Further Progress on Avocado Thrips Biology and Management

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Benefit to the Industry

Avocado thrips, *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae) was discovered in California in July of 1996, and spread rapidly from two initial sites of discovery near Port Hueneme in Ventura County and at the Irvine Ranch in Orange County. Economic losses attributable to avocado thrips have been calculated using 1998 pack-out records. Economic data for 22 anonymous growers were combined with costs of thrips control incurred by using either biological control agents, Veratran-D (sabadilla), or Agri-Mek (abamectin). An economic model was developed by Dr. Karen Jetter at UC Davis to estimate the effects to growers and consumers of rising production costs, retail prices, and losses due to fruit scarring. The model indicated an annual short-run loss to avocado growers of between $7.6 and $13.4 million in 1998 from the combined effects of losses in quality and increased production costs associated with avocado thrips management. Economic losses to avocado thrips continue to accrue annually, but the magnitude of decreased revenue will vary yearly depending on the severity of thrips infestations, costs of control (biological or chemical), percentage of crop damaged, severity of damage, and market value for harvested fruit.

Our research sponsored by the California Avocado Commission has taken a three-pronged approach to investigating potential control strategies to minimize economic losses to avocado thrips. Our thrips management program is based on: (1) an improved understanding of this pest's biology, behavior, ecology, and natural enemies. We intend to use this information for the development of biological and cultural control programs for avocado thrips. (2) Screening and selection of IPM compatible insecticides and monitoring avocado thrips populations for resistance to these insecticides, and (3) investigating cost effective strategies for applying insecticides by air or ground as selected from screening trials. Subproject One is overseen by Hoddle (UCR); Subproject Two is overseen by Morse (UCR); Subproject Three is overseen by Oevering, Faber, and Phillips (UCCE, Ventura).

Objectives

Subproject One: Hoddle (UC Riverside)

1) Investigate and quantify the activity of composted organic mulches used for biological control of avocado root rot for cultural control of avocado thrips larvae and pupae pupating beneath avocado trees.
2) Investigate the efficacy of field releases of mass reared *Franklinothrips orizabensis* for the biological control of avocado thrips in two commercial avocado orchards
3) Design and build an automatic sorter to separate plastic tubes containing pupating *Franklinothrips orizabensis* from empty tubes lacking pupae.
4) Investigate the predatory behaviors of *Franklinothrips orizabensis* towards avocado thrips and greenhouse thrips (*Heliothrips haemorrhoidalis*) in environments of varying complexity.
5) Investigate the effect of density on progeny sex allocation by female *Franklinothrips orizabensis*.

Subproject Two: Morse (UC Riverside)

1) Investigate and determine the potential of the parasitoid *Goetheana incerta* and the predator *Franklinothrips orizabensis* for biological control of avocado thrips.
2) Evaluate the efficacy of pre-bloom insecticide applications for avocado thrips control and fruit damage reduction in northern and southern avocado growing areas.
3) Determine the efficacy of abamectin and spinosad treatments applied at fruit set for avocado thrips control.
4) Screen new and registered pesticides for efficacy against avocado thrips.
5) Develop base line metrics for measuring development of resistance by avocado thrips to sabadilla.

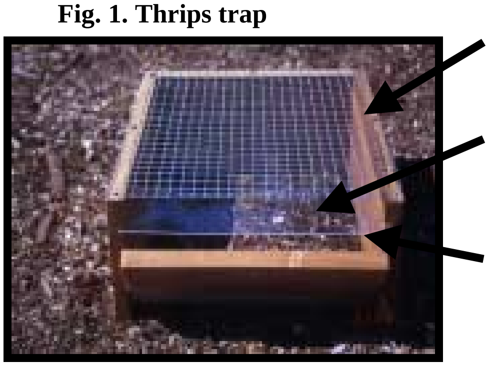
Subproject Three: Oevering, Faber, & Phillips (UCCE Ventura)

