Biology and Chemical Control of Avocado Thrips; Pesticide Resistance Monitoring with Avocado Thrips and Persea Mite

New Project: Year 1

Joseph G. Morse (joseph.morse@ucr.edu), Eduardo C. Humeres (eduardoh@citrus.ucr.edu), Anthony A. Urena (aurena@ucrac1.ucr.edu), Pamela J. Watkins (pjaw@ucrac1.ucr.edu), Arnel P. Flores (apflores@citrus.ucr.edu), and Darren R. Anderson (darrena@citrus.ucr.edu)

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

Cooperating Personnel: Eve Oevering, Phil Phillips, Ben Faber, Mark Hoddle, Lindsay Robinson, Frank Byrne, and Nick Toscano

Benefit to the Industry

As fast as possible, we hope to continue to suggest solutions to the avocado thrips problem based on sound scientific research. We will determine how to use available insecticides most effectively, will search for new control materials, hopefully with different modes of action 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 more difficult to determine whether and to what degree resistance has developed). Should resistance appear (as has been the case with avocado thrips and sabadilla [Veratran D]), it will be important to determine how quickly resistance reverts, whether 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 (i.e. the search for effective control alternatives has yet to yield effective and selective alternatives).

Objectives

Objective 1 – Pesticide Screening Research. Conduct preliminary laboratory and field pesticide screening against avocado thrips. Prioritize materials to be evaluated in later field trials and coordinate with work being done on citrus thrips (by Morse et al. – funded by the Citrus Research Board) and avocado thrips trials conducted by Oevering, Phillips, Faber, and pest control advisors / growers.

Objective 2 – Pesticide Resistance Monitoring. Monitor avocado thrips populations for resistance to sabadilla (Veratran D), abamectin (Agri-Mek), and spinosad (Success) and obtain baseline resistance levels at several field sites before and after these materials are used extensively. Monitor for persea mite base-line resistance to abamectin and milbemectin (Mesa).

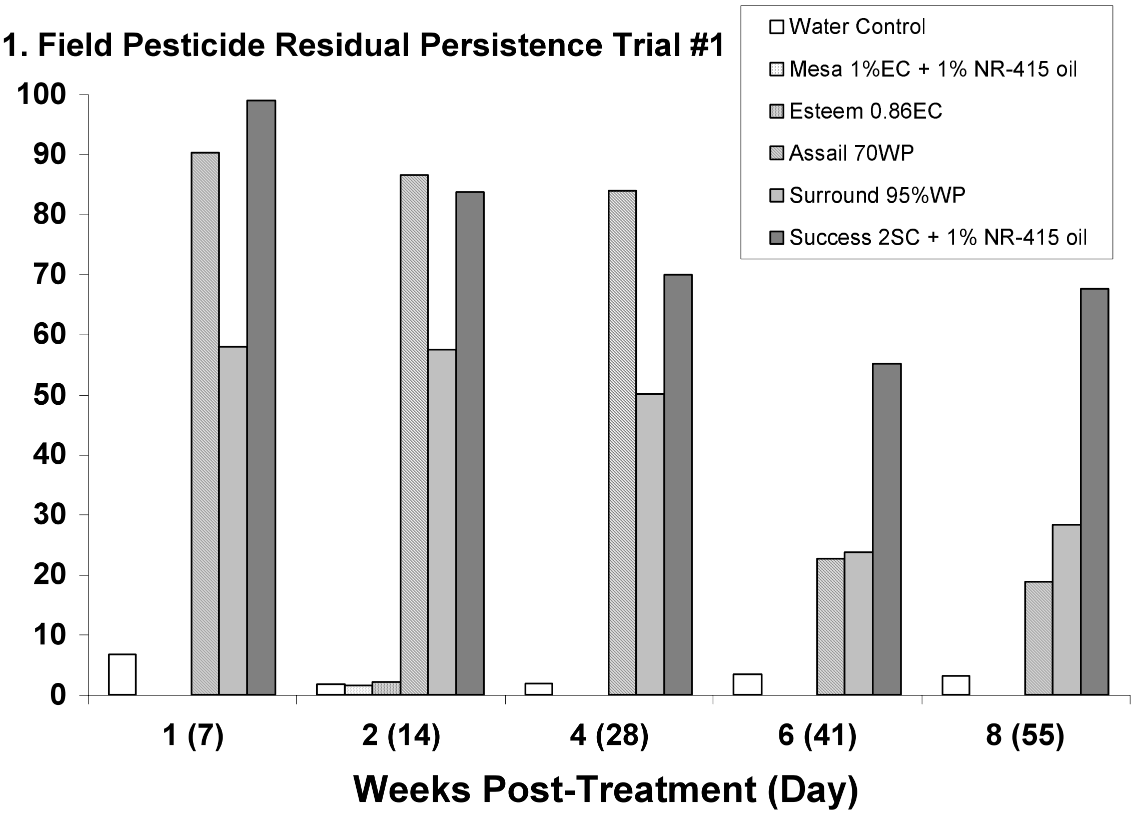
Objective 3 – Thrips Parasitoid Research. Import *Goetheana incerta* from South Africa, evaluate it against avocado thrips, and develop host specificity protocols needed to evaluate its impact on beneficial predatory thrips species. Develop a method of rearing *Ceranisus menes* and determine if it might be practical to select for a strain with increased specificity for avocado thrips. Develop techniques and micro-equipment useful in rapidly collecting large numbers of thrips parasitoids (e.g., from Mexico contingent upon obtaining parasitoid importation permits), determine how to move them through quarantine quickly, and how to mass-rear them.

