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

Continuing Project: Year 2 of 3

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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 Veratran D; we have also seen a loss of susceptibility of persea mite to Agri-Mek in a commercial avocado grove in Ventura Co.), 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 [Veratran D] will be easily replaced if these materials are lost due to resistance (i.e. the search for effective control alternatives has yielded few 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 (as funded by the Citrus Research Board) and avocado thrips trials conducted by Oevering, Phillips, Faber, and pest control advisors. Work with Steve Peirce on any data needed to renew the 2004 Section 18 request for Agri-Mek. Work with Frank Byrne and Nick Toscano to evaluate new systemic chemicals

including imidacloprid (Admire), thiamethoxam (Platinum), dinotefuran (Venom), and TM-444 (Clutch).

Objective 2 – Pesticide Resistance Monitoring. 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 (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 2003 citrus thrips screening trial at the Lindcove Research and Extension Center, 24 treatments were compared. Unfortunately, citrus thrips pressure in our trial in 2003 was quite low (0.3% of outside, lower fruit were scarred by citrus thrips in the untreated control) and thus, statistical separation between treatments was minimal. Two similar citrus thrips field pesticide efficacy trials were conducted in 2004, one at Lindcove and a second in Kern Co. Treatments were applied in late April and fruit scarring data will be taken in November.

1.B. Avocado Thrips Field Pesticide Residual Persistence Studies. We have developed a method of screening potential avocado thrips control materials and initiated our fifth trial on 14 April 2004 (trials 1-2 and 5 were foliar spray trials, 3-4 were systemic pesticide trials). 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. Data from our first three field screening trials were published in the Proceedings of the 1 November 2003 California Avocado Research Symposium. Unfortunately, we cannot present the data from Trial #5 at this time as a secrecy agreement was signed covering this study.

1.C. Studies with Systemic Pesticides.

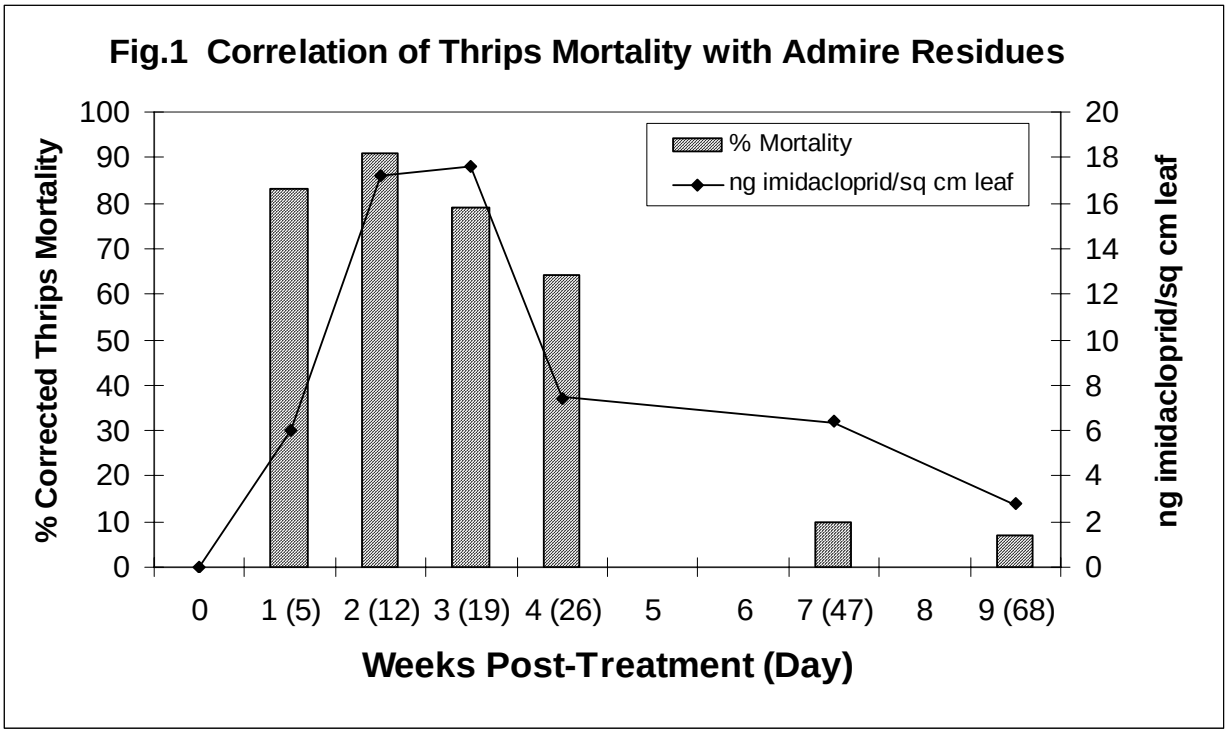
Trial #3, First Systemic Pesticide Study, 4 July 2003. In last year's report (Morse et al. 2003, Proceedings of the 2003 Symposium), we presented data showing the efficacy of Admire (imidacloprid) against avocado thrips on potted avocado. Thrips were bioassayed on leaves collected from the treated plants for 10 weeks post-treatment. Overall, there was excellent mortality of thrips for 4 weeks -- mortality was over 80% for the first three weeks and then 70% during the fourth week. However, by week seven, control was minimal (thrips mortality was approximately 15%).

