EXTENSION PUBLICATIONS

College of Tropical Agriculture
and Human Resources
University of Hawaiʻi at Manoa

Evaluation of Conventional and Organic Insecticides Against Avocado Lace Bug in Hawaiʻi

Introduction

Since the first report of avocado lace bug, *Pseudacysta persea* (Hemiptera: Tingidae), on O'ahu in 2019, it has been found widespread in Hawaiʻi (Matsunaga and Silva, 2020). Avocado (*Persea americana*) trees of various ages and varieties have been found suffering medium to heavy levels of lace bug infestation. Colonies of avocado lace bugs (ALB) often consist of adults alongside excrement, eggs, and nymphs on the underside of the leaves (Fig. 1). Although the lace bug does not attack fruits, their feeding causes leaf drop and reduced fruit yield as chlorotic spots, starting from the interior of the leaf, progressing into brown necrotic dead tissue. The ALB life cycle takes about 3 weeks to complete, with multiple generations per year in Hawaiʻi (Wright, 2020).

Figure 1. Avocado lace bug adult and nymphs.

Though the lace bug is unlikely to kill avocado trees, its impact on yield warrants control measures. The damage of ALB is most severe when the tree is young, as defoliation from ALB would result in sunscald on the tree. In fact, even severe defoliation on older trees has been seen to cause sun scalding on the fruits, which affect the marketability and shelf life of the fruits after harvest (Dan Caroll, personal communication). Although many natural enemies of ALB have been reported, including two egg parasitoids, the green lacewing, and a predacious mirid bug in Florida (TREC, 2021), no parasitoid has been reported attacking ALB in Hawaiʻi.

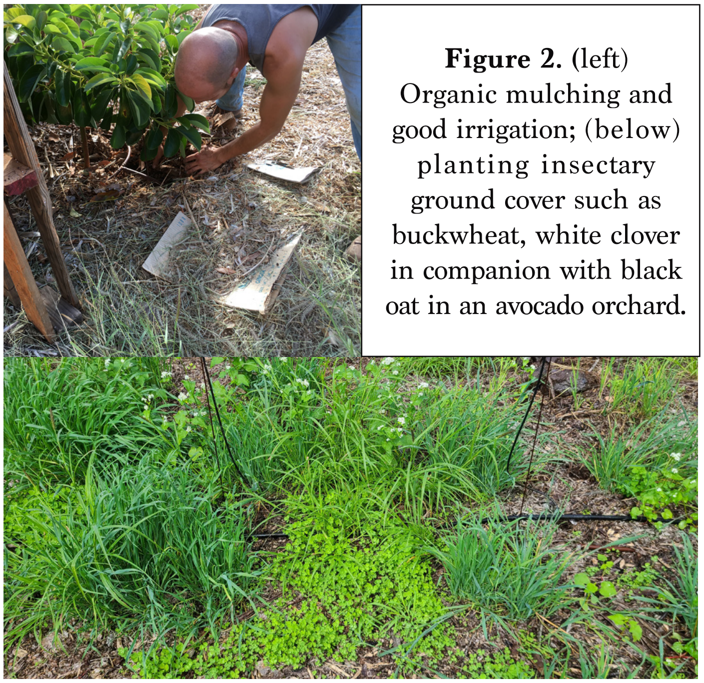

Figure 2. (left) Organic mulching and good irrigation; (below) planting insectary ground cover such as buckwheat, white clover in companion with black oat in an avocado orchard.

Nonetheless, conservation biological control, by establishing insectary plant borders or ground covers, plays a key role in developing an effective integrated pest management program for avocado production. Thick mulching of coarse organic composted materials under

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the tree, along with appropriate irrigation (Fig. 2A) would help avocado trees overcome periodic feeding stress imposed by ALB (Bender et al., 2007). This article will focus on evaluating insecticides registered for use on avocado trees in Hawaiʻi but encourage avocado growers to do farm-scaping (Fig 2B) to enhance the natural enemies for long-term solution of this pest. Specific objectives of this study were to 1) evaluate the efficacy of a range of pesticides registered for use on avocado trees in Hawaiʻi, and 2) to compare conventional vs organic insecticide rotations against ALB.

