Proceedings of the California Avocado Research Symposium, October 29, 2005. University of California, Riverside. Sponsored by the California Avocado Commission. Pages 14-23.

# Biology, Management, and Resistance Monitoring of Avocado Thrips and Persea Mite

**Continuing Project: Year 3 of 3**

*Joseph Morse, Anthony Urena, Eduardo Humeres, Lindsay Robinson, Paul Flores, and Pamela Watkins*

*Department of Entomology, University of California, Riverside, CA 92521*

## Benefit to the Industry

With as much speed as possible, we hope to improve avocado thrips and persea mite management based on sound scientific research. We will determine how to use available pesticides most effectively, will search for new control materials, hopefully with different modes of action from available materials to reduce the potential for pesticide resistance development, and will evaluate alternative methods of pesticide application and timings of treatments.

Baseline resistance monitoring with persea mite and avocado thrips is important before control materials are widely used (without such baseline data, after the material is used, it is difficult to determine whether and to what degree resistance has developed). Should resistance appear (as has been the case with avocado thrips resistance to sabadilla [Veratran D]), it will be important to determine how quickly resistance reverts, to what extent treatments after reversion are effective, and what resistance management protocols might maintain the useful life of these pesticides. In our opinion, it is unlikely that effective and selective materials like abamectin [Agri-Mek], spinosad [Success], and sabadilla will be easily replaced if these materials are lost due to resistance.

It is essential that we find an effective control material for persea mite management so that growers are not tempted to use abamectin [Agri-Mek] for this purpose. Some growers have used Agri-Mek in the spring for avocado thrips control and then the same material in the summer or fall for persea mite management. Because abamectin residues are extremely persistent in leaves and fruit (resulting in mortality for as long as 2-3 months), this could lead to resistance in either avocado thrips or persea mite or both. Growers really should not use this material for control of both pest species.

## Objectives

**Objective 1.** Conduct preliminary laboratory and field pesticide screening against avocado thrips and persea mite. Prioritize materials to be evaluated in later field trials and coordinate with work being done on citrus thrips (Morse – Citrus Research Board) and any avocado thrips or persea mite trials conducted by others.

**Objective 2.** Monitor avocado thrips populations for resistance to sabadilla, abamectin, and spinosad and obtain baseline resistance levels at several field sites before and after sabadilla and abamectin are used extensively. Monitor for persea mite baseline resistance to abamectin and milbemectin.

## Summary

Funding for our research in 2004-05 was cut by 55% (from the 2003-04 level) so for the present, we have dropped all research on biological control of avocado thrips and were forced to reduce effort on preliminary pesticide screening, field pesticide trials, and resistance monitoring.