To better understand what was happening within the leaves in terms of imidacloprid uptake, we conducted imidacloprid residue analyses on the same leaves that were used in the bioassays (Fig. 1). For this, leaf discs were cut from the bioassay leaves using a #4 cork borer (0.39 cm^2) and the imidacloprid titers were quantified using an ELISA technique. As expected, the levels of imidacloprid detected in the leaves on day 5 were high (6 ng imidacloprid per sq cm of leaf) and accounted for the excellent mortality seen in the bioassays. Peak mortality occurred in the bioassays conducted on day 12, by which time the apparent residues had risen to almost 18 ng imidacloprid/sq cm. Similar levels were also detected at 19 days post treatment, after which detectable levels began to decline. Between day 26 and day 47, however, the apparent levels of imidacloprid remained steady at between 6 and 8 ng imidacloprid per sq cm.

It should be pointed out that young, fully expanded leaves were chosen for use in bioassays throughout the monitoring period of this trial because under normal field conditions, these are preferred by thrips. Thus, leaves chosen for later bioassays would not have been present on the young plants at the time of the Admire application. The uptake of imidacloprid into these leaves will be compromised by watering of soil and natural degradation of the product, which combine to reduce available imidacloprid as the season progresses. It is therefore, not unexpected to see dramatic differences in imidacloprid titers between young leaves used in successive bioassays.

Although there was initially a good correlation between imidacloprid titers and mortality, during the later stages of our trial, correlating bioassay data with residue levels proved inconsistent. This was most evident from a comparison of bioassay data from day 5 and day 47 of the nursery trial. Although the ELISA gave approximately similar readings on both days (6 ng imidacloprid/sq cm), the bioassays revealed conflicting mortality levels of 85% on day 5 and 10% on day 47. This is most likely to be due to the cross-reaction of the imidacloprid antibody with metabolites of the insecticide. The metabolism of imidacloprid within plants has been well documented (Westwood et al. 1998, Nauen et al. 1998, 1999), and several of these are known to cross-react with antibodies that have been prepared for the detection of imidacloprid (Li and Li 2000, Lee et al. 2001, Wanatabe et al. 2001). Although there are no data available explaining the fate of imidacloprid in avocados, our results suggest that imidacloprid is broken down into non-toxic derivatives at about 2-3 weeks after application to the plants. For this reason, it will be necessary to carefully select application rates of Admire to ensure that levels of the parent material remain at sufficient levels within the trees to provide effective thrips control. The combined use of the bioassay and ELISA techniques is, therefore, a highly useful approach to identifying the effective window of activity of imidacloprid. It is clear from this trial that time-

