from 900m to 1,800m. For example, if Granny Smith has shown to have demerits at elevation higher than 1,100 m, then it should simply be allocated to areas of lower elevations, and another market demanded variety should be adopted instead, suitable to the place, and with the same characteristics like Shamrock. Another example is that of the Red Delicious variety. What apple growers of the Bekaa need to do when faced with coloration...
problems, is adopt one of the Red delicious mutants like Top Spur or Ace that have better coloration.

The idea is for the growers to hold the responsibility of carefully watching the local and to a wider extent the world markets to find out which of the varieties have a solid demand with the will to quickly adopt them after trying them and allocate them to the place where they best perform.

2. Though the old varieties have lost some of their prestige to new ones, they still have their own and important fan club. There is even a reversion in some world markets to the old McIntosh variety, but of course with improved characteristics like the Red Max and Macspur-varieties that need to be tested in Lebanon. Accordingly, the Lebanese Golden and Red Delicious apples are still demanded, but the problem is that they are still produced the old way. What we need, then, is to modernize the existing orchards gradually and replace the existing varieties of Golden Delicious with not only mutants that have better color, resistance to rusting, and early harvest like Smooth, Golden Glory (spur-like), Lysgolden, Sun Fuji, Golden Supreme, or Early gold or Moufti, but also to fetch the new varieties of the spur type that have many advantages being compact trees in general, and fit better in the high density orchards, in addition to:

- Early bearing, where they peak in production at the age of 4-5 years as compared to the standard types that do so at the age of 10 years
- Increase in yield production per unit area in the sense that, though they bear less fruits per individual tree, a larger number of trees can be planted in the same unit area.

Among the Golden Delicious spur varieties that should be tested in Lebanon, we mention: Golden Spur Delicious, and Spur Gold Blush.

Mutants of the Red Delicious varieties that have proven worthwhile trying in Lebanon are Early Chief, Nured Delicious, and Improved Red Delicious.

As for the Gala family, the mutants that need to be tried are mainly: Lydia's Red Gala, Twin Bee Gala, Royal Gala, Mondial, Galaxy, Spur GalaGoRed, and Buckeye Gala.

3. Apple growers should better exploit the Lebanese climate and geography, as well as adopt varieties that ensure the apples' succession of ripening. For example, there are new varieties, with low chilling requirements, of about 200-400 hours,
and as early harvest as end of June. If these varieties are adopted, growers can benefit from the early market demand at that time of the year. Among these varieties, we can list: Pristine, Lodi, Anna, Dorsett Golden, Ein Shemer. Such a practice that seems adequate, especially when we are talking about replacing the old, early harvested varieties like Mouwashah. Then again, growers are to adopt mid-season harvested varieties like Gala and its mutants and late harvested varieties like Fuji, Granny Smith, and Braeburn etc… to spread to production over a longer period of time to keep just enough offers in the market to be sold at a good price.

4. In an attempt to minimize pesticides use in the framework of integrated pest management approach, the Lebanese farmers are invited to adopt new varieties that are resistant to a number of diseases and at the same time fulfill the crucial condition of the market demand. Such a practice leads directly to a decrease in the cost of production, sparing extra labor and pesticides' cost.

Examples of varieties of apples bred to be resistant to some pests are:

- **Pristine**: It has many of the appreciated characteristics in a cultivar among which are: crispy fruits, medium to big, beautiful attractive yellow finish with no russet, early harvested, stores well, and most importantly it is:
  - Field immune to scab
  - Resistant to powdery mildew
  - Slightly resistant to rust
  - Moderately resistant to fire blight

- **William's Pride**: - Field immune to scab
  - Field immune to rust
  - Resistant to powdery mildew
  - High level of resistance to fire blight

- **Liberty**: - Highly resistant to scab
  - Resistant to rust
  - Moderately resistant to powdery mildew
  - Resistant to fireblight

- **Enterprise**: - Field immune to scab
  - Highly resistant to rust
- Moderately resistant to powdery mildew
- High resistant to fireblight

- Red free - field immune to scab
- Field immune to rust
- Moderately resistant to powdery mildew
- Good resistance to fireblight

- Jonafree - field immune to scab and more resistant
- More resistant than Jonathan for rust, powdery mildew, and fireblight.

5. Growers are to choose the right pollinators for their chosen varieties. This issue will be addressed further in a separate section later on in this study due to its importance. Compatible pollinators have been already listed in the description of the different varieties

6. To have a variety that can keep well and for a long time in refrigeration with the ability to be handled easily in transport with a kind of resistance to bruises, is to be considered a good asset that can help in a safer marketing of fruits. To be able to keep for long means that the grower is not compelled to get rid of its produce fast enough in order for it not to be ruined, and sometimes at lower prices, than he expected, because the market is satiated with all of the produce of one variety all at the same time with more offer than demand. Therefore, apple growers of Lebanon are to choose to plant varieties which handle refrigeration for a long period of time again and be ready to market when the price is more convenient. On the other hand, special care should be taken because keeping fruits long in refrigeration, of course, in case the varieties can handle it, also means an increase in the cost of production that should be finally added to the end tab.

Below are mentioned varieties that can handle long period of normal refrigeration:
<table>
<thead>
<tr>
<th>Variety</th>
<th>Normal refrigeration period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gala</td>
<td>90 days</td>
</tr>
<tr>
<td>Granny Smith, Baujade, JonaGold</td>
<td>90-120 days</td>
</tr>
<tr>
<td>INRA Querina, Falstaff, Fiesta</td>
<td>120 days</td>
</tr>
<tr>
<td>Golden Delicious, Golden Supreme, Red Delicious, Red Winter, Harmonie, Cox's Orange Pippin</td>
<td>120-150 days</td>
</tr>
<tr>
<td>Newgold, Belle de Boskoop</td>
<td>150 days Max</td>
</tr>
<tr>
<td>Braeburn, Melrose, Gloster69, Meran, Delbard, Jubile, Suntan, Regali, Arlet</td>
<td>120-180 days</td>
</tr>
<tr>
<td>Enterprise, Suncrisp</td>
<td>180 days</td>
</tr>
<tr>
<td>Pinova, Reinnettes de Canada, IdaRed</td>
<td>180-210 days</td>
</tr>
<tr>
<td>Fuji</td>
<td>210-240 days</td>
</tr>
</tbody>
</table>

**Table 3. Varieties with relative normal refrigeration period**

Other varieties can be found listed in catalogues of nurseries around the world but the most important thing is to test them, whether in official trial stations or by farmers themselves, before they are being recommended for large scale plantations.
C. Rootstocks

The rootstock is an important part of the apple tree affecting solely or in combination with the scion many of its characteristics which should be taken into account when starting an orchard. The type of rootstock determines the overall size of the tree or vigor, earliness to bear, tolerance to soil and climate factors, and life span and durability of the orchard. The rootstock and the scion both determine the productivity, the fruit qualities, pest susceptibility and plant health in general, chilling requirements and hardiness. Unfortunately, most of the Lebanese apple growers are ignorant to these facts and only few of them look into the rootstock criteria and health when starting an orchard.

In the 1950's, many of the orchards were started and grafted on a seedling i.e. (from a seed). On the other hand, very small areas were started using the prevalent rootstocks of East Malling station at that time mainly the M2, M4, M7, and M16 namely because already grafted seedlings were imported for planting from France and Italy. In the 1960's, and again on a small scale, rootstocks such as the Merton-Malling rootstocks were introduced mainly: MM106 and MM111.

Nowadays, the majority of the nurseries are still using seedlings as rootstocks, and very few, with informed and demanding clients, are selling imported, already grafted, and certified plants on rootstocks such as: M9 (Pajam2, Bud2, Emla9), MM106, MM111, M26, and M7, all of which are virus-free.

Following is a short description of the different rootstocks used for apples in Lebanon categorized according to the most obvious effect they carry over the whole tree i.e. size. Of course, there is a new scale for classification of rootstocks going from 1 to 9, but for our own purposes, we'll keep it for five categories: standard, semi-vigorous and semi-dwarf, dwarf, and very dwarf.

1. Standard size rootstocks

Seedling

Origin: From a seed
Size: Very vigorous- 100% (10)
Height of trees: About 6m

<table>
<thead>
<tr>
<th>Seedling</th>
<th>Origin</th>
<th>Size</th>
<th>Height of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling</td>
<td>From a seed</td>
<td>Very vigorous- 100% (10)</td>
<td>About 6m</td>
</tr>
</tbody>
</table>
**Precocity to production**: Very slow 6-7 years

**Anchorage**: Very well anchored

**Resistance and susceptibility**: Unknown and unpredictable depending on the genetic traits.

**Demerits**: - Heterogeneous with unpredictable behavior  
- Production unpredictable with variable size fruits  
- Large size making all the cultural practices hard to fulfill.

2. **Vigorous**

**MM111**

**Origin**: Northern Spy x Merton 793, 1920

**Size**: Semi-vigorous to vigorous, more vigorous than M106, 65-70% of seedling size, (8)

**Height of trees**: 4.5-5.5 m

**Precocity**: 4 years

**Anchorage**: Very well

**Resistance and susceptibility**: - moderate resistance to crown and root rot  
- moderate resistance to fireblight  
- susceptible to powdery mildew  
- resistant to wooly apple aphids  
- moderately susceptible to tomato ring spot virus

**Merits**: - Most drought resistant apple rootstock and tolerant to a wide range of soil types  
- Appropriate for use for spur type varieties

**Demerits**: Its large size

**Used for**: Precocious varieties like Gala, Fuji, and Spur type varieties

3. **Semi-Vigorous**

**MM106**

**Origin**: Northern Spy x M1, Merton-Malling, 1920.

**Size**: Semi-vigourous, similar in size to M7, 55% of seedling size, (7)

**Height of trees**: 4 to 5 m
Precocity: 3-4 years

Anchorage: Good, needs staking the first 2 years

Resistance and susceptibility:
- Highly susceptible to collar and root rot
- Resistant to woolly apple aphid
- Susceptible to fireblight
- Hypersensitive to Ring spot tomato virus

Merits:
- Can induce early and heavy production in slow bearing scion varieties
- Light suckering
- More productive than M7 on well drained soils

Demerits: Very little cold hardiness

Used for: Suitable for semi-intensive plantings on well-drained sites with most new varieties

4. Semi-Dwarf

M7

Origin: Also called "Doucin Vert", 1913.

Size: Semi-dwarfing, 55 % of seedling size, (6), new strain M7 Emla(virus free M7) is a bit larger.

Height of trees: 4 to 5m

Precocity: 3-4 years

Anchorage: Good, needs staking the first 2-3 years.

Resistance and Susceptibility: - Tolerant to collar and root rot
- Susceptible to wooly apple aphid
- Moderately resistant to powdery mildew
- Resistant to fire blight

Merits: Useful for spur type scions

Demerits: - Suckering is high
- Fruits are smaller and productivity is moderate to low

Used for: Suitable for productive scion varieties in semi-intensive plantings.
5. *Dwarf*

*M26*

**Origin:** M16 x M9, 1929  
**Size:** Dwarfing, 40-50% seedling size, (4)  
**Height of trees:** 2-3 m  
**Precocity:** 3 years  
**Anchorage:** Good, needs staking in early growth  
**Resistance and Susceptibility:** - Susceptible to collar and root rot  
- Susceptible to fire blight  
- Susceptible to woolly apple aphid  
- Moderately resistant to powdery mildew  
- Hypersensitive to tomato ring spot virus  
**Merits:** Induce early bearing and coloring, highly productive  
**Demerits:** - Susceptible to excessive moisture and to drought at the same time. It is not recommended for light soils.  
**Used** only with fire blight resistant varieties

*M9 and its strains*

**Origin:** Jaune de Metz, 1912  
**Size:** Dwarf, 35-40% of seedling size, (3)  
**Height of trees:** 2-3 m  
**Precocity:** 2-3 m  
**Anchorage:** Poor, needs staking  
**Resistance and susceptibility:** - Partially resistant to collar and root rot  
- Susceptible to fire blight  
- Susceptible to woolly apple aphid  
**Merits:** Early bearing and efficient production in terms of fruit size and color  
**Demerits:** - Can't tolerate drought  
- Suckers a lot  

Other strains of M9 have evaluated by different programs such as the Pajam1 (10% smaller than M9), Pajam 2 (10% bigger than M9), NAKB (slightly smaller than M9), M9 Emla, M9 VF.
Used for: Suitable for semi-intensive plantings on well-drained sites with most new varieties.

In order to stress the importance of planting at higher densities using rootstocks, we give the following example based on the Lebanese experience. Most growers who used seedlings planted their trees at distances of 5x5m in the mountains and 6x6m in the Bekaa, i.e. at approximate densities going from 280-400 trees/ha. The yearly yield of a 20 year old orchard amounts to 15 tons/ha and in the best times it goes up to 40 tons/ha. While on the other hand, the growers that used varieties like golden and stark on rootstocks like M2, M7, M106, and M111, planted their orchards at densities of 650-800 trees/ha. The yearly production of a 15 year old orchard is not less than 30 tons/ha and can go up to 60-70 tons/ha.

Accordingly, Lebanese growers are to stop using uncertified seedlings as rootstocks and start using some more reliable, healthy vegetative materials. They are to study their rootstocks and scions traits very carefully and acknowledge their capabilities and limitations to be able to match the combination set they choose to fit their needs. First of all, the chosen variety scion should be compatible with the chosen rootstock, in general, depending on the type of soil, pest problems, and the desired tree size that reflects on the orchard's density. Concerning compatibility of the scion and rootstock, there is one general rule that growers should abide to that goes like "Spur varieties that are, originally, small in size aren't to be grafted on more dwarfing rootstocks", since this practice would result in very weak trees with little production and economical importance. Spur trees are only to be grafted on vigorous and semi-vigorous rootstocks like: MM111, M7, and MM106, and in this case, the trees are planted at the same distances of the dwarfed and semi-dwarfed standard trees. Again, we stress the importance of trials, since there are always exceptions to the rules. For example, Granny Smith, though a very vigorous variety isn't recommended to be grafted on dwarfing rootstocks like M26, due to reasons having to do with the habit of fructification of the tree. As to the choice of reliable rootstocks, growers are to choose the traits that fulfill the required size control, the date of blooming, the precocity, the winter hardiness, and resistance to diseases of concern (Assli, 1996).
Anyhow, there is nothing absolutely good; everything has its advantages and disadvantages. So is the case of apple varieties and rootstocks. Growers are to choose the combination that best suits their purposes, and they are invited to look into the everyday innovations that appear in the world nurseries and to try before adopting.

**D. Source of the vegetative material**

Unfortunately, all the vegetative materials of Lebanon's nurseries are produced without taking into account the obligatory phytosanitary requirements to produce certified virus free or even virus tested materials. Perhaps, it is because the nurseries owners haven't felt the exigency to do so. Initially, most of the growers aren't especially asking for certified materials in particular, making the vegetative materials produced otherwise useless and unmarketable. Most of the growers are content with what they find locally as vegetative materials and trade the low prices for quality. One can find an already grafted seedling with any classical variety of Stark or Golden for a 1.25$ only. Of course, trueness to type in terms of traits of the rootstocks or scions isn't an issue in this case, going by the saying "live to tell" after 5 or 6 years, when the production is due. On the other hand, the state is until now reluctant in issuing a law for certification compelling enough to make the production of certified materials mandatory and binding. The nurseries aren't licensed for production, and the Ministry of Agriculture, who is the responsible body for issuing such licenses, doesn't even keep a record of their identities and locations. As a result, nurseries are left with the freedom to produce and market whatever they think is profitable, regardless of the kind or health of the vegetative materials.

Nevertheleess, some of the known and reputed specialized nurseries are importers of certified and tested vegetative materials from abroad, mostly France and Italy. Of course, these importers are driven by 2 forces: their own profit and the grower's specific request. Still, we owe them the introduction of all of the improved and previously listed varieties and rootstocks. Growers dealing with such importers of vegetative materials are to put up with 2 main obstacles because they appreciate the certified material and understand its importance. First, since this certified material isn't produced locally, the grower has to fill a binding order a long time prior to planting his trees that could extend
for more than a year sometimes. Such delay is attributed most of the time to the availability of the specific varieties in the abroad nurseries. Second, the local grower has to invest a large sum of money for his certified vegetative materials that could go up to 20 or 25$/ certified grafted tree.

Furthermore, in an attempt to improve the previously explained situation, the Ministry of Agriculture has joined effort with the Lebanese Agricultural Research Institute and CIHEAM-BARI, with a funding from the Italian government, and through 11 volunteered Lebanese nurseries, to multiply mother trees of stone and pome fruits of different varieties brought from Italy, to produce 20,000 certified plants during the year 2006, among which 8,500 were apple trees. The multiplied apple varieties were mainly Golden B, Granny Smith, Red Chief, Stark Delicious, and Top Red Grafted mainly on rootstocks such as: seedlings, M9, and MM106. The good news is that all the produced certified plants were sold out at the beginning of 2007. Of course, those certified plants were sold at an encouraging price of 3 to 4 $, depending on the variety. This indicates that apple growers can be appreciative of certified materials, but, of course, at a reasonable price. The growers were willing to pay approximately triple the price of a locally produced uncertified plant, for a certified one. We can reckon that with a little effort of extension to growers, coming hand in hand, with an even optional certification law at the beginning which doesn't have to be compulsory; we can put the train back on the right track.

