

# **Pest Survey of Stone Fruit Crops in Lebanon (2011-2012)**

Final specific crop pest survey report prepared for

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## 2. Executive Summary

- A national survey of pests of stone fruit crops was carried out by the Plant Protection Service in The Ministry of Agriculture in Lebanon from October 2011 to December 2012.
- Five stone fruit species spread over 329 sites in the growing areas of Lebanon were surveyed for pests.
- One thousand and twenty (1020) arthropod and gastropod site-crop-organism records are reported from this survey; 75 of which (72 insects and 3 mites) were first records in Lebanon.
- Six new potential primary insect species (*Agalmatium* sp, *Contarinia pruniflorum*, *Rhabdorrhynchus anchusaes*, *Sibina phalerata*, *Spermophagus* sp., and *Urophorus humeralis*) were recorded for the first time on stone fruits.
- One new thrips, *Mycterothrips albidicornis* (Thripidae), was found with high frequencies in all stone fruit crops. The nature of the host-organism association is still unknown.
- The three newly recorded mites, *Bdella* sp., *Trombidium* sp. and *Arctoseius haarlovi* are predators.
- Twelve nematodes species (*Pratylenchus vulnus*, *Pratylenchus penetrans*, *Tylenchus* sp., *Criconemella xenoplax*, *Aphelenchus* sp, *Aphelenchoides* sp., *Longidorus elongates*, *Meloidogyne hapla*, *Meloidogyne arenaria*, *Pratylenchus pratensis*, *Macrotrophurus* sp. and *Psylenchus* sp) were recorded for the first time in Lebanon.
- Two primary nematode species *Meloidogyne javanica* and *M. incognita* were reported in stone fruits orchards as new host records.
- Three hundred sixty six (366) fungal specimens were identified. Eight primary species were new to Lebanon (*Botryosphaeria dothidea*, *Cercospora circumscissa*, *Leptosphaeria coniothyrium*, *Leucostoma cincta*, *Leucostoma persoonii*, *Neofusicoccum parvum*, *Phomopsis amygdali* and *Phoma pomorum* var. *pomorum*).
- Plum pox virus (PPV), Strawberry latent ringspot virus (SLRV), Raspberry ringspot virus (RpRSV), Tomato ringspot virus (ToRSV), Cherry leafroll virus (CLRv), Arabis mosaic virus (ArMV) and Tobacco ringspot virus (TRSV) were not detected at any site in Lebanon
- Other major viruses of *Prunus* spp. (PNRSV, ACLSV, PDV, ApMV, PLMVd, HSVd, ApLV, APLPV, PBNPaV and AlmWB) occur in Lebanese stone fruit orchards.
- Prunus necrotic ringspot virus (PNRSV) was the most prevalent virus. Plum bark necrosis stem pitting-associated virus (PBNPaV) is a first record in Lebanon.



### **3. Introduction**

From October 2011 to December 2012 the Plant Protection Service in the Ministry of Agriculture in collaboration and support of the Project GCP/LEB/021/ITA, carried out a national pest survey of five stone fruit crops. This survey, along with the citrus pest survey, was the first comprehensive pest survey within the plant protection service plan of surveillance of plant pests in Lebanon. The survey aims to detect the presence of any pest new to Lebanon as well as previously known pests with altered hosts or distributions, in addition to confirming or denying presence of pests historically reported in scientific articles. These data are fundamental to the preparation of pest lists that are used to set import requirements of agricultural commodities as well as providing reliable information to trading partners about crop/pests status in Lebanon.

The Ministry of Agriculture is reviewing import requirements of agricultural commodities. This will be based on pest risk analysis (PRA) which requires the NPPO of the potential supply country to provide appropriate crop/commodity pest list. To support the implementation of the PRA process of the pests listed and categorize them for Lebanon, a comprehensive, accurate, and up-to-date database of agricultural pests is essential. Specific crop/pests surveys provide this information to the Plant Protection Service.

This report documents the findings of the national survey of stone fruit pests, listing new findings (records), new hosts associations, update status of previously reported pests, and their base distribution in Lebanon. Significant findings are discussed.

Weeds are not crop specific therefore they were not included in this survey.

## 4. Methods

### 4.1. Crops Surveyed

Five stone fruit crops were included in this survey. These were Almond (*Prunus amygdalus*), Apricot (*Prunus armeniaca*), Sweet and Sour Cherry (*Prunus avium* and *Prunus cerasi*), Peach (*Prunus persica* including nectarine, *P. persica* var. *nucipersica*) and cultivated Plum (*Prunus domestica* (European) and *Prunus salicina* (Japanese)).

### 4.2. Number and Distribution of Sites Sampled

The survey was designed to detect pests infesting  $\geq 2\%$  of trees at  $\geq 5\%$  of sites with 95% confidence, using the procedure of Dymock & Holder (1996). This means that all five citrus crops were “treated” as a single crop for statistical purposes when calculating the total number of sites to be surveyed.

The Assumptions were:

- A particular pest is equally detectable on any crop it infests
- The proportion of infested sites follows a binomial distribution, and thus the number of sites to be surveyed can be calculated as

$$N = \log (1 - p_1) / \log (1 - p_2 p_3)$$

Where  $N$  is the number of sites,  $p_1$  is the confidence in detecting a pest at one or more sites (**95%**),  $p_2$  is the proportion of sites infested (**2%**),  $p_3$  is the confidence in detecting a pest at a particular site (**90%**)

$$\begin{aligned} N &= \log 0.05 / \log (1 - 0.009) \\ &= -2.99573 / -0.00904 \\ &= 331.38 \end{aligned}$$

This gives a total of **332** sites to be surveyed nationally.

In this survey a, a total of 329 sites were surveyed, 41 in Akkar, 150 in Bekaa, 53 in Baalbeck-Hermel, 34 in Mount Lebanon, 15 in Nabatiyeh, 30 in North-Lebanon, and 6 in South-Lebanon. The distribution of sites was based mainly on the size of the areas. Table 4.1 lists site allocations for each crop by region. The GPS coordonnates of the surveyed sites were plotted per species on a map using Geographic Information System (Figure 4.1).

In addition to commercial production sites (orchards), the survey included nurseries (5% of the total number of sites to be surveyed) and home gardens (5% of the total number of sites to be surveyed). Packing houses were not included in this survey.

**Table 4.1 Region and Crop Site Allocations for Stone Fruit Survey 2011/12**

| <b>Crops<sup>1</sup></b> | <b>Regions<sup>2</sup></b> |            |           |           |           |           |           | <b>Crop Totals</b> |
|--------------------------|----------------------------|------------|-----------|-----------|-----------|-----------|-----------|--------------------|
|                          | <b>AK</b>                  | <b>BE</b>  | <b>BH</b> | <b>ML</b> | <b>NA</b> | <b>NL</b> | <b>SL</b> |                    |
| Almond                   | 21                         | 42         | 14        | 3         | 2         | 4         | 2         | <b>88</b>          |
| Apricot                  | 1                          | 45         | 1         | 0         | 1         | 3         | 0         | <b>51</b>          |
| Cherry                   | 1                          | 32         | 13        | 3         | 1         | 1         | 0         | <b>51</b>          |
| Peach                    | 11                         | 27         | 20        | 18        | 8         | 12        | 4         | <b>100</b>         |
| Plum                     | 7                          | 4          | 5         | 10        | 3         | 10        | 0         | <b>39</b>          |
| <b>Total</b>             | <b>41</b>                  | <b>150</b> | <b>53</b> | <b>34</b> | <b>15</b> | <b>30</b> | <b>6</b>  | <b>329</b>         |

<sup>1</sup>: In this survey, commercial orchards (90%), nurseries (5%) and home gardens (5%) sites were examined. Where more than one host was examined at a property, these have been listed as separate sites

<sup>2</sup>: The region abbreviations from left to right: AK=Akkar; BE=Bekaa; BH=Baalbeck-Hermel; ML=Mount Lebanon; NA=Nabatiyeh; NL=North Lebanon; SL=South Lebanon

### 4.3. Sample Collection

#### 4.3.1. Field Collection

The survey was designed to detect pests with 90% confidence at sites where the percentage of infested plants was at least 5%. The required number of plants for sampling per site was calculated as:

$$n = \log (1 - p_3) / \log (1 - p_4 p_5)$$

where: **n** is the number of plants to be sampled, **p<sub>3</sub>** is the confidence in detecting a pest at a particular site (**90%**), **p<sub>4</sub>** is the percentage of plants infested (**5%**), **p<sub>5</sub>** is the efficacy of detecting an infested host (**90%**).

$$\begin{aligned}
 n &= \log 0.10 / \log (1 - 0.045) \\
 &= -2.302585 / -0.04604 \\
 &= 50.01
 \end{aligned}$$

This gives a minimum of **50** plants to be sampled per site.

Where there are only 50 plants or less, all plants (of the selected type of stone fruit) on the site are to be sampled. Note that for those plants requiring specialized sampling procedures (e.g., soil sampling for nematodes), fewer samples were taken per site. This means that the pests detected in such samples are likely to infest more than 2% of the plants in that site.

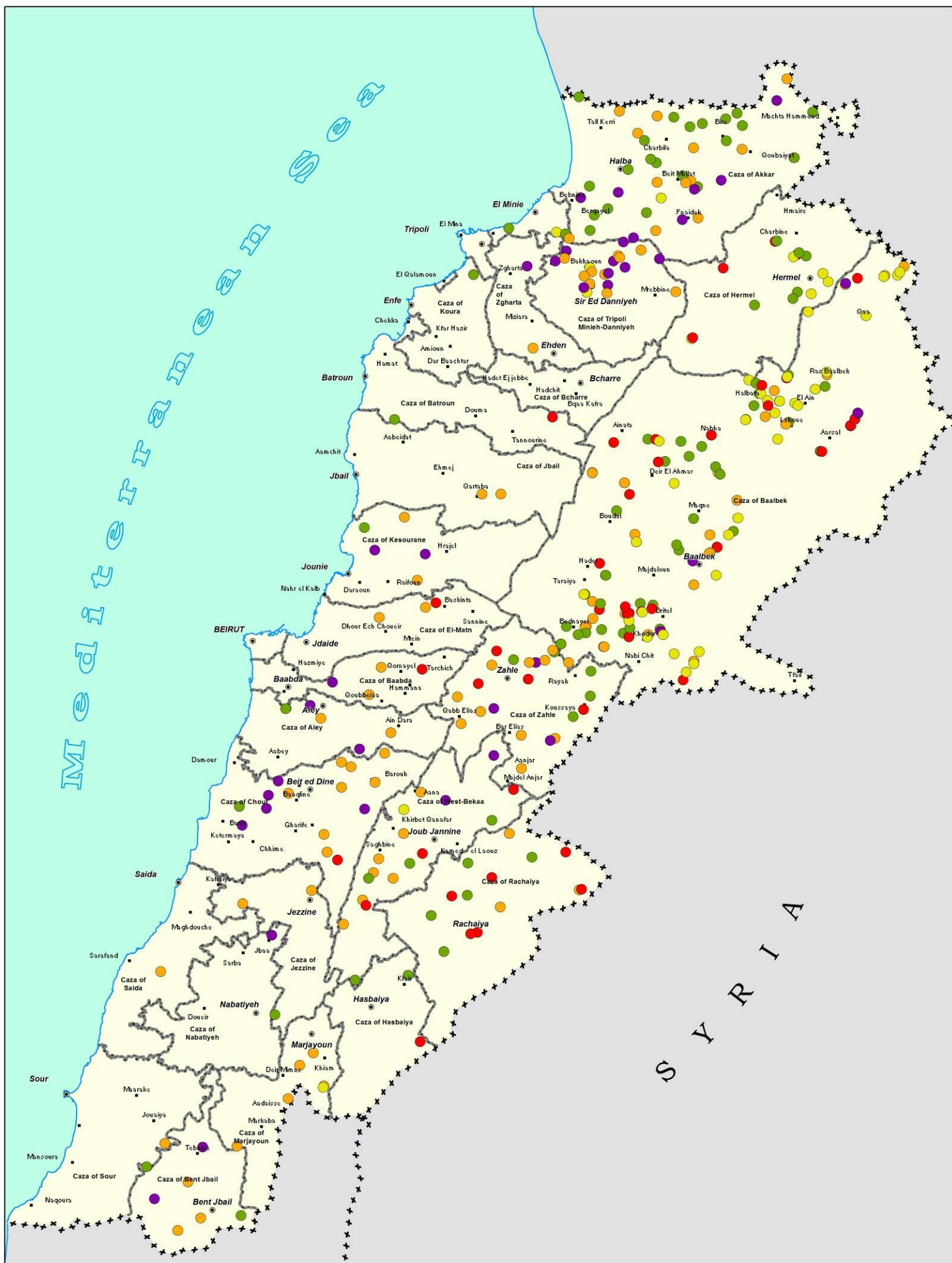
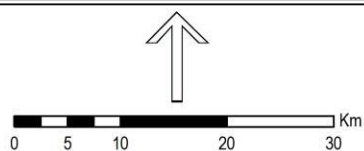


Figure 4.1  
Distribution of sites  
per stone fruit crop



| Host plant                                    | Boundaries                   |
|---|------------------------------|
| <span style="color: orange;">●</span> Peach   | *** International boundaries |
| <span style="color: red;">●</span> Cherries   | — Shoreline                  |
| <span style="color: green;">●</span> Almond   | — Mouhafaza                  |
| <span style="color: yellow;">●</span> Apricot | — Caza                       |
| <span style="color: purple;">●</span> Plum    |                              |

The number of plants examined at each site was based on the following assumptions:

- Visible clumps of symptomatic plants will be sampled to help detect aggregated pests;
- All aerial parts of each plant are sampled;
- Infestation is randomly distributed at a site;
- At least 5% of the plants at a site are infested;
- There is 90% probability of correctly detecting an infested plant.

Wherever possible, at least 50 plants were sampled per site. However, where fewer than 50 plants were available, such as domestic properties, all plants were examined. Ill-thrift areas were also inspected. All parts of selected trees were examined, including buds, flowers, foliage, branches, and trunks. Plant material showing any signs and symptoms of pest or disease infection, as listed on a symptom booklet prepared by LARI team, were collected for laboratory analysis.

For virus and viroids sampling, a total of 10 randomly collected samples were gathered from each field, independently from the presence of viral symptoms. Each sample included 5 one-year-old shoot tips containing at least 3-4 pairs of leaves per shoot were collected from different sides of the tree canopy.

Trees with clear symptoms of virus infection were sampled and marked using spray paint. Marked trees numbers were also recorded in the remarks section of the sampling sheet.

The 10 samples were placed in one bag, labelled and placed into portable refrigerators (2-4 °C) as soon as possible after collection, prior to dispatch to the designated LARI laboratory.

For Nematodes, 1 kg of soil was collected from each visited site. The sample consisted of at least 6 sub-samples collected randomly from the field under the trees canopy following a sampling scheme. Collected samples were subject to subsequent nematode extraction in the laboratory. Particular emphasis was placed on sampling areas in the crop that showed poor vigour, reduced height or yield, stunted growth, wilting, chlorosis, or general ill-thrift.

While in sampling for fungi, bacteria, arthropods and gastropods samples were collected from trees showing symptoms of attacks of pests of these categories.

When symptomatic leaves were identified, the whole shoot bearing the infected leaves was sampled.

For arthropods and gastropods, the field borders were checked first before entering the field. Samples were then labeled in chronological order indicating the field code. The numbering pattern was independent from that of the samples for viruses.

Samples showing the same symptoms were placed together in the same bag and treated as one sample. In cases of uncertainty, a new code number was given to the sample (4-3-a; 4-3-b; 4-3-c, etc.; where 4: the field number, 3 is the sample code, a/b/c of samples showing variant symptoms).

All samples of plant material, pests, and soil were labelled according to symptom, damage, or pest category and each was placed in a separate plastic bag or

polycarbonate vial. Each bag/bottle constituted a sample and was given a separate number.

Samples from each field were then gathered in a one big transparent plastic bag and tightly closed then transported in a cool box and delivered to the nearest LARI station where it was stored at 4 °C.

A sampling sheet designed for this survey and containing information about the site, crop, symptoms, and sample details was attached to each sample bag.

#### **4.3.2. Hygiene**

The survey teams were equipped with disposable gloves, and sampling equipment were cleaned after sampling each site by washing with water and sterilizing with 70% ethanol.

### **4.4. Laboratory Determinations**

#### **4.4.1. Arthropods and Gastropods**

Pest identification was based on the morphological characteristics of the organism.

Plant samples were visually examined for the presence of arthropods, gastropods and related damages and/or symptoms using a stereoscope. When necessary, immature organisms were reared in the laboratory to reach the adult stage. Soft body insects and mites were mounted on slides after cleaning, clearing and maceration.

For specimens belonging to the orders of Coleoptera and Lepidoptera and to the Cicadellidae family, the insect's body was examined under the stereoscope then dissected. Legs, antennae and male genitalia (aedeagus) were then mounted for further detailed examination under microscope. Some specimens of the order Thysanoptera were sent to the Laboratory of Entomology at the National Museum of Natural History - Paris, France for identification.

#### **4.4.2. Nematodes**

Soil from collected samples was subjected to extraction using Bearmann funnel method (Nickel 1991; Shurtleff & Averre III 2005) where a bunch of 100-150 g crumbled soil was placed in the funnel and water was added slowly to moist the soil. After 24 hours, water was collected into a measuring beaker and the volume of water was recorded. Each sample was well mixed and 2 ml suspension was transferred into a counting chamber. Individual nematodes were picked up from soil temporarily mounted on a glass slide for diagnosis. Collected nematodes were afterwards preserved in 5% formaldehyde solution and permanent glycerine mounts of heat killed nematodes. Presence of nematodes in each sample was identified based on taxonomic characters and morphological measurements under light microscope (Southey 1986). The presence of stylet in plant parasitic nematodes allows the exclusion of saprophytic or free living nematodes from plant parasitic nematodes.

For the root knot nematodes identification, one two weeks old tomato seedling plant was planted in one collected soil sample and placed in 1 litre plastic pot. Pots were arranged on a bench in a randomised complete block design, and watered as needed. After 45 days of planting each tomato seedling was carefully removed from the soil

and examined for root knot nematode infection. Galls of infected roots were collected and stored at -20°C for biochemical analysis using isoenzyme present in native polyacrilamide gel electrophoresis and differences in esterase pattern (Ibrahim & Perry 1993). Tail characteristics, stylet length and morphology, perennial patterns and tail morphologies of J2 were important taxonomic characters used to identify *Meloidogyne* species (Perry et al. 2009; Nickle 1991)

#### 4.4.3. Fungi

From each visited site, symptomatic samples from leaves, stems, fruits, branches and/or roots were collected. Disease specimens showing fructifications of fungal species were mounted and examined by direct microscopy.

For samples of leaves and fruits, diseased portions were surface sterilized and placed in sterile humid chambers. Two to seven days later, fructifications were observed by direct microscopy. When needed, evident fructifications of the arising fungal species were transferred to culture media and cultures were stored at 4°C for later identification.

For samples collected from twigs, branches and roots, portions were surface sterilized and at least 10 wood chips were transferred to appropriate culture medium (Potato dextrose agar added with 0.5 g.l<sup>-1</sup> streptomycin). Pure cultures were then prepared for the fungal isolates that appeared in culture.

Identification of the isolates was done based on the morphological characteristics of the fungal species grown on water agar, malt extract agar and potato dextrose agar at 22±1°C.

#### 4.4.4. Bacteria

The received stone fruit samples, suspected to be infected by bacterial diseases were isolated on semi-selective medium, King B medium for fluorescent pseudomonads bacteria and yeast extract dextrose carbonate agar (YDC) medium for *Xanthomonas* spp., and incubated for 48 hours at the appropriate temperature. Fluorescent colonies were visualized by observing plates under UV light (366 nm length) after two days of incubation.

After isolation, various physiological and biochemical tests were conducted to further identify the organisms to the species and pathovar level.

Identification was carried out using **LOPAT** tests including: **L**evan production on sucrose medium, **O**xidase reaction, **P**ectolytic activity on potato slices, **A**rginine dihydrolase production and **T**obacco hypersensitivity. Those tests lead to species level according to Schaad et al. (2001).

In addition, biochemical analyses based on **GAATTa** characters were done, including: **G**elatin liquefaction, **A**esculin/**A**rbutin hydrolysis, **T**yrosinase activity and **T**artrate utilization. Those tests guide to pathovars level according to Obradović et al. (2010).

Additional tests were carried out, based on the schemes presented in Bergey's manual of determinative bacteriology (Holt 2012) and Schaad et al. (2001), such as carbohydrates utilization, lecithinase and starch production, catalase and nitrate reductase reactions.

#### 4.4.5. Virus, Viroids and Phytoplasmas

The entire samples collection was tested by using Double sandwich enzyme-linked immunosorbent assay (DAS-ELISA) (Clark & Adams 1977) for the detection and identification of Prunus necrotic ringspot virus (PNRSV), Prune dwarf virus (PDV), Apple mosaic virus (ApMV), Plum pox virus (PPV), Strawberry latent ringspot virus (SLRV), Raspberry ringspot virus (RpRSV), Tomato ringspot virus (ToRSV), Cherry leafroll virus (CLRV), Arabis mosaic virus (ArMV) and Tobacco ringspot virus (TRSV). For the presence of Apple chlorotic leaf spot virus (ACLSV), Simultaneous ELISA was used. However, for American plum line pattern virus (APLPV) detection, only cherry and plum samples were analyzed by DAS-ELISA. All collected samples were also tested for Almond witches-broom (AlmWB) detection where nucleic acids were extracted from leaf midveins (0.5 g) of plants using the CTAB protocol (Cetyltrimethyl-ammonium bromide) (Maixner et al. 1995) and PCR was done using the two specific primers AIWF2/AIWR2 (Abou Jawdeh et al. 2003). However, only 251 sites were tested by RT-PCR for the presence of Apricot latent virus (ApLV), Plum bark necrosis stem pitting-associated virus (PBNSPaV) and American Plum line pattern virus (APLPV). On the other hand, the same samples were tested by RT-PCR for Peach latent mosaic viroid (PLMVd) and Hop stunt viroid (HSVd) detection. For RT-PCR assay, Total nucleic acid (TNA) extraction and complete DNA synthesis were done as described by Foissac et al. (2001).

#### 4.5. Definitions

##### 4.5.1. Nature of Association

**Primary:** the organism is able to invade and gain sustenance (nutrition) from intact tissues of this plant (and may cause damage or disease to this host, possibly leading to economic loss).

**Potential Primary:** although the biology of this organism on this host is unknown, the part of the plant where this organism was found, and the biology of that family/genus on other hosts suggest a primary relationship.

**Secondary: *plant Pathology*:** the organism attacks and gains sustenance (nutrition) from already impaired tissues of this plant (and may then cause disease or damage to this host, possibly leading to economic loss).

***Other than Plant Pathology*:** the organism infests and gains sustenance from already damaged/overripe tissues of this plant.

**Saprophyte: *Plant Pathology*:** the organism gains sustenance (nutrition) from decaying tissues of this plant.

***Other than Plant Pathology*:** the organism gains sustenance (nutrition) from the rots/fungi that are growing on this host plant, or in decaying plant material. The organism could be associated with any host under similar conditions.

**Unknown:** there is no known information on the biology and hosts of this organism. Therefore, its significance on this crop is unknown.



**In/On Soil:** the organism has been found in/on the soil, not necessarily on the tissues of this host.

**Casual:** any organism that occurs accidentally or as a hitch-hiker, or passenger and is not known:

*either:* to gain sustenance (nutrition) from the tissues of this host plant;

*or:* to live off and gain sustenance from a pest organism that has a known primary, secondary, or saprophyte association with the host organism.

**Predator/Parasitoid:**

*either:* this life stage of this organism is found living off and gaining sustenance from another organism (e.g., another insect) to the detriment of that host organism.

*or:* life stage(s) of this organism are known to live off and gain sustenance from another organism associated with this host plant. This includes biological control agents and organisms that could be considered beneficial.

**Symbiotic:** organisms derive mutual benefit (e.g., protection, food etc.) by living together.

#### **4.5.2. Status of the Record**

**New to Lebanon:** the organism has not been recorded previously on any plant anywhere in the country and, therefore, is new to Lebanon.






**New host:** this is the first record with definite evidence that the organism was living on the plant tissues of this host.

**New Distribution:** this is the first time this pest has been found in this region in Lebanon, on any host.

**New association:** this is the first time this organism has been found in association with this crop. However, there is no evidence that the organism is gaining sustenance from the tissues of this plant.

**Base Record:** this record contributes to background and historical information gained prior to the commencement of this survey.

#### 4.5.3. Key to Results Tables

|   |   |
|---|---|
|  | Previously recorded on this host                    |
|  | Previously recorded on this host and in this survey |
|  | New to Lebanon                                      |
|  | New host in Lebanon                                 |
|  | New distribution                                    |

Where *n* refers to the number of sites at which the organism was recorded

Lebanon Districts Abbreviations:

**AK:** Akkar, **BH:** Baalbeck–Hermel, **BE:** Bekaa, **ML:** Mount Lebanon,  
**NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

## 5. Results and Discussion: Arthropods and Gastropods

Several new records of organisms were found during this survey. Two insect species, previously recorded in Lebanon, were encountered for the first time on stone fruit tree during this survey and they were considered as new host. One new thrips, *Mycterothrips albidicornis* (Thripidae), was found with high level in all stone fruit crops. The genus is known as leaf feeder but no information concerning the host plants. References mentioned that *M. albidicornis* was recorded on *Juniperus communis*, *Quercus robur*, and *Fraxinus* sp. (Masumoto & Okajima 2006).

During the survey, 1090 site-crop-organism records were associated with stone fruit crops in Lebanon, where a particular species occurred in more than one sample from a particular site, it was recorded only once for that site-crop.

Following the text, tables list the presence of organisms found on each surveyed crop, and the number of site per district where a particular organism occurred. The key to table shading is shown on the last page of each table.

### 5.1. Almond (*Prunus amygdalus*)

The following were found: 104 insects and 7 mites of which 24 were new records on almond (23 insects and 1 mite). Prior to this survey, 2 insects have been recorded previously as potential primary on almond and listed in the tables followed by the sign (●) (Abdul Nour & Moussa 2006).

The following types of new records were found in association with almond: 21 first records to Lebanon and 5 new hosts on almond.

The nature of association for these new records was: 2 primary new host, 5 potential primary, 7 saprophytes, 7 casual associates, 3 predators, 2 unknown.

The most common arthropods on almond were: *Eurytoma amygdali*, almond nut borer (34% of sites), *Monosteira unicostata*, almond lace bug (21.5% of sites), *Brachycaudus helichrysi*, peach leaf curl aphid (16% of sites), *Pterochloroides persicae*, clouded peach bark aphid (8% of sites), *Stephanitis pyri*, pear lace bug (8% of sites) and *Tetranychus urticae*, two spotted mite (7% of sites).

*T. urticae* and *Panonychus ulmi*, European red mite were the most abundant mite pests on almond during the survey.

Most pest problems on almond were encountered in Baalbek Hermel district where the production of almond fruits is concentrated.

The predominant leafhopper on almond during the survey was *Assymetrasca decedens*, (7% of sites), while the two leafhoppers, *Frutiodia bisignata* and *Zygina flammigera*, were found at very high incidence on almond (11.3% and 10.2% of sites respectively) without any damage on the trees.

Most aphid and mite predators belonged to the insect families, Coccinellidae and Chrysopidae.

#### ▪ New to Lebanon on Almond

One genus of predatory mite, *Bdella* sp. is a new record to Lebanon.

Seven species of saprophytic insects were potentially new to Lebanon; most of them belonged to the order Psocoptera (67% of total saprophytic insects). They are probably endemic in the region but no study has been done before in Lebanon.

Another new species recorded on almond is the thrips *Mycterothrips albidicornis*. The host-organism association is still unknown.

#### ▪ New Records of Primary and Potential Primary Pest Species on Almond

No insect was newly recorded in this survey as primary pest on almond in Lebanon.

Two new species of insect were recorded as potential primary pest for the first time on almond. They are: *Rhabdorrhynchus anchusae* and *Spermophygus* sp..

Among the new host records, two primary pests and one potential primary pest were recorded for the first time on almond in Lebanon. They are: *Anthonomus cyprius*, *Mercetaspis halli* and *Ceroplastes rusci*.

### 5.2. Apricot (*Prunus armeniaca*)

The following were found: 39 insects of which 9 were new records on apricot. No mites have been recorded during this survey. Prior to this survey, one insect has been recorded previously on apricot and listed in the tables followed by the sign (●) (Abdul Nour & Moussa 2006).

The following types of new records were found in association with apricot: 7 first records to Lebanon and 2 new hosts.

The nature of association for these new records was: 2 potential primary, 1 saprophyte, 3 casual associates, 2 predators, 1 unknown.

The most common arthropods on apricot were: *Monosteira unicastata*, almond lace bug (8% of sites), *Ceratitis capitata*, Mediterranean fruit fly (6% of sites), *Parthenolecanium corni*, European fruit lecanium (6% of sites), and *Scolytus rugulosus*, shothole borer (6% of sites), *Frankliniella occidentalis*, western flower thrips (4% of sites) and *Thrips tabaci*, onion thrips (4% of sites).

Most pest problems on apricot were found in Baalbek Hermel district where the production of apricot fruits is concentrated.

The predominant primary leafhopper on apricot during the survey was *Assymetrasca decedens* (4% of sites) although the incidence of two leafhoppers, *Zygina flammigera* and *Frutoidia bisignata* was high on apricot (20% and 8% of sites respectively) without any damage on the trees.

#### ▪ New to Lebanon on Apricot

Only one new species of saprophytic insect, *Lachesilla* sp., was recorded in Lebanon for the first time.

Also, two predators were found for the first time on apricot. They are: *Aelothrips intermedius* and *Monalocoris* sp.

Other new species recorded on apricot was the thrips *Neohydatothrips abnormis*. The host-organism association is still unknown.

#### ▪ New Records of Primary and Potential Primary Pest Species on Apricot

No insect was newly recorded in this survey as primary pest on apricot in Lebanon.

One species of potential primary pest, *Coccus hesperidum* (brown soft scale) was recorded for the first time on apricot.