Materials and Methods

Trial I (Individual Insecticide Test)

A field trial was conducted from January 13 to March 18, 2021, in a U.H. College of Tropical Agriculture and Human Resources (CTAHR) avocado variety collection orchard at Poamoho Experiment Station. Thirty-six established avocado trees (>20 years old) were randomly selected from the orchard and subjected to 12 foliar sprays, including an untreated control, each with 3 replicated plants.

Insecticides were sprayed at 2-week intervals with 220 gal/acre spray coverage plus Kinetic® (Helena Agri-Enterprises, Collierville, TN) adjuvant using a Stihl backpack mist blower. Modes of action of these insecticides are listed in Table 1.

Data Collection

At 1 week after each spray application, 5 leaves were randomly picked from each tree and counted for the number of ALB, alive and dead, per leaf (Fig 3A). Percent of ALB dead on each leaf was calculated. In addition, overall health of each tree was rated using a lace bug damage rating scale of 1-5, as shown in Fig. 3 B-F on each sampling date. Four spray applications were performed, thus there were 4 sampling dates. Lace bug damage rating and % lace bug dead data were subjected to repeated measure analysis over time and one-way analysis of variance using SAS 9.4 (SAS Inc., Cary, NC). Means were separated using Waller-Duncan k-ratio (k=100) t-test.

Table 1. Active ingredients (a.i.), mode of action (MOA) groups, rates, and manufacturer of insecticides used in Trial I and Trial II.

	a.i.	MOA (Grp)	Rate	Manufacturer
Admire Pro®	imidacloprid	4A	2.8 fl oz/acre	Bayer Crop Science, Research Triangle Park, NC
Danitrol®	fenpropathrin	3	21.0 fl oz/acre	Valent U.S.A. LLC, Walnut Creek, CA
Ecotec®	rosemary oil peppermint oil	N/A	4.0 pt/acre	Brandt Consolidated, Inc., Springfield, IL
Entrust® SC	spinosad	5	3.0 fl oz/acre	Corteva Agriscience, Johnston, IA
Malathion®	Malathion	Organo-phosphate	4.7 fl oz/acre	Loveland Products, INC., Greeley, CO
Molt-X®	azadirachtin	N/A	10.0 fl oz/acre	Bioworks, Inc., Victor, NY
Movento®	spirotetramat	23	10.0 fl oz/acre	Bayer Crop Science, Research Triangle Park, NC
M-pede®	K-salt of fatty acid	N/A	2.0 % v/v	Gowan, Yuma, AZ
Mustang®	zeta-cypermethrin	3A	4.3 fl oz/acre	FMC Cooperate, Philadelphia, PA
Mycotrol®	*Beauveria bassiana* Strain GHA	N/A	1.0 qt/acre	BioWorks Inc., Victor, NY
PureCrop 1®	Soybean oil and corn oil	N/A	1.5% v/v	PureCrop 1, Ukiah, CA
Pyganic®	pyrethrum	N/A	15.6 fl oz/acre	MGK, Minneapolis, MN
Sivanto Prime®	flupyradifurone	4D	14.0 fl oz/acre	Bayer Crop Science, Research Triangle Park, NC

Trial II (Insecticides Rotation Test)

A second trial was conducted from April 9 to September 23, 2021, at Poamoho Experiment Station. Ten avocado trees, randomly selected from CTAHR's avocado varieties collection orchard, were foliar sprayed following 1) conventional (chemical and organic) insecticides rotation, 2) organic (solely OMRI certified) insecticides rotation, or 3) not sprayed (control) in 2- to 4-week intervals with time of application listed in Table 2. Due to the flexible nature of conventional practice, the insecticide rotation included some organic and some synthetic insecticides to provide growers a perspective of rotation scheme that does not need to heavily rely on synthetic insecticides. Application rates of each insecticide used are listed in Table 1. Spray coverage and adjuvant used, as well as data collection, was the same as described in Trial I.

Figure 3. (A) Leaf samples for ALB mortality count; (B-F) avocado lace bug damage rating scale of 1-5 where 1 is healthy and 5 is most damaged.