E. Modern orchard: the trend

We have already stated that most of our apple orchards are old, not only in terms of varieties but also in terms of the mode of conduct, and we suggested modernizing our orchard. Well, what do we mean by a modern apple orchard exactly? Does it have any special characteristics? The answer is yes, and following are the main ones:

1. Varieties:
As was stated before, people's taste over the world has changed. Accordingly, the modern orchard is planted with varieties that suit the nowadays taste in terms of color, size, and taste. Most importantly they easily find their way to the local and the outside markets. Moreover, the
use of pest-resistant varieties is what distinguishes the modern orchard, since less money is spent on spraying and labor, and most importantly the apples produced are pesticides residues free.

2. **Density of plantations:**
The old orchard used to be planted with a density of trees of not more than 100-400 trees/ha and the distances between trees could go up to 10x10m or even 10x11m. The modern orchard, on the other hand, is an **intensive** mode of plantation where the density of the trees can go up to 600-900 trees/ha in the **semi-intensive** orchard, to 1,250 trees/ha in the intensive orchard, and to more than 2,500 trees/ha in the **very intensive** orchard.

3. **Dwarfing rootstocks:**
To be able to plant such intensive density of apple trees/unit area, the size of the trees is controlled by the use of dwarfing rootstocks. The height of the trees is kept in the range of 2.5-3 m.

4. **Precocity**
This kind of intensive orchards is precocious. It fruits much sooner and peaks in production at 3 or 4 years as compared to the traditional orchards that peak in production at the age of 10 years. For example, the production of a modern orchard planted with Lysgolden varieties at a density of 1.5x4m or 1,667 tree/ha is approximated to be about 50 tons/ha at the age of 4 years.

5. **Amount of production:**
The amount of fruits produced is less per individual tree, but this is accounted for in terms of the higher number of trees/unit area, leading to higher tonnage/unit area.

6. **Fruit quality:**
Fruits produced in the modern orchard i.e. on dwarfing rootstocks are usually larger and more intensely colored compared to traditional orchards. I wish the same could be said about the taste, but after all and as the old Lebanese saying goes like "fruits are appreciated for their appearance".
7. Cultural practices:
Because the modern orchard's trees are of the controlled small size, all the cultural practices like pruning, training, spraying, picking etc… are easier to perform and are done from the ground where there is no need for ladders to support the workers. In this sense, the modern orchard is even called the pedestrian orchard, where all the activities are done while strolling on the ground.

8. Labor intensity:
The modern orchard, especially the intensive and the very intensive, is also labor intensive in terms of cultural practices, though they are conducted more easily. The intensive orchards need special type of pruning and training, where the trees, though they are allowed to touch, they aren't permitted to get entangled together. Those types of training mostly require special structures like trellises and wiring.

9. Pest management:
One important feature of the modern orchard is the way pests are managed. Pest management is a job performed on strict requirements that ought to be done by highly trained people because a lot is at stake, and any wrong decision could be disastrous. Therefore, every practice done is already planned for and conducted within the integrated pest management strategy. Pests are controlled, using mostly cultural practices. Chemicals are only sprayed when they are needed with no other way out without them.

10. Life Span
The longevity of the modern orchard isn't more than 12 years, giving it a certain needed dynamicity to cope with the changing market taste as compared to the old orchards with standard type varieties grafted on seedling rootstocks that last for 50 or 60 years. In other word, this aspect of the modern orchard makes the grower somehow more courageous in taking daring decisions in adopting new varieties.
11. Cost:
Of course the initial cost of starting a modern orchard is relatively high because it needs a large investment in the cost of the plants and in the infrastructure like staking, wiring, irrigation systems etc… However, these expenses are quickly recovered since, as already stated, the modern orchards peaks in production in a very short time.

In short, modernization of apple orchards is a delicate equation between economy, labor and knowledge. If the growers are to earn more, they need to use their inputs more wisely, but this doesn't necessarily mean that all the present should be plucked out and substituted with dwarf intensive orchards right away. What we are suggesting is that each grower should stay open to renovate his orchard whenever it is possible and know a priori at what expenses and what fit his purposes, should it be intensive, semi-intensive, or standard orchard.

F. Pollination

Most of the Lebanese apple growers know little about the importance of pollination in apple orchards and how much it reflects on production and quality of their produce. All they know is that, they need to plant Red Delicious along with Golden delicious, but they don't really know why. If some of these growers ever knew the reason behind mixing 2 varieties, which is about pollination, they would be totally ignorant of how to choose a compatible pollinator variety or where to place it to get the best results. One more thing the growers seem ignorant of is the role of bees and insects in the pollination process since they will not hesitate for a second in spraying a bee hazardous pesticide right in the middle of the pollination action when they feel threatened by even a single aphid.

Hence, apple growers should be advised about several aspects related to pollination, mainly:

- Apple trees, even if some varieties are self compatible in terms of pollination, are to be considered as self-incompatible and need to be cross-pollinated to produce good quality fruits. Therefore, when starting an apple orchard, at least 2 compatible varieties in terms of pollination
are needed. In some cases, we need more than 2, depending on the chosen varieties.

- The chosen varieties need to have overlapping blooming periods
- Some apple varieties produce sterile pollen; therefore, pollinizers need to have viable compatible pollen.
- Some apple varieties alternate in bearing every other year if not thinned appropriately. If the pollinator belonged to this category, the other fertilized variety will be affected too and will acquire the habit of biennial bearing if it wasn't originally partially self-pollinated, simply because it didn't have its flowers fertilized.
- For it to be effective, the pollinator variety needs not to be farther than 2 rows from the fertilized variety. A common practice is to have a pollinator every third tree in every third row.
- Pesticides aren't to be sprayed at bloom since this will definitely kill the bees and the other insects that play the primary role in pollination. Furthermore, some insecticides like Carbaryl, for instance, may show plant growth regulator activity that may lead to an increased unintended thinning.
- Placement of bee hives at 10% bloom will have a direct positive effect on pollination.
- Growers need to choose economically important variety as a pollinator if possible. Some extra money for the pollinator's produce will not hurt anyone.

G. Pruning

Pruning is one of the most important cultural practices that is conducted in an apple orchard its direct implications it has on production, yield, fruit quality, and efficient management.

Amongst Lebanese apple growers, very few really know the first basics of pruning an apple tree and perform the job professionally. What they know is that they must prune but the "how" and "why" is a totally different story. In one hand, one can find apple trees that were rendered weak and unproductive because of harsh pruning that created an imbalance, leaving them with little fruit buds. On
the other hand, one can find trees with little or no pruning at all with their branches entangled altogether, resulting also in economically unproductive trees where other cultural practices such as spraying, picking, etc… are performed with major difficulties. Pruning of apple trees is always performed late in the dormant season during winter; no summer pruning is ever performed. Furthermore, pruning activities are many times conducted by hired labors who are supposed to be professionals in this field, but the problem resides in 2 facts:

- Those people are highly waged, if ever available, during the pruning season.

- Another fact is that what these people know is out of practice working with certain varieties, a matter that qualify them to deal with the new dwarf varieties that differ tremendously, in terms of pruning, from the standard varieties.

In any case, and just to be fair, pruning can be the most confusing among all the cultural practices growers are to perform in an orchard. The reason behind it is just because pruning, though it has some basic principles that should be followed, must be performed with certain individuality per each tree that has its own character, personality, and need. There is no one healing prescription that can be applied on all trees.

Before suggesting anything about the best ways to prune apple trees of both standard and spur types, we should set the stage first by enumerating few basic principles that should be useful in explaining the right way to perform this job in Lebanese orchards, mainly:

- The main objectives of pruning are to: control size of the tree, give it strong structure to hold the yield weight, make use of sunlight, improve the fruits quality, and control bearing habits.

- Trees bear fruits to preserve the species, not to serve humanity. They bear more fruits when they sense their weakness and their near death, while they bear less or none when they are strong and full of vegetative growth, since they don’t sense the urge to leave their seeds. In other words, for the humans to exploit well their trees, they need to keep the balance between strong vegetative growth and adequate fruit bearing.
- A professional performing pruning and training of apple trees should be able to predict the result of each cut he performs. For this it is useful to give some details concerning this point. For instance:
  
  • Terminal growing shoots exercise what is known as "terminal dominance" by producing the type of growth regulating substances that inhibit shoot and flower development from lateral buds.
  
  • If an upright branch is bent near a horizontal position, terminal shoots are stopped, and the buds beneath the terminal shoot are stimulated to grow into lateral shoots and more into flowers. On the other hand, if the upright branch is bent below the horizontal position, buds at the base of the branch are differentiated into vegetative and useless water suckers.
  
  • The difference between heading back pruning cuts and the thinning of branch is translated in terms of the removal of the apical dominance. Therefore, heading back cuts stimulate terminal buds, leading to excessive upright vegetative growth, while a complete removal of the branch as a result of thinning has a very little dramatic effect on growth, since the normal flow of the growth regulating materials is unaffected.
  
  - Unwise use of nitrogen fertilizer, in addition to ill-advised harsh pruning such as heading out of branches, lead to excessive vegetative growth on the expense of fruit bearing.
  
  - A decrease in the amount of irrigated water may lead to a decrease in the number of fruiting buds.
  
  - During the life of the tree, there are 3 main types of pruning:
    
    • Structural where shape is given to the tree
    
    • Pruning bearing trees
    
    • Rejuvenation

    For our purpose, we'll go further into the details of each type later on.
  
  - In general, the degree of pruning that should be performed is extremely dependent on the bearing habits of the trees. For instance,
apple trees, in general, bear fruiting buds on wood of 1 year of age in
the standard type and on spurs of 1 year or more than 1 year of age in
the spur type. Therefore, the degree of performed pruning should be
minimal to moderate in most cases, unlike to what most Lebanese
growers tend to do in heading out the branches of 1 year old without
logical validation.

- Sometimes, it is better not to prune a branch in case the effects of the
resulting cut aren't clear, and wait for the next year when the situation
can be easily corrected and effects are more obvious.
- With a keen eye, one can distinguish fruiting buds that look swollen
and round and vegetative buds which are pointed and sticking to the
branch.
- Old and neglected trees need to be pruned and brought to shape
gradually over 2 or 3 years and not all at once.

Taking into account the previously mentioned general principles of pruning and
truly inspired by the practical experience of the late Said Kheirallah, who was considered
one of the best horticulturists in Lebanon, we will elucidate the best suitable ways, to
prune both standard and spur types of apple trees, in Lebanon.

1. Structural pruning of apple trees:
Many types of pruning are known over the world such as bush, cordon, espalier, fan etc.,
but what proved to be efficient and suitable for the Lebanese climate is restricted to 2
types: the modified leader for the standard trees and the cone or pyramid for the
dwarfed and the spur type of trees.

a. Modified leader
   - Year 1: Newly planted trees should be headed out at height of
   about 80-90 cm after tying them to a stake to stimulate the
   lateral buds to grow.
   - Year 2: In the next dormant season, 3 or 4 lateral shoots, or
   scaffolds, are to be kept spread at 15-20 cm away from each
   other with a wide crotch. These lateral shoots are to be
   headed out at 30-40 cm in length. The buds following the

35
cuts are to be directed towards the outside or where there is more space. The other scaffolds are to be thinned out completely. The leader should be headed out at a longer distance than the other scaffold.

- Year 3: each headed out scaffold in the last year, should be left again with 2 or 3 laterals 10-15cm apart.

- Year 4: the same should be repeated in the last year and, by this, the heading out of branches should end. The leader should be cut 5-10 cm lower than the year before and for 2 more consecutive years. Along with this, a tilted branch near the leader should be selected to be headed at 30-40 cm to be ready to replace the leader when it withers and weakens.
b. Pyramid or cone structure

We ought to distinguish 2 categories of trees when performing the pyramid pruning, depending on the growth habit of the trees. The first category is the type of trees that spread their branches and their fruits towards the periphery like the Golden Delicious, the Red Delicious and the Granny smith etc…. Those trees are vigorous in nature and dwarfed by a certain rootstock to be planted intensively. The second category is restricted to all the spur types of trees that are compact in nature with thick and short vegetative growth on which fruits are set near the trunk.

i. Standard size trees

- Year 1: the planted tree is headed at a height of 135 to 150 cm. All the branches are thinned out below 35 cm from the ground level. The number of the other branches should be between 8 and 10 branches of length about 10 to 15 cm. If one of these branches is longer than the others it should be headed out at a length of no more than 10 cm.

- Year 2: The leader is headed again at a height of 20-25 cm. The 3 or 4 primary branches below the leader should be headed out gradually at 15 to 25 cm. The entangled branches that grew last year on the primary branches are to be thinned out completely.

- Year 3: Again the leader is headed out at a height of 15-20 cm and so is the next branch or a bit longer. Again the entangled branches directed upwards or downwards are to be thinned out completely.

- Year 4: the leader is to be headed out if still strong at 15-20 cm. If the leader has weakened, it is better to thin it out completely and give the chance for the next branch to lead instead, after heading it out at 15-20 cm. From now on, no branches are to be head out unless to control a strongly growing branch. Otherwise, only thinning of unwanted branches is permitted.
ii. Spur type trees

- The newly planted tree is to be headed out at a height of 135-150 cm.
- The entangled branches are to be thinned out completely. No heading out of branches is to be performed in this type of trees unless to stop a branch that grew much more than the rest. After all, this kind of trees is small and compact in nature and any unstudied pruning result in weakening the tree.

2. Pruning bearing trees:

Before getting into the details of pruning bearing trees, it is of utmost importance to understand a couple of things. First, the vigor of the tree and the amount of sunlight it receives are 2 interrelated factors. The top of the tree that is mostly exposed to sunlight produces more vigorous shoots and fewer big fruits of less quality. The shoots growing in the heavily shaded area are weak and produce small fruits of inferior quality also. The moderate vegetative growth with high number of good quality fruits can be found on a horizontal branch capturing enough amount of light. Therefore, a balanced and adequate amount of light should be made available uniformly to the tree to sustain a balance between vigor and fruitfulness. Second, apple trees possess the habit of bearing on a 1 year old wood and on 1 year old spurs-in case of spur trees. Therefore, severe pruning will lead to yield loss, in addition to encouragement of more vegetative growth, creating sometimes an irreparable damage. The intensity of pruning is to be in the range of moderate to little.

As to the pruning of the dwarf trees, very little pruning is required if a correct structure has been already established. The only type of necessary cuts might be thinning out of an unwanted branch in an attempt to keep the shape of the pyramid or the cone. Adjacent trees should not be let to touch and get entangled, keeping in mind preservation of the light and vigor balance.

As to the pruning of trees of standard size, we should follow the same principles mentioned before, but few more things are to be taken into account. First, in general, a
tree is considered to be balanced in terms of vigor and fructification if its shoots grow average length of about 30 and 40 cm per year. A tree with longer shoots is considered to be more vigorous, while a tree with smaller shoots is considered to be weak. Out of this practical observation, if we may call it, we can use this indication to direct our pruning towards vigor or fructifying which is ever needed, of course, without forgetting the other cultural practices such as fertilization and irrigation. In this case, thinning out cuts are to be performed in the top part of the tree while keeping the modified structure and more detailed pruning with occasional heading backs cuts are permitted in the lower parts. Second, a common problem is to be identified when dealing with the Lebanese growers in pruning bearing standard size trees that are planted on a seedling, which is the case of most of the rejuvenated orchards. Now this kind of apple trees is very vigorous and tends to grow excessively long 1 year old shoots that the growers try to fix erroneously with heading out cuts that aggravate more the situation. The tree in this case, as indicated previously, will try to replenish with more vegetative growth. This problem is to be solved by one of three methods: First, by summer pruning at the beginning of July, where heading out cuts are to be performed on long vigorous shoots. This type of pruning, though it directs the tree towards bearing by producing many weak fructifying shoots, is not recommended because it weakens the whole tree. Second, bending and tying these long vigorous shoots in early summer will stimulate many short shoots to grow on the base and turn to fructifying shoots and spurs. Those shoots are left if they are of the length of 30-40cm. Otherwise, they are to be headed back at this length in the same summer and wait for the bent part to give its fruits. After fructifying the bent shoot should be thinned out completely, in the next season. Third, long shoots are to be left untouched, at the base of which many shoots and spurs will grow. Many of these new shoots are headed back in the next dormant season along with the thinning out of the older shoot, whereas the others will be headed back the year after. (Kheirallah, 2000)
H. Tillage and cultivation

Unfortunately, it seems like Lebanese apple growers are also dogmatic about tillage, thinking that the more times they cultivate, the better is the production of their crop. Many of the growers, in the different areas of production, couldn't explain the logic behind plowing so many times. They just do it because their grandfathers used to do it too, completely ignoring the fact that their grandfathers planted their orchards rain fed, relying solely on rain precipitations for irrigation. Anyhow, all the apple growers perform a minimum of 3 cultivations per year. This practice is mostly mechanized with tractor. The type of plows used is of the duck type that goes down for 15-20 cm in depth. Some growers own small hand driven tractors equipped with a rotary tiller or a small disk harrower. A few traditional growers still rely on mules to drag a single Arabian plow. The first cultivation is conducted in late October to prepare the soil to receive the maximum amount of precipitation. The second cultivation is performed in late April to break the capillary movement of water and minimize evaporation. The third cultivation is performed, after fruit set, with what it seems as the main objective of weed control.