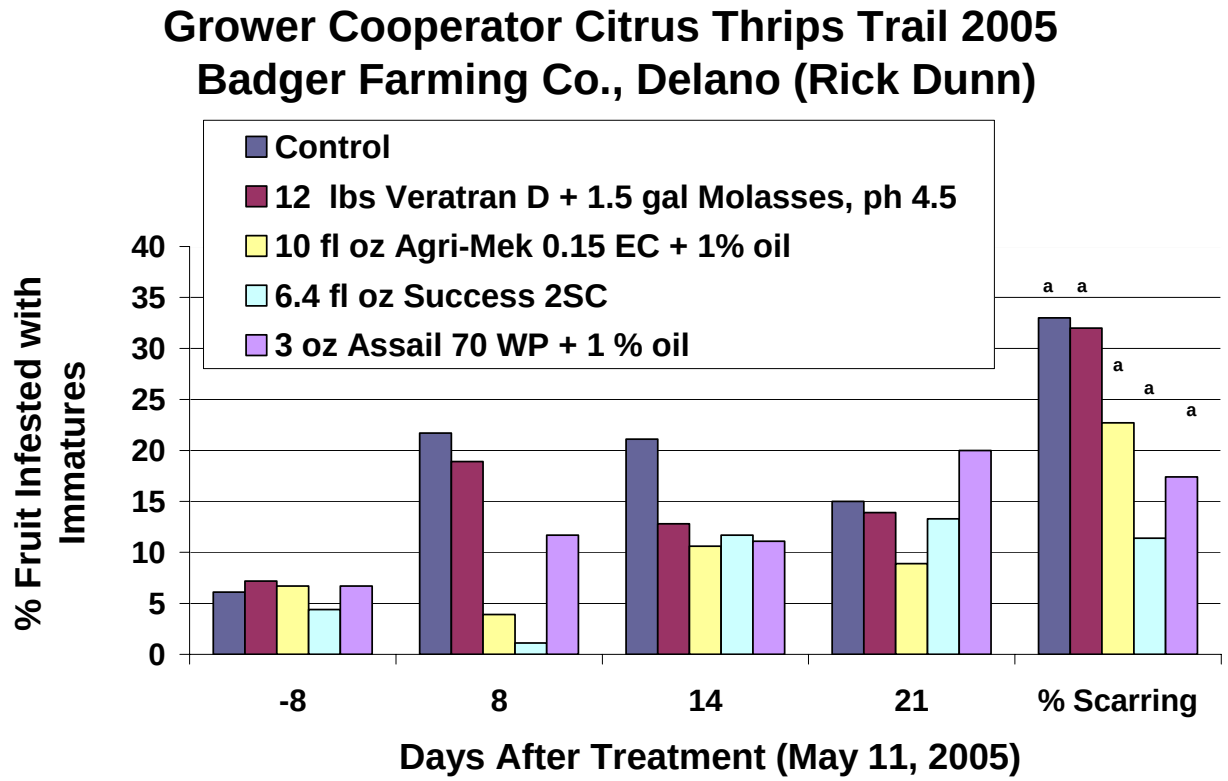
## 1. Pesticide Screening Research.

1.A. Citrus Thrips Research Assists in Avocado Thrips Research.

Our research on citrus thrips as funded by the California Citrus Board feeds into avocado thrips research, at no cost to the avocado industry (and likewise, avocado research benefits citrus growers and our citrus thrips project). Both of these insects are in the genus *Scirtothrips* and although they are different species, we have found that they generally respond in a similar manner to many pesticides. There are differences, however. On citrus, Success + Oil is the most popular material for citrus thrips control whereas on avocado, Agri-Mek + Oil appears to outperform Success + Oil.

Based on limited field citrus thrips pressure over the past several years at the Lindcove Research and Extension Center where we traditionally screen new pesticides, we decided to move screening trials for new, experimental pesticides to greenhouse laurel sumac trials in Riverside. An initial trial run Feb. 2005 showed similar levels of control achieved with Success vs. Success + Oil vs. Entrust (all 3 treatments were quite effective up to 28 days post-treatment under conditions of very high citrus thrips pressure – untreated plants provided high levels of adult female thrips that re-infested treated plants). In our second screening trial run June 2005, we evaluated two new experimental pesticides (both are presently confidential with disclosure expected Dec. 2005) that both looked quite promising against citrus thrips (both were superior to Success which is our standard control material with citrus thrips). Based on these results, both materials will be evaluated in our avocado thrips screening trials (1.B. below). Our third screening trial was started several weeks ago (Sept. 2005) and compares two new formulations of abamectin and two formulations of acetamiprid (Assail) against Agri-Mek and Success.

In spring 2005, we ran two grower-cooperator citrus thrips control trials in which each of 4 treatments were applied with a speed sprayer on 2-acre plots with 3 replicated plots per treatment. In addition, three small, untreated control plots were included to evaluate citrus thrips pressure. Fruit infestation data and fruit scar counts (letters above scarring levels indicate statistical separation) are shown in Figures 1 and 2 below. Although there was limited statistical separation between treatments, treatment efficacy was Success > Agri-Mek or Assail > Veratran D > Untreated Control.