1) Investigate the efficacy of field releases of mass reared *Franklinothrips orizabensis* for the biological control of avocado thrips in a commercial avocado orchard in Ventura (with Hoddle).
2) Evaluate the efficacy of spot application and helicopter pre-bloom insecticide applications for avocado thrips control and fruit damage reduction in Ventura.
3) Determine the effect of time of pruning on occurrence of growth flush as an avocado thrips pre-fruit set breeding substrate.
4) Determine the effect of time of nitrogen fertilization on occurrence of growth flush as an avocado thrips pre-fruit set breeding substrate.
5) Determine the effect of algal sprays and other products used to manipulate bloom/fruit set on occurrence of growth flush as an avocado thrips pre-fruit set breeding substrate.
6) Experimentally relate thrips levels to fruit scarring by treating with sabadilla and/or abamectin at pre-established thresholds and maintaining thrips at or below those levels.

Cultural Control of Avocado Thrips (Research by Hoddle)

Laboratory and field studies indicate that large numbers of second instar avocado thrips larvae abandon leaves and pupate in soil beneath host plants. The motivation for this work was to determine if the pupal stage of the lifecycle, which is protected from insecticides, is amenable to disruption with a cultural control technique. One technique would be to use organic mulches under trees that create a hostile environment for pupating larvae thereby reducing pupation rates. To investigate this, twenty top-worked trees that were flushing heavily were selected in a commercial orchard in Temecula CA for study. Ten trees received composted organic yard waste (radius 10 feet from trunk to a depth of 6-8 inches) and ten trees were designated controls that did not receive mulch and had naturally accumulating leaf duff. Numbers of thrips larvae dropping from trees and numbers of thrips adults emerging from beneath trees were determined through the use of thrips traps (Fig. 1). These boxes had clear plexiglass panels covered in sticky tanglefoot that trapped dropping larvae on the upper surface and emerging adults on the undersides of panels. Panels are replaced are regular sampling intervals and returned to the lab where thrips on the tops and bottoms are counted. If mulches had a suppressive effect differences in adult emergence rates should differ between mulch and control plots.

Fig. 1. Thrips trap



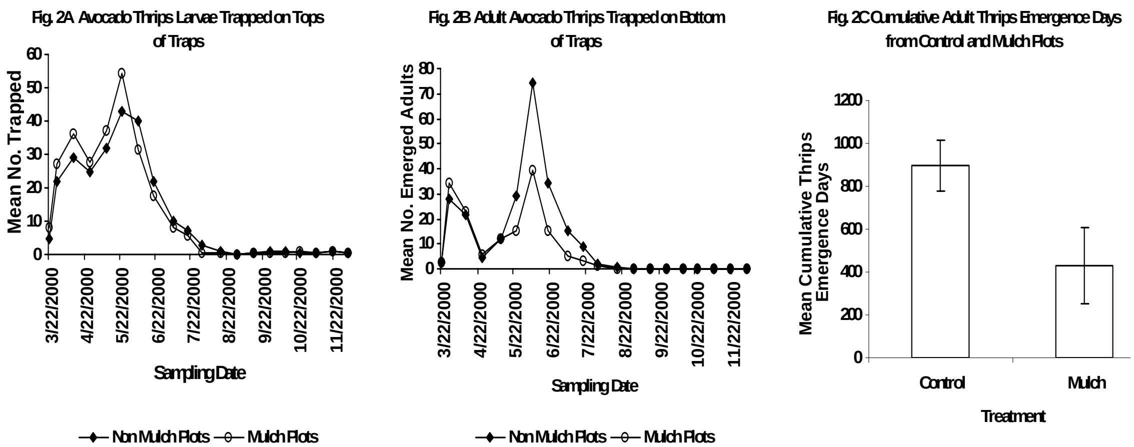
Mesh screen to prevent leaves and twigs sticking to clear plastic panel.

Clear plastic panel covered on both sides with tangle-foot. Thrips larvae dropping from trees are trapped on the top of the panel and winged adult thrips emerging from mulch and flying up to the canopy are trapped on the bottom side of the panel.