I. Irrigation

It is estimated that more than 30% of the apple growers have adopted drip irrigation for they appreciated its effect on saving water, increasing the production, and better controlling the weeds. This is especially true in the areas of Bekaa, where the water is dearer than in other areas. It is mostly extracted from artesian wells where the water table seems to be dropping year after year, and it is becoming more and more expensive to extract it in terms of high fuel cost. Nevertheless, the other 70% of the growers are still traditional concerning irrigation. They water their apple trees, using the flood irrigation method where water is driven into basins dug around the trees. Apple growers of Bekaa start irrigating their orchards starting mid April, while apple growers in the mountainous areas can do without until late May. The frequency of irrigation depends on the area and varies between a week and 2 weeks.

There are many reasons keeping the growers reluctant or hesitant in adopting a drip irrigation system. First, it is probably because they think they don't need it having their orchards near springs in the areas of Mount Lebanon, where plenty of water is available.
Second, it is because of the relatively large initial cost installing an irrigation system requires, in addition to the cost of the reservoir and the pump. Third, many of the land shares in Lebanon get their share of water, based on a prescheduled turn every 10 or 15 days depending on the areas. In this case, and unless every parcel of land has its own reservoir, watering with a drip irrigation system, directly from the source based on a 10 or 15 day frequency, will defeat the purpose of its installation in the first place since the main idea behind installing a drip irrigation is to be able to satisfy the plant need in water whenever needed, depending on the type of soil and its capability to retain water, crop stage, and time of irrigation, and not when the turn permits. Fourth, and this is the case of the majority of growers, they simply ignore the advantages of having a drip irrigation system.

J. Fertilization

Very few are the apple growers who perform periodic soil tests to determine their soils' deficiency in macro and micro nutrients. Nevertheless, if they ever performed a soil test, it would rather be restricted to the main nutrients like nitrogen, phosphorus and potassium. No soil tests are ever conducted to micronutrients and they don't even recognize the plant need for them. In addition to the previous, no leaf tests are ever conducted to be able to compare results with those of the soil test to really assess the availability of the different elements to satisfy the plant's needs. The growers, in general, rely on 2 things: the routine they perform in fertilization every year and on the recommendations given by the merchant or the company from where they buy their fertilizers.

As far as the fertilization routine performed, all the apple growers seem to agree on using organic matter every other year in addition to synthetic bulk fertilizers every year plus few "extras" every now and then. The following is a representation of the most common approaches used:

**Organic matter:** 8 to 10 kg of manure of animal origin like cows, horses, or goats are spread under the tree-sometimes, just piled up- in late November. Many times, this manure is not fermented very well and may carry lots of weed seeds that flourish later on in the season. All the growers seem to favor the goat manure for it is cleaner and more effective. Some growers, because of weeds problems, have started to shift into sterilized
organic matter that is found in the market under different brand and formulas, but of course, the price would play a role in adapting this option. Accordingly, the amount per tree added of treated organic matter is diminished to be a more cost effective alternative in comparison to the manure. What the marketing companies recommends varies between 4 to 5 kg of the averaged priced 70% organic matter of plant origin to as low as half a kg of the more expensive Guanos of fish or Penguin. Furthermore, some growers, especially those who possess an irrigation system, have started to use liquid organic matter 70% at the rate of 4 l/dunum dissolved in the irrigation water at the silver leaf stage.

**Bulk fertilizers:** The great majority of the apple growers utilize formulas of bulk fertilizers such as 17-17-17 that is spread beneath the tree at the rate of 2-3 kg per plant. Nevertheless, this same amount of 17-17-17 is spread as early as late November in the elevated areas of Mount Lebanon and Aakar, whereas it is spread later on during January, when the weather permits, in the areas of the Bekaa.

Taking a different approach within the same strategy, different kinds of bulk fertilizers formulas are recommended by the different fertilizers' companies, but at different rates and different timing. For instance, one program relies on using 1-2 kg per tree of 12-12-17 during March, in addition to 1-2 kg of the same formula during June. During July, 1-2 kg per tree of potassium sulfate would be added in addition to 1-2 kg per tree out of a formula of 15-5-20 during August. Last application would be 2-2.5 kg per tree during the month of November of the formula 15-15-15.

Another program relies on recommending the following: 1.5-2 kg per tree of the formula 14-18-14 in early April, in addition to 1.5-2 kg of the formula 8-16-30 at fruit set stage. A third program relies on recommending the following: During January till February, 2 kg of Di-ammonium phosphate in addition to 1 kg of patent kali per tree. This is followed by 2 applications of 0.5 kg each, made of Potassium nitrate, the first application during August, while the second is in mid September.

**Soluble fertilizers:** The usage of soluble fertilizers is more or less restricted to orchards that are equipped with an irrigation system. Yet some of the farmers that irrigate by furrows might use soluble fertilizers, too, by dissolving the amount of fertilizers they want to use in a 200-lit-capacity barrel that is equipped with a faucet to drain the content in the furrow while watering. Again, different programs are suggested by different
fertilizers' companies and, of course, each recommends and markets its own commodity. Anyhow, following are some examples of programs for additional soluble macronutrients (plus trace elements) fertilizers used during the season; it should be taken into account that growers can't rely solely on these kinds since they are dissolved in the irrigation water. One of the programs proceeds as follows: the first application is timed on the first irrigation of 10-40-10 at the rate of 4 kg/dunum. Another application is made of 20-20-20 formula in addition to 3 kg/dunum of the 30-5-10, at fruit set. A third application is made of potassium thio-sulfate a month before picking.

**Extras:** In addition to the previously mentioned and no matter what program of fertilization is used, growers use foliar spray fertilization rich in some of the important elements such as calcium, boron, and other micronutrient found in different formulas.

<table>
<thead>
<tr>
<th>Time of application</th>
<th>Type</th>
<th>Rate of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver stage</td>
<td>Calcium phosphate</td>
<td>400g/200 lit</td>
</tr>
<tr>
<td>Fruit set</td>
<td>Calcium borate or Boramine</td>
<td>300-400g/200 lit</td>
</tr>
<tr>
<td>Any stage</td>
<td>Foliar 20-20-20 + trace elements</td>
<td>500 g/200 lit</td>
</tr>
<tr>
<td></td>
<td>Microelements(Fetrillon Combi)</td>
<td>200g/200lit</td>
</tr>
<tr>
<td></td>
<td>Foliar Iron</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Types and rates of some sprayed materials

Growers are to become aware that erroneous practice of fertilization leads to many problems. Many times, beautifully fat looking apple fruits at harvest won't store for a long time because of excessive nitrogen fertilizers. Many times, deficiency in one or more element is created because the growers are providing the plant with excessive amounts of another element that is competing with the rest of the needed elements on the plant roots to be absorbed.

Growers are to perform periodic testing of their soils in addition to leaf testing, no matter what the cost is. In all ways, amending the soil with what it needs will be far more cost effective than dumping all kinds of fertilizers unnecessarily.
K. Thinning

Fruit thinning is an important practice that reflects positively on fruit size, color, quality, and yield. It, also, regulates the tendency of alternate bearing. Thinning is performed mainly through 2 methods: manually and chemically, through the use of plant growth regulators or chemicals, mainly pesticides like Carbaryl that has this particular criterion of thinning fruits. In Lebanon, very few growers carry out thinning in general, or even have the need to do it because of the severe pruning most of the growers perform on their apple trees. Nevertheless, many of them recognize the weakening effect of letting newly planted trees to bear fruits, on the structure of the tree. In addition, they admit the positive effect thinning fruits has on mature trees towards maximizing size and quality of the yield. What they do is that they thin manually the fruits of young trees till the age of 3 or 4 years, but they are reluctant in thinning fruits of mature trees, for it is a costly practice.

Very few growers thin chemically fruits of apple trees, using mainly the pesticide Carbaryl, and not because of its thinning effect but primarily for its control of many insects like aphids, coddling moth, and scales. Those growers aren't familiar with the way Carbaryl works in thinning nor are they familiar with the specific rates of use, time of application, suitable apple varieties and most important the affecting environmental conditions that maximize or reduce its thinning effect. Carbaryl 85% WP is used at the rate of 250-300 g/200 lit of water, 20 to 35 days after petal fall. Apple growers are unaware of the presence of other thinning agents like the NAA (Naphtalene acetic acid), NAD (Naphtelacetamide), and Oxamyl etc… and of course of how to use them.

May be, at the time being, the usage of thinner is not that compelling, but once apple production is to evolve to the modernized way in the orchards of high density with the new varieties, thinning is a must practice and we can't do without. In this case, apple growers are to learn and study their thinning alternatives carefully and to experiment them before generalizing their use towards: type, rate, type of varieties, stage of application, effects on quality mainly russetting, effects of environmental conditions like humidity, temperature, and light.
L. *Harvesting*

The criteria that indicate the maturity of the fruits for the growers to set the harvest time are based primarily on appearance of the fruit such as the size, the color of the skin, the color of the seeds, and the grower's experience and memory from previous years. Once the seeds turn into brown or black in color, the grower start the picking. Very few growers use a penetrometer to measure firmness. No tests, whatsoever, are conducted to determine contents of starch, acids, sugars, and ethylene. The picked apples are usually packed into plastic boxes of 20-23 kg. The early varieties such as Mouwashah are picked gradually over more than one time since those are destined for local markets and aren't stored in cold rooms. They are even graded into plastic boxes of 20-23 kg directly in the field and taken to the whole market to pick a relatively good price. In comparison, the golden and red delicious are picked all at once, depending on the elevation. For instance, picking of the Red and Golden Delicious in Aakoura (elevation 1,200m) is performed starting 15th or 20th of August. The apples that are readily sold for export are taken directly to a packing center where they are graded and packed into one-row-plastic boxes or into one row cardboard cell, as it is being imposed by some importing countries, to keep the apple fruits separated. Now, the remaining part that is going to be stored in cold storage is packed into what they call field boxes, and those are of plastic, too and could be filled with about 23 kg per box.

Setting a proper time of harvest can prolong the shelf life of the produce, especially if it comes along with proper storage and refrigeration.
M. Packaging

It may be the most important factor affecting the natural diffusion of Lebanese apples into the foreign and the highly demanding markets. The attractive presentation of the agricultural produce is a key issue in selling the produce, thus, creating a demand for it. Ever since the civil war has started in the second half of the seventies, control and inspection for fruit packaging has been poorly conducted on both quality and type of the materials used. This has opened the way to some of the wicked exporters to cheat and to manipulate the boxes of fruits so as to show the obvious top with good quality produce, while the down part is filled with whatever is of fruits of inferior grade, rubbish, and sometimes even stones. This kind of deeds affected directly the confidence of outside importers and buyers and tagged sometimes the Lebanese produce with a bad reputation. Another factor is the poor packaging material used, in specific, which made the produce less attractive and not answering the consumers' liking.

The mandatory requirements that should be made available in both imported and exported apples are examined by the inspectors of the Lebanese Ministry of Agriculture according to the ministerial decision dating 1997 under the number of 358/1 reference f/4/97 and amended by another ministerial decision dating 2000 under the number 2/1. These decisions set the mandatory conditions concerning quality, size, homogeneity, packing, and labeling of apple fruits. In the following, we will enumerate the main requirements:

1. The fruits should be whole, clean, healthy, and free from any alien materials, pests including physiological and unnatural smells and taste.
2. The fruits should be graded into 3 classes:
   a. X-tra and in this case, fruits of this class should be of an excellent quality, possessing all the criteria of the varieties towards the appearance, maturity, color, and still have a stalk. An insignificant skin blemish is allowed as long it doesn't affect the general appearance of the fruit or its ability to store. A tolerance of 5% out of the total weight or in number of fruits per box is allowed in quality criteria.
b. Grade 1: Fruits of this class should have a good quality with all the criteria of the variety, allowing a slight change in appearance, color, and stalk without any flaws in the flesh. The skin can be allowed to show slight blemish that doesn't affect the general appearance or the quality in such a way that this defect doesn't exceed 2cm in length or 1 cm². In case of scab blotches, those shouldn't exceed 0.25 cm². A tolerance of 10%, in quality criteria, out of the total weight or in number of fruits per box is allowed. In addition, a 25% tolerance is allowed for removed stalk, for fruits of the different varieties-100% in Granny smith-as long as the skin around it is intact.

Size for Golden, Red delicious, and Fuji: 60 mm
Size for varieties like Granny smith, Gala: 55 mm

c. Grade 2: Those are fruits that couldn't be graded as extra or grade 1, but still possess the minimal requirements asked for extra and grade 1, with tolerance for small defects concerning appearance, maturity, and color. It is allowed for a 10% deviation, in quality criteria, out of the total weight of the fruits or their number, in addition to 2% tolerance allowed for blemishes resulting from insect injuries, corky appearance, and obvious cankers.

Size for Golden, Red delicious, and Fuji: 60 mm
Size for varieties like Granny smith, Gala: 50 mm

d. Concerning size, a tolerance of 5 mm is allowed in the extra, grade1, and grade 2 when packed in rows and layers. A tolerance of 10 mm in size is allowed in grade 1 if the boxes are filled in what is known as "dogma" i.e. without layering and rowing.

3. All the fruits in the box should be homogeneous for grades extra and 1. Discrepancies are allowed only in boxes of 2 kg. Packing of the fruits should be conducted in such a way to secure safety of the fruits from
bruises, and in boxes that should be new, clean, made of materials that
doesn't harm the fruits. It is allowed to use labeled paper as long as the
ink doesn't come off to contaminate the fruits. Polystyrene boxes aren't
allowed to be used.

4. Labeling: All the boxes filled with apples should carry a label
specifying:
   - The name of the packing house or the name of the exporter,
   - Address with personal label
   - Identity and content
   - Weight
   - Country of origin
   - Region of production
   - Grade
   - Number and size of fruits
   - Type of production such as organic

Serious work is to be done in terms of developing modern mandatory laws and
adopting of new "selling" types of packaging materials. This shouldn't necessary be the
state's responsibility only. Growers should also have the initiative to deal with reputably
honest merchants that don't abuse their produce and present it to the consumers in its best
looking image.

N. Storage and Refrigeration

Proper storage conditions prolong apples' shelf-life. Consequently, a better
maneuverability is at hands in handling the market's demand so as to keep a balance
between supply and demand to preserve a good marketing price. Unfortunately, storage
and refrigeration mandatory law that is in action today is old, dating back to 1964. An
amendment for this law is a necessity, especially if Lebanon is to recover its old rank as
an apple exporter worldwide. Following is the ministerial decision entitled "Fruits storage
in the cold rooms' law" that sets the main requirements inspected and controlled by the
Ministry of Agriculture, mainly:
1. Storage rooms are numbered and run by an administration that keeps a daily record marked by the ministry stamp to register the quantities and types of fruits received, time of reception, time at which refrigeration started, and the goods owner's name.

2. The cold room's administration has to inform the ministry on weekly basis of the quantities in and out according to a set form.

3. All cold rooms are to be equipped with compressors, fans, back up compressors to account for 30% of the initial refrigeration, thermostat, timer, and thermometer.

4. The cold room administration has to keep enough spare parts to fix emergency break downs within a period not more than 24 hours.

5. The administration should ensure to preserve the goods in places where optimum technical and healthy conditions are prevailing.

6. Refrigeration of goods should be initiated once they are delivered to the cold rooms within a period not exceeding 8 hours.

7. After the completion of the primary refrigeration period, the goods are stored in the cold rooms according to the following:
   a. The boxes within the cold room are to be packed like 13 box per m3 with 3 cm spacing between every 2 boxes.
   b. The boxes are to be put on wooden pallets 6 cm from the floor with passage ways of 90cm in width.
   c. The boxes are to be set 10cm from the walls, 50cm away from the ceiling.

8. It is absolutely forbidden to preserve more than one kind of fruits in the same storage room.

9. It is forbidden to use wooden boxes to pack the fruits

10. Apple is to be preserved under 1 or 2 degrees Celsius and at relative humidity of 85-90%. The temperature of storage is to be kept constant and not fluctuate more than 1 degree and up to 4 degrees within a period of no more than 2 hours.

11. When the cold storage rooms are emptied, a total disinfection is mandatory even for the walls and the ceiling.
Practically speaking, the cold storage rooms assume their work from mid of September until 15\textsuperscript{th} of June. When the packed "field boxes" with apples reach the cold rooms, they undergo a primary cooling which means that the boxes are kept within a corridor outside the cold rooms at a temperature of 5 to 10 degree Celsius and a relative humidity of 85-90\% for about 8 hours, after which they are transferred to the cold rooms.

Cold storage is conducted upon a contract between the growers and the cold room administration. They usually agree on keeping the small quantities of apples from mid September until New Year's Eve for 5-7\$ per box and, for any additional period beyond the first of January, the cold room administrator charges the grower for 10 cents per box per day. As for the large quantities to be stored, the usual fee is about 1-1.5 \$ per box until New Year's Eve, and for any additional period, the charge would increase to 10 cents per box per day.

