

Evaluation of Systemic Chemicals for Avocado Thrips and Avocado Lace Bug Management

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Project Overview

We are evaluating systemic insecticides for the management of current and newly emerging pests of California avocados. Studies are being conducted in commercial avocado groves, under normal agronomic practices. Trees are treated using a variety of techniques – soil application, trunk injection – to establish the methods that will provide the best uptake of insecticide for the protection of the trees. Our primary research focus is on the avocado thrips and the avocado lace bug. Despite its recent introduction, the avocado thrips is already an established pest of avocados in California. The avocado lace bug is a more recent introduction, and has not yet established widely within the avocado growing regions. Current management practices for avocado thrips are centered on the use of foliar insecticides. Several foliar treatments are available (Agri-Mek, Success, and Veratran D) for the control of avocado thrips. However, the number of products is limited, the mode of application can be difficult (helicopter use on steep hillsides, applications near urban regions), and there are risks of resistance development, particularly to Agri-Mek due to it also being used against persea mite during the summer. Systemic neonicotinoid insecticides are relatively easy to apply (via established sprinkler irrigation systems or by modern trunk injection systems), and have a mode of action that has not been in use for the management of avocado thrips. A new mode of action would substantially lower the resistance risk associated with Agri-Mek, and alleviate operational difficulties in the use of foliar treatments.

To measure insecticide uptake, we are using two techniques. First, we collect leaves that are attractive for avocado thrips and avocado lace bug feeding and conduct bioassays by exposing the insects to these leaves for a pre-determined period of time. Leaf punches from these bioassay leaves are also used to quantify the levels of pesticide present within the leaves. In this way, we are able to compare the levels of mortality in our bioassays with the quantity of insecticide that is present in those same leaves. With this information, we can establish activity thresholds for the insecticides, and subsequently evaluate the capacity of different application strategies at achieving these required concentrations. Insecticides that fall short of the activity thresholds will not be recommended for use within the avocado industry.

We are also testing the fruit on these trees to ensure that there are acceptable residue levels present that would not compromise the management effort. It is important to growers that their fruit not be contaminated with pesticides as a consequence of any pest management effort. To address these concerns, we have established a residue analysis program in collaboration with Dr. Robert Krieger at UC Riverside.

Trunk Injections

In 2007, we established a collaboration with Arborjet, Inc., a company specializing in trunk injections. Arborjet has several products already available that we are interested in testing, as well as some under development. In our current trial, we evaluated 4 insecticides, representing 3 chemical classes – neonicotinoids, organophosphates, and avermectins – at different rates of injection. Leaves were sampled for avocado thrips and avocado lace bug bioassays, as well as for residue measurements. Fruit was sampled over 16 weeks to test for insecticide residues.

Bioassays

Bioassays were conducted on leaves sampled from trees that were treated with acephate, a proprietary avermectin, and dinotefuran (Figure 1). Imidacloprid was not included in this program because we have already established activity thresholds for this insecticide, and evaluations could therefore be limited to residue measurements alone. During the first 4 weeks following the treatments, the leaves chosen for bioassays were mature, fully expanded leaves that were present on the trees at the time of the applications. Avocado thrips used for the bioassays were collected from leaves of similar age at an untreated infested grove, vindicating our use of mature leaves in the absence of flushing spring growth. Leaves sampled from acephate-treated trees were highly toxic to avocado thrips for up to 4 weeks following treatment. Dinotefuran efficacy was optimal at 3 weeks, while the efficacy of the avermectin was poor throughout.

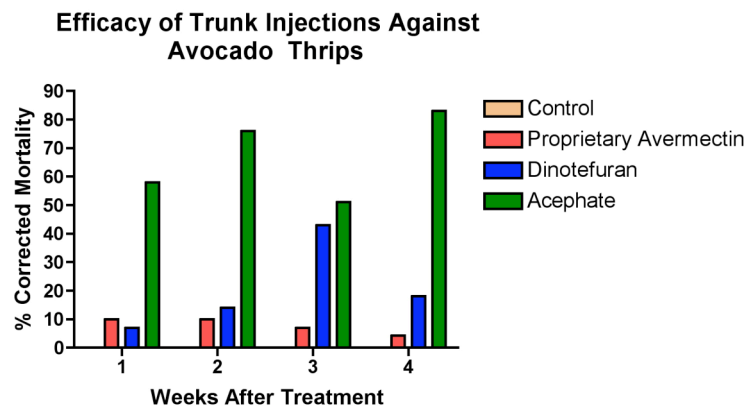


Figure 1. Mortality of avocado thrips exposed to avocado leaves treated systemically with acephate, dinotefuran, and a proprietary avermectin.