Summary of Results to Date

Results - Objective 1. Pesticide Screening Research. *1.A. Synergistic Citrus 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). In our spring 2002 citrus thrips screening trial at the Lindcove Research and Extension Center, 24 treatments were compared. Unfortunately, citrus thrips pressure in our trial in 2002 was quite low (0.7% of fruit severely scarred by citrus thrips in the untreated control) and thus, statistical separation between treatments was minimal. It did appear that Dibrom + Ambush, Dibrom, and Danitol all increased citrus thrips scarring above that seen in the untreated control, probably due to a combination of natural enemy reduction and hormolygosis (sublethal stimulation = hormesis, see e.g., Morse & Zareh 1991, Morse 1998). Some of the more effective treatments included Agri-Mek + Oil, Admire (soil applied systemic treatment), Surround, and Success + Oil. In addition, it appeared that there may be a problem with foliar and fruit phytotoxicity with treatments of Phloxin B + bait (a photo-activated dye which had shown promise in lab studies, Tollerup & Morse 2003, UC patent disclosure 2002-362) although phytotoxicity was reduced substantially when concentrated citrus peel liquor was used instead of cane molasses as the bait. A similar citrus thrips field pesticide efficacy trial was conducted in spring, 2003. Foliar treatments were applied 28-29 May 2003 and fruit scarring data will be taken in October after the fruit have colored.

1.B. Avocado Thrips Field Pesticide Residual Persistence Studies. We have developed a method of screening potential avocado thrips control materials and will soon be initiating our fourth field trial. Small avocado plants in 15-gallon pots 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 and are able to run a total of 6 treatments in each trial. Data from our first field screening trial are shown in Figure 1. Based on these data, it appears that Mesa (milbemectin) and Assail (acetamiprid) can be eliminated from further screening (Mesa because of low efficacy; Assail because of moderate efficacy and its impact on natural enemies extrapolated from recent research on citrus). Esteem appears to have almost no direct toxicity to avocado thrips but some additional trials may be needed to evaluate its possible impact on thrips molting (it is an insect growth regulator and may impact pupal molts). Surround may warrant further testing – it showed moderate but sustained toxicity and may act as a repellant; such activity might be underestimated given our trial protocol. One caution, however, with Surround is that preliminary trials on citrus have shown it to have a detrimental impact on natural enemies, which is not surprising given its similarity to road dust, long known to reduce natural enemy activity.

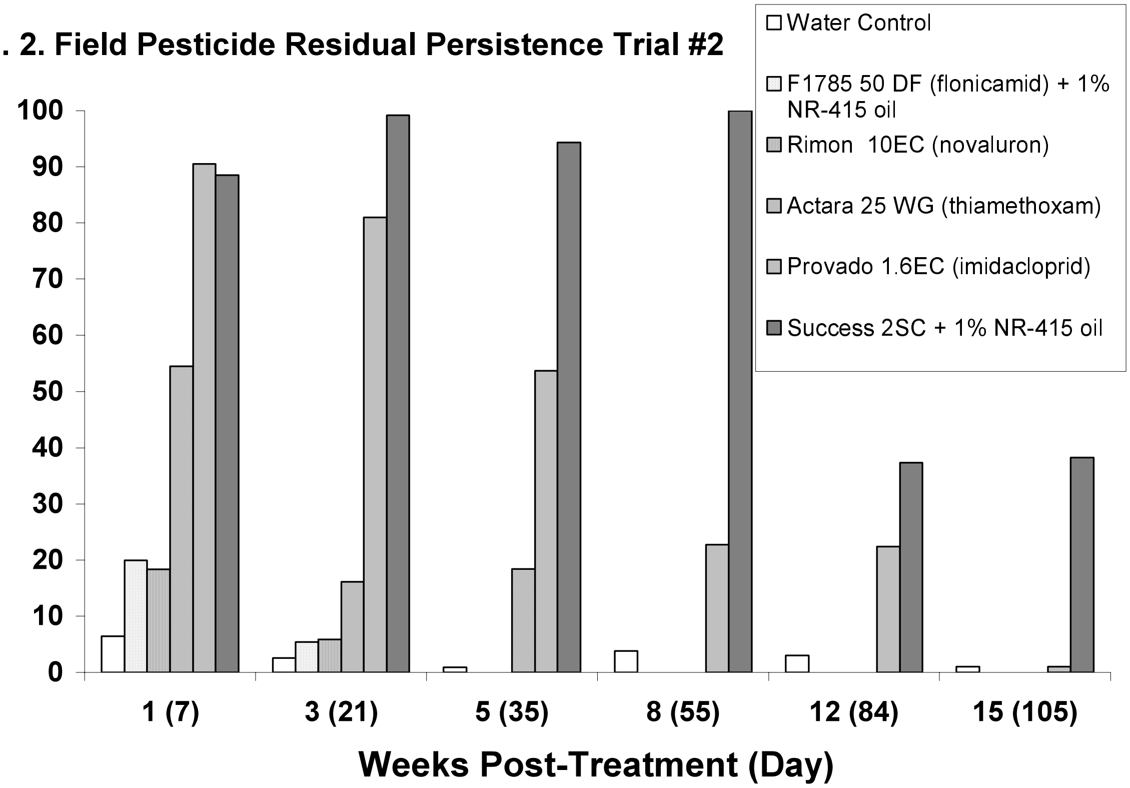
Fig. 1. Field Pesticide Residual Persistence Trial #1



Our second field trial was conducted in a similar fashion with field treatment of different avocado seedlings on 3 March 2003 and evaluated 4 candidate pesticides against a water control and the same positive control (Success plus oil). Results are shown in Fig. 2.

F1785 and Rimon dropped out of the test after week 3 and Actara after week 5. In trials on citrus, use of the foliar form of imidacloprid (Provado) has resulted in flare-ups with secondary pests but as a result of the persistence of this material in this trial, we believe the systemic form of imidacloprid (Admire) may be worthwhile evaluating.