\textbf{O. Weed management}

Weeds, growing in apple orchards, are usually controlled through both mechanical and chemical ways. The mechanical way is performed at the same time when cultivating for the 2\textsuperscript{nd} or the 3\textsuperscript{rd} time, as was mentioned before. Some of the growers rely on hoeing the soil around their trees if the weeds are low or by cutting first, in the case of long weeds and, then, hoeing. The chemical control is conducted through the primarily use of unselective contact or systemic herbicides mainly Paraquat 24\%SL at the rate of 500 cc/200 lit of water or Glyphosate 41\%SL at the rate of 2 lit/200 lit of water. Both paraquat and glyphosate are used anytime during the growing season. Other selective herbicides such as cycloxitidim and fluazifop might be used in very rare cases.

The main weed species, annuals and perennials, are presented in the following table:
<table>
<thead>
<tr>
<th>Latin name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Malva</em> spp</td>
<td><em>Malva</em></td>
</tr>
<tr>
<td><em>Cyperrus rotundus</em></td>
<td><em>Nutsedge</em></td>
</tr>
<tr>
<td><em>Convovolus arvensis</em></td>
<td><em>Bindweed</em></td>
</tr>
<tr>
<td><em>Oxalis</em> spp</td>
<td><em>Wood sorrel</em></td>
</tr>
<tr>
<td><em>Portulaca</em> spp</td>
<td><em>Purslane</em></td>
</tr>
<tr>
<td><em>Cynodon dactylon</em></td>
<td><em>Bermuda grass</em></td>
</tr>
<tr>
<td><em>Amarantus retroflexus</em></td>
<td><em>Pigweed</em></td>
</tr>
<tr>
<td><em>Avena sterilis</em></td>
<td><em>Wild oat</em></td>
</tr>
<tr>
<td><em>Setaria</em> spp</td>
<td><em>Foxtail</em></td>
</tr>
<tr>
<td><em>Sinapis arvensis</em></td>
<td><em>Wild mustard</em></td>
</tr>
</tbody>
</table>

Table 5. Main weed species in Apple orchards

Growers of apples are to become more aware of the proper usage of herbicides for weed control. Judicious use of herbicides can reflect positively on apple production for the fact that herbicides can allow the growers to turn into zero tillage practice, saving at least the cost of the repeated cultivations. Also, they can give a successful control of weeds that harbors the pests and gives them shelter, thus, also saving on the pesticides spraying bill.

**P. Pest management**

If humans, in general, were fearful to what they ignore, it is only logical to reckon that the Lebanese apple growers are in ultimate urge to learn more about not only the pests they are dealing with but also the local natural enemies occurring in their orchards. The more they know about their life cycle, the wiser their decisions will be in choosing the proper control strategy that ultimately will be fit in an integrated pest management program.

Apple, similar to the other Lebanese agricultural produce, receives lots of pesticides' spraying to control the invading pests. One of the growers in Kartaba compares apples to legumes in terms of the frequency of pesticides spraying and sets erroneously a one week interval for pesticides application using all sorts and kinds of both preventive and curative. Many times, pesticides are sprayed without being justified,
at least, by the presence of the pest going by the old saying "Better safe than sorry". Growers spray pesticides based on their own experience and what they remember they did at the same time the year before for they don't keep any records. In general, growers are incapable of identifying all the pests of apples, other than the obvious ones of course. On the other hand, if they could identify some of the diseases, they just don't know the disease life cycle. Pest control is mainly conducted through chemical control and according to already preset programs, depending on the growth stage of the crop. This approach results in 7-8 sprays per season with type of chemicals depending on the agricultural company or the merchant that is giving the grower technical advice (see the following table 6). Upon incidence of even an aphid or so, the crop might be sprayed in addition to the already set programs, with the relevant curative systemic available pesticides. Of course, there is neither monitoring for pests nor for the favoring environmental factors such as temperature, relative humidity, etc… Economical thresholds levels, rate of use, pre-harvest intervals are not at all respected, which leads to an increase in the pest control tab and the maximum residues levels.
<table>
<thead>
<tr>
<th>Pest Growth stage</th>
<th>Pest</th>
<th>Powdery mildew and scab</th>
<th>Fire blight</th>
<th>Codling moth</th>
<th>Woolly apple aphid</th>
<th>Aphids</th>
<th>Mites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wooden stage</strong></td>
<td>- Citrole (Paraffinic Oil 97%) + Copran (Copper Oxochloride 85% WP) /or Kumulus DF (Sulfur 80% DF) + Copran + Rogor (Dimethoate 40% EC)</td>
<td>- Sunpray oil (Summer Oil) + Cupro-cafaro (Copper oxochloride 85% WP) + Dursban (Chlorpyrifos 48% EC)</td>
<td>- Ovipron (paraffinic oil 95% + Oxycal (copper oxochloride 85% WP)</td>
<td>- Stroby (kresoxim-methyl 50% WG)</td>
<td>-score (Difenconazole 25% EC)</td>
<td>- Atemi (Cyproconazole 10% SL)</td>
<td>- Rubigan (Fenarimol 12% EC)</td>
</tr>
<tr>
<td><strong>Silver to Green tip</strong></td>
<td>- Rubigan (Fenarimol 12% EC)</td>
<td>- Capitan (Flusilazole 25% EC)</td>
<td>- Sabithane (Dinocap 32.5% + Mychlobutanil 7.5% EC)</td>
<td>- Bayfidan (triadimol 25% EC)</td>
<td>- Sevin (Carbaryl 85% WP)</td>
<td>- Match (Lufenuron 5% EC)</td>
<td>- Cascade (Flufenexuron 10% DC)</td>
</tr>
</tbody>
</table>
Table 6. The most common pesticides with trade names sprayed on apples are summarized in the above table with inference to the stage of crop growth.
On the other hand, farmers are to keep on monitoring their trees against pests that were suppressed and controlled during the season even after harvest, for farmers neglect their orchards once the fruits are picked. For instance, powdery mildew, woolly white aphids and stem borers will still have time and the ability to flourish and to inflict substantial damage after harvest when their control is discontinued and before the tree goes into dormancy, leading to the weakening and destruction of essential parts of the tree.

Following is a short description of the most commonly pests invading apples in different areas of Lebanon with what is recognized as their respective control methods, along with what we can perceive as needed recommendations:

1. Diseases

a. Powdery mildew or *Podosphaera leucotricha*

It is the most widely spread disease in all the apple orchards of Lebanon. Powdery mildew as its name implies appears as a whitish powder on the young twigs and leaves that turn out to be distorted, narrow, and brittle. It can also infect the flower clusters and fruits, leading to their premature fall or to becoming russetted later on in the season. In either case, it results in affecting both yield and quality of the produce, especially when infecting the more susceptible. The optimal conditions for its development are a temperature between 10-20 degrees Celsius and a high relative humidity even though rain and dew aren't conditions for infection to take place. Young leaves are considered susceptible to powdery mildew within 3-6 days. Leaves older than 14-17 days are considered immune.

i. Control

The chemical option seems like the only way to control powdery mildew in the back mind of the Lebanese growers. All sorts of preventive and systemic Fungicides are used, ranging from the simple inorganic ones like sulfur 80% early in the season, through the little usage of the different Benzimidazoles
like Carbendazim, Thiophanate-methyl, and Benomyl since many complains from farmers are heard about their ineffectiveness, probably due to resistance problem. Same complains are heard about some members of ergosterol biosynthesis inhibitor family (IBE) that are used extensively, mainly Triazoles like Hexaconazole, Mychlobutanil, Cyproconazole, Difenconazole, Fluzilazole etc…along with Fenarimol and Triademefon. Other newer families are used also like the Strobulurins, mainly Kresoxim methyl, Azoxytrobins and Trifloxystrobin.

ii. Recommendations

- Adopt resistant or tolerant varieties.
- Growers are to monitor disease development carefully from shoot emergence till the cease of the terminal growth. Different techniques can be used. For instance, the one recommended by the Ctifl-France is to randomly monitor shoots in the range of 100 shoots per 50 trees distributed like 2 per tree. The top 5 leaves in each shoot are to be observed for infection with frequency of infected shoots with 1 or more leaves.
- Pruning of last year infected shoots is of primary importance during the dormant season since they represent primary reservoirs for the fungus inoculum.
- Growers are to try to match Fungicides spraying timing of both powdery mildew and scab since same pesticides are used to control both.
- Growers are not to use systemic pesticides unless they need to, keeping in mind that they should alternate their usage. In general, 5% of infected leaves incidence is tentatively set to start control with contact fungicides along with sulfur if the infection is below 5%. Beyond 5% infection, systemic fungicides use is in order along with a contact fungicide in case of severe infections.
- Sulfur shouldn't be used with temperature exceeding 25 degrees Celsius for fear of phytotoxicity.
b. Scab or *Venturia inaequalis*

Apple scab is another important disease with a potential to cause serious fruit losses in addition to weakening the tree especially in orchards where high relative humidity is always prevailing. It can infect leaves, sepals, and fruits. Early infection starting on the leaves underside looks like velvety-green patches that distort the leaves and turn them yellow before falling. Fruit spots resemble those of leaves at the beginning then turns brown or black with appearance of cracks eventually.

i. Control

Chemical control is also the only way used to control apple scab by spraying one of the following Fungicides at intervals of 7 to 10 days until harvest unless the farmer notices an outbreak when he uses an additional spray. Approximately the same chemicals used for the control of powdery mildew are also used for the control of scab like the phtalimides: Captan, Carbamates: Ziram, Copper oxycychloride, Dithiocarbamates: Maneb, Mancozeb, Zineb, EBI: Mychlobutanil, tetraconazole, Cyproconazole, Hexaconazole, Anilinopyrimidine: Cyprodinil, Strobilurins and the benzimidazoles etc…

ii. Recommendations

- Fallen leaves from last season are to be destroyed because they are the primary reservoir for infection.
- A successful management of scab is based on early detection and exact timing with full coverage of spray i.e. early control of ascospores.

Farmers are to adopt one of the many forecast models that are initially based on the Mills curves to observe temperature, relative humidity, and duration of humectation to set the moment of scab outbreaks and, consequently, the right moment to spray and what to spray. Practically speaking, this has 2 implications: - by adopting a computer program, a minimal spraying is required and, in this case 3 or 4 applications per season are enough, especially when a mixture of an EBI fungicide is used in addition to a contact one.
- If no computer program is adopted and validated, the spraying of a contact fungicide is necessary at 7 days interval, early in the season can be extended for 3 or 4 days at maximum if weather has been followed attentively, and no rain is expected during this period. Now, if favorable conditions occurred, it is important to intervene with a mixture of a systemic EBI fungicides plus a contact one and, in this case, the end result would be spray applications every 10-14 days at best.

- Alternation of chemicals is a must to prevent resistance build up with the reservation of the systemic fungicides for curative treatments, taking into consideration the control of the powdery that ought to coincide with scab control.

- Chemical sprays are to be repeated in case they are succeeded with about 25 mm of rains.

c. Fire blight or *Erwinia amylovora*

The severity of fire blight on apples, especially on our most common local varieties like the "golden delicious" and the "Sans Pareille" makes it a very deleterious disease. Many times, fire blight has struck Lebanese orchards with the intensity of an epidemic, if we may say so. Last time it happened was back in 1996 when lots of economical losses occurred. This bacterium can infect all the flowers, the twigs and leaves, the fruits, and even the roots. The most obvious symptoms of this disease, as the name implies, are shown by the appearance of the tree as if it had caught fire. The infected flower clusters, that constitute a point of entry, are burnt and turned brownish in color. Under adequate conditions of temperature between 10-21 degrees Celsius and rain, the young growing shoots become blighted and form what is characteristically known as the "shepherd's crook". Bacterial ooze may appear on the stems. These main symptoms are the result of a combination of many factors, mainly: susceptible varieties and rootstocks, temperature, rain or dew, pollinating insects, wounds and especially those created by pruning.
i. Control

The most common control is the use of cupric compounds like copper oxychloride or copper sulfate mixed with oil sprayed in the dormant season after pruning. Fosetyl-aluminium is also used extensively.

ii. Recommendations

- Farmers are to choose a combination of relatively resistant variety and rootstock whenever possible.
- Judicious use of N\textsubscript{2} fertilizer to control unwanted vegetative growth.
- Removal of sources of infection from last year.
- Pruning infected parts of plants below visible symptoms by 15-20 cm with care to cleaning and disinfecting the pruning sheers' blade at each cut by dipping it into formalin, bleach, or alcohol. Special sheers with reservoir for antiseptic can be also used where the disinfectant is self-applied directly on the blade. Wounds are to be covered and infected tissues destroyed and burnt.
- Adoption of computer programs such as the MARYBLYT to predict the onset of symptoms. Other forecasting models are commercially available.

d. Collar rot and Crown rot or Phytophthora spp.

This disease can be described as a panicking disease for the growers, for it is always accompanied by wilting of the plant and rotting of the tissues at the level of the soil and beneath it. It is often associated with water and mostly found in areas with heavy soils and poor drainage. The infected tissues look sunken and dark from the outside, with a reddish brown coloration in the inside. In case of both scion and rootstock susceptibility, the cankers may extend up towards the scion-rootstock union.
i. Control

The mostly used control method is also chemical involving drenches of either Fosethyl-Aluminium or Metalaxyl-M. Other Acylalanines like Benalaxyl may also be used.

ii. Recommendations

- Growers are to choose resistant or at least tolerant varieties and rootstocks if their soil is of the kind that encourages Phytophthora development.
- They should provide good drainage, since chemical control alone will not be sufficient.

e. Armillaria root rot or Armillaria mellea

This disease is accompanied by yellowing and wilting of leaves with a white fan-shaped mycelium between the bark and the wood. It often invades old and weak trees.

i. Control

Many types of pesticides are applied for this disease, but nothing seems to work, and infected trees end up by being cut. The only problem is that new plants are being planted in the same spot only to begin the infection cycle again.

ii. Recommendations

- One way that seems to work is to remove the soil and expose the infected crown area and the upper part of the root. This seems to stop the rot development and allow the tree to re-grow.
- Another effective way is to remove the infected and the surrounding trees, even if they look healthy, and fumigate the soil where they were planted using methyl bromide. After which the use of Trichoderma spp. spores can be an effective biological control.
2. Insects

a. Woolly apple aphid or *Eriosoma lanigerum*

In Lebanon, the woolly apple aphid infests only apple trees and colonizes the roots, the trunk, and the shoots. During May-June, the aphids' colonies mass up in layers to look like covered with a whitish, wool like waxy materials which give them their characteristic appearance. The aphid feeds on the sap of the tree and releases some of its toxic saliva that stimulates the cells near the feeding place to multiply to form gall like tumors that hinder the normal flow of nutrients and eventually leads to the stunting of the trees. In August, although, the development is impaired due to high temperature, it resumes in October-November when the population is increased further, and winged individuals start to appear. In addition to flying, wind can be an important means of dispersal where nymphs are blown from one tree to another. Some individuals of the woolly apple aphids overwinter on the shallow roots, while some others remain sheltered on the aerial parts, mainly in the abandoned tunnels of the *Zeuzera pyrina*.

i. Control

- Chemical: use of dormant oil sprays in addition to a varieties of chemicals during the season mainly: Dimethoate, Chorpyrifos, Vamidothion…

ii. Recommendations

- Use of resistant varieties
- Biological control: It is found that, in Lebanon, a wasp called *Aphelinus mali* is a parasitoid of the woolly apple aphid, but the problem is that it doesn't build enough population for effective control before October. Therefore, it must be integrated within a general approach of management that includes safe insecticidal use that spears Aphelinus.