Avocado lace bug bioassays were conducted with acephate, imidacloprid, and dinotefuran at 6 and 11 weeks after trunk injections (Table 1). Each treatment provided excellent control at week 6. Mortality in acephate-treated trees was poor on week 11, but remained high in both imidacloprid- and dinotefuran-treated trees. Avocado lace bugs feed on older leaves. Therefore, management of this pest will be less constrained by the need to time treatments to optimize uptake into younger flushing foliage, as is the case with avocado thrips.

Insecticide	% Mortality	
	6 Weeks After Treatment	11 Weeks After Treatment
Acephate	64	18
Dinotefuran	99	88
Imidacloprid	89	76

Leaf Residues

The residues of imidacloprid and dinotefuran were measured using commercially available ELISA kits, which utilize insecticide-specific antibodies for quantifying insecticides. We compared the concentrations of these insecticides in mature, fully expanded leaves that were present on the trees at the time of applications, as well as spring flush leaves, which were available for combined bioassay/ELISA tests at 6 weeks after the trees were trunk injected.

The uptake of dinotefuran into leaves was rapid in comparison with imidacloprid (Figure 2). However, once we included spring flush leaves in our bioassays, the dinotefuran was not detected. This indicates that the dinotefuran injected into the tree was mobilized into the foliage already established on the trees. Because our injection date preceded the spring flush, none of these leaves received any detectable insecticide when they began to develop on the trees, as the xylem resources had likely been depleted. In contrast, the movement of imidacloprid was so slow within the xylem system that it remained within the xylem for several weeks after the injections. At the time of active leaf flushing, the residues of imidacloprid were then mobilized within the trees to provide substantial levels of insecticide in the younger foliage. It is clear from a comparison of the young and mature leaves (Figure 3) that the flushing of new growth provides a major push of materials that are present within the xylem. Therefore, if the timing of the injections can be harmonized to the flush, there should be excellent uptake of insecticide into the leaves. This will be essential -- although there was effective uptake of dinotefuran into the leaves, the concentrations were still giving only 60% mortality in bioassays. Improving the timing of treatments will be necessary to provide that extra level of insecticide needed to provide protection to the leaves.

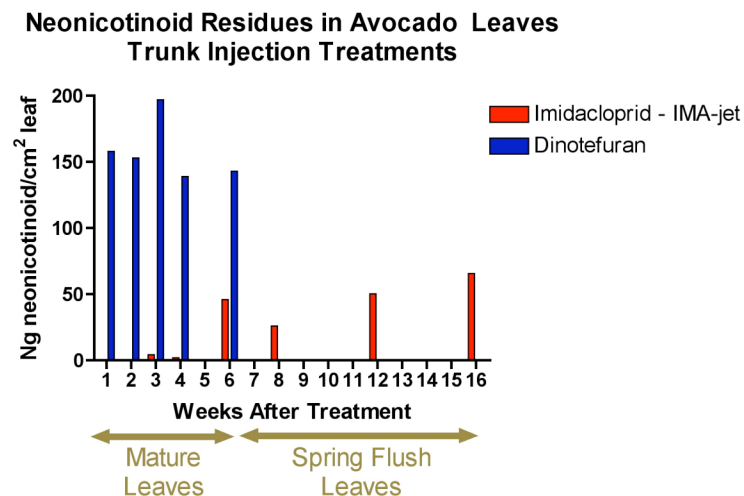


Figure 2. Leaf concentrations of imidacloprid (injected as IMA-jet) and dinotefuran (injected as a proprietary test formulation) in mature and spring flush avocado leaves. Measurements were taken for both neonicotinoids on the following weeks – 1, 2, 3, 4, 6, 8, 12, and 16. Each bar represents the mean concentration for samples from 10 trees.