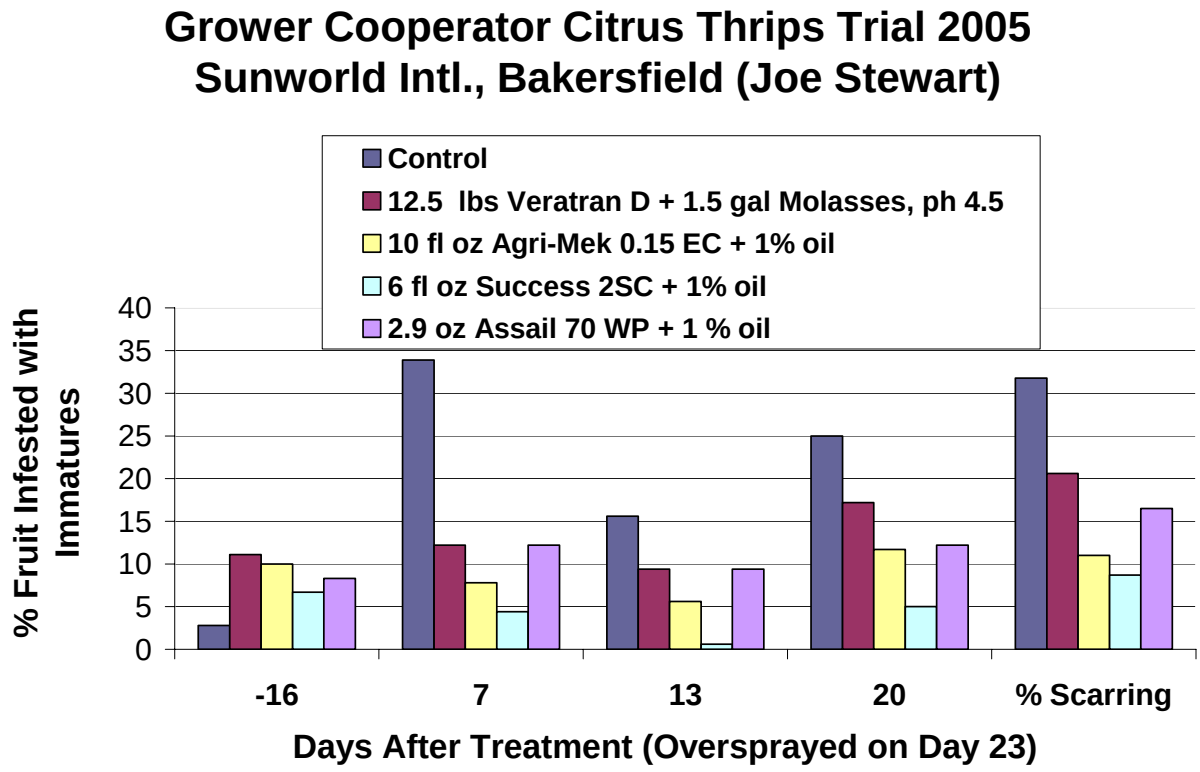



1.B. Avocado Thrips Field Pesticide Residual Persistence Studies.

We have developed a method of screening potential avocado thrips control materials and have run six trials to date (two in 2004, one in 2005). For trials evaluating non-systemic chemicals, potted avocado plants are sprayed to runoff with candidate pesticides, pesticides are allowed to weather in the field, tagged leaves (identifying them as being fully expanded but tender at the time of pesticide application) are picked on various dates post-treatment, immature avocado thrips are placed on the leaves in the laboratory, and thrips mortality is evaluated after 48 hours. We have been using 10 fl oz Success 2SC + 1% NR-415 Oil as our standard in these evaluations. One of the trials run in 2004 evaluated two new, experimental pesticides. One of the materials showed good efficacy against avocado thrips but because we were required to sign a secrecy agreement in order to test the material (it is still under development), we cannot share specifics regarding the trial.

Similar methods were used in our second 2004 trial with systemic pesticides except that treatments were applied in irrigation water and we cooperated with Drs. Frank Byrne and Nick Toscano in analyzing levels of imidacloprid and thiamethoxam present in leaf tissue at various dates post-treatment (data were summarized in the fall 2004 avocado symposium proceedings and a poster was presented at the symposium).