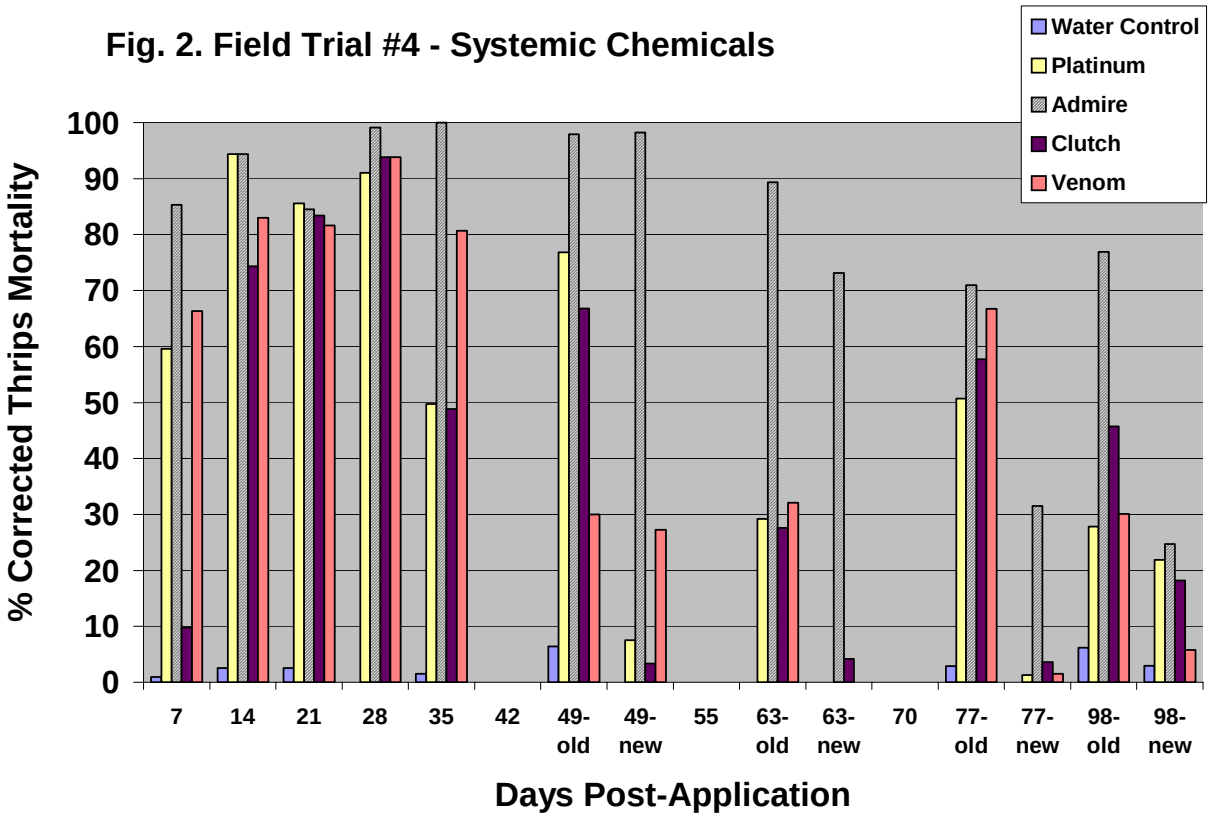
course experiments not only provide valuable information on the initial uptake of the insecticide but also on the longevity of residues in terms of their effectiveness.



Based on these results, the minimum effective concentration of imidacloprid for thrips control is 6 ng imidacloprid per sq cm leaf.