### 5.3. Cherry (*Prunus avium*)

No mite pest was encountered on cherry during this survey. Prior to this survey, one mite has been recorded on cherry and listed in the tables indicated by the sign (●) (Dosse and Musa 1967).

The following were found: 65 insects and 1 mite, of which 14 were first records to Lebanon on cherry. The nature of association for these new records was: 1 potential primary, 7 casual associates, 4 predators, 2 unknown.

The most common arthropods on apricot were: *Assymetrasca decedens*, Cicadellidae (17.5% of sites) followed by *Cerambyx* sp., long horn borer, *Empoasca decepiens*, Cicadellidae, *Scolytus amygdali*, shothole borer and *Scolytus rugulosus*, shothole borer and *Thrips tabaci*, onion thrips (8% of sites each one) and *Monosteira unicastata*, almond lace bug (6% of sites).

Most pest problems on cherry were found in Baalbek Hermel district where the production of cherry fruits is concentrated.

The predominant leafhopper on cherry during the survey was *Assymetrasca decedens*. *Empoasca decepiens* was the second. However, the two leafhoppers, *Zygina flammigera* and *Frutoidia bisignata* were found at a very high number of apricot sites (25.5% and 23.5% of sites, respectively) without any damage on the trees.

The most abundant predator found during the survey was *Chrysoperla* sp., the green lacewing.

#### ▪ New to Lebanon on Cherry

Only one predatory mite, *Arctoseius haarlovi*, was recorded for the first time in Lebanon.

Three predatory insects were found for the first time on cherry, they are: *Cantharis* sp., *Karnyothrips flavipes* and *Scolothrips* sp..

Other new species recorded on cherry was the thrips *Mycterothrips albidicornis*. The new association host-organism is still unknown.

#### ▪ New Records of Primary and Potential Primary Pest Species on Cherry

No insect was newly recorded in this survey as primary pest on cherry in Lebanon.

One species of potential primary pest was recorded for the first time on cherry: *Sibinia phalerata*.

#### 5.4. Peach (*Prunus persica*)

The following were found on peach: 101 insects, 4 mites and 1 gastropod of which 20 were new record on peach. The new records on peach were of the following types: 18 first records to Lebanon and 2 new host records on peach.

The nature of association for these new records was: 4 potential primary, 5 saprophytes, 6 casual associates, 4 predators, 1 unknown.

The most common arthropods on peach were: *Assymetrasca decedens*, Cicadellidae (32% of sites), *Myzus persicae*, green peach aphid (10% of sites), *Ceratitis capitata*, Mediterranean fruit fly (9% of sites), *Brachycaudus helichrysi*, peach leaf curl aphid (7% of sites), *Frankliniella occidentalis*, western flower thrips (7% of sites), *Scolytus amygdali*, shothole borer and *Thrips tabaci*, onion thrips (4% of sites each one).

*Tetranychus urticae*, two spotted mite, was the most abundant mite pest on peach during the survey.

Most pest problems on peach were encountered mainly in Baalbek Hermel.

The leafhoppers, *Frutoidia bisignata* and *Zygina flammigera*, were found at a high number of almond sites (8% and 5% of sites respectively) without any damage on the trees.

Most aphid and mite predators belonged to the insect families, Coccinellidae and Chrysopidae.

#### ▪ New to Lebanon on Peach

One predatory mite, *Trombidium* sp., was recorded for the first time to Lebanon.

Five species of saprophytic insects were potentially new to Lebanon, most of them belonged to the order Psocoptera. They are: *Ectopsocus* sp. *Lachesiella* sp. and *Trichopsocus dalii*, which are probably endemic in the region but no study has been done before in Lebanon. Other new saprophytic insects on peach are the beetles *Melanophthalma rispini* and *Anthelephila ionica*.

Another new species recorded frequently on peach at a considerable number of sites is the thrips *Mycterothrips albidicornis*. The host-organism association is still unknown.

### ▪ New Records of Primary and Potential Primary Pest Species on Peach

No insect was newly recorded in this survey as primary pest on peach in Lebanon.

Two new species of insect were recorded as potential primary pest for the first time in Lebanon. They are: *Agalmatium* sp. and *Urophorus humerali*, pineapple beetle.

Two potential primary pests were recorded for the first time on peach in Lebanon. They are: *Aphis citricola*, green citrus aphid and the snail *Helix aspersa*.

### 5.5. Plum (*Prunus domestica*)

The following were found: 83 insects and 6 mites of which 23 insects were new records on plum. Prior to this survey, 3 mites and one insect have been recorded as primary pest on plum and listed in the tables followed by the sign (●) (Dosse and Musa 1967)

The following types of new records were found in association with plum: 19 first records to Lebanon and 4 new hosts on plum.

The nature of association for these new records was: 1 primary, 5 potential primary, 3 saprophytes, 6 casual associates, 6 predators, 2 unknown.

The most common arthropods on plum were: *Assymetrasca decedens*, Cicadellidae (22.5% of sites) and *Stephanitis pyri*, pear lace bug (20% of sites) followed by *Cerambyx* sp., long horn borer, *Parthenolecanium corni*, *Tetranychus urticae*, two spotted mite (12.5% of sites each one), and *Brachycaudus helichrysi*, peach leaf curl aphid (10% of sites).

Most pest problems on plum were encountered in North Lebanon and Mont Lebanon districts.

The leafhopper, *Zygina flammigera*, was found at many sites (17.5% of sites) without any damage on the trees.

Most aphid and mite predators recorded belonged to the insect families, Coccinellidae and Chrysopidae.

### ▪ New to Lebanon on Plum

Three new species of saprophytic insects were encountered on plum. They were: *Ectopsocus* sp., *Trichopsocus dalii* and *Melanophtalma rispini*.

Another new species recorded on plum was the thrips *Mycterothrips albidicornis*. The host-organism association is still unknown.

### ▪ New Records of Primary and Potential Primary Pest Species on Plum

No insect was newly recorded in this survey as a primary pest on plum in Lebanon.

Two new species of insect were recorded as potential primary pests for the first time on plum. They are: *Contarinia pruniflorum*, Plum flower midge and *Rhabdorrhynchus anchusae*, Curculionidae.

Among the new host records, one primary pest and three potential primary pests were recorded for the first time on plum in Lebanon. They are: *Mercetaspis halli*, hall scale, *Brachycaudus cardui*, Aphididae, *Coccus hesperidum*, brown soft scale and *Parlatoria pergandii*, shaff scale.

## 5.6. General Results and Discussion

During this survey, a total of 411 crop-organism associations were found on stone fruit crops, throughout Lebanon, i.e., 392 insects, 18 mites and 1 gastropod. Including location information, 1090 site-crop organism records were reported during this survey, i.e., 1046 insects, 43 mites and 1 gastropod.

Specimens were collected from the stone fruit crops using two methods. The first one, samples based on visual inspection associated with/without damage symptoms, from twigs, stems, branches, leaves and fruits. The second method, samples were taken by beating.

A comparison of the type of organisms collected by these different methods is shown in the following table.

**Summary of Collection Methods and Organisms collected**

| Nature            | Visual and/or Symptom | Beating    | Total       |
|-------------------|-----------------------|------------|-------------|
| Primary           | 233                   | 237        | 470         |
| Potential primary | 38                    | 54         | 92          |
| Secondary         | 6                     | 4          | 10          |
| Saprophyte        | 3                     | 45         | 48          |
| Casual            | 10                    | 171        | 181         |
| Predator          | 59                    | 159        | 218         |
| Parasitoid        | 4                     | 10         | 14          |
| Unknown           | 2                     | 55         | 57          |
| <b>Total</b>      | <b>355</b>            | <b>735</b> | <b>1090</b> |

Primary and potential primary pests were collected by both methods; visual inspection of crop and beating. The large numbers noticed visually (233 for primary and 38 for potential primary) implies that the majority of pests were directly detected on host plants during the survey. The relationship between the pest and their host was very clear.

The presence of symptoms without any primary pest (31 samples) suggests that chemical treatments may have been applied.

A large number of casual organisms (171) were collected by beating indicating the occasional association between the organisms and the crop.



The majority of predator arthropods were collected by beating. The type of the predation was synchronized with the type of the primary pest on a specific crop, which indicates the relationship between pest-prey-crop.

Immature parasitoids were collected by visual inspection of primary pests. Rearing of the parasitoids was necessary in the laboratory for the identification. Adults of parasitoids were only collected by beating. The type of the parasitism was synchronized with the type of the primary pest on a specific crop, which also indicates the relationship between predator-prey and pest-crop.

The following primary organisms were regularly encountered during this survey:

#### **Acari:**

*Tetranychus urticae* (two spotted mite): 13 records, on leaves, on almond, peach, plum and cherry

*Panonychus ulmi* (European red mite): 4 records, on leaves, on almond, peach and plum

#### **Insecta:**

*Anarsia lineatella* (peach twig borer): 4 records, mostly on twigs, on almond, peach and apricot

*Assymetrasca decedens* (Cicadellidae): 58 records, mostly by beating (93 %), on all crops

*Brachycaudus helishrysi* (peach leaf curl aphid): 27 records, on twigs, on all crops

*Cerambyx dux* and *Cerambyx* sp. (long horn borer): 15 records, on branches, on all crops except apricot

*Frankliniella occidentalis* (western flower thrips): 14 records, mostly by beating (85 %), on all crops

*Monosteira unicastata* (almond lace bug): 30 records, mostly by beating, on all crops

*Myzus persicae* (green peach aphid): 18 records, mostly by beating, on all crops

*Parthenolecanium corni* (European fruit lecanium): 8 records, on twigs, on almond, cherry and plum

*Pseudaulacaspis pentagona* (white peach scale): 8 records, on twigs, on all crops except apricot

*Scolytus amygdali* (shothole borer): 21 records, mostly on branch, on all crops

*Scolytus rugulosus* (shothole borer): 11 records, mostly on branch, on all crops

*Thrips major* (European rubus thrips): 3 records, by beating, on almond, peach and plum

*Thrips tabaci* (onion thrips): 13 records, mostly by beating, on all crops

Overall, *Assymetrasca decedens* (Cicadellidae), *Brachycaudus helishrysi* (peach leaf curl aphid), *Monosteira unicastata* (almond lace bug) and *Scolytus amygdali* (shothole borer) occurred at the most sites and on all hosts during this survey.

There were 75 records new to Lebanon summarized in the following table.

**Summary of New to Lebanon Records**

| Crop         | Primary | Potential primary | Saprophyte | Casual | Predator | Unknown | Total |
|--------------|---------|-------------------|------------|--------|----------|---------|-------|
| Almond       | -       | 2                 | 7          | 7      | 3        | 1       | 20    |
| Apricot      | -       | -                 | 1          | 3      | 2        | 1       | 7     |
| Cherry       | -       | 1                 | -          | 7      | 3        | 2       | 13    |
| Peach        | -       | 2                 | 5          | 6      | 4        | 1       | 18    |
| Plum         | -       | 2                 | 3          | 6      | 5        | 1       | 17    |
| <b>Total</b> | 0       | 7                 | 15         | 30     | 17       | 8       | 75    |

No new primary pest was recorded on stone fruit during this survey. The 75 newly recorded organisms mentioned in the table above comprise 73 insects and 3 mites.

Six new species were records for the first time as potential primary pest on stone fruit. They are: *Agalmatium* sp. on peach, *Contarinia pruniflorum* on plum, *Rhabdorrhynchus anchusaes* on almond and plum, *Sibina phalerata* on cherry, *Spermophagus* sp. on almond and *Urophorus humeralis* on peach.

The 3 newly recorded mites, *Bdella* sp., *Trombidium* sp. and *Arctoseius haarlovi* are predators.

An interesting organism, which was recorded for the first time in Lebanon and found on all crop (17 records), is *Mycterothrips albidicornis* (Thripidae). The nature of the host-organism association is still unknown.

The most abundant saprophytic insects, which were encountered in all samples and on all crops, belonged to the order of Psocoptera (25 records). They are: *Ectopsocus* sp., *Graphopsocus cruciatus*, *Lachesilla* sp., *Mesopsocus unipunctatus*, *Trichopsocus dalii*, and *Valenzuela* sp.. These species are probably endemic in the region. No study has been done before in Lebanon.

Two primary pests were recorded as new host associations on stone fruit. They are: *Anthonomus cyprius* on almond and *Mercetaspis halli* on almond and plum.

Five species were new host association records on stone fruit. They are: *Aphis spiraeicola* on peach, *Brachycaudus cardui* on plum, *Ceroplastes rusci* on almond and *Coccus hesperidum* on apricot and plum and the snail *Helix aspersa* on peach.

**Table 5.1 Distribution of arthropods and gastropods on Almond (*Prunus amygdali*)**

| Arthropod and gastropod species | Order       | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|---------------------------------|-------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                 |             |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed            |             |               | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <b>Primary</b>                  |             |               |                   |    |    |    |    |    |    |       |
| <b>Acari</b>                    |             |               |                   |    |    |    |    |    |    |       |
| <i>Aceria phloeocoptes</i>      | Acariformes | Eriophyidae   |                   | 1  | 1  |    |    |    |    | 2     |
| <i>Brevipalpus phoenicis</i>    | Acariformes | Tenuipalpidae | 1                 |    |    |    |    |    |    | 1     |
| <i>Bryobia rubrioculus</i>      | Acariformes | Tetranychidae |                   |    | 1  |    |    |    |    | 1     |
| <i>Panonychus ulmi</i>          | Acariformes | Tetranychidae |                   | 1  | 1  |    |    | 1  |    | 3     |
| <i>Tetranychus urticae</i>      | Acariformes | Tetranychidae | 3                 | 3  |    |    |    |    |    | 6     |
| <b>Insecta</b>                  |             |               |                   |    |    |    |    |    |    |       |
| <i>Anarsia lineatella</i>       | Lepidoptera | Pyalidae      |                   | 2  |    |    |    |    |    | 2     |
| <i>Anthonomus cyprius</i>       | Coleoptera  | Curculionidae |                   | 1  |    |    |    | 1  |    | 2     |
| <i>Assymetrasca decedens</i>    | Homoptera   | Cicadellidae  |                   | 4  | 1  |    |    | 1  |    | 6     |
| <i>Brachycaudus helichrysi</i>  | Homoptera   | Aphididae     | 1                 | 11 | 1  |    |    | 1  |    | 14    |
| <i>Capnodis carbonaria</i>      | Coleoptera  | Buprestidae   |                   |    | 1  |    |    |    |    | 1     |
| <i>Cerambyx</i> sp.             | Coleoptera  | Cerambycidae  | 1                 |    |    |    | 1  | 1  | 1  | 4     |
| <i>Cydia molesta</i>            | Lepidoptera | Tortricidae   |                   |    |    | 1  |    |    |    | 1     |

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |               | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Ectomyelois ceratoniae</i>     | Lepidoptera  | Pyralidae     | 1                 | 1  |    | 1  |    |    |    | 3     |
| <i>Empoasca decipiens</i>         | Homoptera    | Cicadellidae  |                   | 2  |    |    |    |    |    | 2     |
| <i>Eurytoma amygdali</i>          | Hymenoptera  | Eurytomidae   | 5                 | 18 | 3  | 1  |    | 2  | 1  | 30    |
| <i>Frankliniella occidentalis</i> | Thysanoptera | Thripidae     |                   | 2  | 1  |    |    |    |    | 3     |
| <i>Hyalopterous amygdali</i>      | Homoptera    | Aphididae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Mercetaspis halli</i>          | Homoptera    | Diaspididae   |                   | 3  |    |    |    |    |    | 3     |
| <i>Monosteira unicostata</i>      | Homoptera    | Tingidae      | 3                 | 12 | 3  | 1  |    |    |    | 19    |
| <i>Myzus persicae</i>             | Homoptera    | Aphididae     |                   | 3  |    |    |    | 1  |    | 4     |
| <i>Odinadiplosis amygdali</i>     | Diptera      | Cecidomyiidae |                   | 2  |    |    |    |    |    | 2     |
| <i>Parthenolecanium corni</i>     | Homoptera    | Coccidae      |                   | 1  | 1  |    |    |    |    | 2     |
| <i>Parthenolecanium persicae</i>  | Homoptera    | Coccidae      | 1                 | 1  |    |    |    |    |    | 2     |
| <i>Pseudauleacapsis pentagona</i> | Homoptera    | Diaspididae   |                   | 3  |    |    |    |    |    | 3     |
| <i>Pterochloroides persicae</i>   | Homoptera    | Aphididae     |                   | 6  | 1  |    |    |    |    | 7     |
| <i>Scolytus amygdali</i>          | Coleoptera   | Scolytidae    | 4                 | 2  |    | 1  |    | 1  | 1  | 9     |
| <i>Scolytus rugulosus</i>         | Coleoptera   | Scolytidae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Sphaerolecanium prunastri</i>  | Homoptera    | Coccidae      |                   | 1  | 1  |    |    | 1  |    | 3     |
| <i>Taeniothrips inconsequence</i> | Thysanoptera | Thripidae     | 2                 |    |    |    | 1  | 1  |    | 4     |

| Arthropod and gastropod species  | Order        | Family        | Lebanon Districts |    |    |    |    |    |    |       |
|----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                  |              |               | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed             |              |               | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Thrips major</i>              | Thysanoptera | Thripidae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Thrips tabaci</i>             | Thysanoptera | Thripidae     |                   |    | 1  |    |    |    |    | 1     |
| Potential primary                |              |               |                   |    |    |    |    |    |    |       |
| Insecta                          |              |               |                   |    |    |    |    |    |    |       |
| <i>Agalmatium bilobium</i>       | Homoptera    | Fulgoroidae   |                   | 5  |    |    |    |    |    | 5     |
| <i>Aspidiotus nerii</i> ●        | Homoptera    | Diaspididae   |                   |    |    |    |    |    |    | 0     |
| <i>Bruchidius bimaculatus</i>    | Coleoptera   | Bruchidae     |                   |    | 1  |    |    |    |    | 1     |
| <i>Bruchidius seminarius</i>     | Coleoptera   | Bruchidae     | 1                 | 1  |    |    |    |    |    | 2     |
| <i>Ceroplastes rusci</i>         | Homoptera    | Coccidae      |                   | 1  |    |    |    |    |    | 1     |
| <i>Forficula auricularia</i>     | Dermaptera   | Forficulidae  | 1                 |    |    |    |    |    |    | 1     |
| <i>Guanchia pubescens</i>        | Dermaptera   | Forficulidae  | 2                 |    |    |    |    |    |    | 2     |
| <i>Hemiberlesia lataniae</i> ●   | Homoptera    | Diaspididae   | ●                 |    |    |    |    |    |    | 0     |
| <i>Hypothenemus aspericollis</i> | Coleoptera   | Scolytidae    |                   |    |    | 1  |    |    |    | 1     |
| <i>Lixus longispinus</i>         | Coleoptera   | Curculionidae |                   | 1  |    |    |    |    |    | 1     |
| <i>Lyonetia clerkella</i>        | Lepidoptera  | Lyonetiidae   | 1                 |    |    |    |    |    |    | 1     |
| <i>Myzus varians</i>             | Homoptera    | Aphididae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Parlatoria oleae</i>          | Homoptera    | Diaspididae   | 1                 |    |    |    |    |    |    | 1     |

| Arthropod and gastropod species       | Order        | Family          | Lebanon Districts |    |    |    |    |    |    | Total |
|---------------------------------------|--------------|-----------------|-------------------|----|----|----|----|----|----|-------|
|                                       |              |                 | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                  |              |                 | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Rhabdorrhynchus anchusae</i>       | Coleoptera   | Curculionidae   |                   | 1  |    |    |    |    |    | 1     |
| <i>Spermophagus</i> sp.               | Coleoptera   | Bruchidae       |                   |    | 1  |    |    |    |    | 1     |
| <i>Stephanitis pyri</i>               | Homoptera    | Tingidae        | 7                 |    |    |    |    |    |    | 7     |
| Saprophyte                            |              |                 |                   |    |    |    |    |    |    |       |
| Insecta                               |              |                 |                   |    |    |    |    |    |    |       |
| <i>Anthelephila ionica</i>            | Coleoptera   | Anthicidae      | 2                 |    |    |    |    |    |    | 2     |
| <i>Ectopsocus</i> sp.                 | Psocoptera   | Ectopsocidae    | 1                 | 1  |    |    |    |    |    | 2     |
| <i>Graphopsocus cruciatus</i>         | Psocoptera   | Stenopsocidae   |                   |    |    |    |    |    | 1  | 1     |
| Idolothripinae                        | Thysanoptera | Phlaeothripidae | 1                 |    |    |    |    |    |    | 1     |
| <i>Mesopsocus unipunctatus</i>        | Psocoptera   | Mesopsocidae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Trichopsocus dalii</i>             | Psocoptera   | Trichopsoidae   | 1                 |    |    |    |    |    |    | 1     |
| <i>Valenzuela</i> sp.                 | Psocoptera   | Caeciliusidae   |                   |    |    |    |    |    | 1  | 1     |
| Casual                                |              |                 |                   |    |    |    |    |    |    |       |
| Insecta                               |              |                 |                   |    |    |    |    |    |    |       |
| <i>Agrilus cuprescens chrysoderes</i> | Coleoptera   | Buprestidae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Aphis craccivora</i>               | Homoptera    | Aphididae       |                   | 1  |    |    |    |    |    | 1     |
| <i>Aphthona abdominalis</i>           | Coleoptera   | Curculionidae   |                   |    | 1  |    |    |    |    | 1     |

| Arthropod and gastropod species      | Order               | Family                 | Lebanon Districts |          |          |    |    |    |          | Total    |
|--------------------------------------|---------------------|------------------------|-------------------|----------|----------|----|----|----|----------|----------|
|                                      |                     |                        | AK                | BH       | BE       | ML | NA | NL | SL       |          |
| Total sites surveyed                 |                     |                        | 21                | 42       | 14       | 3  | 2  | 4  | 2        | 88       |
| <i>Aphthona</i> sp.                  | Coleoptera          | Curculionidae          |                   | 1        |          |    |    |    |          | 1        |
| <i>Araecerus fasciculatus</i>        | Coleoptera          | Anthribidae            |                   | 1        |          |    |    |    |          | 1        |
| <i>Cacopsylla myrthi</i>             | Homoptera           | Psyllidae              |                   | 1        |          |    |    |    |          | 1        |
| Chironomidae                         | Diptera             | Chironomidae           |                   | 1        |          |    |    |    |          | 1        |
| <i>Drosophila melanogaster</i>       | Diptera             | Drosophilidae          |                   | 1        |          |    |    |    |          | 1        |
| <i>Dryodurgades anatolicus</i>       | Homoptera           | Cicadellidae           |                   |          | 1        |    |    |    |          | 1        |
| <i>Epuraea</i> sp.                   | Coleoptera          | Nitidulidae            |                   | 1        |          |    |    |    |          | 1        |
| <i>Eurygaster maura</i>              | Heteroptera         | Pentanomidae           |                   | 1        |          |    |    |    |          | 1        |
| <i>Frutiodia bisignata</i>           | Homoptera           | Cicadellidae           |                   | 8        | 2        |    |    |    |          | 10       |
| <b><i>Haplothrips tritici</i></b>    | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> |                   |          | <b>1</b> |    |    |    |          | <b>1</b> |
| <i>Lygaeus equestris</i>             | Heteroptera         | Lygaeidae              |                   |          | 1        |    |    |    |          | 1        |
| <b><i>Malvapion malvae</i></b>       | <b>Coleoptera</b>   | <b>Apionidae</b>       |                   | <b>1</b> |          |    |    |    |          | <b>1</b> |
| <b><i>Melanophthalma rispini</i></b> | <b>Coleoptera</b>   | <b>Latridiidae</b>     | <b>1</b>          |          |          |    |    |    | <b>1</b> | <b>2</b> |
| <i>Microplax albofasciata</i>        | Heteroptera         | Lygaeidae              |                   | 1        |          |    |    |    |          | 1        |
| <i>Myzocallis</i> sp.                | Homoptera           | Aphididae              |                   |          |          |    |    |    | 1        | 1        |
| <b><i>Neoheegeria gigantea</i></b>   | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> | <b>1</b>          | <b>2</b> | <b>1</b> |    |    |    |          | <b>4</b> |
| <i>Oxycarenus hyalinipennis</i>      | Heteroptera         | Lygaeidae              |                   | 1        |          | 1  |    |    |          | 2        |

| Arthropod and gastropod species | Order          | Family        | Lebanon Districts |          |          |    |    |    |    | Total    |
|---------------------------------|----------------|---------------|-------------------|----------|----------|----|----|----|----|----------|
|                                 |                |               | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed            |                |               | 21                | 42       | 14       | 3  | 2  | 4  | 2  | 88       |
| <b><i>Oxythrips</i> sp.</b>     | Thysanoptera   | Thripidae     | <b>1</b>          |          |          |    |    |    |    | <b>1</b> |
| <b><i>Smicronyx</i> sp.</b>     | Coleoptera     | Curculionidae |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Thamnotettix seclusus</i>    | Homoptera      | Cicadellidae  |                   | 1        |          |    |    |    |    | 1        |
| <b><i>Thaumatomyia</i> sp.</b>  | Diptera        | Chloropidae   |                   | 1        |          |    |    |    |    | 1        |
| <i>Vespa orientalis</i>         | Hymenoptera    | Apidae        |                   | 1        |          |    |    |    |    | 1        |
| <i>Zygina flammigera</i>        | Homoptera      | Cicadellidae  | 1                 | 7        | 1        |    |    |    |    | 9        |
| <b>Predator</b>                 |                |               |                   |          |          |    |    |    |    |          |
| <b>Acari</b>                    |                |               |                   |          |          |    |    |    |    |          |
| <b><i>Bdella</i> sp.</b>        | Acariformes    | Bdellidae     |                   |          | <b>1</b> |    |    |    |    | <b>1</b> |
| <i>Typhlodromus pyri</i>        | Parasitiformes | Phytoseiidae  | 1                 |          |          |    |    |    |    | 1        |
| <b>Insecta</b>                  |                |               |                   |          |          |    |    |    |    |          |
| <i>Adalia decempunctata</i>     | Coleoptera     | Coccinellidae |                   |          |          |    |    | 1  |    | 1        |
| <b><i>Aeolothrips</i> sp.</b>   | Thysanoptera   | Aelothripidae |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Anthocoris</i> sp.           | Heteroptera    | Anthocoridae  |                   | 2        |          |    |    |    |    | 1        |
| <i>Aphidolette aphidimyza</i>   | Diptera        | Cecidomyiidae |                   | 1        |          |    |    |    |    | 1        |
| <i>Cantharis</i> sp.            | Coleoptera     | Cantharidae   |                   | 1        |          |    |    |    |    | 1        |
| <i>Chrysopa</i> sp.             | Neuroptera     | Chrysopidae   | 3                 | 6        | 1        |    |    | 1  |    | 11       |



| Arthropod and gastropod species  | Order              | Family          | Lebanon Districts |          |    |    |    |    |    | Total    |
|----------------------------------|--------------------|-----------------|-------------------|----------|----|----|----|----|----|----------|
|                                  |                    |                 | AK                | BH       | BE | ML | NA | NL | SL |          |
| Total sites surveyed             |                    |                 | 21                | 42       | 14 | 3  | 2  | 4  | 2  | 88       |
| <i>Coccinella septumpunctata</i> | Coleoptera         | Coccinellidae   |                   |          | 1  |    |    |    |    | 1        |
| Coccinellidae                    | Coleoptera         | Coccinellidae   |                   | 3        | 1  |    |    |    |    | 4        |
| <i>Epysyrphus balteatus</i>      | Diptera            | Syrphidae       | 1                 |          |    |    |    | 1  |    | 2        |
| <i>Geocoris erythrocephalus</i>  | Heteroptera        | Anthocoridae    |                   | 3        |    |    |    |    |    | 3        |
| <i>Gynaikothrips ficorum</i>     | Thysanoptera       | Phlaeothripinae |                   | 1        |    |    |    |    |    | 1        |
| <i>Hypodamia variegata</i>       | Coleoptera         | Coccinellidae   |                   | 3        | 1  |    |    |    |    | 4        |
| <i>Leucopis</i> sp.              | Diptera            | Chamaemyiidae   |                   | 3        |    |    |    |    |    | 3        |
| <b><i>Monalocoris</i> sp.</b>    | <b>Heteroptera</b> | <b>Miridae</b>  |                   | <b>2</b> |    |    |    |    |    | <b>2</b> |
| <i>Oenopia conglobata</i>        | Coleoptera         | Coccinellidae   |                   | 4        |    |    |    |    |    | 4        |
| <i>Orius albidipennis</i>        | Coleoptera         | Miridae         |                   | 1        |    |    |    |    |    | 1        |
| <i>Rhagonycha fulva</i>          | Coleoptera         | Cantharidae     |                   | 1        |    |    |    |    |    | 1        |
| <i>Scymnus apetizi</i>           | Coleoptera         | Coccinellidae   |                   | 1        |    |    |    |    |    | 1        |
| <i>Scymnus bipunctatus</i>       | Coleoptera         | Coccinellidae   |                   | 1        |    |    |    |    |    | 1        |
| <i>Scymnus frontalis</i>         | Coleoptera         | Coccinellidae   | 1                 |          |    |    |    |    |    | 1        |
| <i>Scymnus</i> sp.               | Coleoptera         | Coccinellidae   | 3                 | 4        |    |    |    |    |    | 7        |
| <i>Scymnus subvillosus</i>       | Coleoptera         | Coccinellidae   | 1                 | 1        | 1  |    |    |    |    | 3        |
| <i>Scymnus suturalis</i>         | Coleoptera         | Coccinellidae   |                   | 2        |    |    |    |    |    | 2        |

