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California Avocado Commission Report: Avocado tour in Israel

During the period of October 20-29th 2012, I visited Israel for the purpose of understanding the impact of Fusarium dieback and Botryosphaeria canker on avocado throughout the country. Fusarium dieback and Botryosphaeria canker are two separate diseases that each cause specific problems on avocado, and thus concern the industry in Israel and California. In addition, the Volcani Research Center invited Shannon Lynch, a researcher in my lab, and myself to present our findings on Fusarium dieback and Botryosphaeria canker on avocado in California. Herein is a summary of what we observed overall on our tour throughout the region and the perspectives we gained from researchers, growers, and extension specialists on the situation in Israel. More details regarding the phytopathological problems observed specifically within groves follow.

According to Homsky (1995) 19,300 acres of land in Israel is utilized for growing avocado, primarily along the coastal plain (13,800), and mostly in its northern and central parts (Fig 1). Another 3,950 acres are throughout the Hulah valleys in the north, Sea of Galilee and in the Izrae'l Valley of Jezre'el. The remaining 1,480 acres are planted in the southern Lachish region and at the foothills of Judea's mountains. Seventy percent of total avocado area in the country is cultivated by Kibbutzim (cooperative settlements mainly traditionally based on agriculture), 75-205 acres each (Homsky 1995). The rest consist mainly of small family orchards of 2.5-7.5 acres.

In total, we visited seven avocado groves representing the major growing regions of the country. The southern region does not have PSHB/FD, but is heavily infested with a recent establishment of two or more species of *Botryosphaeria.* Both growers and researchers are anxious about the problem because several species of *Botryosphaeria* in particular are highly aggressive. Four researchers from the Department of Plant Pathology and Weed Research at the Volcani Research Center, including Professor Dani Shteinberg, Dr. David Ezra, Dr. Stanley Freeman and Dr. Omer Frenkel are currently working on the problem. Researchers are only in the beginning stages of understanding the dynamics of this very recent outbreak. Currently, there are no control solutions .

Most of groves visited were infested with PSHB/FD, and some were also infested with *Botryosphaeria spp*. Prior to our visit, the northern-most extent of the infestation was the northern region of the Sharon Coastal Plain, and Lower Galilee (Fig 1). This area is bound by the Carmel mountain range, which serves as a 3-mile physical boundary separating the aforementioned region with the major avocado growing areas in Israel. Along the base of the western side of the Carmel range are avocado plantations heavily infested with PSHB/FD. Root rot is not an important problem in Israel. Professor Zvi Mendel from the Department of Entomology and Dr. Stanley Freeman from the

Department of Plant Pathology and Weed Research at the Volcani Research Center are currently working on the biology, epidemiology and control of this beetle/disease complex.

Researchers received reports of avocado trees showing symptoms of PSHB/FD within groves in the upper Galilee. Establishment of the beetle was confirmed on this trip, and discoloration caused by *Fusarium sp.* was observed on trees. Symptoms resembling *Botryosphaeria* canker were additionally observed and samples were collected for pathogen confirmation. In addition, we found four symptomatic sycamore (*Platanas orientalis*) trees in a national park and a single infested box elder (*Acer negundo*) in a kibbutz Hagoshrim located less than one and four miles from the grove respectively. An establishment of the beetle in this northern-most avocado-growing region is of great concern to both researchers and the industry because there are no physical boundaries between this and the major avocado growing areas in Israel. Based on the severe damage caused by the beetle and its rapid spread throughout the central and southern Coastal areas (Mendel and Freeman 2012), researchers believe the industry will be adversely affected by beetle contamination within the northern sites.

It is not clear how the beetle entered into this northern location distant from the other infestation and across the Carmel range. There is speculation that the beetle may have arrived on contaminated packing crates from a shared packinghouse. Another possibility is that the beetle flew along a corridor south of the Carmel range and north into the Upper Galilee region, infesting suitable habitat along the way. Currently there are no cohesive monitoring efforts to track the disease spread within Israel and thus measures to prevent beetle establishment into new locations are compromised.