According to the Ctifl, decision for chemical treatment is tentatively set at a threshold of 10% infested twigs out of 100 (2x50 trees over 4 ha with visual
observation), inspected on the lower part of the tree, starting the month of 
June. But of course, this threshold has to be validated for Lebanon.

b. Green apple aphid or *Aphis pomi*

It is widely distributed in all apple orchards of the world. The green apple 
aphid overwinters as eggs laid by the female during autumns on strong twigs. In 
April, they hatch and reach adulthood in 10-12 days, when they start laying 
parthenocarpic eggs that produce larvae that invade the young shoots and 
suckers. At this time, the young shoots become curled and stunted because of 
the feeding that is accompanied by large amounts of sugary excreta on which 
sooty mold grows. The sooty mold may cover the leaves and fruits to an extent 
that hinders photosynthesis and lowers fruit quality grade. At the time winged 
individuals appear, they migrate to other trees. During the summer, when there 
are no fresh twigs, the population is greatly decreased, only to rebuild during 
warm autumn irrigation that causes re-shooting of the trees. In October, the 
fertilized females lay their eggs again, and the cycle continues.

i. Control

- Dormant oil spray that kills overwintering eggs at the rate of 1 lit per 200 lit 
of winter oil.
- Chemical through the use of varieties of insecticides like Cypermethrin, 
Chlorpyrifos, Diazinon, Methidathion etc…

ii. Recommendations

- Biological control: many predators have been found feeding on green apple 
aphid like coccinela, Syrphus, Chrysopa, and Aphidius.
- Soap based insecticides can be effective and IPM compatible
- Chemical control at a tentative threshold of 15% out of 100 visually 
inspected twigs.
c. Leaf miner or *Lyonetia clerkella*

The adult moth bears fore-wings that are silvery white in color with light brown patches on their outer margins. The hind wings are brown in color. In Lebanon, it can mine the leaves of not only apples but also cherries, plums, and apricots, leaving serpentine tunnels, between the lower and upper epidermis of the leaf, which can cross the leaf's veins, leading to its premature fall. The moth overwinters as an unfertilized female in debris and cracks in the trunk of trees. It starts egg laying after being fertilized in the first week of April on leaves. The larvae starts feeding until it pupates on the lower side of the leaf within 15-20 days. After 6 to 9 days, the moth emerges and starts laying eggs after being fertilized on new leaves. The moth has around 4 generations having the first in May and the last in August.

i. Control

Mainly chemical control through the use of Abamectin.

ii. Recommendations

-Biological: it was found (Talhouk 1969) that the larvae of the leaf miner can be heavily parasitized by local parasites of the genera Apanteles, Gelis, and Tetrastichus. This fact should be taken into consideration when an integrated pest management is applied.

d. Leopard moth or *Zeuzera pyrina*

In Lebanon, the caterpillars of this moth are polyphagous of the wood of many tree species, mainly apples, pears, quince, loquat, olives, walnuts, and many ornamentals. The moth is white in color punctuated with blue spots. The larva is colored yellow with blue-black dots. The adult moth appears at different in different locations of Lebanon. It appears in June-July in Mount Lebanon, while it appears in August in the Beqaa. It lays its eggs on the bark in crotches and between the bud and the bark in leaf axil. In October and November, one can start noticing the larvae presence because of their excreta
sticking at the opening of the tunnels. In apples and pears, the caterpillars bore
their tunnels upwards, while in young twigs the reverse happens. Pupation
takes place for about 2 weeks in April or mid-May. In Lebanon, the insect has
one generation per year; however, on high altitude, it extends for more than
one year. Zeuzera caterpillars can damage apple trees so hard, resulting in
weakening the scaffolds, leading to their breakage, and sometimes to the death
of the tree.

i. Control
- Mechanical through the use of a hooked wire that is used to extract the
caterpillar out of its boring hole.
- Blocking the tunnel's entry with a piece of cotton after which an injection of
gasoline is applied inside the tunnel. Another way is to apply aluminum
phosphide paste or any of fumes releasing insecticides inside the bored hole
after which it is sealed with mud or sealing material.
- Use of insecticides like Azinphos methyl, Diazinon, Dichlorovos, and
pirimiphos methyl.

ii. Recommendations
- Growers are to keep their trees vigorous and well cared for in terms of
pruning, fertilization, and irrigation since the leopard moth attacks usually the
neglected weakened trees.
- Monitor the adults by using of traps with pheromones attractant to indicate
the level of the population and to determine the time of pesticides application.
- wrap the trunk of tree, where the adult will emerge to determine a good time
for spraying.
- Light traps to attract the males.
- Use of biological control such as Bacillus thuringiensis
e. Coddling moth or *Cydia pomonella*

It is the most important insect attacking apples and causing the highest amount of economical injury to Lebanese orchards. We won't be exaggerating if we said that it is the prime reason why apples are sprayed with such huge amounts of insecticides and, many times, with some of the most hazardous in the world. Growers seem to be a little bit touchy about the ostentatious damage this moth inflicts on their yield, rendering what is left of it on the trees unmarketable. This polyphagous insect attacks many crops, mainly apples, pears, peaches, plums, apricots, and walnuts. The adult moth is bluish grey in color with distinctive chocolate colored patches with shiny scales on the margins of the wings. The caterpillar is pinkish in color with a brown head. It actually diapause as a fully grown caterpillar hibernating in a tough cocoon during the autumn before it resumes its activity in the next spring about the end of May when the caterpillars have transformed into a moth. The number of generations produced by this moth is 2 full generations with a partial third in the high mountains, having the first as we said before at the end of May, the second in Mid-July, and the third in mid-August. The moth lays its fertilized eggs on the leaves and sometimes on the fruits. The eggs hatch in about five to twelve days into tiny larvae that wander around for a short time and nibble a bit of the leaves and fruits before they find a point of entry to the fruits through the calyx or the stem end or at the point of contact between 2 fruits in contact within a cluster. The larva bores directly towards the seeds and many times feed on them, leading to the fall of the fruit. In about 20 to 25 days after hatching, the larvae complete their development and leave the fruit to pupate. Some of the larvae crawl down the twigs and trunks to the ground, while many others fall with the fruits or reach the ground using a thread they weave for this purpose.

i. Control

- Mostly chemical through the use of many insecticides, mainly: Azinphos methyl, Chlorpyriphos ethyl, Diazinon, Carbosulfan, Dichlorvos, Carbaryl.
ii. Recommendations

The coddling moth can inflict disastrous damage to apple fruits in an infested orchard. Fortunately, there are a variety of tactics that can be used for its successful control, including biological control, mating disruption, cultural control, insecticides, and, best of all, a combination of all the tactics when possible. Nevertheless, monitoring and risk assessment through the use of pheromones traps with regular examination of the fruits is of key importance in taking any decision in a successful control no matter what type it is. Following are important aspects that need to be taken into consideration when the grower is building his defensive strategy.

- Sexual traps are useful to determine the potential risk of infestation and timing of sprays. Targeting the larvae when they emerge from eggs, the first spray is to be applied when a cumulative capture of 5 moths per trap is achieved and an accumulation of 90 degree-day from this biofix taking a 10 degree Celsius as a base, assuming that 90 degree-days are required for the hatching of eggs over an interval period of 20 days following the formula of Sum of (average daily temperature- 10 degree) = 90 degrees. Otherwise, the deposited eggs will not hatch if this amount of degree-days is not accumulated. The biofix is the starting date of the first sustained flight of males captured in pheromone traps. Visual inspections are also necessary of a 1000 fruits in 50 trees x 20 per tree are useful to assess the effectiveness of the control methods used.

- Effective control of the first generation of moths is essential to the success of the control program over the whole season.

- Biological methods: *Trichograma platneri* is a parasitic wasp that lays its eggs in the moth eggs. Unfortunately, it is only effective with timely application and on small population of moths or as a complementary method to mating disruption. Other agents used in the biological control is the use of the *Bacillus thuringiensis, Beauvaria bassiana*, polygranulosis viruses; nevertheless, these products aren't available as commercial formulae in the Lebanese market for they are not registered for use in the Lebanese market yet.
- Control using confusion: this method is also effective on low moth population and is based on spreading sexual pheromones to deter mating of moths.
- Cultural practices can also play a role in an IPM program based on removal of unwanted host plants and improving spray coverage through adequate pruning.
- Trapping larvae migrating to the soil with the use of corrugated cardboards wrapped over the trunk of trees eliminate a large portion of the candidates that start the next generation of moths.
- Chemical control: In the case of insecticidal use, growers are to rotate their products depending on their mode of action and efficiency in the control. For instance, larvicides are to be used at the 90 degrees-day when the biofix is surpassed while ovicides are to be used when the biofix is surpassed in case of low population or even from the first captures if the population is high.

If chemical control is the chosen one, care is to be taken to use specific insecticides that have the lowest effect on natural enemies such as the insect growth regulators and at a proper timing for maximum efficiency.

f. The ivy or oleander scale or *Aspidiotus hederae*

It is a highly polyphagous insect that over winters in different growth stages depending on temperature. In location of apple orchards like the Beqaa where cold is prevailing, it over winters as first or second instar larvae to continue its cycle and reach adulthood in April. It has 3 or 4 generations per year and rarely reaches the stage of a pest unless left to get established in a neglected orchard. The most obvious damage created by this pest besides desiccating apple spurs is on the fruits and twigs, where it leaves purple to red spots similar to the spots caused by anthocyanins coloration. The oil spraying conducted during the dormant season is a sufficient control for this insect.
3. **Mites**

a. **The European red spider or Panonychus ulmi**

It is omnipresent worldwide and can feed on all types of fruit trees, including pome and stone fruits, including grapes, ornamentals, and even forests. In Lebanon, the overwintering eggs, which were laid in the old bark of buds and spurs, hatch, depending on the prevailing temperature, as early as end of March to beginning of April, in areas of elevations between 700m to 1000m. The larvae feed on the leaves that turn eventually to a bronze color and sometimes fall down. Injury inflicted by this mite is expressed by a reduction in fruit quality and size and the damage may be extended in the cases of heavy infestations to the yield of the year after. The number of overlapping generations produced per year is about 9.

i. **Control**

Mostly chemical, in addition to the winter oil spray, through the use of: Abamectin, Pyridaben, Clofentazine, Fenbutatin-oxide, Dicofol, etc ….

ii. **Recommendations**

- Dormant oil sprays are of utmost importance since controlling mites early in the season allow the beneficial predators to keep mites population at check.
- Scouting for red mite is essential following sampling charts based on counting the number of infected leaves out of 20 sampled (4 leaves per tree from 5 trees) starting from petal fall. Using sampling charts for early, mid, and late season is useful in determining the right time for applying miticides.
- Growers are to use miticides that least affects the natural predators.
**b. The two-spotted mite complex *Tetranychus urticae* (green) and *Tetranichus cinnabarinus* (red)**

Originally, these are separate species of two-spotted mites, but they have inter-crossed so much that both species exist as hybrids. Nevertheless, what is important to us is that both are polyphagous and feed on apple leaves. The individuals of this complex pass the winter as fertilized females only in diapause on the trees or on leaves of the winter vegetation. This type of mites forms its web on the underside of the leaves. This pest has 3 larval stages and one can count up to 20 generations per year where the first generation is passed on the wild vegetation before moving to the trees.

i. Control

- Dormant oil sprays
- Chemical through the use of many miticides such as Abamectin, Pyridaben, Clofentazine, Fenbutatin-oxide, Dicofol, etc ….

ii. Recommendations

-Removal of wild vegetation and weeds near orchards.
- In Lebanon, a coccinellide called *Stethorus gilvifrons* was identified as being a predator of the two-spotted mite complex.

**4. viruses**

The only available published information about the presence of apples' viruses in Lebanon is based on a survey conducted by Choueiri in 2003 on stone fruits. Nevertheless, this survey revealed the incidence of Apple Mosaic Virus (ApMV) and Apple Chlorotic Leaf Spot Virus (ACSLV) on stone fruits. We can reckon also the presence of these viruses on apples. A newer survey has been conducted, specifically, on viruses and virus like incidence on Lebanese apples during the year 2006 by the Lebanese Agricultural institute; however, results haven't been revealed yet.
a. **Apple Mosaic virus**

The virus's main symptoms are revealed as yellow random spots all over the leaf, accompanied by yellowing of the leaf's veins in some apple varieties. Sometimes, these yellow spots disappear during summer, when the temperature rises. In some varieties, a 50% decrease in yield is observed with a general weakening of the infected trees.

b. **Apple chlorotic leaf spot virus**

Symptoms of this virus are expressed by what is known as a "russet ring" or yellow ring pattern mosaic. This virus has a weakening effect on apple trees, accompanied with fruits blemishing, rendering them unmarketable.

As is the case with most of the plant viruses, they can be transmitted through production of uncertified plants and exchange of infected vegetative materials through grafting.

The only acceptable way to control viruses is through quarantine, exclusion, and usage of certified materials in starting new orchards.

5. **Physiological diseases**

a. **bitter pit**

This is one physiological disorder with symptoms usually appearing just before harvest and during early conservation of fruits, but it can be managed with proper control in the field. The bitter pit symptoms appear as round, dry, and spongy spots located beneath the epidermis, with diameter of about 5 mm showing to the outside. The reason lying behind bitter pit is ultimately lower calcium content in the fruit in comparison to the content of potassium and
magnesium. The factors favoring the calcium deficiency or its disequilibrium are many:
- Varietal susceptibility and rootstock ability to hold the calcium
- Irregular irrigation
- Mistaken fertilization as is the case in Lebanon, led by addition of large quantities of Nitrogen and Potassium fertilizers.
- Severe pruning, leading to excessive vegetative growth where calcium known for its low mobility is favorably translocated towards the new shoots instead of fruits.
- Early picking of fruits.
- Long time elapsing between harvest and conservation
- Slow refrigeration and at alternating temperatures and humidity

i. Control

This physiological disorder is usually corrected with the addition and spraying of soluble fertilizers rich in high calcium like Calcium nitrate and Calcium borate. Many times, the growers, because they fear the appearance of their fruits with bitter pit, tend to exceed what is needed, leading to further imbalance in the sense that, though they are correcting the calcium deficiency problem, they are encouraging disequilibrium of other micronutrients. This is especially true because it is known that most of the Lebanese soil has a PH higher than 8 with high calcium content.

i. Recommendations

- In our opinion, correction of calcium deficiency should always be corrected with pulverization of soluble fertilizers containing calcium of the nitrate or chloride base rather than topping it to the soil since it is already high in calcium.
- Again, growers are to perform leaf tests in addition to soil test to amend with the correct amounts of fertilizers especially in the case of Nitrogen and Potassium fertilizers.
- Adequate pruning is to be performed.
b. Russetting

This phenomenon is rather considered a consequence to the modification in the fruit epidermis and cuticle where a corky substance is deposited instead of dead cells as a part of a healing process. Russeting can appear as a spot or sometimes as a netlike layer of cork all over the surface of the fruit depending on the cause and its severity. This phenomenon on apple fruits is favored by many factors:
- Susceptibility of some varieties i.e. Golden Delicious
- Severe climatic conditions like hail, high humidity, and decreased temperature below 4°C at blooming or fruit set, etc…
- Disproportionate growth of some cells more or faster than their adjacent ones, leading to the rupture of their cell walls.
- Mechanical damage due to scratches, bruises, and even some diseases like powdery mildew.
- Use of some pesticides' active ingredients or even some specific formulations of these active ingredients.
- Disequilibrium in the plant fertilization like excessive Nitrogen and Boron deficiency.

i. Control

There is no one reversible measure, but some of the Lebanese growers are aware of russeting and spray a priori materials like micronized sulfur at early fruit set and calcium borate during the season. They are even prudent to spray some formulation until the "egg size" fruits as they say.

ii. Recommendations

- Growers are to plant resistant varieties, some of which were listed earlier in the varieties part of this study.
- Keep their plants in a healthy condition using a balanced fertilization and always perform leaf tests in addition to soil test to subsidize for deficient nutrients, especially in micronutrients.
- Use of gibberellins has shown to minimize the phenomenon of russetting.

c. Iron deficiency

Many times chlorosis of the new shoots is observed in Lebanese soil because it is, first of all, mostly calcareous with a high Ph and, second of all, the haphazard use of fertilizers makes other micronutrients compete with iron on the root of the plants. As a consequence, growth of the plant is affected with a reduced flowering and small fruit size.

i. Control

Usually, this deficiency is corrected by addition of chelated iron to the trees or addition of a mixture of iron sulfate plus sulfur.

ii. Recommendations

Growers are to irrigate and fertilize judiciously.

Q. Conclusion

Farmers ought to stop being conventional for once and look for modern alternatives other than what they are practicing on the different levels of production. If the growers were to produce a marketable commodity, they ought to find not only the most effective but also cheaper and environmentally sound alternatives to what they are practicing in pest and weed management, cultivation, fertilization, irrigation, pruning, thinning, choice of varieties, density of plantation, and pollination. Therefore, apple growers are to follow the Integrated Pest Management approach and guidelines such as the Good Agriculture Practices. For this, we might suggest that growers are to:

- Adopt what is known as the Agro-Eco System Analysis in the decision making of spraying pesticides.
- Read pesticides' label very carefully and strictly abide by its content towards the timing and spectrum of application, the rate of use, the pre-harvest intervals and the re-entry periods.
- Give it up on multi-cultivations system and shift towards minimized tillage or even zero tillage.
- Amend their soil with the type and amount of fertilizers that best suit their purpose based always on periodic soil and leaf analysis.
- Use water judiciously and as much as it is needed.
- Prune according to a scientifically acceptable basis.
- Thin to improve quality.
- Establish modern orchards in terms of plant density
- Choose market demanded varieties that would be pest resistant if available.
- Choose adequate pollinators.

Furthermore, growers are to command the whole chain of production and export. Therefore, they are encouraged to get their "feet" wet and get involved. It is their produce and their existence that the merchants are tampering with and they represent the party that is most affected. They need to cooperate on the different level of production, packaging, storage, and, most importantly, marketing of their produce.
II. Olives

A. Introduction

The olive tree originated from the East Mediterranean, specifically, in Lebanon, some 6,000 years ago, still finds evidence of its omnipresence in few trees in Bshaale and Koura- North Lebanon with diameters of more than 24 meters. This “divine” tree has many attributes. It is a symbol of peace. It has brought Noah a sign of Earth after the flood. It is a sacred and blessed tree mentioned with its oil, by many religions in their holy books. The prophet Mohamed of Islam used olive oil to cure people from about 70 diseases and instructed his followers to eat and to anoint with it. In addition, many people are convinced that this is the tree of the poor people, which needs the least care. It is drought resistant; almost 99% of the olive groves in Lebanon are rain fed. It can flourish and develop in poor soils with high lime content. For all the previous reasons and more, olive is considered an important traditional crop in Lebanon though there are no specialized olive farmers. It is a seasonal crop that needs little or occasional care except at the time of harvest when families join the effort to do the picking; nevertheless, sometimes help is hired.