Fig. 2. Field Pesticide Residual Persistence Trial #2



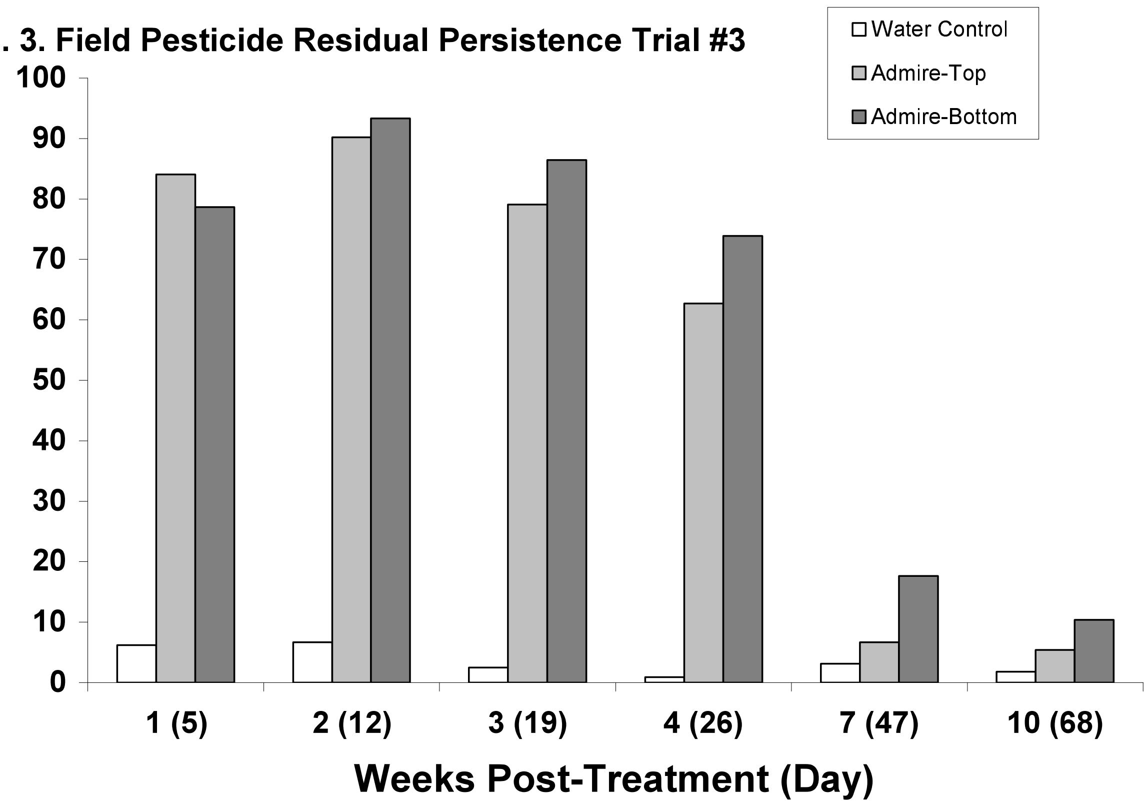
<u>1.C. Studies with Systemic Pesticides.</u> We are presently working with Drs. Frank Byrne and Nick Toscano to develop techniques to evaluate the impact of systemic pesticides against avocado thrips. Four systemic materials warrant further testing – imidacloprid [Admire], thiamethoxam [Platinum], TM-444 (Clutch), and dinotefuran [no trade name assigned as yet].

We had planned a systemic pesticide trial with these 4 systemic pesticides when on 4 July 2003, our cooperator was forced to treat all of his potted seedlings with Admire following observation of sharpshooters (assumed to be glassy-winged sharpshooter) on the seedlings. As we were interested in observing the efficacy of Admire (and couldn't conduct a test until levels of this material declined in the seedlings anyway), we started testing leaves from these treated seedlings against leaves from untreated trees at UC Riverside. Our cooperator applied the Admire in the irrigation water with his normal irrigation (which at the time was 15 minutes of water applied every 2 days), calculated to result in roughly 16 fl oz of Admire 2F per acre. Because we were concerned that there might possibly be more or less Admire in sleeves in the top versus the bottom of the irrigation line, we did bioassays with leaves from both areas and concurrently, Dr. Frank Byrne in Dr. Nick Toscano's laboratory is evaluating ppm of imidacloprid in the leaves using ELISA plates.

In contrast to previous trials done with potted 4-6 ft. tall avocado trees in 15 gallon pots, this trial was done with small seedlings in small sleeves (10-20 cm in height, potted in 1300 cc sleeves). Because we had no advance warning of this treatment, we did not tag fully expanded leaves at the time of treatment (as was done in Tests 1 and 2) for later use in bioassays.

Results from this trial are shown in Fig. 3. The relatively small size of the avocado seedlings may result in Admire uptake to the leaves much more quickly than one might expect with potted small trees or mature trees in the field (based on work done on citrus where peak levels appear in leaves roughly 3 weeks after treatment). It also may result in more rapid decline in efficacy than might be seen in larger trees due to regular irrigation washing the material through the pot. If true, this might also explain slight differences in bioassay results between pots at the top of the irrigation line (higher mortality at day 5 but lower mortality thereafter) versus the bottom. It will be interesting to see if ELISA results confirm this trend.

Fig. 3. Field Pesticide Residual Persistence Trial #3



<u>1.D. 2003 Fallbrook Field Pesticide Efficacy Trial.</u> The purpose of this study was to evaluate several highly refined oil formulations from Petro Canada, Inc. (PC) both alone (i.e. in comparison with NR-415 spray oil, Omni Oil 6E, 98% paraffin base petroleum oil, Helena Chemical Co., Memphis, TN) and in combination with Agri-Mek versus Surround, Success, and Veratran D.