The spread of disease appears to be a combination of factors that include limited understanding of beetle/fungal distribution that would facilitate prevention of spread at the advancing margin of the infestation, and timing of control attempts. At this point in time, researchers and consultants agree that approximately 33-40% of the total avocado-growing region is infested with PSHB/FD, but this may be an underestimate. Without a cohesive monitoring program, researchers rely on reports from growers that tend to come in once the beetle is firmly established within a grove. Furthermore, communication seems limited between growers from distant locations, and it is thus possible that the beetle is present within other avocado growing regions of Israel where it is not viewed as a problem until significant reductions in crop yields arise. At this stage, the infestation is in its advanced stage, and the beetle has likely begun to invade other locations.

The second part of the problem is the timing of control measures. Growers and extension specialists from growing areas where infestation has been reported are concerned about the economic loss of the current year's harvest if they apply pesticides, while researchers are concerned that the inclination to keep the plantations until harvest is exacerbating disease spread. For example, all fruit produced within the kibbutzim we visited in the northern Sharon coastal plain is for export to Europe under European standards that are audited by the Global Gap. The treatment applications that leave low residues have not been effective (Mendel and Freeman 2012). Growers do not want to spray more

powerful insecticides because they will not be able to export their crop, as residues are not suitable for European standards. As an alternative, they plan to postpone pesticide application until after harvest time and before the next flowering period to salvage what fruit they can for the current year's export. Extension specialists and growers are also delaying treatment because they are hopeful for alternative control methods (natural enemies, organic compounds, pheromones, etc.); however, researchers continue to convey that this group of ambrosia beetles does not have natural enemies nor do they use aggregation pheromones. This strategy of postponing treatments is understandable from the growers' perspective. However, we observed larvae and adult beetles ready to emerge within galleries of infested material in many groves, indicating that the beetle is currently active and potentially spreading into nearby groves.

Based on these observations, researchers are suggesting to growers to heavily spray now the plots on the border between infested and non-infested areas with more potent insecticides to reduce beetle populations, and to prevent or to slow the spread of the beetles. The issue whether intensive treatments will allow the growers to cut their losses for this year in particular plots to prevent future and more categorical losses in the years to come is questionable. Simultaneously, they suggest implementing preventative applications of insecticide within non-infested plots at the geographic boundary of the infestation. The challenge the industry currently faces with this control strategy is that without permission of authority, growers are only allowed to spray trees until severely affected, which is based on a rating scale (in this case, level 3). Thus, newly infested groves are not prioritized for control of spread, which is most likely the best method for preventing new invasions.

In conclusion, all members of the industry now agree that PSHB/FD is a very serious problem and in retrospect more aggressive preventative measures could have drastically prevent or slow the spread of this pernicious agent. The history of the problem in Israel is a valuable case study for researchers and the avocado industry in California, where establishment of the beetle is in its early stages. While control measures are extensively being studied, researchers at this point are recommending extensive sanitation, removal of all materials and application of potent insecticide on infected spots. Furthermore, the industry in Israel is concerned about the damage *Botryosphaeria* canker is causing on avocado throughout the region. Researchers are actively studying the problem to understand what are the disease agents and what cause their explosion.

Figure 1. Map of Israel showing the primary avocado growing regions and locations visited. Map is adopted from Homsky (1995).

The following summarizes observations within each particular grove. Numbers correspond to locations visited in Fig. 1 that were explored sequentially.

1. Southern part of the South Negev region (Fig. 2)
Variety: Hass
Size: 295 acres
Accompanied by:
Professor Dani Shteinberg, Volcani Research Center
Dr. Stanley Freeman, Volcani Research Center
Dr. David Ezra, Volcani Research Center
Eli Simenski, private Agronomy consultant, Neva Team

This area is the southern-most avocado-growing region in Israel. The grove we visited was not infested with PSHB/FD, but was heavily infested with two *Botryosphaeria* species. Growers observed symptoms of branch dieback in the understory (Fig. 2A) in November 2011 over a 50-acre area, and within one year, the outbreak spread over 135 acres with no epicenter. The understory branches, where the infection primarily occurred, support all the fruit produced on the tree, and all the fruit on infected branches ultimately died along with the branches. Approximately 20% of the tree was affected and symptoms were observed on every tree.