Table 2. Application dates and insecticides used in Conventional vs Organic rotations in Trial II.

Date	Conventional	Organic	Date	Conventional	Organic
April 9, 2021	Ecotec*	Molt-X*	July 6, 2021	PureCrop 1*	PureCrop 1*
April 23, 2021	Ecotec*	Molt-X*	Aug 9, 2021	Danitol	Molt-X*
May 14, 2021	Admire Pro	Ecotec*	Sept 8, 2021	Sivanto®	PureCrop 1*
May 26, 2021	Ecotec*	Ecotec*	Sept 17, 2021	No treatment	PureCrop 1*
June 23, 2021	Malathion	Pyganic*			

Results and Discussion

Trial I

Efficacy of individual insecticide: During Trial I, most of the trees at this site flowered from January to the end of March and did not flush out new leaves until flowering was over. Thus, data from the damage rating might not be meaningful, since the plants did not produce new leaves and did not show good signs of recovery. Therefore, damage rating data was not presented here. Nonetheless, the untreated control had the highest ALB damage rating. In terms of % death of ALB on the leaves, Admire Pro, EcoTec, Mustang, and Sivanto were most effective in causing death to ALB (Fig. 4).

Trial II

Overall, the Conventional Chemical rotation significantly reduced ALB damage as well as increased mortality of ALB throughout the 5-month observation period. The Conventional Chemical rotation scheme worked despite using some organic insecticides, which were not effective on their own, in the rotation with the synthetic insecticides.

Data in Fig. 5 shows the percent death of ALB following the flowering phenology of avocado. Since most of the avocado flowered by March to early April in this orchard, toward the end of April, ALB population densities increased due to the flush of new leaves. Thus, more ALB

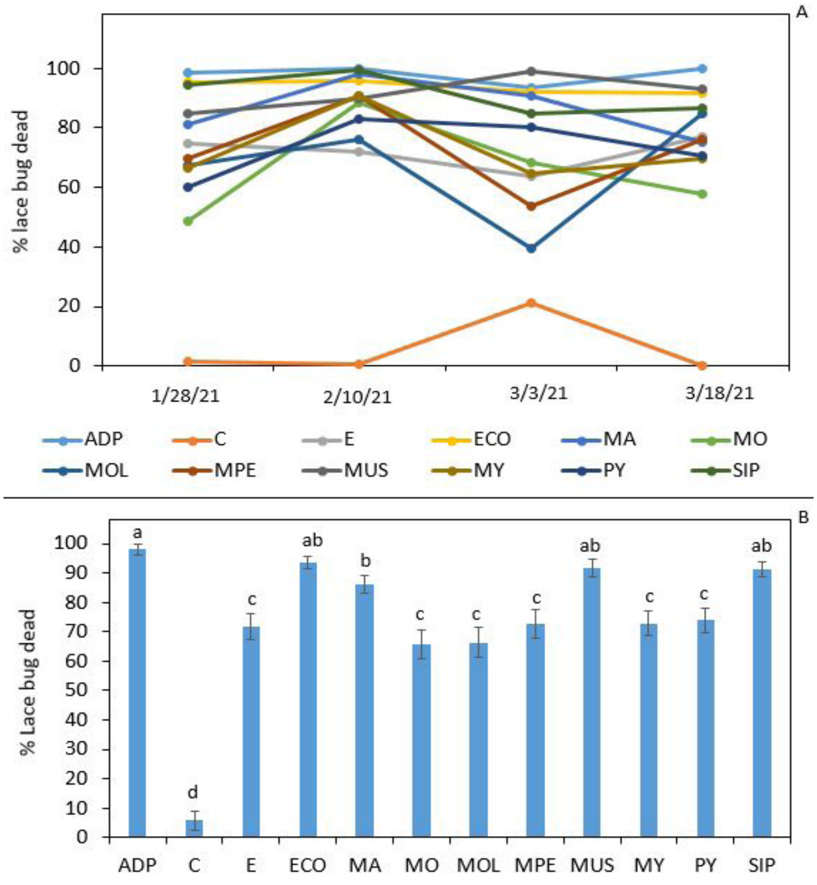

Figure 4. Effects of 11 insecticides against avocado lace bugs on the mortality of avocado lace bugs at Poamoho Experiment Station.