Trial #4, Second Systemic Pesticide Study, 14 April 2004. In this study, four systemic pesticides were applied to 1.5 cubic cm potted avocado seedlings by pre-watering the soil and applying the chemical mixed in water to the pot. Rates used were 1.14 ml per pot Admire 2F, 0.56 ml per pot Platinum 2SC, 0.32 gm per pot Venom 75SG, and 0.68 gm per pot Clutch 16WSG. Fully expanded young leaves at the time of treatment were tagged and these same leaves were later used in bioassays with second instar avocado thrips collected from the field or our laboratory colony. Ten to 15 avocado thrips per Munger cell were bioassayed per replicate with 10 replicates per chemical. Data are presented in Fig. 2.

By day 49 of the study, a new flush of leaves was present on the seedlings and we decided to split our bioassays into 5 replicates on both “old” (the leaves tagged at the beginning of the study) and “new” (the new flush) leaves. All four systemic chemicals showed activity against avocado thrips. Mortality on leaves from Platinum treated pots peaked at day 14 and continued high until day 49 (with a slight unexplained drop at day 35). Mortality on Admire leaves rose quickly and stayed high on old leaves through day 63. New flush leaves from Admire pots also were toxic to thrips on days 49 and 63. Leaves from Clutch treated pots showed slight thrips mortality on day 7, rose through days 14-28, and then declined thereafter. Mortality on leaves from Venom treated pots was high on days 7-35 but dropped thereafter. Based on these results, we are excited about evaluating these materials in field trials on commercial size avocado trees.