Occupying an area of about 58,531 ha and a total production tonnage of 167,289 tons, olive culture is ranked first in terms of area dedicated for fruit crops production (FAO Census, 2004). Because of alternate bearing habit the olive tree has, in addition to other factors like negligence and erroneous practices such as pruning, fertilization and harvesting, drops of the production tonnage every other year. For instance, for about the same area of production, the tonnage in 2003 was about 83,250 tons that is about half what was produced in 2004. In 2005, the tonnage produced was 76,500 tons in about the same area of production. Thus, the productivity of olive groves ranges between 1.5 to 3 tons per ha, depending on the year of production.
<table>
<thead>
<tr>
<th>2004</th>
<th>Surface area (Ha)</th>
<th>Production (Tons)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Lebanon</td>
<td>8,704</td>
<td>10,720</td>
<td>15.12</td>
</tr>
<tr>
<td>North</td>
<td>21,982</td>
<td>40,580</td>
<td>38.19</td>
</tr>
<tr>
<td>South</td>
<td>10,211</td>
<td>10,532</td>
<td>17.74</td>
</tr>
<tr>
<td>Nabatiyeh</td>
<td>13,367</td>
<td>13,977</td>
<td>23.22</td>
</tr>
<tr>
<td>Bekaa</td>
<td>3,300</td>
<td>7,441</td>
<td>5.73</td>
</tr>
<tr>
<td>Lebanon</td>
<td><strong>57,564</strong></td>
<td><strong>83,250</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 7. Production areas and tonnage in different Mouhafazats

In general, most of the land exploitations are fragmented into small proportions, and that might be the main reason hindering the introduction of improvements to olive culture on the level of mechanization and Integrated Pest Management (IPM). Geographically, the largest areas planted with olives listed by order of importance are located in the North of Lebanon, amounting to about 40% of the total area, mainly in the areas of: Trablous, Mejdlaya, Deir jdeide, Aalma, Ras kifa, Rachain, Douma, Chikka, Ras nahhach, Dambou, Akroum, Berquayel, Beino, Kfarhabou, and Minie, followed with Nabatieh about 24%, mainly in: Yohmor, Roumine, Jibchit, Houmine, Sarba, Aarab salim, Jbaa, Yater, Ainata, Bent Jbayl, Marjaayoun, Kfarkilla, Dayr mimas, Kfarshouba, and Hasbayah, South Lebanon about 18% in: Kfarmelki, Aanqoun, Tanbourit, Kfarhatta, Qraiyeh, Quana, Maarakheh, chehabieh, and Jezzine, Mount Lebanon about 15% mainly in the areas of: Ras el Metn, Aabadiyeh, Salima, Gharifeh, Baakline, Chhim, and Daraya, Charoun, and Bejii, followed by the Bekaa about 5% mainly in the areas of: Bekaa el gharby, Baalbeck, El hermel, and Rachayiah.

(See map, FAO census 1999)
Fig. 2. Areas of production and distribution of Olive in Lebanon

The largest portion of the olives production is destined for local markets, where about 70% is consumed as olive oil where the rest is destined for pickling (see table 8 and 9). The fruits used for pickling are those that are attractive, unblemished, and of high quality. They are picked by hands with largest size, relatively, of weight 3.5 - 4 g, whereas the smaller sizes are milled and used for oil extraction. The fallen fruits beneath the trees are milled separately to produce oil of lower quality used to produce soap. Nevertheless, many farmers, out of carelessness, mix the harvested fruits altogether with the fallen ones, which reflects badly on the oil quality extracted. The pomace produced after milling is sold for heating purposes or gathered and
composted, after mixing it with other sources of vegetative by-products like molasses, by some agricultural companies to produce organic fertilizers.

<table>
<thead>
<tr>
<th>Year</th>
<th>Production in tons</th>
<th>Import in tons</th>
<th>Export in tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>83,250</td>
<td>435</td>
<td>6</td>
</tr>
<tr>
<td>2004</td>
<td>167,289</td>
<td>2,069</td>
<td>30</td>
</tr>
<tr>
<td>2005</td>
<td>76,500</td>
<td>3,586</td>
<td>13</td>
</tr>
<tr>
<td>2006</td>
<td>n/a</td>
<td>2,137</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 8. Import and export of olive fruits

Relatively speaking, most of the oil produced is also destined for local markets, where very little export and import is registered. It is approximated that the quantity of olive oil extracted is about 20% in weight out of the total weight of milled fruits. The amount of olive oil produced will also vary according to the year, naturally. As the next table shows, olive oil production is estimated to be about 23,500 tons, while it can decrease until about 10,000 tons in some years due to alternate bearing.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated production in tons</th>
<th>Import in tons</th>
<th>Export in tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>11,655</td>
<td>3</td>
<td>485</td>
</tr>
<tr>
<td>2004</td>
<td>23,420</td>
<td>34</td>
<td>427</td>
</tr>
<tr>
<td>2005</td>
<td>10,710</td>
<td>1,492</td>
<td>441</td>
</tr>
<tr>
<td>2006</td>
<td>n/a</td>
<td>829</td>
<td>477</td>
</tr>
</tbody>
</table>

Table 9. Import and export of olive oil (Lebanese customs)

Following is a baseline study on olives produced in Lebanon showing the different stages of production and pinpointing erroneous practices performed by the olive growers. Recommendations are cited when seen necessary and possible to amend the present situation that is characterized by a low production, sharp alternate bearing, increased cost of production, low and sometimes impossibility of mechanization, and, in some cases presumably, increased maximum residues limit (MRL) due to pesticides “abuse”.

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B. Varieties

Olive is not an exception from the other fruit trees in terms of having a multitude of names for the same variety. It seems that every region adopts its own naming for olives' varieties- as in other crops-, relying on nothing more than the fruits size, shape, and purpose of use. It is a free country after all! Another matter that is complicating the situation has to do with the olive tree in particular in the sense that the same variety performs differently under different climatic conditions such as temperature, rainfall, and humidity and in different soils. Furthermore, Lebanon's production area is known for having climatic and soil discrepancies. The same variety can give fruits with a different coloration, size, shape, oil content, and even taste. Anyhow, to cut the long story short, the only way to be certain about varieties of olives in Lebanon, is to conduct a genotypic testing. Nevertheless, what follows is a description of what most of the Lebanese agreed on calling varieties in their old orchards like the Soury or Baladi, Ayrouni, Khoudairy and Smakmaki, in addition to the varieties of a couple millions trees, that were brought from Syria and distributed by the Ministry of Agriculture for free to growers wishing to initiate new groves like the Sourani, Kaisi, and Zaiti.

1. Soury

The Soury is the main local variety that is most widespread in all the regions of the country. Nevertheless, it is called under many names, depending on the area like the Baladi meaning indigenous, Ayrouni, Bayadi meaning egg-like, and the Smakmaki. The Ayrouni is a known nomenclature in North of Lebanon to refer to the smaller sized fruit of the Soury of weight not exceeding more than 2.5 g. The Smakmaki is also a Soury but small sized fruits of 1.5 g weight.

Vigor of the tree: Medium
Fruit shape: Ovoid
Color: Green and black
Fruit weight: 2 to 4 g
Oil content: 18-22%
Pollination: Self-compatible
Tolerance to disease: Susceptible to olive peacock's eye, verticillium, and olive knot.
Tolerance for abiotic conditions: Moderately resistant to drought and cold.
Purpose: - oil
- Green and black pickling

2. Khoudairy

Vigor of the tree: Medium
Fruit shape: Elongated
Color: Black
Fruit weight: 2-4g
Oil content: 22-28%
Pollination: Self-compatible
Tolerance to disease: Tolerant to peacock's eye. Susceptible to stem borer and olive fly.
Tolerance for abiotic conditions: Resistant to cold and drought
Purpose: - Oil
- Pickling

3. Sorany

Vigor of the tree: Strong
Fruit shape: Ovoid
Color: Black
Fruit weight: 2-4g
Oil content: 25-30%
Pollination: Self-compatible
Tolerance to disease: Resistant to peacock's eye and olive knot and susceptible to verticillium.
Tolerance for abiotic conditions: Tolerant to cold, drought, and salinity.
Purpose: - Oil
- Pickling
4. **Kaissy**

Vigor of the tree: Strong  
Fruit shape: Spherical  
Color: Green  
Fruit weight: 2-4g  
Oil content: 18-20%  
Pollination: Self-compatible  
Tolerance for abiotic conditions: Tolerant to cold and drought  
Purpose: Pickling

5. **Zaiti**

Vigor of the tree: Medium  
Fruit shape: Spherical  
Fruit weight: 2-4g  
Oil content: 30%  
Pollination: Self-incompatible  
Tolerance to disease: Tolerant to peacock's eye and olive knot  
Tolerance for abiotic conditions: Some tolerance to cold and salinity  
Purpose: Oil

Since the most problematic issue about olive production in Lebanon is its production's cost effectiveness in comparison to the neighboring countries, growers are to start looking into varieties that are more adapted to mechanization in terms of homogeneity in growth and harvest. Moreover, there are many new varieties that are more producing in terms of yield and resistant to many pests that are found in the Lebanese olive groves.

C. **Source of vegetative material**

Plant material used to establish new orchards of olives is mostly found in some of the specialized nurseries of the Nabatieh area. The trees produced are composed of a seedling rootstock, started from a seed, and then grafted with different kinds of local varieties such as: Soury, Soourany, Kaissi, or with other foreign
varieties from outside such as: the ostentatious Kalamata, Manzanilla, etc… The seedlings rootstock are mostly from naturally germinating fruits fallen from the trees during the spring, then transplanted into tin cans where they are kept for a year before being grafted. Of course, those nurseries are specialized in the sense that most of their production is of olives. Unfortunately, the production of these nurseries is neither certified nor controlled for pests. Many times, they even play a role in spreading viruses, root fungi, and nematodes into newly established orchards. Nevertheless, most of the growers seem to favor the plants produced in the nurseries of Nabatieh to any other source for they say they are of superior quality. The Ministry of Agriculture has been encouraging olive plantation for over than the last ten years and, for that, it has distributed about a million trees per year between 1994 and 2003. The distributed trees were acquired from the Nabatieh nurseries in addition to about 2,300,000 trees, vegetatively propagated as a donation from the Syrian Government.

Olive growers should check carefully the propagating material used and make sure that they are planting trees not only of known varieties, true to type, adapted to mechanization but also, healthy trees free from pests for this can ensure the homogeneity of their orchards in terms of production.
D. Pruning olive trees

Unfortunately, it seems there is a consensus among the agriculturists of Lebanon to plant a tree that needs the least caring; olive is one of the best choices in this respect. Accordingly, and going by the same token, olive growers hardly perform any pruning at all to their olive trees unless it is either intended for rejuvenation in a neglected orchard, or during harvest, when they cut either a bearing branch with fruits hard to be reached at its far away tip or another that got entangled with the other branches making the harvest very difficult. Nevertheless, and because olive trees are the most prone to alternate bearing, they are the type of trees that need most regular pruning.

Before going into the details of what should be done in pruning olive trees, it is important to focus on few points:

- Olive trees bear their fruits on one year old wood. This means in the language of pruning that we should provide enough one year old branches constantly to have a constant production without having to grow branches that go up to 3 meters in length sometimes, bearing fruits only at the periphery when the rest of the branch till the trunk is naked of leaves or fruits. Therefore, severe pruning is recommended to keep the fruits as much as possible in proximity and towards the trunk.
- In Lebanon, most of the planted olive trees are rain fed. Consequently, vegetative growth isn't that strong, and it should be regulated to have a constant yield.
- Branches in the olive tree are set symmetrical to each other, and can't be left to grow as such because of the risk of breaking.
- Olive trees are evergreen and can be pruned anytime during the year, but winter pruning is preferred.

As every kind of trees, 3 types of pruning are to be performed:

- Structural
- Pruning bearing trees
- Rejuvenation
1. **Structural pruning:**

Being a tree of the semi-arid area, opening up its top will not harm it. Therefore, the recommended type of structural pruning is a combination between a modified leader and the calyx shape.

Year 1: Newly planted trees are to be headed back at a height of about 80cm.

Year 2: 3 or 4 primary branches that grew in the previous summer, in addition to the leader, are left on the main trunk. These branches are chosen to be set about 15 cm apart and in an unsymmetrical way after which they are head back at 40 cm in length. All the other branches are removed in addition to all the branches up to 30 cm above the ground.

Year 3: 2 secondary branches are to be left on the primary branches set the year before in addition to the leader.

Year 4: the leader is eliminated for another open angle branch.

2. **Pruning bearing trees**

The olive tree, as previously mentioned, carries fruits on one year old wood that bends downwards under the extra weight of the fruits. This, in turn, allows buds on the base of these branches to shoot upwards. The idea behind pruning for bearing in olives is to have a constant supply of one year old branches to bear fruits close in proximity to the trunk. For that, we need to keep these new shoots and discard the bent and already fruited branches. In addition to this, cleaning cuts are to be performed on diseased branches that turned bear from leaves.

3. **Rejuvenation pruning:**

This type of pruning is commonly performed for it is the only way to correct the accumulated mistakes in pruning over past years. Secondary branches and, many times primary branches are cut on a length of not more than 30 cm. From now on, the same principle of pruning bearing trees is to be applied. Otherwise, the same mistake is committed and rejuvenation pruning would be needed again in not more than five
years. In addition to weakening the tree, we would be losing much of the production of the tree per unit time that won't be recovered before a minimum of 3 years.

E. Irrigation

More than 99% of olive groves are rain fed with no less than 400 mm of water from precipitations in the different areas of production. Most of the times, these areas were chosen to be planted, in the first place, with olives and not with another kind of water-demanding fruit trees because they are situated geographically, in hills or valleys, far away from any water source, making irrigation difficult or not so much cost effective. In these cases, what is a better tree than the olive to tolerate drought and benefit its grower with a commodity that he needs? Another reason why olive is not irrigated is because growers are convinced that watering might be deleterious to the oil quality and it might badly affect its taste and its storage shelf-life. In fact, olives are only irrigated when we have a mixed plantation with other fruit trees. On the other hand, drip irrigation system, though has a high initial cost for a crop such as olive, is worth giving a shot for it has proven to increase the yield in many countries in Europe, of course along with other practices, up to 10 tons per ha when the average yield in the Lebanese groves is about 1.5 to 2 tons per ha. Therefore, Lebanese growers are to try out some irrigation for olives and assess its effect on both yield and oil quantity and quality. In any case, this is better than keeping the ripened fruits unpicked until February, which will only result in an increase in oil content of lower quality.

F. Fertilization

Being famous for being "the tree of the poor" and for requiring the least care have obviously reflected on the way olive is fertilized. Also, the fact that most of the trees are rain fed has limited the choices of fertilizers. The fertilization programs, followed by olive's growers, vary tremendously. For instance, some growers, and these are a minority, follow a "zero fertilization" program where just nothing is amended to the soil. Another part of the growers follow an "organic program" for fertilization, in the sense that only animal originated manure is applied every other year at the rate of about 15 kg per tree during the month of November or before cultivation to incorporate it in the soil. Many times, the manure isn't fermented enough and might carry a number of weed seeds and pests. A third program relies on using both types of...
fertilizers- organic and synthetic. In this case, growers amend with the organic fertilizers every other year at the rate used above and at the same time of year. Some growers, because of the alternate bearing phenomenon of olives, fertilize the soil only on the "on" year of bearing and neglect their orchards in the "off" year.

Different kinds of synthetic bulk fertilizers are used mostly during January to February, depending on the weather, at the rate of 2-3 kg from an almost proportionally based N,P,K of 1:1:1. Sometimes those fertilizers are spread under the rain in some areas. Examples of the types of fertilizers used per tree are summarized in the following table:

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Amount per tree depending on age</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-17-17</td>
<td>2-3 kg</td>
</tr>
<tr>
<td>Di-Ammonium nitrate+Patent kali</td>
<td>2+1 kg</td>
</tr>
<tr>
<td>Ammonium sulfate + Mono-ammonium phosphate or di-ammonium phosphate + Potassium sulfate</td>
<td>2-3 kg</td>
</tr>
</tbody>
</table>

Table 10. Fertilizers and used rates

Bashour in 2002 recommends a two-application- per-year-program, for fertilizing rain fed olive groves. This program is based on applying 250g to 2.5 kg per tree, aging from 2 to more than 15 years old respectively of a formula of 3:1:1. The same amount will be applied twice; the first application is timed in December before a second one during February.
G. Cultivation

Most of the olive groves in Lebanon are cultivated at an average of 3 cultivations per year. Some growers don't cultivate at all, while others cultivate up to 5 cultivations per year. In either case, these growers are a minority. The first 2 cultivations are a must in rain fed plantations such as olive. The first cultivation is conducted in the month of October, before the rain, to fill the water table with a maximum amount from precipitations. This cultivation is also beneficial to bury fallen leaves because of diseases' infestations such as the peacock's eye disease, thus, reducing the amount of inoculum that would be ready to start the infestation in next February. The second cultivation is conducted when the rain stops and the soil is dry enough to be workable. This cultivation is necessary to decrease the soil evaporation. The third cultivation is conducted during the month of June. Some growers in Koura think that this 3rd cultivation is needed to bury fallen and infected leaves and control weeds mechanically. All the conducted cultivations are performed, using modified duck plows driven by a tractor. The depth of plowing is about 15-20 cm.