It appears that the fungus is able to enter through natural wounds caused by sunburn injury (Fig 2 C), at the attachment point of dead twigs (Fig. 2 E) and through pruning wounds. This poses a challenge to growers because pruning alone is not the sole cause of fungal infection. In an attempt to sterilize the trees, branches were cut ~6 in past the branch infection. However, infection persisted and we observed that the fungus was able to travel down through the pith of the trunk (Fig. 2 D&E).

Fig. 2. Branch canker and dieback symptoms on avacodo (cv. Hass). A. Branch dieback; B. Sunburn damage on a one-year-old branch; C. Fungal discoloration at the base of a dead twig; D. Fungal infection within the tree trunk after cutting a stumped tree. E. Persisting fungal infection down the pith of the tree.

2. Rishpon (Figs. 3-5)
Variety: Pinkerton on Nabal root stock
Size: 2.5 acres
Accompanied by:
Professor Zvi Mendel, Volcani Research Center
Dr. Stanley Freeman, Volcani Research Center

This plot of avocado was adjacent to plots of olive, citrus and persimmon. We were told that they had found infested castor bean in the area and removed it. However, the avocado grove was already infested. They believe the grove had been infested for four years and within the plot, 100% of the trees were infested. Trees were not dead, but it was clear they were no longer economically viable because the limbs that support the avocado fruit were weakened by beetle attack and the weight of the branches thus forced them to break (Fig. 3). The grower tried stumping trees to keep the beetle population down, but efforts were not successful (Fig. 4).

Fig 3. Fusarium dieback symptoms caused by PSHB/FD in a commercial avocado grove. A. Fallen limbs on the ground, broken from beetle attack; B. Dead branches on a tree caused by beetle attack; C. Close up of a broken limb with beetle galleries and fungal discoloration on a cut branch; D. A recently broken limb and its previously attached fruits on the ground.