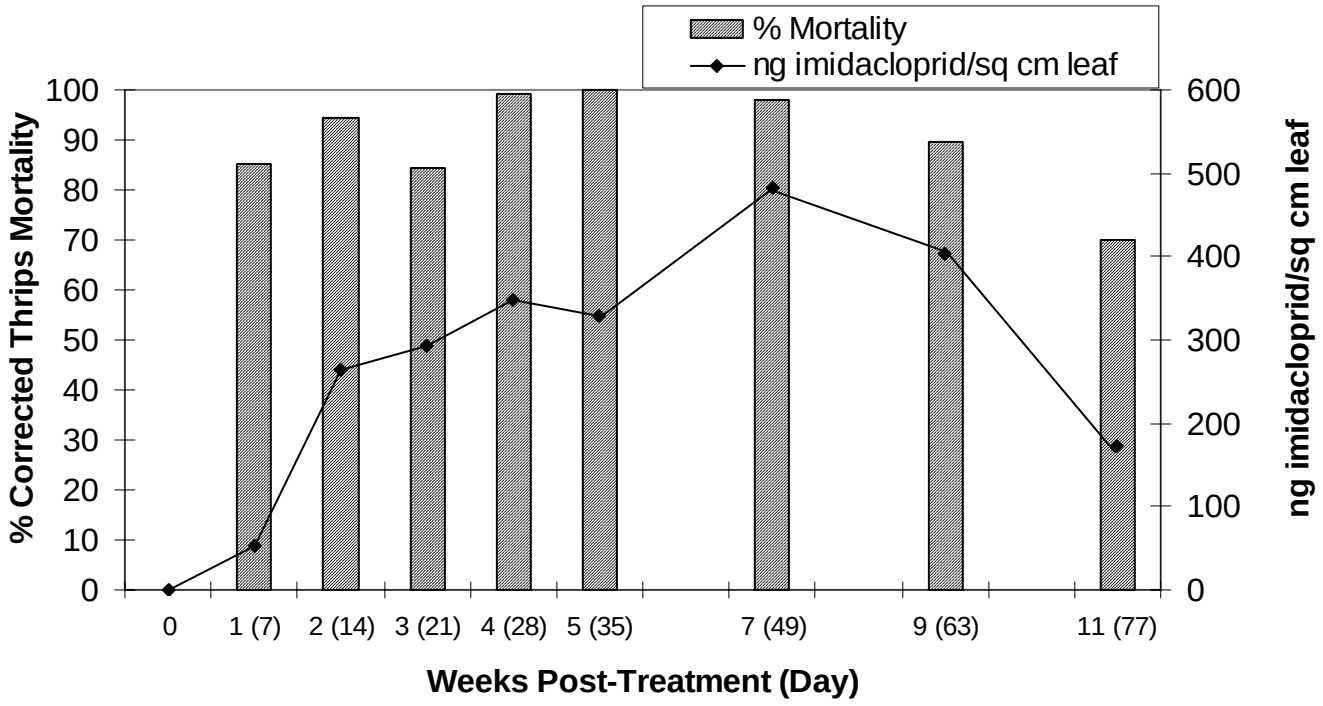


As noted above, in Trial #4, we assessed the efficacy of four neonicotinoids against avocado thrips using our standard laboratory bioassay. Because of the successful partnership between the bioassay and the ELISA in Trial #3, we also conducted residue analyses on leaf discs cut from the bioassay leaves for two of the pesticides used in this trial (Admire and Platinum treated leaves). In this report, we present the complete set of data for the Admire study. We are currently calibrating an ELISA assay for measuring Platinum residues in avocado leaf samples.

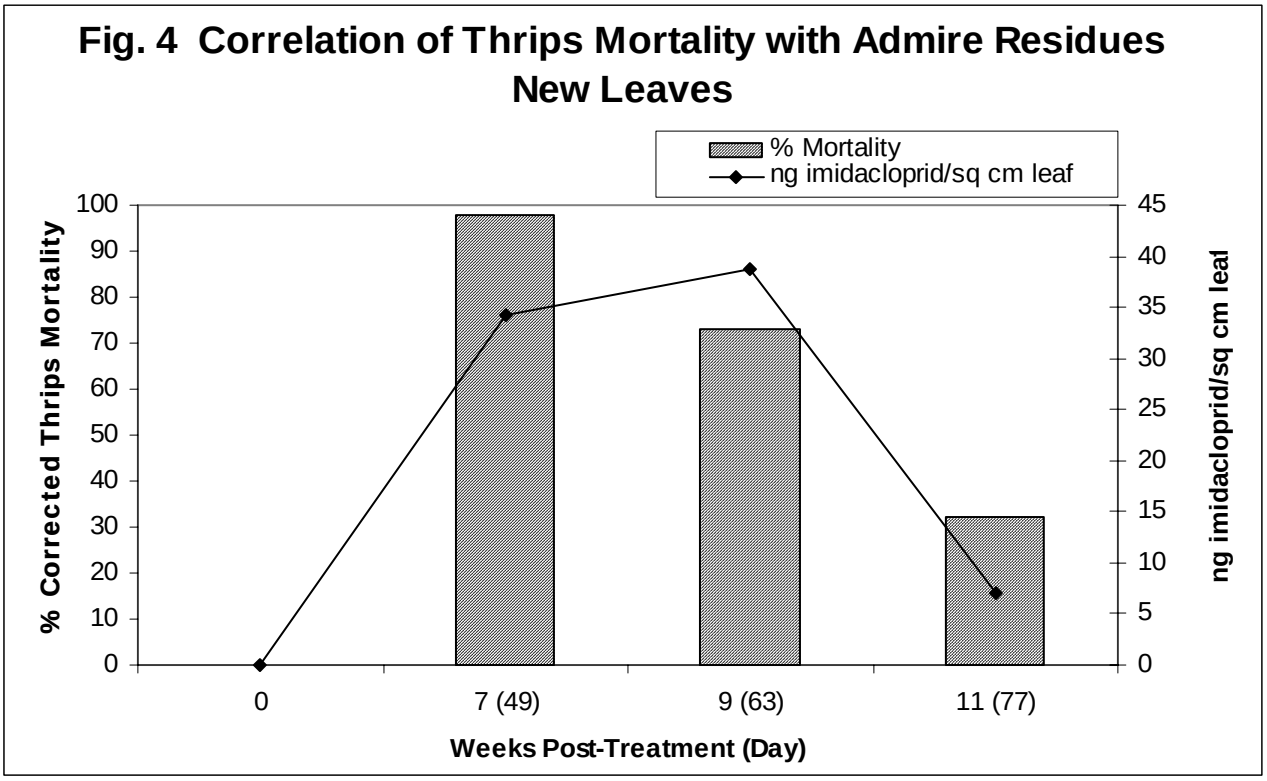
As observed in Trial #3, imidacloprid was rapidly taken up into the leaves (Fig. 3). Again, there was excellent mortality associated with the high residues detected. In this experiment, potted avocados were treated with the rate of Admire recommended for use on potted citrus, as there was no label recommendation for avocados. Not unexpectedly, therefore, this rate of application resulted in extremely high levels of imidacloprid in the leaves, which were far in excess of those measured in the previous trial (up to 5-fold greater). Within 1 week of treatment, leaf concentrations were already at 50 ng/sq cm, and these increased to 500 ng/sq cm by week 7. Excellent control of thrips was observed during this period. By week 11, control declined appreciably, which was surprising given the apparently high levels of imidacloprid present in the leaves. However, our results from Trial #3 provided us with valuable insight into the behavior of imidacloprid within avocado leaves, and allowed us to rationalize the results from the current trial. During the first bioassay, the imidacloprid titers were approximately 50 ng/sq cm of leaf. In bioassays conducted at week 11, mortality was lower despite apparent 3-fold greater levels of

