Evaluation of Systemic Chemicals for the Management of Avocado Pests

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Current management practices for avocado thrips rely on the use of foliar insecticides. However, the number of products is limited, the mode of application can be difficult (helicopter use on steep hillsides, applications near urban regions, potential for groundwater contamination), and there are risks of resistance development, particularly to abamectin (Agri-Mek and generics) due to it also being used against persea mite during the summer. Systemic neonicotinoid insecticides are relatively easy to apply and represent 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 abamectin, and alleviate operational difficulties in the use of foliar treatments. In this project, we are evaluating several members of the neonicotinoid insecticide class as potential control agents for avocado pests. In particular, there are several methods by which these chemicals can be applied to trees to achieve systemic uptake, and we are comparing the efficacy of each of these methods to determine which is most effective. We conduct our research in commercial avocado groves so that our evaluations are realistic and relevant to California growers and grove conditions.

Field Trials

In this project, we are evaluating 3 modes of application for systemic neonicotinoids – soil drench, trunk injection and trunk paint treatments. During the Summer and Fall of 2010, we conducted a trial at a commercial grove in Oxnard with treatments at that site completed on May 26. We have one more set of samples to collect during November in order to complete the 6-month evaluation. The details of the trial are summarized in the following table.

Treatment	Active Ingredient	Application Type	Rate (g ai/tree)	Post-Treatment Evaluations
IMA-jet	Imidacloprid	Trunk Injection	3.6 g	Leaf Residues
IMA-jet New formulation	Imidacloprid	Trunk Injection	3.6 g	Leaf Residues
AJ-F-08	Dinotefuran	Trunk Injection	5.4 g	Leaf and Fruit Residues
Venom 20SG	Dinotefuran	Trunk Paint	6 g	Leaf Residues
Venom 20SG + Pentra-Bark	Dinotefuran	Trunk Paint	6 g	Leaf Residues
Venom 20SG	Dinotefuran	Soil Drench	1.88 g	Leaf Residues
Admire Pro	Imidacloprid	Soil Drench	1.88 g	Leaf Residues
Controls	--	--	--	Leaf and Fruit Residues

Imidacloprid Trunk Injections
We did not observe any significant improvement in the uptake of imidacloprid when we compared a newer experimental trunk injection formulation with the current commercial IMA-jet formulation (Figure 1). In fact, with the experimental formulation, leaf residues of imidacloprid did not reach the LC_{50} for avocado thrips control (73 ng/cm^2 of leaf tissue). The IMA-jet product was successful in delivering the desired dose of imidacloprid to the leaves. The uptake was rapid and peak concentrations were achieved at 2 weeks after injection. Both trunk injection treatments out-performed the soil drench application of Admire Pro.

DInotefuran Trunk Injections
Trunk injections of an experimental formulation of dinotefuran delivered concentrations of insecticide that attained the LC_{50} for avocado thrips (LC_{50} = 545 ng/cm^2 of leaf tissue) within 1 week (Figure 2). The uptake of dinotefuran was rapid and the LC_{50} concentrations were maintained for up to 4 weeks after injection.

Dinotefuran Trunk Paints
Trunk paint treatments of dinotefuran have proven effective for the management of other tree pests (e.g., emerald ash borer), and Pentra-Bark is used to enhance the movement of the insecticide through the bark into the cambium. Trunk paint treatments offer growers the possibility of a very simple mode of application, in contrast to the more labor intensive and expensive trunk injection method. In addition, there is no wounding of the tree with trunk paint treatments, which is a requirement for trunk injection.

We applied dinotefuran to avocado trees and compared treatments with and without the addition of Pentra-Bark. The formulated insecticide was diluted in water and 300 mls of the dilution were applied to the bark of each tree using a hand-held sprayer. In treatments with Pentra-Bark, the adjuvant was added at a concentration of 2% according to recommendations from the manufacturers (Quest Products Corp., Kansas, MO).

Dinotefuran was detected within the leaves of treated trees within 1 week of application with either dinotefuran alone or the combination of dinotefuran and Pentra-Bark (Figure 3). However, we observed higher levels of dinotefuran when Pentra-Bark was included in the treatments. With both applications, dinotefuran was not detected after 2 weeks suggesting that the material was rapidly absorbed at the time of application. The concentrations measured within the leaves were much lower (about 15-fold at peak uptake) than concentrations detected after trunk injection.

Soil Applications of Neonicotinoids
Soil applications of imidacloprid (Figure 1) and dinotefuran (Figure 2) have not been successful at other field sites, and this trend was continued during the 2010 trial. It is clear from a comparison of soil and trunk injections (for both imidacloprid and dinotefuran) that the uptake of insecticide is seriously compromised by the organic matter content in the soils. Bypassing the soil component by either direct injection into the tree or direct application to the trunk improves the uptake of insecticide considerably.

Fruit Residues
In 2009, we were unable to conduct a fruit residue analysis due to low fruit yields on our study trees. This objective was postponed until 2010 when fruit yields were higher. Fruit was collected at 2-weekly intervals for 12 weeks and the fruit were then submitted to a commercial laboratory for residue analysis by LC/MS.

Residues of dinotefuran were detected in avocado fruit at 2 weeks after trees were injected (Figure 3). Peak residue levels occurred at 4 weeks. Thereafter, there was a steady decline in residues. In the final sample at week 12, residues of dinotefuran were still detectable in some fruit.