A small avocado grove near Fallbrook, CA was chosen for the field trial based on high levels of avocado thrips (ca. 9 immature avocado thrips per leaf pre-treatment) and availability of a suitable number of study trees. Three blocks of trees were chosen for the study based on tree uniformity and the presence of moderate levels of avocado thrips. Trees were 2.5-year old top-worked Hass avocado on 30-year old Zutano rootstock, planted at a 16 foot by 16 foot spacing (170 trees per acre). At the time of the study, trees were 8-12 feet in height and 5-8 feet in diameter. Pre-counts of avocado thrips levels were taken on 24-30 trees in each block on 30 April 2003 by randomly picking 10 fully expanded but tender leaves on each tree and counting the number of immature avocado thrips on the underside of each leaf using a 10X head lens. Based on these pre-counts, 24 trees in each block were chosen for the study (trees with very high or low initial avocado thrips levels were excluded) and 2 trees from each block were randomly assigned to each of 12 treatments (Table 1). Thus, there were 6 single-tree replicates (2 in each of 3 blocks) of each treatment. Trees in each block surrounding experimental trees and in adjacent blocks were unsprayed and provided a source of invading adult thrips, thus providing a fairly rigorous test of the residual efficacy of treatments.

Sprays were applied 6-7 May 2003 using an SR-400 Pacific Stihl low-volume backpack mist-sprayer (L&M Fertilizer, Temecula, CA), nozzled to deliver a fine mist to the exterior of each tree. Treatments 1-5 (see Table 1) were applied in order 8 a.m. to 2 p.m. on 6 May and treatments 6-12, 8 a.m. to 2 p.m. on 7 May. In order to reduce drift to adjacent trees, a portable barrier, 12 feet high by 8 feet wide, was constructed using a plastic tarp reinforced on both sides with PVC pipe. As a tree was sprayed, the barrier was rotated to shield the opposite side of the tree to prevent spray drift to adjacent trees. Pesticide concentrations were based on standard per-acre use rates using a dilution of 100 gallons of water per acre, which is typical for air treatments on avocado. Spray coverage was designed to mimic a helicopter application to the degree possible. Because trees used in this study were planted at a somewhat more dense spacing but were of a smaller size than is typical in mature avocado groves, actual spray gallonage applied was less than 100 gpa (i.e. with this tree spacing and size, it was 85 gallons per acre). To follow the efficacy and persistence of sprays, post-treatment assessments of immature avocado thrips levels were taken 7, 21, 35, and 49 days post-treatment using the same methodology as used for the pre-counts (i.e. 10 leaves were sampled on each of the 6 replicate trees per treatment). Based on high avocado thrips levels on some experimental trees and in nearby blocks, the site was over-treated with Agri-Mek plus oil on 25 July 2003, thus terminating the study.

Table 1 and Figures 4a, 4b (SEM = standard error of the mean) show avocado thrips levels observed on trees sprayed with the various treatments. Success and Agri-Mek (with any of the 3 oils evaluated) were effective in maintaining avocado thrips at low levels through 35 days post-treatment but at the +45 day evaluation, thrips levels on trees treated with Success at 10 fl oz/acre were somewhat less (numerically, but without statistical separation in most cases) than on those treated with Agri-Mek at 10 fl oz/acre. These results conflict with results of past trials, which have generally shown greater persistence of efficacy with Agri-Mek versus Success. Several factors should be considered when interpreting these data. First, surrounding avocado trees were unsprayed and provided a source of immigrating adult thrips, challenging the treatments as the trial progressed. Second, these trees were relatively vigorous and continued to flush as the trial proceeded. Thus, it was likely that leaves selected for monitoring later in the trial were quite small at the time of spray application, leading to some dilution of residues as the leaves expanded.

Both Veratran D and Surround provided avocado thrips control through day 21 but levels on treated leaves returned to levels observed in the water control on day 35, probably because of the high level of thrips invading from surrounding, untreated trees. It should be noted that Surround normally should be applied every 10-14 days to maintain efficacy. Success alone appeared to outperform Success plus Surround.

There was no statistical separation between avocado thrips levels observed on trees treated with the four Petro Canada oil treatments versus Veratran D. On day 35, it appeared that thrips levels with the 5% PC 470 oil were elevated somewhat above those observed on water control trees but this difference was not statistically significant. It appeared that addition of 2% 415 Petro Canada oil to Agri-Mek outperformed 2% NR oil plus Agri-Mek but this difference was also not statistically significantly.

Based on these data, further trials evaluating the addition of Petro Canada 415 oil to Agri-Mek or Success as an alternative to NR 415 oil may be warranted.

Table 1. Treatments applied in a 2003 Fallbrook avocado thrips spray trial.

	Date	4/30/03		5/14/03		5/28/03		6/11/03		6/25/03	
	Days Post-treatment	Pre (-6)		7		21		35		49	
Treatment	Rate Per Acre	Immature Avocado Thrips Per Leaf [a]									
9. Success 2SC + 2% NR 415 oil	10 fl oz + 2%	9.07	A	0.87	B	0.12	B	1.18	C	4.25	C
3. Agri-Mek + 2% PC 415 oil	10 fl oz + 2%	9.02	A	1.07	B	0.20	B	1.38	C	9.20	BC
11. Surround 95 WP + Success 2SC + 2% NR 415 oil	50 lbs + 10 fl oz + 2%	9.02	A	0.87	B	1.31	B	1.53	C	13.45	ABC
4. Agri-Mek + 2% PC 455 oil	10 fl oz + 2%	8.95	A	0.98	B	0.10	B	1.82	C	13.82	ABC
2. Agri-Mek + 2% NR 415 oil	10 fl oz + 2%	9.03	A	1.32	B	0.10	B	4.43	BC	16.85	AB
7. 5% PC 455 oil	5%	9.03	A	3.25	B	4.07	AB	21.25	AB	19.52	AB
12. Veratran D + sugar	15 lbs + 10 lbs	9.02	A	0.58	B	1.73	B	15.62	ABC	19.97	AB
10. Surround 95 WP	50 lbs	9.47	A	1.37	B	1.77	B	13.03	ABC	20.20	AB
8. 5% PC 470 oil	5%	9.03	A	4.92	AB	4.13	AB	29.52	A	21.20	AB
1. Water control	--	9.08	A	12.37	A	6.85	A	13.93	ABC	22.00	AB
6. 2% PC 455 oil	2%	9.10	A	6.93	AB	3.08	AB	18.40	ABC	22.83	A
5. 5% PC 415 oil	5%	8.97	A	6.88	AB	3.53	AB	22.42	A	26.03	A