Our 2005 trial is in progress (the 3-week evaluation has been done and the 6-week evaluation is scheduled for the week of Sept. 19, 2005).




1.C. Work in Support of the 2004 and a possible 2005 Agri-Mek Section 18 Request.

In contrast to past Section 18 requests, EPA came close to denying the 2004 request and only through unusual effort by CA-DPR, CAC, and others was the request granted (see details in the article by Guy Witney in the March 2004 issue of AvoResearch, Witney 2004).

On 8 March 2004, EPA informed Guy Witney of three additional data sets needed for them to consider a 2005 Section 18 request for Agri-Mek, should it be needed (i.e. if full registration was not obtained in time for the 2005 field season). Briefly stated, these were (1) details on the cost of additional helicopters being made available to the industry, (2) additional field trials determining how many spinosad treatments by air would be needed to equal the efficacy of abamectin, and (3) data delimiting the efficacy of spinosad against persea mite.

Working with Guy Witney, Steve Peirce, representatives of Syngenta and Dow AgroSciences (the manufacturers of Agri-Mek and Success), Ben Faber, Eve Oevering, Aspen Helicopter, and pest control advisors Dave Machlitt and Tom Roberts, five field trials were done (3 in Ventura Co., 2 in San Diego Co.) to satisfy requirement #2. At each site, 2-3 plots were treated by helicopter with Success and 2-3 with Agri-Mek. We obtained funding from Syngenta, Dow AgroSciences, and the CAC to conduct these studies. Despite the Section 3 (full registration) for Agri-Mek being granted this spring, because of this funding we were obligated to complete these studies by evaluating fruit scarring on plots treated with Agri-Mek vs. Success.

Fruit scarring data are listed below (Table 1). At Camarillo, relatively little fruit scarring occurred because the weather turned very warm shortly after treatment and thrips levels crashed. At Somis #1 and #2 a single treatment of Success was not as strong as the Agri-Mek spray (we had intended to compare two treatments of Success to a single treatment of Agri-Mek but thrips pressure did not appear high enough to warrant the second Success spray. Data from Fallbrook may have been somewhat misleading as a fair amount of avocado thrips fruit scarring occurred before treatments were applied (there was quite a long queue for helicopter treatments – thanks to Steve Peirce for using his influence to get us moved to the front of the queue). A second factor at this site resulted in high Success scarring. Our grower-cooperator at this site had not used Success in the past and thus, wanted the Success plots to be relatively small. As a result, Success was applied in two corners of the block which in retrospect, resulted in poor spray coverage on some of the data trees (these two corners were near a house and a power line, respectively, resulting in less than optimal coverage by helicopter).

**Table 1. - Fruit Scar Counts 2004 Avocado Helicopter Spray Trials**

| Site | Treatment | Rep | No. of fruit | % unscarred | % slight | % moderate | % severe |
|---|---|---|---|---|---|---|---|
| Sites in the North (Ventura Co.) | | | | | | | |
| **Site #1 (Camarillo) - Fruit scar assessment 19 Jan. 2005** | | | | | | | |
| **Camarillo** | Agri-Mek | 3 | 519 | 100.0 | 0.0 | 0.0 | 0.0 |
| | Agri-Mek | 5 | 604 | 100.0 | 0.0 | 0.0 | 0.0 |
| | Agri-Mek | 6 | 520 | 100.0 | 0.0 | 0.0 | 0.0 |
| | **overall** | | **1,643** | **100.0** | **0.0** | **0.0** | **0.0** |
| **Camarillo** | Success | 1 | 545 | 100.0 | 0.0 | 0.0 | 0.0 |
| | Success | 2 | 550 | 100.0 | 0.0 | 0.0 | 0.0 |
| | Success | 4 | 709 | 100.0 | 0.0 | 0.0 | 0.0 |
| | **overall** | | **1,804** | **100.0** | **0.0** | **0.0** | **0.0** |
| **Site #2 (Somis #1) – Fruit scar assessment 18 April 2005** | | | | | | | |
| **Somis #1** | Agri-Mek | 1 | 668 | 98.5 | 1.5 | 0.0 | 0.0 |
| | Agri-Mek | 3 | 688 | 99.3 | 0.7 | 0.0 | 0.0 |
| | Agri-Mek | 5 | 587 | 99.0 | 1.0 | 0.0 | 0.0 |
| | **overall** | | **1,943** | **98.9** | **1.1** | **0.0** | **0.0** |
| **Somis #1** | Success | 2 | 639 | 90.0 | 9.9 | 0.2 | 0.0 |
| | Success | 4 | 654 | 92.8 | 7.2 | 0.0 | 0.0 |
| | Success | 6 | 574 | 99.1 | 0.9 | 0.0 | 0.0 |
| | **overall** | | **1,867** | **94.0** | **6.0** | **0.1** | **0.0** |

