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The 'Ambrosia Beetle' in Israel

The avocado orchards in Israel cover an area of approximately 18,000 acres, with 'Hass' covering about half of the area. During the 2014-15 season about 174 million pounds were produced, with approximately 55 percent of the crop destined for export, most of it to European markets.

Until recently, the avocado industry enjoyed low pressure by pests and diseases making the management scheme of commercial plantations comparable to organic farms. The great majority of the 90 species of phytophagous insects and mites known to feed on avocado trees in Israel are under good biological balance. Ten species (half of them invasive) are of economic importance, but only one, the ambrosia beetle, *Euwallacea* nr. *fornicatus* (Coleoptera: Scolytinae) is now ranked as a serious pest.

For years, fungal pathogens did not pose a serious threat to avocado in Israel, with a limited incidence of damage caused by *Phytophthora cinammomi*. However, during the last decade *Botryosphaeria* spp. fungal pathogens have become an important issue.

The ambrosia beetle is a new invasive species to Israel, and to date the beetle has been recorded from 48 tree species representing 25 plant families. The beetle carries within its mandibular mycangia three primary fungal symbionts: *Fusarium euwallaceae*, *Graphium* sp. and *Acremonium* sp.; these fungi also being cultivated in beetle brood galleries. Larvae and adult beetles feed on *F. euwallaceae* and *Graphium* sp. The same beetle species and fungal complex also are known from California (Los Angeles County region, known as PSHB), South Africa and Southeast Asia (Vietnam and China), with the latter probably serving as the origin of the beetle (R. Stouthamer and A. Eskalen, pers. communication).

To date, the beetle has spread to approximately 60 percent of the avocado plantations in Israel. In 25 percent of the infested plantations, the damage level is ranked as moderate to severe (comprising dieback of mature limbs and loss of yield). The *F. euwallaceae* population in Israel appears to be uniform and clonal indicating a single introduction of the beetle. The beetle fungal interactions and the pathogenic role of these three fungal species in avocado dieback are under investigation.

The most typical symptom of attack by the beetle on avocado trees is the exudation of a sugary substance (mostly perseitol) that marks the penetration spots. Stems and branches of various diameters attacked by the beetle display this symptom within a few days after the beetle has penetrated the xylem. Many of the attacks on avocado do not end in successful establishment of the beetle, and infection by *F. euwallaceae* alone results in typical cankers that increase in size, especially in large (> 4 inches) diameter branches. While the cortex does not seem to be injured by the assault, the xylem surrounding the gallery generated by the beetle is stained dark brown. The xylem staining is linked to the development of *F. euwallaceae*, likely caused by products originating from the fungi, and may appear close to the gallery or up to 16 inches away from the beetle penetration points. *F. euwallaceae* does not significantly injure young vegetative avocado tissues. Infection by the fungus appears to be localized and restricted to a few centimeters beyond the galleries and therefore is not always detected in the stained tissue.

Successful branch colonization, as reflected by predominant development of the brood, is related to previous fungal inoculation by the beetle or in the base of weak, small diameter (.75 – 2.5 inches) branches usually during the previous season. Most of the flying beetles return to attack branches displaying the typical symptoms of the beetle assault. At this stage, new beetle penetrations are not associated with massive sugar exudation. In avocado, successful reproduction occurs mainly in thin branches, and attacks on the stem and large diameter branches do not terminate in brood galleries. However, in other suitable reproductive trees, such as English oak (several *Quercus* spp.), box elder (*Acer negundo*) or sycamore (*Platanus* spp.) the beetle attack and establishment is more successful on the trunks and large diameter branches than on thin branches.

Development cycle of the beetle may last between five and eight weeks. Adult brood emergence is dependent on the deterioration of surrounding tissue. Emergence in avocado takes place between one and two years after the initial (unsuccessful) attack. The thin branches usually desiccate after about two beetle generations. In tree species where the beetle colonizes much larger branches, they survive for longer periods, and may produce more generations

before moving to a new breeding site (branch, tree or plantation). Branch colonization happens usually close to the base of the branch near the shoulder of a larger one. The beetle and fungi development disrupt the water flow and the rest of the branch dries and wilts even before the emergence of the brood. Examining the beetle age distribution in the grove clearly showed that all developmental stages are found all year round. However, flight occurrences are intensified during the second half of the summer (July – September).

Tree susceptibility is ranked according to three main parameters: frequency of attack, gallery density and offspring production. Among several suitable tree species for beetle production, avocado is considered among the least susceptible. Although all avocado varieties are susceptible to some degree, differences in susceptibility to the beetle and the fungal symbiont complex were observed between several avocado varieties in the following order (most affected to least): Fino > Hass > Reed > Pinkerton > Nabal> Ettinger + Fuerte > Galil + Ardit. Information accumulated suggests that beetle attack frequency coincides with alternation as sugar exudation and dying branches increase after fruit 'on' bearing season. However, preliminary analysis of fruit yield data in Hass avocado orchards, as related to the ambrosia beetle infestation, does not imply any significant yield loss in the moderately infested orchards.

Several management strategies were examined during the last five years since the beginning of the 'ambrosia problem'. The use of several fungicides and insecticides to cope with the problem was evaluated in both laboratory and field trials. Both compounds possessing systemic modes of action as well as insecticides for cover spray were assessed. Systemic compounds were ruled out due to a combination of inefficient transport through the water system, residue hazard and cost. Cover sprays are not considered a routine measure since they were not sufficiently effective and pose a risk to disrupt the biological balance of many potential insect pests. Preliminary treatments with commercial *Beauveria bassiana* (entomopathogenic fungus) products as a preventive measure were disappointing.

Our current recommended management in light and moderately infested avocado orchards is based on several measures: (1) extensive monitoring; (2) removing thin (<6 cm diam.) infested branches; (3) removing wilted branches and treating cuts on a main branch with Bifenthrin, a pyrethroid (1 percent) and (4) the bark area around the lesions on > 2.5 inches diameter thick branches should be treated with Bifenthrin (1 percent) 12 inches beyond the lesion on both sides of the branch in order to prevent further beetle attack. The effect of additional treatment with Acetamiprid (neonicotinoid), which aimed to kill the fungal symbiont, is under study.

Typical exterior symptoms of beetle penetration of a weakened avocado branch

Typical interior symptoms of beetle penetration into a weakened avocado branch - yet no successful beetle establishment and breeding

Tree response two weeks after artificial inoculation of avocado branches with the symbiotic fungus Fusarium euwallaceae