Means (n= 60) are an average of 5 leaves per plant from 3 plants per treatment over 4 sampling times. Each insecticide was treated every 2 weeks from January 21 to March 11, 2021. Data was taken 1 week after each treatment.

ADP = Admire Pro
C = untreated control
E = Entrust
Eco = EcoTec
MA = Malathion
Mo = Movento
MOL = Molt-X
MUS = Mustang
MY = Mycotrol
PY =Pyganic
SIP = Silvanto Prime

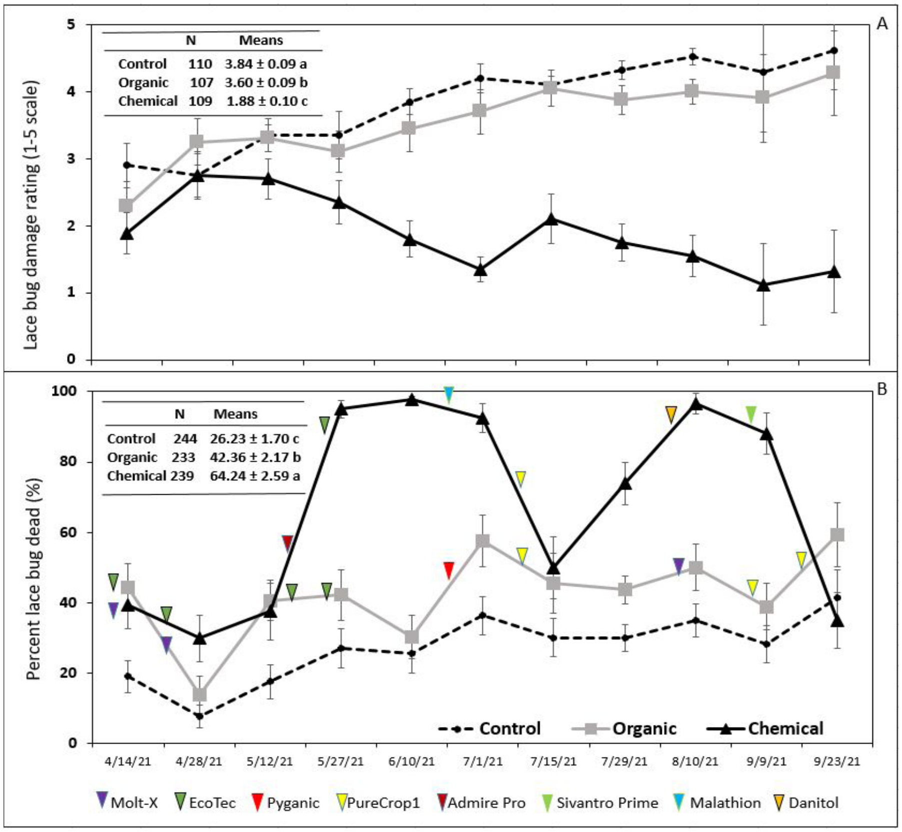

Figure 5. A) Avocado lace bug damage rating (n=10), and B) % of lace bug dead (n = 4 plants × 5 leaves), as affected by organic insecticides vs conventional chemical insecticide rotation in Trial II at the Poamoho Experiment Station.

Insecticide treatment dates and types are marked with triangles. Data was taken at 2-week intervals.

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damage was observed in May, especially in the untreated control as the leaves slowly matured (Fig. 5A). The first two EcoTec (Rosemary and peppermint oil extracts) applications in the Conventional chemical rotation did not reduce ALB damage (Fig. 5 A) or increase the percent of ALB death (Fig. 5B), as observed in Trial I (Fig. 4B). However, starting from the May 14 Admire Pro application, a dramatic increase in ALB mortality (> 95% ALB death) accompanied by a decline in damage rating of ALB were observed. This effect lasted until July 1 (Fig. 5).