**Site #3 (Somis #2) – Fruit scar assessment 27 April 2005**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Somis #2** | Agri-Mek | 2 | 575 | 86.1 | 13.7 | 0.2 | 0.0 |
| | Agri-Mek | 4 | 455 | 95.6 | 4.4 | 0.0 | 0.0 |
| | Agri-Mek | 6 | 625 | 86.9 | 13.1 | 0.0 | 0.0 |
| | **overall** | | **1,655** | **89.5** | **10.4** | **0.1** | **0.0** |
| **Somis #2** | Success | 1 | 568 | 80.2 | 19.8 | 0.0 | 0.0 |
| | Success | 3 | 616 | 84.3 | 15.7 | 0.0 | 0.0 |
| | Success | 5 | 534 | 88.9 | 11.1 | 0.0 | 0.0 |
| | **overall** | | **1,718** | **84.4** | **15.6** | **0.0** | **0.0** |

Sites in the South (San Diego Co.)

**Site #4 (Fallbrook) – Fruit scar assessment 25 Feb. 2005**

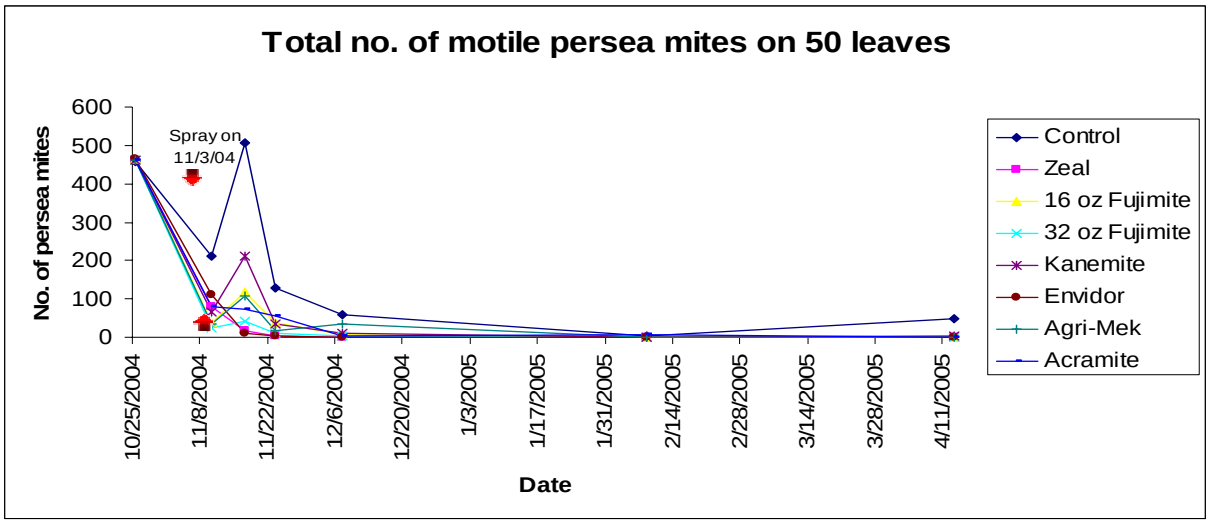
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fallbrook** | Agri-Mek | 2 | 1,747 | 74.3 | 25.3 | 0.3 | 0.0 |
| | Agri-Mek | 3 | 1,708 | 82.6 | 16.1 | 1.2 | 0.1 |
| | **overall** | | **3,455** | **78.5** | **20.7** | **0.8** | **0.0** |
| **Fallbrook** | Success | 1 | 1,649 | 59.2 | 39.0 | 1.8 | 0.0 |
| | Success | 4 | 1,737 | 53.2 | 40.7 | 5.3 | 0.8 |
| | **overall** | | **3,386** | **56.2** | **39.9** | **3.5** | **0.4** |