Hinged front panel on trap opens to allow the removal of the plastic sheet so tanglefoot and insects are not scrapped off when the panel is removed and wrapped in a clear plastic bag for transportation to the lab. Each trap measures 30 cm wide, 35 cm

Results:

Numbers of thrips larvae dropping from trees were slightly higher in the control plots because mulch promoted greater plant vigor and higher leaf flush levels which provided greater resources for ovipositing females and feeding larvae (Fig 2A). Peak emergence rates of adult thrips out of the soil were reduced by 50% in the mulch plots (Fig. 2B), and cumulative adult thrips emergence days were significantly lower in mulch plots ($t = 2.19$, $df = 12$, $p = 0.049$) (Fig 2C).



Our data indicate that thrips pupation rates may be substantially reduced under trees that have organic mulch laid underneath them. The exact mechanism of suppression is unknown but may be due to predatory microarthropods such as mites, or increased levels of entomopathogens such as fungi and nematodes. Additional work is needed to determine if pest population suppression can be achieved in large plots treated with mulch and pest densities compared to control plots. The mechanisms responsible for observed suppression in mulch plots need to be identified also.

Biological Control of Avocado Thrips

Subproject One & Three

Field Evaluations of Franklinothrips orizabensis for Control of Avocado Thrips (Research by Hoddle, Oevering, Faber, Phillips, & Blehm)

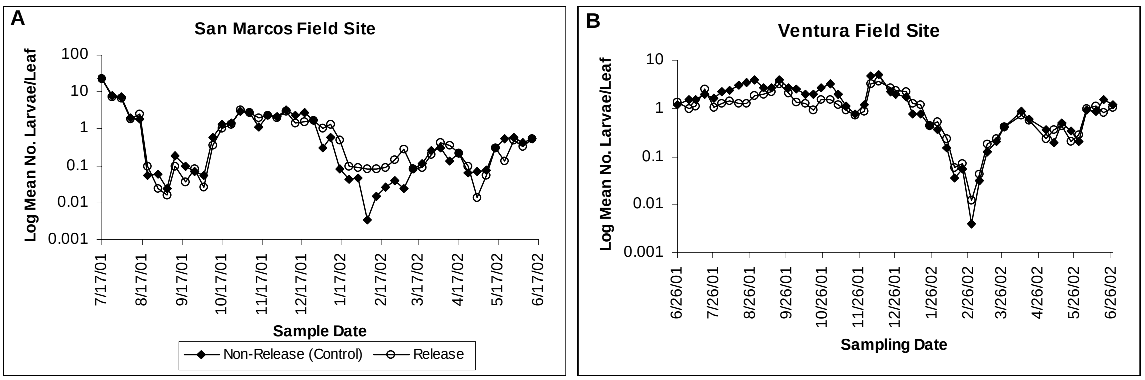
Mass reared *Franklinothrips orizabensis* produced by UCR and Buena Biosystems (Jake Blehm cooperator) were evaluated in two commercial avocado orchards; San Marcos in San Diego County (UCR) and Hueneme in Ventura County (UCCE Ventura). Approximately fifty *Franklinothrips orizabensis* were placed weekly into trees in plastic release vials as pupae in plastic tubes. Tubes were left in trees for 2-4 weeks (depending on temperature) before being removed and assessed for percentage emergence. Additionally, pupae in tubes were held in the lab each week and percentage emergence rates and the sex ratio of emerging adults was determined. Weekly counts of avocado thrips on *Franklinothrips* release trees were made by inspecting 10 immature leaves on each of five trees in each of five experimental blocks in each orchard. Trees were then divided into quarters and beat sampled and predators on beat trays were identified and numbers of each species were recorded. Avocado thrips and predators were similarly monitored on non-release trees (controls) to determine if significant differences existed between treatments. Additionally, yellow and white sticky cards were deployed at each experimental site to determine aerial movement of avocado thrips and *Franklinothrips* into and out of experimental plots. We also caged adult *Franklinothrips* males and females with varying amounts of food to determine how long they would survive for in the field. Maximum amount (100%) of food provided per vial was 200 irradiated *Ephestia* eggs.