Although EcoTec and Malathion were also applied during this period, and might have kept the population of ALB low, the systemic nature of imidacloprid (Bayer Crop Science®) might have contributed to the low lace bug damage in the chemical rotation treatment over a period of 1.5 months. It is important to schedule an application of Admire Pro or other imidacloprid product away from the flowering period, as it is harmful to honeybees upon ingestion (Suchail et al., 2001).

PureCrop1® composed of soybean and corn oil nanoparticles is labeled as an insecticide, fungicide, biostimulant, and surfactant. The micelle of PureCrop1® is attracted to the bacteria in the sap-sucking insect gut, and can penetrate into the cellular wall of the insect and disrupt their enzymes (https://www.purecrop1.com/products/label/). This effect of PureCrop1® was not obvious in either of the Conventional and Organic rotations, though it maintained a higher mortality rate than the untreated control (Fig 6B). However, in the chemical rotation, the % death of ALB two weeks after PureCrop1 application increased (~73.8% ALB death) despite no other treatment for 3 weeks. It is unclear why the different results of PureCrop1 were observed.

Danitol® contains fenpropathrin, a broad-spectrum insecticide with the same mode of action as many synthetic pyrethroids, but it is proven not to flare mites (Valent®), which is often seen when using pyrethroids that lead to an outburst of mites due to their non-target effect on the natural enemies of mites. One-time application of Danitol showed promising results in maintaining a high mortality of ALB (~96.7%) in the Conventional rotation scheme (Fig. 5B). Bear in mind that, just as with other pyrethroids, some insects are known to develop resistance to this product if used repeatedly. Thus, it is recommended to rotate this insecticide with other insecticides.

Sivantro® is the first insecticide in the newly created IRAC subgroup 4D, the Butenolides, and has shown excellent control of neonicotinoid-resistant aphids and whiteflies (Bayer Crop Sciences). It precisely targets sap-sucking pests with a long-lasting residual activity, while helping to safeguard beneficial insects. However, results in Fig. 5B did not show it has long-lasting residual effects, as the % death of ALB dropped from 88.2% mortality to 34.9% at two weeks after Sivantro® application.

The organic insecticides rotation scheme tested in this trial provided intermediate control of ALB where the damage rating was only slightly lower (Fig. 5A), and the % dead ALB was slightly higher than the untreated control (Fig. 5B). Among the organic insecticides tested, Pyganic® was able to inflict the greatest ALB death (57.5%). Interestingly, PureCrop1® applied consecutively on Sept. 8 and 17, 2021, resulted in a 59.3% spike in ALB mortality.

Summary

This study provides examples of insecticide rotation schemes for effective management of ALB. While implementing these rotation schemes, one should follow pesticide labels, especially, on whether a pesticide is labeled for the target crop and the state, and other specifications, such as preharvest intervals, re-entry intervals, and maximum rate allowed per acre per crop cycle. It is important not to spray during the flower bloom period when honey bees are foraging.

One should also avoid broad-spectrum and long residual insecticides (e.g. carbamates, organophosphate, pyrethroids), as they may kill natural enemies, rendering a pesticide treadmill scenario. Imidacloprid (Admire Pro) and Malathion are very effective for ALB control, but these insecticides cannot be applied weekly and only applied when avocado is not in bloom. Imidacloprid can also be applied via soil drenching, as it will translocate to leaves and avoid contact with beneficials. BioAdvanced® (SBM Life Science Corp, Cary, NC) is another imidacloprid product labeled for residential use. "Softer" contact insecticides, such as M-Pede, Mycotrol (*Beauveria bassiana*), Molt-X, Pyganic, and Ecotec only provide temporary control when ALB infestation is low.

While options of insecticides are available to overcome the immediate problem or in cases of outbreak, the most ideal way to manage ALB is by integrated pest management strategies to maximize conservation of natural enemies, along with the judicious use of insecticides. If insecticide application is needed, farmers should consider the insecticide rotational scheme, as suggested in this article. The use of insecticides of different Mode of action (MOA) groups in rotational schemes will limit the possible development of insecticide-resistant populations to one particular insecticide.

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