Vista (Site #5; not in the table) -- the site was harvested before we got in to take fruit scar counts. This was not a great loss as there were very few fruit per tree after they finished pulling trees and doing major pruning about 4 months ago.

For avocado thrips scar count ratings, we used a 1-10 scale where 0= no scarring, 1-3= slight scarring, 4-6= moderate scarring and 7-10= severe. For the 1-3 category any perceivable scarring around the calyx, even if less than 10% of the surface area received a rating of 1. Category 2 & 3 indicates the scar moves down the neck of the fruit, covering up to 30% of the surface area. Depending on the packinghouse, volume of fruit, demand, etc., a 3 would likely be downgraded to second grade. For category 4-6, the scarring extended down the shoulder of the fruit covering an area of up to 60% of the fruit surface. These fruit could be packed for the local ethnic markets or to the restaurant industry (packinghouses have found markets for highly scarred fruit but with lower returns). The 7-10 category are fruit that have 70-100% of the surface damaged from avocado thrips. We typically see these packed under the papacado-type brand.

1.D. Persea Mite Pesticide Screening Trial. As mentioned above, we believe it is imperative that an alternative to abamectin [Agri-Mek] be found for persea mite control so that growers restrict abamectin use to a single (or less, ideally) treatment per year and use it only for avocado thrips control, using a different chemical with alternative chemistry for persea mite control, if treatment is needed. Towards this end, with the assistance of Steve Peirce and Guy Witney, we found an avocado grove near Fallbrook, CA with moderate persea mite densities and conducted a screening trial with 8 treatments applied on 3 November 2004. Although persea mite densities were moderately high prior to treatment (9.2 – 9.3 per leaf), they crashed within 3 weeks after treatment, even on untreated control trees (see the graph below). Thus, we will repeat the study

with an added experimental material in 2005. A field site has been identified (3.5-year old Hass avocado trees near Irvine) and we plan to apply treatments the week of 26 September 2005.




**2. Pesticide Resistance Monitoring.** As published in the Proceedings of the 1 November 2003 Avocado Symposium, we have developed baseline data on the susceptibility of persea mite to abamectin (Agri-Mek) and milbemectin (Mesa – a material being considered for registration on avocado but not registered at present). These data are now published in the Journal of Experimental and Applied Acarology (Humeres & Morse 2005). Should either Agri-Mek or Mesa persea mite resistance be suspected in the future, the resistance monitoring technique and baseline data we have developed will allow us to rapidly determine if resistance is responsible for a control failure in contrast to factors such as application method, timing, the presence of high populations, or optimal weather for persea mite population growth.

Avocado thrips resistance testing with sabadilla (Veratran D) was done at 4 sites in southern California having limited past exposure to this material with the objective of establishing baseline susceptibility for the purpose of resistance monitoring. Reports of avocado thrips resistance in a grove receiving six sabadilla sprays over two years were confirmed when a bioassay indicated resistance ratios of 7.7 and 18.8 at the LC50 and LC90, respectively (the concentration of sabadilla needed to kill 50 and 90% of the thrips). Due to the availability of abamectin, sabadilla sprays were discontinued at this site and after 5.5 years, resistance ratios had dropped to near baseline levels (an article on this subject has been submitted to Pest Management Science, Humeres & Morse 2006).