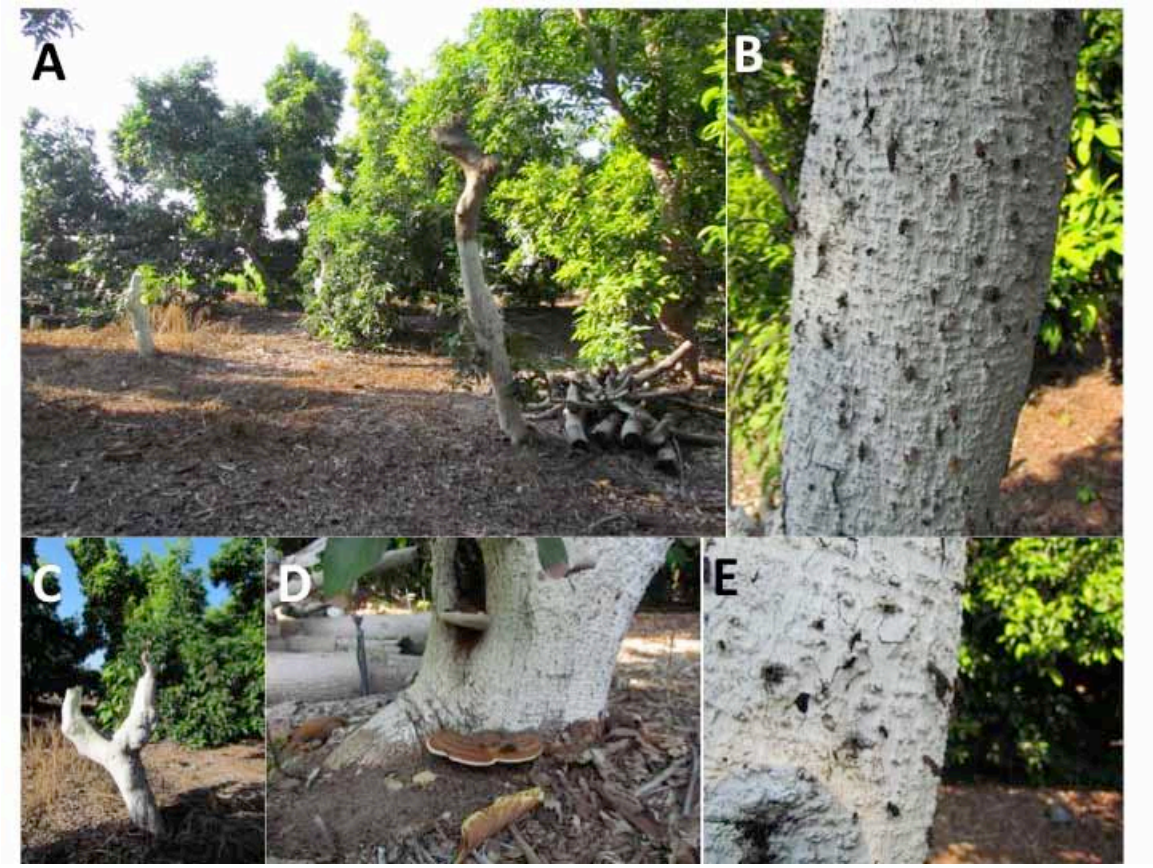

Fig. 4. A. Examples of stumping treatments on infested avocado trees in an attempt to reduce beetle populations; B. Close up of a stumped avocado tree showing symptoms of severe attack by PSHB; C-D. Dead (C) and dying (D) avocado trees post-stumping treatment; E. Frass symptoms indicating beetle colonization post-stumping treatment.

The persimmon grove was newly planted and not infested. Olives in the adjacent plot, approximately 55 yards away, showed symptoms of PSHB attack at the base of the trunk (Fig. 5).

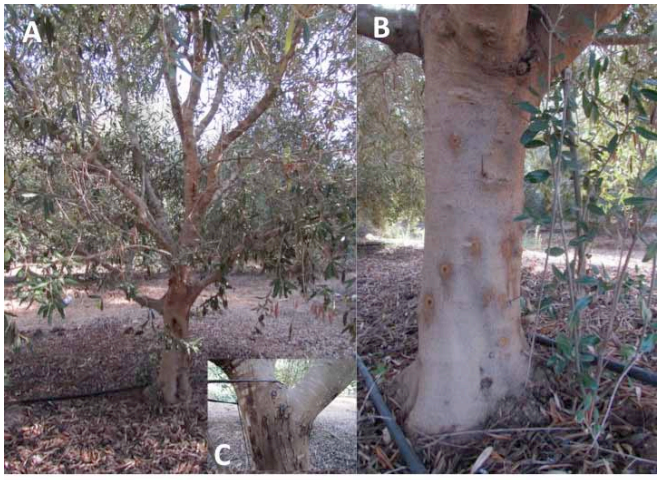

Fig. 5. A. Infested olive trees next to infested avocado grove; B. Beetle entry holes without gumming symptoms; C. Beetle entry holes with gumming.

3. Kibbutzim of Ma'agan Mikha'el and Nakhsholim (Fig. 6-8)
South coast section of the northern part of the country
Variety: Hass
Size: 247 Acres
Accompanied by:
Michael Noy, State extension specialist in subtropical fruit, Israeli Ministry of Agruculture
Jonathon Izhar, extension entomologist and private consultant
Jonathan Mazor, PhD candidate
Professor Zvi Mendel, Volcani Research Center
Dr. Stanley Freeman, Volcani Research Center

Within the kibbutzim, approximately 10 tons of avocado per acre are produced. Avocado in this area was originally cultivated organically, but the infestation has forced them to try more conventional control measures.

Kibbutz Ma'agan Mikha'el (Figs. 6-7)
This location was previously known as the northern-most part of the infestation, which started just north of the kibbutz Ma'agan Mikha'el, and is believed to be the main problematic area. Symptoms of FD/PSHB were observed approximately 2-3 years ago on persimmon adjacent to an avocado plot. This plot is now 100% infested (Fig. 6) and according to Jonathan, they are seeing total loss in yield. The beetle/fungus is now firmly established in the avocado plot adjacent to the originally infested avocado plot. According to extension officers, this happened over a period of two months. They applied insecticides one month later, but treatment was not successful. It is likely the beetle was in the plot for a longer period of time.