imidacloprid. This is further evidence for the degradation of imidacloprid within avocado leaves. For these bioassays, we only used leaves that were fully developed (and tagged) at the time of Admire application and thus, all leaves would have received imidacloprid. By week 11, therefore, there was ample opportunity for plant enzymes to metabolize imidacloprid residues to non-toxic derivatives.

Fig. 3 Correlation of Thrips Mortality with Admire Residues Old Leaves



In week 7, we conducted additional bioassays on newly developed leaves, which would not have been present at the time of the Admire treatment. Even at this late stage, there was evidence that imidacloprid was still available for uptake (Fig. 4). Concentrations of imidacloprid of 35 ng/sq cm were detected in these leaves, resulting in excellent mortality. But within two weeks, mortality was reduced, suggesting an effective stability within the leaves of 2 weeks. This corroborates our findings from Trial #3 on the stability of imidacloprid once it has been transported to the leaves.



Our conclusions from the combined residue/bioassay components of Trials #3 and #4 indicate that application rates must be tailored to the needs of the control situation. They must be sufficiently high to attain toxic concentrations within the leaves (6 ng per sq cm of leaf) while there must also be an allowance for the loss in material through plant degradation mechanisms to ensure that toxic concentrations are maintained for sufficient time to provide satisfactory control.

1.D. Persea mite new pesticide screening trial. In research previously funded by CAC, we evaluated nine treatments for control of persea mite on avocados (Morse et al. 2001). The best treatment was Mesa, followed closely by Agri-Mek. Unfortunately, Mesa is related in chemistry to Agri-Mek and as the data in last year's Proceedings article (Morse et al. 2003) indicated, there was a loss of persea mite susceptibility to both Agri-Mek and Mesa following Agri-Mek treatments.

For this reason, we have decided it would be nice to find a new miticide for persea mite control with a chemistry unrelated to Agri-Mek, Success, or Mesa (they are all in the macrocyclic lactone class of chemistry). Working with Steve Peirce, we have identified an avocado grove with an appropriate persea mite population and a screening trial of new miticides is planned for October 2004.

1.E. Work in Support of the 2004 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). Below, we list contributions by this project in supporting the 2004 Section 18 request and research planned to support the 2005 request (anticipating that such a request may be needed).

On 8 September 2003, we provided a letter to Mr. Steve Peirce that was included in the original Section 18 request covering the 2004 field season. This letter outlined: (1) Our general strategy in identifying possible control materials for avocado thrips management; (2) How we have used past data collected with citrus thrips as a first step in avocado thrips pesticide research (including a list of 71 chemicals evaluated over the period 1982-2003); (3) Field Pesticide Residual Persistence Studies initiated in 2002 and used to further screen materials for avocado thrips control; (4) Details of the Field Pesticide Residual Persistence Protocol (5) Results to date using this protocol; and (6) A summary of conclusions to date.