Avocado Thrips Bioassays

We have completed our evaluation of clothianidin against avocado thrips in Munger cell bioassays. Clothianidin is being increasingly used in agricultural systems and we expect a registration for use on avocados in the future. For bioassays, leaves were treated systemically with different concentrations of clothianidin using the same petiole uptake method used for imidacloprid and dinotefuran bioassays. Avocado thrips were confined on the leaves in Munger cells for 48 hours and mortality was then determined.

Clothianidin toxicity was intermediate between imidacloprid (LC_{50} = 73 ng/cm^2 of leaf tissue) and dinotefuran (LC_{50} = 545 ng/cm^2 of leaf tissue). The LC_{50} for clothianidin was calculated to be 217 ng/cm^2 of leaf tissue.

Publications

A paper entitled "Field evaluation of systemic imidacloprid for the management of avocado thrips and avocado lace bug in California avocado groves" (authors Frank Byrne, Eduardo Humeres, Alan Urena, Mark Hoddle, and Joseph Morse) has been published in Pest Management Science (Volume 66, Issue 10, Pages 1041–1155).

Future Research Plans

We plan several additional field trials with various neonicotinoids applied as trunk paints. This method of application has some real advantages and we'd like to see if we can make it work with avocados. Now that clothianidin is being developed commercially, we'd like to run several trials with this product – we expect its persistence in foliage (i.e. duration of control) to be intermediate between imidacloprid (persistent) and dinotefuran (short persistence). It will be very interesting to see what kind of uptake we get with trunk paints of clothianidin. Valent claim that they can get close to 1ppm clothianidin into trees by application to the trunk. We will work with Valent to optimize an application protocol for avocado trees.

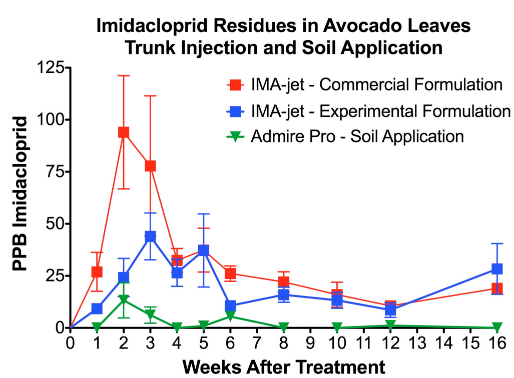

Figure 1. Uptake of imidacloprid in avocado trees treated by soil application as Admire Pro (green line) and by direct injection into the trunk as IMA-jet®. Two formulations of IMA-jet were compared – the current commercial IMA-jet product (red line) and a modified experimental formulation of IMA-jet (blue line). Each point represents the mean (±SEM) concentration for 6 trees.

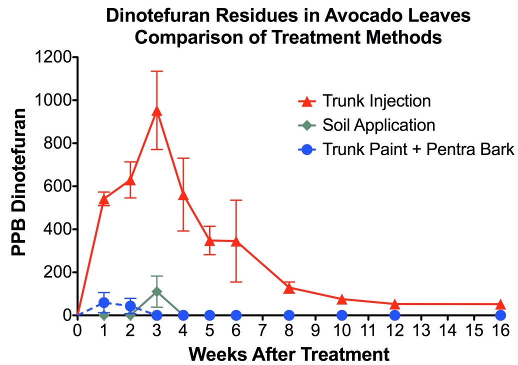

Figure 2. Uptake of dinotefuran in avocado trees treated by trunk injection (red line), trunk paint (blue line) and soil application (green line). Each point represents the mean (±SEM) concentration for 6 trees.

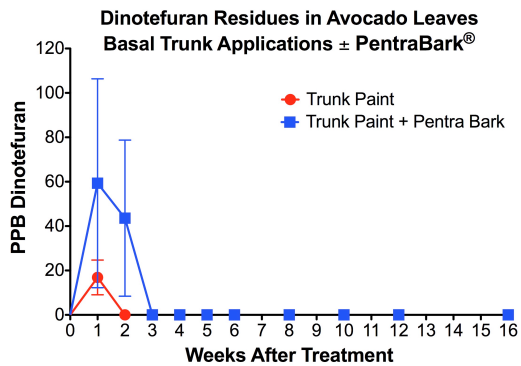

Figure 3. Uptake of dinotefuran in avocado trees treated by trunk paint. Dinotefuran was applied alone (red line) or in combination with Pentra-Bark® (blue line). Each point represents the mean (±SEM) concentration for 6 trees.

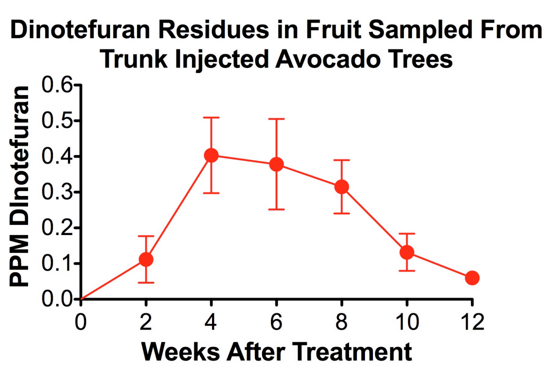

Figure 4. Residues of dinotefuran in avocado fruit collected from trees trunk-injected with dinotefuran at a rate of 5.4 g per tree. Each point represents the mean residue level (±SEM) for 6 trees.