***Results**:*

Field Trials

Mean weekly counts of avocado thrips larvae revealed no significant differences between release plots and non-release plots in San Marcos (Fig. 3A) or Ventura (Fig. 3B).

Fig. 3. Larval avocado thrips counts on *Franklinothrips orizabensis* non-release and release trees at the San Marcos (A) and Ventura (B) field sites.



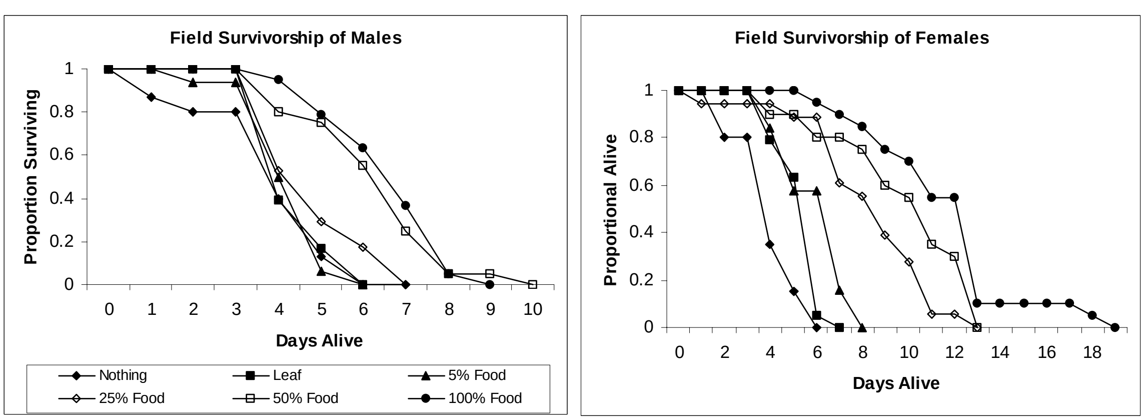
Quality Control and Sex Ratio of Franklinothrips orizabensis Pupae (Research by Hoddle and Oevering)

Franklinothrips pupae had very high survivorship and emergence rates at both the San Marcos and Ventura field sites. On average, 81-87% of pupae emerged (average lab emergence of mass reared Franklinothrips = 84-87%; average field emergence – 81%). Sex ratio of emerging *Franklinothrips* was highly male biased. On average, approximately 70% of emerged adults were males. Males are on average shorter lived than females, they do not eat as much, and they tend to be more vagile as they search for females to mate with.

Longevity of Franklinothrips orizabensis adults in the Field (Research by Hoddle)

On average females tended to live longer than males, and the greater the amount of food supplied the greater the survivorships rates and longevity (Fig. 4). Mean temperatures in the orchard at the time this trial was run were 8.15°C (min.) and 22.41°C (max.) over the period March 13, 2002 to April 4, 2002.

Fig. 4. Survivorship curves for male and female *Franklinothrips orizabensis* fed varying amounts of food.



<u>Automated Sorter for Separating Franklinothrips orizabensis Pupae in Plastic Pupation Tubes (Research by Hoddle)</u>

An automated sorter for separating plastic tubes occupied with Franklinothrips pupae and non occupied tubes has been designed and built by KSE Engineering and is currently being tested in the lab (Fig. 5). The machine sorts tubes via a Venturi canon that uses a differential in air pressure that is created by the bore of a tube either being partially blocked by a pupating *Franklinothrips* (high pressure) or one that is empty (low pressure). The air stream propels occupied tubes further than empty tubes and the two classes of tubes fall into separate collecting buckets. The machine has a sorting accuracy of 95% in the lab when separating occupied tubes from unoccupied tubes. This work was supported by grants from the Hansen Trust and the Center for Pest Management Research and Extension.

Fig. 5. Automate *F. orizabensis* pupae sorter (A), plastic tubes with F. *orizabensis* cocoons are put into the funnel and then vibrated along a tube (B) where they drop individually into a glass tube where a stream of air is used to separate occupied tubes from unoccupied tubes (C).