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    |       |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed              |              |               | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Stethorus gilviformis</i>      | Coleoptera   | Coccinellidae | 3                 | 3  |    |    |    |    |    | 6     |
| <i>Zicrona caerulea</i>           | Coleoptera   | Curculionidae |                   | 1  |    |    |    |    |    | 1     |
| Parasitoid                        |              |               |                   |    |    |    |    |    |    |       |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Ephedrus persicae</i>          | Hymenoptera  | Braconidae    |                   | 4  |    |    |    |    |    | 4     |
| <i>Leptomastix</i> sp.            | Hymenoptera  | Chalcidoidea  |                   | 1  |    |    |    |    |    | 1     |
| Unknown                           |              |               |                   |    |    |    |    |    |    |       |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Hypera postica</i>             | Coleoptera   | Curculionidae |                   | 1  |    |    |    |    |    | 1     |
| Cixiidae                          | Homoptera    | Cixiidae      |                   | 1  |    |    |    |    |    | 1     |
| <i>Mycterothrips albidicornis</i> | Thysanoptera | Thripidae     | 1                 | 2  |    |    |    |    |    | 3     |

|   |   |          |                     |    |   |
|---|---|----------|---------------------|----|---|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 5.2 Distribution of arthropods and gastropods on Apricot (*Prunus armeniaca*)**

| Arthropod and gastropod species   | Order        | Family       | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|--------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |              | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |              | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 51    |
| Primary                           |              |              |                   |    |    |    |    |    |    |       |
| Insecta                           |              |              |                   |    |    |    |    |    |    |       |
| <i>Anarsia lineatella</i>         | Lepidoptera  | Pyralidae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Assymetrasca decedens</i>      | Homoptera    | Cicadellidae |                   | 2  |    |    |    |    |    | 2     |
| <i>Brachycaudus helishrysi</i>    | Homoptera    | Aphididae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Ceratitis Capitata</i>         | Diptera      | Tephrididae  |                   | 1  |    | 1  |    | 1  |    | 3     |
| <i>Empoasca decipiens</i>         | Homoptera    | Cicadellidae |                   | 1  |    |    |    |    |    | 1     |
| <i>Frankliniella occidentalis</i> | Thysanoptera | Thripidae    |                   | 2  |    |    |    |    |    | 2     |
| <i>Hyalopterous amygdali</i>      | Homoptera    | Aphididae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Monosteira unicastata</i>      | Homoptera    | Tingidae     |                   | 4  |    |    |    |    |    | 4     |
| <i>Myzus persicae</i>             | Homoptera    | Aphididae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Parthenolecanium corni</i>     | Homoptera    | Coccidae     |                   | 3  |    |    |    |    |    | 3     |
| <i>Psaulaulacaspis pentagona</i>  | Homoptera    | Diaspididae  |                   | 2  |    |    |    |    |    | 2     |
| <i>Scolytus amygdali</i>          | Coleoptera   | Scolytidae   |                   | 1  |    |    |    |    |    | 1     |
| <i>Scolytus rugulosus</i>         | Coleoptera   | Scolytidae   |                   | 3  |    |    |    |    |    | 3     |
| <i>Thrips tabaci</i>              | Thysanoptera | Thripidae    |                   | 2  |    |    |    |    |    | 2     |

| Arthropod and gastropod species       | Order             | Family               | Lebanon Districts |    |    |    |    |    |    | Total    |
|---------------------------------------|-------------------|----------------------|-------------------|----|----|----|----|----|----|----------|
|                                       |                   |                      | AK                | BH | BE | ML | NA | NL | SL |          |
| Total sites surveyed                  |                   |                      | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 51       |
| <b>Potential primary</b>              |                   |                      |                   |    |    |    |    |    |    |          |
| <b>Insecta</b>                        |                   |                      |                   |    |    |    |    |    |    |          |
| <i>Coccus hesperidum</i>              | Homoptera         | Coccidae             |                   |    |    |    | 1  |    |    | 1        |
| <i>Lixus anguinus</i>                 | Coleoptera        | Curculionidae        |                   | 1  |    |    |    |    |    | 1        |
| <i>Lixus angustatus</i>               | Coleoptera        | Curculionidae        |                   | 1  |    |    |    |    |    | 1        |
| <i>Mercetaspis halli</i> •            | Homoptera         | Diaspididae          |                   |    |    |    |    | •  |    | 0        |
| <i>Stephanitis pyri</i>               | Homoptera         | Tingidae             |                   | 1  |    |    |    |    |    | 1        |
| <b>Saprophyte</b>                     |                   |                      |                   |    |    |    |    |    |    |          |
| <b>Insecta</b>                        |                   |                      |                   |    |    |    |    |    |    |          |
| <i>Corticaria</i> sp.                 | Coleoptera        | Corticariidae        |                   | 1  |    |    |    |    |    | 1        |
| <b><i>Lachesilla</i> sp.</b>          | <b>Psocoptera</b> | <b>Lachesillidae</b> | <b>1</b>          |    |    |    |    |    |    | <b>1</b> |
| <b>Secondary</b>                      |                   |                      |                   |    |    |    |    |    |    |          |
| <b>Insecta</b>                        |                   |                      |                   |    |    |    |    |    |    |          |
| <i>Drosophila melanogaster</i>        | Diptera           | Drosophilidae        |                   | 1  |    |    |    |    |    | 1        |
| <b>Casual</b>                         |                   |                      |                   |    |    |    |    |    |    |          |
| <b>Insecta</b>                        |                   |                      |                   |    |    |    |    |    |    |          |
| <i>Agrilus cuprescens chrysoderes</i> | Coleoptera        | Buprestidae          |                   | 1  |    |    |    |    |    | 1        |

| Arthropod and gastropod species       | Order               | Family                 | Lebanon Districts |          |    |    |    |          |    | Total    |
|---------------------------------------|---------------------|------------------------|-------------------|----------|----|----|----|----------|----|----------|
|                                       |                     |                        | AK                | BH       | BE | ML | NA | NL       | SL |          |
| Total sites surveyed                  |                     |                        | 1                 | 45       | 1  | 0  | 1  | 3        | 0  | 51       |
| <i>Cacopsylla myrthi</i>              | Homoptera           | Psyllidae              |                   | 2        |    |    |    |          |    | 2        |
| <i>Cloeon dipterum</i>                | Ephemeropte         | Baetidae               |                   | 1        |    |    |    |          |    | 1        |
| <i>Frutoidia bisignata</i>            | Homoptera           | Cicadellidae           |                   | 4        |    |    |    |          |    | 4        |
| <b><i>Haplothrips cerealis</i></b>    | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> |                   |          |    |    |    | <b>1</b> |    | <b>1</b> |
| <i>Homotoma ficus</i>                 | Homoptera           | Homotomidae            |                   | 1        |    |    |    |          |    | 1        |
| <i>Guanchia brignolii</i>             | Dermaptera          | Forficulidae           | 1                 |          |    |    |    |          |    | 1        |
| <b><i>Neoheegeria dalmatica</i></b>   | <b>Thysanoptera</b> | <b>Phlaeothripinae</b> |                   | <b>1</b> |    |    |    |          |    | <b>1</b> |
| <b><i>Nysius sp.</i></b>              | <b>Heteroptera</b>  | <b>Lygaeidae</b>       |                   | <b>1</b> |    |    |    |          |    | <b>1</b> |
| <i>Zygina flammigera</i>              | Homoptera           | Cicadellidae           |                   | 10       |    |    |    |          |    | 10       |
| <b>Predator</b>                       |                     |                        |                   |          |    |    |    |          |    |          |
| <b>Insecta</b>                        |                     |                        |                   |          |    |    |    |          |    |          |
| <b><i>Aeolothrips intermedius</i></b> | <b>Thysanoptera</b> | <b>Aelothripidae</b>   |                   | <b>1</b> |    |    |    |          |    | <b>1</b> |
| <i>Chrysopa sp.</i>                   | Nervoptera          | Chrysopidae            |                   | 5        |    |    |    |          |    | 5        |
| Hemerobiidae                          | Neuroptera          | Hemerobiidae           | 1                 |          |    |    |    |          |    | 1        |
| <b><i>Monalocoris sp.</i></b>         | <b>Heteroptera</b>  | <b>Miridae</b>         |                   | <b>1</b> |    |    |    |          |    | <b>1</b> |
| <i>Oenopia conglobata</i>             | Coleoptera          | Coccinellidae          |                   | 2        |    |    |    |          |    | 2        |
| <i>Scymnus sp.</i>                    | Coleoptera          | Coccinellidae          |                   | 2        |    |    |    |          |    | 2        |

| Arthropod and gastropod species | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|---------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                 |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed            |              |               | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 51    |
| <i>Stethorus gilviformis</i>    | Coleoptera   | Coccinellidae |                   | 1  |    |    |    |    |    | 1     |
| Unknown                         |              |               |                   |    |    |    |    |    |    |       |
| Insecta                         |              |               |                   |    |    |    |    |    |    |       |
| <i>Neohydatothrips abnormis</i> | Thysanoptera | Thripidae     |                   | 1  |    |    |    |    |    | 1     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 5.3 Distribution of arthropods and gastropods on Cherry (*Prunus avium*)**

| Arthropod and gastropod species   | Order        | Family         | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|----------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |                | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |                | 1                 | 32 | 13 | 3  | 1  | 1  | 0  | 51    |
| <b>Primary</b>                    |              |                |                   |    |    |    |    |    |    |       |
| <b>Acari</b>                      |              |                |                   |    |    |    |    |    |    |       |
| <i>Tetranychus urticae</i> ●      | Acariformes  | Tetranychidae  |                   |    |    |    |    |    |    | 0     |
| <b>Insecta</b>                    |              |                |                   |    |    |    |    |    |    |       |
| <i>Assymetrasca decedens</i>      | Homoptera    | Cicadellidae   | 1                 | 4  | 3  | 1  |    |    |    | 9     |
| <i>Brachycaudus helishrysi</i>    | Homoptera    | Aphididae      |                   | 1  |    |    |    |    |    | 1     |
| <i>Calioroa cerasi</i>            | Hymenoptera  | Tenthredinidae |                   | 1  |    |    |    |    |    | 1     |
| <i>Capnodis</i> sp.               | Coleoptera   | Buprestidae    |                   | 1  | 1  |    |    |    |    | 2     |
| <i>Cerambyx</i> sp.               | Coleoptera   | Cerambycidae   |                   | 2  | 1  |    | 1  |    |    | 4     |
| <i>Diaspidiotus perniciosus</i>   | Homoptera    | Diaspididae    |                   | 1  |    |    |    |    |    | 1     |
| <i>Empoasca decipiens</i>         | Homoptera    | Cicadellidae   |                   | 4  |    |    |    |    |    | 4     |
| <i>Frankliniella occidentalis</i> | Thysanoptera | Thripidae      |                   |    |    | 1  |    |    |    | 1     |
| <i>Hyalopterous pruni</i>         | Homoptera    | Aphididae      |                   | 1  |    |    |    |    |    | 1     |
| <i>Monosteira unicastata</i>      | Homoptera    | Tingidae       |                   | 2  | 1  |    |    |    |    | 3     |
| <i>Myzus persicae</i>             | Homoptera    | Aphididae      |                   | 1  |    | 1  |    |    |    | 2     |
| <i>Parthenolecanium corni</i>     | Homoptera    | Coccidae       |                   | 1  |    |    |    |    |    | 1     |

| Arthropod and gastropod species  | Order             | Family               | Lebanon Districts |          |    |    |    |    |    | Total    |
|----------------------------------|-------------------|----------------------|-------------------|----------|----|----|----|----|----|----------|
|                                  |                   |                      | AK                | BH       | BE | ML | NA | NL | SL |          |
| Total sites surveyed             |                   |                      | 1                 | 32       | 13 | 3  | 1  | 1  | 0  | 51       |
| <i>Perotis chlorana</i>          | Coleoptera        | Buprestidae          |                   |          | 1  |    |    |    |    | 1        |
| <i>Psaudaulacaspis pentagona</i> | Homoptera         | Diaspididae          |                   | 1        | 1  |    |    |    |    | 2        |
| <i>Recurvaria nanella</i>        | Lepidoptera       | Gelechiidae          |                   |          | 1  |    |    |    |    | 1        |
| <i>Scolytus</i> sp.              | Coleoptera        | Scolytidae           |                   | 1        |    |    |    |    |    | 1        |
| <i>Scolytus amygdali</i>         | Coleoptera        | Scolytidae           |                   | 3        | 1  |    |    |    |    | 4        |
| <i>Scolytus rugulosus</i>        | Coleoptera        | Scolytidae           |                   | 2        | 1  |    | 1  |    |    | 4        |
| <i>Thrips tabaci</i>             | Thysanoptera      | Thripidae            |                   | 4        |    |    |    |    |    | 4        |
| <i>Zeuzera pyrina</i>            | Lepidoptera       | Cossidae             |                   |          | 1  |    |    |    |    | 1        |
| <b>Potential Primary</b>         |                   |                      |                   |          |    |    |    |    |    |          |
| <b>Insecta</b>                   |                   |                      |                   |          |    |    |    |    |    |          |
| <i>Agalmatium bilobium</i>       | Homoptera         | Fulgoroidae          |                   | 1        |    |    |    |    |    | 1        |
| <i>Forficula auricularia</i>     | Dermaptera        | Forficulidae         |                   | 1        |    |    |    |    |    | 1        |
| <i>Lygaeus pandurus</i>          | Heteroptera       | Lygaeidae            |                   | 1        |    |    |    |    |    | 1        |
| <i>Lyonetia clerkella</i>        | Lepidoptera       | Lyonetiidae          |                   | 2        | 1  |    |    |    |    | 3        |
| <b><i>Sibinia phalerata</i></b>  | <b>Coleoptera</b> | <b>Curculionidae</b> |                   | <b>1</b> |    |    |    |    |    | <b>1</b> |
| <i>Sinoxylon sexdentatum</i>     | Coleoptera        | Bostrichidae         |                   | 1        |    |    |    |    |    | 1        |
| <i>Stephanitis pyri</i>          | Homoptera         | Tingidae             | 1                 | 1        |    |    |    |    |    | 2        |



| Arthropod and gastropod species    | Order               | Family                 | Lebanon Districts |          |          |    |    |    |    | Total    |
|------------------------------------|---------------------|------------------------|-------------------|----------|----------|----|----|----|----|----------|
|                                    |                     |                        | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed               |                     |                        | 1                 | 32       | 13       | 3  | 1  | 1  | 0  | 51       |
| <i>Vespa orientalis</i>            | Hymenoptera         | Apoidae                |                   | 1        |          |    |    |    |    | 1        |
| <b>Saprophyte</b>                  |                     |                        |                   |          |          |    |    |    |    |          |
| <b>Insecta</b>                     |                     |                        |                   |          |          |    |    |    |    |          |
| <i>Corticaria</i> sp.              | Coleoptera          | Corticariidae          |                   | 1        |          |    |    |    |    | 1        |
| <i>Melanophthalma</i> sp.          | Coleoptera          | Latridiidae            |                   |          | 1        |    |    |    |    | 1        |
| <b>Casual</b>                      |                     |                        |                   |          |          |    |    |    |    |          |
| <b>Insecta</b>                     |                     |                        |                   |          |          |    |    |    |    |          |
| <b><i>Aphthona flaviceps</i></b>   | <b>Coleoptera</b>   | <b>Curculionidae</b>   |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Aphthona</i> sp.                | Coleoptera          | Curculionidae          |                   |          | 1        |    |    |    |    | 1        |
| <i>Cacopsylla myrthi</i>           | Homoptera           | Psyllidae              |                   | 4        |          |    |    |    |    | 4        |
| Chironomidae                       | Diptera             | Chironomidae           |                   | 2        | 1        |    |    |    |    | 3        |
| <b>Chloropidae</b>                 | <b>Diptera</b>      | <b>Chloropidae</b>     |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Chromaphis juglandicola</i>     | Homoptera           | Aphididae              |                   | 1        |          |    |    |    |    | 1        |
| <i>Ficocyba ficaria</i>            | Homoptera           | Cicadellidae           |                   | 1        |          |    |    |    |    | 1        |
| <i>Fruticoidia bisignata</i>       | Homoptera           | Cicadellidae           |                   | 9        | 2        |    | 1  |    |    | 12       |
| <i>Macropsinae</i> sp.             | Homoptera           | Cicadellidae           |                   | 1        |          |    |    |    |    | 1        |
| <b><i>Neoheegeria gigantea</i></b> | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> |                   | <b>1</b> | <b>1</b> |    |    |    |    | <b>2</b> |

| Arthropod and gastropod species     | Order                 | Family                 | Lebanon Districts |          |    |          |    |    |    | Total    |
|-------------------------------------|-----------------------|------------------------|-------------------|----------|----|----------|----|----|----|----------|
|                                     |                       |                        | AK                | BH       | BE | ML       | NA | NL | SL |          |
| Total sites surveyed                |                       |                        | 1                 | 32       | 13 | 3        | 1  | 1  | 0  | 51       |
| <i>Platymetopius</i> sp.            | Homoptera             | Cicadellidae           |                   | 1        |    |          |    |    |    | 1        |
| <b><i>Smicronyx</i> sp.</b>         | <b>Coleoptera</b>     | <b>Curculionidae</b>   |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <b><i>Taeniapion rufescens</i></b>  | <b>Coleoptera</b>     | <b>Apionidae</b>       |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <b><i>Tephritis postica</i></b>     | <b>Diptera</b>        | <b>Tephritidae</b>     |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <b><i>Tychius medicaginis</i></b>   | <b>Coleoptera</b>     | <b>Curculionidae</b>   |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <i>Zygina flammigera</i>            | Homoptera             | Cicadellidae           |                   | 11       | 1  |          |    | 1  |    | 13       |
| <b>Predator</b>                     |                       |                        |                   |          |    |          |    |    |    |          |
| <b>Acari</b>                        |                       |                        |                   |          |    |          |    |    |    |          |
| <b><i>Arctoseius haarlovi</i></b>   | <b>Parasitiformes</b> | <b>Ascidae</b>         |                   |          |    | <b>1</b> |    |    |    | <b>1</b> |
| <b>Insecta</b>                      |                       |                        |                   |          |    |          |    |    |    |          |
| <i>Anthocoris nemoralis</i>         | Heteroptera           | Anthocoridae           |                   | 1        |    |          |    |    |    | 1        |
| <b><i>Cantharis</i> sp.</b>         | <b>Coleoptera</b>     | <b>Cantharidae</b>     |                   |          |    | <b>1</b> |    |    |    | <b>1</b> |
| <i>Chrysopa</i> sp.                 | Neuroptera            | Chrysopidae            |                   | 9        |    | 1        | 1  | 1  |    | 12       |
| Coccinellidae                       | Coleoptera            | Coccinellidae          |                   | 1        | 1  |          |    |    |    | 2        |
| <i>Conwentzia</i> sp.               | Neuroptera            | Coniopterygidae        |                   | 1        |    | 1        |    |    |    | 2        |
| <b><i>Karnyothrips flavipes</i></b> | <b>Thysanoptera</b>   | <b>Phlaeothripinae</b> |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <i>Malthinus rufifrons</i>          | Coleoptera            | Cantharidae            |                   | 1        |    |          |    |    |    | 1        |

| Arthropod and gastropod species          | Order               | Family                 | Lebanon Districts |          |          |    |    |    |    | Total    |
|--|---------------------|------------------------|-------------------|----------|----------|----|----|----|----|----------|
|  |                     |                        | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed                     |                     |                        | 1                 | 32       | 13       | 3  | 1  | 1  | 0  | 51       |
| <i>Manthis religiosa</i>                 | Mantodae            | Manthidae              |                   | 1        |          |    |    |    |    | 1        |
| <i>Nebria hemprichi</i>                  | Coleoptera          | Carabidae              |                   |          | 1        |    |    |    |    | 1        |
| <i>Oenopia conglobata</i>                | Coleoptera          | Coccinellidae          |                   | 2        |          |    |    |    |    | 2        |
| <i>Rhagonycha fulva</i>                  | Coleoptera          | Cantharidae            |                   | 2        |          |    |    |    |    | 2        |
| <i>Rhagonycha lignosa</i>                | Coleoptera          | Cantharidae            |                   |          |          | 1  |    |    |    | 1        |
| <b><i>Scolothrips</i> sp.</b>            | <b>Thysanoptera</b> | <b>Thripidae</b>       |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Scymnus</i> sp.                       | Coleoptera          | Coccinellidae          |                   | 1        |          |    | 1  |    |    | 2        |
| <i>Stethorus gilvifrons</i>              | Coleoptera          | Coccinellidae          |                   | 1        |          |    |    |    |    | 1        |
| <b>Parasitoid</b>                        |                     |                        |                   |          |          |    |    |    |    |          |
| <b>Insecta</b>                           |                     |                        |                   |          |          |    |    |    |    |          |
| <i>Microterys</i> sp.                    | Hymenoptera         | Chalcidoidae           |                   |          | 1        |    |    |    |    | 1        |
| <b>Unknown</b>                           |                     |                        |                   |          |          |    |    |    |    |          |
| <b>Insecta</b>                           |                     |                        |                   |          |          |    |    |    |    |          |
| <b><i>Haplothrips</i> sp.</b>            | <b>Thysanoptera</b> | <b>Phlaeothripinae</b> |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <b><i>Mycterothrips albidicornis</i></b> | <b>Thysanoptera</b> | <b>Thripidae</b>       |                   | <b>1</b> | <b>1</b> |    |    |    |    | <b>2</b> |
| <i>Squamapion phocopus</i>               | Coleoptera          | Apionidae              |                   |          | 1        |    |    |    |    | 1        |

|   |   |          |                     |    |   |
|---|---|----------|---------------------|----|---|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon |    |   |

Lebanon districts: **AK**: Akkar, **BH**: Baalbeck – Hermel, **BE**: Bekaa, **ML**: Mount Lebanon, **NA**: Nabatiyeh, **NL**: North Lebanon, **SL**: South Lebanon

**Table 5.4 Distribution of arthropods and gastropods on Peach (*Prunus persica*)**

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |               | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| Primary                           |              |               |                   |    |    |    |    |    |    |       |
| Acari                             |              |               |                   |    |    |    |    |    |    |       |
| <i>Bryobia preatiosa</i>          | Acariformes  | Tetranychidae | 1                 |    |    |    |    |    |    | 1     |
| <i>Panonychus ulmi</i>            | Acariformes  | Tetranychidae |                   |    |    | 1  |    |    |    | 1     |
| <i>Tetranychus urticae</i>        | Acariformes  | Tetranychidae | 2                 |    |    |    |    |    |    | 2     |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Anarsia lineatella</i>         | Lepidoptera  | Pyralidae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Assymetrasca decedens</i>      | Homoptera    | Cicadellidae  | 3                 | 7  | 6  | 4  | 1  | 8  | 3  | 32    |
| <i>Brachycaudus helichrysi</i>    | Homoptera    | Aphididae     | 1                 | 6  |    |    |    |    |    | 7     |
| <i>Capnodis tenebrionis</i>       | Coleoptera   | Buprestidae   |                   | 2  |    |    |    |    |    | 2     |
| <i>Cerambyx dux</i>               | Coleoptera   | Cerambycidae  |                   | 1  |    |    |    |    |    | 1     |
| <i>Cerambyx</i> sp.               | Coleoptera   | Cerambycidae  |                   |    |    | 1  |    |    |    | 1     |
| <i>Ceratitis capitata</i>         | Diptera      | Tephrididae   | 1                 | 3  | 1  | 2  |    | 2  |    | 9     |
| <i>Diaspidiotus perniciosus</i>   | Homoptera    | Diaspididae   | 2                 |    |    |    |    |    |    | 2     |
| <i>Empoasca decipiens</i>         | Homoptera    | Cicadellidae  |                   |    |    | 1  |    |    |    | 1     |
| <i>Frankliniella occidentalis</i> | Thysanoptera | Thripidae     |                   | 1  |    | 3  | 1  | 2  |    | 7     |

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |               | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| <i>Guanchia pubescens</i>         | Dermaptera   | Forficulidae  |                   |    |    | 1  |    | 1  |    | 2     |
| <i>Hyalopterous amygdali</i>      | Homoptera    | Aphididae     |                   |    | 1  | 1  |    |    |    | 2     |
| <i>Monosteira unicastata</i>      | Homoptera    | Tingidae      |                   | 2  |    |    |    |    |    | 2     |
| <i>Mysus persicae</i>             | Homoptera    | Aphididae     | 1                 | 3  | 3  | 2  | 1  |    |    | 10    |
| <i>Philaenus spumarius</i>        | Homoptera    | Aphrophoridae |                   |    |    |    |    | 1  |    | 1     |
| <i>Psaudaulacaspis pentagona</i>  | Homoptera    | Diaspididae   | 1                 |    |    |    |    |    |    | 1     |
| <i>Pterochloroides persicae</i>   | Homoptera    | Aphididae     |                   |    |    |    | 2  |    |    | 2     |
| <i>Scolytus</i> sp.               | Coleoptera   | Scolytidae    |                   |    |    | 1  |    | 1  |    | 2     |
| <i>Scolytus amygdali</i>          | Coleoptera   | Scolytidae    | 1                 | 2  |    |    |    | 1  |    | 4     |
| <i>Scolytus rugulosus</i>         | Coleoptera   | Scolytidae    | 1                 |    |    |    |    |    |    | 1     |
| <i>Taeniothrips inconsequence</i> | Thysanoptera | Thripidae     | 1                 |    |    |    |    |    |    | 1     |
| <i>Taeniothrips meridionalis</i>  | Thysanoptera | Thripidae     |                   | 1  |    |    |    |    |    | 1     |
| <i>Thrips imaginis</i>            | Thysanoptera | Thripidae     |                   |    |    | 1  |    |    |    | 1     |
| <i>Thrips major</i>               | Thysanoptera | Thripidae     | 1                 |    |    |    |    |    |    | 1     |
| <i>Thrips tabaci</i>              | Thysanoptera | Thripidae     |                   | 1  | 1  | 1  | 1  |    |    | 4     |

| Arthropod and gastropod species | Order           | Family        | Lebanon Districts |    |    |    |    |    |    |       |
|---------------------------------|-----------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                 |                 |               | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed            |                 |               | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| Potential Primary               |                 |               |                   |    |    |    |    |    |    |       |
| Insecta                         |                 |               |                   |    |    |    |    |    |    |       |
| Agalmatium sp.                  | Homoptera       | Fulgoroidae   |                   |    |    | 1  |    |    |    | 1     |
| Aphis spiraecola                | Homoptera       | Aphididae     |                   |    |    |    | 2  |    |    | 2     |
| Lixus angustatus                | Coleoptera      | Curculionidae |                   | 2  |    |    | 1  |    |    | 3     |
| Lyonetia clerkella              | Lepidoptera     | Lyonetiidae   |                   |    |    | 1  |    | 1  |    | 2     |
| Macrosiphum euphorbiae          | Homoptera       | Aphididae     |                   | 1  | 1  |    |    |    |    | 2     |
| Palomena prasina                | Heteroptera     | Pentanomidae  |                   |    |    |    |    | 1  |    | 1     |
| Stephanitis pyri                | Homoptera       | Tingidae      | 1                 |    |    |    |    | 3  |    | 4     |
| Urophorus humeralis             | Coleoptera      | Nitidulidae   |                   |    | 1  |    |    |    |    | 1     |
| Gastropoda                      |                 |               |                   |    |    |    |    |    |    |       |
| Helix aspersa                   | Stylommatophora | Helicidae     |                   | 1  |    |    |    |    |    | 1     |
| Secondary                       |                 |               |                   |    |    |    |    |    |    |       |
| Insecta                         |                 |               |                   |    |    |    |    |    |    |       |
| Carpophilus hemipterus          | Coleoptera      | Nitidulidae   | 1                 | 1  |    |    |    |    |    | 2     |
| Drosophila melanogaster         | Diptera         | Drosophilidae |                   | 2  |    | 1  |    |    |    | 3     |

| Arthropod and gastropod species | Order      | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|---------------------------------|------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                 |            |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed            |            |               | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| Saprophyte                      |            |               |                   |    |    |    |    |    |    |       |
| Insecta                         |            |               |                   |    |    |    |    |    |    |       |
| Anthelephila ionica             | Coleoptera | Anthicidae    | 1                 |    |    |    |    |    |    | 1     |
| Bruchidius sp.                  | Coleoptera | Bruchidae     |                   |    |    |    | 1  |    |    | 1     |
| Ectopsocus sp.                  | Psocoptera | Ectopsocidae  | 2                 |    |    | 1  |    | 1  | 2  | 6     |
| Epuraea sp.                     | Coleoptera | Nitidulidae   | 1                 |    |    |    |    |    |    | 1     |
| Lachesilla sp.                  | Psocoptera | Ectopsocidae  |                   |    | 1  |    |    | 1  |    | 2     |
| Longitarsus pellucidus          | Coleoptera | Nitidulidae   |                   | 1  |    |    | 1  |    |    | 2     |
| Melanophthalma rispini          | Coleoptera | Latridiidae   |                   |    |    | 1  | 1  | 1  |    | 3     |
| Melanophthalma sp.              | Coleoptera | Latridiidae   | 1                 |    |    |    |    |    | 1  | 2     |
| Staphylinidae                   | Coleoptera | Staphylinidae | 1                 |    |    |    |    |    |    | 1     |
| Trichopsocus dalii              | Psocoptera | Trichopsoidae |                   |    |    | 1  |    |    |    | 1     |
| Casual                          |            |               |                   |    |    |    |    |    |    |       |
| Insecta                         |            |               |                   |    |    |    |    |    |    |       |
| Apion frumentarium              | Coleoptera | Curculionidae |                   |    |    |    |    | 1  |    | 1     |
| Anaceratagallia laevis          | Homoptera  | Cicadellidae  |                   |    |    |    |    | 1  |    | 1     |
| Anacridium aegyptium            | Orthoptera | Acrididae     |                   |    | 1  |    |    |    |    | 1     |