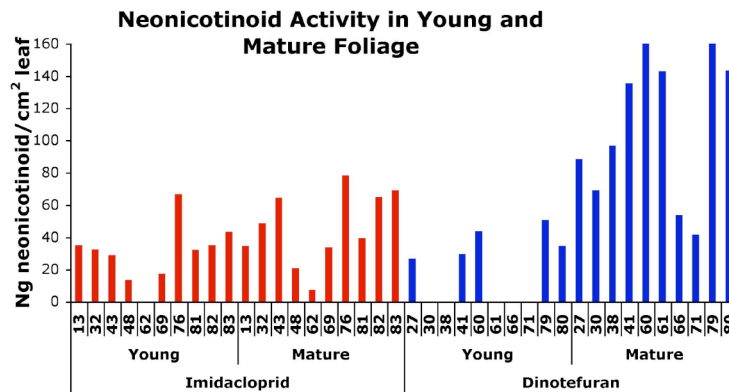


Figure 3. Concentrations of imidacloprid and dinotefuran in young flush (young) and pre-flush (mature) avocado leaves. Measurements were made at 6 weeks after the trees were trunk injected. Data are for samples from individual trees.

Fruit Residues

Mature, marketable fruit was collected from treated trees and insecticide residues tested using standard IR-4 protocols. We followed IR-4 procedures because this format will be needed to generate data required for subsequent pesticide registration applications.

Dinotefuran and imidacloprid residues were undetected in all fruit sampled for 16 weeks after trees were treated. In contrast, acephate and its primary metabolite, methamidophos, were detected, but only during the first 4 weeks after injection. Although there are no pesticide tolerances (referred to as MRLs = Maximum Residue Limits) for dinotefuran, imidacloprid, or acephate in avocados, our data are encouraging. Typical MRLs for acephate/methamidophos (combined residue measurements) in other food groups include 0.5 ppm for cranberry, 2 ppm for cauliflower, 3 ppm for beans, and 10 ppm for celery and lettuce. In week 2, the combined residues of acephate and methamidophos (0.05 ppm) were one-tenth the levels established for cranberries.

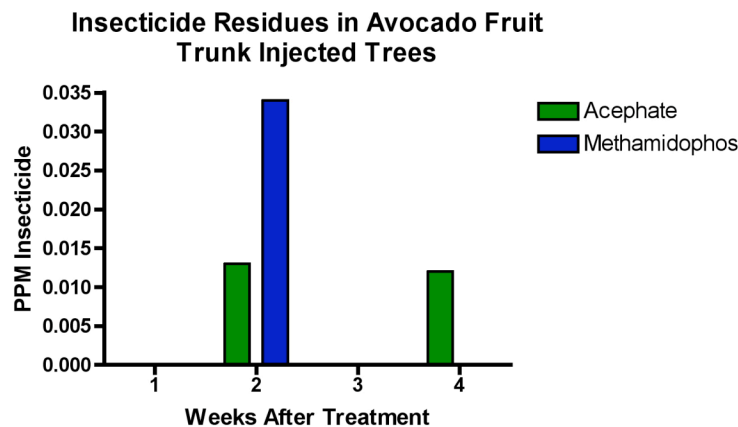


Figure 4. Residues of acephate and methamidophos in avocado fruit sampled from trees that were trunk-injected with ACE-jet (acephate). Methamidophos is a metabolite of acephate. Each bar is the mean residue concentration for fruit sampled from 4 trees. Two sets of 6 fruit were sampled from each tree for 16 weeks after injection. Residues were only detected on weeks 2 and 4.

Soil Treatments

Imidacloprid (Admire Pro) and dinotefuran (Venom) were applied at full label rates to trees via sprinkler irrigation. Dinotefuran is 80-fold more water-soluble than imidacloprid, and may prove to be more effective as a soil treatment than imidacloprid. In our earlier trials, we established that imidacloprid was not effectively absorbed by tree roots due to work being done in heavy soils that were rich in organic matter content. Although imidacloprid was detected within the leaves (indicating that uptake did occur), we found that the rate of uptake was too slow to keep pace with the rate of leaf growth that occurred during a typical leaf flush. The greater water solubility of dinotefuran has been shown in other plant systems to contribute to more rapid uptake. However, in the current trial, we observed poor uptake of dinotefuran (Figure 5). Although it was slightly better than with imidacloprid, the overall consistency of the uptake was unacceptable, and was considerably lower than the levels achieved by trunk injection.