Fig. 6. A. Meeting with extension specialist, researchers and growers; B. Grove infested with PSHB/FD; C. Symptoms of beetle/fungal attack on secondary branches; D. Beetle galleries on a broken limb; E. Perseitol exudates on an avocado tree infested with PSHB/FD.

Fig. 7. Branch dieaback symptoms in a heavily infested avocado grove. A. Branch dieback symptoms. B.C. Diebacked branches showing shriveled fruits on them

Kibbutz Nakhsholim (Fig. 8)

This grove was un-infested at the time of writing. It is located approximately 220 yards from Kibbutz Mikha'el. The grower expressed his concern over a looming beetle invasion and anxiety over losing his crop. As a preventative measure, the grower sprayed the first three lines closest to the infested grove (Fig. 8 A), and is hopeful this strategy will be sufficient in blockading the beetle. Given that the beetle can fly up to two miles, researchers are skeptical that this measure will prevent beetle establishment within the grove.

There is an experimental plot at this location where there are ongoing insecticide studies (Fig 8 B).

Fig. 8. A. Grower pointing at the un-infested avocado grove he sprayed to prevent a beetle invasion; B. Experimental grove utilized for insecticide treatments.

4. Nordiya (Fig. 9)
Accompanied by Dr. David Ezra, Volcani Research Center

This location comprised of a four year old persimmon (Virginiana variety) plot adjacent to Pinkerton and Hass avocado variety plots. All plots were infested with PSHB/FD.

Extensive gumming was observed on the persimmon (Fig 9). Although persimmon is not a suitable host for beetle reproduction and the fungus therefore cannot colonize the xylem of the tree, it can colonize the cambium with multiple attacks by the beetle, which could thereby girdle the branch. Mechanical damage caused by multiple beetle attacks can also weaken the branch of the tree.