| Arthropod and gastropod species       | Order               | Family                 | Lebanon Districts |    |    |          |          |    |    | Total    |
|---------------------------------------|---------------------|------------------------|-------------------|----|----|----------|----------|----|----|----------|
|                                       |                     |                        | AK                | BH | BE | ML       | NA       | NL | SL |          |
| Total sites surveyed                  |                     |                        | 11                | 27 | 20 | 18       | 8        | 12 | 4  | 100      |
| <i>Aphis gossypii</i>                 | Homoptera           | Aphididae              |                   |    | 1  |          |          |    |    | 1        |
| <i>Aphthona</i> sp.                   | Coleoptera          | Curculionidae          | 1                 |    |    |          |          |    |    | 1        |
| <i>Cacopsylla bidens</i>              | Homoptera           | Psyllidae              |                   |    | 1  | 1        |          |    |    | 2        |
| <i>Cacopsylla myrthi</i>              | Homoptera           | Psyllidae              |                   | 2  |    | 1        |          | 2  |    | 5        |
| Chironomidae                          | Diptera             | Chironomidae           |                   | 1  |    | 1        |          |    |    | 2        |
| <b><i>Chlorops</i> sp.</b>            | <b>Diptera</b>      | <b>Chloropidae</b>     |                   |    |    |          | <b>1</b> |    |    | <b>1</b> |
| <i>Chromaphis juglandicola</i>        | Homoptera           | Aphididae              |                   |    |    | 1        |          |    |    | 1        |
| <i>Cryptocephalus dahdah</i>          | Coleoptera          | Chrysomelidae          | 1                 |    |    | 1        |          |    |    | 2        |
| <i>Eurydema ornata</i>                | Heteroptera         | Pentatomidae           |                   |    |    |          | 1        |    |    | 1        |
| <i>Fruticoidia bisignata</i>          | Homoptera           | Cicadellidae           |                   | 2  | 2  | 1        |          |    |    | 5        |
| <i>Homotoma ficus</i>                 | Homoptera           | Homotomidae            |                   |    |    |          |          | 1  |    | 1        |
| <i>Lasius</i> sp.                     | Hymenoptera         | Formicidae             |                   |    |    | 1        |          |    |    | 1        |
| <i>Limothrips cerealium</i>           | Thysanoptera        | Thripidae              |                   |    |    |          | 1        |    |    | 1        |
| <i>Megophthalmus scabripennis</i>     | Homoptera           | Cicadellidae           |                   |    |    |          | 1        |    |    | 1        |
| <i>Microcephalothrips abdominalis</i> | Thysanoptera        | Thripidae              |                   |    | 1  |          |          |    |    | 1        |
| <b><i>Neoheegeria dalmatica</i></b>   | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> | <b>1</b>          |    |    | <b>1</b> |          |    |    | <b>2</b> |
| <i>Noctua janthe</i>                  | Lepidoptera         | Noctuidae              |                   |    |    |          |          | 1  |    | 1        |



| Arthropod and gastropod species     | Order               | Family             | Lebanon Districts |    |          |          |          |    |    | Total    |
|-------------------------------------|---------------------|--------------------|-------------------|----|----------|----------|----------|----|----|----------|
|                                     |                     |                    | AK                | BH | BE       | ML       | NA       | NL | SL |          |
| Total sites surveyed                |                     |                    | 11                | 27 | 20       | 18       | 8        | 12 | 4  | 100      |
| <i>Otites grata</i>                 | Diptera             | Ulidiidae          |                   |    |          |          | 1        |    |    | 1        |
| <b><i>Oxythrips ajugae</i></b>      | <b>Thysanoptera</b> | <b>Thripidae</b>   |                   |    |          | <b>1</b> |          |    |    | <b>1</b> |
| <b><i>Protapion dissimile</i></b>   | <b>Coleoptera</b>   | <b>Apionidae</b>   |                   |    |          |          | <b>1</b> |    |    | <b>1</b> |
| <b><i>Thaumatomyia</i> sp.</b>      | <b>Diptera</b>      | <b>Chloropidae</b> |                   |    |          |          | <b>1</b> |    |    | <b>1</b> |
| <i>Zygina flammigera</i>            | Homoptera           | Cicadellidae       |                   | 5  |          | 1        |          | 2  |    | 8        |
| <b>Predator</b>                     |                     |                    |                   |    |          |          |          |    |    |          |
| <b>Acari</b>                        |                     |                    |                   |    |          |          |          |    |    |          |
| <b><i>Trombidium</i> sp.</b>        | <b>Acariformes</b>  | <b>Trombididae</b> | <b>1</b>          |    |          |          |          |    |    | <b>1</b> |
| <b>Insecta</b>                      |                     |                    |                   |    |          |          |          |    |    |          |
| <i>Adalia bipunctata</i>            | Coleoptera          | Coccinellidae      | 1                 |    |          |          |          |    |    | 1        |
| <i>Anthocoris nemoralis</i>         | Heteroptera         | Anthocoridae       |                   |    |          |          | 1        |    |    | 1        |
| <i>Cantharis</i> sp.                | Coleoptera          | Cantharidae        |                   |    |          |          | 1        |    |    | 1        |
| <i>Chrysopa</i> sp.                 | Neuroptera          | Chrysopidae        |                   | 6  | 1        | 1        | 1        | 2  |    | 11       |
| <i>Chrysopa vulgaris</i>            | Neuroptera          | Chrysopidae        |                   |    |          | 2        |          |    |    | 2        |
| <i>Coccinella septumpunctata</i>    | Coleoptera          | Coccinellidae      |                   |    |          |          | 1        |    |    | 1        |
| Coccinellidae                       | Coleoptera          | Coccinellidae      |                   | 1  |          |          |          |    |    | 1        |
| <b><i>Deraeocoris lutescens</i></b> | <b>Heteroptera</b>  | <b>Miridae</b>     |                   |    | <b>1</b> |          |          |    |    | <b>1</b> |

| Arthropod and gastropod species | Order              | Family               | Lebanon Districts |          |          |    |    |    |    | Total    |
|---------------------------------|--------------------|----------------------|-------------------|----------|----------|----|----|----|----|----------|
|                                 |                    |                      | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed            |                    |                      | 11                | 27       | 20       | 18 | 8  | 12 | 4  | 100      |
| <i>Epicometrs hirta</i>         | Coleoptera         | Scarabaeidae         |                   |          |          |    | 1  |    |    | 1        |
| <i>Epysyrphus balteatus</i>     | Diptera            | Syrphidae            |                   | 1        |          |    |    |    |    | 1        |
| <i>Geocoris erythrocephalus</i> | Heteroptera        | Anthocoridae         | 1                 |          |          |    |    |    |    | 1        |
| Hemerobiidae                    | Neuroptera         | Hemerobiidae         |                   | 1        |          |    |    |    |    | 1        |
| <i>Hypodamia variegata</i>      | Coleoptera         | Coccinellidae        |                   | 1        | 1        |    |    |    |    | 2        |
| <i>Leucopis</i> sp.             | Diptera            | Chamaemyiidae        |                   | 1        | 1        |    |    |    |    | 2        |
| <i>Liorhyssus hyalinus</i>      | Heteroptera        | Rhopalidae           |                   | 1        | 1        |    |    |    |    | 2        |
| <i>Malthinus rufifron</i>       | Coleoptera         | Cantharidae          |                   |          |          |    | 1  |    |    | 1        |
| <b><i>Monalocoris</i> sp.</b>   | <b>Heteroptera</b> | <b>Miridae</b>       |                   | <b>1</b> |          |    |    |    |    | <b>1</b> |
| <i>Oenopia conglobata</i>       | Coleoptera         | Coccinellidae        |                   | 1        |          |    |    |    |    | 1        |
| <i>Rhagonycha fulva</i>         | Coleoptera         | Cantharidae          |                   |          |          | 2  | 1  |    |    | 3        |
| <i>Rhagonycha</i> sp.           | Coleoptera         | Cantharidae          |                   |          |          | 1  |    |    |    | 1        |
| <i>Scymnus apetizi</i>          | Coleoptera         | Coccinellidae        |                   | 1        |          |    |    |    |    | 1        |
| <i>Scymnus bipunctatus</i>      | Coleoptera         | Coccinellidae        |                   |          |          | 1  |    |    |    | 1        |
| <b><i>Scymnus mitior</i></b>    | <b>Coleoptera</b>  | <b>Coccinellidae</b> |                   |          | <b>1</b> |    |    |    |    | <b>1</b> |
| <i>Scymnus</i> sp.              | Coleoptera         | Coccinellidae        |                   | 2        |          |    |    |    |    | 2        |
| <i>Scymnus subvillosus</i>      | Coleoptera         | Coccinellidae        |                   | 1        |          |    | 1  |    |    | 2        |

| Arthropod and gastropod species   | Order        | Family          | Lebanon Districts |    |    |    |    |    |    | Total |
|-----------------------------------|--------------|-----------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |                 | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed              |              |                 | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| <i>Scymnus suturalis</i>          | Coleoptera   | Coccinellidae   | 1                 |    |    |    |    |    |    | 1     |
| <i>Stethorus gilviformis</i>      | Coleoptera   | Coccinellidae   | 2                 | 2  |    | 2  |    |    |    | 6     |
| Unknown                           |              |                 |                   |    |    |    |    |    |    |       |
| Insecta                           |              |                 |                   |    |    |    |    |    |    |       |
| Cecidomyiidae                     | Diptera      | Cecidomyiidae   |                   | 1  |    | 1  |    |    |    | 2     |
| <i>Haplothrips</i> sp.            | Thysanoptera | Phlaeothripidae |                   |    | 1  |    |    |    |    | 1     |
| <i>Mycterothrips albidicornis</i> | Thysanoptera | Thripidae       | 1                 | 4  | 3  | 2  |    |    |    | 10    |
| Oedemeridae                       | Coleoptera   | Oedemeridae     |                   |    |    |    | 1  |    |    | 1     |

|   |   |          |                     |    |   |
|---|---|----------|---------------------|----|---|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 5.5 Distribution of arthropods and gastropods on Plum (*Prunus domestica*)**

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    |       |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed              |              |               | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 40    |
| Primary                           |              |               |                   |    |    |    |    |    |    |       |
| Acari                             |              |               |                   |    |    |    |    |    |    |       |
| <i>Eutetranychus carpini</i> ●    | Acariformes  | Tetranychidae |                   |    |    |    |    |    |    | 0     |
| <i>Panonychus ulmi</i> ●          | Acariformes  | Tetranychidae |                   |    |    |    |    |    |    | 0     |
| <i>Tetranychus urticae</i>        | Acariformes  | Tetranychidae | 2                 |    |    | 2  |    | 1  |    | 5     |
| <i>Tetranychus viennesis</i> ●    | Acariformes  | Tetranychidae |                   |    |    |    |    |    |    | 0     |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Assymetrasca decedens</i>      | Homoptera    | Cicadellidae  | 1                 | 2  |    | 1  | 2  | 3  |    | 9     |
| <i>Brachycaudus helichrysi</i>    | Homoptera    | Aphididae     | 1                 | 1  |    | 1  | 1  |    |    | 4     |
| <i>Capnodis carbonaria</i>        | Coleoptera   | Buprestidae   |                   | 1  |    |    |    |    |    | 1     |
| <i>Cerambyx</i> sp.               | Coleoptera   | Cerambycidae  | 1                 |    |    | 1  |    | 3  |    | 5     |
| <i>Empoasca decipiens</i>         | Homoptera    | Cicadellidae  |                   | 1  |    |    |    |    |    | 1     |
| <i>Frankliniella occidentalis</i> | Thysanoptera | Thripidae     |                   |    | 1  |    |    |    |    | 1     |
| <i>Hedya nubiferana</i>           | Lepidoptera  | Tortricidae   | 1                 |    |    |    |    |    |    | 1     |
| <i>Hyalopterous pruni</i>         | Homoptera    | Aphididae     |                   |    |    | 1  |    |    |    | 1     |
| <i>Mercetaspis halli</i>          | Homoptera    | Diaspididae   | 1                 |    |    | 1  |    |    |    | 2     |

| Arthropod and gastropod species  | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                  |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed             |              |               | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 40    |
| <i>Monosteira unicostata</i>     | Homoptera    | Tingidae      |                   |    |    |    | 1  | 1  |    | 2     |
| <i>Mysus persicae</i>            | Homoptera    | Aphididae     |                   |    |    | 1  |    |    |    | 1     |
| <i>Parthenolecanium corni</i>    | Homoptera    | Coccidae      | 1                 |    | 1  | 3  |    |    |    | 5     |
| <i>Parthenolecanium persicae</i> | Homoptera    | Coccidae      |                   |    |    |    |    | 2  |    | 2     |
| <i>Parthenolecanium</i> sp.      | Homoptera    | Coccidae      |                   |    |    |    |    | 1  |    | 1     |
| <i>Perotis chlorana</i>          | Coleoptera   | Buprestidae   |                   | 1  |    |    |    |    |    | 1     |
| <i>Philaenus spumarius</i>       | Homoptera    | Aphrophoridae | 1                 |    |    |    |    |    |    | 1     |
| <i>Psaulacaspis pentagona</i>    | Homoptera    | Diaspididae   | 1                 |    |    |    | 1  |    |    | 2     |
| <i>Pterochloroides persicae</i>  | Homoptera    | Aphididae     |                   | 1  |    | 1  |    |    |    | 2     |
| <i>Recurvaria nanella</i>        | Lepidoptera  | Gelechiidae   |                   |    |    |    |    | 1  |    | 1     |
| <i>Retithrips syriacus</i>       | Thysanoptera | Thripidae     |                   |    |    | 1  |    |    |    | 1     |
| <i>Scolytus amygdali</i>         | Coleoptera   | Scolytidae    |                   | 1  |    |    |    | 1  |    | 2     |
| <i>Scolytus rugulosus</i>        | Coleoptera   | Scolytidae    | 1                 |    |    |    |    | 1  |    | 2     |
| <i>Scolytus</i> sp.              | Coleoptera   | Scolytidae    | 1                 |    |    |    |    |    |    | 1     |
| <i>Sphaerolecanium prunastri</i> | Homoptera    | Coccidae      | 1                 |    |    | 1  |    |    |    | 2     |
| <i>Thrips major</i>              | Thysanoptera | Thripidae     |                   |    |    |    | 1  |    |    | 1     |
| <i>Thrips tabaci</i>             | Thysanoptera | Thripidae     |                   |    |    |    |    | 2  |    | 2     |

| Arthropod and gastropod species        | Order             | Family               | Lebanon Districts |          |    |          |    |    |    | Total    |
|--|-------------------|----------------------|-------------------|----------|----|----------|----|----|----|----------|
|  |                   |                      | AK                | BH       | BE | ML       | NA | NL | SL |          |
| Total sites surveyed                   |                   |                      | 7                 | 4        | 5  | 10       | 3  | 10 | 0  | 40       |
| <b>Potential primary</b>               |                   |                      |                   |          |    |          |    |    |    |          |
| <b>Acari</b>                           |                   |                      |                   |          |    |          |    |    |    |          |
| <i>Bryobia rubrioculus</i>             | Acariformes       | Tetranychidae        |                   |          |    |          |    | 2  |    | 2        |
| <i>Orthotydeus californicus</i>        | Acariformes       | Tydeidae             | 1                 |          |    |          |    |    |    | 1        |
| <b>Insecta</b>                         |                   |                      |                   |          |    |          |    |    |    |          |
| <i>Agalmatium bilobium</i>             | Homoptera         | Fulgoroidae          |                   | 1        |    |          |    |    |    | 1        |
| <i>Brachycaudus cardui</i>             | Homoptera         | Aphididae            |                   |          |    | 1        |    |    |    | 1        |
| <i>Coccus hesperidum</i>               | Homoptera         | Coccidae             | 1                 | 1        |    |          |    |    |    | 2        |
| <b><i>Contarinia pruniflorum</i></b>   | <b>Diptera</b>    | <b>Cecidomyiidae</b> |                   |          |    | <b>1</b> |    |    |    | <b>1</b> |
| <i>Cyclophora pendulinaria</i>         | Lepidoptera       | Geometridae          |                   |          |    | 1        |    |    |    | 1        |
| <i>Lixus angustatus</i>                | Coleoptera        | Curculionidae        |                   | 1        |    |          |    |    |    | 1        |
| <i>Parlatoria pergandii</i>            | Homoptera         | Diaspididae          |                   |          |    |          |    | 1  |    | 1        |
| <i>Parlatoria oleae</i>                | Homoptera         | Diaspididae          |                   |          |    | 1        |    |    |    | 1        |
| <b><i>Rhabdorrhynchus anchusae</i></b> | <b>Coleoptera</b> | <b>Curculionidae</b> |                   | <b>1</b> |    |          |    |    |    | <b>1</b> |
| <i>Rhaphigaster nebulosa</i>           | Heteroptera       | Pentatomidae         |                   |          |    | 1        |    |    |    | 1        |
| <i>Sinoxylon sexdentatum</i>           | Coleoptera        | Scolytidae           |                   |          |    |          |    | 1  |    | 1        |
| <i>Stephanitis pyri</i>                | Homoptera         | Tingidae             | 1                 |          |    | 3        |    | 4  |    | 8        |

| Arthropod and gastropod species | Order        | Family        | Lebanon Districts |    |    |    |    |    |    | Total |
|---------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                 |              |               | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed            |              |               | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 40    |
| Secondary                       |              |               |                   |    |    |    |    |    |    |       |
| Insecta                         |              |               |                   |    |    |    |    |    |    |       |
| <i>Drosophila melanogaster</i>  | Diptera      | Drosophilidae |                   |    |    | 1  |    |    |    | 1     |
| <i>Drosophila simulans</i>      | Diptera      | Drosophilidae |                   |    |    | 1  |    | 1  |    | 2     |
| Saprophyte                      |              |               |                   |    |    |    |    |    |    |       |
| Insecta                         |              |               |                   |    |    |    |    |    |    |       |
| <i>Ectopsocus</i> sp.           | Psocoptera   | Ectopsocoidae |                   |    |    | 1  | 2  | 2  |    | 5     |
| <i>Melanophthalma rispini</i>   | Coleoptera   | Latridiidae   |                   |    |    | 1  |    |    |    | 1     |
| <i>Melanophthalma</i> sp.       | Coleoptera   | Latridiidae   |                   |    |    | 2  | 3  |    |    | 5     |
| <i>Trichopsocus dalii</i>       | Psocoptera   | Trichopsoidae |                   |    |    | 3  |    |    |    | 3     |
| Casual                          |              |               |                   |    |    |    |    |    |    |       |
| Insecta                         |              |               |                   |    |    |    |    |    |    |       |
| <i>Anaphothrips obscurus</i>    | Thysanoptera | Thripidae     |                   |    |    | 1  |    |    |    | 1     |
| <i>Apion frumentarium</i>       | Coleoptera   | Curculionidae |                   |    |    | 1  |    |    |    | 1     |
| <i>Austroagallia sinuata</i>    | Homoptera    | Cicadellidae  |                   |    |    |    | 1  |    |    | 1     |
| <i>Cacopsylla myrthi</i>        | Homoptera    | Psyllidae     |                   |    | 1  |    | 1  | 1  |    | 3     |
| <i>Cacopsylla pulchella</i>     | Homoptera    | Psyllidae     |                   |    |    |    |    | 1  |    | 1     |

| Arthropod and gastropod species      | Order               | Family                 | Lebanon Districts |    |    |    |          |          |    | Total    |
|--------------------------------------|---------------------|------------------------|-------------------|----|----|----|----------|----------|----|----------|
|                                      |                     |                        | AK                | BH | BE | ML | NA       | NL       | SL |          |
| Total sites surveyed                 |                     |                        | 7                 | 4  | 5  | 10 | 3        | 10       | 0  | 40       |
| Chironomidae                         | Diptera             | Chironomidae           |                   |    |    | 1  |          |          |    | 1        |
| <i>Chironomus Pluminosus</i>         | Diptera             | Chironomidae           |                   |    |    | 1  |          |          |    | 1        |
| <b><i>Dendrothrips saltatrix</i></b> | <b>Thysanopter</b>  | <b>Thripidae</b>       |                   |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <i>Guanchia brignolii</i>            | Dermaptera          | Forficulidae           |                   |    |    |    | 1        |          |    | 1        |
| <i>Guanchia pubescens</i>            | Dermaptera          | Forficulidae           |                   |    |    | 1  |          |          |    | 1        |
| <b><i>Haplothrips tritici</i></b>    | <b>Thysanoptera</b> | <b>Phlaeothripidae</b> |                   |    |    |    | <b>1</b> |          |    | <b>1</b> |
| <i>Homotoma ficus</i>                | Homoptera           | Homotomidae            |                   |    |    |    |          | 1        |    | 1        |
| <b><i>Hypolixus nubilous</i></b>     | <b>Coleoptera</b>   | <b>Curculionidae</b>   |                   |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <i>Lygaeus equestris</i>             | Heteroptera         | Lygaeidae              |                   |    |    | 1  |          |          |    | 1        |
| <b><i>Nysius sp.</i></b>             | <b>Heteroptera</b>  | <b>Lygaeidae</b>       | <b>1</b>          |    |    |    |          |          |    | <b>1</b> |
| <i>Zygina flammigera</i>             | Homoptera           | Cicadellidae           |                   | 2  | 1  | 2  | 2        |          |    | 7        |
| <b>Predator</b>                      |                     |                        |                   |    |    |    |          |          |    |          |
| <b>Acari</b>                         |                     |                        |                   |    |    |    |          |          |    |          |
| <i>Agistemus sp.</i>                 | Acariformes         | Stigmaeiidae           |                   |    |    | 1  |          |          |    | 1        |
| <i>Pseudoscorpion sp.</i>            | Acari               |                        | 1                 |    |    |    |          |          |    | 1        |
| <i>Typhlodromus occidentalis</i>     | Parasitiformes      | Phytoseiidae           | 2                 |    |    |    |          |          |    | 2        |



| Arthropod and gastropod species       | Order               | Family           | Lebanon Districts |          |    |          |          |          |    | Total    |
|---------------------------------------|---------------------|------------------|-------------------|----------|----|----------|----------|----------|----|----------|
|                                       |                     |                  | AK                | BH       | BE | ML       | NA       | NL       | SL |          |
| Total sites surveyed                  |                     |                  | 7                 | 4        | 5  | 10       | 3        | 10       | 0  | 40       |
| <b>Insecta</b>                        |                     |                  |                   |          |    |          |          |          |    |          |
| <i>Adalia decempunctata</i>           | Coleoptera          | Coccinellidae    |                   | 1        |    |          |          |          |    | 1        |
| <i>Anthocoris nemoralis</i>           | Heteroptera         | Anthocoridae     |                   | 1        |    |          |          |          |    | 1        |
| <i>Chrysopa</i> sp.                   | Neuroptera          | Chrysopidae      | 1                 | 2        |    | 2        |          | 3        |    | 8        |
| Coccinellidae                         | Coleoptera          | Coccinellidae    |                   | 3        |    |          |          |          |    | 3        |
| <b><i>Deraeocoris</i> sp.</b>         | <b>Heteroptera</b>  | <b>Miridae</b>   |                   |          |    |          |          | <b>1</b> |    | <b>1</b> |
| <i>Epysyrphus balteatus</i>           | Diptera             | Syrphidae        |                   |          |    | 1        |          |          |    | 1        |
| <b><i>Harpalus rufipes</i></b>        | <b>Coleoptera</b>   | <b>Carabidae</b> |                   |          |    | <b>1</b> |          |          |    | <b>1</b> |
| Hemerobiidae                          | Neuroptera          | Hemerobiidae     |                   |          |    | 1        |          |          |    | 1        |
| <b><i>Monalocoris</i> sp.</b>         | <b>Heteroptera</b>  | <b>Miridae</b>   | <b>1</b>          | <b>1</b> |    |          |          |          |    | <b>1</b> |
| <b><i>Phytocoris</i> sp.</b>          | <b>Heteroptera</b>  | <b>Miridae</b>   |                   |          |    |          |          | <b>1</b> |    | <b>1</b> |
| <i>Pterostichus</i> sp.               | Coleoptera          | Carabidae        |                   |          |    | 1        |          |          |    | 1        |
| <i>Rhagonycha fulva</i>               | Coleoptera          | Cantharidae      |                   |          |    | 1        |          |          |    | 1        |
| <b><i>Scolothrips longicornis</i></b> | <b>Thysanoptera</b> | <b>Thripidae</b> |                   | <b>1</b> |    |          |          |          |    | <b>1</b> |
| <b><i>Scolothrips</i> sp.</b>         | <b>Thysanoptera</b> | <b>Thripidae</b> |                   |          |    |          | <b>1</b> |          |    | <b>1</b> |
| <i>Scymnus</i> sp.                    | Coleoptera          | Coccinellidae    |                   | 2        |    |          | 1        |          |    | 3        |
| <i>Stethorus gilviformis</i>          | Coleoptera          | Coccinellidae    | 1                 | 1        |    | 1        |          |          |    | 3        |

| Arthropod and gastropod species   | Order        | Family        | Lebanon Districts |    |    |    |    |    |    |       |
|-----------------------------------|--------------|---------------|-------------------|----|----|----|----|----|----|-------|
|                                   |              |               | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed              |              |               | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 40    |
| Parasitoid                        |              |               |                   |    |    |    |    |    |    |       |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Aphidius colmani</i>           | Hymenoptera  | Braconidae    |                   |    |    | 1  |    |    |    | 1     |
| <i>Rhyssa</i> sp.                 | Hymenoptera  | Ichneumonidae |                   |    |    | 1  |    |    |    | 1     |
| Unknown                           |              |               |                   |    |    |    |    |    |    |       |
| Insecta                           |              |               |                   |    |    |    |    |    |    |       |
| <i>Haplothrips</i> sp.            | Thysanoptera | Thripidae     |                   | 1  |    |    |    | 1  |    | 2     |
| <i>Mycterothrips albidicornis</i> | Thysanoptera | Thripidae     | 1                 |    |    |    |    | 1  |    | 2     |
| <i>Othiorrhynchus</i> sp.         | Coleoptera   | Curculionidae |                   |    |    | 1  |    |    |    | 1     |
| <i>Raphigaster nebulosa</i>       | Heteroptera  | Pentatomidae  |                   | 1  |    |    |    |    |    | 1     |
| <i>Reptalus horridus</i>          | Homoptera    | Cixidae       |                   |    |    |    |    | 1  |    | 1     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

## 6. Results and Discussion: Nematodes

Nematodes refer to microscopic worm-like organisms some of which are plant parasitic. Some species are known to damage roots which result in a reduced uptake of nutrients and water. Numerous species of Plant Parasitic Nematode (PPN) attack stone fruit roots by direct feeding and by burrowing through roots tissues. Their damage reduces tree vigour (growth productivity and longevity).

A survey on stone fruits was conducted where 329 soil samples were collected. Almost all the collected soil samples were infested with nematodes. The level of infestation of soil sample varied from one area to another. The current survey was the first carried out on different varieties of stone fruits in Lebanon. Taylor et al. (1969) mentioned different pathogenic genera present in Lebanon without reporting their species. This is the first attempt to document the species of nematodes occurring on stone fruits in Lebanon.

### 6.1. Root Lesion nematodes, *Pratylenchus* species

Refer to Tables 6.1 – 6.5

According to Nyczepir & Halbrecht (1993), *Pratylenchus vulnus* and *Pratylenchus penetrans* are the major species of Root Lesion nematode (RLN) of economic importance although more than 10 others have been reported in association with stone fruits (Lownsbery, Moody & Braun, 1974).

*Pratylenchus* species were reported for the first time in Lebanon.

These migratory endoparasitic nematodes feed on host root surface and penetrate inside. A restriction of nutrients uptake occurs within larger roots and many smaller ones are killed. In some cases, dark lesions many form on the surface of infested roots increasing the incidence of contamination by other pathogens.

*Pratylenchus vulnus* was reported in 27 soil samples of stone fruits where the infection was found primary in 8% (7) of almond, 8% (4) of cherry, 9% (9) of peach and 10% (4) of plum site samples. Also, 6% (3) apricot sites presented a potentially primary attack.

*Pratylenchus penetrans* occurred as a primary pest in 27% (14) of cherry, 26% (26) of peach orchards and a potentially primary association between this nematode species and apricot was apparent in 24% (12) sites while a secondary association was recorded in 19% (17) of almond sites.

Plum rootstocks were not susceptible to this nematode with only 13% (5) of surveyed sites showing its presence in soil.

*Pratylenchus* spp. were found in 8% (7) of almond, 2% (1) of cherry, 9% (9) of peach and 3% (1) of plum sites. These root lesion nematodes found in soil and feeding on the roots of weeds and cover crops, do not have any harmful effect on these crops to be recorded as pests of stone fruits unless they occur in abundance within the roots of the tree. In addition, *P. pratensis* was also extracted from one site in Akkar region.

## 6.2. Ring nematodes, *Criconemella xenoplax*

Refer to Tables 6.1 – 6.5.

Ring nematodes are migratory ectoparasites that become sedentary on the roots of many hosts.

Their feeding has a root pruning effect on plants leading to the reduction of small feeder roots and the ability to withstand stress. It also reduces nutrient uptake resulting in poor tree growth. High populations predispose trees to bacterial canker or spot (*Xanthomonas arbricola* pv .*pruni*), *Fusarium* and *Pythium* spp.

*Criconemella xenoplax* was not reported in Lebanese orchards prior to this survey.

This survey shows a primary association of this pest with stone fruit in 3% (3) of almond, 4% (2) of apricot, 4% (4) of peach and 8% (3) of plum sites while 2 cherry sites were infected by ring nematode. These sites are located in Bekaa and Baalbeck-Hermel regions and only 1 site of peach in Mount Lebanon.

## 6.3. Root Knot nematodes, *Meloidogyne* species

Refer to Tables 6.1 – 6.5

*Meloidogyne* species are sedentary endoparasites. They spend most of their life inside the roots of the host plant. Four species (*M. javanica*, *M. incognita*, *M. arenaria* and *M. hapla*) are the major pests causing economic damage worldwide (Simeone & Divito, 1992). Root knot nematode reduces fruit production in several economically important *Prunus* spp.

*M. javanica* was the predominant species in 33 soil samples where 13% (5), 10% (10), 10% (9), 10% (5) and 8% (4), respectively, of plum, peach, almond, cherry and apricot sites showing thus its dangerous presence.

Also, 12% (6) of apricot, 11% (11) of peach, 9% (8) of almond, 8% (4) of cherry sites and 2 other sites of plum made a total of 31 sites primary infected with *M. incognita*. Taylor et al. (1969) mentioned the presence of these species of root knot in Lebanon on other crops giving the occurrence of *M. javanica* and *M. incognita* in this survey as a new association with this crop.

Two other species have been first reported in the country, *M. hapla* found primary associated with 1 cherry site and 2 peach sites and *M. arenaria* reported in only 1 site of plum.

## 6.4. Dagger nematodes, *Xiphinema* species

Refer to Tables 6.1 - 6.5

All stone fruit species are susceptible hosts to dagger nematodes. These ectoparasites feed outside roots but several transmit soil borne plant viruses (Brown et al 1993).

Nyczepir and Becker (1998) mentioned at least 7 species of *Xiphinema* in association with nepoviruses.