Late in October 2003, we were contacted by US EPA and were asked to provide economic information related to the impact of avocado thrips on avocados in California in the absence of Agri-Mek (i.e. if the Section 18 request were denied). Working with Dr. Karen Jetter of the Agricultural Issues Center located at UC Davis and Steve Peirce, an economic analysis was performed and was emailed to EPA on 5 November 2003 (the analysis was later published in the March 2004 issue of AvoResearch – see Jetter and Morse 2004).

Late in January 2004, we were contacted by CA-DPR and asked to provide additional details on: (1) The relative efficacy of abamectin, spinosad, and sabadilla against avocado thrips; (2) Estimates of economic damage to avocado growers if abamectin were not made available in 2004; and (3) Data on the efficacy of abamectin applied by air. These data were provided to CA-DPR in a letter dated 2 February 2004, which was then forwarded to US EPA.

Additional details and copies of several research articles were requested by CA-DPR and were emailed to them on 4 February 2004.

Additional details and the answers to several key questions were requested by EPA on 4 February. With the assistance of Steve Peirce, Guy Witney, Reuben Hofshi, Karen Jetter, Dave Machlitt, and Ben Faber, a response was emailed to EPA on 6 February.

CA-DPR contacted us on 17 February for additional details on past avocado thrips pesticide efficacy trials. A draft response, summarizing 23 field avocado thrips spray trials conducted by UC researchers (Faber, Hoddle, Morse, Phillips, Oevering, and Yee) was prepared but at the last minute, was not submitted because we were informed on 19 February that the Section 18 had been granted.

On 8 March, 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 is 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 are 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 makers of abamectin and spinosad), Ben Faber, Eve Oevering, Aspen Helicopter, Pacific Rotors, and pest control advisors Matt Hand, Dave Machlitt, Mark Nyberg, and Tom Roberts, five field trials were applied in mid-May 2004 (three in Ventura County and two in San Diego Co.) to satisfy requirement #2.

Although both Dow AgroSciences (the makers of Success) and we are convinced that spinosad has little activity against persea mite, to satisfy EPA requirement #3, we will include a ground treatment of spinosad in the persea mite efficacy trial planned for October 2004 (1D above).

Results - Objective 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 and milbemectin. These data were submitted 14 June 2004 for publication in the Journal of Experimental and Applied Acarology. Unexpectedly, loss of Mesa susceptibility was observed in one field in Ventura Co. after 7 Agri-Mek treatments over 2000 through 2003 (a spring treatment each of 4 years for avocado thrips and a fall treatment each of 3 years before our bioassays in August 2003). We were concerned about possible cross resistance between Mesa, Agri-Mek, and Success but were surprised that the beginnings of this appeared before Mesa was used in the field. Based on these data, we have asked that the manufacturers of Mesa not pursue registration of this product on California avocados and they have agreed to this request. Potential resistance of persea mite and avocado thrips to the macrocyclic lactone class of chemistry (Agri-Mek, Success, and Mesa are all of this class) remains a concern.

Should Agri-Mek 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.

Resistance monitoring with avocado thrips is continuing and at present we have good data from two groves with both Agri-Mek and Success.

Results - Objective 3. Thrips Parasitoid Research. *Goetheana incerta* is a small eulophid parasitoid that was found in 1995 to attack South African citrus thrips (same genus but a different species from both the citrus thrips and avocado thrips we have in California). Dr. Tim Grout sent us a shipment of parasitoids that arrived 26 April 2004. This shipment was the first processed through UCR's new Quarantine facility. After several months of work we were able to clearly observe parasitism and emergence of second generation parasitoids out of California citrus thrips but were frustrated by our inability to maintain the culture in quarantine or to test it against avocado thrips. For the near future, we plan to concentrate on rearing *Ceranisus menes* on flower and avocado thrips. We plan to later return to work on *Goetheana*.

Relevant Recent Publications / Cited References

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

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