Though some growers, in order to decrease their cost of production, have tried the zero tillage for one season and observed that, at least, there is no real effect on their yield, the great majority of growers are still unconvinced.

For the reason of storing and preserving water in the soil, in a rain fed plantation, perhaps, the first and the second cultivation are justified. Nevertheless, any additional cultivation isn't justified at all in the current situation of increased cost of production, in addition to the fact that already 2 cultivations are detrimental enough to the tree root system to affect badly all the production, the health of the tree, and the alternate bearing phenomenon.

Lebanese olive growers shall, at least, minimize on cultivation if not give it up at all. In addition, they are to adopt more cost effective ways of weed control.

H. Harvesting

Most of the olive growers still use the old fashioned manual methods of harvesting such as milking and/or knocking the olive fruits off the tree where they literally "beat them with the stick". Olives, destined for pickling or fresh
consumption, are picked carefully by hands, while olives destined for oil are beaten, and this is when the massacres occur. Because harvesting is conducted manually, its timing is largely dependent on the convenience of the grower and his family, rain, in addition to fruit maturity indications, mainly the color and the size of the fruits. Southern growers set the start of harvesting once it rains, that is usually in the second half of October. The reason behind this timing is that rain washes the fruits from dirt and add some extra size and oil into them. On the other hand, Northern growers start their harvest as late as late November and may extend till late January sometimes. The convenience of the grower plays a role in the provision of enough labor at the right time and long enough to finish this difficult and time consuming process of harvest. Hired help for harvesting olives is not cost effective, especially for small groves owners. That is why those growers have to depend mainly on their family members to do the job. Nevertheless, it is becoming more and more customary to hire whole families that harvest a grove in return of 50% of its yield, in spite of the fact that some groves' owners have complained about the cursory work being conducted in this way and how much damage has been inflicted on their trees. Of course, it is clear that the hired families for harvesting olives are the kind of temporary help that only cares to how much fruit is being gathered and not how many branches are being chopped from a tree to get some far-fetched fruits high on the tree top or simply to speed up the picking process.

Before picking starts, whether in milking or beating the stage must be set to receive the fallen fruits, and some equipment has to be provided. The floor underneath the tree has to be cleared from weeds after which naturally fallen fruits are gathered. Sometimes those fruits are set apart and, many times, mixed with the rest of the picked fruits. Once this is done, nets or old cover of plastic or tissues are spread beneath the tree. Most of the time, growers use the milking and the beating methods in combination. They milk the branches reached from the ground with their hands or, sometimes, they use plastic combs and beat those that are far off using long sticks. Sometimes, ladders are used to reach the top of the tree. The fruits fallen on the cover are gathered in plastic or jute bags and set aside waiting to be taken to the mill to be processed once the picking of all the trees in the grove is done or when the grower's turn is up in the mill.
Manual picking is the least harmful method for both the trees and the fruits, while the beating, though it speeds up picking and makes harvesting more cost effective, is detrimental to all: the tree, the fruits, and the quality of oil extracted. First of all, it has been said before that the olive tree carries its fruits on a one-year-old twigs and, when the branches are beaten, there is no distinction between those carrying the fruits and those that will carry fruits in the next season. Accordingly, the direct consequence of the beating method is that it is breaking the twigs that potentially should bear the fruits for the next year and, directly, contributing in aggravating the alternate bearing phenomenon. Another consequence for beating the branches is that injuries and wounds are created, out of which, bacteria such as those of the olive knot disease will find their way into the tree to start their infection. Thus, beating the trees is being an efficient way to spread bacterial diseases. Second, beating the branches exposes the fruit to direct injury to the fruits in addition to injuries created because of falling. With the pulp exposed and met with bad storage conditions before milling, processes like oxidation and fermentation might start, leading to deterioration in oil quality.

It has been known that the fruits harvested earlier, though they produce less amount of oil, they produce the better, higher priced extra-virgin oil. The latter the time of harvest is set, the more oil of lesser quality is extracted, in addition to the effect that late time of harvest has on decreasing the number of flower buds and fruit settings in the next season, thus, contributing to alternate bearing. Furthermore, the latter the fruits are harvested the more the potential injury is because of pests invading the fruits and causing their fall, leading in turn to bad quality oil.

Therefore, farmers are to find the correct time of harvesting olive relying on more scientific ways to ensure minimum harm to the trees and maximum quantity of good quality oil. Farmers are to give up beating the trees and start looking for a mechanized, more economical method of harvesting that does least harm to the trees. A couple of years ago, the Ministry of Agriculture has been keen in introducing a semi-mechanized way of picking through free distribution of about 200 tractor-driven machines to cooperatives of farmers for trial. These machines are mainly made of a compressor that pressurize air into a hand carried mechanism of 2 hand-like combs that flap together and knock-off olive fruits in between them. The hand of this machine can be extended to reach high branches, and it might be suitable to the old,
mostly wooden trees we have in our orchards. Those who tried those machines seem to appreciate them for they are fast and convenient nevertheless, some of them complained about how vulnerable and easily breakable those machines are being made out mostly of plastic. In our opinion, those machines are worth a shot, for they might be the answer for decreasing the cost and the labor intensive requirements of harvesting olive.

I. Alternate bearing

Though alternate bearing is an outcome of many factors such as genetics, environment, and history of bearing, the Lebanese olive growers are doing many of the cultural practices in the way that accentuates its sharpness. Yes, there are many things that growers can do little about, but, on the other hand, there are few practices they can perform to mild its effect.

Before we get into what farmers ought to do, it is of importance to mention few facts about biennial bearing, mainly:

- Fruits of olives develop on the vegetative growth of last year.
- The vegetative growth is lower in the trees bearing large number of fruits. The higher the fruit bearing in the current year is the lower the vegetative growth is and, consequently, the lower the differentiation and fruit set in the year after is.
- In a certain year, the lower the number of fruits is, the larger their size is. Thus, the lower the degree of alternation is. This is because the developing seeds are the governor of alternation. Alternate bearing is controlled by induction and differentiation inducers and oppressors produced by the developing fruits. Their effectiveness is governed by climatic conditions.
- Not only the fruit load but also its distribution plays an important role in the control of alternate fruit bearing.
- High or low winter chilling plays a role in flower bud differentiation, for different reasons, with a consequent effect of aggravating alternate bearing
- Young trees are less prone to alternate bearing due to the vigorous yearly growth.
- Alternate bearing shows in both non-irrigated and irrigated trees. Fertilization and irrigation can increase the yield and can be used as a control tool for alternate bearing.
- It is thought that the latter the harvest time is (until December to February), the lower the yield in the following year is.

There is no elixir in curing a phenomenon that has a lot to do with genetics and climatic conditions. Nevertheless, there are practices that growers can perform in controlling alternate bearing. All of these are to be focused on bringing a lost balance between vegetative growth and fruit set in a tree, among which:

- Pruning is to be performed in adequate and regular manner as already specified in the pruning section, to ensure a constant supply of one year old branches to bear the fruits.
- Optimization in the use of the type and amounts of fertilizers that bring the tree to a balance. If the trees can't be broken back from alternate bearing at least an increase in the amount of yield is observed.
- Winter spraying of gibberellins at moderate concentration can decrease the number of inflorescence in the "on" year, thus, giving a higher potential of inflorescence and fruit set in the next year.
- Give up the beating method of harvesting can preserve the one year branches from harm and, thus, increase the chance of bearing.
- Shift to a minimum tillage operations that prevent root chopping, thus, less negative effect on the tree.
- Practices such as scaffold girdling every other year on half of the tree scaffolds in addition to the use of plant growth regulators to thin out fruit settings have shown to encourage yearly production.
J. Milling

Fruits gathered from the grove are either kept in jute or plastic bags if the queue to the mill is short, or spread on covers if milling is to be performed in more than a couple of days. At this time, the growers may take the opportunity to discard the leaves and pick some of the attractive big fruits for pickling. When milling time is due, growers fill again the fruits in bags and transport them to the mill. Some misinformed growers may sometimes leave their harvest in the bags, for more than a week, waiting for their turn before the fruits are milled and processed into oil. Once the olive fruits arrive at the mill, they undergo many steps before they turn into oil, depending on the type of the extraction method.

Types of mills in Lebanon:
It is estimated that there exists more than 500 mills in Lebanon, where only about 10% are of the modernized types that use the centrifugal method of extraction, while the rest depends on the traditional mechanical or hydraulic pressing. The modernized types are fully automated and fast, with no human interference in the sense that the fruits are put on one side and oil is gathered from the other. On the other hand, the hydraulic press mills vary between types with semi-automation and those that are still very rudimentary and require human attendance and handling before and after all the steps of the extraction process.

1. Hydraulic pressing: Many steps are involved, mainly:
   - Leaf removal and washing to eliminate all the foreign materials like leaves, dirt, etc…
   - Crushing and mixing: The fruits are fed to a system made of 2 large granite wheels revolving around a basin to produce a paste. The paste produced undergoes a thorough mixing after being transferred to a mixer that raises its temperature up to about 30 degrees Celsius.
   - Pressing: The paste produced is filled into mats made of nylon and stacked on top of each other before being loaded to the press. Oil and water produced are taken into a ceramic basin for decantation, whereas the pomace is discarded.
- Separation: The oil, having a less density than water, separates naturally and floats on the top. In some of the most rudimentary mills, it is collected by hand, while in the more advanced, the mixture of water and oil is taken into a centrifuge. The oil, at this step, is stored in plastic or stainless steel containers or galvanized cans.

2. Modern extraction: Though it is fast and more hygienic than the pressing and involves minimum interference, growers, complaining about the inferior quality of oil produced in terms of taste and smell, are still a bit reluctant in its adoption. It involves many continuous steps mainly:
   - Leaf removal and washing
   - Crushing that involves chopping of the fruits into small pieces, after having them revolving in a centrifuge equipped with knives, resulting directly into paste. Afterwards, the paste is beaten and further mixed with hot water up to 50 degrees Celsius to facilitate the oil extraction.
   - Decantation is performed in a centrifuge that separates water from the oil. The resulting water still containing a bit more of oil is centrifuged again to extract some additional oil that is added to what was gathered before.

Growers seem to appreciate more the oil produced by the hydraulic method, for it is less prone to hot water that destroys some of its constituents which in turn reflects badly on its taste and smell. Nevertheless, no matter what types of mills growers choose to extract their oil, there is a couple of things that they need to take in consideration to extract oil of good quality:
   - They should never mix fallen fruits with what they have harvested.
   - They should never store the picked fruits in bags for a long time before they are taken to be processed. It is useful for them to use boxes instead of bags and mill their harvest daily.
K. Weed management

The most common weeds found in olive orchards are listed in the following table:

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyperrus rotendus</td>
<td>Nutsedge</td>
</tr>
<tr>
<td>Convvolus arvensis</td>
<td>Bindweed</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>Bermuda grass</td>
</tr>
<tr>
<td>Avena sterilis</td>
<td>Wild oat</td>
</tr>
<tr>
<td>Setaria spp</td>
<td>Foxtail</td>
</tr>
<tr>
<td>Sinapis arvensis</td>
<td>Wild mustard</td>
</tr>
<tr>
<td>Phalaris spp.</td>
<td>Canary grass</td>
</tr>
<tr>
<td>Digitaria spp.</td>
<td>Crab grass</td>
</tr>
<tr>
<td>Chenopodium spp.</td>
<td>Goose foot</td>
</tr>
<tr>
<td>Avena fatua</td>
<td>Wild oat</td>
</tr>
<tr>
<td>Lolium spp.</td>
<td>Rye grass</td>
</tr>
<tr>
<td>Capsella bursa-pastoris</td>
<td>Shepherd's purse</td>
</tr>
</tbody>
</table>

Table 11. Most important weeds in olive orchards

Control methods: - Mostly mechanical depending on repeated cultivations. A practice that doesn't seem cost effective, for it is repeated many times, in addition to the main disadvantage of unnecessarily disturbing the tree's root system and transmission of different kinds of pests.

- Chemical control: Some growers rely on non-selective herbicides for control of both kinds of annuals and perennials weeds mainly Glyphosate 360g/l SL, or, Paraquat 24% SL.
L. Pest management

Pest control deviates from zero or no control in some areas towards an excessive radical control that involves the use of large quantities of pesticides in other areas, dis-equilibrating the natural balance and leading to unneeded selection of resistant strains.

The main pests controlled are listed as follows:

1. Diseases

   a. Olive peacock's eye or Spilocea (Cycloconium) oleaginea

      All the olive growers seem to be familiar with this disease; they even enumerate it first when listing the olive's diseases. It is considered the most important for its occurrence in all the Lebanese olive groves, especially in those areas like Koura (North Lebanon) where favorable conditions of high relative humidity and high temperature are prevailing. Another reason is the dramatic sight of fallen leaves showing green-black blotches with a yellow halo similar to the eyes on the peacock's tail. This fungus overwinters as a mycelium in the fallen leaves waiting for the necessary conditions for its spores release like the occurrence of temperatures ranging between 18 to 22°C and a minimum wetting periods of about 24 hours (at 20°C) provided by a continuous period of rainfall or very high relative humidity above 98%. The infected new growth turns yellow eventually and falls prematurely, leading many times to defoliation of the trees.

      i. Control

      Most of the control conducted is chemical through the use of copper-oxychloride 85% WP sprays at the rate of 500g/200lit in the spring and on the new growth.
ii. Recommendations

- Cultural practices such as pruning and opening up the trees help in providing more aeration and sunlight, creating unfavorable conditions for the disease's development.
- Fall plowing buries the disease debris and minimizes the primary inoculum.
- An additional spray of cupric compounds in the end of the season and after pruning is recommended to decrease also the primary infectious materials.

b. Olive knot disease or *Pseudomonas syringae pv. Savastanoi*

It is a serious bacterial disease with conspicuous symptoms revealed as galls or swelling developing on the twigs, branches, trunks, fruit stems, and even roots. The bacteria living in these galls is washed out in the fall or spring in the presence of rains or any other means of transportation with an adequate temperature ranging between 23 to 30 degrees Celsius to find a point of entry in the trees to penetrate and start its infections. Points of entries are provided by leaf scars, pruning wounds, and bark cracks produced by using the sticks for fruit harvesting. Once inside the tissues, the bacterium produces toxins that enhance multiplication and proliferation of these tissues, giving the tumor look appearance.

i. Control

Farmers are stunned with this disease with not much thing to do.

ii. Recommendations

There is no adequate control that really cures this disease. All what it seems as control is to prevent the spread of the disease and eliminate its points of entry that the bacteria need to cause an infection. The main procedures are summarized in the following:
- Growers are to stop using the sticks for fruits' harvesting for they are creating injuries that constitute points of entry and helping to transmit the disease from one infected branch to another.
- Pruning sheers blades are to be sterilized, using solutions of alcohol 70% or better Hypochlorite solutions 5% where sheers are soaked before each cut. Sterilization solution can be applied directly on the blades, using special sheers with reservoirs. Pruning cuts are to be made 15-20cm below the infections and sealed with special material or with a paste of copper-oxychloride. The best way is to spray copper oxychloride or copper sulfate directly after pruning. The left-overs of pruning are to be burnt separately and destroyed.

c. **Sooty mold or Capnodium oleaginum**

   The black superficial showy growth of this mycelium that covers the twigs and the leaves gives it a spectacular appearance that alerts growers and makes them prepare their nozzle heads to start the pesticides spraying. However, the truth of the matter is nothing but a simple fungus that grows on the excreta of some insects like Psylla and black scales and can be a good indication for their presence. It doesn't require any special treatment except to control the reason for their occurrence. Of course, they inflict an indirect damage by depriving the trees of photosynthesis.

   i. Control:
   
   some growers spray copper oxychloride and Mancozeb.

d. **Verticillium wilt or Verticillium dahliae**

   As its name implies, wilting of one branch or more in a tree occurs early in spring and increases later on in the season, leading many times to the yellowing and curling of leaves and death of the tree. The disease is eminent in the soil and the roots of infected trees all year round and ready to be
transmitted to the new roots of other trees. Darkening of the xylem is an evident symptom of the disease, but again infection could occur without showing it.

i. Control

No control is ever conducted, if erroneous speculative methods such as severe pruning to rejuvenate or painting the tree's stem with lime are not to be accounted for. The infected trees are left to weaken and die without pointing a mercy bullet at their head.

ii. Recommendations

Cultural practices such as plowing are to be minimized for they rupture the roots and can help in transmitting the disease to healthy trees.
- Pulling out the infected trees and applying methyl bromide for fumigation seems to be the most effective method of all. Nevertheless, infected trees are to be burnt and destroyed completely after pulling out their roots with one condition that the soil is dry for the gas to penetrate as deep as needed.
- Biological control agents such as *Aspergillus terrus* and *Talaromyces flavus* are found to control verticillium; nevertheless, these aren't found in commercial formulas in the Lebanese market.