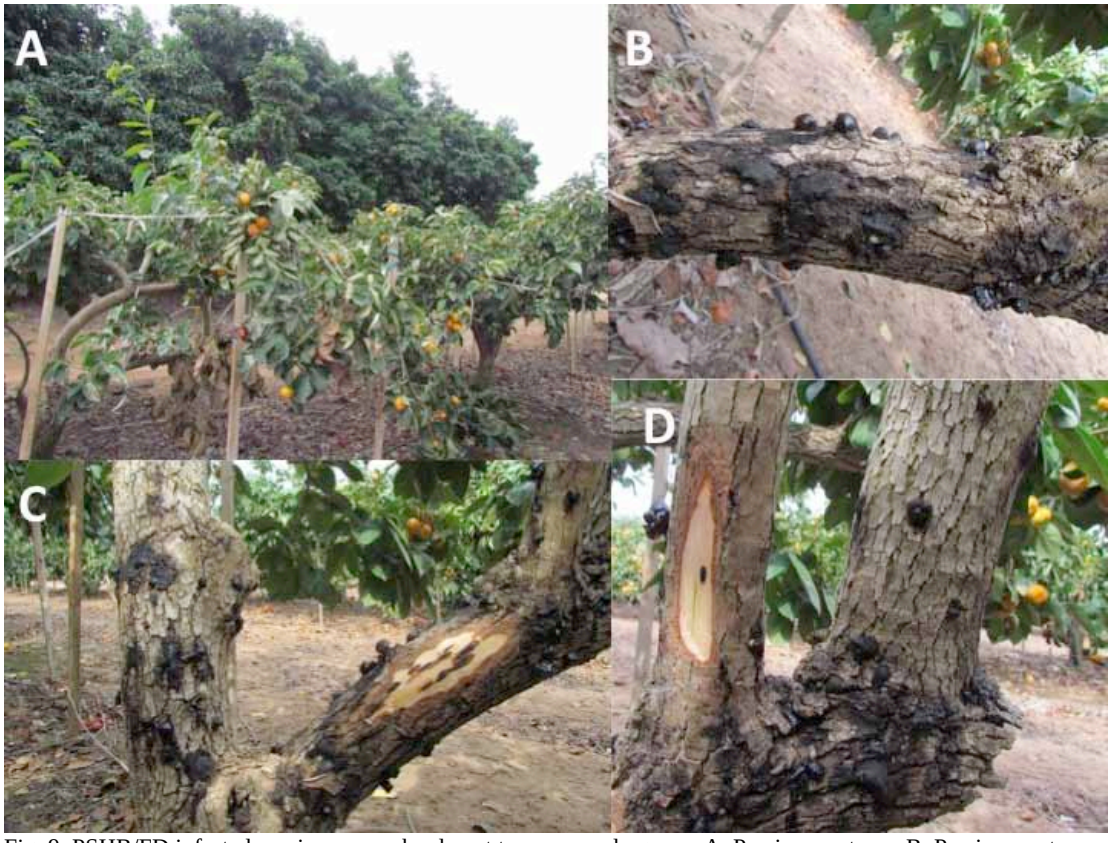

Fig. 9. PSHB/FD infested persimmon orchard next to an avocado grove. A. Persimmon trees. B. Persimmon trees showing gumming symptoms; C-D. Gumming and fungal discoloration on the cambium of persimmon trees.

5. Ma'abarot
Variety: Hass
Accompanied by: Dr. David Ezra
Infested by PSHB/FD.

6. Hefer Valley (**Two Kibbutzim) (Fig. 10)**
Variety: Ardit
Accompainied by:
Dr. David Ezra, Volcani Research Center
Eli Simenski, private agronomy consultant, Neva Team
Jonathan Izhar, entomologist and private consultant

Managers practice girdling to encourage more fruit production at this location. The beetle has been in the grove for three years and three weeks prior to our visit, growers noticed symptoms resembling Botryosphaeria canker. At this point, it is difficult to assess the impact of two aggressive diseases, Fusarium Dieback and Botryosphaeria canker, within a grove. Given that both cause severe damage on their own, the impact could be devastating.

Based on our observations at this site, hot summers seem to be preferable conditions for fungal infection by *Botryosphaeria spp.* and the fungus seems to enter primarily through sunburn wounds and dead twigs. Researchers at the Volcani Research Center are studying fungal identification, distribution and precise mode of transmission and aggressiveness by the fungi.