<u>Predatory Behaviors of Franklinothrips orizabensis Towards Avocado Thrips and Greenhouse Thrips and the Effect of Environmental Complexity on Attack Efficacy (Research by Hoddle)</u>

The foraging behaviors of predatory female *Franklinothrips orizabensis* Johansen towards *Scirtothrips perseae* and *Heliothrips haemorrhoidalis* on avocado leaf arenas were videotaped and analyzed. *Franklinothrips orizabensis* preferentially attacked second instar *S. perseae* with 80% (n = 113) attacks on this life stage being observed compared to 20% on first instars (n = 28) when equal numbers of these prey were presented simultaneously. Successful attacks by *F. orizabensis* were only made against propupal *H. haemorrhoidalis* (n = 6) that lacked protective fecal droplets. Second instar *H. haemorrhoidalis* larvae bearing protective droplets were not attacked when equal numbers of both stages were presented simultaneously. Consequently, the mean proportion of the time spent grooming by *F. orizanbensis* females attacking immature *H. haemorrhoidalis* was four times greater than that for females attacking *S. perseae* larvae even though there was no significant difference in mean time (s) spent in each grooming bout. Significant differences in mean consumption times by *F. orizabensis* existed across life stages and prey species. Consumption times were shortest for first instar *S. perseae* larvae, intermediate for second instars, and longest for *H. haemorrhoidalis* propupae. Mean consumption times for sequentially attacked second instar *S. perseae* declined significantly indicating satiation of predators. Predators would spend on average approximately 7-13 s probing leaves with mouthparts and feeding on fluids. This result may explain observed mortality of *F. orizabensis* in the laboratory and field when this predator forages on avocado leaves that have been treated with insecticides that exhibit translaminar activity. A second study investigating the effect of environmental complexity as measured by the number of corners a thrips could hide in a munger cell (zero corners for a circle and 18 corners for a snowflake shaped arena) revealed that fewer prey were attacked in 24 hrs as the environment became more complex and *F. orizabensis* had to search more corners for prey. The average maximum number of avocado thrips found and eaten in 24 hrs was 14-19 avocado thrips larvae (depending on shape) and only 1-2 greenhouse thrips in a 24 hr period regardless of environmental complexity. This work was supported by grants from the Hansen Trust and the Center for Pest Management Research and Extension.

Effect of Density on Sex Allocation by Female Franklinothrips orizabensis (Research by Robinson and Hoddle)

The effect of density (male:female and female:female) on ovipositing female *Franklinothrips* is under investigation to elucidate possible factors affecting sex ratio determination of offspring. *Franklinothrips* are haplodiploidy and females chose the sex of their offspring by electing to lay either unfertilized eggs (which become male) or fertilized eggs (which become female). Results from other insects (e.g., parasitic wasps) that exhibit haplo-diploidy indicate that when conditions are crowded more males are produced in response to this stress factor. A better understanding of factors affecting sex ratio allocation in *Franklinothrips* could help insectary operations produce female biased colonies thereby lowering the cost of production. This project is currently ongoing.

Subproject Two

Goetheana incerta Annecke *(Hymenoptera: Eulophidae) (Research by Morse, Urena, Flores, and Watkins).*

This parasitoid was first observed attacking South African citrus thrips, *Scirtothrips aurantii*, in 1995 (Grout and Stephen 1995) and we are interested in ascertaining whether it will attack avocado thrips and how effective it may in control of California citrus thrips, *Scirtothrips citri*. Over the last six months, we have been working with a micro-engineering company, Rose Engineering in Hesperia, to build tiny, escape-proof cages that can be used to confine parasitoids and first and second instar thrips. Our cooperator in South Africa, Dr. Tim Grout, has been collecting parasitoids and plans to send us a shipment some time in September.