In 2005, we received a number of phone calls and emails from growers and pest control advisors reporting concerns about lack of avocado thrips field control with Agri-Mek. We made a number of field visits and tried to follow up on all reports. Doing bioassays on a field population of avocado thrips is a fairly laborious procedure, taking 3 people most of a day. We treat leaves with six to seven rates of Agri-Mek (spaced appropriately on a log scale based on past bioassay results) and then hand-transfer 15 or so second instar thrips to each of 5 replicate

leaves placed inside a Munger cell to contain the thrips on the leaf. Thus, 75 or so thrips are tested at each of 6-7 rates plus a water-treated control (to test for natural mortality). At times, we may need to test a population 2-3 times before a usable data set is obtained (acceptable levels of control mortality, at least 5 levels of corrected mortality greater than 0 and less than 100% mortality, a consistent relation between rate and mortality resulting in a chi-square statistic greater than 0.05, etc.). Mortality readings are taken at 48 (most pesticides) or 72 hours (Agri-Mek), data are corrected for control (natural) mortality, and the results are subjected to probit analysis.

Data from field-testing with Agri-Mek are shown below (Table 2). One should not try to match the mortality observed in these laboratory bioassays with the amount of mortality one would expect in the field when Agri-Mek is sprayed. Rather, these tests provide data on the relative susceptibility of avocado thrips collected from different sites to Agri-Mek.

San Diego Co. #1 was an organic grove, never sprayed with Agri-Mek before the bioassay in 2004. San Diego Co. #2 was sprayed with Agri-Mek in 2001 and 2003, with Success in 2002, and was bioassayed before being sprayed in 2004. Ventura Co. #1 was sprayed with Agri-Mek ca. 9 times over 2000 – 2005 (we are checking on details). Both San Diego #3 and Santa Barbara #1 were sites that reported concerns with Agri-Mek control in 2005. As seen in Table 2, there is some variability in the amount of Agri-Mek required to kill 50% of the avocado thrips population tested in the laboratory (i.e. the LC50). This variation is expected based on previous bioassays we have done and did not correlate with field control concerns.

The good news is that to date and based on these data, we have not seen signs of avocado thrips showing resistance to Agri-Mek. There are, however, strong reasons to be concerned about the development of Agri-Mek resistance and growers should try to minimize the number of Agri-Mek sprays applied in their grove (limit Agri-Mek sprays for avocado thrips and persea mite combined to one per year maximum). Avocado thrips will eventually develop resistance to Agri-Mek and those growers treating excessively with this material are the ones most likely to experience problems controlling avocado thrips and the fruit scarring they can cause.

Table 2. Avocado Thrips Bioassays with Agri-Mek
Tests are run with second instar avocado thrips collected directly from field sites

| Field Site | Date Tested | Chi-Sq | Slope ± SE | LC50 (mg ai/l) | | 95% Fiducial Limits |
|---|---|---|---|---|---|---|
| Ventura Co. #1 | Aug-05 | 0.302 | 3.7834 ± 0.6194 | 0.00734 | a | 0.00616-0.00853 |
| Santa Barbara Co. #1 | Aug-05 | 0.209 | 3.2695 ± 0.4802 | 0.00764 | a | 0.00640-0.00893 |
| San Diego Co. #3 | Jul-05 | 0.099 | 2.0201 ± 0.2570 | 0.02282 | b | 0.01439-0.03586 |
| San Diego Co. #2 | May-04 | 0.129 | 1.4046 ± 0.1083 | 0.02784 | b | 0.02176-0.03525 |
| San Diego Co. #1 | Apr-04 | 0.869 | 1.7417 ± 0.1369 | 0.03827 | b | 0.03054-0.04788 |

LC50s followed by the same letter are not significantly different based on overlap of 95% fiducial limits.

**Relevant Recent Publications (2003 to present)**


Byrne, F. J., N. C. Toscano, A. A. Urena, and J. G. Morse. 2005. Quantification of Imidacloprid Toxicity to Avocado Thrips *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae), Using a Combined Bioassay and ELISA Approach. Pest Manage. Sci. 61: 754-758.