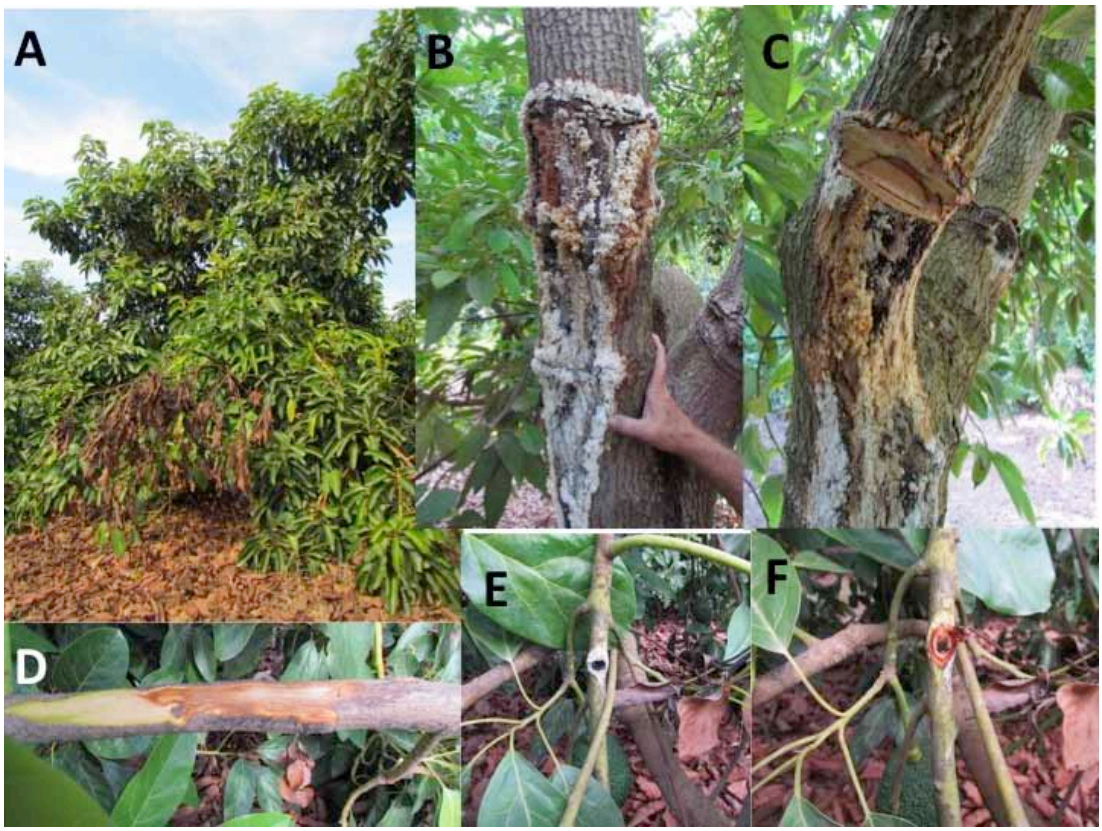

Fig. 10. A. Avocado branch dieback symptoms caused by *Botryosphaeria* spp.; B-C. Perseitol excuding from girdled avocado branches attacked by PSHB and (C) fungal colonization by *Fusarum sp.*; D. Cankered secondary branch caused by *Botryosphaeria sp.*, which entered through a sunburn wound; E-F Fungal colonization of *Botryosphaeria sp.* observed under the base of cut-off dead twigs.

7. Ha-Goshrim (Fig. 11)
Total growing area: 6.4 acres
Area visited: 2.5 acres
Variety: Gallin
Accompanied by:
Professor Zvi Mendel, Volcani Research Center
Dr. Stanley Freeman, Volcani Research Center
Jonathan, grove manager
Eli, landscape architect for northern Kibbutzim
Dr. Rakefet, regional entomologist, Ministry of Agriculture

Both the beetle and larvae were observed within galleries of infested branches, confirming presence of PSHB/FD in the northern-most avocado-growing region of Israel. Jonathan stated that he noticed symptoms nine months ago, but the infestation exploded within the last month. According to Professor Mendel, the beetle therefore must have been within the grove for approximately two years.

Fig. 11. A. Branch dieback and wilt symptoms caused by PSHB/FD on Gallin variety avocado trees in Ha-Goshrim; B-C. Beetle galleries and internal discoloration caused by PSHB and *Fusarim* sp.

8. Kibbutz (Fig. 12)
Accompanied by:
Professor Zvi Mendel, Volcani Research Center
Dr. Stanley Freeman, Volcani Research Center
Eli, landscape architect for northern Kibbutzim

This kibbutz was not an avocado grove, but a community area located approximately 4 miles southeast of Ha-Goshrim. The kibbutz is landscaped with various ornamental and Israeli-native trees. A single box elder with symptoms on a single branch was encountered. Larvae and the beetle were found in the branch, and discoloration caused by the fungus was observed in the cambium.

Fig. 12. A. Box elder tree infested with PSHB/FD in a Kibbutz in northern Israel, approximately four miles southeast of Ha-Goshrim; B. Professor Mendel examining an infested branch; C-D. Discoloration within the cambium, suggesting fungal growth of *Fusarium* sp.

9. Khorshat Tal National Park (Fig. 13)

This national park is less than one mile south of Ha-Goshrim. We encountered four sycamores (*Platanus orientalis*), all spaced approximately eight yards apart, with staining and exit hole symptoms.

Fig. 13. A-B. Sycamore trees showing symptoms resembling PSHB/*Fusarium* sp. attack.

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