[a] Means within a column followed by the same letter are not significantly different (REGWQ within SAS for PC version 8.0, p = 0.05). Treatments are ordered by immature avocado thrips levels on 49 days post-treatment.

Fig. 4a. Fallbrook Oil Spray Trial

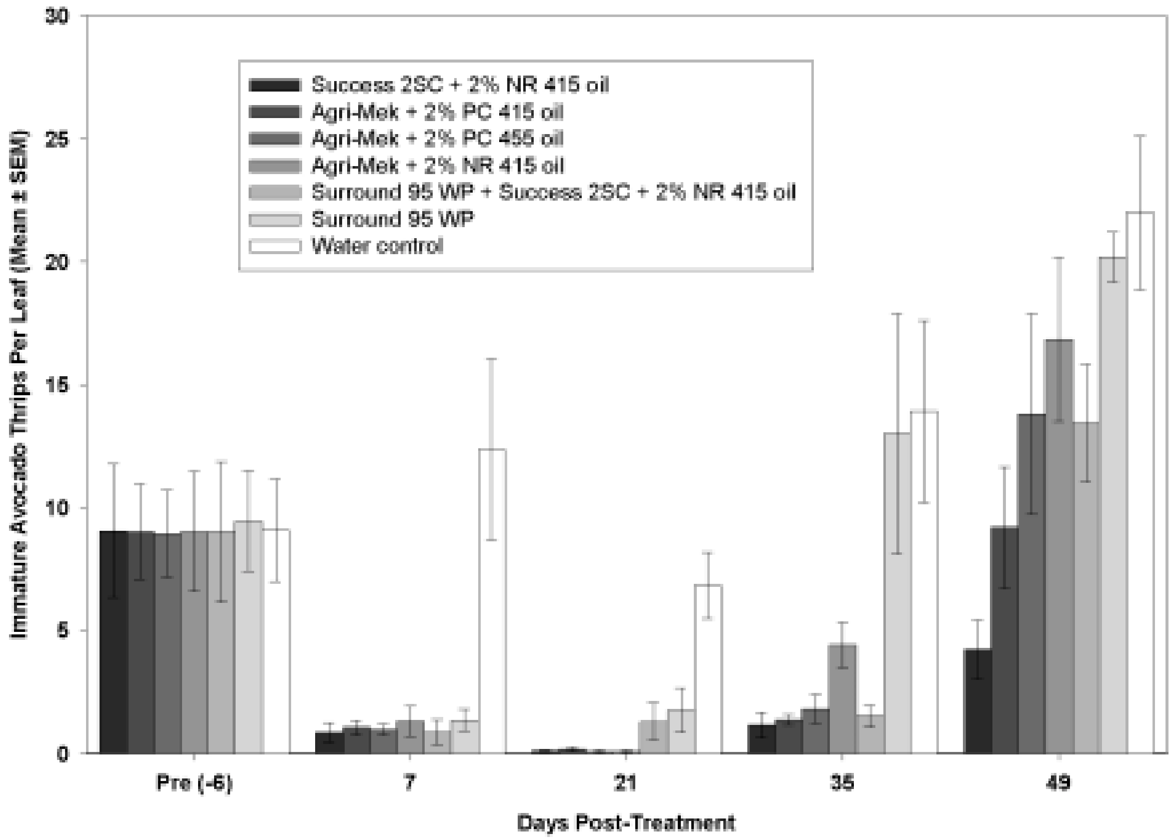
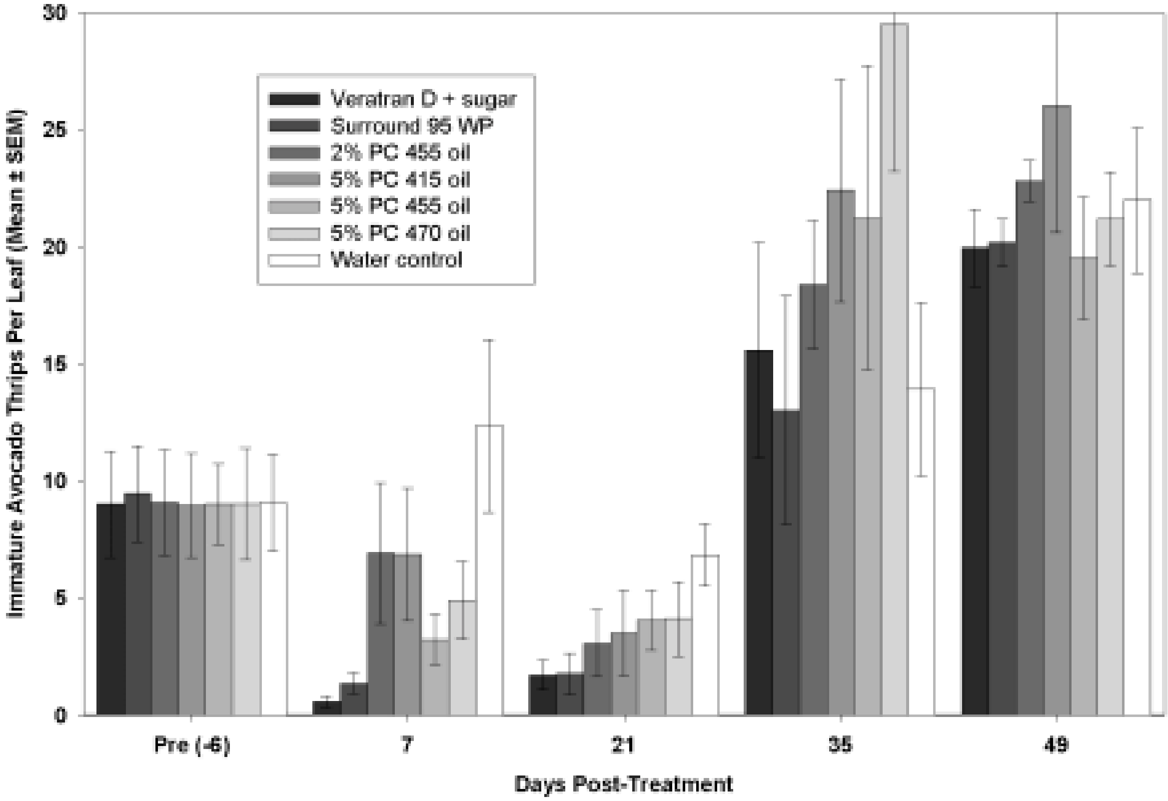