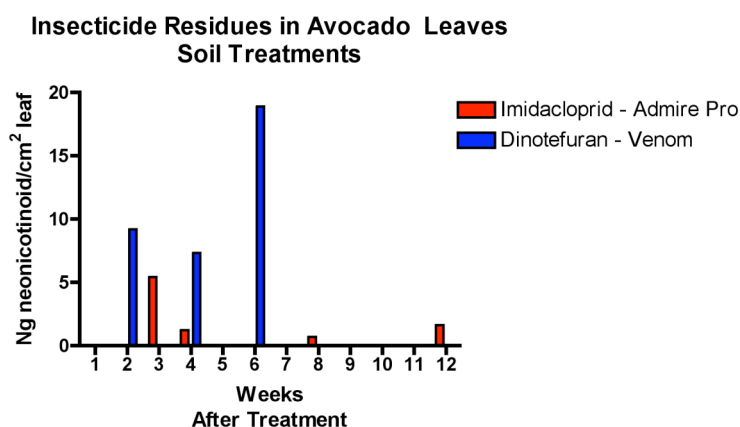


Figure 5. Concentrations of imidacloprid and dinotefuran in leaf discs cut from leaves sampled from trees treated with the full label rates of Admire Pro and Venom, respectively. Each bar represents the mean residue level in 10 trees. Measurements for each insecticide were determined on weeks 1, 2, 3, 4, 6, 8 and 12.

Benefits of the Research to the Industry

The payoff for the avocado industry for supporting this research will be a thorough evaluation of systemic insecticides for the management of important avocado pests. While we have already established from bioassays that the neonicotinoid insecticides are inherently toxic to avocado thrips, the mode of application will be the key element that ensures proper delivery and optimized performance. Upon completion of this research, the industry will know what chemicals will work for them, and how they need to be applied. The neonicotinoids will be a valuable addition to the arsenal of chemicals available to growers, and because they are a new mode of action for avocado thrips control, they will lessen the resistance risk faced by other products currently in use. We do not anticipate that every chemical we evaluate will work for the industry. Our ultimate goal is to present to the growers practical solutions to their pest problems, and guidelines for improved pest management in a climate of increasing pest pressure. In addition to hoping we can add to the arsenal of chemistries available for avocado thrips control, the neonicotinoid insecticides (either as soil- or trunk-applied materials) show good efficacy against avocado lace bug, should it spread outside the current containment area. Also, one of the unregistered neonicotinoids shows promise in control of armored

scale insects, should one of the species present on avocados imported from Mexico establish in California.

Achievements and Future Prospects

- One of the major achievements of this project has been the establishment of activity thresholds for the neonicotinoid imidacloprid. We know that an avocado lace bug feeding on a leaf that has a concentration of 20 ng imidacloprid per cm² of leaf tissue will not survive. We have also determined that a second instar avocado thrips feeding on a leaf that has a concentration of 100 ng imidacloprid per cm² will not survive. Having established these thresholds of activity, we now have target levels of insecticide that must be met by the different modes of application that we are evaluating. Bioassays are time-consuming, and thrips are not always available for bioassays. The ELISA method can be used to evaluate insecticide treatments, and in the future could be used as a monitoring tool to determine the levels of protection in a grove that has been treated by a grower.
- Avocado lace bug is more susceptible to neonicotinoids than avocado thrips. Soil applications of imidacloprid were effective against this pest, even in the most challenging tree size tested. We do not anticipate major concerns about the control of this pest if it becomes established within avocado groves.
- We have completed the first round of residue analyses for fruit. The results are quite encouraging, and suggest that pre-harvest intervals (PHI) need not be excessive (for example, the current PHI for Admire Pro is 30 days). Imidacloprid and dinotefuran were not detected in any fruit samples. Although acephate was detected, residues had dissipated by 28 days after injection.
- Trunk injection of neonicotinoids may be a viable option for pest management. The importance of timing must now be investigated in order to provide a treatment schedule based around the spring flush.
- Acephate showed promise as a trunk injection. Bioassay data confirm that it is rapidly taken up into leaves following injection, and has a long residual activity against both avocado thrips and avocado lace bug.

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