Goetheana is very difficult to work with. Adults are small and fragile and emerge from within second instar thrips. Behavioral differences allow us to separate males and females to some degree, otherwise sexual differentiation is very difficult, even when adults are slide mounted and examined under a microscope. The ovipositor of the female is tiny and visible under high magnification only when she is in the process of stinging thrips. Unmated females lay only male eggs (males are obviously of limited value in building up a colony except for their critical input during mating).

Once we have developed a method of rearing *Goetheana* within the UCR Quarantine facility, our next step will be to evaluate its host range on various thrips species. We are unsure how well it will attack avocado thrips and it would be interesting to see if we might be able to select for a sub-strain of this species that will attack avocado thrips readily. Before we will be allowed to release *Goetheana* from quarantine, we must demonstrate that it will not endanger beneficial predatory thrips species such as sixspotted thrips, *Franklinothrips orizabensis*, or *Aeolothrips* spp. We anticipate that rearing, basic biology, and host range studies may take a year or more before we will be ready to release this parasitoid in the field. An additional benefit of such studies, however, are that they will likely make the search for parasitoids of avocado thrips parasitoids in Mexico much easier due to a better understanding of parasitoid biology and behavior.

Chemical Control of Avocado Thrips: Pre-bloom and Fruit Set Spray Trials, Pesticide Screening Studies, Pesticide Resistance Studies

Spray Trials with Avocado Thrips (Research by Morse, Hoddle, and Urena; Companion field studies run in Ventura County by Oevering, Faber, and Phillips)

A priority of spray trials the last two years was to determine if early, pre-bloom treatments of abamectin or spinosad might give persistent control of avocado thrips. Growers might want to use early treatments for three main reasons: (1) to depress unusually high pre-bloom avocado thrips populations; (2) to avoid treatment when honey bees might be present in the grove during bloom; or (3) because the number of helicopters available for air treatment is limited, waiting until fruit set for treatment might result in being placed in a “spray queue,” and if one is late in the queue, significant thrips scarring could result prior to treatment.

Detailed results from our 2001 spray trials were published in a previous CAC newsletter (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: 1-5, 8). Results from our 2002 study in the south are still being gathered and analyzed. In these studies, we confirmed that abamectin is extremely persistent inside avocado leaves and provides avocado thrips control for 6-10 weeks. This persistence, however, is a two-edged sword. If used properly, abamectin can be a very useful avocado thrips control material. However, if multiple abamectin sprays are applied in a grove within a season or over several seasons, they have the potential to select for resistance. In the absence of other effective chemicals being made available for avocado thrips control, we believe the avocado industry should do whatever they can to prevent avocado thrips from developing resistance to abamectin.

For this reason, pre-bloom abamectin sprays should be limited to situations in which it is clear that avocado thrips populations on leaves are quite high during the pre-bloom period (perhaps in the range of 5-10 immature thrips per leaf) and options for fruit set sprays are limited (if treatments cannot be applied other than by using helicopter application and there is a concern regarding a long fruit-set-timing spray queue). In situations where thrips levels warrant treatment and to the degree it is allowed by label restrictions, the ideal timing for an avocado thrips treatment would be late during bloom, allowing limited time for thrips levels to rebound from treatment prior to when young fruit, susceptible to scarring, are present.

Pesticide Screening Studies with Avocado Thrips (*Research by Morse, Urena, Flores, and Watkins)*

Recently, we have been asked to screen a number of chemicals potentially useful against avocado thrips. These include materials identified by EPA, DPR, the Avocado Commission, those that are registered for use on avocados, and any new materials that have shown promise in our citrus thrips research. Based on our research over the years, we developed a protocol for such tests as listed below.