Fig. 4b. Fallbrook Field Oil Spray Trial



Results - Objective 2. Pesticide Resistance Monitoring. Dr. Eduardo Humeres, who conducted his Ph.D. research on abamectin resistance in populations of the twospotted spider mite, was hired in January 2003 as a postdoctoral scientist to conduct research on avocado thrips and persea mite resistance to various pesticides. Recall that previously we had demonstrated resistance to sabadilla [Veratran D] in two Ventura avocado thrips field populations and that this resistance reverted to susceptible levels after several years without sabadilla treatments. It is interesting that a recent publication reported resistance to spinosad in diamondback moth populations from both Hawaii and Thailand (Zhao et al. 2002). In addition, a recent unpublished report from Sygenta Crop Protection reports that abamectin and spinosad have different modes of action and that there is no cross resistance with these two chemicals in *Liriomyza* leafminer populations. If this turns out to be the case with avocado thrips, this is very good news.

To date Dr. Humeres has concentrated on developing baseline data on the susceptibility of persea mite to abamectin (Agri-Mek) and milbemectin (Mesa) before these materials are used widely for persea mite control in the field. After evaluating several bioassay methods, the following standard methodology was chosen. Avocado leaves were picked from trees with no prior pesticide exposure at UC Riverside, were washed, left to dry, and then dipped for 8 sec in the appropriate pesticide concentration. Mite susceptibility to six pesticide concentrations (and a water control) was evaluated with 5 replicate leaves per concentration. After the leaves had dried, each was placed on top of a wet sponge inside a plastic container (767 ml *Rubbermaid* sandwich container). To prevent mites from abandoning the leaf, each leaf was bordered with a sticky *Tanglefoot*® barrier and 20 to 25 adult female persea mites were transferred to the leaf using a small brush. After 72 hours at room temperature, mortality was assessed, data were corrected for control mortality using Abbott's formula, and data were statistically analyzed. Mites were considered alive if they exhibited vigorous repetitive movement of one or more appendages after prodding with a brush.

Persea mite susceptibility sampling sites were chosen based on the intensity of abamectin use over the last five seasons. In addition, we attempted to sample from the various regions of southern California where avocados are grown. Sample sites ranged from avocado groves where the assayed pesticide (Agri-Mek or Mesa) was never used to heavily sprayed sites (one to two sprays of Agri-Mek per season) in San Diego, Ventura, and Santa Barbara Counties.

To date, results with persea mite have revealed some natural variability in susceptibility to Agri-Mek and Mesa but no clear indication of pest resistance. The data showed that the Agri-Mek LC_{50} (pesticide concentration at which 50% of the population is killed) was not significantly different between the tested strains, except that the Oxnard strain was slightly more tolerant of Agri-Mek (Fig. 5). In fact, the LC_{50} of the Oxnard strain was statistically separable only from the strain with the lowest LC_{50} (the Rainbow strain). The resistance ratio (at the LC_{50}) between the two strains was 2.1 – thus, no major concern at this point, but something to keep an eye on.

With Mesa (Fig. 6), no statistical separation was found among the persea mite strains, as expected, because this pesticide has yet to be registered for use by California avocado growers.

No cross-resistance test was possible at this time between Agri-Mek and Mesa. In addition, it is too early to conduct resistance stability studies. Because resistant field populations were not found at present, we plan to initiate artificial selection in a greenhouse to study Agri-Mek resistance stability and the potential for cross-resistance to Mesa.

In summary, we have developed a suitable persea mite bioassay methodology and have established base-line susceptibility levels to Agri-Mek and Mesa. These data can be used to keep an eye on resistance evolution in field populations of the persea mite.