According to Lamberti & Siddiqi (1977), *X. mediterraneum* and other *Xiphinema* spp. of the americanum group are neither reported to cause any significant damage, nor to transmit any virus diseases. They may be found in common broadleaved weeds present in stone fruit orchards (Nyczepir & Esmenjaud 2008).

Taylor et al. (1969) reported the presence of *X. mediterraneum* in our country. All of these nematodes extracted from collected soil samples were located in Bekaa region in 8% (4) of apricot, 6% (3) of cherry, 5% (4) of almond sites also in 2 peach and 1 plum sites.

## 6.5. Other nematodes

Refer to Tables 6.1 - 6.5

Lots of nematode species were found in the soil of stone fruit orchards. Many present weeds and herbaceous plants that may be hosts of different plant parasitic nematodes showing a prevalent diversity of genera in this survey which are often not regarded as significant parasites.

Species of *Helicotylenchus*, *Tylenchus*, *Paratylenchus*, *Tylenchorynchus*, *Aphelenchoides* and *Gracilacus* were extracted from soil in all regions of all stone fruit species.

While *Rotylenchus* was present in 1 site of almond, 1 site of peach also in 2 other sites of cherry, stem nematode *Aphelenchus* was in soil of all crops except in almond variety where 2 nematodes were identified from each apricot, cherry and peach and a single one from plum sites.

A species of *Psylenchus* and another of *Macrotrophurus* were found in 2 distinct sites of cherry in Bekaa-Hermel region.

*Longidorus elongatus* occurred only in Bekaa-Hermel region in an apricot site and a cherry one.

Note that, citrus nematode *Tylenchulus semipenetrans* was found occasionally in soil at Nabatieh in only one almond site and at North Lebanon in 2 plum sites. This nematode species, very pathogenic to citrus crops was noticed in regions where citrus crops are planted. Its association with stone fruits is unknown and requires further investigation.

## 6.6. Summary of New Records

### ▪ New host records

This survey shows *Meloidogyne javanica* and *M. incognita* reported in stone fruit orchards as new host records.

### ▪ New to Lebanon

12 nematodes species belonging to 7 genera were recorded for the first time in the Lebanese fauna:

*Pratylenchus vulnus*, *Pratylenchus penetrans*, *Tylenchus*, *Criconemella xenoplax* and *Aphelenchoides* from soil samples at all stone fruit species:

*Aphelenchus* from apricot, cherry, peach and plum sites.

*Longidorus elongatus* from apricot, and cherry sites at Baalbeck-Hermel

*Meloidogyne hapla* from cherry and peach sites.

*Meloidogyne arenaria* and *Pratylenchus pratensis* from plum sites.

*Macrotrophurus* and *Psylenchus* from cherry sites.

## 6.7 General Discussion

Yield loss due to nematode infection depends on soil conditions, cultivar tolerance and the type of this population involved. The presence in soil of these pests feeding on roots is not indicative of nematode disease until the diagnosis occurs and their economical damage determined.

Plant parasitic nematodes have been found throughout Lebanon in great diversity. The major pests that cause important and significant yield losses in many regions of the world were recognized at almost all local stone fruit crops and are *M. javanica*, *M. arenaria*, *P. vulnus*, *P. penetrans* and *C. xenoplax* (McKenry, 2004). Most of these pathogens were identified as the most frequent and dominant in stone fruit growing areas in Bekaa and Baalbeck-Hermel where stone fruits are the most prevalent in these regions.

These nematodes occurring in low population density allow Lebanon to remain in an enviable position with appropriate awareness. Development of nematode management systems through fundamental and applied research will provide the basis for pest control to avoid their dispersal.

**Table 6.1 Distribution of nematodes on Almond (*Prunus amygdali*)**

| Nematode species                 | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|----------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                  |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed             |                       | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Aphelenchoides</i> sp.        | In soil               |                   | 11 | 1  |    |    | 1  |    | 13    |
| <i>Criconemella xenoplax</i>     | Primary               |                   | 2  | 1  |    |    |    |    | 3     |
| <i>Gracilacus</i> sp.            | In soil               |                   | 1  | 1  |    | 1  |    |    | 3     |
| <i>Helicothylenchus</i> sp.      | In soil               | 1                 | 15 | 3  | 2  | 1  | 2  | 1  | 25    |
| <i>Meloidogyne incognita</i>     | Primary               |                   | 5  | 2  |    | 1  |    |    | 8     |
| <i>Meloidogyne javanica</i>      | Primary               | 1                 | 3  | 3  | 1  |    |    | 1  | 9     |
| <i>Paratylenchus</i> sp.         | In soil               | 2                 | 7  | 2  |    | 1  |    |    | 12    |
| <i>Pratylenchus penetrans</i>    | Secondary             | 2                 | 11 | 4  |    |    |    |    | 17    |
| <i>Pratylenchus</i> sp.          | In soil               |                   | 5  |    | 1  |    | 1  |    | 7     |
| <i>Pratylenchus vulnus</i>       | Primary               | 1                 | 5  | 1  |    |    |    |    | 7     |
| <i>Rotylenchus</i>               | In soil               |                   | 1  |    |    |    |    |    | 1     |
| <i>Tylenchorenchus</i> sp.       | In soil               | 1                 | 11 |    |    |    | 1  |    | 13    |
| <i>Tylenchulus semipenetrans</i> | Casual                |                   |    |    |    | 1  |    |    | 1     |
| <i>Tylenchus</i> sp.             | In soil               | 4                 | 7  | 4  |    |    | 1  | 1  | 17    |
| <i>Xiphinema mediterraneum</i>   | In soil               |                   | 4  |    |    |    |    |    | 4     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 6.2 Distribution of nematodes on Apricot (*Prunus armeniaca*)**

| Nematode species               | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|--------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed           |                       | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 51    |
| <i>Aphelenchoides</i> sp.      | In soil               |                   | 8  |    |    |    |    |    | 8     |
| <i>Aphelenchus</i> sp.         | In soil               |                   | 2  |    |    |    |    |    | 2     |
| <i>Criconemella xenoplax</i>   | Primary               |                   | 2  |    |    |    |    |    | 2     |
| <i>Gracilacus</i> sp.          | In soil               |                   | 2  |    |    |    |    |    | 2     |
| <i>Helicothylenchus</i> sp.    | In soil               |                   | 8  |    |    |    | 1  |    | 9     |
| <i>Longidorus elongates</i>    | Secondary             |                   | 1  |    |    |    |    |    | 1     |
| <i>Meloidogyne incognita</i>   | Potential primary     |                   | 5  |    |    |    | 1  |    | 6     |
| <i>Meloidogyne javanica</i>    | Potential primary     |                   | 4  |    |    |    |    |    | 4     |
| <i>Paratylenchus</i> sp.       | In soil               |                   | 10 |    |    |    | 1  |    | 11    |
| <i>Pratylenchus penetrans</i>  | Potential primary     |                   | 11 |    |    |    | 1  |    | 12    |
| <i>Pratylenchus vulnus</i>     | Potential primary     |                   | 3  |    |    |    |    |    | 3     |
| <i>Tylenchorenchus</i> sp.     | In soil               |                   | 7  |    |    |    |    |    | 7     |
| <i>Tylenchus</i> sp.           | In soil               |                   | 10 | 1  |    |    | 1  |    | 12    |
| <i>Xiphinema mediterraneum</i> | In soil               |                   | 4  |    |    |    |    |    | 4     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon



**Table 6.3 Distribution of nematodes on Cherry (*Prunus avium*)**

| Nematode species              | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|-------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                               |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed          |                       | 1                 | 32 | 13 | 3  | 1  | 1  | 0  | 51    |
| <i>Aphelenchoides</i> sp.     | In Soil               |                   | 5  | 1  |    |    | 1  |    | 7     |
| <i>Aphelenchus</i> sp.        | In Soil               |                   |    | 1  |    |    | 1  |    | 2     |
| <i>Criconemella xenoplax</i>  | Potential primary     |                   |    | 2  |    |    |    |    | 2     |
| <i>Gracilacus</i> sp.         | In Soil               |                   | 2  | 1  |    |    | 1  |    | 4     |
| <i>Helicothylenchus</i> sp.   | In Soil               | 1                 | 7  | 3  | 1  | 1  | 1  |    | 14    |
| <i>Longidorus elongates</i>   | Secondary             |                   | 1  |    |    |    |    |    | 1     |
| <i>Macrotophurus</i> sp.      | In Soil               |                   | 1  |    |    |    |    |    | 1     |
| <i>Meloidogyne hapla</i>      | Primary               |                   | 1  |    |    |    |    |    | 1     |
| <i>Meloidogyne incognita</i>  | Primary               |                   | 1  | 1  | 1  | 1  |    |    | 4     |
| <i>Meloidogyne javanica</i>   | Primary               |                   | 4  | 1  |    |    |    |    | 5     |
| <i>Paratylenchus</i> sp.      | In Soil               | 1                 | 10 | 3  |    |    | 1  |    | 15    |
| <i>Pratylenchus penetrans</i> | Primary               |                   | 9  | 3  | 1  |    | 1  |    | 14    |
| <i>Pratylenchus</i> sp.       | In Soil               |                   |    | 1  |    |    |    |    | 1     |
| <i>Pratylenchus vulnus</i>    | Primary               |                   | 4  |    |    |    |    |    | 4     |
| <i>Psilenchus</i> sp.         | In Soil               |                   |    | 1  |    |    |    |    | 1     |

| Nematode species               | Nature of association | Lebanon Districts |          |          |          |          |          |    | Total     |
|--------------------------------|-----------------------|-------------------|----------|----------|----------|----------|----------|----|-----------|
|                                |                       | AK                | BH       | BE       | ML       | NA       | NL       | SL |           |
| Total sites surveyed           |                       | 1                 | 32       | 13       | 3        | 1        | 1        | 0  | 51        |
| <i>Rotylenchus</i> sp.         | In Soil               |                   | 1        |          |          |          |          |    | 1         |
| <i>Tylenchorenychus</i> sp.    | In Soil               |                   | 3        |          | 1        |          |          |    | 4         |
| <b><i>Tylenchus</i> sp.</b>    | <b>In Soil</b>        | <b>1</b>          | <b>6</b> | <b>3</b> | <b>1</b> | <b>1</b> | <b>1</b> |    | <b>13</b> |
| <i>Xiphinema mediterraneum</i> | In Soil               |                   | 2        | 1        |          |          |          |    | 3         |

|   |   |          |                     |  |
|---|---|----------|---------------------|--|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | n: No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon |  |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 6.4 Distribution of nematodes on Peach (*Prunus persica*)**

| Nematode species              | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|-------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                               |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed          |                       | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
|                               |                       |                   |    |    |    |    |    |    |       |
| <i>Aphelenchoides</i> sp.     | In Soil               | 1                 | 8  | 4  | 3  |    | 3  |    | 19    |
| <i>Aphelenchus</i> sp.        | In Soil               |                   |    | 1  | 1  |    |    |    | 2     |
| <i>Criconemella xenoplax</i>  | Primary               |                   | 2  | 1  | 1  |    |    |    | 4     |
| <i>Gracilacus</i> sp.         | In Soil               |                   | 1  | 1  | 1  |    | 1  |    | 4     |
| <i>Helicothylenchus</i> sp.   | In Soil               | 2                 | 7  | 8  | 7  | 4  | 3  |    | 31    |
| <i>Meloidogyne hapla</i>      | Primary               |                   | 1  | 1  |    |    |    |    | 2     |
| <i>Meloidogyne incognita</i>  | Primary               | 1                 | 3  | 4  | 2  |    | 1  |    | 11    |
| <i>Meloidogyne javanica</i>   | Primary               | 2                 | 2  |    | 2  | 1  | 2  | 1  | 10    |
| <i>Paratylenchus</i> sp.      | In Soil               | 3                 | 7  | 2  | 1  | 1  | 3  |    | 17    |
| <i>Pratylenchus penetrans</i> | Primary               | 2                 | 9  | 3  | 6  | 2  | 3  | 1  | 26    |
| <i>Pratylenchus</i> sp.       | In Soil               |                   | 2  | 4  | 1  |    | 1  | 1  | 9     |
| <i>Pratylenchus vulnus</i>    | Primary               |                   | 3  | 3  |    |    | 2  | 1  | 9     |
| <i>Rotylenchus</i> sp.        | In Soil               |                   |    | 1  |    |    |    |    | 1     |
| <i>Tylenchorenchus</i> sp.    | In Soil               | 1                 | 7  | 8  | 1  | 1  | 1  |    | 19    |
| <i>Tylenchus</i> sp.          | In Soil               | 4                 | 7  | 4  | 5  |    | 5  |    | 25    |

| Nematode species               | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|--------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed           |                       | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| <i>Xiphinema mediterraneum</i> | In Soil               |                   | 1  | 1  |    |    |    |    | 2     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 6.5 Distribution of nematodes on Plum (*Prunus domestica*)**

| Nematode species                 | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|----------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                  |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed             |                       | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 39    |
| <i>Aphelenchoides</i> sp.        | In Soil               | 1                 |    |    |    | 1  | 3  |    | 5     |
| <i>Aphelenchus</i> sp.           | In Soil               |                   |    |    |    |    | 1  |    | 1     |
| <i>Criconemella xenoplax</i>     | Primary               |                   |    | 1  |    |    | 2  |    | 3     |
| <i>Gracilacus</i> sp.            | In Soil               |                   |    |    |    |    | 1  |    | 1     |
| <i>Helicothylenchus</i> sp.      | In Soil               | 2                 |    |    | 1  | 1  | 6  |    | 10    |
| <i>Meloidogyne arenaria</i>      | Primary               |                   |    |    | 1  |    |    |    | 1     |
| <i>Meloidogyne incognita</i>     | Primary               |                   |    |    |    |    | 2  |    | 2     |
| <i>Meloidogyne javanica</i>      | Primary               | 1                 |    | 3  |    |    | 1  |    | 5     |
| <i>Paratylenchus</i> sp.         | In Soil               |                   |    | 1  | 1  |    | 2  |    | 4     |
| <i>Pratylenchus penetrans</i>    | In Soil               |                   | 1  | 1  | 1  |    | 2  |    | 5     |
| <i>Pratylenchus pratensis</i>    | In Soil               | 1                 |    |    |    |    |    |    | 1     |
| <i>Pratylenchus</i> sp.          | In Soil               |                   |    |    |    | 1  |    |    | 1     |
| <i>Pratylenchus vulnus</i>       | Primary               |                   |    |    | 1  |    | 3  |    | 4     |
| <i>Tylenchorenchus</i> sp.       | In Soil               |                   |    |    | 1  | 1  | 3  |    | 5     |
| <i>Tylenchulus semipenetrans</i> | Casual                |                   |    |    |    |    | 2  |    | 2     |

| Nematode species               | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|--------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed           |                       | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 39    |
| <i>Tylenchus sp.</i>           | In Soil               |                   | 1  | 1  | 4  | 2  | 6  |    | 14    |
| <i>Xiphinema mediterraneum</i> | In Soil               |                   |    | 1  |    |    |    |    | 1     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

## 7. Results and Discussion: Fungi

A total of 472 samples were collected from the visited stone fruit sites. Details are shown in the table below. From the symptomatic organs, 366 fungal specimens were identified directly from the infected tissue or following isolation on appropriate culture medium.

**Number of collected samples and fungal specimens from stone fruit crops**

| Host plant   | Samples   |          |           |            |          |            |            | Fungal specimens |
|--------------|-----------|----------|-----------|------------|----------|------------|------------|------------------|
|              | Branches  | Flowers  | Fruits    | Leaves     | Roots    | Twigs      | Total      |                  |
| Almond       | 6         | 3        | 6         | 26         | 0        | 91         | 132        | 126              |
| Apricot      | 2         | 0        | 1         | 7          | 0        | 26         | 36         | 14               |
| Cherry       | 6         | 0        | 0         | 17         | 0        | 33         | 56         | 35               |
| Peach        | 11        | 0        | 14        | 39         | 1        | 108        | 173        | 156              |
| Plum         | 5         | 0        | 5         | 21         | 0        | 44         | 75         | 35               |
| <b>Total</b> | <b>30</b> | <b>3</b> | <b>26</b> | <b>110</b> | <b>1</b> | <b>302</b> | <b>472</b> | <b>366</b>       |

Fungal specimens isolated from all stone fruit crops belonged to 26 species and five genera. In order to assess the status of the record of each taxon, results were compared to previous reports and publications on phytopathogenic fungal species in Lebanon (Saad and Nienhaus, 1969; Khatib et al., 1970; Khouzami et al., 1996).

Incidence of the fungal species was calculated as follows:

$$\text{Incidence (\%)} = [\text{No. of infected sites} / \text{Total No. of sites}] \times 100$$

The most widespread fungi in all visited stone fruit orchards were *Wilsonomyces carpophilus* (27.1%) causing shot hole disease on almond, apricot, peach and plum; *Sphaerotheca pannosa* (18.5%) causing powdery mildew on almond, apricot, peach and plum; *Alternaria alternata* (13.1%) found in all sampled stone fruit sites, causing leaf spots or as saprophyte in the wood; *Cercospora circumscissa* (7.0%) causing Cercospora leaf spot disease on cherry and *Taphrina deformans* (5.5%), causing leaf curl disease on almond and peach. Among these species, *C. circumscissa* is a new species to Lebanon.

In addition, other primary pathogens new to Lebanon were also reported during this survey with lower incidence, such as *Leucostoma cincta* (2.4%) causing Leucostoma canker disease on apricot, cherry, peach and plum, and *Phomopsis amygdali* (1.2%) causing twig canker and blight on almond and peach.

Three fungal species previously reported in Lebanese stone fruit orchards (Saad and Nienhaus, 1969; Khouzami et al., 1996) were not detected during the survey: *Cladosporium carpophilum* (Syn. *Venturia carpophila*), causal agent of scab, *Monilinia fructicola*, causal agent of brown rot and *Rosellinia necatrix*, causal agent of white root rot.

In the Results Tables (Tables 7.1-7.5), all species are listed under their teleomorph names followed by their anamorph names (in brackets) where possible.

### 7.1. Almond (*Prunus amygdalus*)

A total of 88 almond sites were sampled from all Lebanese districts, predominately from Baalbeck-Hermel (47.7%), Akkar (23.9%) and Bekka (15.9%). From these sites, 23 fungal species were detected (Table 7.1). Among these, eight were new to Lebanon (Table 7.1; bold text and red background); four were primary pathogens and four were saprophytes.

Seven fungal species were new host records (Table 7.1; grey background); five were primary or potential primary, one was secondary and one was primary / saprophyte.

Three taxa were classified as having unknown nature of association because the species level of identification was not possible.

Of the fungal species or genera previously known to occur on almond in Lebanon (Saad and Nienhaus, 1969; Khatib et al., 1970; Khouzami et al., 1996; Saad and Masannat, 1997), eight were recovered in this survey. The most commonly detected base record species were *Wilsonomyces carpophilus*, causal agent of shot hole (31.8%); *Polystigma ochraceum*, causal agent of red leaf blotch disease (14.7%); *Tranzschelia pruni-spinosae* var. *discolor*, causal agent of rust (6.8%) and *Taphrina deformans*, causal agent of leaf curl disease (5.7%).

One primary fungal species on almond in Lebanon, *Verticillium dahliae*, was not noted during this survey. This species is the causal agent of Verticillium wilt disease on many host plants in Lebanon, particularly on almond (Makhlouf and Geagea, 2005; Saad et al., 2009).

#### ▪ New to Lebanon on Almond

Eight fungal species new to Lebanon were recorded on almond in this survey.

**Primary and Potential primary:** *Botryosphaeria dothidea*, '*Botryosphaeria*' *parva* (*Neofusicoccum parvum*), *Leptosphaeria coniothyrium* (*Microsphaeropsis fuckelii*) and *Phomopsis amygdali*.

The importance of these species is their ability to cause dieback and cankers in affected twigs. With the exception of *P. amygdali*, all the primary pathogens new to Lebanon were detected in only one sample.

*Phomopsis amygdali* was recorded in three sites in Akkar district, causing dieback and decline in affected trees.

**Saprophyte:** *Bionectria ochroleuca*, *Cladosporium cladosporioides*, *Geotrichum candidum* and *Pleospora herbarum*. All these species are common saprophytes frequently found in the wood of fruit trees.

#### ▪ New Host Recordings for Almond

Seven fungal species were reported for the first time on almond: *Alternaria alternata*, '*Botryosphaeria*' *obtusum* (*Diplodia seriata*), '*Botryosphaeria*' *rhodina* (*Botryodiplodia theobromae*), *Botryotinia fuckeliana* (*Botrytis cinerea*), *Eutypa lata*, *Sphaerotheca pannosa* and *Valsa sordida* (*Cytospora chrysosperma*).

Except *B. fuckeliana*, causal agent of grey mold on several hosts in Lebanon (Khouzami et al., 1996), these species are primary pathogens on almond.



*Alternaria alternata* was the second most widespread fungal species (29.6%) on almond. This species caused zonate leaf spot disease and was rarely found as saprophyte in wood and flowers of almond. The disease is reported for the first time in Lebanon during this survey; however the species, *A. alternata*, is a base record in Lebanon.

An important finding was the recovery of '*Botryosphaeria*' *obtusa*, *Botryodiplodia theobromae* and *Eutypa lata* in almond sites. These species caused wilting, decline or dieback symptoms in affected trees. The pathogens were previously recorded in Lebanon on grapevine or citrus crops (Saad and Nienhaus, 1969; Choueiri et al., 2006).

On the other hand, *S. pannosa*, the causal agent of powdery mildew on peach in Lebanon (Khouzami et al., 1996), was recorded for the first time on almond in this survey. *Cytospora chrysosperma*, associated with trunk canker of poplar trees in Bekaa district of Lebanon (Saad and Nienhaus, 1969), was also found on almond in BH district.

#### ▪ New Distributions on Almond

This is the first report of *Wilsonomyces carpophilus* on almond in BH and BE districts.

### 7.2. Apricot (*Prunus armeniaca*)

A total of 50 apricot sites were sampled from most Lebanese districts, predominately from Baalbeck-Hermel (90.0%). From these sites, eight fungal species were detected (Table 7.2). Among these, three were new to Lebanon (Table 7.2; bold text and red background); two were primary pathogens and one was a saprophyte.

Three fungal species were new host records (Table 7.2; grey background); two were primary and one was a saprophyte.

Of the fungal species or genera previously known to occur on apricot in Lebanon, two were recovered in this survey: *Monilinia laxa*, causal agent of brown disease on stone fruits (4.0%) and *Wilsonomyces carpophilus*, causal agent of shot hole (10.0%).

Two primary fungal species on apricot in Lebanon were not noted during this survey: *Rosellinia necatrix*, causal agent of white root rot disease of fruit trees (Khouzami et al., 1996) and *Tranzschelia pruni-spinosae* causing rust disease on apricot (Saad and Nienhaus, 1969).

#### ▪ New to Lebanon on Apricot

Three fungal species new to Lebanon were recorded on apricot in this survey.

**Primary:** *Leucostoma cincta* (*Cytospora cincta*) and *Leucostoma personii* (*Cytospora leucostoma*).

These species are economically important primary pathogens responsible for Leucostoma canker disease of stone fruits. The disease appears as cankers on one-year-old shoots accompanied with gum exudates that later provoke dieback (Biggs

and Grove, 2005). *Cytospora cincta* was found in one sample of apricot from NL district, whereas *C. leucostoma* was isolated from one sample in BH district.

**Saprophyte:** *Pleospora herbarum*. The species is common saprophyte in the wood of fruit trees.

#### ▪ New Host Recordings for Apricot

Three fungal species were reported for the first time on apricot: *Alternaria alternata*, '*Botryosphaeria*' *rhodina* (*Botryodiplodia theobromae*) and *Sphaerotheca pannosa*.

The first is a saprophyte in the wood; previously recorded on vegetables in Lebanon (Khouzami et al., 1996), while *S. pannosa*, the causal agent of powdery mildew of stone fruits was reported on peach from Lebanon (Saad and Nienhaus, 1969). In addition, *B. theobromae* is a common primary pathogen of lemon and orange in Lebanon (Saad and Nienhaus, 1969), causing twig dieback.

### 7.3. Cherry (*Prunus avium*)

A total of 51 cherry sites were sampled from most Lebanese districts, predominately from Baalbeck-Hermel (62.8%) and Bekaa (25.5%). From these sites, four fungal species were detected (Table 7.3). Among these, three were new to Lebanon (Table 7.3; bold text and red background); two were primary pathogens and one was a saprophyte. One fungal saprophytic species was a new host record (Table 7.3; grey background).

Two primary fungal species on cherry in Lebanon were not noted during this survey: *Monilinia laxa*, causal agent of brown disease on stone fruits and *Wilsonomyces carpophilus*, causal agent of shot hole (Saad and Nienhaus, 1969; Khouzami et al., 1996).

#### ▪ New to Lebanon on Cherry

Three fungal species new to Lebanon were recorded on cherry in this survey.

**Primary:** *Cercospora circumscissa* and *Leucostoma cincta* (*Cytospora cincta*).

As indicated for apricot, *L. cincta* is economically important primary pathogen of stone fruits. The pathogen can provoke twig dieback and therefore considerably reduce the yield. The pathogen was recovered in three cherry sites (5.9%) located in ML and BH districts.

On the other hand, *Cercospora circumscissa*, causing Cercospora leaf spot disease of cherries worldwide, was widespread in Lebanese cherry orchards with an incidence of 45.1%.

**Saprophyte:** *Geotrichum candidum*. The species is a common saprophyte in the wood of fruit trees.

#### ▪ New Host Recordings for Cherry

One fungal species was reported for the first time on cherry: *Alternaria alternata*. The species is a saprophyte in wood; previously recorded on vegetables in Lebanon (Khouzami et al., 1996).

#### 7.4. Peach (*Prunus persica*)

A total of 100 peach sites were sampled from all Lebanese districts. From these sites, 21 fungal species were detected (Table 7.4). Among these, ten were new to Lebanon (Table 7.4; bold text and red background); four were primary pathogens, five were saprophytes and one was secondary.

Three fungal species were new host records (Table 7.4; grey background); two were primary and one was saprophyte.

One taxon was classified as having unknown nature of association because the species level of identification was not possible.

Of the fungal species or genera previously known to occur on peach in Lebanon, six were recovered in this survey. The most commonly detected base record species were *Sphaerotheca pannosa*, causal agent of powdery mildew (53.0%) and *Wilsonomyces carpophilus*, causal agent of shot hole (48.0%). Other primary base record species were also found in this survey, such as *Verticillium dahliae* and *Tranzschelia prunispinosae*.

Three primary fungal species previously reported on peach in Lebanon were not detected during this survey: *Cladosporium carpophilum*, causal agent of peach scab, *Monilinia laxa*, causal agent of brown rot of stone fruits and *Rosellinia necatrix* causing white root rot disease (Saad and Nienhaus, 1969; Khouzami et al., 1996). Further monitoring may be required during the growing season to confirm the presence of these species.

#### ▪ New to Lebanon on Peach

Ten fungal species new to Lebanon were recorded on peach in this survey.

**Primary:** *Leucostoma cincta* (*Cytospora cincta*), *Leucostoma persoonii* (*Cytospora leucostoma*), *Phoma pomorum* var. *pomorum* and *Phomopsis amygdali*.

The importance of these species is their ability to cause dieback and cankers in affected twigs.

Both *Leucostoma* species are economically important pathogens causing Leucostoma canker of stone fruits. These were detected in four peach sites (Biggs and Grove, 2005). *Phomopsis amygdali*, mainly found on almond worldwide (Diogo et al., 2010), was isolated from a peach sample collected from Nabatiyeh district. In addition, *P. pomorum*, which can cause canker and dieback, was recovered in one site in Mount Lebanon.

**Saprophyte:** *Acremonium* sp., *Bionectria ochroleuca*, *Cladosporium cladosporioides*, *Pleospora herbarum* and *Ulocladium botrytis*. All these species are common saprophytes frequently found in the wood of fruit trees.

**Secondary:** *Geotrichum candidum*. This species was isolated from the wood of peach tree and may cause sour rot on peach fruits.

#### ▪ New Host Recordings for Peach

Three fungal species were reported for the first time on peach: *Alternaria alternata*, *Glomerella cingulata* (*Colletotrichum gloeosporioides*) and *Phytophthora cactorum*.

*Alternaria alternata* was isolated from 9.0% of the visited peach sites and in all cases was found as saprophyte in the wood. *Glomerella cingulata*, a common primary pathogen causing twig dieback of citrus in Lebanon, was recovered in one site in South Lebanon.

Furthermore, *Phytophthora cactorum*, previously reported on loquat in Lebanon (Khouzami et al., 1996), was found to cause crown rot of peach in BH and BE districts. The infection by *P. cactorum* evolves into a general decline and death of affected trees.

### 7.5. Plum (*Prunus domestica*)

A total of 39 plum sites were sampled from most Lebanese districts. From these sites, 13 fungal species were detected (Table 7.5). Among these, six were new to Lebanon (Table 7.5; bold text and red background); three were primary pathogens and three were saprophytes.

Four fungal species were new host records (Table 7.5; grey background); three were primary pathogens and one was primary / saprophyte.

One taxon was classified as having unknown nature of association because the species level of identification was not possible.

Of the fungal species or genera previously known to occur on plum in Lebanon, three were recovered in this survey. The most commonly detected base record species were *Wilsonomyces carpophilus*, causal agent of shot hole (20.5%) and *Tranzschelia pruni-spinosae* var. *discolor*, causal agent of rust (15.4%).

Two primary fungal species on plum in Lebanon were not noted during this survey: *Monilinia fructicola*, the causal agent of brown rot and *Rosellinia necatrix*, causal agent of white root rot of fruit trees (Saad and Nienhaus, 1969; Khouzami et al., 1996).

#### ▪ New to Lebanon on Plum

Six fungal species new to Lebanon were recorded on plum in this survey.

**Primary:** *Leptosphaeria coniothyrium* (*Microsphaeropsis fuckelii*), *Leucostoma cincta* (*Cytospora cincta*) and *Phoma pomorum* var. *pomorum*.

The importance of these species is their ability to cause dieback and cankers in affected twigs. The three primary pathogens on plum were detected in samples collected from NL district.