Field Pesticide Residual Persistence Study Protocol -- Protocol to evaluate potential avocado thrips control materials:

1. Select 4 chemicals to evaluate at maximum expected use rate on avocados along with a positive control, and a water control
2. Select maximum expected use rate per acre for each material and guess at maximum longevity of trial for each material (x weeks).
3. For non-systemic materials, select fully expanded but tender leaves, tag them, and on day 0, spray them so that each tagged leaf is sprayed on the under surface (where we will later put the thrips) such that the droplet pattern appears similar to what one might get with a ground application at 300 gallons per acre. The key is consistent coverage of the leaf from trial to trial (same equipment, person). If a material will be used with oil or some other additive, use that additive in the application. Depending on number of tagged leaves needed and how many good leaves there are per tree, we could use 1-3 trees per material. These trees would not be reused in later trials except as discussed (if we are very sure residues are gone).
4. On day 7 and tentatively, weekly thereafter, randomly select 10 leaves from those that are tagged for each material, put in a labeled paper bag (or 2 – N, S), take to lab, set up in Munger cells, and introduce minimum of 10 second instar avocado thrips per leaf.
5. Evaluate mortality at 48 hr unless there is a suggestion that the material is slow acting or has an unusual mode of action (e.g., insect growth regulators or sterilants) – in these cases, other protocols or bioassay methods may be needed.
6. Continue weekly bioassays until mortality from 2 successive bioassays drops close to normal control mortality (perhaps 15%). Some materials may go quite some time (e.g., pryiproxyfen, abamectin) so if e.g., two materials drop out, select two new materials, spray them along with needed controls (we will need to discuss the need to continue a positive control once we get a feeling for typical results) and bioassays could start with them while the other 2 chemicals still remaining in the trial are finishing up.

The present status of screening trials using the protocol -- Our first trial with this new protocol was initiated with field treatment on 24 July 2002 and bioassays on 31 July and 7 August 2002. The first materials evaluated were Esteem 0.86 EC (pyriproxyfen), Surround 95% WP (kaolin), Mesa 1% EC (milbemectin) + NR-415 oil, and Assail 70 WP (acetamiprid) against a water control and positive standard. The trial is still in progress.

Baseline Pesticide Resistance Monitoring Studies with Avocado Thrips (Research by Morse, Urena, and Watkins)

Research on other economic thrips species, e.g., citrus thrips, indicates that thrips generally have the ability to develop resistance to pesticides that are used repeatedly for control (Morse and Brawner 1986, Immaraju et al. 1989a, b, Khan et al. 1998). For this reason, we initiated studies to determine the baseline susceptibility of avocado thrips to abamectin, sabadilla, and spinosad on populations of thrips that had minimal previous exposure to these materials. Using these data, any future cases of suspected resistance can be evaluated to determine if the cause of questionable control is in fact resistance or might be due to other causes (high thrips population pressure, less than optimal timing of treatment, poor spray coverage, etc.). In addition, we have evaluated several groves in which multiple applications of sabadilla were applied to see if sabadilla resistance was present.

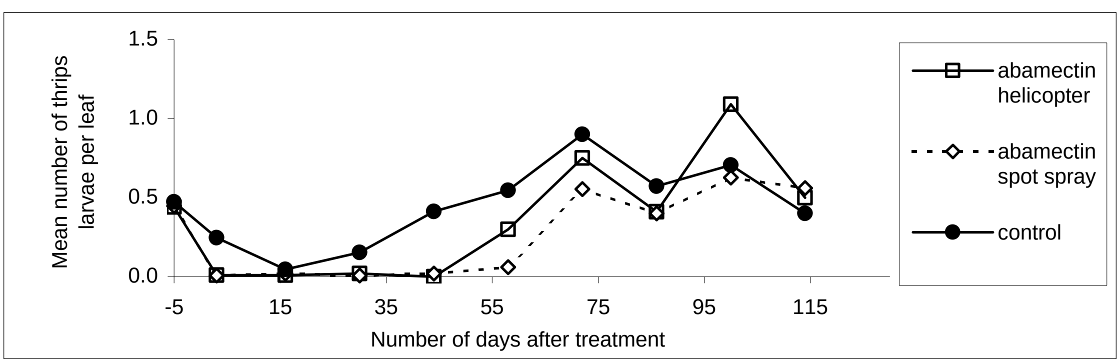
Results to date indicate that avocado thrips have the ability to develop resistance to sabadilla (see last year's symposium proceedings). To date we have no indication that resistance to either abamectin or spinosad has appeared in California avocado thrips populations.