Fig. 5. Persea Mite - Agri-Mek 0.15 EC (abamectin)

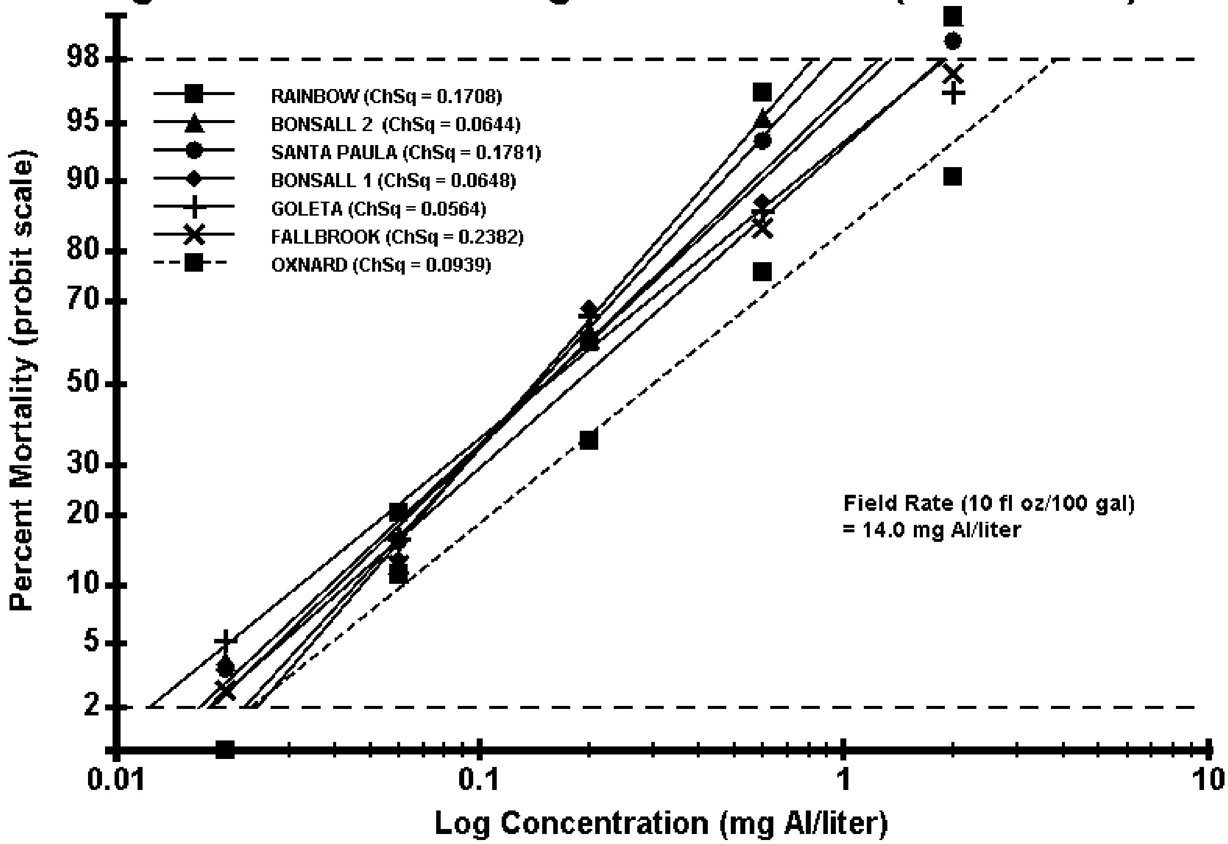
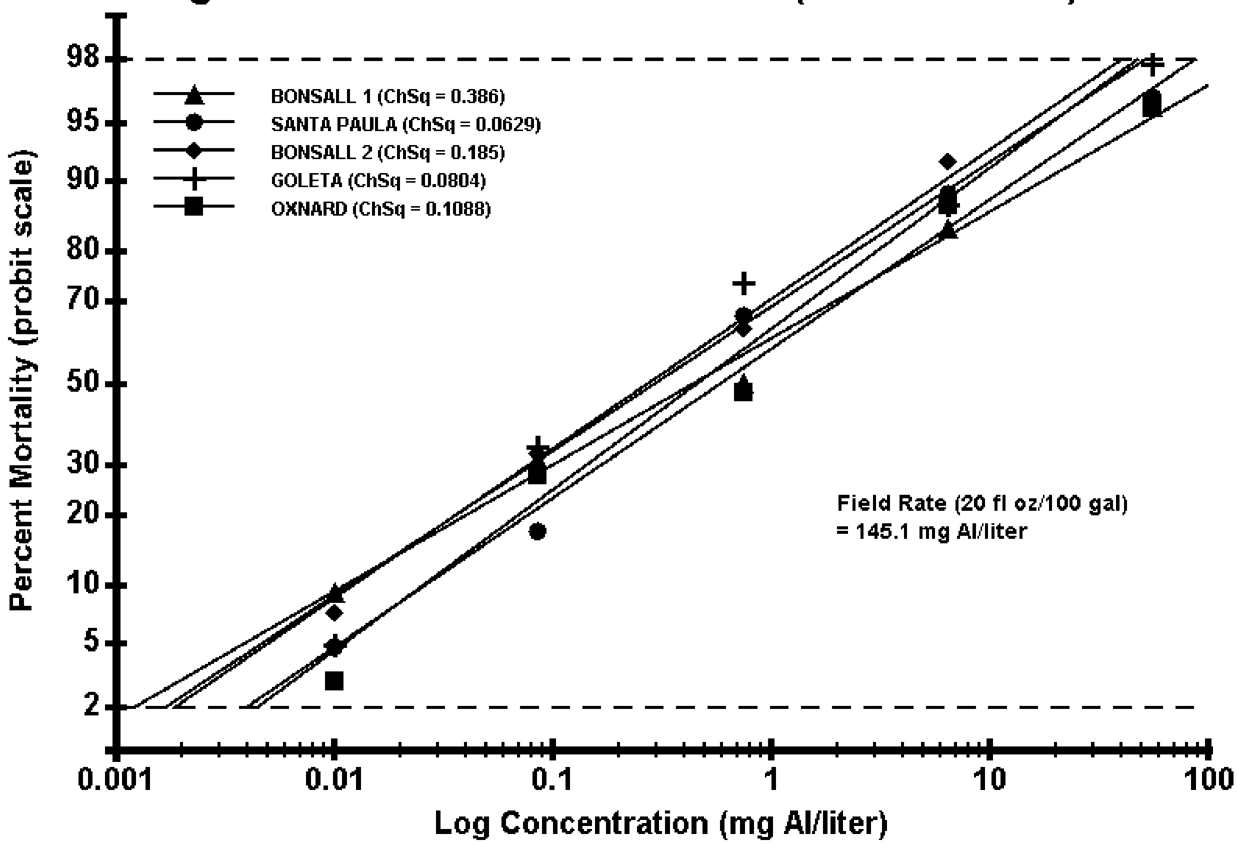