Hoddle, M. S. and J. G. Morse. 2003. Avocado Thrips Biology and Control. AvoResearch Special Edition, Spring 2003. 8 pp.

Hoddle, M. S., G. S. Bender, J. G. Morse, D. Kellum, R. Dowell, G. W. Witney. 2005. Avocado Lace Bug. AvoResearch. Spring 2005. Calif. Avoc. Commission, Irvine, CA. 2 pp.

Hoddle, M. S., K. M. Jetter, and J. G. Morse. 2003. The Economic Impact of *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae) on California Avocado Production. Crop Protection 22(3): 485-493.

Hoddle, M. S., K. M. Jetter, and J. G. Morse. 2003. Introduction and Establishment of Exotic Insect and Mite Pests of Avocados in California, Changes in Sanitary and Phytosanitary Policies, and Their Economic and Social Impact. Chapter 12, pp. 185-202. *In*: Exotic Pests and Diseases: Biology and Economics for Biosecurity. (D. A. Sumner, ed.). Iowa State Press, Ames, IA.

Humeres, E. C. and J. G. Morse. 2005. Baseline Susceptibility of Persea Mite (Acari: Tetranychidae) to Abamectin and Milbemectin in Avocado Groves in Southern California. Experim. & Appl. Acarol. 36: 51-59.

Humeres, E. C. and J. G. Morse. 2006. Resistance of Avocado Thrips (Thysanoptera: Thripidae) to Sabadilla, a Botanically Derived Bait. Pest Manage. Sci. (Submitted).

Hoddle, M. S., G. S. Bender, J. G. Morse, D. Kellum, R. Dowell, G. W. Witney. 2005. Avocado Lace Bug. AvoResearch. Spring 2005. Calif. Avoc. Commission, Irvine, CA. 2 pp.

Jetter, K. M. and J. G. Morse. 2004. Agri-Mek Section 18 Approved for the 2004 Field Season. AvoResearch 3(1): 1-2, 4-6.

Morse, J. G. 2004. Avocado Thrips Resistance: A Real Concern for the Future. Update, Mission Avocados, Oxnard, CA. December 2004, p. 3.

Morse, J. G. and M. S. Hoddle. 2006. Invasion Biology of Thrips. Ann. Rev. Entomol. 51: 67-89.

Morse, J. G., E. C. Humeres, A. A. Urena, P. J. Watkins, A. P. Flores, and D. R. Anderson. 2003. Biology and Chemical Control of Avocado Thrips; Pesticide Resistance Monitoring with Avocado Thrips and Persea Mite. *In*: Proceedings, California Avocado Commission Research Symposium, November 1, 2003, California Avocado Commission, Santa Ana, CA. pp. 55-67.

Morse, J. G., E. C. Humeres, A. A. Urena, P. J. Watkins, A. P. Flores, and D. R. Anderson. 2004. Biology and Chemical Control of Avocado Thrips; Pesticide Resistance Monitoring with Avocado Thrips and Persea Mite. Pp. 43-53, *In*: *Proceedings*, California Avocado Commission Research Symposium, October 30, 2004, California Avocado Commission, Santa Ana, CA. 125 pp.

Morse, J. G. and G. W. Witney. 2005. Avocado Thrips – Resistance to Pesticides. AvoResearch, Spring 2005, Calif. Avoc. Commission, Irvine, CA. 2 pp.

Tollerup, K. E. and J. G. Morse. 2006. The Effect of Horticultural Spray Oil and Surfactants on the Residual Efficacy of Spinosad against Avocado Thrips, *Scirtothrips perseae* (Thysanoptera: Thripidae). J. Agric. & Urban Entomol. (Submitted).

Triapitsyn, S. V. and J. G. Morse. 2005. A Review of the Species of *Ceranisus* Walker (Hymenoptera: Eulophidae) in the New World. Trans. Amer. Entomol. Soc. 131: 69-86.

Witney, G. 2004. The Long Road to Section 18 Registration. AvoResearch 3(1): 3-4.