**Saprophyte:** *Acremonium* sp., *Bionectria ochroleuca* and *Cladosporium cladosporioides*. All these species are common saprophytes frequently found in the wood of fruit trees.

### ▪ New Host Recordings for Plum

Four fungal species were reported for the first time on plum: *Alternaria alternata*, *Phytophthora cactorum*, *Sphaerotheca pannosa* and *Wilsonomyces carpophilus*.

Except *A. alternata*, these species are primary pathogens on plum. *Alternaria alternata* was recovered in 12.8% of plum sites. This species caused leaf spots and was found as saprophyte in wood.

The most widespread fungal species on plum was *Wilsonomyces carpophilus* (20.5%), the causal agent of shot hole. The species was previously reported on all stone fruit crops except plum (Saad and Nienhaus, 1969; Khatib et al., 1970; Khouzami et al., 1996). In addition, *S. pannosa*, previously reported on peach and roses (Khatib et al., 1970; Khouzami et al., 1996), was found associated to plum in AK and NL districts.

An important finding was the recovery of *Phytophthora cactorum* in one plum site from BE district. *Phytophthora cactorum*, previously reported on loquat in Lebanon (Khouzami et al., 1996), may cause general decline and death of affected trees.

### ▪ New Distributions on Plum

*Tranzschelia pruni-spinosae* var. *discolor* was detected for the first time on plum in NA district.

## 7.6. General Results and Discussion

This report contains a comprehensive list of the fungal diseases affecting stone fruit crops in Lebanon. The latest publication concerning fungal diseases affecting these crops dates from 1969, when the authors have identified the major diseases affecting all crops in Lebanon (Saad and Nienhaus, 1969). Later on, other reports had listed the diseases of stone fruits, however, in most cases, these reports were not based on scientific approach, and therefore they might have been unreliable and the identification could be erratic.

From October 2011 till October 2012, a total of 472 samples of symptomatic organs were collected from 329 stone fruit sites. From these, 366 fungal specimens were identified directly from the infected tissues and/or following isolation on appropriate culture medium. Fungal specimens belonged to 26 different species and five genera.

In general, 14 species were reported for the first time in Lebanon during this survey, eight of which are primary pathogens. Also, 10 fungal species were new host records on their respective host plant (Refer to tables below).

### Distribution of fungal species new to Lebanon on stone fruit sites

| Fungal Species                           | Number of sites |         |        |       |      | Total |
|--|-----------------|---------|--------|-------|------|-------|
|  | Almond          | Apricot | Cherry | Peach | Plum |       |
| <i>Acremonium</i> sp.                    | -               | -       | -      | 1     | 1    | 2     |
| <i>Bionectria ochroleuca</i>             | 3               | -       | -      | 1     | 1    | 5     |
| <i>Botryosphaeria dothidea</i>           | 1               | -       | -      | -     | -    | 1     |
| <i>Botryosphaeria parva</i>              | 1               | -       | -      | -     | -    | 1     |
| <i>Cercospora circumscissa</i>           | -               | -       | 23     | -     | -    | 23    |
| <i>Cladosporium cladosporioides</i>      | 6               | -       | -      | 2     | 1    | 9     |
| <i>Geotrichum candidum</i>               | 1               | -       | 1      | 2     | -    | 4     |
| <i>Leptosphaeria coniothyrium</i>        | 1               | -       | -      | -     | 1    | 2     |
| <i>Leucostoma cincta</i>                 | -               | 1       | 3      | 3     | 1    | 8     |
| <i>Leucostoma persoonii</i>              | -               | 1       | -      | 1     | -    | 2     |
| <i>Phoma pomorum</i> var. <i>pomorum</i> | -               | -       | -      | 1     | 1    | 2     |
| <i>Phomopsis amygdali</i>                | 3               | -       | -      | 1     | -    | 4     |
| <i>Pleospora herbarum</i>                | 2               | 1       | -      | 2     | -    | 5     |
| <i>Ulocladium botrytis</i>               | -               | -       | -      | 1     | -    | 1     |

### Distribution of new host fungal species records on stone fruit sites

| Fungal Species                  | Number of sites |         |        |       |      | Total |
|---------------------------------|-----------------|---------|--------|-------|------|-------|
|                                 | Almond          | Apricot | Cherry | Peach | Plum |       |
| <i>Alternaria alternata</i>     | 26              | 1       | 2      | 9     | 5    | 43    |
| <i>Botryosphaeria obtusa</i>    | 1               | -       | -      | -     | -    | 1     |
| <i>Botryosphaeria rhodina</i>   | 1               | 1       | -      | -     | -    | 2     |
| <i>Botryotinia fuckeliana</i>   | 2               | -       | -      | -     | -    | 2     |
| <i>Eutypa lata</i>              | 1               | -       | -      | -     | -    | 1     |
| <i>Glomerella cingulata</i>     | -               | -       | -      | 1     | -    | 1     |
| <i>Phytophthora cactorum</i>    | -               | -       | -      | 2     | 1    | 3     |
| <i>Sphaerotheca pannosa</i>     | 4               | 2       | -      | -     | 2    | 8     |
| <i>Valsa sordida</i>            | 1               | -       | -      | -     | -    | 1     |
| <i>Wilsonomyces carpophilus</i> | -               | -       | -      | -     | 8    | 8     |

The most widespread fungal pathogens in Lebanon were *Wilsonomyces carpophilus* and *Sphaerotheca pannosa*. The first, *W. carpophilus* (Syn. *Coryneum beijerinckii*), the causal agent of shot hole disease of stone fruits, was detected on almond (31.8%), apricot (10.0%), peach (48.0%) and plum (20.5%). On the other hand, *S. pannosa*, the causal agent of powdery mildew, was detected primarily on peach (53%) and rarely on almond (4.5%), apricot (4.0%) and plum (5.1%). Both pathogens were encountered in all the Lebanese districts.

*Cercospora circumscissa*, the causal agent of cherry leaf spot disease was detected in 45.1% of visited cherry sites. Under favorable conditions, the pathogen can cause severe defoliation of affected trees. This is the first report of the pathogen in Lebanon.

One of the most notable results of the present survey is the detection of *Cytospora* species on all stone fruit crops. On almond, *Valsa sordida* (*Cytospora chrysosperma*), previously reported on poplar in Lebanon (Saad and Nienhaus, 1969), was detected in one site in BH district. Valsa canker of poplar is an important disease threatening ecological, environmental and commercial forest damage. *Valsa sordida* is a facultative parasite, and its invasion and spread are restricted by environmental factors (Yang et al., 1994). In this survey, the pathogen was isolated from canker affected branches.

In addition, *Leucostoma cincta* (*Cytospora cincta*) and *L. persoonii* (*C. leucostoma*), the causal agents of Leucostoma canker disease of stone fruits were reported for the first time in Lebanon in this survey. Leucostoma pathogens can invade the host only if the host is predisposed to infection through mechanical wounding or freeze injury. In mature peach and nectarine orchards where *L. cinctum* is the primary pathogen, many new infections appear at the nodes on one-year-old shoots. The pathogen enters the node through leaf scars or dead buds during the dormant season. Small twigs killed by *L. cinctum* are pathways by which the pathogen can reach older limbs and initiate cankers that may then result in death of large portions of the tree. Many new infections also take place at pruning wounds, and the fungus most often isolated at these sites is *L. persoonii* (Biggs and Grove, 2005). Usually the first external symptom of such cankers is the excessive production of amber-colored gum. As the canker ages, the gum becomes dark brown, and the infected bark dries and cracks open exposing blackened tissue beneath.

It is very difficult to manage this disease once it is well established. Regular monitoring of susceptible plants, proper pruning and sanitation should be a priority for all stone fruits commercial growers.

Furthermore, four fungal species belonging to the family Botryosphaeriaceae were found in this survey. These were: '*Botryosphaeria*' *rhodina* (*Lasiodiplodia theobromae*) on almond and apricot; *B. dothidea* (*Fusicoccum aesculi*), '*B.*' *parva* (*Neofusicoccum parvum*) and '*B.*' *obtusum* (*Diplodia seriata*) on almond. The distribution of these species was limited because each of the species was detected in only one visited site.

Species of Botryosphaeriaceae are important pathogens on many woody plants, causing fruit rots, frog-eye leaf spot, stem and branch cankers, gummosis, dieback and in some cases tree death (Slippers et al. 2007). Infection takes place either through wounds, or directly through the stomata and other openings (Kim et al. 2001). These fungi can then persist in healthy tissue. Successful infection and susceptibility of infected trees is closely linked to environmental conditions, where high temperatures, water logging and other forms of stress favour infection (Ahimera et al. 2003).

Effective management of diseases caused by species of Botryosphaeriaceae is achieved through integrated control strategies, which take into account cultivar susceptibility, environmental conditions, tree management and chemical (Beckman et al. 2003). This effective control requires knowledge regarding the taxonomy and epidemiology of the pathogen involved. Furthermore, due to enhanced quarantine requirements, correct identification of the fungal pathogens that affect stone fruit crops has become increasingly important in the export of fruit products.

On the other hand, *Phomopsis amygdali*, the causal agent of twig canker and blight of almond and peach wherever these hosts are grown (Diogo et al. 2010), was detected in three almond sites in AK district and one peach site in NA district. The species was also reported on grapevine from South Africa (Mostert et al. 2001). Results of pathogenicity trials indicate that this species could potentially be a serious grapevine pathogen (van Niekerk et al. 2005).

An important finding was the recovery of *Phytophthora cactorum*, causing crown rot and general decline on peach and plum in BE and BH districts. *Phytophthora cactorum* has an extremely wide host range and one of the most economically significant diseases it causes is root, crown and collar rot of woody species, in particular apples and pears. All *Prunus* species are major hosts of this pathogen. It is very widely distributed in temperate regions of the world, being recorded on every continent except Antarctica. According to EPPO (2006), the species is widespread in Lebanon; however, available scientific publications have reported its presence only on loquat (Khouzami et al. 1998).

Verticillium wilt caused by *Verticillium dahliae* is a destructive disease attacking vegetable crops and fruit trees. Even though the species was not recovered from almond in this survey, there is a strong evidence on its widespread presence in Lebanon on this crop (Makhlouf and Geagea, 2005; Saad et al. 2009). In the present survey, the pathogen was isolated from peach in BE district.

Eutypa dieback, caused by the fungus *Eutypa lata*, is a major trunk disease of grapevines. In this survey, the pathogen was recovered in one almond site. *Eutypa lata* can infect 88 species of plants including stone fruit, pome fruit, citrus, fig, olive, pistachio, walnut, quince, poplar, and rose (Carter, 1991). The most commonly seen symptoms are stunted and deformed shoots, accompanied with cankers and internal brown, wedge-shaped necrotic area in the vascular symptom. The disease can be controlled by protecting wounds from infection by *E. lata* spores or by physically removing infected wood.

*Leptosphaeria coniothyrium* is particularly important as wound pathogen and can infect all species in the genus *Rubus*, roses, juniper and other perennials and woody plants. *Prunus* species are considered minor hosts (Punithalingam, 1980). In this survey, the pathogen was detected on almond and plum causing cankers on affected twigs.

*Colletotrichum gloeosporioides* (*Glomerella cingulata*) is a common saprobe and opportunistic invader of dead or damaged plant material, although there are many aggressively pathogenic forms which are morphologically indistinguishable. It can be frequently isolated from apparently healthy tissue of crops and exists both as an endophyte and as a constituent of the plant surface microflora. On peach and almond, the species is able to infect ripening fruits causing typical anthracnose lesions of dark, sunken and circular necrotic tissues (Peres et al. 2005). In the present survey, the species was detected in one peach site.



Other fungal species having less economic importance on stone fruits were also reported in Lebanon, namely *Geotrichum candidum* and *Pleospora herbarum* (*Stemphylium herbarum*). The first is the causal agent of citrus and peach sour rot diseases and the latter may cause leaf blights on *Allium* sp.

**Table 7.1 Distribution of fungi on Almond (*Prunus amygdali*)**

| Fungal species   | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|--|-----------------------|-------------------|----|----|----|----|----|----|-------|
|  |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed   |                       | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Alternaria alternata</i>  | Primary or saprophyte | 12                | 9  | 1  | 2  | 0  | 1  | 1  | 26    |
| <i>Alternaria</i> sp.  | Unknown               |                   |    | 1  |    |    |    |    | 1     |
| <i>Bionectria ochroleuca</i> ( <i>Gliocladium roseum</i> )                   | Saprophyte            | 1                 | 1  |    | 1  |    |    |    | 3     |
| <i>Botryosphaeria dothidea</i> ( <i>Fusicoccum aesculi</i> )                 | Primary               | 1                 |    |    |    |    |    |    | 1     |
| ' <i>Botryosphaeria</i> ' <i>obtus</i> ( <i>Diplodia seriata</i> )           | Potential primary     |                   |    |    |    |    | 1  |    | 1     |
| ' <i>Botryosphaeria</i> ' <i>parva</i> ( <i>Neofusicoccum parvum</i> )       | Primary               |                   |    |    |    |    |    | 1  | 1     |
| ' <i>Botryosphaeria</i> ' <i>rhodina</i> ( <i>Lasiodiplodia theobromae</i> ) | Primary               | 1                 |    |    |    |    |    |    | 1     |
| <i>Botryotinia fuckeliana</i> ( <i>Botrytis cinerea</i> )                    | Secondary             |                   | 2  |    |    |    |    |    | 2     |
| <i>Cladosporium cladosporioides</i>  | Saprophyte            | 2                 | 3  |    | 1  |    |    |    | 6     |
| <i>Eutypa lata</i>   | Primary               |                   | 1  |    |    |    |    |    | 1     |
| <i>Geotrichum candidum</i>   | Saprophyte            |                   | 1  |    |    |    |    |    | 1     |
| <i>Leptosphaeria coniothyrium</i> ( <i>Microsphaeropsis fuckelii</i> )       | Primary               |                   | 1  |    |    |    |    |    | 1     |
| <i>Penicillium</i> sp.   | Secondary             |                   | 1  |    |    |    |    |    | 1     |
| <i>Phomopsis amygdali</i>  | Primary               | 3                 |    |    |    |    |    |    | 3     |
| <i>Pleospora herbarum</i> ( <i>Stemphylium herbarum</i> )                    | Saprophyte            | 2                 |    |    |    |    |    |    | 2     |

| Fungal species  | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-----------------------|-------------------|----|----|----|----|----|----|-------|
|   |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                                    |                       | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <i>Polystigma ochraceum</i>                             | Primary               | 6                 | 5  | ●  | ●  |    | 2  |    | 13    |
| <i>Rhizoctonia</i> sp.                                  | Unknown               |                   | 1  |    |    |    |    |    | 1     |
| <i>Sphaerotheca pannosa</i>                             | Primary               | 3                 |    | 1  |    |    |    |    | 4     |
| <i>Stemphilium</i> sp.                                  | Unknown               |                   | 1  |    |    |    |    |    | 1     |
| <i>Taphrina deformans</i>                               | Primary               | 2                 |    | 1  | 1  |    | 1  |    | 5     |
| <i>Tranzschelia pruni-spinosae</i> var. <i>discolor</i> | Primary               | 4                 |    |    | 1  |    | 1  |    | 6     |
| <i>Valsa sordida</i> ( <i>Cytospora chrysosperma</i> )  | Primary               |                   | 1  |    |    |    |    |    | 1     |
| <i>Verticillium dahliae</i>                             | Primary               |                   | ●  | ●  |    |    |    |    | 0     |
| <i>Wilsonomyces carpophilus</i>                         | Primary               | 13                | 11 | 2  | 1  |    | 1  |    | 28    |

|   |   |          |                     |          |   |
|---|---|----------|---------------------|----------|---|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | <b>n</b> | New distribution in Lebanon             |
| n | Previously recorded on this host and in this survey | <b>n</b> | New host in Lebanon | n:       | No. of sites at which organism recorded |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 7.2 Distribution of fungi on Apricot (*Prunus armeniaca*)**

| Fungal species   | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|--|-----------------------|-------------------|----|----|----|----|----|----|-------|
|  |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed   |                       | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 50    |
| <i>Alternaria alternata</i>  | Saprophyte            |                   | 1  |    |    |    |    |    | 1     |
| ' <i>Botryosphaeria</i> ' <i>rhodina</i> ( <i>Lasiodiplodia theobromae</i> ) | Primary               | 1                 |    |    |    |    |    |    | 1     |
| <b><i>Leucostoma cincta</i> (<i>Cytospora cincta</i>)</b>                    | <b>Primary</b>        |                   |    |    |    |    | 1  |    | 1     |
| <b><i>Leucostoma persoonii</i> (<i>Cytospora leucostoma</i>)</b>             | <b>Primary</b>        |                   | 1  |    |    |    |    |    | 1     |
| <i>Monilinia laxa</i> ( <i>Monilia laxa</i> )                                | Primary               |                   | 1  |    |    |    | 1  |    | 2     |
| <b><i>Pleospora herbarum</i> (<i>Stemphylium herbarum</i>)</b>               | <b>Saprophyte</b>     | 1                 |    |    |    |    |    |    | 1     |
| <i>Rosellinia necatrix</i>   | Primary               |                   | •  | •  |    |    | •  |    | 0     |
| <i>Sphaerotheca pannosa</i>  | Primary               | 1                 | 1  |    |    |    |    |    | 2     |
| <i>Tranzschelia pruni-spinosae</i>   | Primary               |                   |    |    |    |    | •  |    | 0     |
| <i>Wilsonomyces carpophilus</i>  | Primary               |                   | 4  |    |    |    | 1  |    | 5     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| • | Previously recorded on this host                    | n | New to Lebanon      | n  | New distribution in Lebanon             |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon | n: | No. of sites at which organism recorded |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 7.3 Distribution of fungi on Cherry (*Prunus avium*)**

| Fungal species                                       | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|--|-----------------------|-------------------|----|----|----|----|----|----|-------|
|  |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                                 |                       | 1                 | 32 | 13 | 3  | 1  | 1  | 0  | 51    |
| <i>Alternaria alternata</i>                          | Saprophyte            |                   |    | 1  |    | 1  |    |    | 2     |
| <i>Cercospora circumscissa</i>                       | Primary               |                   | 17 | 3  | 2  | 1  |    |    | 23    |
| <i>Geotrichum candidum</i>                           | Saprophyte            |                   | 1  |    |    |    |    |    | 1     |
| <i>Leucostoma cincta</i> ( <i>Cytospora cincta</i> ) | Primary               |                   | 2  |    | 1  |    |    |    | 3     |
| <i>Monilinia laxa</i> ( <i>Monilia laxa</i> )        | Primary               |                   | •  | •  | •  |    |    |    | 0     |
| <i>Wilsonomyces carpophilus</i>                      | Primary               |                   | •  | •  |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| • | Previously recorded on this host                    | n | New to Lebanon      | n  | New distribution in Lebanon             |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon | n: | No. of sites at which organism recorded |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 7.4 Distribution of fungi on Peach (*Prunus persica*)**

| Fungal species  | Nature of association | Lebanon Districts |          |    |          |          |          |          | Total    |
|---|-----------------------|-------------------|----------|----|----------|----------|----------|----------|----------|
|   |                       | AK                | BH       | BE | ML       | NA       | NL       | SL       |          |
| Total sites surveyed  |                       | 11                | 27       | 20 | 18       | 8        | 12       | 4        | 100      |
| <b><i>Acremonium</i> sp.</b>  | <b>Saprophyte</b>     |                   |          |    |          |          |          | <b>1</b> | <b>1</b> |
| <i>Alternaria alternata</i>   | Saprophyte            | 1                 | 1        |    | 2        | 3        | 1        | 1        | 9        |
| <i>Alternaria</i> sp.   | Saprophyte            |                   | 1        |    |          | 1        |          |          | 2        |
| <b><i>Bionectria ochroleuca</i> (<i>Gliocladium roseum</i>)</b>       | <b>Saprophyte</b>     |                   |          |    |          |          | <b>1</b> |          | <b>1</b> |
| <i>Chondrostereum purpureum</i>                                       | Primary               |                   | 1        |    |          |          |          |          | 1        |
| <i>Cladosporium carpophilum</i>                                       | Primary               |                   | •        | •  | •        |          |          |          | 0        |
| <b><i>Cladosporium cladosporioides</i></b>                            | <b>Saprophyte</b>     | <b>1</b>          |          |    |          |          |          | <b>1</b> | <b>2</b> |
| <b><i>Geotrichum candidum</i></b>                                     | <b>Secondary</b>      |                   | <b>1</b> |    | <b>1</b> |          |          |          | <b>2</b> |
| <i>Glomerella cingulata</i> ( <i>Colletotrichum gloeosporioides</i> ) | Primary               |                   |          |    |          |          |          | 1        | 1        |
| <b><i>Leucostoma cincta</i> (<i>Cytospora cincta</i>)</b>             | <b>Primary</b>        |                   | <b>1</b> |    | <b>2</b> |          |          |          | <b>3</b> |
| <b><i>Leucostoma persoonii</i> (<i>Cytospora leucostoma</i>)</b>      | <b>Primary</b>        |                   |          |    |          |          | <b>1</b> |          | <b>1</b> |
| <i>Monilinia laxa</i> ( <i>Monilia laxa</i> )                         | Primary               |                   | •        | •  | •        |          |          |          | 0        |
| <b><i>Phoma pomorum</i> var. <i>pomorum</i></b>                       | <b>Primary</b>        |                   |          |    | <b>1</b> |          |          |          | <b>1</b> |
| <b><i>Phomopsis amygdali</i></b>                                      | <b>Primary</b>        |                   |          |    |          | <b>1</b> |          |          | <b>1</b> |
| <i>Phytophthora cactorum</i>  | Primary               |                   | 1        | 1  |          |          |          |          | 2        |

| Fungal species  | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-----------------------|-------------------|----|----|----|----|----|----|-------|
|   |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                                      |                       | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| <i>Pleospora herbarum</i> ( <i>Stemphylium herbarum</i> ) | Saprophyte            |                   |    |    | 1  |    | 1  |    | 2     |
| <i>Rosellinia necatrix</i>                                | Primary               | ●                 | ●  | ●  | ●  | ●  | ●  | ●  | 0     |
| <i>Sphaerotheca pannosa</i>                               | Primary               | 5                 | 14 | 3  | 14 | 4  | 11 | 2  | 53    |
| Sterile basidiomycete                                     | Unknown               | 1                 |    |    |    |    |    |    | 1     |
| <i>Taphrina deformans</i>                                 | Primary               | 2                 |    | 1  | 6  | 4  |    |    | 13    |
| <i>Tranzschelia pruni-spinosae</i> var. <i>discolor</i>   | Primary               |                   |    |    |    | 1  |    |    | 1     |
| <i>Ulocladium botrytis</i>                                | Saprophyte            |                   | 1  |    |    |    |    |    | 1     |
| <i>Verticillium dahliae</i>                               | Primary               |                   |    | 1  |    |    |    |    | 1     |
| <i>Wilsonomyces carpophilus</i>                           | Primary               | 6                 | 11 | 4  | 7  | 6  | 11 | 2  | 48    |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n  | New distribution in Lebanon             |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon | n: | No. of sites at which organism recorded |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

Table 7.5 Distribution of fungi on Plum (*Prunus domestica*)

| Fungal species  | Nature of association | Lebanon Districts |    |    |    |          |          |    | Total    |
|---|-----------------------|-------------------|----|----|----|----------|----------|----|----------|
|   |                       | AK                | BH | BE | ML | NA       | NL       | SL |          |
| Total sites surveyed  |                       | 7                 | 4  | 5  | 10 | 3        | 10       | 0  | 39       |
| <b><i>Acremonium</i> sp.</b>  | <b>Saprophyte</b>     |                   |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <i>Alternaria alternata</i>   | Primary or saprophyte | 2                 |    |    | 1  |          | 2        |    | 5        |
| <i>Alternaria</i> sp.   | Unknown               | 1                 |    |    |    |          |          |    | 1        |
| <b><i>Bionectria ochroleuca</i> (<i>Gliocladium roseum</i>)</b>             | <b>Saprophyte</b>     | <b>1</b>          |    |    |    |          |          |    | <b>1</b> |
| <b><i>Cladosporium cladosporioides</i></b>                                  | <b>Saprophyte</b>     |                   |    |    |    | <b>1</b> |          |    | <b>1</b> |
| <b><i>Leptosphaeria coniothyrium</i> (<i>Microsphaeropsis fuckelii</i>)</b> | <b>Primary</b>        |                   |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <b><i>Leucostoma cincta</i> (<i>Cytospora cincta</i>)</b>                   | <b>Primary</b>        |                   |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <i>Monilinia fructicola</i> ( <i>Monilia fructicola</i> )                   | Primary               |                   | •  | •  |    |          |          |    | 0        |
| <i>Penicillium</i> sp.  | Secondary             | 1                 |    |    |    |          |          |    | 1        |
| <b><i>Phoma pomorum</i> var. <i>pomorum</i></b>                             | <b>Primary</b>        | <b>1</b>          |    |    |    |          | <b>1</b> |    | <b>1</b> |
| <i>Phytophthora cactorum</i>  | Primary               |                   |    | 1  |    |          |          |    | 1        |
| <i>Rosellinia necatrix</i>  | Primary               |                   | •  | •  |    |          |          |    | 0        |
| <i>Sphaerotheca pannosa</i>   | Primary               | 1                 |    |    |    |          | 1        |    | 2        |
| <i>Tranzschelia pruni-spinosae</i> var. <i>discolor</i>                     | Primary               | 2                 |    |    | 2  | 1        | 1        |    | 6        |
| <i>Wilsonomyces carpophilus</i>   | Primary               | 4                 |    | 1  | 2  |          | 1        |    | 8        |

|   |   |          |                     |          |   |
|---|---|----------|---------------------|----------|---|
| • | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | <b>n</b> | New distribution in Lebanon             |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon | n:       | No. of sites at which organism recorded |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon



## 8. Results and Discussion: Bacteria

Several pathogenic bacteria were detected on stone fruit crops in this survey. They caused serious problems in old neglected properties but are seldom of importance in well managed orchards where regular disease control measures are applied. The majority of orchards contain old trees and sometimes a mixture of different crops. The higher prevalence of bacterial canker was detected on cherries, and had a large distribution in Bekaa and Mount Lebanon as showed in this survey. Other crops such as peach and almonds show a low level of bacterial damage. Also a range of saprophytic bacteria belonging to *Pseudomonas* sp. was detected for the first time in this survey.

Some bacteria species previously reported in Lebanon (Saad & Nienhaus 1969) were not recovered during this survey, such as *Agrobacterium tumefaciens* on plum and *Xanthomonas pruni* on almond and peach.

### 8.1. Almond (*Prunus amygdalus*)

One species of bacteria, *Pseudomonas syringae* pv. *syringae* was detected on almond crop in Akkar district.

### 8.2. Apricot (*Prunus armeniaca*)

No pathogenic bacterium was recorded. *Pseudomonas fluorescens*, a saprophyte, is recorded for the first time on apricot.

### 8.3. Cherry (*Prunus avium*)

Three species of saprophytic bacteria, *Pseudomonas fluorescens*, *Pseudomonas putida* and *Pseudomonas aeruginosa* were detected in Bekaa and Mount Lebanon; furthermore, fifteen pathogenic bacteria, belonging to *Pseudomonas syringae* pv. *syringae* (previously recorded) were detected in Nabatiyeh (1 site), Bekaa (10 sites) and Mount Lebanon (4 sites).

### 8.4. Peach (*Prunus persica*)

No bacterial growth was detected in a sample of peach from Akkar region. Only one sample was infected by *Pseudomonas syringae* pv. *morsprunorum* (previously recorded) in Mount Lebanon.

### 8.5. Plum (*Prunus domestica*)

From three samples of infected plum, only one from North Lebanon showed bacterial canker symptoms caused by *Pseudomonas syringae* pv. *syringae* (previously recorded).

## 8.6. General Results and Discussion

A serious bacterial damage was detected on cherries with a wide prevalence. The climate conditions in Bekaa valley and Mount Lebanon area is suitable for the development of bacterial canker caused by *Pseudomonas syringae* pv. *syringae* because the bacterial proliferation is more significant in wetter season. Moreover, it seems that the cultivars are not resistant to this bacterium. The same pathovar has been isolated from the almond crop.

Another bacterial canker, caused by *Pseudomonas syringae* pv. *morsprunorum* had been detected on peach crop in Mount Lebanon but in a limited distribution.

Other pathogenic species such as *Xanthomonas arboricola*, *Agrobacterium tumefaciens* and *Xylella fastidiosa* were not detected in this survey.

On another side, many saprophyte bacteria, belonging to *Pseudomonas* species had been isolated for the first time in this survey.