2. Insects

e. Olive fruit fly or *Bactrocera (Dacus) oleae*

   It is mostly known to the growers by the obvious damage it inflicts on the olive fruits, especially in areas of production where the harvest is being extended towards the end of the year or so. Most of the growers have never seen this insect but they are familiar with the holes appearing on the fruits and their sight when fallen beneath the trees sometime around the end of August. Individuals of this insect pass the winter as pupae in the 3-4cm on top of the soil or as larvae inside the fallen fruits. Nevertheless, adults of this fly have been found during December. This insect can have up to 5 or 6 overlapping
generations due to the differences in the microclimate of the different regions. The first ovipositions are noticed as of the 3rd week of July in Koura when the fruits starts being suitable. A necessary pre-oviposition period is required for the adult females to be mature during which they feed on honey dew, nectar, and sometimes excretions from insects. The length of the generation can extend from 2 to 3 weeks, depending on the climatic conditions as it is longer in colder areas. The adult female lays up to 200 eggs oviposited like 1 per fruit. The egg hatches into 3 larval stages, feeding and tunneling into the flesh of fruits until it pupates. Furthermore, pupae of this fly were found on the walls of oil mills where the infested fruits' leftovers provided it with a good shelter to continue its life cycle. Damage inflicted on the fruits directly leads to a decrease in yield, accumulation of acids in the fruits, and consequently deterioration in the quality of both the fruits and oils. The severity of damage is directly related to suitable climatic conditions (moderate temperature and humidity) in addition to a varietal susceptibility. Predators of this fly are many, but the most important is a braconid called Opius concolor.

i. Control

- Most of the control used is chemical through the usage of pesticides like dimethoate, Methidation, Diazinon .... These pesticides are sprayed every 15 days, starting from July until end of September.
- Some growers, who were introduced to protein hydrolysate, use it in mixture with an insecticide such as Dimethoate at the rate of 500cc of protein hydrolysate and 250-300cc per 200 lit of water and spray an area of 1 m2 of the trees towards the South-East direction, at the start of June. Other growers use the mixture to spray one row of trees leaving another untreated.
- In an attempt to mend the situation by decreasing the amount of pesticides used, an ICU-Rome project, along with the EU and in cooperation with the Ministry of Agriculture in the areas of Nabatieh-Hassbiah (ended last year) has been promoting a technique based on sampling fruits and counting cumulative infested ones effectively to set an economic injury level of 10-15% in olives designated for oil extraction and 2-5% in olives tended for pickles.
- Another attempt was made by the Ministry of Agriculture in 2003 when dome traps along with protein hydrolysate were distributed to farmers for free. All those growers who have tried this method found it very effective in that particular year.

ii. Recommendations

-Cultural: Some cultural practices are helpful in this fly's control such as:
- Plowing the surface of the earth is important in destroying a big portion of the insects' pupae.
- Growers are to pick and destroy all the fallen fruits and never mix them with what is picked from the trees.
- Usage of mass trapping with food like protein hydrolysate or with Di-Amonium phosphate and yeast.
- Judicious use of pesticides is imperative and only in extreme cases with the type of insecticides that don't dissolve in oil and beyond the insecticides' pre-harvest intervals.
- Early harvest of fruits can be an important factor to save them from a few extra stings inflicted by this fly and minimize the accumulation of the amount of acids and peroxidases produced as a result of stinging and thus better oil quality.

f. Olive moth or Prays oleae

In Lebanon, it is as important as the fruit fly for the similar damage it inflicts on the yield. This moth is silvery in color with few undefined dark dots. The wing expanse is about 12mm. This insect has 3 defined generations per year where each of them feeds on specific organ of the tree to end up having the leaves generation, the blossoms...
generation, and the fruits generation. This moth overwinters as an active larva, mining the leaves with S-shaped tunnels. In the second half, till end of February, depending on altitudes, this caterpillar pupates by tying a few leaves together to emerge as an adult starting end of March till end of April. The adult lays its eggs on the blossom giving rise to larva that feed on them. The adult of this generation will lay their eggs on the fruit set during end of May till beginning of June. The larvae of this generation will feed on the pulp of the fruits and even devour the cotyledons, leading to their premature fall. Now, adults of this generation will lay their eggs on the underside of the leaves giving rise to the leaves generation. The length of the life cycle is approximated to 45-60 days.

i. Control

The growers direct their control mainly to the blossom generation where they spray an insecticide such as Cypermethrin, Deltamethrine, Dimethoate, Lamda-cyhalothrin, Abamectin, Pirimiphos-methyl, … in addition to 500 g/ 200 lit of copper oxychloride to control both the flower moth and the peacock's eye disease in one spray. This is probably because the leaves generation isn't considered to inflict an important damage, in addition to the fact that the fruits generation will be controlled along when they spray for the fruit fly and doesn't require special treatment as long as the treatment is conducted with broad spectrum systemic insecticides such as Dimethoate that works on both the moth and the fly.

ii. Recommendations

- Cultural practices such as cleaning and destroying the fallen fruits from beneath the trees is very important to eliminate another source for infestation.
- Use of spray of Bacillusthuringiensis instead of chemicals can be an important practice to preserve the pests’ natural enemies that are around.
Another tactic in the biological control strategy is through the use of many agents that attack different stages of the moth mainly: *Trichogramma spp.*, *Ageniaspis fusciollis*, Chrysopidae, Syrphids flies, and Anthocoridae.

g. Olive scale or *Saissetia oleae*

It occurs on olives as well as on citrus, especially in neglected groves where dense and unpruned trees constitute a preferable place for it to flourish. This scale is black in color about 2 to 5 mm in size with an H shape on its shield. It is always accompanied with sooty mold growing on its honeydew excreta, giving the trees a black appearance. It has 1 or 2 generations per year and overwinters in its egg or larval stages. As the climatic conditions are favorable, it continues its development to be ready to let its crawlers spread to the leaves and twigs during the month of May-June. This scale feeds on the leaves and twigs that get covered with the black sooty mold that prevents photosynthesis and weakens the tree.

i. Control

Chemical through the use of Methidathion, Carbaryl, Chlorpyriphos, Methomyl, Carbaryl etc…

ii. Recommendations

- Using cultural practices such as pruning and opening up the trees for air circulation to discourage this pest's development.
- Use of oil spray that should be timed once the crawlers are out.
- Minimize the use of broad spectrum chemicals to allow the many natural enemies present in Lebanese grove to perform their job efficiently i.e. like *Rhyzobius sp.*, *Scutellista cyanea* and others.
h. Leopard moth or Zeuzera pyrina

(It is the same insect mentioned earlier in the apple section with the same control.)

i. Olive bark beetle or Phleotribus scarabeoides also known among growers as the "Neiroun"

The adult of this insect is a small black beetle with distinguishing 3 branched antennas. It belongs to the Coleopteran order that feeds on the bark of the young and old twigs, branches, and stems with a preference to broken branches of the weak pruned trees and pruning left-over. Individuals of this species can overwinter as larva, pupa, or an adult in olive bark. As early as February, the adults start boring tunnels in the base of young twigs and leaves axils where one can notice the ejected frass at the entrance of the tunnels. A male and a female are always found together in the dug tunnels, where the females lay its eggs in a connected tunnel that was bore in the cambium. The emerging larva did their own tunnels perpendicular to the mother's tunnels until they pupate and produce an adult in about 10 days. The length of the generation varies between and 45 and 60 days, depending on the climatic conditions. The damage inflicted by this insect is demonstrated by the death of young twigs and falling off of the blossoms and fruits.

i. Control

Many pesticides are used such as Chlorpyriphos, Dimethoate, and Methomyl... without being many times as effective as they should since the insects are beyond their reach, depending on the insect stage of development.

ii. Recommendations

- Cultural practice, depending largely on pruning the infested parts of the trees and keeping the leftover aside in the olive grove for about a week to trap the adults and, then, burn them, for this insect is attracted to broken and cut branches.
- Keep the trees healthy.
- If insecticides are to be used, proper timing is an important factor to match adult emergence. This can be done, using small net traps that cover some of the infested branches or twigs at an adequate distance from both sides of the entrance of the dug tunnels to capture the emerging adult.
j. Olive bark borer or *Hylesinus oleiperda*

It is very similar to the Neiroun in its shape but only a bit larger with tapered antennas. It is not considered an important pest, for it has only one generation per year.

k. Olive Psylla or *Euphytleura olivine*

It can be described as a modest insect that is turned a pest because of the extensive use of broad spectrum pesticides that kill most of its many natural enemies. It is just that the growers are driven crazy by the flagrant white waxy filaments entangled on the twigs. Those are secreted by the feeding larva to end up covering their bodies. It overwinters as an adult in the bud axils before it becomes active again in the spring and produce larvae that feed on the leaves and the flowers, also accompanied with the growth of sooty mold. The whole life cycle takes about 7 weeks. In Lebanon, this psyllid can accomplish about 3 generations, but the interesting thing about it is that the adults becomes quiescent when the temperature rises above 20 degree Celsius, making the first spring generation of economical interest.

i. Control through the use of insecticides like Amitraz, Chlorpyriphos, Methomyl

ii. Recommendations
   - Cultural practices like good pruning of trees
   - Minimize chemical sprays and use of natural enemies like *Psyllaephagus Euphyllurae*, Syrphid flies, Anthacoroids etc…

l. Olive leaf midge or *Dasyneura oleae*

It is a small fly about 2 mm in length with a pale yellow color. It passes the winter as an incomplete larval stage that resumes its growth and emerges as an adult from a pupa during March. The adult lays its eggs in the flower or on the leaves, thus,
creating important losses to the yield. The emerging larva bores inside the leaf tissues a tunnel, causing a fast multiplication of the cells around it, showing galls and malformations. The number of generations is dependent on the place where the female lays its eggs, in the sense that, if it lays its eggs on the leaves, the larvae will develop slowly during the summer and overwinter as a 3rd instar larvae to emerge as an adult in the next spring, but, if the eggs were deposited on the flower, the development of the larvae is fast and emerges as a mature adult by the end of May of the same year. Therefore, the number of generations varies between one, extending for a year, and 2 if the eggs were laid on the flower with duration, extending from 6 to 8 weeks.

i. Control

It is mainly chemical through the use of insecticides, at same time when Olive flower is being controlled. The main pesticides used are like Chlorpyriphos, Cypermethrin, Lambda-Cyhalothrin, Dimethoate, etc…

m. Olive bark midge or Resseliella oleisuga

It is a 3 mm in length dipterous insect, black in color with orange abdominal segments in the female and grayish in the male. It overwinters as a larva and/or nymph, before the adult emerges at the beginning of spring. The fertilized females deposit their eggs in packs of 10-30 eggs, under the bark of young twigs, making use of injuries created by other insects, pruning, and twigs rubbing due to wind. The developing larvae feed for about 3 weeks on the cambium tissues of the twig, causing the depression and cracking of the bark that turns reddish to brown. The infested twigs desiccate and wilt as a result of the feeding. When the period of 3 weeks is over, the larvae abandon the colony and fall to the ground where they pupate. The insect has 2 to 3 overlapping generations per year with a life cycle, extending for a period of about a month.
i. **Control**

The control conducted is mostly through the use of chemicals, mainly: Dimethoate, Cypermethrin, Chlorpyriphos, etc.

ii. **Recommendations**

Cultural practices: - cutting and burning of infested twigs.  
- sealing of pruning cuts.  

Biological control: It has been found that this insect has a natural enemy mainly: An ectoparasite called *Eupelmus hartigi*.

### 3. Lichens

Their yellowish to greenish patches of growth on the scaffolds or trunks of olive trees drive some growers to think that it is the end of their olive trees, while in reality, lichens aren't as serious as they seem. Lichens are nothing but the simple presentation of a symbiosis between a plant organism and some types of fungi where the first provides photosynthesis and the other provides the minerals and water. They usually flourish on trees where high relative humidity is prevailing in the microclimate. Also it is a matter of fact that lichens play a role in harboring some kind of insects and fungi and may weaken the tree. Nevertheless, the control of lichens is very easy and can be achieved through cultural practices, such as pruning, where opening up the trees for sunlight makes the microenvironment unsuitable for their growth. Also chemical control is performed through spraying the trunk and the limbs with copper oxychloride while treating for peacock's eye disease.

### 4. Viruses

During the year 2003, a survey conducted in the main areas of olives' production all over the country, has revealed, the presence of 5 types of viruses with different incidence in different areas (Fadel 2005). The main viruses found are:
- The Strawberry Latent Ring Spot Virus (SLRV) described as causing leaves and seeds deformations in infected trees with a general weakness and a bushy growth.
- The Arabis Mosaic Virus (ArMV) described as causing a general weakness with no obvious symptoms.
- The Cherry Leaf Roll Virus (CLRV) with no obvious symptoms.
- Olive Latent Virus 1 (OLV-1) where infected trees may show leaf abnormalities.
- Olive Leaf Yellowing Associated Virus (OLYaV) characterized by obvious leaf yellowing.

The mentioned viruses are transmitted through mechanical means, pollen, nematodes, and mainly through infected plant materials. There is no real control for viruses except through prevention. Accordingly, growers, with intentions to start new orchards, are to make sure that they are using healthy trees. Another control tactic is by culling and destroying infected trees in addition to destroying the vectors and eliminating the means of transmission.

5. *Nematodes and mainly the Root knot nematodes or Meloidogyne spp.*

The most obvious symptoms of the root knot nematodes are a general wilting of leaves as well as weakening and stunting of the tree. Galls or knots appear on the roots of the infected trees. Nematodes larva, after hatching from its eggs, look out for the plant roots and penetrate them once it finds them. It sticks its stiletto inside the cells and some of its saliva contains materials that encourage the surrounding cells to multiply and form tumor cells to diverge water and nutrients towards them, thus, depriving the rest of the tree from its nutrition. The mostly seemed affected by root knot nematodes are the trees in the nurseries, probably, because they are the easiest to be pulled when they show symptoms of stunting and weakening. Usually, chemical control is applied through Oxamyl, Fenamiphos, and Carbofuran.

The most commonly used pesticides with trade names and timing are listed in the following table:
<table>
<thead>
<tr>
<th>Pest</th>
<th>Peacock's eye</th>
<th>Flower moth</th>
<th>Fruit fly</th>
<th>Olive bark beetle</th>
<th>Scale insect</th>
<th>Psylla</th>
</tr>
</thead>
</table>
| **March to April** | *- Oxycal (Copper oxychloride 85% WP)*  
*- Cobox (Copper oxychloride 85% WP)*  
*- Kocide (Copper hydroxide 54% WP)*  
*- Cuprocaffaro (Copper oxychloride 85% WP)* | *- Renox (Cypermethrin 25% EC)*  
*- Perfekthion (Dimethoate 40% EC)*  
*- Baythroid (Cyfluthrin 5% EC)*  
*- Decis (Deltamethrin 2.5% EC)*  
*- Fastac (Alphacypermethrin 10% EC)*  
*- Karate (Lambda-cyhalothrin 5% EC)* | - Renox (Cypermethrin 25% EC)  
- Perfekthion (Dimethoate 40% EC)  
- Decis (Deltamethrin 2.5% EC)  
- Renox (Cypermethrin 25% EC)  
- Tocal (Dimethoate 40% EC)  
- Dursban (Chlorpyriphos 48% EC)  
- Lannate (Methomyl 90% SP)  
- Actellic (Pirimiphos methyl 50% EC)  
- Supracide (Methidathion 40% EC) | - | - | - |
| **July to September every 15 days** | - | - | - | - | - | - |
| **November** | *- Cuproxat (Copper sulfate 35% FL)*  
*- Cobox (Copper oxychloride 85% WP)* | - | | | | - |

*Table 12. Pesticides mostly used with commercial names*
M. Conclusion

Based on what has been mentioned, the olive sector in Lebanon is suffering from several problems in terms of different levels, hindering its reformation and development. The present situation is, perhaps, still partially acceptable in spite of the many hardships the olive sector is facing for the simple fact that the olives and the oil produced are somehow still finding channels for local commercialization, primarily among relatives and friends. Nevertheless, one can expect the worst when the offer will exceed the demand by far, especially when the surface area planted with olives is increasing. In this case, the Lebanese olive sector will not hold under the pressure of the ferocious competition imposed by the neighboring countries which produce at a lower cost compared to a local surplus characterized by a high cost of production. The only way out of this vicious circle is to lower the cost of production and, at the same time, improve the quality of both olives and olive oil to make them eligible for export.

Therefore, the official sector and growers are to join efforts and work hand in hand in a duly harmonized plan to get the olive sector off the hook. Otherwise, deleterious implications will have their impact on both the social and economic levels. The official sector, embodied in the Ministry of Agriculture, Lebanese Agricultural Research Institution and the Ministry of Economics, is to:

- Instigate the cooperation and the coordination of the different sectors.
- Set modernized laws rules and see to their enforcement.
- Set quality standards for both olives and olive oil production and assign bodies for quality control.
- Find suitable ways to accredit labs for quality control.
- Orient the research to be more of the applied type for solving problems and finding solutions.
- Conduct extension in a more efficient way to reach the growers.
- Control the mills and set standards for their work.

As far as the growers are concerned, they need to:
- Take the initiative to start some serious agricultural work and aggregate in cooperatives capable of fulfilling this sector's welfare in improving its production on the different levels.

- Adopt what is known as integrated pest management to diminish pesticides' use.

- Acquire varieties that are homogeneous in their growth and production and more adapted to mechanization.

- Conduct pruning according to scientific basis.

- Minimize cultivation and find alternatives to weed management fit to integrated pest management.

- Conduct trials on olive irrigation.

- Set time of olive harvest depending on a balance between yield and quality.

- Start introducing some mechanization to solve the issue of hand labor.

- Conduct soil and leaf analysis for fertilizers' amendment and according to need.
IV. References