Subproject Three

Field Trials on Chemical Control of Avocado Thrips (Research by Oevering, Faber, Phillips, Mills, Payne and Rodgers)

Since abamectin application by backpack is effective (Oevering *et al.*, in. AvoResearch April 2002: 1-5, 8) but labor intensive, we tested the use of an ATV towing a 200gallon container with 2 handguns on hoses as an alternative to a backpack. Following mixing 200 gallons (20oz Agri-Mek per gallon, 1% NR415 oil), the material was applied selectively to the flushing parts of trees on April 24, 2002, resulting in the application of 30 gallons mixture per acre. In Fillmore, a 4 year old Hass grove planted with 120 trees per acre was divided into 12 plots of 9x9 trees on which the following treatments were randomly assigned (3 replicates): (1) 20oz per acre in 100 gallons abamectin by helicopter, (2) abamectin spot spray by ground application during pre bloom/early bloom, (3) as (2) with an identical second application during fruit set when required, (4) untreated control. Every two weeks for 20 weeks, counts of avocado thrips were made by inspecting 10 immature leaves on each of five center trees in each treatment. These mean weekly counts of avocado thrips larvae revealed no significant differences between the abamectin treatments (Fig. 6). In addition, studies to relate thrips levels experimentally to fruit scarring started on May 8, 2002 and were terminated in July when thrips numbers did not reach the required levels. Low thrips levels were likely the cause of the results this year, and both studies on both objectives will be repeated next season.

Fig. 6. Mean larval avocado thrips counts on trees in the 2002 abamectin trial, Ventura.



Evaluation of Cultural Tree Management to Affect Tree Phenology and Therewith the Potential Food Source for Avocado Thrips

The Effects of Pruning, Fertilization Schemes and Algal Sprays on Tree Phenology (Research by Oevering, Faber Phillips and Mills)

Avocado thrips feed on young flush leaves that are present during certain growth periods of the tree. Several cultural management actions affect tree phenology and have been studied to indicate their effect on the presence of flush as a potential food source for thrips. Studies on the effects of pruning started in January 2002, and will continue until summer 2003. Observations on the effect of different fertilization schemes started in May 2002 and because of large variations in phenological responses of the trees, the differences found were negligible and the project was abandoned in September 2002.

Following the application of bloom enhancement products (including algal sprays) in 2001, no significant effects on growth and fruit set of avocado trees were found on mature trees, although studies in New Zealand showed otherwise (Faber, unpublished). A study on nursery trees in 2001 also showed no effects, but indicated some improvements in trial design were required. This year a new extract from New Zealand was tested on nursery trees (Ettinger - Toro Canyon) and a kelp extract from Nova Scotia (EcoNutrient) was used as a comparison. The main objective for the use of these materials was to stop or slow down tree growth (flush output) following application of low concentrations. One of eight treatments were applied to ten trees: 5%, 10% or 25% solution of Eco Nutrient; 5%, 10% or 25% solution of New Zealand extract, a control sprayed with water and an untreated control. The trees were placed 0.4m apart to allow for more equal light intercept (compared to the 2001 trial). For 9 weeks, the tree phenology, stem girth and height were measured. As a measure of the total increase in "biomass" the increase in length of all branches was added to the increase in height for each tree.

Tree phenology scores, girth or height increase during the trial did not differ significantly between the treatments. The increase in "biomass" was significantly larger on trees treated with 10% New Zealand extract, or 25% New Zealand extract compared to the controls (Multifactor ANOVA: df=7, F=12.69, $P<0.0001$; with LSD $P<0.05$), whilst other treatments did not differ significantly from the controls (Fig 7). Since the main objective for use of these materials was to stop or slow down tree growth, neither of the materials had a desired effect.

Fig. 7. Mean increase in "biomass" + SE over 9 weeks following application of a New Zealand kelp extract or EcoNutrient solution on nursery trees in Ventura (different letters indicate significant differences, ANOVA).