**Table 8.1 Distribution of bacteria on Almond (*Prunus amygdali*)**

| Bacteria species                      | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|---------------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                       |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed                  |                       | 21                | 43 | 14 | 3  | 4  | 4  | 0  | 89    |
|                                       |                       |                   |    |    |    |    |    |    |       |
| Agrobacterium tumefaciens             | Primary               |                   |    |    |    |    |    |    | 0     |
| Pseudomonas amygdalii                 | Primary               |                   |    |    |    |    |    |    | 0     |
| Pseudomonas syringae pv. morsprunorum | Primary               |                   |    |    |    |    |    |    | 0     |
| Pseudomonas syringae pv. syringae     | Primary               | 1                 |    |    |    |    |    |    | 1     |
| Xanthomonas arboricola pv. pruni ●    | Primary               |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 8.2 Distribution of bacteria on Apricot (*Prunus armeniaca*)**

| Bacteria species                                    | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-----------------------|-------------------|----|----|----|----|----|----|-------|
|   |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                                |                       | 1                 | 44 | 1  | 0  | 1  | 3  | 0  | 50    |
| <i>Agrobacterium tumefaciens</i>                    | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas fluorescens</i>                      | Saprophyte            |                   |    |    | 1  |    |    |    | 1     |
| <i>Pseudomonas syringae</i> pv. <i>morsprunorum</i> | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas syringae</i> pv. <i>syringae</i>     | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Xanthomonas arboricola</i> pv. <i>pruni</i>      | Primary               |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 8.3 Distribution of bacteria on Cherry (*Prunus avium*)**

| Bacteria species                                    | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|---|-----------------------|-------------------|----|----|----|----|----|----|-------|
|   |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed                                |                       | 1                 | 32 | 13 | 3  | 1  | 1  | 0  | 51    |
|   |                       |                   |    |    |    |    |    |    |       |
| <i>Agrobacterium tumefaciens</i>                    | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas aeruginosa</i>                       | Saprophyte            |                   |    |    | 1  |    |    |    | 1     |
| <i>Pseudomonas fluorescens</i>                      | Saprophyte            |                   |    | 1  |    |    |    |    | 1     |
| <i>Pseudomonas putida</i>                           | Saprophyte            |                   |    |    | 1  |    |    |    | 1     |
| <i>Pseudomonas syringae</i> pv. <i>avii</i>         | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas syringae</i> pv. <i>morsprunorum</i> | Primary               |                   | ●  | ●  |    |    |    |    | 0     |
| <i>Pseudomonas syringae</i> pv. <i>syringae</i>     | Primary               |                   |    | 10 | 4  | 1  |    |    | 15    |
| <i>Xanthomonas arboricola</i> pv. <i>pruni</i>      | Primary               |                   |    |    |    |    |    |    | 0     |

|   |   |
|---|---|
| • | Previously recorded on this host                    |
| n | Previously recorded on this host and in this survey |

|   |                     |
|---|---------------------|
| n | New to Lebanon      |
| n | New host in Lebanon |

n: No. of sites at which organism recorded

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 8.4 Distribution of bacteria on Peach (*Prunus persica*)**

| Bacteria species                                    | Nature of association | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-----------------------|-------------------|----|----|----|----|----|----|-------|
|   |                       | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed                                |                       | 12                | 27 | 20 | 18 | 12 | 11 | 3  | 103   |
| <i>Agrobacterium tumefaciens</i>                    | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas syringae</i> pv. <i>morsprunorum</i> | Primary               |                   |    |    | 1  |    |    |    | 1     |
| <i>Pseudomonas syringae</i> pv. <i>persicae</i>     | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Pseudomonas syringae</i> pv. <i>syringae</i>     | Primary               |                   |    |    |    |    |    |    | 0     |
| <i>Xanthomonas arboricola</i> pv. <i>pruni</i>      | Primary               |                   |    |    | ●  |    |    |    | 0     |
| <i>Xylella fastidiosa</i>                           | Primary               |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 8.5 Distribution of bacteria on Plum (*Prunus domestica*)**

| Bacteria species                      | Nature of association | Lebanon Districts |    |    |    |    |    |    |       |
|---------------------------------------|-----------------------|-------------------|----|----|----|----|----|----|-------|
|                                       |                       | AK                | BH | BE | ML | NA | NL | SL | Total |
| Total sites surveyed                  |                       | 8                 | 4  | 5  | 10 | 4  | 9  | 0  | 40    |
|                                       |                       |                   |    |    |    |    |    |    |       |
| Agrobacterium tumefaciens             | Primary               |                   | ●  | ●  |    |    |    |    | 0     |
| Pseudomonas syringae pv. morsprunorum | Primary               |                   |    |    |    |    |    |    | 0     |
| Pseudomonas syringae pv. syringae     | Primary               |                   |    |    |    |    | 1  |    | 1     |
| Xanthomonas arboricola pv. pruni      | Primary               |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |  |
|---|---|---|---------------------|--|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |  |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

## 9. Results and Discussion: Viruses, Viroids and Phytoplasma

Based on all previous surveys conducted on stone fruit crops in Lebanon, Plum bark necrosis stem pitting-associated virus (PBNSPaV) was found as a new virus on almond, cherry and peach in Lebanon. American plum line pattern virus (APLPV) was reported for the first time on peach and plum (new host record for peach and plum) as well as Peach latent mosaic viroid (PLMVd) which was detected for the first time in almond in Lebanon (new host for almond).

A total of 3290 samples were tested by ELISA. There were 1000 samples from 100 peach sites, 880 samples from 88 almond sites, 510 samples from 51 apricot sites, 510 samples from 51 cherry sites and 390 samples from 39 plum sites.

However 251 sites (10 samples / site) were tested by RT-PCR. The sites were distributed as follows: (81 peach sites, 69 almond sites, 37 apricot sites, 35 cherry sites and 29 plum sites).

### Antisera Used for ELISA

Antisera specific to the following viruses were used in this survey:

PNRSV, *Prunus necrotic ringspot Ilarvirus*<sup>1</sup>

PDV, *Prune dwarf Ilarvirus*<sup>1</sup>

ACLSV, *Apple chlorotic leaf spot Trichovirus*<sup>1</sup>

ApMV, *Apple mosaic Ilarvirus*<sup>1</sup>

PPV, *Plum pox Potyvirus*<sup>1</sup>

SLRV, *Strawberry latent ringspot Sadwavirus*<sup>1</sup>

RpRSV, *Raspberry ringspot Nepovirus*<sup>1</sup>

ToRSV, *Tomato ringspot Nepovirus*<sup>1</sup>

CLRV, *Cherry leafroll Nepovirus*<sup>1</sup>

ArMV, *Arabis mosaic Nepovirus*<sup>1</sup>

TRSV, *Tobacco ringspot Nepovirus*<sup>1</sup>

APLPV, *American plum line pattern Ilarvirus*<sup>2\*</sup>

<sup>1</sup>LOEWE, Germany

<sup>2</sup>Agdia, USA

\* *American plum line pattern virus* (APLPV) was tested by ELISA only on Plum and Cherry



### Primers used for PCR

AlmWB, *Phytoplasma Almond witches'-broom disease*, *Candidatus Phytoplasma phoenicium*, Amplified fragment (390 bp) (Abou-Jawdah et al. 2003)

APLPV, *American plum line pattern Ilarvirus*, Amplified fragment (560 bp) (Sanchez-Navarro et al. 2005)

ApLV, *Apricot latent Foveavirus*, Amplified fragment (200 bp) (Nemchinov et al. 1998)

PBNPaV, *Plum bark necrosis stem pitting-associated Ampelovirus*, Amplified fragment (290 bp) (Abou Ghanem-Sabanadzovic et al. 2001)

PLMVd, *Peach latent mosaic Pelamoviroid*, Amplified fragment (315 bp) (Gazel et al. 2008)

HSVd, *Hop stunt viroid Hostuviroid*, Amplified fragment (302 bp) (Levy et al. 1992)

### 9.1. Almond (*Prunus amygdalus*)

PNRSV, PDV, ACLSV and ApMV were detected in almonds (Table 9.1). Samples were collected from 88 sites around Lebanon and PNRSV, PDV, ApMV and ACLSV were detected in 11 (12.5%), 6 (7%), 2 (2.3%) and 1 sites (1.1%), respectively. High levels of virus infection were detected in almond trees sampled from the Baalbeck-Hermel and Bekaa districts, however, for the other districts, the levels of infection were less.

Kanaan-Attallah et al. 2000 found that 3.3%, 2.7%, 2.5% and 1.8% of almonds sampled in Lebanon were infected with PNRSV, ACLSV, PDV and ApMV respectively. In comparison with this Kanaan-Attallah results, the levels of infection were reduced for ACLSV and ApMV, however, the level of PNRSV and PDV has increased in our current study. In an old study, the PNRSV level infection on almonds reached 63%, PDV 28%, while ACLSV and ApMV were not presented (Jawhar et al. 1996).

Of the 88 sites tested by ELISA, 18 (20.4%) were infected by at least one virus. Of the ELISA-positive sites, 16 (88.8%) were infected only by one virus. However 2 sites belonging to Bekaa district (11.2%) were infected by 2 viruses: PNRSV+PDV (Table 9.2).

Three almond sites (3.4%) were infected by *Phytoplasma Almond witches'-broom disease* (AlmWB) (Table 9.1). However, 3 almond sites belonging to Akkar, Baalbeck-Hermel and Bekaa (4.3%) were infected by Plum bark necrosis stem pitting-associated virus (PBNPaV) and 1 site belonging to Bekaa (1.5%) was infected by Peach latent mosaic viroid (PLMVd) (Table 9.2). This finding constitutes that PBNPaV is new to Lebanon and PLMVd is a new host record for almond.

The other viruses (PPV, SLRV, RbRSV, ToRSV, CLRV, ArMV, TRSV and APLPV) and the viroid (HSVd) were not encountered on almond in Lebanon.

## 9.2. Apricot (*Prunus armeniaca*)

ApMV was detected in apricot at 8% (4) of sites, PNRSV at 6% (3) of sites, PDV and ACLSV at 4% (2) of sites (Table 9.3). Almost all viruses detected on apricot trees have been found in Baalbeck-Hermel district (Tables 9.3 and 9.4).

The level of infection by PDV was less to that reported by Jawhar et al. (1996), however PNRSV, ACLSV and ApMV were not reported by Jawhar et al. (1996), but their rate of infection were high in comparison with those found by the Department of Plant Protection (LARI) (Choueiri, unpublished data).

Of the 51 sites tested by ELISA, 9 (17.6%) were infected by at least one virus. Of the ELISA-positive sites, 7 (77.7%) were infected by at least one virus. However, 2 sites (22.2%) have mixed infection (PDV+ApMV) and (PNRSV+PDV).

Three sites (8%) were infected by Apricot latent virus (ApLV) and 4 sites (10.8%) were infected by Hop stunt viroid (HSVd) (Table 9.4). However, 1 site has a mixed infection of ApLV+HSVd. The level of infection of ApMV was higher than that found by Jarrar et al. (2007) which was 1.8%, while the average infection by HSVd was less than that presented by Choueiri et al. (2002) being 28%.

The other viruses (PPV, SLRV, RpRSV, ToRSV, CLRV, ArMV, TRSV and APLPV) and the viroid (HSVd) were not encountered on apricot in Lebanon.

## 9.3. Cherry (*Prunus avium*)

Viruses were detected at 18 of 51 sites tested. High levels of virus infection were detected in cherry trees from Baalbeck-Hermel and Bekaa districts (Table 9.5). PDV occurred at 21.5% (11), followed by PNRSV at 17.6% (9), ACLSV at 7.8% (4) and ApMV at 2% (1) of sites tested.

PDV and PNRSV were the most common viruses detected in Lebanese cherry trees during this survey and this is similar to previous findings (Jawhar et al. 1996, Choueiri et al. 2003). ACLSV was less diffused than PDV and PNRSV confirming previous report of Jawhar et al. (1996). Cherry samples collected from Baalbeck-Hermel showed the highest level of virus infection, followed by those collected from Bekaa, from Mount Lebanon, North Lebanon and Nabatiyeh.

ApMV was found in one site at Baalbeck-Hermel. This is a new host record for cherry.

Mixed infections were found in several sites. The three viruses (PNRSV+PDV+ACLSV) were present in 2 sites of the infected ones (Table 9.6). Combinations of two viruses were also common. PNRSV+PDV were detected in 2 sites while ACLSV+ApMV were found in 1 site.

PBNSPaV tested by RT-PCR was found in two sites of Baalbeck-Hermel and Bekaa Districts while APLP analyzed by RT-PCR was found only in one site of Bekaa. PBNSPaV is new for Lebanon.

The other viruses (PPV, SLRV, RpRSV, ToRSV, CLRV, ArMV, TRSV and APLPV) and the viroid (HSVd) were not found on cherry in Lebanon.

#### 9.4. Peach (*Prunus persica*)

100 peach sites were tested by ELISA during this study. Baalbeck-Hermel, Mount Lebanon and Bekaa showed the highest mean infection rate (Tables 9.7 and 9.8).

PNRSV, ApMV, ACLSV and PDV were detected in 14% (14), 10% (10), 8% (8) and 5% (5) respectively of the peach sites (Table 9.7). PNRSV was the most widespread virus on Lebanese peach trees confirming previous studies of Jawhar et al. (1996) and Choueiri et al. (2001a) where the average infection being 71% and 61.2% respectively. The level of ApMV has increased to 10%, while it was not present during the first survey done by Jawhar et al. (1996) and was by far the less represented virus (2.1% incidence) according to Choueiri et al. (2001). The relative incidence of ACLSV was similar to that found by Jawhar et al. (1996) (8.5%), but less than that reported by Choueiri et al. (2001a) (27.1%). The average infection of PDV on peach was less than that described by Jawhar et al. (1996) (16.5%) and by Choueiri et al. (2001a) (22.4%) respectively.

Of the ELISA-positive sites, 21 (72.4%) were infected by only one virus; whereas the remaining 8 sites (27.6%) were infected by two viruses. Infection with a combination of PNRSV+ACLSV, PDV+ApMV and ACLSV+ApMV was detected in 2 sites each one followed by an infection of one mixture of PNRSV+ApMV and one mixture of PNRSV+PDV (Table 9.8).

None of the following viruses was detected: PPV, SLRV, RpRSV, ToRSV, CLRV, ArMV and TRSV.

AlmWB was found in one site.

Of the 81 sites tested by PCR, APLPV was detected in 7 sites (8.6%) constituting a new host record for peach followed by PLMVd which was detected in 6 (7.4%) and PBNSPaV detected in 3 (3.7%). PBNSPaV is a new virus on peach for Lebanon (Table 9.8).

3 mixed infections APLPV+PLMVd, APLPV+PLMVd and APLPV+PLMVd were found on peach in the current survey (Table 9.8).

#### 9.5. Plum (*Prunus domestica*)

Out of 39 sites tested by ELISA, 8 (20.5%) were infected by at least one virus. ACLSV, PNRSV, PDV and ApMV were detected in 10% (4), 5% (2), 5% (2) and 2.5% (1) of the sites respectively on plum (Table 9.9).

The level of infection by PDV and PNRSV was less than what has been previously reported by Jawhar et al. (1996); ACLSV and ApMV were not reported by Jawhar et al. (1996), but their rate of infection were less in comparison with those found by the Department of Plant Protection (LARI) (Choueiri, unpublished data).

One site was infected by mixed infection PNRSV+ApMV (Table 9.10).

Among the viruses tested by PCR, only one site was infected by APLPV. This is a new host record for plum in Lebanon (Table 9.10).

None of the following viruses was detected: PPV, SLRV, RpRSV, ToRSV, CLRV, ArMV and TRSV.

## 9.6. General Results and Discussion

The present survey, the largest carried out in Lebanon provides a relatively clear picture of the virological problems of stone fruits. The results of field surveys and laboratory assays revealed that most of the major viruses of *Prunus* spp. (PNRSV, ACLSV, PDV, ApMV, PLMVd, HSVd, ApLV, APLPV, PBNSPaV and AlmWB) occur in Lebanese stone fruit orchards.

The survey covered 100 selected peach orchards, 88 almond orchards, 51 apricot orchards, 51 cherry orchards and 39 plum orchards.

Out of 329 sites tested by ELISA, 82 (25%) were infected by at least one virus, with overall rates ranging from 20.4% in almond to 35.2% in cherry. Intermediate infection levels were found in peach (29%), plum (20.5%) and apricot (17.6%). Remarkable differences were observed between the different districts surveyed, the most affected being South Lebanon (66% average infection) followed by North Lebanon (61%), Mount Lebanon (47%), Nabatiyeh (40%), Bekaa (34%), Baalbeck-Hermel (30.6%) and Akkar (12.5%).

PNRSV was found in a high proportion of plantings (47.5%), confirming previous reports from Lebanon (Jawhar et al. 1996, Choueiri et al. 2001a) and from other Mediterranean countries (Llácer et al. 1986, Choueiri et al. 1993, Gatt et al. 1998). As this virus is transmitted by pollen and seeds (Digiario & Savino, 1992; Boari et al. 1998) as well as by propagation, it is difficult to control. In Lebanon, It has been demonstrated that PNRSV can cause significant yield reductions, particularly if found in mixed infections with other viruses such as PDV and depending from the species and varieties (E. Choueiri, unpublished data).

PDV was second in prevalence, occurring in 31.7% of the surveyed sites, with particularly high presence for cherry (21.5% of the sites) and almond (6.8% of the sites); however it was less present in the other species. PDV is associated with several economically important diseases of stone fruit, including chlorotic discolorations of various types like mottling, ring spot, line pattern on cherry and stunting on peach (Jawhar et al. 1996; Choueiri et al. 2001a).

In the present survey, ACLSV was found in 19 sites (23%), with high relative incidence on plum (10.2% of the sites), followed by peach (8%), cherry (7.8%), apricot (3.9%) and almond (1.1%) respectively. According to the previous reports done in Lebanon, ACLSV was more widespread on peach Choueiri et al. (2001), on almond (2.7%) Kanaa-Atallah et al. (2000), while it was less diffused on cherry (3%) Jawhar et al. (1996).

ApMV, which was not detected in a previous survey (Jawhar et al. 1996), occurs in 22% (18 sites) in the current survey. High level of ApMV infection was detected in peach (10% of the sites), followed by apricot (7.8%), while the rate of infection was low for the other species. The level of ApMV has increased to 10% in peach in comparison with the previous survey done on peach (2.1%) by Choueiri et al. 2001.

All cherry and plum sites tested by ELISA for the presence of APLPV were negative; however, through RT-PCR one site of cherry located in the Bekaa district and another plum site located in north Lebanon tested positive for APLPV, consequently APLPV is a new host record for plum.

APLPV was found in plum and peach orchards for the first time in Lebanon, while its presence in cherry was reported previously by Choueiri et al. (2006). So far, there is

no report on natural transmission of APLPV. Further investigations are desirable to assess the spread of this virus in Lebanese stone fruit orchards.

A significant finding of the survey is that PPV was not detected in any of its hosts, which makes Lebanon one of the few Mediterranean countries which are free from sharka disease, despite its presence in the neighboring countries such as Syria and Turkey (Dunez 1989, Roy & Smith, 1994).

Almond Witches' broom was found in 4 sites, however, the stone fruit production in Lebanon is threatened by the alarming spread of this emerging and lethal disease which was firstly reported in Lebanon in 2001 and responsible for the death of more than 100.000 almond trees in the country and representing a risk for the stone fruit production not only in Lebanon but also in the Middle East and Mediterranean regions (Choueiri et al. 2001c, Abou Jawdeh et al. 2002, Abou Jawdeh et al. 2009, Verdin et al. 2003).

The other viruses (SLRV, RpRSV, ToRSV, CLRV, ArMV and TRSV) were not detected in Lebanon.

The survey covered also 81 selected peach orchards, 69 almond orchards, 37 apricot orchards, 35 cherry orchards and 29 plum orchards tested by RT-PCR for the presence of (ApLV), (PBNSPaV), (APLPV), (PLMVd) and (HSVd).

In addition, out of 251 sites tested by RT-PCR, 27 (31%) were infected by at least one virus or viroid, with overall rates ranging from 3.7% in plum to 48.1% in peach. Intermediate infection levels were found in apricot (22.2%), almond (14.8%) and cherry (11.1%).

PBNSPaV was detected for the first time in Lebanon on peach, almond and cherry while it was reported in neighboring Mediterranean countries like Jordan (Sanchez-Navaro et al. 2005), Morocco (Bouani et al. 2004) and Turkey (Usta et al. 2007). PBNSPaV is transmitted by grafting (Marini et al. 2002). Infected propagating material is probably the primary source of new infections (Martelli et al. 2002) and natural spread of PBNSPaV has not been reported in orchards.

ApLV was detected in 3 apricot sites and is currently considered as a pathogen in minor economic importance. No vector is currently known for any of the ApLV isolates.

PLMVd was found in peach as reported previously in Lebanon (Choueiri et al. 2001c) and in almond sites. To our knowledge, this is the first report of PLMVd in almond in Lebanon. In recent years, using molecular diagnostic techniques such as RT-PCR and molecular hybridization, PLMVd was found to occur naturally in almond (Fekih Hassen et al. 2005). Mechanical transmission of PLMVd by pruning equipment may occur in stone fruit trees and in pear trees (Hadidi et al. 1997).

HSVd was found only in apricot sites despite it infects a relatively wide range of crops (peach, plum, sweet cherry, etc.). There are no known insect vectors.

In terms of virus and viroid infection level, the overall of the Lebanese stone fruit crops in Lebanon seems to be relatively less infected than other Mediterranean countries. Further investigations should be carried out particularly in the infected sites to check thoroughly the symptoms associated to virus and virus like diseases. The certification program adopted in Lebanon for the production and distribution of certified material has helped to reduce the spread of virus and virus-like diseases of stone fruits.

**Table 9.1 Distribution of viruses and Phytoplasma on Almond (*Prunus amygdali*)**

| Viruses and Phytoplasma   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 21                | 42 | 14 | 3  | 2  | 4  | 2  | 88    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                                   |                   |    |    |    |    |    |    | 0     |
| <i>Apple chlorotic leaf spot virus</i> (ACLSV); <i>Trichovirus</i>                                    |                   |    |    |    | 1  |    |    | 1     |
| <i>Apple mosaic virus</i> (ApMV); <i>Ilarvirus</i>  |                   | 1  |    |    |    |    | 1  | 2     |
| <i>Arabis mosaic virus</i> (ArMV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Cherry leafroll virus</i> (CLRV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Plum pox virus</i> (PPV); <i>Potyvirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Prune dwarf virus</i> (PDV); <i>Ilarvirus</i>  |                   | 2  | 3  | 1  |    |    |    | 6     |
| <i>Prunus necrotic ringspot virus</i> (PNRSV); <i>Ilarvirus</i>                                       | 1                 | 4  | 4  |    |    | 2  |    | 11    |
| <i>Raspberry ringspot virus</i> (RpRSV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Strawberry latent ringspot virus</i> (SLRV); <i>Sadwavirus</i>                                     |                   |    |    |    |    |    |    | 0     |
| <i>Tobacco ringspot virus</i> (TRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <i>Tomato ringspot virus</i> (ToRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b>Phytoplasma</b> Almond witches'-broom disease (AlmWB);<br><i>Candidatus</i> Phytoplasma phoenicium | 1                 |    | 1  |    | 1  |    |    | 3     |

|   |   |   |                     |   |   |
|---|---|---|---------------------|---|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |   |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 9.2 Distribution of viruses and viroids on Almond (*Prunus amygdali*)**

| Viruses and viroids  | Lebanon Districts |          |          |    |    |    |    | Total    |
|--|-------------------|----------|----------|----|----|----|----|----------|
|  | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed   | 20                | 33       | 9        | 1  | 2  | 3  | 1  | 69       |
| <b>Viruses</b>   |                   |          |          |    |    |    |    |          |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                              |                   |          |          |    |    |    |    | 0        |
| <i>Apricot latent virus</i> (ApLV); <i>Foveavirus</i>  |                   |          |          |    |    |    |    | 0        |
| <b><i>Plum bark necrosis stem pitting-associated virus</i> (PBNSPaV);<br/><i>Ampelovirus</i></b> | <b>1</b>          | <b>1</b> | <b>1</b> |    |    |    |    | <b>3</b> |
| <b>Viroids</b>   |                   |          |          |    |    |    |    |          |
| <i>Hop stunt viroid</i> (HSVd); <i>Hostuviroid</i>   |                   |          |          |    |    |    |    | 0        |
| <i>Peach latent mosaic viroid</i> (PLMVd); <i>Pelamoviroid</i>                                   |                   |          | 1        |    |    |    |    | 1        |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

- *American plum line pattern virus* (APLPV) was tested by PCR on all stone fruit species and by ELISA only on Plum and Cherry;
- Mixed infection: **BE:** PNRSV+PDV: 2 samples

**Table 9.3 Distribution of viruses and Phytoplasma on Apricot (*Prunus armeniaca*)**

| Viruses and Phytoplasma   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 1                 | 45 | 1  | 0  | 1  | 3  | 0  | 51    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                                   |                   |    |    |    |    |    |    | 0     |
| <i>Apple chlorotic leaf spot virus</i> (ACLSV); <i>Trichovirus</i>                                    |                   | 2  |    |    |    |    |    | 2     |
| <i>Apple mosaic virus</i> (ApMV); <i>Ilarvirus</i>  |                   | 4  |    |    |    |    |    | 4     |
| <i>Arabis mosaic virus</i> (ArMV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Cherry leafroll virus</i> (CLRV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Plum pox virus</i> (PPV); <i>Potyvirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Prune dwarf virus</i> (PDV); <i>Ilarvirus</i>  |                   | 2  |    |    |    |    |    | 2     |
| <i>Prunus necrotic ringspot virus</i> (PNRSV); <i>Ilarvirus</i>                                       |                   | 3  |    |    |    |    |    | 3     |
| <i>Raspberry ringspot virus</i> (RpRSV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Strawberry latent ringspot virus</i> (SLRV); <i>Sadwavirus</i>                                     |                   |    |    |    |    |    |    | 0     |
| <i>Tobacco ringspot virus</i> (TRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <i>Tomato ringspot virus</i> (ToRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b>Phytoplasma</b> Almond witches'-broom disease (AlmWB);<br><i>Candidatus</i> Phytoplasma phoenicium |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |   |   |
|---|---|---|---------------------|---|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |   |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon



**Table 9.4 Distribution of viruses and viroids on Apricot (*Prunus armeniaca*)**

| Viruses and viroids   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 1                 | 33 | 1  | 0  | 1  | 1  | 0  | 37    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                   |                   |    |    |    |    |    |    | 0     |
| <i>Apricot latent virus</i> (ApLV); <i>Foveavirus</i>                                 |                   | 2  |    |    | 1  |    |    | 3     |
| <i>Plum bark necrosis stem pitting-associated virus</i> (PBNSPaV); <i>Ampelovirus</i> |                   |    |    |    |    |    |    | 0     |
| <b>Viroids</b>  |                   |    |    |    |    |    |    |       |
| <i>Hop stunt viroid</i> (HSVd); <i>Hostuviroid</i>                                    |                   | 4  |    |    |    |    |    | 4     |
| <i>Peach latent mosaic viroid</i> (PLMVd); <i>Pelamoviroid</i>                        |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

- *American plum line pattern virus* (APLPV) was tested by PCR on all stone fruit species and by ELISA only on Plum and Cherry;
- Mixed infection: BH: PDV+ApMV: 1 sample; PNRSV+PDV: 1 sample
- Mixed infection: BH: ApLV+HSVd

**Table 9.5 Distribution of viruses and phytoplasma on Cherry (*Prunus avium*)**

| Viruses and Phytoplasma   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 1                 | 32 | 13 | 3  | 1  | 1  | 0  | 51    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                                   |                   |    |    |    |    |    |    | 0     |
| <i>Apple chlorotic leaf spot virus</i> (ACLSV); <i>Trichovirus</i>                                    |                   | 2  | 1  | 1  |    |    |    | 4     |
| <i>Apple mosaic virus</i> (ApMV); <i>Ilarvirus</i>  |                   | 1  |    |    |    |    |    | 1     |
| <i>Arabis mosaic virus</i> (ArMV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Cherry leafroll virus</i> (CLRV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Plum pox virus</i> (PPV); <i>Potyvirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Prune dwarf virus</i> (PDV); <i>Ilarvirus</i>  |                   | 5  | 3  | 1  | 1  | 1  |    | 11    |
| <i>Prunus necrotic ringspot virus</i> (PNRSV); <i>Ilarvirus</i>                                       |                   | 5  | 2  | 1  |    | 1  |    | 9     |
| <i>Raspberry ringspot virus</i> (RpRSV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Strawberry latent ringspot virus</i> (SLRV); <i>Sadwavirus</i>                                     |                   |    |    |    |    |    |    | 0     |
| <i>Tobacco ringspot virus</i> (TRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <i>Tomato ringspot virus</i> (ToRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b>Phytoplasma</b> Almond witches'-broom disease (AlmWB);<br><i>Candidatus</i> Phytoplasma phoenicium |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 9.6 Distribution of viruses and viroids on Cherry (*Prunus avium*)**

| Viruses and viroids  | Lebanon Districts |          |          |    |    |    |    | Total    |
|--|-------------------|----------|----------|----|----|----|----|----------|
|  | AK                | BH       | BE       | ML | NA | NL | SL |          |
| Total sites surveyed   | 1                 | 22       | 8        | 3  | 0  | 1  | 0  | 35       |
| <b>Viruses</b>   |                   |          |          |    |    |    |    |          |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                              |                   |          | 1        |    |    |    |    | 1        |
| <i>Apricot latent virus</i> (ApLV); <i>Foveavirus</i>  |                   |          |          |    |    |    |    | 0        |
| <b><i>Plum bark necrosis stem pitting-associated virus</i> (PBNSPaV);<br/><i>Ampelovirus</i></b> |                   | <b>1</b> | <b>1</b> |    |    |    |    | <b>2</b> |
| <b>Viroids</b>   |                   |          |          |    |    |    |    |          |
| <i>Hop stunt viroid</i> (HSVd); <i>Hostuviroid</i>   |                   |          |          |    |    |    |    | 0        |
| <i>Peach latent mosaic viroid</i> (PLMVd); <i>Pelamoviroid</i>                                   |                   |          |          |    |    |    |    | 0        |

|   |   |          |                     |  |
|---|---|----------|---------------------|--|
| ● | Previously recorded on this host                    | <b>n</b> | New to Lebanon      | n: No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n        | New host in Lebanon |  |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

- *American plum line pattern virus* (APLPV) was tested by PCR on all stone fruit species and by ELISA only on Plum and Cherry;
- Mixed infection: BH: PNRSV+PDV: 1 sample; ACLSV+ApMV:1 sample; PNRSV+PDV+ACLSV: 1 sample; NL: PNRSV+PDV: 1 sample; ML: PNRSV+PDV+ACLSV: 1 sample