Fig. 6. Persea Mite - MESA 1% (milbemectin)



Results - Objective 3. Thrips Parasitoid Research. A new Ph.D. graduate student, Ms. Casandra Lloyd, with biological control expertise, started at UC Riverside in September 2003 and is interested in conducting research on parasitoids of avocado and citrus thrips. We plan to first develop a colony of *Ceranisus menes* collected from avocado thrips in Ventura County (Eve Oevering and Tom Roberts have seen moderate populations of this parasitoid on yellow sticky traps in groves with high avocado thrips populations and has observed parasitization of avocado thrips in the field). Once our methodology for rearing thrips parasitoids is established and our new micro-apparatus developed for this purpose by Rose Engineering, Inc. has been lab tested, we plan to import *Goetheana incerta* from South Africa (this parasitoid is present attacking *Scirtothrips aurantii* in the field and our cooperator is standing by to send a shipment to the quarantine facility in Riverside). It is unclear how effective either parasitoid species might be in control of avocado thrips but we are interested in pursuing biological control to the maximum extent possible.

Relevant References

(Contact Ms. Pamela Watkins at pjaw@ucrac1.ucr.edu if you would like a copy of any of these)

Hoddle, M. S., J. G. Morse, Y. L. Yee, and P. A. Phillips. 2001. Further Progress on Avocado Thrips Biology and Management. California Avocado Society 1999 Yearbook 83: 105-114, 116-125.

Hoddle, M. S., J. G. Morse, Y. L. Yee, P. A. Phillips, and B. A. Faber. 2001. Managing Thrips In Avocado Orchards. Citrograph 86: 6-7.

Hoddle, M. S., J. G. Morse, Y. L. Yee, P. A. Phillips, and B. A. Faber. 2001. A New Look at Managing Avocado Thrips. California Grower 25: 16-18.

Hoddle, M. S., J. G. Morse, Y. L. Yee, P. A. Phillips, and B. A. Faber. 2001. A Growers' Guide to Avocado Thrips Management 2001. AvoResearch 1: 1-5.

Hoddle, M. S., J. G. Morse, P. Oevering, P. A. Phillips, and B. A. Faber. 2002. Further Progress on Avocado Thrips Biology and Management. *In*: Proceedings, California Avocado Commission Research Symposium, October 26, 2002, California Avocado Commission, Santa Ana, CA. pp. 1-9.

Hoddle, M. S., J. G. Morse, P. A. Phillips, B. A. Faber, and K. M. Jetter. 2002. Avocado Thrips: New Challenge For Growers. Calif. Agric. 56: 103-107.

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.

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

Morse, J. G. 1998. Agricultural Implications of Pesticide-Induced Hormesis of Insects and Mites. Human & Experimental Toxicology 17: 266-269

Morse, J. G. and N. Zareh. 1991. Pesticide-Induced Hormoligosis of Citrus Thrips (Thysanoptera: Thripidae) Fecundity. J. Econ. Entomol. 84: 1169-1174.

Morse, J. G., E. E. Grafton-Cardwell, and A. A. Urena. 2001. Management Options for Citrus Thrips in the San Joaquin Valley. Citrograph 86: 4-5, 12.

Morse, J. G., M. S. Hoddle, and A. A. Urena. 2001. Persea Mite Pesticide Efficacy Trial. California Avocado Society 2000 Yearbook 84: 127-137.

Oevering, P., J. G. Morse, M. S. Hoddle, B. A. Faber, P. A. Phillips, A. A. Urena, and D. R. Anderson. 2002. Results of 2001 Avocado Thrips Field Pesticide Efficacy Trials. AvoResearch April 2002 (Special Edition): 1-5, 8.

Tollerup, K. and J. G. Morse. 2003. Evaluation of Phloxine B as a Possible Citrus Thrips (Thysanoptera: Thripidae) Control Agent. J. Econ. Entomol. 96(3): 629-635.

Yee, Y. L, P. A. Phillips, B. A. Faber, J. G. Morse, and M. S. Hoddle. 2001. Control of Avocado Thrips Using Aerial Applications of Insecticides. California Avocado Society 1999 Yearbook 83: 141-150, 152-162.

Yee, W. L., J. G. Morse, B. A. Faber, and P. A. Phillips. 2004. Control of *Scirtothrips perseae* (Thysanoptera: Thripidae) Using Spinosad and Abamectin Applied by Helicopter and Backpack in Southern California Avocado Orchards. Pest Management Science (submitted).

Zhao, J.-Z., Y.-X. Li, H. L. Collins, L. Gusukuma-Minuto, R. F. L. Mau, G. D. Thompson, and A. M. Shelton. 2002. Monitoring and Characterization of Diamondback Moth (Lepidoptera: Plutellidae) Resistance to Spinosad. J. Econ. Entomol. 95(2): 430-436.

Acknowledgment

We would like to acknowledge the assistance of Steve Maddock at the Maddock Nursery in Fallbrook who kindly allowed us to use potted avocado trees in the avocado thrips pesticide residual persistence studies. We thank Angel Huerta, Gerardo Huerta, Reuben Hofshi, and Robert Siemer for allowing us to conduct research in their groves. Matt Hand, Dave Machlitt, Mark Nyberg, Eve Oevering, Tom Roberts, and Mauricio Tapia assisted in obtaining field sites and spray records. Steve Peirce and Guy Witney have also been quite helpful in numerous aspects of our research.