**Table 9.7 Distribution of viruses and Phytoplasma on Peach (*Prunus persica*)**

| Viruses and Phytoplasma   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 11                | 27 | 20 | 18 | 8  | 12 | 4  | 100   |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                                   |                   |    |    |    |    |    |    | 0     |
| <i>Apple chlorotic leaf spot virus</i> (ACLSV); <i>Trichovirus</i>                                    | 1                 | 2  | 1  | 2  | 1  | 1  |    | 8     |
| <i>Apple mosaic virus</i> (ApMV); <i>Ilarvirus</i>  |                   | 5  |    | 3  | 1  |    | 1  | 10    |
| <i>Arabis mosaic virus</i> (ArMV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Cherry leafroll virus</i> (CLRV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Plum pox virus</i> (PPV); <i>Potyvirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Prune dwarf virus</i> (PDV); <i>Ilarvirus</i>  |                   | 4  | 1  |    |    |    |    | 5     |
| <i>Prunus necrotic ringspot virus</i> (PNRSV); <i>Ilarvirus</i>                                       | 1                 | 2  | 3  | 4  | 2  |    | 2  | 14    |
| <i>Raspberry ringspot virus</i> (RpRSV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Strawberry latent ringspot virus</i> (SLRV); <i>Sadwavirus</i>                                     |                   |    |    |    |    |    |    | 0     |
| <i>Tobacco ringspot virus</i> (TRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <i>Tomato ringspot virus</i> (ToRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b>Phytoplasma</b> Almond witches'-broom disease (AlmWB);<br><i>Candidatus</i> Phytoplasma phoenicium |                   | 1  |    |    |    |    |    | 1     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 9.8 Distribution of viruses and viroids on Peach (*Prunus persica*)**

| Viruses and viroids  | Lebanon Districts |    |    |    |    |    |    | Total |
|--|-------------------|----|----|----|----|----|----|-------|
|  | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed   | 10                | 22 | 17 | 13 | 5  | 12 | 2  | 81    |
| <b>Viruses</b>   |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                              |                   | 1  | 1  | 2  | 2  | 1  |    | 7     |
| <i>Apricot latent virus</i> (ApLV); <i>Foveavirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b><i>Plum bark necrosis stem pitting-associated virus</i> (PBNSPaV);<br/><i>Ampelovirus</i></b> |                   |    | 3  |    |    |    |    | 3     |
| <b>Viroids</b>   |                   |    |    |    |    |    |    |       |
| <i>Hop stunt viroid</i> (HSVd); <i>Hostuviroid</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Peach latent mosaic viroid</i> (PLMVd); <i>Pelamoviroid</i>                                   |                   | 1  | 2  | 2  | 1  |    |    | 6     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

- *American plum line pattern virus* (APLPV) was tested by PCR on all stone fruit species and by ELISA only on Plum and Cherry;
- Mixed infection: ML: PNRSV+ACLSV: 1 sample; ACLSV+ApMV: 1 sample; SL: PNRSV+ApMV: 1 sample; BE: PNRSV+PDV: 1 sample; PNRSV+ACLSV: 1 sample; BH: PDV+ApMV: 2 samples; ACLSV+ApMV: 1 sample
- Mixed infection: ML: APLPV+PLMVd; NA: APLPV+PLMVd; BE: APLPV+PLMVd

**Table 9.9 Distribution of viruses and Phytoplasma on Plum (*Prunus domestica*)**

| Viruses and Phytoplasma   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 7                 | 4  | 5  | 10 | 3  | 10 | 0  | 39    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                                   |                   |    |    |    |    |    |    | 0     |
| <i>Apple chlorotic leaf spot virus</i> (ACLSV); <i>Trichovirus</i>                                    | 1                 |    |    | 1  |    | 2  |    | 4     |
| <i>Apple mosaic virus</i> (ApMV); <i>Ilarvirus</i>  |                   | 1  |    |    |    |    |    | 1     |
| <i>Arabis mosaic virus</i> (ArMV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Cherry leafroll virus</i> (CLRV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Plum pox virus</i> (PPV); <i>Potyvirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Prune dwarf virus</i> (PDV); <i>Ilarvirus</i>  |                   |    |    | 2  |    |    |    | 2     |
| <i>Prunus necrotic ringspot virus</i> (PNRSV); <i>Ilarvirus</i>                                       | 1                 | 1  |    |    |    |    |    | 2     |
| <i>Raspberry ringspot virus</i> (RpRSV); <i>Nepovirus</i>   |                   |    |    |    |    |    |    | 0     |
| <i>Strawberry latent ringspot virus</i> (SLRV); <i>Sadwavirus</i>                                     |                   |    |    |    |    |    |    | 0     |
| <i>Tobacco ringspot virus</i> (TRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <i>Tomato ringspot virus</i> (ToRSV); <i>Nepovirus</i>  |                   |    |    |    |    |    |    | 0     |
| <b>Phytoplasma</b> Almond witches'-broom disease (AlmWB);<br><i>Candidatus</i> Phytoplasma phoenicium |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

**Table 9.10 Distribution of viruses and viroids on Plum (*Prunus domestica*)**

| Viruses and viroids   | Lebanon Districts |    |    |    |    |    |    | Total |
|---|-------------------|----|----|----|----|----|----|-------|
|   | AK                | BH | BE | ML | NA | NL | SL |       |
| Total sites surveyed  | 6                 | 2  | 4  | 5  | 3  | 9  | 0  | 29    |
| <b>Viruses</b>  |                   |    |    |    |    |    |    |       |
| <i>American plum line pattern virus</i> (APLPV); <i>Ilarvirus</i> *                   |                   |    |    |    |    | 1  |    | 1     |
| <i>Apricot latent virus</i> (ApLV); <i>Foveavirus</i>                                 |                   |    |    |    |    |    |    | 0     |
| <i>Plum bark necrosis stem pitting-associated virus</i> (PBNSPaV); <i>Ampelovirus</i> |                   |    |    |    |    |    |    | 0     |
| <b>Viroids</b>  |                   |    |    |    |    |    |    |       |
| <i>Hop stunt viroid</i> (HSVd); <i>Hostuviroid</i>                                    |                   |    |    |    |    |    |    | 0     |
| <i>Peach latent mosaic viroid</i> (PLMVd); <i>Pelamoviroid</i>                        |                   |    |    |    |    |    |    | 0     |

|   |   |   |                     |    |   |
|---|---|---|---------------------|----|---|
| ● | Previously recorded on this host                    | n | New to Lebanon      | n: | No. of sites at which organism recorded |
| n | Previously recorded on this host and in this survey | n | New host in Lebanon |    |   |

Lebanon districts: **AK:** Akkar, **BH:** Baalbeck – Hermel, **BE:** Bekaa, **ML:** Mount Lebanon, **NA:** Nabatiyeh, **NL:** North Lebanon, **SL:** South Lebanon

- *American plum line pattern virus* (APLPV) was tested by PCR on all stone fruit species and by ELISA only on Plum and Cherry;
- Mixed infection: BH: PNRSV+ApMV: 1 sample

## 10. References

- Abdul-Nour, H & Z. Moussa 2006. Survey and new records of Diaspididae scales from Lebanon, (Hemiptera, Sternorrhyncha, Coccoidae). *Bulletin de la Société Entomologique de France* 111(4): 517 – 520.
- Abou Ghanem-Sabanadzovic, N., M. Mahboubi, B. Di Terlizzi, S. Sabanadzovic, V. Savino, Uyemoto J.K. & Martelli G.P. 2001. Molecular detection of a *closterovirus* associated with *Apricot stem pitting* in southern Italy. *Journal of Plant Pathology* 83: 125-132.
- Abou-Jawdah, Y., A. Karakashian, H. Sobh, M. Martini & I.M. Lee. 2002. An epidemic of almond witches'-broom in Lebanon: classification and phylogenetic relationship of the associated phytoplasma. *Plant Disease* 86: 477-484.
- Abou-Jawdah, Y., H. Dakhil, S. El-Mehtar & I.M. Lee. 2003. Almond witches'-broom phytoplasma: a potential threat to almond, peach and nectarine. *Canadian Journal of Plant Pathology* 25: 28-32.
- Abou-Jawdah, Y., H. Sobh, & M. Akkary. 2009. First report of almond witches' broom phytoplasma ('*Candidatus* Phytoplasma phoenicium') causing a severe disease on nectarine and peach trees in Lebanon. *EPPO Bulletin* 39: 94-98.
- Ahimera, N., G.F. Driever & T.J. Michailides. 2003. Relationships among propagule numbers of *Botryosphaeria dothidea*, latent infection, and severity of panicle and shoot blight in Pistachio orchards. *Plant Disease* 87: 846-853.
- Anonymous, 2005a. *Pseudomonas syringae* pv. *persicae*. OEPP/EPPO Standards 2005. Bulletin 35, 285-287. PM 7/43 (1).
- Anonymous, 2005b. *Xanthomonas axonopodis* pv. *citri*. OEPP/EPPO standards 2005. Bulletin 35, 289-294. PM 7/44 (1).
- Anonymous, 2006. *Xanthomonas arboricola* pv. *pruni*. OEPP/EPPO standards 2006. Bulletin 36, 129-133. PM 7/64 (1).
- Balachowsky, A. 1948. Les cochenilles de France, d'Europe, du nord de l'Afrique et du bassin medetiraneen: Monographie des coccidea Diaspidinea (premier partie), Herman And Cle, Rue De La Sorbonne, Paris.
- Balachowsky, A. 1950. Les cochenilles de France, d'Europe, du nord de l'Afrique et du bassin medetiraneen: Monographie des coccidea Diaspidinea (deuxième partie), Herman And Cle, Rue De La Sorbonne, Paris.
- Balachowsky, A. 1951. Les cochenilles de France, d'Europe, du nord de l'Afrique et du bassin medetiraneen: Monographie des coccidea Diaspidinea (troisième partie), Herman And Cle, Rue De La Sorbonne, Paris.
- Balachowsky, A. 1953. Les cochenilles de France, d'Europe, du nord de l'Afrique et du bassin medetiraneen: Monographie des coccidea Diaspidinea IV, Herman And Cle, Rue De La Sorbonne, Paris.
- Balachowsky, A. 1954. Les cochenilles palearctiques de la tribu des diaspidinea, Institut Pasteur, Rue Du Docteur Roux, ParisXV. 450 pp.
- Barnett, H.L. & B.B. Hunter. 1998. Illustrated Genera of Imperfect Fungi – Fourth Edition. APS Press, St Paul, Minnesota, USA, 218 pp.



- Beckman, T.G., P.L. Pusey & P.F. Bertrand. 2003. Impact of fungal gummosis on peach trees. *HortScience* 38: 1141-1143.
- Biggs, A.R. & G.G. Grove. 2005. Leucostoma canker of stone fruits. *The Plant Health Instructor* DOI: 10.1094/PHI-I-2005-1220-01.
- Blackman, R.L. & V.F. Eastop. 2006. Aphids on the world's trees an identification and information guide, CAB International. CPI Antony Rowe, Eastbourne, UK. 987 pp.
- Boari, A., D. Boscia, B. Di Terlizzi & V. Savino. 1998. Study on seed transmission of prune dwarf virus (PDV) in *Prunus mahaleb* L. *Advances in Horticultural Science* 12: 89-92.
- Boerema, G.H., J. de Gruyter, M.E. Noordeloos & M.E.C. Hamers. 2004. *Phoma Identification Manual: Differentiation of Specific and Intra-specific Taxa in Culture*. CABI Publishing, Cambridge, USA, 470 pp.
- Bouani, A., A. Minafra, I. Alami, M. Zemzami & A. Myrta. 2004. First report of Plum bark necrosis stem-pitting associated virus in Morocco. *Journal of Plant Pathology* 86: 91-92.
- Carter, M.V. 1991. The status of *Eutypa lata* as a pathogen. International Mycological Institute, *Phytopathological Paper*: 32.
- Choueiri E., F. Jreijiri, P. Chlela, G. Louvet, & P. Lecomte. 2006. Occurrence of grapevine declines and first report of black dead arm associated with *Botryosphaeria obtusa* in Lebanon. *Plant Disease* 90(1): 115.
- Choueiri E., N. Abou Ghanem-Sabanadzovic, K. Khazzaka, S. Sabanadzovic, B. Di Terlizzi, A. Myrta, S. El Zammar, F. Jreijiri & V. Savino. 2002. First report of hop stunt viroid in apricot in Lebanon. *Journal of Plant Pathology* 84: 69.
- Choueiri, E., N. Abou Ghanem-Sabanadzovic, S. El Zammar & F. Jreijiri. 2003. Viruses of stone fruit trees in Lebanon. In: Options Méditerranéennes Number 45, Virus and virus-like diseases of stone fruits, with particular reference to the Mediterranean region (eds Myrta A, Di Terlizzi B, and Savino V), CIHEAM, Valenzano (IT), pp. 25-27.
- Choueiri, E., A. Myrta, M.C. Herranz, C. Hobeika, M. Digiaro & V. Pallás. 2006. First report of American Plum Line Pattern Virus in Lebanon. *Journal of Plant Pathology* 88: 227.
- Choueiri, E., C. Haddad, N. Abou Ghanem-Sabanadzovic, F. Jreijiri, S. Issa, A.T. Saad, B. Di Terlizzi & Savino V., 2001a. A survey of peach viruses in Lebanon. *Bulletin OEPP/EPPO Bulletin* 31: 493-497.
- Choueiri, E., F. Jreijiri, S. Issa, E. Verdin, J.M. Bové & M. Garnier M. 2001b. First report of a phytoplasma disease of almond (*Prunus amygdalus*) in Lebanon. *Plant Disease* 85: 802.
- Choueiri, E., N. Abou Ghanem-Sabanadzovic, K. Khazzaka, S. Sabanadzovic, B. Di Terlizzi, F. Jreijiri & V. Savino. 2001c. Identification of peach latent mosaic viroid in Lebanon. *Journal of Plant Pathology* 83: 225.
- Clark, M.F. & A.N. Adams. 1977. Characteristic of the microplate method of enzyme-linked immunosorbant assay for the detection of plant viruses. *Journal of General Virology* 34: 475-483.

- Damm, U., P.W. Crous & P.H. Fourie. 2007. Botryosphaeriaceae as potential pathogens of *Prunus* species in South Africa, with descriptions of *Diplodia africana* and *Lasioidiplodia plurivora* sp. nov. *Mycologia* 99(5): 664-680.
- Delobel, A. & M. Tran. 1993. Les coléoptères des denrées alimentaires entreposées dans les régions chaudes. Delagarde INC., Paris 424 pp.
- Digiario, M. & V. Savino V.1992. Role of pollen and seeds in the spread of ilarviruses in almond. *Advances in Horticultural Science* 6: 134-136.
- Diogo, E.L.F., J.M. Santos & A.J.L. Philips. 2010. Phylogeny, morphology and pathogenicity of *Diaporthe* and *Phomopsis* species on almond in Portugal. *Fungal diversity* 44: 107-115.
- Dosse, G. & S. Musa. 1967. Phytophagous Mites in Lebanon and their Predators. *Magon. No 12*. Numnom Press. 23 pp.
- Dugan, F.M. 2006. The Identification of Fungi: An Illustrated Introduction with Keys, Glossary, and Guide to Literature. APS Press, St Paul, Minnesota, USA, 184 pp.
- Dunez, J., 1989. Situation of virus and virus-like diseases of stone fruit trees in the Mediterranean and near east counties. *Arab journal of plant protection* 7: 209-210.
- Dymock, J.J. & P.W. Holder. 1996. Nationwide survey of arthropods and molluscs on cut flowers in New Zealand. *New Zealand Journal of Crop and Horticultural Science* 24: 249-257.
- EPPO, 2006. PQR database (version 4.5). Paris, France: European and Mediterranean Plant Protection Organization. [www.eppo.org](http://www.eppo.org).
- Fekih Hassen, I., S. Marbot, J. Kumeert, H. Kafhfath, H.M. Marrakchi & M.H. Jijakli. 2005. *Peach latent mosaic viroid* detected for the first time on almond trees in Tunisia. *Plant Disease* 89: 1244.
- Foissac, X., L. Svanella-Dumas, L.P. Gentit, M.J. Dulucq & T. Candress. 2001. Polyvalent detection of fruit tree Tricho, Capillo and Foveavirus by nested RT-PCR using degenerated and Iosine containing primers (DOP RT-PCR). *Acta Horticulturae* 550: 37-43.
- Freidman, A.L.L. & A. Freidburg. 2007. The apionidae of Israel and the Sinai peninsula (Coleoptera: Curculionidea). *Israel Journal of Entomology* 37: 55-180.
- Gallegly, M.E. & C. Hong. 2008. Phytophthora: Identifying Species by Morphology and DNA Fingerprints. APS Press, St Paul, Minnesota, USA, 158 pp.
- Gatt, M., V. Merciera & V. Farrugia. 1998. Mediterranean stone fruit industry and its sanitary status (Malta). In: Options Méditerranéennes Number 19, StoneFruit Viruses and Certification in the Mediterranean Countries: Problems and Prospects, (eds Myrta A, Di Terlizzi B, and Savino V), pp. 59-60. CIHEAM, Valenzano (IT).
- Gazel, M., C. Ulubas Serce, K. Caglayan, M. Luigi & F. Faggioli. 2008. Incidence and genetic diversity of Peach latent mosaic viroid isolates in Turkey. *Journal of Plant Pathology* 90: 495-503.
- Gentry, W.J. 1965. Crop insect of northeast Africa-southwest Asia. Government Printer, Washington, D.C., U.S.A. 210 pp.
- Gill, J.R., S. Nakhara & M.L. Williams. 1977. Occasional papers in entomology, Department of food and agriculture division of plant industry. California, USA. 41 pp.

- Goszczynska, T., J.J. Serfontein & S. Serfontein. 2000. Introduction to practical phytobacteriology. Safrinet manual for phytobacteriology, the southern African (SADC) LOOP of BioNet-International. 83 pp.
- Habib, W., S. Pollastro, E. Choueiri & F. Faretra. 2009. First report of fungi associated with wood discolouration of grapevine rootstocks from Lebanese nurseries. *Journal of Plant Pathology* 91(2): 503.
- Hadidi, A., L. Giunchedi, A. M. Shamloul, C. Poggi Pollini & M.A. Amer. 1997. Occurrence of *Peach latent mosaic viroid* in stone fruits and its transmission with contaminated blades. *Plant Disease* 81: 154-158.
- Hodgson, G.J. 1994. The scale insect family, Coccidae: An identification manual to genera. International institute of entomology. CABI. University Press, Cambridge. 639 pp.
- Holt J.G 2012. Bergey's manual of determinative bacteriology, ninth edition, Springer. 304 pp.
- Ibrahim, S.K. & R.N. Perry. 1993. Use of esterase patterns of females and galled roots for the identification of species of *Meloidogyne*. *Fundamental. Applied Nematology* 16: 187-191.
- Janse J. D 2006. Phytobacteriology principles and practice, CABI publishing. 360 pp.
- Jarrar, S., E. Choueiri, J.A. Sánchez-Navarro, A. Myrta, S. El Zammar, V. Savino & V. Pallas. 2007. First report of Apricot Latent Virus in Lebanon. *Journal of Plant Pathology* 89: 303.
- Jawhar, J., B. Di Terlizzi, W. Khoury, & V. Savino. 1996. Preliminary account of the phytosanitary status of stone-fruit trees in Lebanon. *Bulletin OEPP/EPPO Bulletin* 26: 161-166.
- Kannan-Atallah, Z., Abou-Jawdah Y & S. Adib. 2000. Virus diseases infecting almond germplasm in Lebanon. *Phytopathologia Mediterranea* 39: 417-422.
- Khatib, H., P. Davet & G. Sardy. 1970. Liste des Maladies des Plantes au Liban. Publication de l'Institut de Recherches Agronomiques, Fanar, Liban, 41 pp.
- Khouzami, M., A. Hayek, M. Bassil & L. Fortunat. 1996. Etude de la Diversité Biologique du Liban – Liste des Espèces, Volume 1. Report Project GF/6105-92-72, Ministère de l'Agriculture, Programme des Nations Unies pour l'Environnement (PNUE), 323 pp.
- Kim, K.W, E.W. Park, Y.H. Kim, K.K Ahn, P.G. Kim & K.S. Kim. 2001. Latency- and defense-related ultrastructural characteristics of apple fruit infected with *Botryosphaeria dothidea*. *Phytopathology* 91: 165-172.
- Krantz, J.D. and Walter, D.E. 2009. A manual of acarology 3<sup>rd</sup> edition. Texas Tech University Press, Texas, USA. 807 pp.
- Lamberti, F. & M.R. Siddiqi. 1977. *Xiphinema pachtaicum* (= *X. mediterraneum*). CIH Descriptions of Plant-parasitic Nematodes No 94. CAB International, Wallingford, UK.
- Levy, L. & A. Hadidi. 1992. Reverse Transcription –Polymerase chain reaction assay for the rapid detection of citrus viroid using multiplex. Primer sets. *Proceedings 7<sup>th</sup> International Citrus Congress. Acireale 1992*: 881-895.

- Lichou, J., J. Mandrin & D. Breniaux. 2001. Protection intégrée des fruits à noyau. Ctifl, Centre Technique Interprofessionnel Des Fruits Et Légumes, Rue Bergere 75009, Paris. 271 pp.
- Llácer, G. M. Cambra, A. Lavina & J. Aramburu. 1986. Viruses infecting stone fruits in Spain. *Acta Horticulturae* 193: 95-99.
- Lownsbery, B.F, E.H. Moody & A.L. Braun. 1974. Plant parasitic nematodes in California prune orchards. *Plant Disease Reporter* 58: 633-636.
- Maixner, M., U. Ahrens & E. Seemuller. 1995. Detection of the German grapevine yellows (VergibungsKransKheit) MLO in grapevine, alternative hosts and a vector, by a specific PCR procedure. *European Journal of Plant Pathology* 101: 241-250.
- Makhlouf, J. & L. Geagea. 2005. Prevalence and survey of *Verticillium dahliae* on stones fruits and olive trees in two regions of Lebanon. *Annales de Recherche Scientifique* 6: 301-317.
- Marini, D., Y.A. Rowhani & J. K. Uyemoto. 2002. Graft-transmissible agent causes bark necrosis and stem pitting in plum trees. *Calif. Agric* 56: 108-111.
- Martelli, G.P., V. Savino, & M. Digiario. 2002. Mediterranean almond viruses. Pages 36-37 in: Compendium of Nut Crop Diseases in Temperate Zones. APS Press, St. Paul, MN, USA.
- Masumoto, M. & S. Okajima. 2006. A revision and key to the world species of *Mycterothrips* Trybom (Thysanoptera, thripidae), Zootaxa 1261. Magnolia Press, Auckland, New Zealand. 87 pp.
- McKenry, M.V. 2004. Three nematode genera and the damage they cause for plum producers. *Journal of Nematology* 36: 333.
- Mostert, L., P.W. Crous, J. C. Kang & A.J.L. Phillips. 2001. Species of *Phomopsis* and a *Libertella* sp. occurring on grapevines with specific reference to South Africa: morphological, cultural, molecular and pathological characterization. *Mycologia* 93(1): 146-167.
- Mound, A.L. & A.K. Walker. 1986. Fauna of New Zealand number 10 Tubilifera (Insecta: Thysanoptera). Crown Copyright. 146 pp.
- Mound, L.A. & G. Kibby. 2005. Thysanoptera an identification guide, 2nd edition. CABI. Antony Rowe Limited, Eastbourne, UK. 70 pp.
- Mound, L.A. & M. Masumoto. 2005. The genus Thrips (Thysanoptera, Thripidea) in Australia, New Caledonia and New Zealand, Zootaxa 1020. Magnolia Press, Auckland, New Zealand. 64 pp.
- Murillo, J. & A. Sesma. 2001. The biochemistry and molecular genetics of host range definition in *Pseudomonas syringae*, review. *Phytopathologia Mediterranea* 40: 3-26.
- Nemchinov, L. & A. Hadidi. 1998. *Apricot latent virus*: a novel stone fruit pathogen and its relationship to apple stem pitting virus. *Acta Horticulturae* 472: 159-174.
- Nickle, R.W. 1991. Manual of Agricultural Nematology. Arcel Dekker, Inc. 1035 pp.
- Nyczepir, A.P. & J.M. Habrendt. 1993. Nematode pests of deciduous fruit and nut trees. pp. 381-425 in: Evans, K. Trudgill, D.L. & Webster, J.M., (eds). Plant Parasitic Nematodes in Temperate Agriculture. CAB International, Wallingford, England.

- Nyczepir, A.P., & D. Esmenjaud. 2008. Nematodes. *The Peach. Botany, Production and Uses*. CAB International.
- Nyczepir, A.P. & J.O. Beker. 1998. Fruit and Citrus Trees. In K.R. Barker et al (eds), *Plant Nematode interactions, Agronomy Monograph 36*: 637-684.
- Obradovic, A., J.M. Young, J.D. Janse, E. Stefani & M. Scorichini. 2010. *Pseudomonas* pathogens of stone fruits and nuts: classical and molecular phytobacteriology. *European Science Foundation*. 71 pp.
- Ogawa, J.M., E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu & J.K. Uyemoto. 1995. *Compendium of Stone Fruit Diseases*. APS Press, St Paul, Minnesota, USA, 98 pp.
- Perry, R.N., M. Moens & J.L. Starr. 2009. *Root-Knot Nematodes*. CAB International. 448 pp.
- Punithalingam, E. 1980. *Leptosphaeria coniothyrium*. Descriptions of pathogenic fungi and bacteria. no. 663. Kew, Surrey, UK: Commonwealth Mycological Institute.
- Richmond, J.E., J.M. Cowley, A. Day, J.C. Hurrell, G.D. Page, V.E. Herrera & T.E. Smales. 1998. Pest and Disease Survey of Stonefruit Crops in New Zealand (1997/1998). Report prepared by the New Zealand Plant Protection Center, 115 pp.
- Roy, A.S. & I.M. Smith. 1994. Plum pox virus situation in Europe. *Bulletin OEPP/EPPO Bulletin 24*: 515-524.
- S.M. Iablokoff-kahzorian 1982. Les Coccinelles. Coléoptères-Coccinellidae. Tribu Coccinellini des régions Paléarctiques et Orientale. Imprimerie Seprint à Cergy. pp 568.
- Saad, A.T. & F. Nienhaus. 1969. Plant diseases in Lebanon, zeitschrift für pflanzenkrankheiten (pflanzenpathologie) and pflanzenschutz. 76. Band, jahrgang, heft 9/20.
- Saad, A., K. Bouazza, L. Hanna, M. Kattar & E. Chnais. 2009. Characterization and genomic variations among *Verticillium* populations in Lebanon. *Arab Journal of Plant Protection 27 (Supplement)*: E61-E62.
- Saad, A.T. & F. Nienhaus. 1969. Plant diseases in Lebanon. *Z. Pflkrankh. Pflpath. Pflschutz 76*: 537-551.
- Saad, A.T. & K. Masannat. 1997. Economic importance and cycle of *Polystigma ochraceum*, causing red leaf blotch disease of almond, in Lebanon. *EPPO Bulletin 27*: 481-485.
- Sanchez-Navarro, J.A., F. Aparicio, M. C. Herranz, A. Minafra, A. Myrta & V. Pallas. 2005. Simultaneous detection and identification of eight stone fruit viruses by one step RT-PCR. *European Journal of Plant Pathology 111*: 77-84.
- Schaad, N.W., J.B. Jones & W. Chun. 2001. Laboratory guide for identification of plant pathogenic bacteria. Third edition. APS press, the American phytopathological society. 373 pp.
- Seifert, K. 1996. FusKey – Fusarium Interactive Key. *Agriculture and Agri-Food Canada*, 65pp. Webpage: <http://res.agr.ca/brd/fusarium/home1.html>
- Shurtleff, M.C. & C.W. Averre III. 2005. Diagnosing plant diseases caused by nematodes. The American Phytopathological Society Press. 187 pp.

- Simeone, A.M. & M. Divito. 1992. Reactions to nematodes of selection of peach rootstocks. *Acta horticulturae* 315: 197-202.
- Simmons, E.G. 2007. *Alternaria: An Identification Manual*. CBS Fungal Biodiversity Centre, Utrecht, the Netherlands, 775 pp.
- Slippers, B., W.A. Smit, P.W. Crous, T.A. Coutinho, B.D. Wingfield & M.J. Wingfield. 2007. Taxonomy, phylogeny and identification of Botryosphaeriaceae associated with pome and stone fruit trees in South Africa and other regions of the world. *Plant Pathology* 56: 128-139.
- Southey, J.F. 1986. Laboratory Methods for Work with Plant and Soil Nematode. Technical Bulletin No. 2. 202 pp.
- Taylor, P.D., A.T. Saad & W.E. Schlösser. 1972. Occurrence and Distribution of Plant-Parasitic Nematodes in Lebanon. *Plant Protection Bull.* 20: 105-110.
- Usta, M., H.M. Sipahioglu, M. Ocak & A. Myrta. 2007. Detection of Apricot latent virus and Plum bark necrosis stem pitting-associated virus by RT-PCR in the Eastern Anatolia. *Bulletin OEPP/EPPO Bulletin* 37: 181-185.
- Van Niekerk, J.M., J.Z. Groenewald, D.F. Farr, P.H. Fourie, F. Halleen & P.W. Crous. 2005. Reassessment of *Phomopsis* species on grapevines. *Australasian Plant Pathology* 34: 27-39.
- Verdin, E., P. Salar, P., J. Danet, E. Choueiri, F. Jreijiri, S. El Zammar, B. Gélie, J. M. Bové & M. Garnier. 2003. 'Candidatus phytoplasma phoenicium' sp. nov., a novel phytoplasma associated with an emerging lethal disease of almond trees in Lebanon and Iran. *International Journal of Systematic and Evolutionary Microbiology* 53: 833-838.
- W. Junk B.V. 1976. Aphid Parasites (Hymenoptera, Aphidiidae) of the mediterranean area. Petr Sary, Prague. 95 pp.
- Wang, F., L. Zhao & G. Li. 2011. Identification and characterization of *Botryosphaeria* spp. causing gummosis of peach trees in Hubei Province, Central China. *Plant Disease* 95: 1378-1384.
- Watanabe, T. 2010. Pictorial Atlas of Soil and Seed Fungi - Morphologies of Cultured Fungi and Key to Species, Third Edition. APS Press, St Paul, Minnesota, USA, 396 pp.
- Yang, Z.X., T.Z. Wang, H. Hao, Z.X. Kang & Y.F. Jiang. 1994. Relationship between canker-tolerance and spring-freezing tolerance of poplar clones. *Forest Research*, 7(1): 116-120.
- Brown, D.J.F., R.T. Halbrendt, R.T. Robbins & T.C. Vrain. 1993. Transmission of nepoviruses by *Xiphinema americanum* group nematodes. *Journal of Nematology* 25: 349-354.
- Zhang, Z.Q. & R. Henderson. 2001. Key to Tetranychidae of New Zealand, MAF Science Policy, Project FMA180. 61 pp.
- Zhang, Z.Q., D. Bejakovich & A.N. Martin. 2001. Key to Tydeidae of New Zealand, MAF Science Policy, Project FMA171. 36 pp.